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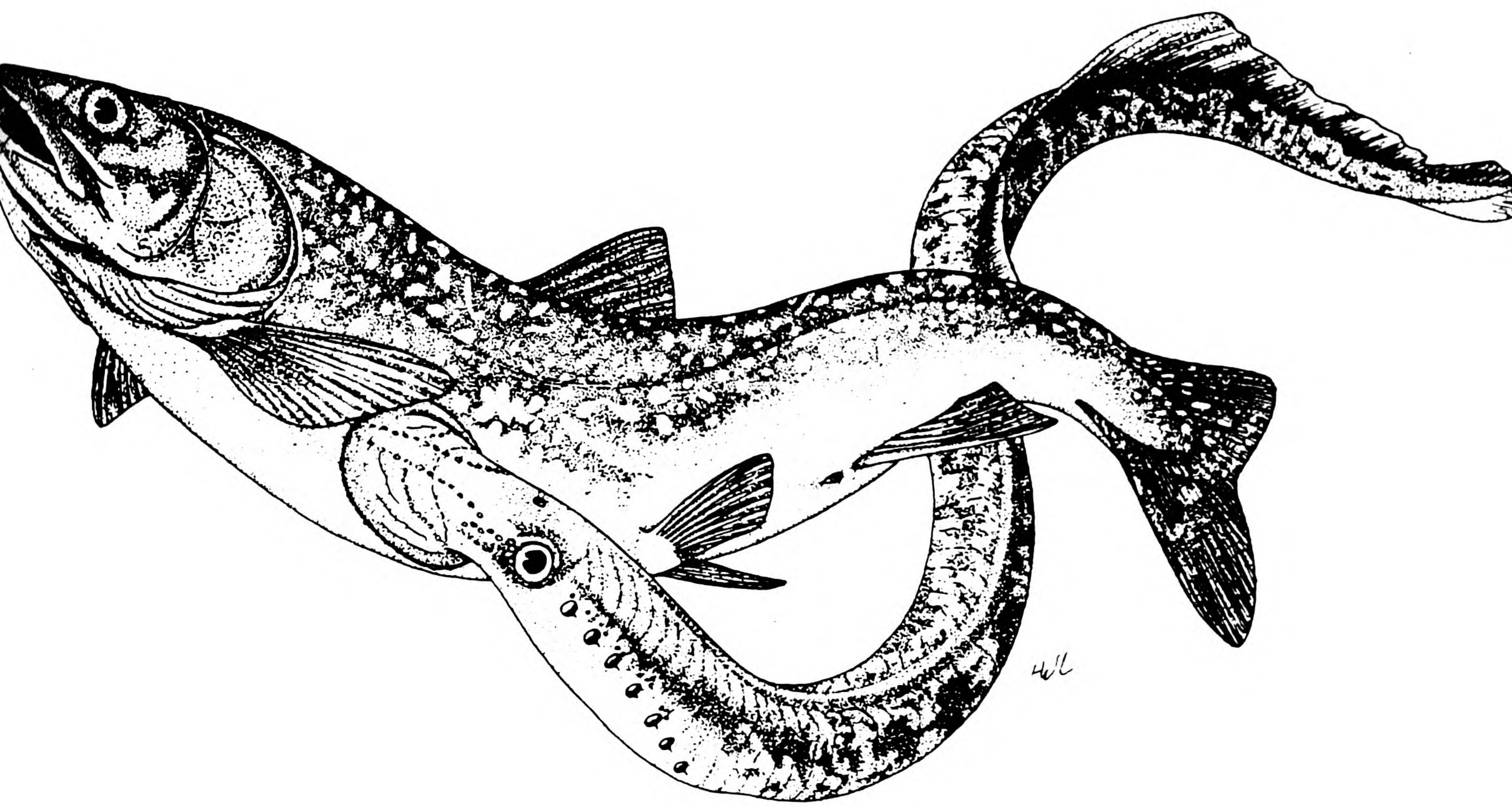
APPENDIX VII

SEA LAMPREY MANAGEMENT IN THE GREAT LAKES IN 1990

ANNUAL REPORT

TO

GREAT LAKES FISHERY COMMISSION



by

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This is a joint report that summarizes sea lamprey management and control efforts conducted by the United States Fish and Wildlife Service and the Department of Fisheries and Oceans Canada. ---- management activities include: larval assessment, la treatment, spawning-phase assessment, parasitic-phase ass construction of low-head barrier dams, and assessment of the of lampricides on nontarget organisms. Larval assessment sur completed on 395 Great Lakes tributaries, 4 inland lakes, areas of 25 streams, and deltas of 5 streams. Lampricide t were completed on 64 tributaries to the Great Lakes (Table U.S. waters, three lampricide treatments on rivers were because of low number of lamprey larvae and to accommodate cooperative studies with Hammond Bay Biological Station. In Canadian waters, three treatments were postponed on tributaries to Lake Huron (all due to unsatisfactory water discharge). Assessment traps placed in 50 tributaries to the Great Lakes captured 58,830 spawning-phase sea lampreys (Table 2). A total of 6,048 parasitic-phase sea lampreys were collected from commercial and sport fishermen in Lakes Superior, Michigan, Huron, and Erie. Tests of the short-term effects of lampricides on nontarget organisms were conducted in treated and control sections of two streams in two lake basins. Long-term monitoring of the effects of lampricides to the mayfly Hexagenia *and other organisms continued in two streams.*

LAKE SUPERIOR

Larval Assessment

United States

Surveys monitored reestablished and residual populations of larval sea lampreys, prepared for lampricide treatments, and searched for new infestations of larvae in 113 Lake Superior tributaries. Sea lampreys had reestablished in at least 30 streams.

Surveys to assess recruitment of the 1990 year class were conducted in 65 streams and young-of-the-year larvae were recovered in 18. Surveys to assess recruitment of the 1990 year class larvae in 13 additional streams were postponed until 1991 due to inclement weather and high stream flows. Young-of-the-year larvae have not been detected for 5 or more years in 19 streams that have been examined annually.

