APPENDIX XXII

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SEA LAMPREY MANAGEMENT IN THE GREAT LAKES 1987

by

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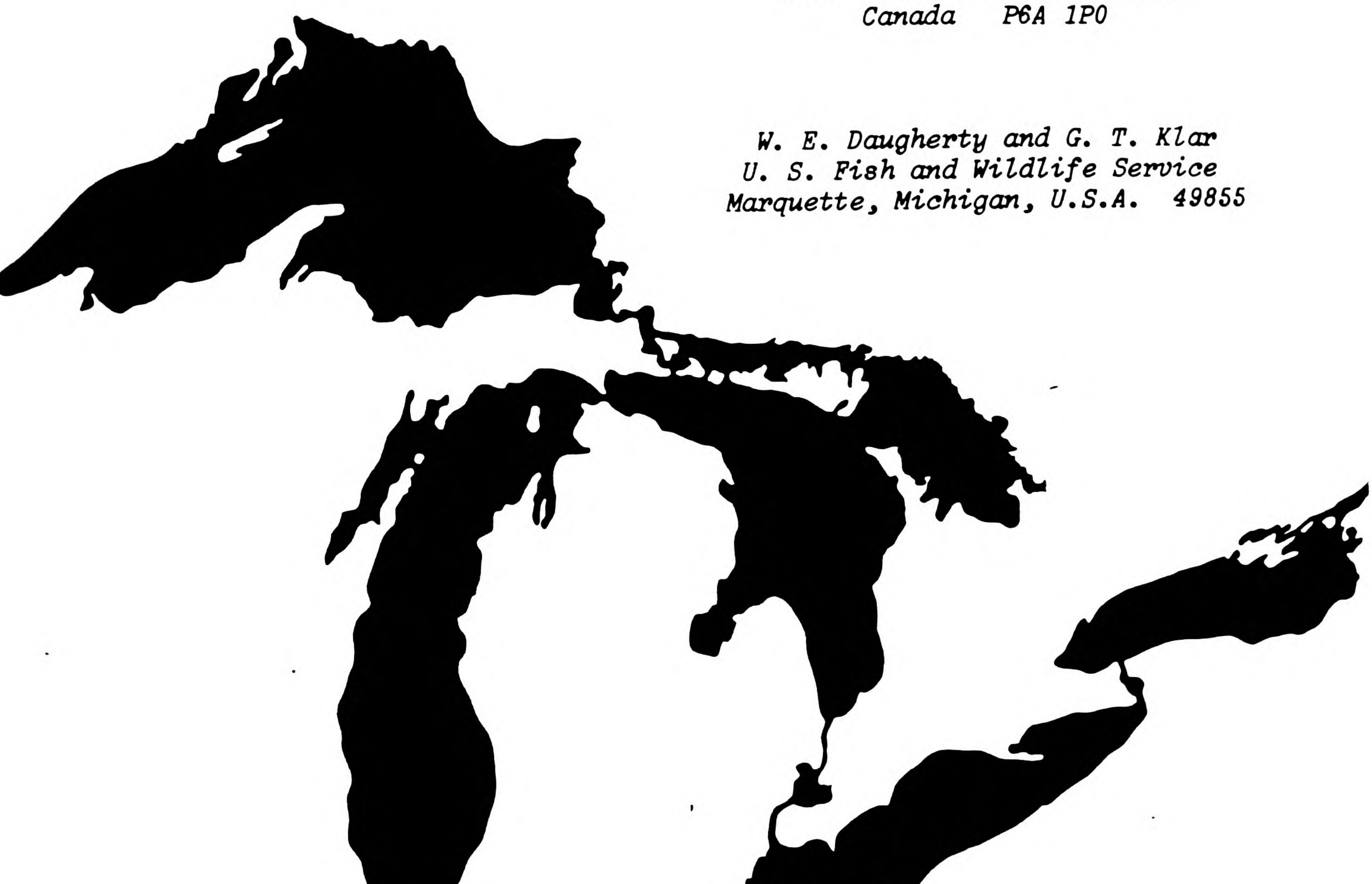

Great Lakes Fishery Commission

SEA LAMPREY MANAGEMENT IN THE GREAT LAKES 1987

EXECUTIVE SUMMARY

Management of sea lampreys in the Great Lakes by the Department of Fisheries and Oceans Canada and the United States Fish and Wildlife Service in 1987 included: larval surveys, lampricide treatments, assessment of adult sea lamprey populations, construction of low-head barrier dams, and assessment of the effects of lampricides on non-target organisms.

Surveys for larval sea lampreys were conducted on 448 tributaries -- 148 of Lake Superior, 132 of Lake Michigan, 92 of Lake Huron, 23 of Lake Erie, and 53 of Lake Ontario. Larvae were found for the first time in Red Cliff Creek of Lake Superior and the Shebeshekong River of Lake Huron. A total of 2,653 sea lamprey larvae, including 45 recently metamorphosed, were collected in surveys of the St. Marys River. In addition, 65 recently metamorphosed lampreys were collected by fyke nets from the river. Extensive surveys by both agents on the Niagara River produced only 48 larval sea lampreys, 34 above and 14 below Niagara Falls.

Lampricide treatments were completed on 70 tributaries (Table 1): 24 of Lake Superior, 19 of Lake Michigan, 10 of Lake Huron, 8 of Lake Erie and 9 of Lake Ontario. In addition, granular Bayer 73 treatments were conducted on 10 lentic areas (Table 1). The eight sea lamprey producing tributaries of Lake Erie: Grand River and Big, Young, Forestville, Cranes, Fishers, East and Catfish creeks were treated for the first time (the other 10 infested tributaries were treated in 1986). Unsuitable water discharges caused postponement of treatments in the Amnicon and White rivers of Lake Superior; the Millecoquins (Furlong Creek), Ford (Ten Mile Creek), the lower Brevort, and upper Cedar rivers and Beattie Creek of Lake Michigan; and the Cheboygan River (Little Pigeon River) and two tributaries of the Saginaw River (Carroll and Big Salt creeks) of Lake Huron. Treatment of the Spanish River of Lake Huron was deferred until court proceedings on a spill are completed against a private paper company. Mortality to non-target fish was minimal during most treatments, but significant numbers were killed during treatments of the Rouge River (Lake Ontario), the Little River (tributary to the Oconto River of Lake Michigan), and the Chippewa River (Lake Huron).

Assessment traps fished in 63 tributaries captured a total of 50,688 spawning phase sea lampreys (Table 2): 3,504 from Lake Superior, 9,635 from Lake Michigan, 26,900 from Lake Huron, 1,958 from Lake Erie, and 8,691 from Lake Ontario. To evaluate Lake Superior as a potential site for implementing the sterile male release technique, 6,324 tagged, male sea lampreys were released at 13 shoreline locations. Of these, 552 were recaptured in 23 tributaries and four shoreline locations. An estimated 23,166 spawning-phase sea lampreys were present in the U.S. waters of Lake Superior and another 10,000 in Canadian waters. From Lake Huron tributaries, an estimated 20,840 spawning-phase sea lampreys were in the St. Marys River, 12,236 in the Thessalon River, and 21,406 in the Cheboygan River.

Barrier dams with built-in traps to prevent the upstream migration of spawning-phase sea lampreys were constructed on the Wolf River (Lake Superior) and Grafton Creek (Lake Ontario). An adult trap was installed on the newly constructed dam and fishway on the McIntyre River (Lake Superior).

Commercial and sport fishermen collected 6,205 parasitic phase sea lampreys: 532 from Lake Superior, 1,004 from Lake Michigan, 4,391 from Lake Huron, and 278 from Lake Erie. Charter boat captains examined 40,874 lake trout and 75,982 chinook salmon taken from the upper lakes to report the incident of sea lamprey attachment and the number of sea lamprey wounds. As in 1986, the incidence of sea lampreys on lake trout and chinook salmon and the number of sea lamprey wounds on these fish were significantly higher in Lake Huron than in Lakes Superior or Michigan.

Tests of the short-term effects on lampricides on non-target organisms were conducted in treated and control sections of three streams in three lake basins. Long-term monitoring of the effects of lampricides to the mayfly, Hexagenia, and other organisms continued in four streams.

This report describes, by lake, the sea lamprey management activities in 1987.

Table 1. Summary of chemical treatments in streams and bays of the Great Lakes in 1987.

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

Lake	Number of treatments	Discharge		TFM[a]		Bayer 73 Powder		Bayer 73 Granules	
		m3/s	f3/s	kg	lbs	kg	lbs	kg	lbs
Superior	28	105.6	3,733	11,808	26,030	70.7	155.8	63.5	140.0
Michigan	19	87.9	3,108	24,793	54,654	41.2	91.0	-	-
Huron	16	127.3	4,500	22,544	49,700	29.2	64.4	61.7	136.0
Erie	8	12.1	426	3,301	7,273	-	-	-	-
Ontario	9	65.0	2,295	8,311	18,322	14.6	32.2	0.4	0.9
Totals	80	397.9	14,062	70,757	155,979	155.7	343.4	125.6	276.9

[a]Includes 1,035 TFM bars (227 kg, 501 lbs) applied in 18 streams.

Table 2. Number and biological characteristics of adult sea lampreys captured in assessment traps in 63 tributaries of the Great Lakes in 1987.

Lake	Number of streams	Total captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g)	
					Males	Females	Males	Females
Superior	23	3,504	759	42	438	426	187	179
Michigan	12	9,635	2,580	41	481	484	246	259
Huron	11	26,900	3,291	50	457	461	228	232
Erie	4	1,958	1,690	52	510	506	287	290
Ontario	13	8,691	2,134	63	496	486	258	261

LAKE SUPERIOR

LARVAL ASSESSMENT

United States

Surveys were conducted in 94 Lake Superior tributaries in 1987 in preparation for chemical treatments, to monitor reestablished and residual populations, and to search for new infestations. Pretreatment investigations were completed in 21 streams; 10 were later treated and 11 are being considered for treatment in 1988 or 1989.

Reestablished populations of sea lampreys were present in at least 38 streams at the end of the 1987 field season. Reinfestation appeared most significant in the Bad, Firesteel, Amnicon, and Chocolay rivers based on the number, size, and distribution of larvae. Sea lamprey distribution increased in the Waiska, Firesteel, and Nemadji rivers.

Moderate numbers of residual larval sea lampreys were found in the Sucker, Falls, and Brule rivers and fewer residuals were observed in 22 other streams. The Sucker and Falls rivers were later treated and the Brule River is scheduled for treatment in 1989 or 1990. A posttreatment survey of the Sucker River after the 1987 chemical treatment showed moderate numbers of residual sea lampreys still present; 207 larvae (6 to 88 mm long) and 1 transforming lamprey (166 mm) were collected. Numerous springs and old beaver ponds in this river apparently allowed some of the larvae to survive the treatments.

Surveys were conducted to assess the effectiveness of four low-head barrier dams. No recent larval recruitment was found upstream from the barrier dam on the Miners, Brule, and Middle rivers. The Misery River barrier was only partially effective in 1985 and 1986 because larvae of these year classes were present in the upper river. It is likely that high water levels during the early part of the season allowed escapement of spawning-run adults over the structure. Although the abundance of larvae in the upper river appears lower now than it was before the dam was constructed, chemical treatment should be anticipated. It is possible that the blocking effect of the dam may, at least in part, be responsible for the increases of larval distribution in adjacent streams. Surveys of other streams near the Misery River found a significant reinfestation of the upper East Sleeping River and an extension of larval distribution in the Firesteel River.

The value of regular monitoring of streams with potential for sea lamprey production was again demonstrated when a population of sea lampreys was discovered in Red Cliff Creek, a small stream in Bayfield County, Wisconsin, with no history of sea lamprey production. A total of 262 larvae ranging from 16 to 160 mm long were collected from six stations and four year classes are likely present. The stream is on the 1988 treatment schedule and has a relatively short drainage. Seven other streams with no history of sea lamprey production were examined and no larval sea lampreys were found.

Sea lampreys were collected from 2 of 10 offshore areas in Lake Superior. Many larvae were taken off the Falls River and a few off the Ravine River. These two streams were treated later. Delta areas in five inland lakes also were examined and larvae were found off the mouths of inlet streams in each lake. The largest collections were in Au Train Lake where 228 sea lampreys were taken off Coles Creek and the upper Au Train River. Both streams were later treated. Lentic populations were small in the four other inland lakes.

Canada

Surveys were conducted on 54 tributaries to Lake Superior in 1987. Population and distribution surveys were done on 10 streams in preparation for treatment in 1988 and 1989. Routine surveys of 24 streams with sea lamprey potential but no production were negative.

The Wolf and Jackfish Rivers have very high larval densities and both are scheduled for treatment in 1988.

Sea lamprey were collected for the first time from West Fox Creek, a tributary to Pays Plat River, which is a regular sea lamprey producer.

Population surveys were done on a number of streams that have a history of lamprey production but with apparent low densities. On the White River, index stations were established and sampled with granular Bayer 73 as relative abundance indicies prior to chemical treatment. The index results will be compared to a population estimate conducted during the chemical treatment of the river in 1988. Surveys of the Jackpine River yielded a larger number (32) of larvae than in earlier years. This river has never been treated with lampricide.

Extensive survey effort on the Pic River yielded only 106 sea lamprey larvae from 30 sites totalling 1.49 ha (3.7 acres). This represents less than 0.15% of the available habitat. The habitat is predominately silt-clay and recent research suggests that clay and organics very quickly reduce the efficiency of Bayer 73. Assuming a 10% efficiency in the Pic River survey plots, the larval density was calculated to be 700/ha (283/acre) with a total population estimate of 0.7 million.

In 1986 the lentic population of sea lamprey larvae adjacent to the mouth(s) of the Nipigon River in Helen Lake was treated with granular Bayer 73 at the same time TFM was flushing from the river treatment. Reduced river flows had created the best conditions possible for treating this lentic population. This lentic population of sea lamprey in Lake Helen was monitored again in 1987. Survey results included 851 larval sea lamprey and two marked brook lamprey (from the 1986 release) in 1.92 ha (4.7 acres). Index sites (eight) of 1,000 square meters (10,764 sq ft) were established in Helen Lake and will be sampled annually.

CHEMICAL TREATMENTS

United States

Chemical treatments were completed on 18 streams (Table 3, Fig. 1) with a combined flow of 68.1 m^3/s (2,408 f^3/s). The St. Louis River was treated for the first time. Low water levels caused postponement of the Amnicon River treatment and created problems during treatment of the Sucker and Two Hearted rivers.

Abundance of ammocoetes was high in the Two Hearted, Sucker, Betsy, Miners, and Falls rivers, and medium to low in the other treated streams. Among the larger streams treated, numbers of larval sea lampreys in collections were largest in the Sucker River (6,729) and smallest in the St. Louis River (184).

Transforming sea lampreys were collected in 10 of the 14 streams treated after July 15. Though the density of larval sea lampreys was low in the St. Louis River, over half of the ammocoetes collected exceeded 100 mm long and 16% showed signs of transformation.

Mortality to fish was minimal during most treatments. The largest numbers of dead fish observed were 105 spawning pink salmon near the mouth of the Miners River, and 53 walleye and numerous stonecats, logperch, and trout-perch in an upper section of the St. Louis River.

Ten bioassays to determine minimum lethal and maximum allowable concentrations of TFM for sea lampreys were conducted on Lake Superior streams before treatment. Results of these bioassays for minimum lethal concentrations agreed closely with the prediction charts.

Canada

The lampricide TFM was applied to six Lake Superior tributaries and granular Bayer 73 was used to treat four bay/lake areas (Table 3, Fig. 1). Very high water discharge throughout the year in the White River caused its treatment to be deferred until 1988. However, with the exception of the Kaministikwia River, which was treated at an Ontario Hydro controlled discharge, the remaining five streams were treated at lower than normal discharges. Despite these low flows, all treatments were successful, with lethal blocks of TFM maintained to stream mouths.

Larval sea lamprey were moderately abundant in all streams treated with non-target fish mortality being negligible.

Granular Bayer applications to areas of Batchawana, Mountain, and Cypress bays and Polly Lake produced lower numbers of larval sea lamprey than in past years.

SPAWNING-PHASE SEA LAMPREYS

United States

Assessment traps placed in 14 tributaries captured 3,323 adult sea lampreys in 1987 (Table 4, Fig. 1), compared with 8,777 in 1986. The reduction largely was due to a 74% decrease in the number of lampreys captured in the Brule River (7,006 in 1986 vs. 1,825 in 1987). The catches also declined in the other tributaries monitored (1,771 in 1986 vs. 1,498 in 1987). The average length and weight of lampreys taken in 1987 was about the same as those taken in 1986, but the percentage males in the sample (n = 759) increased from 38 to 42. Spawning runs in six streams were monitored through cooperative agreements with the Great Lakes Indian Fish and Wildlife Commission (Amnicon, Middle, Bad, Silver, and Huron rivers) and the Wisconsin Department of Natural Resources (Brule River).

The total number of spawning-phase sea lampreys was estimated in U.S. waters of Lake Superior for the second consecutive year. The estimate, based on a significant relation ($y = 5.38x$; $P < 0.01$, $r = 0.74$) between average stream

Table 3. Details on the application of lampricides to streams, lakes, or bays of Lake Superior, 1987.

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

Stream, lake, or bay	Date	Discharge		TFM[a]		Bayer 73				Stream treated		Area treated	
						Powder		Granules					
		m^3/s	f^3/s	kg	lbs	kg	lbs	kg	lbs	km	miles	ha	acres
UNITED STATES													
L. Two Hearted R. (3)	June 5	1.47	52	93	204	-	-	-	-	8.1	5.0	-	-
Betsy R. (2)	June 8	1.98	70	123	271	-	-	-	-	16.1	10.0	-	-
Two Hearted R. (4)	June 20	3.68	130	672	1,482	-	-	-	-	77.4	48.0	-	-
Tahquamenon R. (1)	July 2	10.62	375	1,007	2,220	15	33	-	-	29.0	18.0	-	-
Iron R. (12)	July 16	1.98	70	170	374	-	-	-	-	4.8	3.0	-	-
Sullivans Cr. (6)	July 31	0.03	1	10	22	-	-	-	-	3.2	2.0	-	-
Sucker R. (5)	Aug. 1	1.36	48	265	585	-	-	-	-	40.3	25.0	-	-
Silver R. (15)	Aug. 28	1.42	50	114	250	-	-	-	-	4.8	3.0	-	-
Ravine R. (14)	Aug. 29	0.34	12	40	88	-	-	-	-	4.8	3.0	-	-
Salmon Trout R. (17)	Aug. 31	1.13	40	130	286	-	-	-	-	1.6	1.0	-	-
Falls R. (16)	Sept. 1	1.42	50	110	242	-	-	-	-	1.6	1.0	-	-
St. Louis R.[b] (18)	Sept. 11	36.81	1,300	3,764	8,299	56	123	-	-	8.1	5.0	-	-
Harlow Cr. (11)													
Bismark Cr.	Sept. 16	0.03	1	2	5	-	-	-	-	1.6	1.0	-	-
Furnace Cr. (9)	Sept. 24	0.23	8	10	22	-	-	-	-	1.6	1.0	-	-
Miners R. (8)	Sept. 25	0.28	10	60	132	-	-	-	-	1.6	1.0	-	-
Beaver L. Outlet (7)													
L. Beaver Cr.	Sept. 27	0.06	2	10	22	-	-	-	-	1.6	1.0	-	-
Au Train R. (10)													
Cole Cr.	Sept. 28	0.11	4	20	44	-	-	-	-	1.6	1.0	-	-
Upper Au Train R.	Oct. 27	2.69	95	555	1,223	-	-	-	-	6.5	4.0	-	-
Pine R. (13)	Oct. 27	2.55	90	249	550	-	-	-	-	6.5	4.0	-	-
Total		68.19	2,408	7,404	16,321	71	156	-	-	220.8	137.0	-	-
CANADA													
Stillwater Cr. (20)	July 9	0.09	3	18	40	-	-	-	-	1.2	0.7	-	-
Polly Cr. (21)	July 12	0.13	5	60	132	-	-	-	-	2.6	1.6	-	-
Little Gravel R. (25)	July 15	0.05	2	6	13	-	-	-	-	4.3	2.7	-	-
Cash Cr. (23)	July 19	0.79	28	359	791	-	-	-	-	22.8	14.2	-	-
Kaministikwia R. (19)	Aug. 22	36.28	1,281	3,933	8,671	-	-	-	-	36.3	22.6	-	-
Little Carp R. (28)	Sept. 1	0.17	6	28	62	-	-	-	-	9.1	5.7	-	-
Cypress Bay (24)	July 8	-	-	-	-	-	-	9.1	20.0	-	-	0.7	1.7
Polly Lake (22)	July 14	-	-	-	-	-	-	4.5	10.0	-	-	0.4	1.0
Mountain Bay (26)	July 18	-	-	-	-	-	-	18.1	40.0	-	-	1.5	3.7
Batchawana Bay (27)													
- off Sand Pt.	Aug. 20	-	-	-	-	-	-	9.1	20.0	-	-	0.7	1.7
- off Batchawana R.	Aug. 21	-	-	-	-	-	-	11.3	25.0	-	-	0.9	2.2
- off Harmony R.	Aug. 24	-	-	-	-	-	-	2.3	5.0	-	-	0.2	0.5
- off Chippewa R.	Sept. 30	-	-	-	-	-	-	9.1	20.0	-	-	0.7	1.7
Total		37.51	1,325	4,404	9,709	-	-	63.5	140.0	76.3	47.5	5.1	12.5
GRAND TOTAL		105.70	3,733	11,808	26,030	71	156	63.5	140.0	297.1	184.5	5.1	12.5

[a]Includes 269 TFM bars (56 kg, 124 lbs) applied in eight streams.
[b]Initial treatment.