Surveys to schedule (pretreatment) lampricide applications were conducted in 21 streams. Pretreatment surveys were conducted in 9 streams for treatment in 1990 (all later were successfully treated) and 12 for future treatment. Assessment of past treatments (posttreatment surveys) were completed in three streams.

Residual lampreys were found in 13 streams, but comprised less than 5% of the total number of larvae collected in all streams except in the Bad River (about 14%). The large number of residual lampreys in the Bad River indicates a need for retreatment in 1991.

Surveys were conducted in Washington Creek, Siskiwit Lake Outlet, and the Big and Little Siskiwit rivers on Isle Royale, and no larvae were found. Sea lampreys have been absent from Washington Creek since the last treatment in 1980 and never have been found in the other streams.

Table 1. Summary of chemical treatments in streams of the Great Lakes in 1990. [Lampricides used are in kilograms/pounds of active ingredient.]

Lake	Number of Streams	Discharge		TFM[a]		Bayer 73		Distance	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles
Superior	27	149.5	5,281	14,659	32,317	101.1	230.7	659.4	410
Michigan	10	99.7	3,522	20,374	44,916	84.0	185.0	456.5	284
Huron	13	35.4	1,252	3,967	8,746	0.8	1.7	241.6	151
Erie	4	28.4	1,000	6,164	13,590	0	0	162.6	101
Ontario	10	10.5	372	2,698	5,948	0.3	0.6	120.7	74
Total	64	323.5	11,427	47,862	105,517	186.2	418.0	1,640.8	1,020

[a]Includes 883 TFM bars (184.5 kg., 406.6 lbs.) applied in 30 streams.

Table 2. Number and biological characteristics of adult sea lampreys captured in assessment traps in 50 tributaries of the Great Lakes in 1990.

Lake	Number of Streams	Total captured	Number sampled	Percent males	Mean Length (mm)		Mean Weight (g)	
					Males	Females	Males	Females
Superior	20	2,807	717	43	428	427	230	221
Michigan	12	16,926	1,899	45	482	482	252	262
Huron	6	36,837	2,572	52	477	480	234	246
Erie	3	279	277	62	493	489	266	266
Lake Ontario	9	1,981	344	57	484	474	267	265
Total	50	58,830	5,809	48	470	469	233	240

Many small streams of Lake Superior are not routinely surveyed because previous surveys found no sea lampreys. Some have not been examined since initial surveys at the start of the control program. Natural or manmade changes in stream character could make the stream more favorable to sea lampreys. A plan to survey all such tributaries began in 1989 and continued in 1990. No new populations were found in 37 streams examined along the Minnesota shore.

The populations of larval sea lampreys were estimated in six Lake Superior tributaries through habitat-based techniques in 1990. These studies determined the amounts of habitat for larvae (3 types) and the number of larvae and transformers inhabiting each river, and compared the feasibility and effectiveness of 2 habitat-based methods (random transects and representative reach). The tributaries included: Tahquamenon, Betsy, Sucker, Traverse, and Firesteel rivers, and Galloway Creek. Densities of larval lamprey were determined with electrofishing gear or bottom filtration equipment. Length frequency data provided a basis to estimate the number of lamprey in each age class, the number that have reached minimum length for transformation (120 mm), and the number of transformed lampreys that would be expected to migrate into Lake Superior. The Tahquamenon, Betsy, Sucker, and Traverse rivers later were treated in 1990, and the Firesteel River and Galloway Creek respectively are scheduled for treatment in 1991 and 1992. A mark and recapture estimate was used in the Traverse River to verify the habitat-based techniques. The procedures for each technique are described in turn.

The random transects method was used in the Betsy, Sucker, Traverse, and Firesteel rivers and Galloway Creek. Amount of habitat in the streams was estimated by random selection of a 5-foot (1.5 m) wide transect across the river at either 250-foot (76.2 m) intervals throughout the stream length (Galloway Creek), or by concentration of the transects within 1,000 feet (304.8 m) of access sites when access to the streams was limited (Betsy, Sucker, Traverse, and Firesteel rivers). The amount and type of substrate (sand, silt, gravel, clay, etc.) along the transect were recorded. From these measurements, the substrates were divided into three broad categories based on potential for habitation by lamprey larvae: type I habitat was considered optimal, type II was acceptable though not preferred, and type III was uninhabitable. Lamprey densities at each transect were determined by a depletion method of sampling.

Areas of types I and II habitat in each transect were sampled one or more times with electrofishing gear. The diminishing number of lampreys captured in each sample site in successive passes with the gear was used to estimate lamprey density. All lampreys captured in each depletion were identified, counted, measured for total length, and removed from the stream. The total area of the stream, the percent of each habitat type, and the mean lamprey density in each habitat type were used to calculate the total number of larvae and larvae $\geq$120 mm (the size when transformation may occur) in each river. The number of transformers were calculated as the percentage of those lampreys $\geq$120 mm that would be expected to transform in each stream (based on past collections of larvae during lampricide treatments for each river).

The representative reach technique was used in the Betsy and a segment of the Traverse river. The method divides the river into smaller sections (known as macrohabitat sections) based on characteristics such as sinuosity, gradient, and substrate size. A representative portion (reach) of each macrohabitat section is selected and sampled for habitat type and lamprey density. Quantification of habitats, lamprey densities, and measurements were the same as the random transect method. The number of lampreys in each river were obtained by adding the estimates for each macrohabitat section.

A mark-recapture technique was used in the Traverse River to verify the habitat-based estimates. Larval lampreys were captured throughout the river with electrofishing gear, marked with a dye, and released into the stream prior to lampricide treatment. Recapture of larvae occurred during treatment and the Petersen formula was used to estimate the population.

The number of lampreys inhabiting deep water areas (>3 feet in depth) was determined by use of a method that combined bottom filtration and a stratified random design of sampling. The deep water areas included: the offshore area of the Sucker river; the estuary areas of the Betsy, Sucker, Traverse, and Firesteel rivers; and the middle portion of the Tahquamenon River. SCUBA divers place a 1 m^2 template in each type of habitat on the stream bottom at predetermined random locations. The divers removed the bottom sediments within the template to a depth of 200 mm using a hose attached to a suction pump mounted on a boat. Larval lampreys are filtered onto the screen and the fine sediments returned to the water. The sampling yielded a mean density of lamprey per m^2 and was expanded by the total area of the deep water inhabited by lampreys.

The estimated number of lampreys ranged from 2,428 in Galloway Creek to 758,884 in the Sucker River (Table 3). The number of larvae estimated by the random transects method was lower than the representative reach method where the two techniques were used (Betsy River, 41,518 vs. 74,602 larvae respectively; Traverse River, 34,494 vs. 54,355 in the macrohabitat section where the techniques were compared). Fewer larvae were estimated by mark and recapture in the Traverse River than the random transects technique (89,766 vs. 177,155), but this difference likely is due to a factor that caused unequal probability of recapture of marked and unmarked larvae. The estimated number of lampreys in the deepwater areas ranged from 375 (Betsy River) to 14,829 (Firesteel River). More transformers were estimated in the Betsy River than in the other streams.

A deepwater sampling unit for larvae that combines an electroshocker and suction pump was tested in areas of the Traverse and St. Marys (Lake Huron) rivers and in Batchawana (Canadian waters) and Furnace bays. The unit consists of a section that is lowered from a boat to the river or lake substrate, a flexible hose, suction pump, Abp electroshocker, and a filtration screen. The lower section has a base that is rectangular (covers 0.6 m^2 of substrate; has PVC sheet stock for sides and electrodes of stainless steel that are oriented parallel to the interface of the water and the substrate), tapers upward 3 feet in the shape of a pyramid (PVC sheet stock sides) to the connection with 20 feet of 3-inch diameter flexible hose, and connects to an 8 hp gold-dredge pump and inducer. The section with electrodes is lowered from an anchored boat and, once the section is on the bottom, the operator activates the electricity and the suction pump. The larvae within the enclosed sampling area are irritated from the bottom, caught in the upward flow of water through the pump, and deposited on the filtration screen aboard the boat. The unit is activated for 1 minute, followed by a 5-minute rest period and then the sequence is repeated until no larvae are brought to the screen. Following sampling with the unit, a dredge was used to sample the same site to determine efficiency (the dredge is 100% effective). The unit also was tested at a variety of combinations of voltage gradients (0.4 and 0.8 v/cm) and duty cycles (10% and 25%).

The deep-water shocker was highly efficient in the capture of larval sea lampreys. At the 95% level of confidence, efficiency for 1 or 3 activations of the unit respectively was 87% (78 - 97%) and 95% (87 - 100%). The unit was most efficient with 0.8 v/cm and a 10% duty cycle. The development of this tool represents a significant advancement in the ability of the program to assess contribution of larvae in deep water areas to the parasitic stocks of lampreys in the Great Lakes.

Larval Assessment

Canada

Surveys were conducted on 80 Lake Superior tributaries, 2 instream lakes, and off-shore areas of 18 streams, in 1990.

Surveys of three streams scheduled for treatment in 1990 and five recommended for treatment in 1991 did not reveal any significant change in the distribution of larval sea lamprey from past treatments. Extensive surveys of Polly Creek found only one larva and consequently the stream was removed from the original list of streams proposed for treatment in 1991. Treatment evaluation surveys on the 7 streams treated in 1989 found a small number of residual sea lamprey larvae in the Pigeon River. Evaluation surveys on five of the 12 streams treated in 1990 found low numbers of residual larvae in the Cypress River and the Neebing McIntyre Floodway, and none in the Gravel, Wolf and Goulais Rivers.

Re-establishment surveys done on streams treated in 1988 and 1989 indicate that most have re-established sea lamprey populations. One notable exception is the White River, which was last treated in September 1988. Surveys conducted to study the larval population of two known, but marginally producing streams, found low numbers of larvae, including a transformer, in the Agawa River, and no larvae in the Jackpine River.

Table 3. The estimated amount of habitat (ft^2) for sea lamprey larvae, density (larvae/ft^2), total number of year classes in the population, total larvae and transformers in the population, number ≥120 mm, and number of transformers for six tributaries of Lake Superior, 1990. (The 95% confidence intervals for total numbers, number ≥120 mm, and transformers are listed in parenthesis below each respective estimated value.) The methods of estimation include techniques listed as random transects, deepwater representative reach, offshore, and mark and recapture, and each is described in the footnotes.

River	Method of Estimation	Area of Habitat Types[1] I	II	III	Density of Larvae[2] I	II	Year[3] Classes	Total Larvae[4] and transformers	Number[5] ≥120 mm	Number of[6] transformers
Galloway	Random Transects[7]	56,756	41,268	1,899	0.037	0.001	5	2,428 (62-5,139)	187 (6-453)	-
Tahquamenon	Deepwater[8]	267,427	270,785	176,598	0.034	0.002	3	9,479 (4,305-15,186)	0	-
Betsy	Random transects	289,011	1,237,089	3,058	0.107	0.009	3	41,518 (11,701-71,336)	3,635 (129-8,467)	409 (15-953)
	Representative Reach[9]	636,341	1,046,787	0	0.071	0.028	3	74,602 (24,556-125,003)	6,765 (25-13,722)	761 (3-1,544)
	Deepwater	68,741	185,844	0	0.006	0.000	3	375 (1-1,196)	0	-
Sucker	Offshore[7]	161,464	0	0	0.023	-	2	3,750 (643-6,856)	0	-
	Random Transects	1,281,439	2,691,450	312,860	0.490	0.049	2	758,884 (432,988-1,084,781)	4,070 (11-11,020)	260 (1-705)
	Deepwater	42,239	165,274	0	0.056	0.002	2	2,758	0	-
Traverse	Random Transects	461,606	380,741	0	0.353	0.032	4	175,395 (68,049-353,058)	20,583 (73-104,312)	298 (15-1,513)
	Deepwater	65,360	250,732	0	0.018	0.002	4	1,760 (308-3,824)	0	-
	Mark and Recapture[10]	-	-	-	-	-	4	89,766 (80,939-98,593)	-	-
								(1,266-4,409)		

Table 3. Continued.