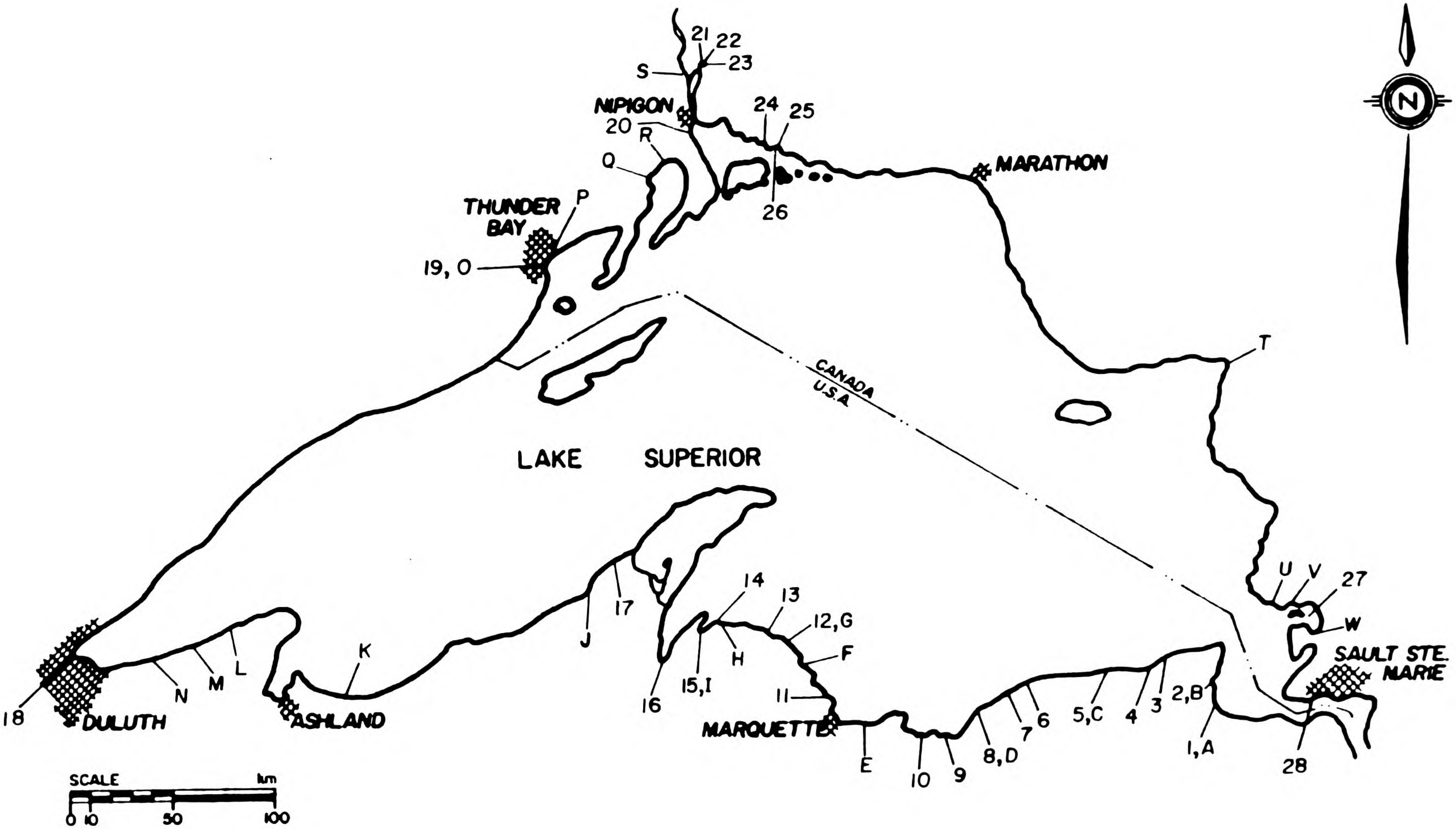

Figure 1. Location of streams treated with lampricides (numerals; see Table 3 for names of streams), and of streams where assessment traps were fished (letters; see Table 4 for names of streams) in 1987.

Table 4. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Superior, 1987.

[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
UNITED STATES							
Tahquamenon R. (A)	159	2	100	400	-	213	-
Betsy R. (B)	59	6	67	427	427	194	201
Sucker R. (C)	4	0	-	-	-	-	-
Miners R. (D)	15	0	-	-	-	-	-
Rock R. (E)	304	125	38	420	414	175	158
Big Garlic R. (F)	6	2	50	432	418	182	245
Iron R. (G)	10	0	-	-	-	-	-
Huron R. (H)	2	1	0	-	395	-	140
Silver R. (I)	4	4	75	362	440	131	278
Misery R. (J)	419	124	41	434	404	184	170
Bad R. (K)	439	85	32	452	410	181	145
Brule R. (L)	1,825	406	44	444	442	193	196
Middle R. (M)	16	1	100	450	-	228	-
Amnicon R. (N)	61	3	67	385	515	157	318
Total or average	3,323	759	42	438	426	187	179
CANADA							
Stokely Cr. (W)	5	0	-	-	-	-	-
Carp R. (V)	29	0	-	-	-	-	-
Pancake R. (U)	44	0	-	-	-	-	-
Michipicoten R. (T)	0	0	-	-	-	-	-
Nipigon R. (S)	0	0	-	-	-	-	-
Black Sturgeon R. (R)	0	0	-	-	-	-	-
Wolf R. (Q)	34	0	-	-	-	-	-
Neebing-McIntyre R.(P)	69	0	-	-	-	-	-
Kaministikwia R. (O)	0	0	-	-	-	-	-
Total or average	181	0	-	-	-	-	-
GRAND TOTAL OR AVERAGE	3,504	759	42	438	426	187	179

Spawning-phase Sea Lampreys (Continued)

discharge ($x = 4,306\ ft^3/s$) and the number of adult lampreys that enter tributaries, was 23,166 spawning-phase sea lampreys, compared with an estimate of 60,517 lampreys in 1986. The decrease of the lakewide estimate for 1987 is verified in other measures of lamprey abundance: concurrent decreases in trap catches, decreases in spring wounding rates on lake trout in most areas of the lake, and regional increases of lake trout abundance.

Canada

Support and funding of a lake-wide study of spawning-phase sea lampreys by the Great Lakes Fishery Commission's Sterile Male Release Technique (SMRT) task force allowed the Canadian agent to expand their trapping efforts on Lake Superior from the three tributaries scheduled in the Memorandum of Agreement to nine. The catch of resident spawning-phase sea lamprey from this enhanced trap network was 181. No comparison with 1986 results is possible, as there were no trap operations on the Canadian side of Lake Superior that year. Although modified Schaefer population estimates were proposed for all nine tributaries, returns of marked specimens were generally too low to provide true measures. Estimates and trap efficiencies for Stokely Creek (6; 40%), Carp River (35; 66%), and Pancake River (124; 21%) may be valid, but were not sufficiently representative to permit extrapolation to the entire Canadian shoreline. All resident sea lamprey caught were used for the marking study so that biological data is unavailable.

Sterile Male Release Technique

As a 1987 initiative, the Sterile Male Release task force recommended a trial release of tagged, normal male lampreys at locations around the shore of Lake Superior and recapture in tributary streams to better evaluate Lake Superior as a potential site for implementing the sterile male release technique. The objectives of the study were to: 1) determine whether introduced male lampreys disperse and mix randomly with the resident population in Lake Superior, 2) determine whether introduced male lampreys behave and compete normally with resident males for females and spawning habitat, and 3) develop an estimate of the population of lampreys in Lake Superior from the ratio of recovered marked males to unmarked lampreys.

Male sea lampreys used in this field trial were captured in assessment traps in the Cheboygan and Ocqueoc rivers (Lake Huron) and the Manistique River (Lake Michigan). Each lamprey was tagged with a 7.7 cm (3 inch), fluorescent orange, spaghetti tag inserted in the anterior dorsal fin. Each tag was identified by a letter to indicate point of release.

A total of 6,324 tagged male sea lampreys were released at 13 locations in Lake Superior (Tables 5 and 6, Fig. 2). Twelve locations were in shoreline waters (A-L) and one was about 3.2 km (2 mi) offshore (M). Of the total tagged, 2,499 were released at five sites in Canada (A-E) and 3,825 at eight sites in the United States (F-M). Distribution began on May 12 and concluded June 4.

A total of 38 tributaries of Lake Superior were searched for tagged sea lampreys, and tagged lampreys were recovered by more than one method in many of the streams. Assessment traps were operated in 23 streams--9 in Canada and 14 in the United States (Table 5, Fig. 2). Spawning gravel was searched in index

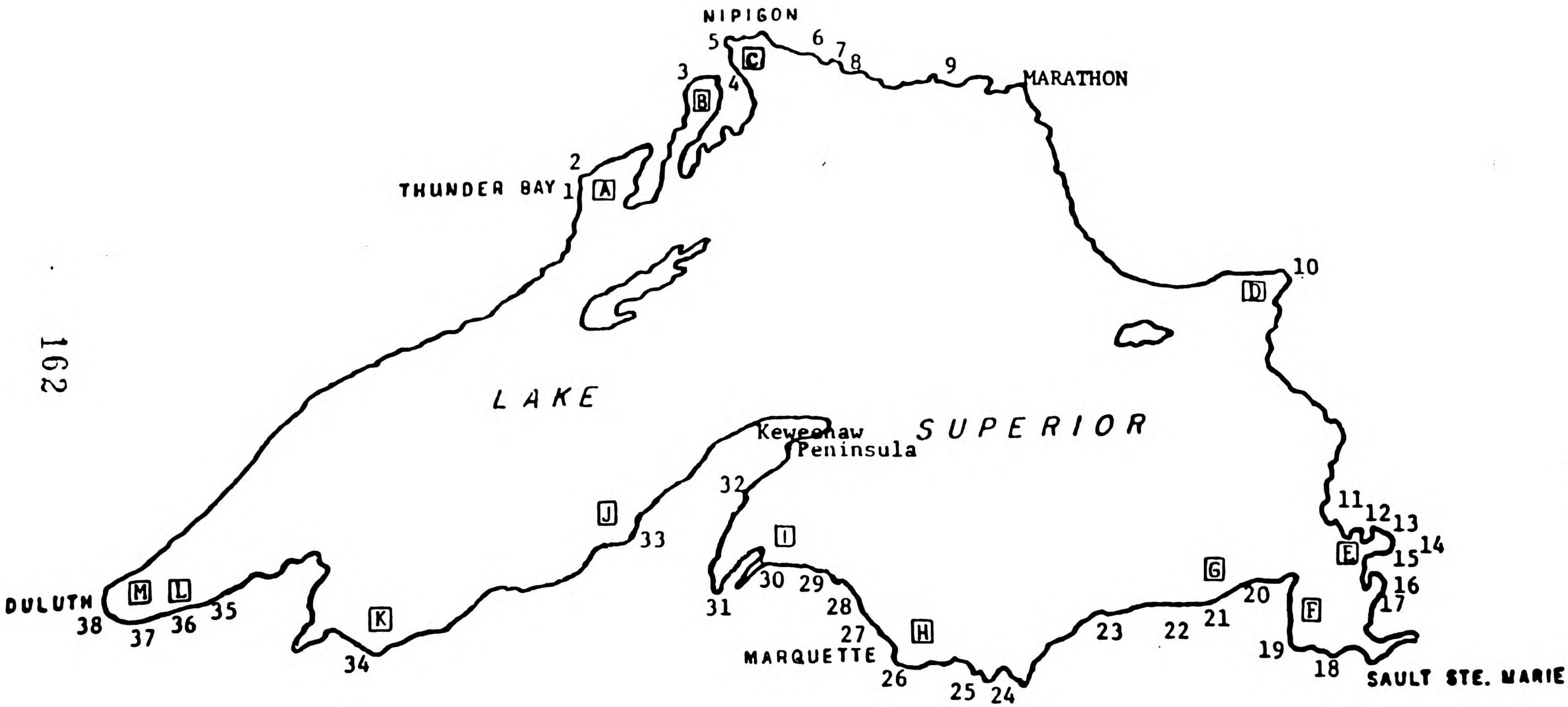

Figure 2. Release sites (letters) of tagged male sea lampreys, and areas of search (numbers) to locate tagged lampreys in 1987. Names of locations are given in Tables 5 and 6.

Table 5. Areas of search to determine dispersion of male sea lampreys which had been tagged and released at 13 locations in Lake Superior in 1987.

[**The primary methods of search to locate tagged sea lampreys were** capture in **assessment traps and** observations in spawning areas of streams. Number and letter **indicate** location in Figure 2.]

	Canada	Assessment trap	Spawning areas		United States	Assessment trap	Spawning areas
			Areas of search				
1	Kaministiquia R.	X	X	18	Pendills Cr.		X
2	Neebing R.	X	X	19	Tahquamenon R.	X	X
	McIntyre R.		X	20	Betsy R.	X	X
3	Wolf R.	X	X	21	Two Hearted R.		X
4	Black Sturgeon R.	X	X	22	Sucker R.	X	X
5	Nipigon R.	X	X	23	Miners R.	X	
6	Cypress R.		X	24	Rock R.	X	
7	Little Gravel R.		X	25	Chocolay R.		X
8	Gravel R.		X	26	Little Garlic R.		X
9	Steel R.		X	27	Big Garlic R.	X	
10	Michipicoten R.	X	X	28	Iron R.	X	X
11	Pancake R.	X	X	29	Salmon Trout R.		X
12	Carp R.	X	X	30	Huron R.	X	X
13	Batchawana R.		X	31	Silver R.	X	X
14	Chippewa R.		X	32	Traverse R.		X
15	Harmony R.		X	33	Misery R.	X	X
16	Stokely Cr.	X	X	34	Bad R.	X	X
17	Goulais R.		X		Potato R.		X
				35	Brule R.	X	
				36	Middle R.	X	X
				37	Nemadji R.		
					Black R.		X
				38	Amnicon R.	X	X
			Release sites				
A	Thunder Bay			F	Paradise		
B	Black Bay Harbor			G	Muskalonge Lake		
C	Nipigon R.			H	Marquette Harbor		
D	Michipicoten Bay			I	Huron Bay		
E	Batchawana Bay			J	Misery Bay		
				K	Saxon Harbor		
				L	Bardon Cr.		
				M	Superior[a]		

[a]Lampreys were released about 3.2 km (2 mi) offshore.

Table 6. Number and percentage of tagged sea lampreys recaptured of 500 released at each of 11 locations in Lake Superior, 499 in the Nipigon River, and 325 at Misery Bay in 1987. Recaptures were taken in assessment traps and (in parentheses) other methods--commercial fishermen, nest and larval surveys, chemical treatments, and by the general public.

[Figure 2 shows location of release as indicated by letters A through M]

Location of recapture	Location and date of release													TOTAL RE-CAPTURED
	Canada					United States								
	Thunder Bay A	Black Bay Harbor B	Nipigon River C	Michipi-coten Bay D	Batcha-wana Bay E	Para-dise F	Muska-longe Lake G	Marq-uette Harbor H	Huron Bay I	Misery Bay J	Saxon Harbor K	Bardon Creek L	Superior M	
	May 12	May 12	May 12	May 28	May 28	Jun 4	Jun 2	Jun 4	May 19	May 20	May 15	May 15	May 15	
UNITED STATES														
Tahquamenon Is.						0 (4)								0 (4)
Tahquamenon R.					0 (1)	13 (4)								13 (5)
Betsy R.						12 (5)								12 (5)
Sucker R.							8 (3)							8 (3)
Grand Marais Shoreline							0 (1)							0 (1)
Rock R.	1 (0)						2 (0)		2 (0)		1 (0)			6 (0)
Chocolay R.								0 (1)						0 (1)
Marquette Hbr.								0 (1)						0 (1)
Salmon Trout R.									0 (1)					0 (1)
Huron R.									0 (2)					0 (2)
Slate R.									0 (1)					0 (1)
Silver R.									0 (5)					0 (5)
Traverse R.									0 (1)					0 (1)
Misery R.										109 (1)				109 (1)
Bad R.			1 (0)								18 (6)	3 (0)		22 (6)
Middle R.	1 (0)											0 (1)		1 (1)
Amnicon R.												2 (2)	2 (3)	4 (5)
Nemadji R. Black R.												0 (1)		0 (1)
Brule R.	13 (0)	1 (0)	1 (0)								4 (0)	89 (0)	55 (1)	163 (1)
Arrowhead R.										0 (1)				0 (1)
Total	15	1	2	0	1	38	14	2	12	111	29	98	61	384
Percentage	3.0	0.2	0.4	0.0	0.2	7.6	2.8	0.4	2.4	34.2	5.8	19.6	12.2	6.1
CANADA														
Neebing R.	13 (13)										1 (0)	0 (1)	0 (1)	14 (15)
Wolf R.	1 (1)	15 (10)												16 (11)
Nipigon R.			1 (5)							0 (1)				1 (6)
Michipicoten R.				0 (1)										0 (1)
Mamainse Hbr.					0 (2)									0 (2)
Pancake R.	1 (0)				46 (2)		1 (0)							48 (2)
Carp R.					52 (0)									52 (0)
Total	29	25	6	1	102	0	1	0	0	1	1	1	1	168
Percentage	5.8	5.0	1.2	0.2	20.4	0.0	0.2	0.0	0.0	0.3	0.2	0.2	0.2	2.7
GRAND TOTAL	44	26	8	1	103	38	15	2	12	112	30	99	62	552
PERCENTAGE	8.8	5.2	1.6	0.2	20.6	7.6	3.0	0.4	2.4	34.5	6.0	19.8	12.4	8.7

Sterile Male Release Technique (Continued)

areas in 34 streams--17 each in Canada and the United States (Table 5, Fig. 2). Crews also looked during chemical treatments and during larval surveys for these lampreys. In addition, personnel of State and Provincial Departments of Natural Resources and members of the public returned tagged lampreys.

A total of 552 tags or tagged sea lampreys (8.7%; 182 or 7.3% of those released in Canada and 370 or 9.7% of those in the United States) were recovered. (Some tags were found separated from the lampreys--43 in Canada and 12 in the United States--the result of an accidental dislodgment from the lamprey or the lamprey being eaten by a predator, but in this report all recoveries hereafter are referred to as tagged lampreys.) Of the total tagged lampreys recovered, 168 were taken in Canada and 384 in the United States.

Tagged lampreys were recaptured in 23 tributaries and 4 shoreline locations of Lake Superior. Most were taken in assessment traps (469). Lampreys were recovered in 14 of the trapped streams; most recaptures were in the Pancake (48), Carp (52), Misery (109), and Brule (163) rivers. In addition, 58 were recovered during searches of index streams in gravel areas, 7 were turned in by tribal commercial fishermen who operate trap nets in the mouths of two streams, 6 were taken during chemical treatments, and 12 were turned in by members of other fishery agencies or the general public.

Most of the recovered tagged lampreys were taken in the same country in which they were released and near their respective release sites. Lampreys were recovered from all groups released (range, 0.2% from site D to 34.5% from site J). A total of 163 of the 168 tagged lampreys taken in Canada were released in Canadian waters and 365 of the 384 taken in the United States had been released in the country. On the basis of straightline miles by water, 513 (92.9%) were recaptured within 80 km (50 mi) of the release site and another 15 within 160 km (100 mi). Of the other 24 lampreys, 2 were taken within a range of 160 to 240 km (100 to 150 mi), 16 within 240 to 320 km (150 to 200 mi), and 6 within 320 to 368 km (200 to 230 mi). The longest distance from point of release to point of recapture was about 368 km (230 mi--Nipigon Bay to Brule River or Thunder Bay to Pancake River).

Recoveries of tagged sea lampreys were significantly greater from those released in the western area of Lake Superior (381 of 3,325 released in sites A, B, C, J, K, L, M; 11.5%) than the eastern area exclusive of Whitefish Bay (30 of 2,000 released in sites D, G, H, I; 1.5%). (An arbitrary line between the Keweenaw Peninsula, Michigan, and Marathon, Ontario, is considered as the boundary between the western and eastern areas; Fig. 2.) In Whitefish Bay (sites E and F), 141 of 1,000 (14.1%) were recovered. Low trap efficiency in a few streams may explain some of these results, but it is unlikely that emigration contributed significantly.

The rate of return for the offshore release (12.4% at site M) was slightly higher than the average rate for the 12 shoreline releases (8.4% at sites A to L) and also was slightly higher than the overall rate of 8.7%. The difference in rates may have been more a factor of time or release or more efficient trap sites in the area, or both, than the lampreys from site M dispersing into more areas.

Tagged lampreys recaptured at most areas originated from a single release location. Of the 27 recapture locations, 17 had lampreys from a single release site and 10 had individuals from 2 to 6 release sites (Table 6). The tagged lampreys captured in the Misery and Brule rivers demonstrate the variation that occurred in some situations. All of the 110 lampreys captured in the Misery River were released at a single site (J), whereas those recaptured in the Brule River came from six sites (A, B, C, K, L, and M).

Lampreys released early in the spawning season were recovered at a higher rate than those released later in the run. Of the 6,324 released in Lake Superior, 4,824 were released from May 15 to 28, and 1,500 from June 2 to 4. A total of 497 (10.3%) from the first group were recovered, whereas only 55 (3.7%) were taken from the second group. Perhaps lampreys released early in the spawning run may mix more actively with the native population or move further upstream and be more susceptible to trapping than those released late in the run.

Tagged males were found on 22 nests in nine tributaries. The males were observed on nests at the same time normal males and females were observed spawning. The behaviour of the introduced males was typical during nest building and spawning on all nests. While this is encouraging, not enough information was gathered to be certain that the behaviour and competitiveness of these males were similar to that of Lake Superior males.

Cruise surveys of major spawning facilities in 34 streams located some 510 sea lamprey nests. Of these, 162 were sampled (a number repeatedly) until 132 were ultimately shown to produce prolarvae, a nest success rate of 81%. While several problems were encountered which clouded interpretation of these results, it would appear that determining rate of nesting success offers a further method for measuring effectiveness of a sterile male release programme on at least certain streams.

An estimate of the number of sea lampreys in Lake Superior was developed based on a simple ratio of untagged to tagged lampreys captured in assessment traps. From a ratio of 465 tagged sea lampreys recaptured from a release of 6,324 animals, the total capture of 3,504 untagged lampreys was expanded to an estimated lake population of 47,662. With an estimated 23,166 lampreys in U.S. waters of the lake (based on the discharge values of the major lamprey-producing streams) and conservatively another 10,000 in Canadian waters, the estimate of 47,662 would seem about 14,500 high. Several factors likely bias high the above estimate and include: lack of a uniform time of release for all sites, unequal vulnerability to recapture from the different release sites, possible mortality of some tagged lampreys, tag loss of some lampreys, and release and recapture sites were not selected at random.

PARASITIC-PHASE SEA LAMPREYS

United States

A total of 473 sea lampreys were collected from commercial fishermen in Lake Superior through October 1987 (Table 7), compared with 219 taken in 1986. Fishermen in statistical districts MS-4 (Munising, Michigan, area) and Wisconsin collected most sea lamprey from U.S. waters of Lake Superior--241 and 131, respectively. In 1986, 130 lampreys were taken in MS-4 and 59 in the Wisconsin district.

Parasitic-phase sea lampreys are collected throughout the year from commercial fishermen, therefore, lampreys that would spawn in either the present or succeeding two years may be found in the catch. Spawning year was determined for the 473 parasitic-phase sea lampreys captured in 1987; 367 would have spawned in 1987 and 106 in 1988 (Table 7). In addition, 64 lampreys of the 1987 spawning year were taken in 1985 and 1986 (2 and 62, respectively), bringing the total collected for that spawning year to 431. This represents an increase in the number of parasitic-phase sea lampreys captured by commercial fishermen (239 of the 1986 spawning year vs. 431 of the 1987 spawning year).

Lake Superior sport fishermen captured 58 parasitic-phase sea lampreys in 1987 (Table 7), compared with 63 in 1986. Of the total, 29 were from captains of charter boats and 29 were from noncharter fishermen. Fifty-three charter 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 0.4 lamprey attached per 100 trout in their catch (Table 8). Fresh wounds (Type A, Stages I-III) per 100 trout were observed at 5.9 in the spring, 0.8 in the summer, and 2.4 in the fall (Table 9). Through a cooperative agreement with the Wisconsin Department of Natural Resources, information is now obtained on the occurrence of sea lampreys from the entire Wisconsin charter fishery.

Canada

No parasitic sea lamprey were submitted to the programme from the commercial fisheries of Lake Superior. Information supplied by sport fishermen via the Co-operator Diary Programme and the Batchawana Bay fishing derby resulted in the recovery of one parasitic sea lamprey which was attached to one of 56 lake trout examined.

Due to the low response from the commercial and sport fisheries (presumably because of the lack of lamprey) and the expansion of the Ontario Ministry of Natural Resources (OMNR) monitoring programmes, the solicitation of parasitic lamprey from the fisheries of Lake Superior will be discontinued in 1988.

BARRIER DAMS

A low-head barrier dam was constructed on the Wolf River, 5.4 km (3.4 mi) above its mouth. The dam was constructed at a cost of $42,000. on a bedrock chute which had been an obstacle to adult lamprey migrations. A built-in adult trap is incorporated in the design.

A trap designed at the Sea Lamprey Control Centre was installed on the McIntyre River at Lakehead University in conjunction with a new fishery and dam constructed by the Lakehead Region Conservation Authority.

Table 7. Number of parasitic-phase sea lampreys collected in commercial and sport fisheries in U.S. waters of the Upper Great Lakes in 1987.

LAKE SUPERIOR				LAKE MICHIGAN				LAKE HURON			
	Spawning year[a]				Spawning year[a]				Spawning year[a]		
	Commercial		Sport		Commercial		Sport		Commercial		Sport
District	1987	1988	1988	District	1987	1988	1988	District	1987	1988	1988
M-1	-	-	13	MM-1	40	85	-	MH-1	156	787	393
M-2	-	1	-	MM-2	-	4	-	MH-2	11	125	575
M-3	1	1	3	MM-3	4	22	14	MH-3	-	-	710
Wis.	107	24	19	MM-4	-	-	2	MH-4	6	67	274
MS-1	-	-	-	MM-5	-	-	71	MH-5	-	-	241
MS-2	6	-	4	MM-6	-	-	92	MH-6	-	-	34
MS-3	61	9	2	MM-7	-	31	27				
MS-4	183	58	17	MM-8	-	-	11				
MS-5	5	6	-	WM-1	23	1	13				
MS-6	4	7	-	WM-2	5	60	23				
				WM-3	6	16	46				
				WM-4	40	1	240				
				WM-5	-	-	113				
				WM-6	-	-	5				
				Ill.	-	-	5				
				Ind.	-	-	4				
Total	367	106	58		118	220	666		173	979	2,227

[a]Parasitic sea lampreys are collected throughout the year from commercial fishermen; therefore, lampreys that would spawn in either the present or succeeding years may be found in the catch. Those lampreys taken in the sport fishery are collected primarily in the summer when only lampreys that would spawn 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, 1987.

[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
UNITED STATES				
Superior				
M-1	1.0	583	0.0	27
M-2	1.0	201	0.0	27
Wis.	0.3	5,176	0.0	462
MS-3	0.0	89	-	-
MS-4	0.4	454	0.0	8
All districts	0.4	6,503	0.0	524
Michigan				
MM-3	0.0	130	0.0	42
MM-4	0.0	66	0.0	39
MM-5	0.5	551	0.7	1,128
MM-6	0.0	286	0.4	564
MM-7	0.0	770	0.0	1,332
MM-8	0.4	1,176	0.0	957
WM-1	-	-	0.8	264
WM-2	0.0	13	0.2	6,437
WM-3	0.1	966	0.6	9,449
WM-4	0.02	10,593	0.2	23,850
WM-5	0.2	6,208	0.2	24,209
WM-6	0.1	10,441	0.1	4,553
Ill.	0.0	318	0.0	332
Ind.	0.0	112	0.0	51
All districts	0.1	31,630	0.3	73,207
Huron				
MH-1	3.4	58	6.6	721
MH-2	6.4	31	9.2	316
MH-3	1.2	2,005	8.8	810
MH-4	1.7	516	3.3	120
MH-5	8.3	120	14.6	199
MH-6	9.1	11	8.2	85
All districts	1.8	2,741	8.3	2,251

[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 MS-2, MS-6, MM-1, and MM-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, 1987[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	
UNITED STATES												
Superior												
M-1	1.6	(181)	0.6	(318)	2.4	(84)	0.0	(8)	0.0	(13)	0.0	(6)
M-2	0.0	(51)	1.3	(150)	-		0.0	(1)	0.0	(26)	-	
MS-3	2.8	(35)	0.0	(47)	0.0	(7)	-		-		-	
MS-4	9.5	(338)	1.2	(82)	2.9	(34)	-		0.0	(7)	0.0	(1)
All districts	5.9	(605)	0.8	(597)	2.4	(125)	0.0	(9)	0.0	(46)	0.0	(7)
Michigan												
MM-3	1.5	(67)	0.0	(63)	-		0.0	(6)	3.8	(26)	0.0	(10)
MM-4	0.0	(66)	-		-		0.0	(22)	-		0.0	(17)
MM-5	11.3	(282)	6.6	(257)	8.3	(12)	5.3	(75)	2.0	(920)	1.5	(133)
MM-6	6.5	(199)	6.9	(87)	-		0.0	(72)	1.3	(392)	0.0	(100)
MM-7	4.2	(523)	5.1	(237)	0.0	(10)	0.0	(251)	0.9	(856)	0.9	(225)
MM-8	4.2	(850)	2.6	(273)	3.8	(53)	0.3	(369)	0.2	(477)	0.0	(111)
Ill.	8.9	(169)	13.5	(141)	0.0	(8)	1.2	(86)	1.1	(174)	0.0	(72)
Ind.	17.0	(53)	17.0	(59)	-		10.5	(19)	0.0	(32)	-	
All districts	5.8	(2,209)	6.4	(1,117)	3.6	(83)	0.9	(900)	1.2	(2,877)	0.6	(668)
Huron												
MH-1	6.5	(46)	8.3	(12)	-		10.7	(75)	9.1	(484)	3.0	(101)
MH-2	16.7	(24)	0.0	(7)	-		17.2	(128)	20.3	(187)	0.0	(1)
MH-3	13.7	(1,190)	19.0	(815)	-		10.6	(66)	16.1	(707)	21.6	(37)
MH-4	16.1	(242)	13.1	(274)	-		3.8	(78)	15.0	(40)	0.0	(2)
MH-5	15.0	(67)	22.6	(53)	-		12.5	(80)	32.6	(86)	51.5	(33)
MH-6	27.3	(11)	-		-		16.5	(85)	-		-	
All districts	14.0	(1,580)	17.6	(1,161)	-		12.5	(512)	15.3	(1,504)	16.1	(174)

[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 MS-2, Wisconsin, MS-5, and MS-6 of Lake Superior or from districts MM-1, MM-2, WM-3, WM-4, WM-5, and WM-6 of Lake Michigan.

LAKE MICHIGAN

LARVAL ASSESSMENT

During the 1987 field season, 132 streams tributary to Lake Michigan and five offshore areas associated with power plant discharges were surveyed to assess larval sea lamprey populations.

Pretreatment investigations were conducted in 36 streams; 17 were subsequently treated and the others are tentatively scheduled for treatments in 1988 and 1989.

Surveys to evaluate the effectiveness of recent treatments were carried out on 16 streams. The most significant numbers of residual lampreys were recovered in three tributaries of the Whitefish River (Bills and Haymeadow creeks and the West Branch). These have been consistent problem areas because of numerous springs which dilute the chemical concentrations. Residual larvae were much less abundant in the Ford, Cedar, Sturgeon, Fishdam, Little Fishdam, Boardman, Pere Marquette, White, and Grand rivers and absent from six other streams.

At the end of the 1987 field season, reestablished sea lampreys were present in at least 51 streams, with larvae of the 1987 year class being collected in 32. There has been no evidence of reinfestation for the past four or more years in 18 Wisconsin and Upper Peninsula streams which have been monitored annually. Extensive sampling in the Manistique River above the paper company dam indicates that the reestablished population in the upper river remains small and well scattered. At least two year classes of larvae were represented in the collections in 1987, with the largest ammocoete measuring 123 mm in May. At present, the small numbers of sea lampreys indicated does not appear to warrant treatment of this large river above the dam. The river below the dam is scheduled for treatment in 1988 to reduce a large lamprey population.

In the spring of 1987, the Michigan Department of Natural Resources installed an experimental electric barrier on Haymeadow Creek, a tributary of the Whitefish River, in an attempt to stop spawning-phase sea lampreys. In June, a visual survey was conducted to assess the effectiveness of the barrier. Eight sea lamprey nests were observed; five contained eggs. Electrofishing surveys in October recovered 426 young-of-the-year sea lamprey larvae in 3.9 hours of sampling. Evidently the barrier was not installed early enough to stop the early migrants, or it was ineffective for some reason during the operational period.

Surveys above the low-head barrier dam on the Days River and the dam at Mishicot on the East Twin River indicate that these structures have been effective barriers to spawning-run adult lampreys in recent years.

Discharge areas of five power plants in the Lower Peninsula were examined for possible offshore sea lamprey populations. Although some potential for lamprey production was evident, no lampreys were found. The power plants investigated were the Northern Michigan Electric Coop, Big Rock Nuclear Plant, Pallisades Power Plant, Cook Power Plant, and the Ludington Pumped-Storage Reservoir.

Other lentic surveys included sampling with Bayer granules offshore of eight stream mouths. A total of 25 sea lamprey larvae (76 to 160 mm) were found off the Manistique River, 40 larvae (64 to 176 mm) off the Ogontz River, and 25 sea lampreys (82 to 147 mm) off the Boyne River. No sea lampreys were taken offshore of the other five streams.

An experimental, deepwater shocking device was tested during surveys of the Menominee and Peshtigo rivers. Test results indicated that the deepwater unit had some potential, but that more research and refinement are needed.

Eighteen streams with no history of sea lamprey production were examined, but no new infestations were discovered. Included in these investigations were surveys of the Fox River and several of its tributaries above Lake Winnebago and the Manitowoc River. Although no sea lampreys were found in the Fox River drainages, the presence of native lampreys (Ichthyomyzon spp.) in tributaries such as the White, Black, and Mecan rivers suggests that conditions may be suitable for sea lampreys and that additional work is needed in that part of the system. Old navigational locks and dams on the upper Fox River do not appear to be effective barriers to adult migrations. On the Manitowoc River, a dam that had been a probable barrier to adult sea lampreys was removed, opening about 16 km (10 mi) of river to lampreys. The best potential for larval production appeared to be in one tributary, Branch Creek, but no lampreys of any kind were found.

Larval sea lampreys (age V) were collected in May 1987 from Whitefish Bay Creek, a tributary of the west shore of Lake Michigan in Door County, Wisconsin. The mean total length of the 110 larvae was 150 mm (range, 130 to 174 mm). The ammocoetes were held in two aquaria at the Marquette Station until September to further define the rate of transformation. The aquaria were at room temperature and aerated, but larvae were not fed. At the completion of the study, 58 ammocoetes (53%) had undergone transformation. Similar studies conducted when the larvae were ages III and IV had shown transformation rates of 2 and 38%, respectively. The stream was treated in the spring, and reexamined in the fall. No lampreys were found in the posttreatment survey, indicating a successful treatment.

CHEMICAL TREATMENTS

Chemical treatments were completed on 19 streams (Table 10, Fig. 3) with a combined discharge of 87.9 m^3/s (3,108 f^3/s). Low water levels complicated treatments during the first half of the field season and also caused the postponement of treatments until 1988 in five streams--Millecoquins (Furlong Creek), Ford (Ten Mile Creek), the lower Brevort and upper Cedar rivers and in Beattie Creek. Sections of the Pere Marquette, White, and Ford rivers were treated separately because of complexity, available manpower, and in some stretches, low water levels. Relative abundance of sea lampreys was high in the White and Grand (Norris and Crockery creeks) rivers and Hibbards and Hog Island creeks and moderate to low in the other treated streams.

Mortality of fish was significant during treatment of the Little River, a tributary of the Oconto River. Mortality was greatest in one tributary of the Little River, Kelly Brook, where many species of fish were killed in a 16 km (10 mi) section of stream. Low oxygen and high ammonia levels developed within the TFM bank as it travelled downstream. These conditions were not present in water samples tested before the arrival of the chemical bank. Personnel from the

Table 10. Details on the application of lampricides to streams of Lake Michigan, 1987.