River	Method of Estimation	Area of Habitat Types[1] I	II	III	Density of Larvae[2] I	II	Year[3] Classes	Total Larvae[4] and transformers	Number[5] ≥120 mm	Number of[6] transformers
steel	Random Transects	1,161,720	3,269,584	1,556,945	0.206	0.026	2	323,745	763	234
								(109,664-537,825)	(12-1,999)	(4-612)
	Deepwater	186,221	462,034	0	0.059	0.009	2	14,829	474	145
								(7,440-22,217)	(357-591)	(109-181)

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

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

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

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

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

[6]The number of transformers was estimated as either the number taken in the sampling procedures, or the percentage of those larvae ≥120 mm that were undergoing transformation that were collected during treatments of 1990 or previous years. The percentage is different for each stream and ranges from 1.5% for the Traverse River to 29.7% for the Firesteel River. No data existed to calculate a value for Galloway Creek.

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

[8]The deepwater and offshore method involved the use of a bottom filtration method where SCUBA divers filtered larvae from the bottom sediments and incorporated a random stratified sampling design. The deepwater area of river generally is the section of stream that extends immediately upstream of the mouth for a few hundred feet in small streams to several miles in large rivers.

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

[10]The mark and recapture technique involves the use of a simple Petersen formula where larvae are marked and released before a lampricide treatment and recaptured during the treatment. The estimated number of larvae and transformers (89,766) combines separate mark and recapture techniques in the river and estuary.

Surveys done to check the effectiveness of low head barrier dams on Stokely and Gimlet Creeks indicated that both are functioning well. A single 121 mm larva taken above the Gimlet dam is believed to be a residual from before the dam's 1979 construction! Larval collections made during the 1990 lampricide treatments show that the Wolf River barrier dam, built in 1987, has been effective to date, whereas the effectiveness of the dam on the Carp River, built in 1983, has been rather inconsistent. An analysis of survey and treatment larval collections made since its construction indicates that sea lamprey have spawned above it in all but two years (1985, 1989). Routine surveys of 48 streams, thought to be potential sea lamprey nursery streams but with no earlier record of production, found two with larval populations. A moderately high density, multi-year class population was found in the Gargantua River located on the east shore of Lake Superior in Lake Superior Provincial Park. A natural falls limits the infestation to the lower 1.7 km of stream. The Gargantua River is scheduled for treatment in 1991.

Low numbers of possibly two year classes of sea lamprey were found in Haviland Creek, a small Batchawana Bay tributary. This population will be closely watched for the next few years.

Lentic populations in several locations continue to be probable sources of recruitment to the parasitic stocks of sea lamprey in Lake Superior. Significant numbers of larvae are found in Batchawana Bay, particularly off the Batchawana and Chippewa Rivers; Mountain Bay off the Gravel River; Helen Lake located between the Upper and Lower Nipigon Rivers; Cypress Bay off the Cypress River; Mackenzie Bay off the Mackenzie River, and Thunder Bay off the Current River.

Chemical Treatment

United States

Lampricide treatments were completed on 15 streams (Table 4, Fig. 1) with a combined flow of 31.0 m^3/s (1,095 f^3/s). Toxicity tests were conducted on the Tahquamenon and Nemadji rivers prior to treatment. Lampreys were more abundant in the Sucker, Traverse, and Au Train rivers and Red Cliff Creek than in the other streams. The treatment of Red Cliff Creek included the estuary. The primary difficulty during treatments was low water which slowed and diluted lampricide banks. Although all treatments were successful in eradication of most of the larval sea lampreys, low water contributed to a relatively high incidence of residual lampreys in the Nemadji, Cranberry, Potato, and Traverse rivers. Nontarget mortality was low in all treated streams.

Canada

Lampricide treatments were carried out on all 12 streams listed in the 1990 Memorandum of Agreement (Table 4, Fig. 1). The Pic and Batchawana Rivers had been deferred from 1989.

Treatment personnel experienced no major problems and efforts resulted in effective treatments within each watershed. Collections made during treatments indicate that dams/barriers intended to block sea lamprey spawning runs appear effective on the Wolf River but not so on the Carp River and Neebing branch of the Neebing McIntyre Floodway.

Sea lamprey larval abundance ranking on treated streams ranged from scarce in the Harmony, Chippewa, Gravel and Cypress Rivers to abundant in the Batchawana, Goulais and Wolf Rivers. Larval sea lamprey abundance in the remaining five rivers was subjectively ranked as moderate. With the exception of Cranberry Creek and Harmony River, successful annual sea lamprey reproduction was evident in all watersheds treated. Low larval numbers and sporadic reproduction describes the state in these latter streams. Non-target fish mortality was negligible or very light in the streams treated.

Spawning-phase Assessment

United States

Assessment traps placed in 20 tributaries of Lake Superior captured 2,807 spawning-phase sea lampreys (Table 5, Fig. 1), less than half the number taken in 1989 (6,932). Catches of lampreys increased in the Amnicon, Firesteel, Traverse, Silver, Huron, and Sucker rivers; remained the same in the Otter and Iron rivers; and decreased in the remaining nine tributaries. The largest decrease in catch of number of lampreys occurred in the Brule River (from 3,697 to 780). Traps were placed for the first time in the Nemadji and Ontonagon rivers and Red Cliff Creek. The average length and weight and percentage of males of lampreys sampled from Lake Superior tributaries was similar to that of 1989. Spawning runs were monitored in the Nemadji, Amnicon, Middle, Bad, Ontonagon, Firesteel, Misery, Traverse, Sturgeon (Otter), Silver, and Huron rivers and Red Cliff Creek through a cooperative agreement with the Great Lakes Indian Fish and Wildlife Commission, and in the Brule River through a cooperative agreement with the Wisconsin Department of Natural Resources.