[Number in parentheses corresponds to location of stream in Figure 3. 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
Horton Cr. (12)	May 6	0.5	17	140	308	-	-	1.6	1
Ford R. (6)									
Below Woodlawn	May 6	7.8	275	2,476	5,458	-	-	72.6	45
Above Woodlawn	May 23	3.5	125	1,085	2,390	-	-	96.8	60
East Twin R. (2)	May 8	1.1	40	449	990	-	-	9.7	6
Oconto R. (5)									
Little R.	May 8	0.7	25	235	517	-	-	29.0	18
Fisher Cr. (1)	May 10	0.1	2	40	88	-	-	3.2	2
Whitefish Bay Cr. (3)	May 12	0.3	12	91	201	-	-	1.6	1
Hibbards Cr. (4)	May 12	0.2	6	70	154	-	-	6.5	4
Days R. (7)	June 9	0.7	23	148	326	-	-	8.1	5
Grand R. (19)									
Norris Cr.	June 26	0.2	7	36	80	-	-	4.8	3
Crockery Cr.	June 29	0.9	32	491	1,082	-	-	25.8	16
Pentwater R. (16)									
North Branch	July 10	1.0	37	608	1,340	-	-	25.8	16
Stoney Cr. (17)	July 22	1.3	45	436	961	-	-	11.3	7
Pere Marquette R.[b] (15)	Aug. 20	28.3	1,000	10,089	22,242	-	-	241.9	150
Boardman R. (13)	Aug. 28	19.8	700	2,918	6,433	23.6	52.1	9.7	6
Betsie R. (14)	Sept. 10	6.2	220	1,553	3,424	-	-	16.1	10
White R. (18)	Sept. 15	14.2	500	3,672	8,096	17.6	38.9	121.0	75
Hog Island Cr. (9)	Oct. 9	0.1	4	72	160	-	-	6.5	4
Black R. (8)	Oct. 10	0.6	22	117	257	-	-	40.3	25
Paquin Cr. (10)	Oct. 11	0.3	12	53	117	-	-	1.6	1
Brevort R. (11)									
Silver Cr.	Oct. 13	0.1	4	14	30	-	-	4.8	3
TOTAL		87.9	3,108	24,793	54,654	41.2	91.0	738.7	458

[a]Includes 703 TFM bars (158 kg, 348 lbs) in eight streams.
[b]Tributaries were treated in May.

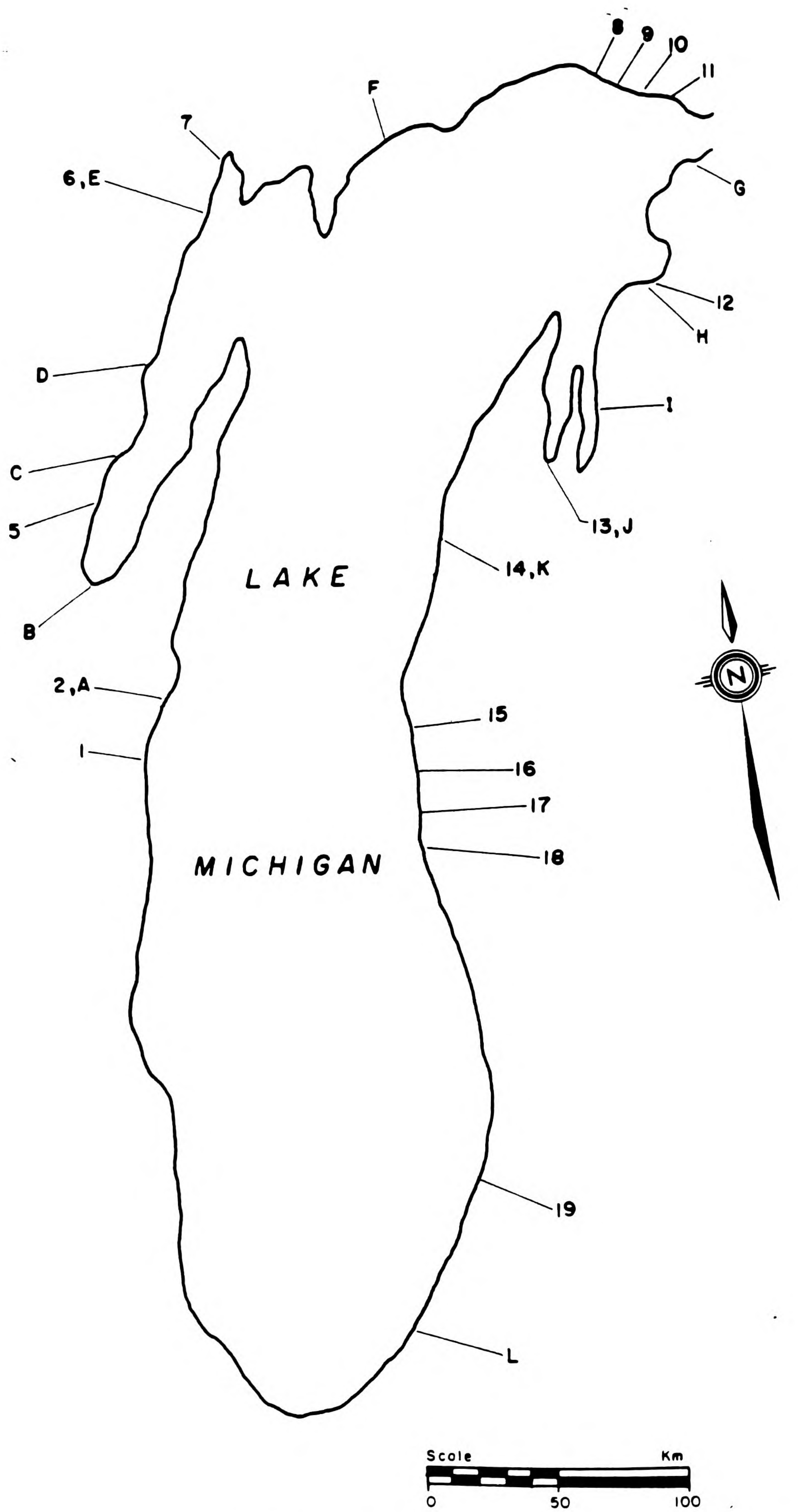

Figure 3. Locations of streams treated with lampricides (numerals; see Table 10 for names of streams), and of streams where assessment traps were fished (letters; see Table 11 for names of streams) in 1987.

Wisconsin Department of Natural Resources aerated the stream water in an attempt to increase the oxygen and reduce the ammonia, but results were mostly ineffective. The toxic effects diminished in the upper section of the Little River as TFM concentrations attenuated.

Some fish were killed in the other treated streams. Mortality was moderate in Stoney Creek, the Pentwater River, and in sections of the Pere Marquette River and low in the rest. Although mortality of fish was low during the treatment of the White River, the size and species of fish affected (spawning chinook salmon) caused public criticism and attention.

Invertebrates were affected during treatment of four streams. Mayflies were killed in the Pentwater and Pere Marquette rivers and Stoney Creek. A significant number of dead caddisflies were observed in the estuary of Hog Island Creek after treatment.

Onsite toxicity tests conducted in the Lower Peninsula on tributaries of Lake Michigan during the field season generally indicated significantly higher minimum lethal concentrations of TFM were required to kill sea lampreys than those indicated by prediction charts. However, two toxicity tests conducted in two hard water streams (Fisher Creek and the East Twin River) in Wisconsin gave results that were significantly lower than the charts indicated. The charts were used with good results for most treatments of Lake Michigan tributaries in the Upper Peninsula. Prediction charts are especially valuable when results of toxicity tests are questionable or when the water chemistry of the stream is changing during treatment.

A portable, flow-through bioassay unit was developed to better define toxicity of TFM to target and nontarget organisms under ambient stream conditions. Preliminary field tests in 1987 demonstrated the versatility of the unit compared to static tests. The principal advantages are: TFM toxicity affected by changes in water quality can be tested by the continuous pumping of stream water through the test chambers, larger size and greater numbers of fish can be tested, substrate can be more easily added, and chemical banks can be simulated by varying concentration and time in each test chamber. Routine use of this unit is planned for 1988.

SPAWNING-PHASE SEA LAMPREYS

A total of 9,635 sea lampreys were captured in assessment traps place in six west shore and six east shore tributaries of Lake Michigan in 1987 (Table 11, Fig. 3), compared to 10,781 in 1986. The average length and weight of specimens taken throughout Lake Michigan decreased slightly in 1987, whereas the percentage of males was similar to those taken in 1986.

Along the west shore, the catch of sea lampreys declined in the Manistique River from the number taken in 1986 (9,080 vs. 7,668), however, a stratified tag and recovery system used for the fourth consecutive year to estimate the number of spawning-phase sea lampreys indicated a larger spawning population in the river than in 1986 (Table 12; 23,725 vs. 29,416). Operation of additional spillgates at the trap site in 1987 contributed to a reduced efficiency of the trap which resulted in the decreased catch. The catch of lampreys was about the same in the Peshtigo River as in 1986, but increased in the Menominee and Ford rivers by 181 and 122, respectively. Increased effort and low stream discharge may have contributed to the increased catch in the Ford River. No lampreys were taken for the ninth consecutive year in the Fox River.

The catch of sea lampreys in streams along the east shore of Lake Michigan remained about the same (988 in 1986 vs. 975 in 1987). The total of trap catches in the St. Joseph, Carp Lake, and Boardman rivers increased slightly (from 624 to 722), but decreased in the Betsie and Elk rivers and Deer Creek (from 364 to 253).

Table 11. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan, 1987.

[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
West Shore							
East Twin R. (A)	17	13	23	457	436	231	192
Fox R. (B)	0	-	-	-	-	-	-
Peshtigo R. (C)	343	339	51	490	488	247	264
Menominee R. (D)	508	482	48	485	487	244	259
Ford R. (E)	124	116	40	468	484	235	267
Manistique R. (F)	7,668	723	46	481	483	252	264
East Shore							
Carp Lake R. (G)	94	65	28	455	437	200	180
Jordan R. (H)							
Deer Cr.	87	79	11	446	484	189	257
Elk R. (I)	0	-	-	-	-	-	-
Boardman R. (J)	105	101	18	418	485	205	260
Betsie R. (K)	166	150	17	424	487	194	275
St. Joseph R. (L)	523	512	41	488	487	257	258
Total or Average	9,635	2,580	41	481	484	246	259

Table 12. Estimated number of spawning-phase sea lampreys in four U.S. tributaries, 1984-87.

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

Lake	Stream	1984	1985	1986	1987
Michigan	Manistique River	24,659	38,260	23,725	29,416
Huron	Cheboygan River	25,457	39,626	28,293	21,406
Huron	Ocqueoc River	-	11,966	9,038	-
Huron	St. Marys River	-	23,852	16,812	20,840

PARASITIC-PHASE SEA LAMPREYS

Lake Michigan commercial fishermen captured 338 sea lampreys through October 1987 (Table 7), compared with 304 in the same period in 1986. Of the total, 174 were collected from northern Lake Michigan and 164 from Green Bay, compared with 164 and 140, respectively, in 1986.

Spawning year was determined for the 338 parasitic-phase sea lampreys; 118 would have spawned in 1987 and 220 in 1988. In addition, 175 lampreys of the 1987 spawning year were taken in 1986, bringing the total collected for this spawning year to 293.

A total of 666 sea lampreys were obtained from the sport fishery (253 from charter and 413 from noncharter fishermen) in 1987 (Table 7), compared with 780 (50 charter, 730 noncharter) in 1986. As in 1986, 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. Information on occurrence of sea lampreys and lamprey wounds on fish was reported by 638 charter captains (Tables 8 and 9). Lakewide, 81% of the lampreys collected were attached to chinook salmon. The number of lampreys per 100 lake trout decreased from 0.5 in 1986 to 0.1 in 1987, and the number per 100 chinook salmon also decreased, 0.4 in 1986 to 0.3 in 1987. Lakewide, wounds per 100 lake trout and per 100 chinook salmon remained nearly the same in 1987 (5.2 for trout; 0.9 for salmon) as in 1986 (5.4 for trout; 1.1 for salmon); seasonal rates were combined. Wounding rates were derived from data collected in Michigan, Illinois, and Indiana waters only.

LAKE HURON

LARVAL ASSESSMENT

United States

Surveys were conducted on 45 tributaries of Lake Huron in preparation for chemical treatments, to monitor reestablished and residual sea lamprey populations, and to search for newly infested streams.

Pretreatment investigations were completed on two streams (East Au Gres and Saginaw rivers) that were treated later in the field season and on seven others recommended for treatments in 1988 and 1989. In the streams still to be treated, populations are judged to be highest in the Rifle, Carp, and Pine (Mackinac County) rivers and Albany Creek.

Reestablished sea lampreys were present in at least 23 streams at the end of the 1987 field season. Young-of-the-year larvae were found in 14 of these streams.

Residual larvae were collected in five streams last treated in 1986 or 1987, but populations in all but two were too low to warrant any remedial action. The largest number of residual ammocoetes was in Albany Creek where 394 larvae (38 to 132 mm) that had survived the May 1986 treatment were recovered. Extensive beaver floodings and low stream flows severely reduced the effectiveness of the lampricide treatment. Albany Creek is scheduled for re-treatment in 1988. Smaller numbers (86) of residual lampreys, all of the 1986 year class, were present in the Ocqueoc River above the falls that is normally a barrier to adult migrations. This population, initially detected in 1986, is the first indication of reproduction above the falls in many years and probably resulted from a gradual erosion of the falls.

No larvae of the 1987 year class were recovered during surveys above the sea lamprey barrier dams in the East Au Gres River and Albany Creek, indicating that these structures were effective in stopping the 1987 adult spawning runs.

Two untreated Upper Peninsula streams were surveyed to monitor the status of recently established sea lamprey populations. Only native lampreys were found in Huron Point Creek where a single sea lamprey had been collected in 1986. In Saddle Creek, 172 sea lampreys (22 to 67 mm) were recovered. The population consisted of ammocoetes of the 1985 and 1986 year classes, and treatment of the stream is anticipated in 1989.

Sea lampreys were found in lentic areas off the mouths of four of the five streams sampled with granular Bayer. None of the populations off the Pine and Carp rivers or Albany and Nuns creeks were large or unexpected.

Larval surveys in the St. Marys River consisted of monitoring designated index areas for larval densities and growth and investigating other areas suspect of harbouring high larval densities.

A total of 1,896 sea lamprey larvae (11 to 162 mm), including 34 recently transformed larvae, were collected from 20 sites examined with granular Bayer and one site with electrofishing gear. All of the transformed lampreys and 1,851 of the larvae were collected from the 12 index sites examined.

Assessing emigration of recently metamorphosed sea lampreys in the St. Marys River is an important aspect in assessing lamprey-induced mortality in fish stocks in Lake Huron. A fyke netting study was conducted in 1983 and seven transformed sea lampreys were captured. The nets were fished for 11,500 hours and filtered more than 11 million cubic meters (388 million cubic feet) of water. This pilot study demonstrated the feasibility of using fyke nets as an assessment tool for metamorphosed lampreys in the St. Marys River. In 1987, another fyke netting operation was conducted in the river to further explore the use of fyke nets to assess emigrating transformed sea lampreys.

Fifteen riffle fyke nets with openings 0.7 m^2 (8 ft^2) and mesh of 0.64 cm (0.25 inch) and three modified Susquehanna hoop trap nets with openings of 3.3 m^2 (36 ft^2) and mesh of 0.64 cm and 15.2 x 1.8 m (50 x 6 ft) wings were fished from October 28 to December 9. The fyke nets were attached to navigational buoys and were set to fish the top 1 m (39 inches) of water. The hoop nets were set in shallow (1.8 m, >6 ft) areas in the Little Rapids cut between the Sugar Island Ferry crossing and Lake Nicolet. Three hoop nets and two fyke nets were fished in the upper river (Little Rapids cut), 10 fyke nets were fished in Middle Neebish Channel, and three in West Neebish Channel. The channel north of Sugar Island and the St. Joseph Channel at the outlet of Lake George were not fished.

A total of 65 recently metamorphosed sea lampreys were collected during the study. Thirty-five were collected in the upper river and 30 in the Neebish Channels. The nets were fished for 17,000 hours and filtered over 16 million cubic meters (565 million cubic feet) of water. The total volume fished was $1.67 \times 10^{-8}\%$ of that in the channels sampled.

Although fyke nets are not recognized as precise scientific tools, they are currently our most effective tool for sampling emigrating transforming lampreys in the St. Marys River. The number of metamorphosed lampreys (65) collected during the 1987 netting operation accounted for more than 23% of the total number of transformed lampreys collected during past surveys dating to 1963.

Canada

Surveys were conducted on 47 tributaries to Lake Huron in 1987. Distribution surveys were done on 10 streams in preparation for treatment in 1988 and 1989. No significant change in distribution was indicated in these streams. Routine surveys were conducted on 12 streams with no previous sea lamprey history and one stream (Shebeshekong River) was found to harbour a small population of larval sea lamprey. Treatment evaluation surveys in five streams (Echo, Serpent, Manitou and Sauble rivers, and Blue Jay Creek) were completed.

Residual lamprey were collected from the Echo River system above the dam following the 1987 treatment. A small number of residual sea lamprey were also found in the Serpent River system.

Reestablishment surveys were positive for all streams treated in 1985 and 1986 with the exception of the Sauble River. This moderately large river has historically produced low numbers of sea lamprey and survey efforts to date may have been insufficient to identify a very small population.

Sucker, H-68, Lauzon and Silver Lake creeks appear to have minor reestablished populations. The Wanapitei River has strong 1985 and 1986 year classes present.

With the exception of the Musquash and Sturgeon rivers, all other historical sea lamprey producing streams in southern Georgian Bay (8), have not been reestablished by sea lamprey.

Surveys have identified only a small number (18) of larval sea lamprey from the Saugeen River, all downstream of Denny's Dam.

Numbers of larval sea lamprey have increased significantly in recent years in the Musquash River, resulting in the scheduling of this river for treatment in 1988.

One new sea lamprey producing stream was identified in 1987. The Shebeshekong River, a tributary to central Georgian Bay, appears to have low numbers of the 1986 and 1987 year classes present. The removal of rubble from several rapids areas to improve boating has exposed underlying rock and gravel, providing spawning opportunities for sea lamprey.

Only nine of 34 index sites on the St. Marys River were sampled in 1987 because of time and manpower constraints. The size of the index plots and application rates for chemical are standardized. Collection effort is consistent for comparison of results. Surveys were conducted in September to identify transformation except for one plot sampled in July for specimens destined for scientific analysis.

A total of 757 larval sea lamprey were collected from 0.9 ha (2.2 acres) sampled in the St. Marys River. In the September surveys, 11 transformers were captured along with 161 larval sea lamprey. The transformation rate was 61% for all larvae greater than 120 mm.

CHEMICAL TREATMENTS

United States

Chemical treatments were completed on five streams (Table 13, Fig. 4) with a combined discharge of 55.9 m^3/s (1,979 f^3/s). Early season drought complicated several treatments. Upper application sites were moved downstream to more treatable sections in Elliot Creek and some tributaries of the East Au Gres River and a longer than normal chemical bank was applied in Schmidt Creek. Low water levels forced the cancellation of treatments of a tributary of the Cheboygan River system (Little Pigeon River) and two tributaries of the Saginaw River (Carroll and Big Salt creeks).

A drastic increase in the abundance of sea lamprey ammocoetes in the Shiawassee and Chippewa rivers, tributaries of the Saginaw River system, indicates a developing problem with sea lamprey control in this area. These streams were last treated in 1984 and would under normal conditions be re-treated in 1988. However, surveys indicated the growth rate of the 1985 year class of sea lampreys was sufficient to allow larvae to metamorphose in 1987. In addition, surveys documented an extensive increase in the distribution of sea lampreys in three tributaries of the Chippewa River, consequently, these streams were treated in 1987. Length frequencies of larvae collected during treatments indicated that 87% from the Shiawassee River and 40% from the Chippewa River exceeded 120 mm.

Collections during treatments of other Lake Huron streams indicated sea lamprey abundance was high in Schmidt Creek and the main Au Sable River, medium in Elliot Creek, and low in the Pine and East Au Gres rivers. Abundance in the upper East Au Gres River was lower than in past treatments, presumably because of the new low-head lamprey barrier.

A significant number of fish were killed during treatments of two tributaries of the Chippewa River; brook trout in Cedar Creek and non-game fish species in the Coldwater River. Onsite toxicity tests had been run on water from the Coldwater River and main Chippewa River. Results of the toxicity tests indicated higher minimum lethal levels of TFM than normally expected for sea lampreys, but mortality to native fishes tested was insignificant within the treatment range.

Fish mortality in the Au Sable River was low during treatment though large numbers of planted, triploid chinook salmon and adult chinook salmon were present in the river. Thousands of alewives were also present in this river but none were killed.

Canada

Four streams tributary to the North Channel and one stream tributary to the main basin of Lake Huron were treated with the selective lampricide TFM and Bayer 73 granules were applied to six lentic areas (Table 13, Fig. 4).

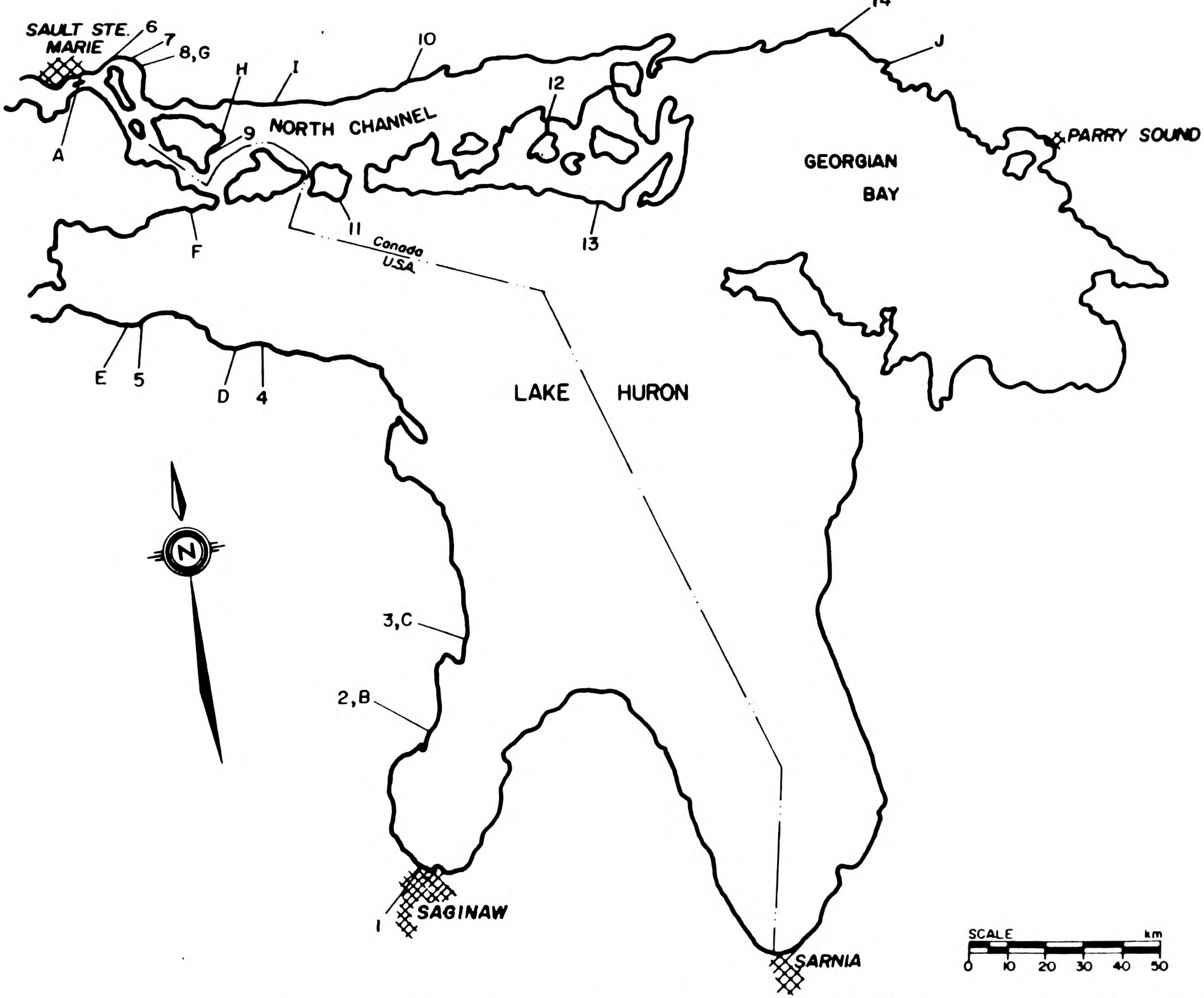

Figure 4. Location of streams treated with lampricides (numerals; see Table 13 for names of streams), and of streams where assessment traps were fished (letters; see Table 14 for names of streams) in 1987.

Table 13. Details on the application of lampricides to streams, lakes, or bays of Lake Huron, 1987.

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

Stream, lake, or bay	Date	Discharge		TFM[a]		Bayer 73 Powder		Bayer 73 Granules		Stream treated		Area treated	
		m^3/s	f^3/s	kg	lbs	kg	lbs	kg	lbs	km	miles	ha	acres
UNITED STATES													
Elliot Cr. (5)	May 1	0.23	8	40	88	–	–	–	–	3.2	2.0	–	–
Schmidt Cr. (4)	May 4	0.17	6	32	70	–	–	–	–	1.6	1.0	–	–
Au Sable R. (3)													
Pine R.	May 30	2.55	90	649	1,430	–	–	–	–	12.8	8.0	–	–
Main stream	June 2	33.98	1,200	6,138	13,533	29.2	64.4	–	–	19.4	12.0	–	–
East Au Gres R. (2)	June 11	1.84	65	737	1,625	–	–	–	–	51.6	32.0	–	–
Saginaw R. (1)													
Chippewa R.	Oct. 10	9.34	330	5,609	12,366	–	–	–	–	108.1	67.0	–	–
Shiawassee R.	Nov. 5	7.93	280	2,495	5,500	–	–	–	–	21.0	13.0	–	–
Total		56.04	1,979	15,700	34,612	29.2	64.4	–	–	217.7	135.0	–	–
CANADA													
Garden R. (7)	June 22	6.00	212	607	1,338	–	–	0.4	0.9	58.1	36.1	–	–
Echo R. (8)	July 7	0.60	21	241	531	–	–	–	–	39.7	24.7	–	–
Mississagi R. (10)	July 28	62.80	2,218	5,711	12,590	–	–	–	–	35.5	22.1	–	–
Root R. (6)	Sept. 9	1.87	66	228	503	–	–	0.1	0.2	45.7	28.4	–	–
Sand Cr. (11)	Oct. 6	0.17	6	57	126	–	–	–	–	1.1	0.7	–	–
Solar Lake (8)	July 15	–	–	–	–	–	–	19.3	42.5	–	–	1.8	4.4
Echo Lake (8)	Aug. 5	–	–	–	–	–	–	9.1	20.1	–	–	0.7	1.7
Tenby Bay (9)	Aug. 6	–	–	–	–	–	–	11.3	24.9	–	–	0.9	2.2
French R. (14)	Aug. 8	–	–	–	–	–	–	7.9	17.4	–	–	0.5	1.2
Michael Bay (13)	Aug. 10	–	–	–	–	–	–	4.5	9.9	–	–	0.4	1.0
Mudge Bay (12)	Aug. 11	–	–	–	–	–	–	9.1	20.1	–	–	0.7	1.7
Total		71.44	2,523	6,844	15,088	–	–	61.7	136.0	180.1	112.0	5.0	12.2
GRAND TOTAL		127.48	4,502	22,544	49,700	29.2	64.4	61.7	136.0	397.8	247.0	5.0	12.2

[a]Includes 63 TFM bars (13 kg, 29 lbs) applied in two streams.

Treatment of the Spanish River was deferred at the request of the Ontario Ministry of the Environment, until court proceedings regarding a private paper company's spill on this river in 1983 are completed.

Successful treatments were achieved on Sand Creek and the Root, Garden and Mississagi rivers, whereas treatment effectiveness on the complex Echo River system was hindered by low discharge, beaver impoundments, thermal stratification and limited access. Larval sea lamprey were very abundant in the Root, Garden, Echo and Mississagi rivers and moderately abundant in Sand Creek.

Bayer 73 granules were applied to lentic areas of Echo and Solar lakes, Tenby, Mudge and Michael bays, and an area in the lower French River system. Sea lamprey larvae were abundant in Solar Lake, moderately abundant in the French River and scarce in the remaining areas.

Mortality of non-target fish was insignificant in all areas treated with TFM and Bayer 73 granules.

SPAWNING-PHASE SEA LAMPREYS

United States

During the 1987 spawning season, 18,235 sea lampreys were captured in assessment traps placed in six tributaries of Lake Huron (Table 14, Fig. 4), compared with 18,872 in 1986. The catch of lampreys is similar to the number taken in 1986 in the Cheboygan (14,790 in 1987 vs. 14,126 in 1986) and East Au Gres (441 in both years) rivers. An estimated 21,406 spawning-phase sea lampreys were in the Cheboygan River compared with an estimated 28,293 in 1986 (Table 12). Trap catches of lampreys increased in the St. Marys River from 1,120 in 1986 to 1,292 in 1987 and in Albany Creek from 98 in 1986 to 319 in 1987. The catch of lampreys in the Ocqueoc River declined by 56% (from 3,064 in 1986 to 1,358 in 1987) and is partially attributed to the test operation of an electric weir (Smith-Root) installed by the Michigan Department of Natural Resources which prevented lampreys from further upstream migration to the trap site. The electric weir failed after two weeks when the electrodes became defective, thus an estimate of the spawning run was not obtained for the river. An estimated 20,840 sea lampreys were present in the spawning run of sea lampreys in the St. Marys River in 1987 (Table 12). Lampreys taken from assessment traps in 1987 averaged 20 mm shorter and 13 g lighter than those taken in 1986. The percentage of males was 4% higher than in 1986.

Canada

A total of 8,665 sea lampreys were captured from the spawning migrations in five rivers of Lake Huron (Figure 4). A sample of 2,329 adults were examined to obtain biological data (Table 14).

Trapping efficiency was estimated to be: St. Marys River (31%), Kaskawong River (34%), and Thessalon River (15%). Population estimates for these rivers were: St. Marys River, 20,840; Kaskawong River, 477; and Thessalon River, 12,236. No population estimates were conducted on the Echo and Still rivers.

The Still River was trapped for the first time since the electrical barrier was removed after the 1978 spawning season. The number of adult sea lampreys captured at the electrical barrier had averaged only 17 animals annually during

Table 14. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1987.

[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							
St. Marys R. (A)	1,292	147	44	466	468	249	256
East Au Gres R. (B)	441	441	51	423	428	205	208
Au Sable R. (C)	21	21	57	421	469	214	233
Van Etten Cr.	14	14	71	430	409	194	174
Ocqueoc R. (D)	1,358	24	46	482	482	259	247
Cheboygan R. (E)	14,790	0	-	-	-	-	-
Albany Cr. (F)	319	315	36	422	422	179	180
Total or Average	18,235	962	46	447	440	213	203
CANADA							
St. Marys R. (A)	6,982	1,452	55	470	474	234	242
Echo R. (G)	105	46	67	482	477	238	240
Kaskawong R. (H)	177	57	56	471	454	229	211
Thessalon R. (I)	847	237	59	477	471	245	245
Still R. (J)	554	537	38	411	465	226	258
Total or Average	8,665	2,329	52	461	471	234	246
GRAND TOTAL OR AVERAGE	26,900	3,291	50	457	461	228	232

the last six years of operations. The 1987 catch of 554 adults at the newly constructed barrier dam trap was unexpected. Whether this year's catch was a reflection of increased lamprey numbers or a measure of relative effectiveness between the old electrical barrier and the new trapping device is unknown. Trend over time data may clarify the situation.

The barrier dam, constructed on the Echo River in 1986, was bypassed by sea lampreys in 1987. As a result the number trapped in 1987 represents a small sample of the total run based on the observed nests and adults upstream of the dam. Remedial works carried out on the dam in 1987 are expected to stop lamprey runs in 1988.

Observations of sea lamprey spawning in the St. Marys River demonstrated nest building commenced July 1, egg deposition began July 7, and spawning behaviour continued until July 31. A total of 30 adults were observed and 47% were males. A total of 87 nest sites were located, with eggs being found in 40 nests. Four nests were subsequently lost and 31 out of 36 (86%) nests produced prolarvae.

PARASITIC-PHASE SEA LAMPREYS

United States

A total of 1,152 sea lampreys were collected by commercial fishermen in Lake Huron (Table 7). Fishermen from statistical district MH-1 (DeTour-Rogers City, Michigan, area) contributed the largest number of sea lampreys (943). The Agreement for Entry to Consent Order of 1985 of the State of Michigan eliminated most of the state-licensed, commercial fishermen from further fishing in MH-1 in 1986; however, collections now include lampreys taken by several native American commercial fishermen. A total of 943 parasitic-phase sea lampreys was taken in MH-1 in 1987, compared with 652 in 1986. The number of sea lampreys collected by commercial fishermen in statistical district MH-2 (Alpena, Michigan, area) increased from 88 in 1986 to 136 in 1987 and decreased in MH-4 (Tawas City-Bay Port, Michigan, area) from 96 to 73.

Spawning year was determined for the 1,152 parasitic-phase sea lampreys collected by the commercial fisheries; 173 would have spawned in 1987 and 979 in 1988 (Table 6). In addition, 711 lampreys of the 1987 spawning year were taken in 1986, bringing the total collected for this spawning year to 884.

Sport fishermen on the U.S. side of Lake Huron captured 2,227 parasitic-phase sea lampreys (284 from charter and 1,943 from noncharter fishermen) in 1987 (Table 7), compared with 2,069 (188 charter, 1,881 noncharter) in 1986. Lampreys were collected from all statistical districts of the lake, with the largest number taken in MH-3 (Black River to Au Sable Point, Michigan, area; 710).

Information on occurrence of sea lampreys and lamprey wounds on fish was reported by 45 charter captains (Tables 8 and 9). Lakewide, 81% of the lampreys were attached to chinook salmon, compared with 83% in 1986. The number of lampreys attached per 100 fish remained virtually unchanged for lake trout (2.0 in 1986 vs. 1.8 in 1987), whereas it decreased slightly for chinook salmon (9.8 in 1986 vs. 8.3 in 1987).

Canada

A total of 1,012 parasitic sea lamprey have been submitted from Lake Huron during 1987. Fifty-eight per cent (587) of the sea lamprey were obtained from the North Channel area and 40% (404) came from the Canadian waters immediately south and east of the St. Marys River, statistical districts OH-1 and OH-2. Collections directed specifically at Georgian Bay were discontinued because of low returns.

Two fishing derbies targeting chinook salmon in the St. Marys River were monitored. The Strohs Light King Salmon Derby (August 22 to September 12) and the Can-Am Team Salmon Tournament (August 28 to 30) provided observations from 644 salmon caught. An average of 39 wounds per 100 salmon were observed with 30% of all fish wounded.

BARRIER DAMS

No new barrier dams were constructed on Lake Huron tributaries in 1987. Improvements in the form of stone and geotextile filters placed at the Echo River dam will hopefully block the passage of lamprey through subterranean seepage.

On the Still and Echo river barrier dams, 15 cm (6 inch) diameter pipes were extended to the opposite side of the dams from the built-in traps to provide passage for lampreys into these traps. Results show that lamprey used these pipes successfully to access the traps, approximately 14 meters (46 ft) away from the pipe openings. In fact, at both barriers returns were significantly higher in the section of trap accessed via pipe: Still River - 61% of 556, Echo River - 98% of 105. This assessment information, in conjunction with a tag release study, suggests that for built-in traps, entrances through which outside light can be seen have higher escapement rates than dark (extended pipe) entrances.

LAKE ERIE

LARVAL ASSESSMENT

United States

Twelve tributaries of Lake Erie were surveyed in 1987 to evaluate initial chemical treatments, monitor larval growth, and detect recent infestations by sea lampreys. Six of the seven streams treated in 1986 (Cattaraugus, Delaware, Canadaway, Crooked, and Raccoon creeks and Halfway Brook) revealed no evidence of residual lampreys from the 1986 treatments. A total of 21 residual lampreys were recovered from scattered locations in the Conneaut Creek drainage, but the need for remedial treatment action is not apparent in this stream. Larvae of the 1987 year class were recovered from Cattaraugus, Raccoon, and Conneaut Creeks. No residual sea lampreys were observed in the Grand River proper after chemical treatment in the spring of 1987, but two larvae (110 and 122 mm) were collected in the harbour area offshore of the mouth of the river. Surveys showed no evidence of recent reinfestation in Wheeler Creek, the Sandusky River, or in a stream with no previous history of lamprey production, the Ashtabula River.

Canada

Larval surveys were conducted on 11 tributaries to Lake Erie in 1987.

Treatment evaluations were conducted on three streams treated in the fall of 1986 and seven in the spring of 1987. A single residual sea lamprey larva was found in Bradley Creek, a tributary to Catfish Creek. The residual sea lamprey found in Big Creek (25) came principally from two untreated areas; a large pool at the base of a dam at Teeterville, and the Town of Delhi's water supply reservoir at the confluence of North and South creeks. Small numbers of residual sea lamprey larvae (50 to 70 mm in length) were also collected from East, Fishers and Young creeks.

Clear and Big creeks provided substantial numbers of the 1987 year class, reestablished following treatment. Only a single larva (25 mm in length) suggests Forestville Creek has a reestablished population. No young-of-the-year larvae were found in Big Otter, South Otter, or Cranes (Potters) creeks.

Persistent reports of sea lamprey spawning in the Grand River encouraged an extensive survey effort on this river from the dam at Caledonia to the mouth of Mackenzie Creek. Granular Bayer 73 was used exclusively because of the high turbidity and hard water encountered. Water temperatures encountered during survey work ranged from 27 to 30°C (81 to 86°F). No sea lamprey were found in 1.87 ha (4.6 acres) (33 plots) in the Grand River nor in 0.12 ha (0.3 acre) (11 plots) in Mackenzie Creek and its tributary, Bostons Creek.

LAKE ERIE

CHEMICAL TREATMENTS

United States

The Grand River, Lake County, Ohio, was treated for the first time in 1987 and concluded the first round of treatments of infested U.S. tributaries of Lake Erie. The treatment began on April 26, when 900 kg (1,980 lbs) of TFM were applied to a discharge of 5.7 m^3/s (200 f^3/s) in the 43.5 km (27 mi) of infested stream (Table 15, Fig. 5). Intensive collections during treatment recovered 1,089 sea lampreys, of which 96% were over 100 mm long.

Mortality of nontarget species in the Grand River was low. Only a few dead mudpuppies, catfish sp., and minnow sp. were observed.

Canada

Seven streams tributary to Lake Erie were treated with lampricide for the first time in May and June of 1987 (Table 15, Fig. 5). Favourable discharges and weather conditions contributed to successful treatments on all streams.

Treatments on Forestville, Young, Cranes, Fishers, East, and Catfish (Bradley) creeks were uncomplicated due to their small size and absence of major tributaries.

The treatment of 103 km (64 mi) of Big Creek required the combined efforts of two treatment units to achieve a successful treatment. Considerable time was expended contacting landowners to secure access and to determine crop irrigation practices. Numerous tributaries were treated to counteract dilution and escapement, whereas Venison Creek, the major sea lamprey producing tributary system, had to be treated separately.

Larval sea lamprey were moderately abundant in Big, Young, and Catfish creeks, but were very scarce in the remaining streams. Incidental mortality of nontarget fishes was very light during these treatments.