The total number of spawning-phase sea lampreys was estimated in U.S. waters of Lake Superior for the fifth consecutive year (Table 6). The estimate, based on a significant relation of average stream discharge (x) and the estimated number of adult lamprey (from mark-recaptures) that enter tributaries (y), was calculated separately for streams east and west of the Keweenaw Peninsula. In western waters, an estimated 23,604 lampreys were present ($y=9.18x$; $P<0.05$, $r=0.988$), while 7,100 lampreys were estimated ($y=2.37x$; $P<0.01$, $r=0.880$) east of the Keweenaw Peninsula. The total estimate of 30,704 sea lampreys was calculated using a combined flow of 6,331 cfs (3,227 cfs west and 3,104 cfs east) and compares with 55,032 sea lampreys estimated in 1989.

Canada

The three streams trapped provided a count of 503 adults (Table 5, Fig. 1).

Trapping efficiencies, based on the ratio of released to recaptured, and stratified population estimates, were determined to be:

Stokely Creek	23%	23
Carp River	55%	337
Wolf River	67%	367

Numbers on the Wolf River are comparable to past years, whereas the Carp River catch was up significantly from the past two years. The trap on Stokely Creek had not been operated since 1988, when 17 adults were collected.

While the Stokely Creek dam continues to serve as a barrier to spawning sea lamprey, the dams on the other two are questionable. An adult spawner was collected above the Carp River dam in June during the lampricide treatment, as were numbers of young larvae. Similarly, the trap operator on the Wolf River observed an adult immediately above the dam during routine servicing.

Nest Surveys

High summer discharges hindered studies this season. Of 29 positive nests eventually sampled in the Pancake River, two were unsuccessful in reaching the hatching stage, and one was marginally so, with heavy mortality occurring into the early pro-larval stages. There was no apparent survival beyond the gill-cleft stage. Of the 26 nests experiencing acceptable 'hatching success' at Stage 14, all went on to yield final stage prolarvae or early larvae.

By the time the Batchawana River levels receded sufficiently to survey, most of the nests were abandoned. Of 56 nests probed, only six yielded embryos. In four of these, the samples consisted of dead eggs. A measure of hatching success was impossible. However, the remaining two nests were of interest in indicating the relative impact of a TFM treatment of the Batchawana River, conducted on July 24-26, 1990. At the time of lampricide exposure, one of the nests contained numbers of live Stage 12 eggs, while the other yielded sick and dying early prolarvae. By nine days post-treatment, the former nest contained many healthy Stage 16 prolarvae, while the latter yielded one living Stage 17 on Day 7. It is evident that egg stages are resistant to TFM, and that even Stage 15 prolarvae have some ability to survive a treatment.

Parasitic-phase Assessment

United States

A total of 216 parasitic-phase sea lampreys were collected from Lake Superior commercial fishermen in 1990 (Table 7), compared with 295 taken in 1989. The largest number of sea lampreys were collected from fishermen in the Wisconsin management unit of Wi-2 (Apostle Island area), similar to the number taken in 1989 (64 in 1989 vs. 57 in 1990). Fishermen from the management units of Mi-4, 5, and 6 (Keweenaw Peninsula, Marquette and Munising, Michigan areas) captured 76 lampreys in 1990, a decrease from 157 taken in 1989. Most lampreys were collected by fishermen using gill nets (80%), during April-June (44%), and primarily were attached to lake whitefish (50%) and lake trout (47%).

Parasitic-phase sea lampreys are collected throughout the year from commercial fishermen. Therefore, lampreys that would spawn in either the present or succeeding 2 years may be found in the catch. Spawning year was determined for the 216 parasitic-phase sea lampreys captured in 1990 (170 would have spawned in 1990 and 46 in 1991). A total of 268 lampreys of the 1990 spawning year class have been collected (98 in 1989 and 170 in 1990) and represent a decrease when compared to the number of the 1989 spawning year class (334) captured by commercial fishermen.

Sport fishermen captured or reported 156 parasitic-phase sea lampreys in 1990 (Table 8). (Modification in the methods of collecting sea lamprey data does not warrant an annual comparison.) Of the total, 119 were from the charterboat fishery and 37 were from noncharter fishermen. Most lampreys were collected or reported by fishermen during June-August (86%), and primarily were attached to lake trout (98%). The Michigan Department of Natural Resources provided data on the occurrence of parasitic-phase sea lampreys in Michigan charterboat catches.