During the pretreatment phase of the Big Creek lampricide treatment, it became obvious that a number of landowners were planning to irrigate their recently planted crops with water drawn directly from the stream. After appreciable negotiations and compromises, the farmers agreed to suspend irrigating for the short period that the lampricide (TFM) was available to their

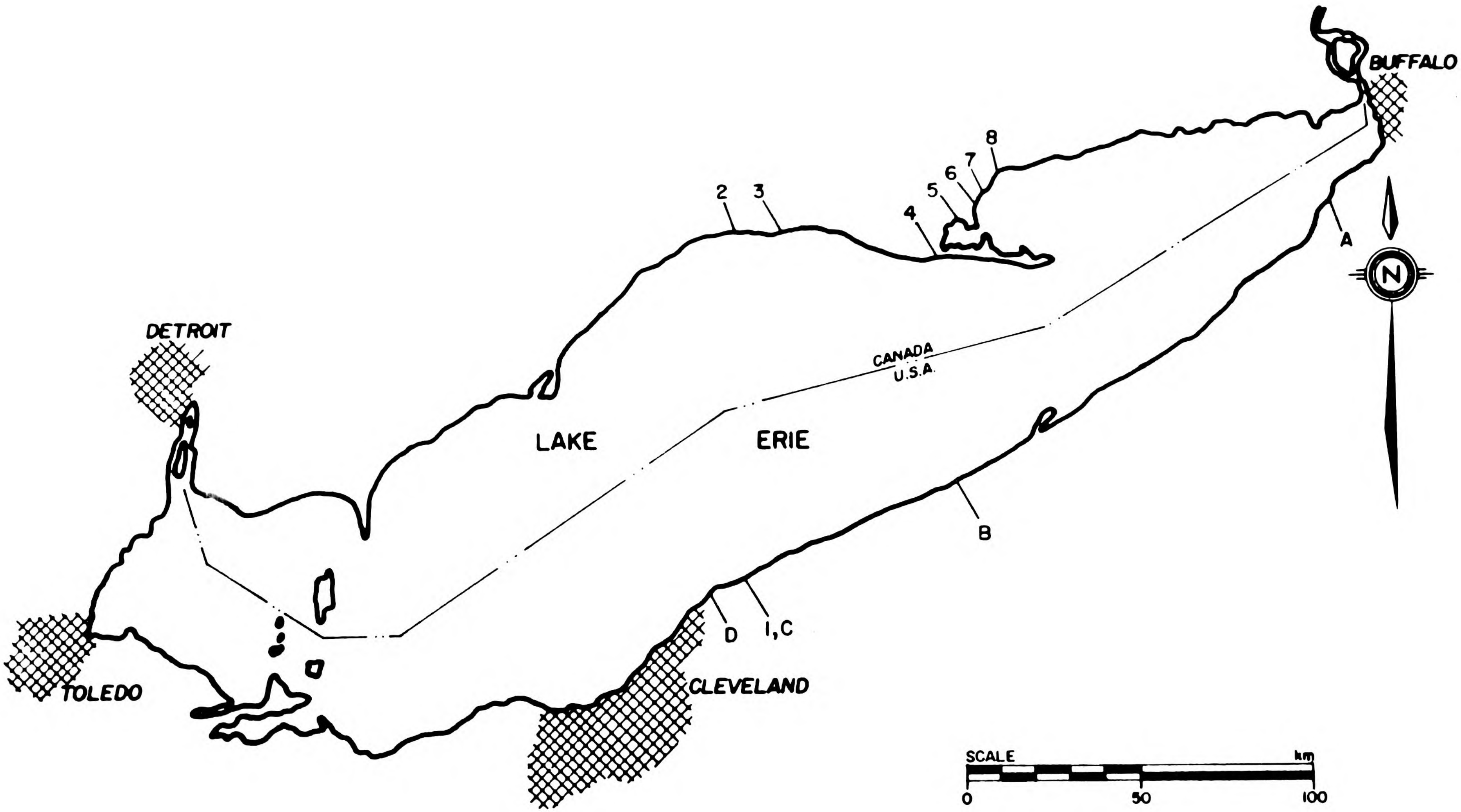

Figure 5. Location of streams treated with lampricides (numerals; see Table 15 for names of streams), and of streams where assessment traps were fished (letters; see Table 16 for names of streams) in 1987.

Table 15. Details on the application of lampricides to streams of Lake Erie, 1987.

[Number in parentheses corresponds to location of stream in Figure 5. 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							
Grand R. (1)	Apr. 26	5.66	200	898	1,980	43.5	27.0
Total		5.66	200	898	1,980	43.5	27.0
CANADA							
Forestville Cr. (5)	May 29	0.11	4	31	68	3.0	1.9
Young Cr. (8)	May 30	0.74	26	206	454	4.4	2.7
Cranes Cr. (6)	May 31	0.14	5	35	77	2.3	1.4
Big Cr. (4)	June 1	4.90	173	2,001	4,411	102.9	63.9
Fishers Cr. (7)	June 5	0.26	9	55	121	3.5	2.2
East Cr. (2)	June 7	0.09	3	36	79	1.6	1.0
Catfish Cr. (3)	June 7	0.16	6	37	82	1.5	0.9
Total		6.40	226	2,401	5,292	119.2	74.0
GRAND TOTAL		12.06	426	3,299	7,272	162.7	101.0

watering system. Since no data was available to the Centre regarding the effects of the TFM on truck gardening crops, an immediate request was made to the La Crosse National Fisheries Research Center for their assistance in this matter. A study was promptly carried out to assess the effects of TFM on lettuce, radish, cucumber, tomato and potato plants. A Special Report, 'Effects of Lampricide (TFM) Treated Irrigation Water on Selected Vegetable Plants' indicated that lettuce, radish and potato plants were not affected. Tomato plants exhibited a slight discolouration on some leaves for up to five days after treatment. Cucumber plants sustained severe damage; 20% of the plants died and about 40% of the leaves on the surviving plants were dead after eight days.

We express our thanks to the staff of the National Fisheries Research Center, U.S. Fish and Wildlife Service in La Crosse, Wisconsin, for their prompt response to our request for this information.

During the treatment of Big Creek the Principal of Valley Heights High School, located in Walsingham, informed our personnel that the school drew water from Big Creek. Their water system included sand filtration and chlorinators only. They had observed the yellow colour of the TFM in the stream and shut off their pumps. Subsequent water analysis showed no TFM in their holding tanks, however the Centre supplied the school with drinking water until the TFM block was clear of their water intake system.

The Ontario Ministry of Environment (OME) was advised of this situation and indicated that they would conduct an investigation of the school's water system in view of the intense agricultural practices which occur throughout the Big Creek watershed.

SPAWNING-PHASE SEA LAMPREYS

United States

A total of 1,958 sea lampreys were captured in assessment traps placed in four tributaries of Lake Erie (Table 16, Fig. 5), a 48% increase over the number taken in 1986 (1,326). Trap catches increased in three of the four streams monitored in 1987. The largest increase occurred in Cattaraugus Creek where 1,224 lampreys were taken in 1986 and 1,627 in 1987. The average length and weight of lampreys and percentage of males taken remained about the same as those taken in 1986.

Canada

No spawning runs of sea lamprey were sampled in tributaries of Lake Erie in 1987.

Table 16. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Erie, 1987.

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

Stream	Number captured	Number sampled	Percent males	Mean length (mm) Males	Mean length (mm) Females	Mean weight (g) Males	Mean weight (g) Females
UNITED STATES							
Cattaraugus Cr. (A)	1,627	1,365	53	512	508	292	296
Conneaut Cr. (B)	1	1	100	558	-	312	-
Grand R. (C)	184	184	51	499	497	258	266
Chagrin R. (D)	146	140	53	504	495	267	265
TOTAL OR AVERAGE	1,958	1,690	52	510	506	287	290

PARASITIC-PHASE SEA LAMPREYS

United States

No parasitic-phase sea lampreys were collected from Lake Erie in 1987.

Canada

The number of parasitic sea lamprey collected by the commercial fishery was 278, down 30% from the 453 submitted in 1986.

LAKE ONTARIO

LARVAL ASSESSMENT

United States

Ten Lake Ontario streams, including six tributaries to the Oswego River (Fish, Big Bay, and Ninemile creeks and Carpenter, Crane, and Cold Spring brooks), were surveyed by the U.S. agent to assess larval sea lamprey populations and to monitor larval growth.

Surveys were conducted on the Black River and Salmon, Oak Orchard, and North Sandy creeks. Prior to treatment, four offshore locations of Black River were examined and 15 sea lamprey larvae (48 to 167 mm) were recovered. No sea lampreys were observed at one location examined in Salmon Creek; however, high and turbid water existed during the survey. Conditions for survey were also unfavourable in Oak Orchard Creek, but 13 sea lamprey larvae (58 to 100 mm) were collected from two of four sites examined. Salmon and Oak Orchard creeks are scheduled for initial chemical treatments in 1988. Two locations in North Sandy Creek were surveyed; no larval sea lampreys were collected. This stream has little potential for lamprey survival in the main stream because water temperatures are high during the summer.

Surveys of the Oswego River system consisted of examining index areas in six tributaries to monitor larval growth and recent infestations. A total of 780 sea lampreys (779 larvae ranging from 27 to 157 mm and one transformed lamprey, 154 mm) were collected from six locations in Fish Creek. Included in the collection were 75 lampreys of the 1987 year class and 21 lampreys residual from the 1984 chemical treatment. A total of 79 larval sea lampreys (85 to 155 mm), including two residual lampreys, were collected during surveys of an index area in Big Bay Creek. Fish Creek is scheduled for chemical treatment in 1988. No sea lampreys were observed during surveys at nine locations in Ninemile Creek (a tributary of Onondaga Lake), a stream with no previous history of lamprey production. Three tributaries of the Seneca River on the Oswego River system were also surveyed. Collections taken during surveys included 63 larvae (48 to 137 mm) and one recently transformed lamprey (130 mm) from Carpenters Brook and 38 larval lampreys (45 to 145 mm) from Cold Spring Brook. No larval sea lampreys were taken in Crane Brook.

A total of 16 sea lamprey larvae (68 to 175 mm) were collected from 7 of 23 sites (16 locations downstream of the falls and seven above the falls) examined with granular Bayer in U.S. waters of the Niagara River. Four larvae (80 to 175 mm) were taken from 2 of 16 locations surveyed downstream of the Niagara Falls. Areas of the Niagara River examined extended downstream from Lewiston, New York, to about 2.4 km (1.5 mi) offshore in the delta in Lake Ontario. The sea lamprey larvae were collected near Lewiston. In addition, five larval American brook lampreys were collected from the downstream areas. Larval habitat is sparse in most of the areas surveyed below the falls. The areas of deposition in the lower river appear to be on the Canadian side of the river, especially in the area near Niagara-on-the-Lake. Offshore substrate deposition also lies mostly in Canadian waters.

Twelve sea lamprey larvae (68 to 147 mm) and 155 American brook larvae were collected from five of the seven sites examined above the falls on the Niagara River. Areas sampled ranged from locations near the current deflectors on the western tip of Buckhorn Island upstream to Edgewater, New York, on the northeast side of Grand Island. Larval habitat is sparse in most areas except for an area of deposition near the current deflectors. Accuracy of the results of surveys with granular Bayer in the Niagara River is questionable because of the effects of rapid water velocity and dense beds of macrophytes.

Larval surveys were conducted on 21 New York State tributaries by the Canadian agent in 1987. Distribution surveys were done on nine streams, treatment evaluation on three streams treated in 1986 and reestablishment surveys on 11 streams.

Treatment evaluation surveys found a few residuals in the Salmon River and one in the Deer and Snake creeks. Surveys found no changes in larval sea lamprey distribution from previous years. Reestablished populations were found in the Salmon and Little Salmon rivers, Deer, Snake, Sodus and First creeks. No evidence of reestablishment was found in Blind, Sage, Butterfly, Blind Sodus and Wolcott creeks.

Canada

Larval surveys were conducted on 22 Canadian tributaries to Lake Ontario. Treatment evaluation and reestablishment surveys were done on 12 streams, distribution on six streams and population assessments on eight streams.

Small numbers of residual sea lamprey were found in four streams: Graham Creek, 1; Shelter Valley Brook, 2; Proctor Creek, 4; and Mayhew Creek, 4.

Bronte, Oshawa, Bowmanville, Wilmot, Cobourg, and Mayhew creeks, and Shelter Valley Brook were reestablished by sea lamprey after the last treatment. No reestablished populations of sea lamprey have been found in the Credit River, Lynde, Graham, Proctor and Smithfield creeks since their last treatments.

Distribution surveys have verified that the recently constructed dams on Shelter Valley Brook, Lakeport and Graham creeks have effectively stopped the upstream migration of adult sea lamprey on these streams. Surveys on Bowmanville Creek indicate that no sea lamprey bypassed the Goodyear dam to gain access to the headwaters of this stream, opened up when an upstream mill dam was washed out in the fall of 1986.

Population surveys to evaluate existing larval sea lamprey populations revealed that the reestablished year classes in Ancaster and Duffin creeks could no longer be found. Ancaster Creek has always been a marginal producer but the Duffin Creek has historically had substantial numbers. Small numbers of sea lamprey were found in the Napanee River and Farewell Creek.

An extensive survey effort was conducted on the Niagara River in cooperation with the U.S. Fish and Wildlife Service from Marquette, Michigan, to evaluate the sea lamprey production potential from this river. In the Canadian waters of the river, 57 plots representing 5.84 ha (14.4 acres) of larval habitat were sampled with a capture success of 32 larval sea lamprey and 1,109 native American brook lamprey.

In the upper river, 22 sea lampreys were captured in 24 survey plots (2.50 ha; 6.2 acres). In the lower river, 10 sea lampreys were captured in 25 survey plots (2.24 ha; 5.5 acres). No larval sea lamprey were captured in eight plots (1.10 ha; 2.7 acres) along the delta area of the river.

CHEMICAL TREATMENTS

United States

Five New York State tributaries were treated by the Canadian agent in 1987 (Table 17, Fig. 6). The lampricide treatments of Catfish and South Sandy creeks were straightforward, but tributary systems, beaver impoundments and seepage areas on Grindstone and Little Sandy creeks made these treatments more difficult. The Black River was treated in August to take advantage of lower summer flows. Because of hydro-electric generation on the Black River by various public and private companies, stream discharge varied wildly for short-term periods, necessitating constant changes in lampricide application rates. Despite these discharge fluctuations and some problems with mixing and attenuation in the lower river, it is felt an effective treatment resulted.

Larval sea lamprey were very abundant in the Black River, with numerous transforming sea lamprey, and moderately abundant in the other four streams. Non-target fish mortality was minimal in all five streams treated.

Canada

Four Ontario tributaries were treated with the selective lampricide TFM (Table 17, Fig. 6). Stable and adequate stream discharges in the spring contributed to the success of the four treatments in Ontario. Temperature stratification in the extreme lower ends of Oshawa Creek and the Credit River may have resulted in marginal sea lamprey escapement in those sections.

Larval sea lamprey were moderately abundant in Oshawa and Lynde creeks and the Credit River, but relatively scarce in the Rouge River. Non-target fish mortality was minimal in all but the Rouge River, where several thousand adult common white suckers were killed. A combination of a rapid increase in water temperature during the treatment, the poor condition of those post-spawning phase suckers, and TFM levels applied at near maximum rates to ensure a lethal block to the mouth, all contributed to the mortality. Considerable time and effort was spent by Centre personnel cleaning up the dead fish.

SPAWNING-PHASE SEA LAMPREYS

United States

A total of 501 spawning-phase sea lampreys were captured in assessment traps placed in six tributaries of Lake Ontario (Table 18, Fig. 6). The catch is slightly less than the number taken in 1986 (574). Trap catch increased in South Sandy Creek (from 10 in 1986 to 114 in 1987), but decreased in the other tributaries. The average length of lampreys taken in Lake Ontario tributaries was about the same as those in 1986, but the average weight decreased 57 g (sexes combined). The percentage of males increased from 68 to 74%.

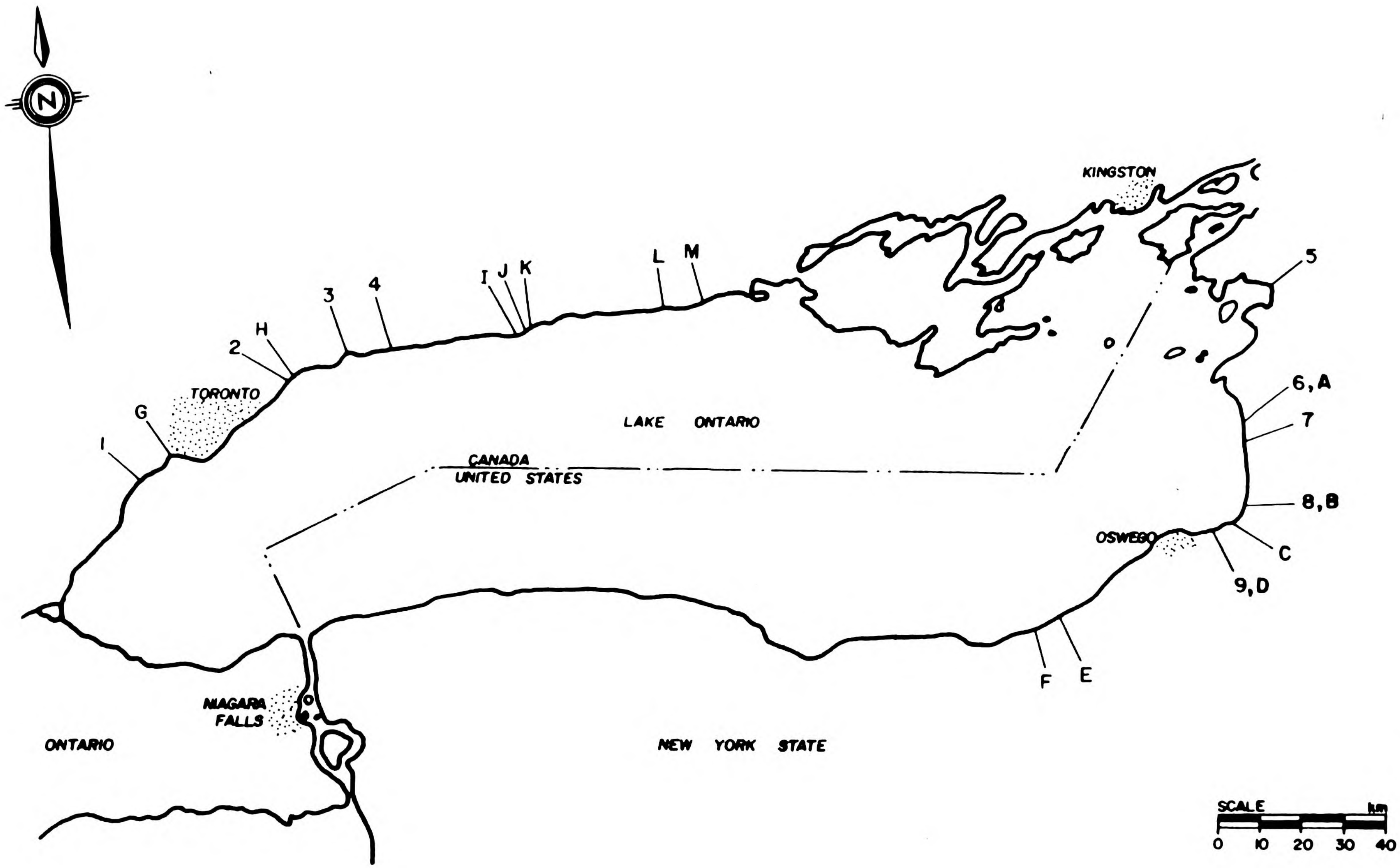

Figure 6. Location of streams treated with lampricides (numerals; see Table 17 for names of streams), and of streams where assessment traps were fished (letters; see Table 18 for names of streams) in 1987.

Table 17. Details on the application of lampricides to streams of Lake Ontario, 1987.

[Number in parentheses corresponds to location of stream in Figure 6. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge		TFM[a]		Bayer 73 Powder		Bayer 73 Granules		Stream treated	
		m^3/s	f^3/s	kg	lbs	kg	lbs	kg	lbs	km	miles
NITED STATES											
South Sandy Cr. (6)	Apr. 30	7.60	268	783	1,726	–	–	–	–	11.4	7.1
Little Sandy Cr. (7)	May 3	1.17	41	176	388	–	–	–	–	12.4	7.7
Grindstone Cr. (8)	May 5	1.16	41	171	377	–	–	–	–	31.6	19.6
Catfish Cr. (9)	May 9	0.47	17	87	192	–	–	–	–	1.2	0.7
Black R. (5)	Aug. 10	43.43	1,534	3,954	8,717	–	–	–	–	14.9	9.3
Total		53.83	1,901	5,171	11,400	–	–	–	–	71.5	44.4
CANADA											
Lynde Cr. (3)	Apr. 30	0.59	21	306	674	–	–	–	–	10.8	6.7
Credit R. (1)	May 3	8.72	308	1,901	4,191	14.6	32.2	0.3	0.7	35.5	22.1
Oshawa Cr. (4)	May 7	0.86	30	458	1,010	–	–	–	–	19.0	11.8
Rouge R. (2)	May 10	0.98	35	475	1,047	–	–	0.1	0.2	13.8	8.6
Total		11.15	394	3,140	6,922	14.6	32.2	0.4	0.9	79.1	49.2
GRAND TOTAL		64.98	2,295	8,311	18,322	14.6	32.2	0.4	0.9	150.6	93.6

Canada

Seven streams had the spawning run of sea lamprey sampled in 1987 (Table 18, Fig. 6). A total of 8,190 adults were trapped.

Trapping efficiency studies and population estimates were conducted on four streams. Trap efficiency estimates were: Graham Creek, 77%; Shelter Valley Brook, 63%; Duffin Creek, 53%; and the Humber River, 45%. Population estimates for the four streams were: Graham Creek, 256; Shelter Valley Brook, 1,370; Duffin Creek, 2,446, and the Humber River, 9,467.

The total catch of lamprey increased 46 per cent over 1986, from 5,627 to 8,190. In the Humber River, the only river with 1986 and 1987 trapping efficiency estimates, the efficiency of capture increased 25% in 1987. In the four streams where population estimates were made in 1987, there was an increase in total captures of 37%.

The sex ratio of the spawning population shifted from 65% males in 1986 to 61% in 1987. The average length of the spawners decreased in 1987. Males were 494 mm in length compared to 502 mm in 1986, and females were 484 mm in length compared to 497 mm in 1986. The weights increased for males from 267 g in 1986 to 272 g in 1987, and females dropped slightly from 273 g to 269 g in 1987.

Table 18. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Ontario, 1987.

[Letter in parentheses corresponds to location of stream in Figure 6.]

Stream	Number captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g)	
				Males	Females	Males	Females
UNITED STATES							
South Sandy Cr. (A)	114	112	73	508	506	218	229
Grindstone Cr. (B)	56	54	74	498	494	208	213
Little Salmon R. (C)	1	1	100	513	-	245	-
Catfish Cr. (D)	1	0	-	-	-	-	-
Sterling Valley Cr.(E)	304	233	80	499	492	210	203
Sterling Cr. (F)	25	23	44	496	506	208	219
Total or Average	501	423	74	501	498	212	213
CANADA							
Humber R. (G)	4,870	551	56	485	471	267	259
Duffin Cr. (H)	1,320	238	62	498	494	282	282
Bowmanville Cr. (I)	641	438	64	498	492	268	271
Wilmot Cr. (J)	133	126	62	488	478	262	253
Graham Cr. (K)	224	76	66	500	507	273	291
Shelter Valley Br.(L)	905	196	65	510	498	293	292
Lakeport Cr. (M)	97	86	59	482	479	254	254
Total or Average	8,190	1,711	61	494	484	272	269
GRAND TOTAL OR AVERAGE	8,691	2,134	63	496	486	258	261

PARASITIC-PHASE SEA LAMPREYS

No parasitic-phase sea lampreys were collected from Lake Ontario.

BARRIER DAMS

Canada

A low-head barrier dam incorporating a built-in adult trap was constructed 0.3 km (0.2 mi) above the mouth on Grafton Creek (Figure 6). Cost for this concrete structure was $35,000.

Remedial work was completed at Reid's Milling Dam on the Credit River to correct gouging below, and washout around, the low-head dam on the overflow channel.

Normal maintenance was also carried out at existing barrier dams located on the Humber River, Shelter Valley Brook, and Duffin, Graham and Lakeport creeks.

LAKES SUPERIOR, MICHIGAN, HURON, ERIE, AND ONTARIO

TREATMENT EFFECTS ON NONTARGET ORGANISMS (SHORT-TERM TESTS)

Caged studies--Routine monitoring of the immediate effects of lampricides upon nontarget organisms continued in 1987. *In situ* assays were completed by caging fish in the White (Lake Michigan) and Shiawassee (Lake Huron) rivers, and fish, invertebrates, and amphibians in the Grand River (Lake Erie).

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

Mortality of caged fish in the Shiawassee and Grand rivers was limited to a single common shiner, whereas mortality in the White River was higher because Bayer was used with TFM at one of the two cage sites (Table 19). At the uppermost site in the White River, only TFM was present and no mortality of caged fish was observed. Bayer and TFM were present at the lower site where all caged Esocids, Ictalurids, and rainbow darters died. Other species, including some tested at both sites, were unaffected. Bayer concentration at the cage site averaged 0.039 mg/L (range, 0.036 to 0.047 mg/L) for 11 hours, and of those species that died, all are extremely sensitive to Bayer at these treatment levels. Nontarget mortality was localized near the cage site because treatment concentrations of Bayer decline rapidly in downriver areas to levels where fish were not affected.

As a response to concerns over the effects of lampricides to nontarget organisms in the initial treatments in Ohio tributaries of Lake Erie in 1986, mudpuppies and invertebrates, in addition to fish, were caged in the Grand River before treatment in 1987. Mortality of caged mudpuppies (Table 19), which was limited to small (<50 mm, 2 inch) specimens, may have been caused by overcrowding in the test cages.

Table 19. Number of fish and amphibians caged in three U.S. streams before a lampricide treatment with TFM and at an additional site in one of the streams below the introduction of Bayer 73 to synergize with the TFM, and number live after treatment, 1987.

	White River (Lake Michigan)				Shiawassee R. (Lake Huron)		Grand River (Lake Erie)	
	TFM		TFM-Bayer 73		TFM		TFM	
	Number		Number		Number		Number	
Species	Caged	Live	Caged	Live	Caged	Live	Caged	Live
Central mudminnow			8	8				
Grass pickerel			7	0				
Central stoneroller					9	9	1	1
Carp							10	10
Hornyhead chub			3	3	14	14	2	2
Pugnose minnow							1	1
Common shiner					20	19	9	9
Bluntnose minnow					4	4	1	1
Rosyface shiner					3	3	1	1
Spotfin shiner							16	16
Longnose dace	9	9						
White sucker							2	2
Creek chubsucker			2	2				
Northern hogsucker							2	2
Redhorse sp.							5	5
Yellow bullhead			2	0				
Tadpole madtom			1	0				
Banded killifish	1	1						
Rockbass	2	2	2	2	6	6	5	5
Green sunfish	1	1						
Pumpkinseed	20	20					25	25
Bluegill	1	1						
Smallmouth bass	2	2						
Largemouth bass	10	10	10	10				
Black crappie	2	2						
Rainbow darter	10	10	4	0	6	6		
Blackside darter	5	5	1	1				
Greenside darter					9	9		
Fantail darter					21	21		
Johnny darter					3	3		
Mudpuppy (*Necturus maculosus*)								
Small (<50 mm)							5	0
Medium (51-199 mm)							8	8
Large (>200 mm)							26	26

Survival was excellent among the 16 invertebrate genera tested in the Grand River, with only the Tricopteran Chimarra showing any susceptibility to the lampricide (Table 20). Chimarra was shown to be sensitive to the lampricide in previous tests in the upper lakes. Mortality of Ceratopsyche, Amphinemura, and Ephemerella was limited to one specimen each. These results are consistent with tests in the upper lakes which indicated these genera are tolerant of the lampricide.

Invertebrate drift--Mortality estimates on selected organisms have been determined from caged specimens in streams during treatments since 1983. However, some organisms must be assessed by other techniques because of their small size, scarcity, inability to survive in cages, or difficulty in being collected. Sampling of invertebrate drift is a valuable method to determine which riffle species are sensitive to the chemical, although estimates of the percentage which later die cannot be determined by the technique. The use of drift studies, in combination with other sampling methods, provides the best evaluation on a community-wide basis.

Invertebrate drift was sampled during the 1986 treatments of the Brule and Whitefish rivers and Bear Creek (Manistee River tributary). (Analyses of the samples were not completed until 1987.) Samples were collected every two hours for periods of 15 minutes throughout the duration of each treatment (14 to 18 hours) and, as a control, for a similar time frame before treatment. TFM was maintained between the minimum lethal dose for larval lampreys (MLC, concentration killing 99.9% of the test larvae within nine hours) and maximum allowable dosage (MAC, concentration prediced to kill 25% of test rainbow trout within 24 hours) in each river and ranged from 1.3 times MLC (2.0 mg/L TFM) in the Brule to 1.6 times MLC (5.0 mg/L TFM) in the Whitefish rivers. Time above MLC averaged 11 hours in each river.

Table 20. Number of invertebrates caged in the Grand River, Lake Erie, the day before a lampricide treatment, and number live after treatment, 1987.

Taxon	Number Caged	Number Live	Taxon	Number Caged	Number Live
Plecoptera			Tricoptera (continued)		
Nemouridae			Polycentropodidae		
Amphinemura	1	0	Polycentropis	1	1
Perlidae				[a]1	1
Neoperla	10	10	Cernotina	1	1
Ephemeroptera			Hydropsychidae		
Baetidae			Ceratopsyche	3	2
Baetis	1	1	Macrostemum	10	10
Oligoneriidae			Leptoceridae		
Isonychia	2	2	Ceraclea	7	7
Heptageniidae			Coleoptera		
Stenacron	6	6	Psephenidae		
Stenonema	4	4	Psephenus	10	10
Ephemerellidae			Elmidae		
Ephemerella	10	9	Stenelmis (larvae)	9	9
Trichoptera			Stenelmis (adult)	10	10
Philopotamidae			Diptera		
Chimarra	8	6	Tipulidae		
	[a]11	0	Hexatoma	1	1

[a]Additional caged downstream.

Drift increased significantly in all three streams (Table 21). The greatest increase was in Bear Creek (675%), followed by the Whitefish (461%) and Brule (115%) rivers. In general, the increase was attributed to only a few organisms. Aquatic worms (Annelida) and blackfly larvae (Simuliidae) increased in the drift of all streams. Drift of Baetidae, Hydropsychidae, Chironomidae, Ferrisia (Gastropoda), and the Amphipod Gammarus increased substantially in Bear Creek and the Brule River. Hydroptilidae (microcaddis) and Tipulidae, although represented in the drift of all three streams, increased significantly only in the Whitefish River.

Hexagenia—Samples of Hexagenia were collected before and after chemical treatment of the Pere Marquette River (Lake Michigan) in 1987 to compare with collections taken in a similar manner during the 1983 treatment. Random samples (3 from each of 10 silt beds) were collected with an Eckman dredge. Total abundance of nymphs declined 69% from the pretreatment (720/m^2) to posttreatment (224/m^2) samples in 1987. The larger, age I nymphs were most seriously affected and declined from 578/m^2 before treatment to 59/m^2 after treatment. In 1983, samples of Hexagenia collected before and after treatment showed only an 8% decline in total abundance (from 438/m^2 to 405/m^2). Again, most of the decline was attributed to mortality of age I nymphs.

The decline in abundance of Hexagenia in 1987 in the Pere Marquette River was the result of an exceedingly long chemical bank at higher TFM concentrations than in 1983 (Fig. 7). The bank in 1987 was over 20 hours, including nine hours over the MLC of 6.0 mg/L compared with a bank in 1983 of just over 12 hours with 7.5 hours over the MLC of 4.5 mg/L. A bioassay conducted in 1986 that simulated treatment conditions showed that the gradual buildup and tapering of TFM banks can greatly increase mortality of Hexagenia by lowering 12-hour LC50 values as much as 30%.

TREATMENT EFFECTS ON NONTARGET ORGANISMS (LONG-TERM TESTS)

Hexagenia--Samples of Hexagenia were collected in the spring and fall in the Whitefish River (Lake Michigan) to determine effects of lampricides on populations. Random samples (3 from each of 10 silt beds at a control area and a treated area, or 60 samples) were collected with an Eckman dredge. Originally, Scott Creek (Whitefish River tributary) was selected as the control area, but the site was later abandoned because beavers caused the area to flood. An untreated portion of the nearby Indian River, a tributary of the Manistique River, replaced Scott Creek as the control area in the fall of 1986.

Abundance of Hexagenia nymphs in the Whitefish River declined 41%, from 119/m^2 in September 1986 to 70/m^2 in October 1987. A treatment of the river in June 1986 seriously depleted nymphs of the 1984 cohort that subsequently produced nymphs of the 1986 cohort. These individuals, now age I, remain at abundance levels significantly lower than pretreatment abundances of similar age groups. Adding to the overall decline in abundance is production of age 0 (1987 cohort) nymphs. These nymphs are progeny of the 1985 cohort whose abundance was also affected by the 1986 treatment, but to a much lesser degree than the 1984 cohort. Although the treatment in 1986 negatively impacted the abundance of nymphs in 1987, natural factors probably added to the decline. Abundance of nymphs in the control area also declined (56%) from September 1986 to October 1987. Leading this decline was low production of age 0 nymphs from the 1985 cohort which suggests a failure of the year class, perhaps a result of overwinter mortality, or a succession of dry summers.

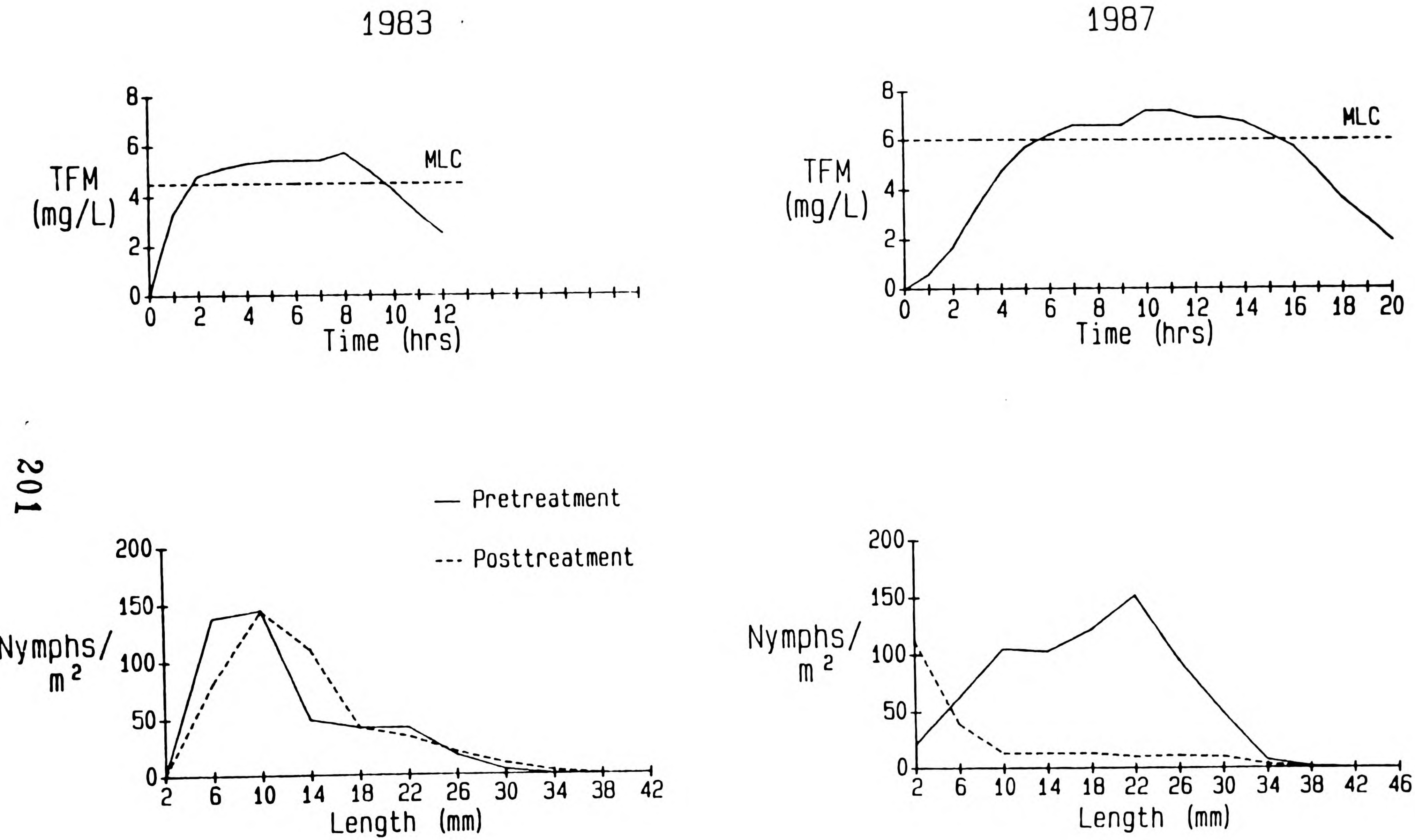

Figure 7. Concentrations of TFM during lampricide applications (July 24, 1983; August 20, 1987), and the number of Hexagenia collected with an Eckman dredge before treatments (July 21, 1983; August 20, 1987) and after treatments (August 6, 1983; August 24, 1987) of the Pere Marquette River.

Table 21. Total number of organisms sampled in drift during 15-minute periods every 2 hours the day before chemical treatment (control) and at corresponding periods on the day of application of lampricide (treatment) to three U.S. streams in 1986.

[Brule River totals are the average of two nets.]