Table 4. Details on the application of lampricides to streams of Lake Superior, 1990.
[Number in parentheses corresponds to location of stream in Fig. 1. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge		TFM[1]		Bayer 73		Distance	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles
UNITED STATES									
Middle R. (14)	May 18	1.3	45	84	186	0	0	8.0	5
Nemadji R. (15)	May 23	8.8	310	956	2,108	0	0	112.6	70
Potato R. (11)	June 28	0.1	4	67	147	0	0	25.7	16
Red Cliff Cr. (13)	June 28	0.0	1	254	560	0	0	3.2	2
Cranberry R. (12)	June 29	0.1	4	51	113	0	0	17.7	11
Betsy R. (2)	July 13	2.0	70	154	339	0	0	16.1	10
Tahquamenon R. (1)	July 21	7.9	280	1,053	2,322	17	37	16.1	10
Rock R. (6)	July 27	0.5	17	172	380	0	0	11.3	7
Au Train R. (5)	July 30	6.0	213	1,301	2,867	0	0	33.8	21
Sucker R. (3)	Aug. 10	1.5	54	351	774	0	0	53.1	33
Furnace Cr. (4)	Aug. 23	0.3	10	62	136	0	0	4.8	3
Falls R. (9)	Sept. 9	1.3	45	144	317	0	0	1.6	1
Silver R. (8)	Sept. 10	0.7	25	92	202	0	0	4.8	3
Traverse R. (10)	Sept. 21	0.2	7	41	91	0	0	14.5	9
Harlow Cr. (7)	Oct. 31	0.3	10	24	53	0	0	1.6	1
Total		31.0	1,095	4,806	10,595	17	37	324.9	202
CANADA									
Cranberry Cr. (27)	June 5	0.33	12	39	86	-	-	7.6	5
Goulais R. (26)	July 30	17.21	608	1,718	3,788	0.7	1.5	114.0	71
Harmony R. (25)	May 31	0.56	20	22	49	-	-	2.6	2
Chippewa R. (24)	Aug. 8	2.74	97	264	582	-	-	2.9	2
Batchawana R. (23)	July 24	9.07	320	611	1,347	-	-	13.0	8
Carp R. (22)	June 12	1.86	66	103	227	0.1	0.2	11.3	7
Michipicoten R.(21)	Aug. 18	55.19	1,949	2,519	5,553	39.9	87.9	19.6	12
Pic R. (20)	Aug. 22	13.32	470	2,051	4,522	37.6	91.4	101.7	63
Gravel R. (19)	July 17	5.14	182	324	714	5.6	12.3	16.1	10
Cypress R. (18)	July 6	1.51	53	85	187	-	-	5.5	3
Wolf R. (17)	July 14	6.85	242	1,399	3,084	-	-	11.3	7
Neebing McIntyre Floodway (16)	July 10	4.72	167	718	1,583	0.2	0.4	28.9	18
Total		118.50	4,186	9,853	21,722	84.1	193.7	334.5	208
GRAND TOTAL		149.50	5,281	14,659	32,317	101.1	230.7	659.4	410

[1] Includes 286.5 TFM bars (59.9 kg, 131.8 lbs.) applied in 15 streams.

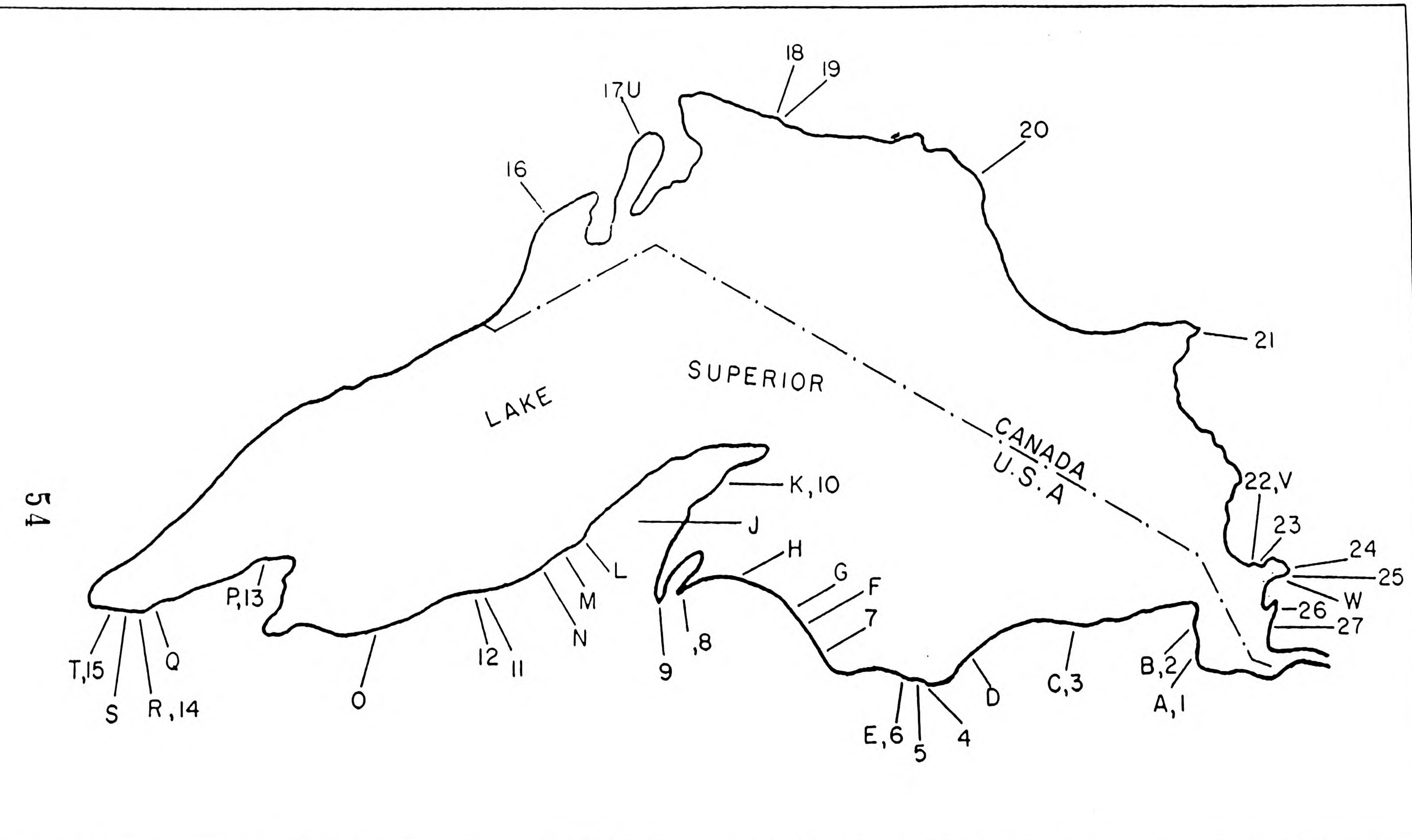


Figure 1. Location of Lake Superior tributaries treated with lampricides (numerals; see Table 4 for names of streams), and of streams where assessment traps were fished (letters; see Table 5 for names of streams) in 1990.

ble 5. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Superior, 1990.

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

tream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
nited States							
ahquamenon River (A)	332	37	65	451	439	207	201
etsy River (B)	83	19	63	405	403	161	164
ucker River (C)	56	6	33	376	412	110	150
iners River (D)	25	7	43	423	340	188	107
ock River (E)	576	419	40	426	429	192	201
ig Garlic River (F)	20	6	33	423	384	179	146
ron River (G)	6	0	-	-	-	-	-
uron River (H)	9	0	-	-	-	-	-
ilver River (I)	26	0	-	-	-	-	-
tter River (J)	0	0	-	-	-	-	-
raverse River (K)	31	0	-	-	-	-	-
isery River (L)	164	25	32	395	409	127	160
iresteel River (M)	42	2	0	-	436	-	167
ntonagon River (N)	56	11	54	409	398	176	199
ad River (O)	465	84	28	405	422	151	177
ed Cliff Creek (P)	14	4	25	371	357	95	205
rule River (Q)	780	87	57	428	432	181	197
iddle River (R)	1	1	100	469	-	296	-
mnicon River (S)	118	9	78	428	369	176	113
emadji River (T)	3	0	-	-	-	-	-
Total or average	2,807	717	43	424	425	184	192
Canada							
Stokely Creek (W)	13	0					
Carp River (V)	221	0					
Wolf River (U)	269	54	50	472	458	258	245
Total or average	503	54	50	472	458	258	245
GRAND TOTAL	3,310	771	43	428	427	230	221

Table 6. Estimated discharge and number of spawning-phase sea lampreys for U.S. streams located east and west of Keweenaw Peninsula in Lake Superior from May 13 to July 7, 1990. Streams are ranked as primary and secondary producers of sea lampreys.

[Population estimates were calculated from results of stratified multiple tag and recapture techniques in 12 streams with assessment traps and a linear regression for all streams based on the relation of mean stream discharge and the number of lampreys entering tributaries.]

PRIMARY STREAMS

Stream	Discharge CFS	Population Estimate by Tag/Recapture	Population Estimate by Regression
WEST			
Nemadji River	422	-	3,875
Amnicon River	87	1,260	799
Middle River	22	-	202
Poplar River	26	-	239
Brule River	140	1,316	1,285
Red Cliff Creek	1	2	9
Fish Creek	23	-	211
Bad River	308	2,674	2,828
Ontonagon River	1,331	-	12,220
Firesteel River	72	18	661
Misery River	66	651	606
Subtotal			
With Traps	2,005	5,921	18,408
Without Traps	493	-	4,527
Total West Primary and Secondary	3,227	23,543	
EAST			
Traverse River	17	105	40
Sturgeon River	381	-	906
Falls River	67	-	159
Silver River	95	41	226
Slate River	23	-	55
Ravine River	35	-	83

SECONDARY STREAMS

Stream	Discharge[a] CFS	Estimate by Regression
WEST		
Washington Creek	29	27
Arrowhead River	347	319
Poplar River	45	41
Gooseberry River	3	3
Split Rock River	10	9
Sand River	11	10
Black River	97	89
Cranberry River	60	55
Potato River	36	33
East Sleeping River	26	24
Elm River	21	19
Salmon Trout River	44	40
Subtotal	729	669
EAST		
Big Gratiot River	12	3
Eliza Creek	1	1
Dead River	50	12
Sand River	16	4
Five Mile Creek	2	1
Beaver Lake Outlet	17	4

Table 6. Continued.

PRIMARY STREAMS

Stream	Discharge CFS	Population Estimate by Tag/Recapture	Population Estimate by Regression
Huron River	164	-	390
Salmon Trout River	75	-	178
Iron River	139	-	331
Big Garlic River	16	15	38
Little Garlic River	12	-	29
Harlow Creek	23	-	55
Chocolay River	106	-	252
Laughing Whitefish R.	36	-	86
Rock River	36	1,349	86
Au Train River	131	-	312
Furnace Creek	8	-	19
Miners River	41	17	98
Sucker River	79	174	188
Two Hearted River	247	-	587
Little Two Hearted R.	66	-	157
Betsy River	96	308	228
Tahquamenon River	986	2,313	2,345
Waiska River	92	-	219
Subtotal			
With Traps	1,366	4,322	3,249
Without Traps	1,605	-	3,818
Total East			
Primary and Secondary	3,104	7,100	
Primary Lake Total			
With traps	3,371	10,243	21,657
Without traps	2,098	-	8,345
Secondary Lake Total[b]	862		
Lake Total			30,704

SECONDARY STREAMS

Stream	Discharge[a] CFS	Estimate by Regression
Sable Creek	10	2
Galloway Creek	4	1
Pendills Creek	21	5
Subtotal	133	33

[a]Average flows taken during past chemical treatments.

[b]Electrical weirs on secondary streams had collected one-tenth of the sea lampreys per cubic foot of flow as primary streams, and the flow for these streams was adjusted to correspond to the lower sea lamprey production (862 x 0.1 =86).

Table 7. Number of parasitic-phase sea lampreys collected in sport fisheries in U.S. waters of the Upper Great Lakes in 1990[a]. A zero (0) indicates sampling effort with negative results and a dash (-) indicates no effort.