	Lake Superior		Lake Michigan			
	Brule River		Whitefish River		Manistee River[a]	
Taxon	Control	Treatment	Control	Treatment	Control	Treatment
Collembola	5.0	1.5	4	5		
Ephemeroptera						
Baetidae	121.5	176.0	112	112	89	180
Oligoneuriidae			3	6	0	1
Heptageniidae	4.5	10.0	9	9	9	10
Ephemerellidae	24.0	26.0	4	6	10	11
Caenidae			1	41		
Tricorythidae		1.0			4	7
Leptophlebiidae	1.5	1.0	4	10	1	0
Ephemeridae			1	2	0	34
Unknown					4	6
Odonata						
Cordulegastridae			1	0		
Gomphidae	0.5	0.5				
Calopterygidae					1	3
Zygoptera sp.			0	2	1	6
Plecoptera						
Pteronarcyidae		0.5				
Perlidae	3.5	0.5	2	1	0	3
Perlodidae	2.5	5.0	0	2		
Unknown	1.5	0.5	0	14		
Hempitera						
Corixidae					0	32
Megaloptera						
Corydalidae			1	0		
Trichoptera						
Philopotamidae			3	81	0	3
Psychomiidae	0.0	12.5	0	7	2	3
Polycentropodidae	3.0	2.0			2	25
Hydropsychidae	155.0	172.5	23	31	51	137
Rhyacophilidae					0	1
Glossosomatidae	48.5	65.5	2	4	0	3
Hydroptilidae	25.0	83.0	8	1,071	2	2
Phryganeidae		0.5			1	1
Brachycentridae	44.5	97.5	0	3	0	3
Lepidostomatidae	24.0	28.5	0	2		
Limnephilidae	3.0	4.5				
Odontoceridae			0	1		
Helicopsychidae	0.5	2.5	0	1	0	1
Leptoceridae	3.0	5.5	12	3	91	125
Unknown	1.0	0.0			2	4
Lepidoptera	0.5	0.5			0	1
Coleoptera						
Elmidae	37.5	44.0	9	8	10	23

(continued)

Table 21. Continued

Taxon	Lake Superior		Lake Michigan			
	Brule River		Whitefish River		Manistee River[a]	
	Control	Treatment	Control	Treatment	Control	Treatment
Diptera						
Tipulidae	35.5	35.0	17	101	3	6
Ceratopogonidae		0.5				
Simuliidae	162.5	647.5	17	43	76	1,052
Chironomidae	282.5	315.0	146	89	279	749
Athericidae	22.0	31.5	0	4	0	2
Empididae	11.0	6.5	2	0	9	9
Adult	25.5	25.0	97	146	4	13
Pupae	23.5	39.5	73	55	52	87
Miscellaneous						
Turbellaria			0	11		
Annelida	10.0	309.5	7	1,185	39	3,675
Cladocera			0	9	0	3
Copepoda			0	34	0	3
Ostracoda			0	3	0	1
Isopoda	0.0	0.5			2	23
Amphipoda	5.5	7.0			61	174
Gastropoda	4.5	293.0	0	6	4	240
Pelecypoda	2.5	3.0	1	1	0	1
Hydracarina	256.5	311.0	10	12	65	84
Terrestrial	33.5	34.5	22	179	0	17
Total	1,385.0	2,800.5	591	3,330	874	6,764

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

Riffle Community index--Index areas of invertebrate communities were established in treated and control sections of the Whitefish (Lake Michigan) and Sturgeon (a tributary of the Cheboygan River, Lake Huron) rivers in 1985. Initial samples were collected in the fall of 1985 at control and treated areas upstream and downstream of the lamprey barrier in the Whitefish River. Because of problems associated with comparability of control and treated areas in the Sturgeon River (little diversity in numbers of species and inadequate samples of the species present at the control area), a control area was selected in an untreated portion upstream of dams in the Boardman River (Lake Michigan) in spring 1986. Samples since have been collected in the spring and fall at all areas using the standard travelling kick method. The investigator holds a standard D-frame, invertebrate kick net (30.5 cm x 15.2 cm, 12 inches x 6 inches) in his forward path, then moves downstream for 30 second along 4 m (13.1 ft) of stream bottom. In addition, collections were taken from each index area before and immediately after treatment of the Whitefish River in 1986. Samples from the Whitefish River had been sorted and identified through 1985 and those from the Sturgeon and Boardman rivers through 1986. These long-term studies in invertebrate community structure require the establishment of several years of data to draw conclusions that relate to stream treatments. Thus far, the results show little difference in changes in invertebrate populations between control and treatment areas (Table 22).

The construction of the lamprey barrier on the Brule River provided the opportunity to design a study on invertebrate communities that included index sites upstream and downstream of the barrier in a regularly treated stream to follow both community structures as the upstream site is phased out of lampricide applications. The barrier was completed in 1985 and initial samples were collected that fall (the sampling schedule includes spring and fall collections through a minimum of two treatment cycles). In addition, collections were taken from each site before and immediately after lampricide treatment in 1986. (The treatment included both areas in the river, but future treatments should include only the area downstream of the barrier.) Samples have been sorted and identified through the 1986 collections.

The lampricide application in 1986 did not reduce the total number of organisms in the Brule River (Table 23). All orders of invertebrates increased in posttreatment samples at both index sites except Trichoptera which declined below the barrier. Some individual organisms declined at both sites and included Helicopsyche, Hexatoma, and Similium. All groups of organisms except Trichoptera increased from the fall of 1985 to the fall of 1986 at both sites. Total numbers increased 147% at the downstream site and 64% above the barrier. Benthic invertebrate abundance was low in 1985 probably because of a flood in early September. These results suggest the recovery of the invertebrate community from the flood had not been hampered by the lampricide treatment.

Table 22. Mean number of organisms from five samples taken by kick nets in riffle communities in the Whitefish River in 1985 and in the Sturgeon River in 1986 in areas that are periodically treated and in areas that are not treated (control).[a]

[Whitefish River on Lake Michigan was treated in October 1983 and August 1986. The Sturgeon River, a tributary of the Cheboygan River on Lake Huron, was last treated in September 1985; the control area is in the Boardman River on Lake Michigan.]

	Whitefish River		Sturgeon River			
	1985		1986			
	Treated area	Control area	Treated area		Control area (Boardman River)	
Taxa	Fall	Fall	Spring	Fall	Spring	Fall
Ephemeroptera						
Baetidae						
Baetis			121.4	1.0	51.6	1.6
Pseudocloeon	6.4	6.0				1.0
Oligoneuriidae						
Isonychia	7.4	8.0				
Heptageniidae						
Epeorus	88.4	45.8	0.2		0.4	
Leurocuta	14.2	26.4				
Rhithrogena			106.8	94.0	19.6	11.2
Stenacron		0.4				
Stenonema	58.4	37.4	0.2	7.8		0.4

(continued)

Table 22. Continued

	Whitefish River		Sturgeon River			
	1985		1986			
	Treated area	Control area	Treated area		Control area (Boardman River)	
Taxa	Fall	Fall	Spring	Fall	Spring	Fall
Ephemeroptera (continued)						
Ephemerellidae						
Drunella			179.4		80.6	
Ephemerella	710.0	384.2	54.4	89.4	443.8	74.0
Eurylophella	0.2	1.4				
Serratella	116.4	85.6	2.5	4.4		1.0
Caenidae						
Caenis	6.4	5.4				
Leptophlebiidae						
Paraleptophlebia	90.8	56.4	0.6	2.8	5.0	7.0
Ephemeridae						
Ephemera	0.4					
Odonata						
Gomphidae						
Ophiogomphus	2.2	6.8			1.6	1.0
Stylogomphus	0.2	1.6				
Aeshnidae						
Boyeria	0.4	0.2				
Calopterygidae						
Calopteryx	0.2					
Plecoptera						
Pteronarcyidae						
Pteronarcys			0.6	2.4	1.0	0.6
Taeniopterygidae						
Taeniopteryx	6.0	8.0		0.4		8.4
Strophopteryx	19.2	10.0				0.2
Nemouridae						
Amphinemura					1.2	
Ostrocerca	0.6	2.8				
Shipsa		0.6		0.2		
Capniidae						
Paracapnia		2.0				
Perlidae						
Acroneuria	12.2	20.0	0.4	0.4	0.2	
Paragnetina	2.2	2.4	0.8	1.8	0.2	0.2
Perlinella		0.6				
Phasganophora	5.8	5.2				0.2
Perlodidae						
Cultus			1.2			
Isogenoides			0.2	35.6	0.2	6.0
Isoperla	12.6	10.2	0.8	5.0	1.6	5.6
Unknown				3.0	0.8	4.4

(continued)

Table 22. Continued

Taxa	Whitefish River 1985 Treated area Fall	Whitefish River 1985 Control area Fall	Sturgeon River 1986 Treated area Spring	Sturgeon River 1986 Treated area Fall	Sturgeon River 1986 Control area (Boardman River) Spring	Sturgeon River 1986 Control area (Boardman River) Fall
Megaloptera						
Corydalidae						
Nigronia	2.6	1.0			0.2	
Trichoptera						
Philopotamidae						
Chimarra	3.4	1.0				
Dolophilodes	3.4	1.6		4.2	0.2	0.8
Psychomyiidae						
Psychomyia				0.2		
Hydropsychidae						0.6
Ceratopsyche	120.6	87.0	2.8	7.2	6.0	52.8
Cheumatopsyche	29.2	11.0				
Hydropsyche		0.6			0.4	
Rhyacophilidae						
Rhyacophila	5.6	2.4	2.6	2.2	1.8	1.8
Glossosomatidae			13.4	0.2	6.8	
Glossosoma	45.8	14.8	20.0	2.2	37.4	31.2
Protoptila			11.2	23.0	147.8	47.6
Hydroptilidae						
Hydroptila	5.2	4.4	0.2		3.6	1.2
Leucotrichia	5.0	1.2		0.2		
Brachycentridae					0.6	
Brachycentrus	9.2	6.2	0.6	16.8	19.4	13.4
Micrasema			3.2	16.8	51.6	13.6
Lepidostomatidae						
Lepidostoma	13.4	34.4	5.2	7.4	6.6	8.8
Limnephilidae	1.2					
Neophylax		0.2	1.8		2.4	
Odontoceridae						
Psilotreta	3.0	5.8				
Helicopsychidae						
Helicopsyche	2.4	2.8	8.8	40.4		
Leptoceridae						
Ceraclea	2.6	5.2				
Mystacides		0.2				
Oecetis	0.8				0.4	
Setodes	0.2	0.6				
Pupae	5.5	2.2			0.4	0.2
Unknown				0.4		
Coleoptera						
Dytiscidae						
Hydaticus		0.2				

(continued)

Table 22. Continued

Taxa	Whitefish River 1985 Treated area Fall	Whitefish River 1985 Control area Fall	Sturgeon River 1986 Treated area Spring	Sturgeon River 1986 Treated area Fall	Sturgeon River 1986 Control area (Boardman River) Spring	Sturgeon River 1986 Control area (Boardman River) Fall
Coleoptera (continued)						
Psephenidae						
Ectopria		0.4				
Psephenus	2.4	4.2				
Elmidae						
Dubiraphia (larvae)		0.2				
Macronychus (larvae)		0.2				
Optioservus (larvae)	94.8	106.0	83.8	356.0	55.6	63.6
Optioservus (adult)	47.4	28.6	43.2	181.0	28.8	20.2
Stenelmis (larvae)	2.8	0.4				
Stenelmis (adult)	4.0	8.0				
Curculionidae						
Stenopelmus		0.2				
Diptera						
Tipulidae						
Tipula				0.2	0.4	
Antocha	37.0	22.8	3.2	6.8	0.8	0.8
Dicranota	0.2	2.4			0.2	
Hexatoma	4.0	3.4				
Limonia					0.2	
Ceratopogonidae						
Bezzia	0.6	0.6				
Simuliidae						
Ectemnia						0.2
Prosimulium	0.2	2.6	0.8	1.6	4.2	0.4
Simulium	2.6	0.6	0.2	8.7	24.4	5.4
Chironomidae	119.2	210.2	6.0	49.6	68.4	382.0
Athericidae						
Atherix	52.2	20.8	7.2	20.2	52.4	29.0
Empididae						
Chelifera			1.2	0.6	14.4	14.0
Hemerodromia	4.2	8.6	2.4	1.8	7.0	2.4
Pupae	0.4		0.8	0.6	1.2	1.0
Adult		0.4		0.2		0.2
Miscellaneous						
Turbellaria	0.2					
Planaria	16.4	3.4				
Nematoda	0.6	1.0				
Annelida						
Oligochaeta	17.2	3.6	40.4	129.6	67.8	65.0
Branchiobdellidae	13.4	45.6				
Hirudinea				0.4		0.2

(continued)

Table 22. Continued

Taxa	Whitefish River 1985 Treated area Fall	Whitefish River 1985 Control area Fall	Sturgeon River 1986 Treated area Spring	Sturgeon River 1986 Treated area Fall	Control area (Boardman River) Spring	Control area (Boardman River) Fall
Miscellaneous (continued)						
Isopoda						
Asellus		0.2	0.4	6.0	0.2	
Amphipoda						
Gammarus		0.2		0.6	3.8	5.6
Decapoda						
Astacidae	0.6	2.4				
Hydracarina	3.0	2.0	2.0	6.6	17.2	17.8
Gastropoda						
Physidae						
Physa	2.8	1.2		3.4	3.2	3.0
Gyraulus						0.2
Hydrobildae						
Amnicola				0.2	0.2	0.4
Ancylidae						
Ferrisia				1.8	0.2	
Pelecypoda						
Sphaeriidae						
Sphaerium	1.0	2.6	0.6	1.2	3.0	1.4
Terrestrial	1.0	0.2		0.8		0.2
Total	1,847.9	1,393.2	731.5	1,147.3	1,247.0	907.8

[a]Samples from the Whitefish River in 1986-87 and the Sturgeon and Boardman rivers in 1987 will be given, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

Table 23. Mean number of organisms from five samples taken in kick nets at sites downstream and upstream of the lamprey barrier in the Brule River, 1985-86.

[Samples were taken in fall 1985, spring and fall of 1986, and before and after application of lampricides in August 1986.]

	Downstream site					Upstream site				
	1985	1986				1985	1986			
Taxa	Fall	Spring	Before	After	Fall	Fall	Spring	Before	After	Fall
Ephemeroptera										
Baetidae				0.4						
Baetis	0.4	42.2	17.2	40.0	2.8	1.8	22.0	52.5	38.8	1.2
Pseudocloeon	4.2		7.8	32.2	2.2	9.2		10.4	37.6	3.4
Oligoneuriidae										
Isonychia									0.6	
Heptageniidae										
Leurocuta				0.2			0.2		0.2	
Nixe										0.2
Rhithrogena	6.0	17.4	3.2	7.0	29.4	6.4	11.0	3.8	4.6	8.2
Stenonema	1.2	0.8	0.2	1.0	1.0	0.6	0.4	0.6	1.2	2.0
Ephemerellidae				0.6						
Ephemerella	70.2	118.2	0.4	0.6	280.0	88.0	86.4	0.2	0.8	433.8
Serratella		1.8	0.2	1.8	2.8	0.6	6.2	0.2	0.6	14.6
Leptophlebiidae										
Paraleptophlebia	0.2				0.8		0.2			0.8
Odonata										
Gomphidae										
Ophiogomphus	0.2	2.0		0.4	0.2	0.4	1.0	0.2	0.4	0.8
Aeshnidae										
Boyeria					0.2					
Plecoptera										
Pteronarcyidae										
Pteronarcys	0.2	0.2			0.4	0.6	0.6	0.6		1.8
Taeniopterygidae										
Taeniopteryx	1.6				10.4	0.8				11.6
Strophopteryx	2.4				15.2	2.8				8.0
Nemouridae										
Nemoura	0.2	0.2			0.2					
Capniidae					0.2					1.8
Paracapnia					1.0					2.2
Perlidae										
Paragnetina					0.8				0.2	
Acroneuria	3.6	2.8	7.8	11.0	7.6	4.2	5.8	4.6	7.0	7.2
Perlodidae										
Isogenoides				0.2					0.2	
Isoperla	0.8	1.0			7.0	2.0	0.2	0.6		14.4
Unknown				0.2						1.8
Hemiptera							0.2			
Megaloptera										
Corydalidae										
Nigronia					0.2					

(continued)

Table 23. Continued

Taxa	Downstream site 1985 Fall	Downstream site 1986 Spring	Downstream site 1986 Before	Downstream site 1986 After	Downstream site 1986 Fall	Upstream site 1985 Fall	Upstream site 1986 Spring	Upstream site 1986 Before	Upstream site 1986 After	Upstream site 1986 Fall
Trichoptera										
Psychomyiidae										
Psychomyia		1.2		0.8	0.4			0.2	0.2	
Polycentropodidae										
Polycentropus		0.2								
Hydropsychidae										
Ceratopsyche	2.6	2.6	4.8	6.8	5.0	3.4	12.6	4.8	6.8	6.2
Cheumatopsyche			0.4	0.2	0.6	4.8	10.2	0.2	0.6	1.6
Rhyacophilidae										
Rhyacophila	0.4					0.2				
Glossosomatidae										
Glossosoma	5.0	0.6		0.2	12.4	7.8		0.4		1.6
Protoptila	185.2	43.0	281.6	289.8	85.4	57.6	61.6	114.6	102.4	23.8
Hydroptilidae										
Hydroptila	0.2	0.4			0.6	1.4	1.8		0.4	1.4
Brachycentridae										
Brachycentrus	0.8	0.8	1.0	1.8	1.8	2.2	1.8	0.4	1.0	7.0
Micrasema	0.2				0.4	2.0	13.4		0.6	4.0
Lepidostomatidae										
Lepidostoma	0.2	0.2	0.4	0.2	0.6	3.4	3.8	0.6	1.2	7.8
Helicopsychidae										
Helicopsyche	5.0	0.4	3.8	3.2	0.4	15.4	4.8	3.2	1.4	0.8
Leptoceridae										
Ceraclea				0.2				0.2	0.2	
Mystacides	0.2									
Setodes	0.8	0.2	0.2	0.2	0.2	0.4	2.6			0.2
Unknown				0.2						
Lepidoptera										
Pyralidae	0.2					0.2				0.2
Coleoptera										
Dytiscidae										0.2
Elmidae										
Optioservus (larvae)	20.8	4.0	10.2	18.0	26.8	26.2	7.6	5.8	9.0	23.6
Optioservus (adult)	0.2	15.6	1.8	2.8	0.6	1.2	6.0	1.2	1.0	1.8
Stenelmis (larvae)	0.2			0.4			0.2			
Stenelmis (adult)	0.2									
Diptera										
Blephariceridae										
Philorus		0.2					2.0			
Tipulidae										
Antocha	0.4	1.0	0.6	0.8	1.0	3.6	5.6	1.4	1.8	8.0
Dicranota										0.2
Hexatoma	0.4		2.4	2.2	1.8	6.4	1.6	4.4	3.2	8.8
Limonia				0.2						
Ceratopogonidae	0.2	0.2	0.2	0.6	0.8	0.2				1.6

(continued)

Table 23. Continued

	Downstream site					Upstream site				
	1985	1986				1985	1986			
Taxa	Fall	Spring	Before	After	Fall	Fall	Spring	Before	After	Fall
Diptera (continued)										
Simuliidae										
<u>Ectemnia</u>										0.4
<u>Prosimulium</u>				0.4	0.2			0.8	0.8	4.2
<u>Simulium</u>			1.2	0.6	0.6	0.8	7.4	0.8		5.0
Chironomidae	1.4	26.6	5.6	15.8	17.0	19.6	112.4	2.8	10.4	54.8
Athericidae										
<u>Atherix</u>	9.6	7.6	16.2	19.6	15.0	8.2	7.8	11.0	13.8	24.0
Empididae										
<u>Hemerodromia</u>		0.4					1.4	0.2		0.4
Pupae	0.2	4.8		0.6	1.0	0.4	20.0	0.8		0.6
Adult	0.4	0.6		0.6			0.6			
Miscellaneous										
Annelida										
Oligochaeta	0.6	5.2	0.4	2.6	2.0	0.4	6.4	0.6	0.4	2.8
Amphipoda										
<u>Gammarus</u>		0.2		0.4	0.6	0.2			0.2	
Hydracarina		0.8		0.8	0.2	1.0	9.2			4.6
Gastropoda										
<u>Amnicola</u>			0.2							
<u>Physa</u>	0.2		0.4	0.2	0.2					
<u>Ferrisia</u>	0.4			0.2		0.2				0.4
Pelecypoda										
<u>Sphaerium</u>	0.6		0.2	0.6	0.6	0.4	0.2	0.2	0.2	0.2
Terrestrial			0.2			0.6	0.4	0.2		
Total	327.8	303.4	368.6	466.6	538.6	285.6	435.6	228.5	247.8	710.0