Lake Superior			Lake Michigan			Lake Huron		
Unit	Charter	Noncharter	Unit	Charter	Noncharter	Unit	Charter	Noncharter
M-1	0	3	MM-1	1	1	MH-1	302	674
M-2	0	2	MM-2	-	-	MH-2	229	460
M-3	0	1	MM-3	38	12	MH-3	499	349
Wi-1	3	2	MM-4	24	5	MH-4	124	110
Wi-2	0	6	MM-5	121	40	MH-5	254	108
Mi-1	-	-	MM-6	172	24	MH-6	42	14
Mi-2	36	5	MM-7	115	5			
Mi-3	4	0	MM-8	159	16			
Mi-4	0	4	WM-1	2	12			
Mi-5	24	8	WM-2	3	6			
Mi-6	3	6	WM-3	1	11			
Mi-7	49	0	WM-4	4	28			
Mi-8	-	-	WM-5	21	33			
			WM-6	3	14			
			Ill.	0	2			
			Ind.	-	-			
Total	119	37		664	209		1,450	1,715

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

Table 8. Incidence of sea lampreys and numbers of lake trout and chinook salmon[a] taken by captains in the Michigan charterboat fishery, 1990.

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

Lake and Unit[b]	Incidence on lake trout: Sea lampreys per 100 trout	Number of trout	Incidence on chinook salmon: Sea lampreys per 100 salmon	Number of salmon
UNITED STATES				
Superior				
Mi-2	1.4	2,574	0	30
Mi-3	1.0	416	0	0
Mi-5	1.1	2,144	0	34
Mi-6	0.3	930	0	3
Mi-7	31.6	155	0	0
All Units	1.9	6,219	0	67
Michigan				
MM-1	0	0	0.7	142
MM-3	1.4	1,608	2.7	555
MM-4	1.0	1,909	0.7	590
MM-5	2.0	4,922	0.5	4,638
MM-6	1.9	6,646	0.5	9,054
MM-7	2.2	4,218	0.4	4,806
MM-8	1.5	9,654	0.3	5,550
All Units	1.8	28,957	0.4	25,335
Huron				
MH-1	22.4	85	30.7	920
MH-2	22.5	173	19.6	970
MH-3	5.9	3,825	15.0	1,830
MH-4	9.8	879	11.0	346
MH-5	4.9	3,072	18.3	574
MH-6	46.7	30	10.1	277
All Units	6.6	8,064	18.7	4,917

[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 units Mi-1, Mi-4, Mi-8, and MM-2.

Table 9. Number of parasitic-phase sea lampreys collected in commercial fisheries in 1990 and year lampreys would have spawned[a]. A zero (0) indicates sampling effort with negative results and a dash (-) indicates no effort.

Lake Superior			Lake Michigan			Lake Huron		
Unit	Spawning Year		Unit	Spawning Year		Unit	Spawning Year	
	1990	1991		1990	1991		1990	1991
M-1	-	-	MM-1	94	21	MH-1	165	1,025
M-2	2	0	MM-2	2	0	MH-2	9	35
M-3	2	0	MM-3	4	6	MH-3	-	-
Wi-1	-	-	MM-4	-	-	MH-4	26	66
Wi-2	44	13	MM-5	-	-	MH-5	-	-
Mi-1	-	-	MM-6	0	1	MH-6	-	-
Mi-2	-	-	MM-7	17	72			
Mi-3	-	-	MM-8	-	-			
Mi-4	29	2	WM-1	-	-			
Mi-5	2	3	WM-2	1	21			
Mi-6	31	9	WM-3	13	28			
Mi-7	44	2	WM-4	28	2			
Mi-8	16	17	WM-5	1	1			
			WM-6	-	-			
			Ill.	-	-			
			Ind.	-	-			
Total	170	46		160	152		200	1,126

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

Presence of sea lampreys was reported by charterboat captains in 5 of the 8 management units of Michigan (Table 9). The operators reported 1.9 lampreys attached per 100 lake trout. The largest number of lampreys per 100 lake trout (31.6) were seen in the management unit of MI-7 (Grand Marais, Michigan area), which corresponds to an observed high rate of wounds on lake trout (22.4/100 fish; Michigan Department of Natural Resources).

Biological Studies

Canada

In 1989, the Pancake River was sampled to estimate its larval sea lamprey population prior to lampricide treatment. Back-pack electrofishers were used at randomly selected sites to estimate larval populations and densities using quantitative depletion methodology. Results were as follows:

Date of Survey	Sea Lamprey Population Estimate x 10^3	Sea Lamprey Average Larval Density (No/m^2)
June	1,205	19.91

In 1990 estimates were made of residual and young-of-the-year (YOY) sea lamprey larvae in the Pancake River. Results were as follows:

Date of Survey	Type of Survey	Population Estimate x 10^3	Transformer Estimation (No/m^2)
June	Residual	0	0
	YOY	143	N.A.

The population estimate was adjusted for electrofishing efficiency based on a regression of observed density (during treatment) vs. calculated density (using the depletion estimates).

LAKE MICHIGAN

Larval Assessment

A total of 117 Lake Michigan tributaries and 7 offshore areas were surveyed in 1990 to prepare streams for lampricide treatment, assess annual recruitment of residual populations of larvae, and search for new infestations. Sea lampreys had reestablished in at least 48 streams.

Surveys to assess recruitment of the 1990 year class were conducted in 57 streams and young-of-the-year larvae were recovered in 33. Recruitment in 18 other streams with a history of sea lamprey infestation has not occurred since their respective last chemical treatments.

Pretreatment surveys were conducted in 33 streams; 7 later were treated in 1990 and 16 are scheduled for treatment in 1991. The remaining 10 were deferred for treatment until 1992 or later.

Lentic areas in Lakes Manistee and Charlevoix were examined for the presence of sea lampreys. A few larvae were recovered off the mouths of the Manistee and Little Manistee rivers in Lake Manistee, and off the mouths of 3 of 5 streams (Boyne and Jordan rivers and Porter Creek) in Lake Charlevoix. The Boyne River was treated in 1990 and will be treated again in 1991 to prevent young-of-the-year larvae from moving out of the stream into Lake Charlevoix.

Posttreatment surveys were conducted on four streams to evaluate the effectiveness of recent treatments. Moderate numbers of residual larvae were found in the Muskegon, Manistee, and Ogontz rivers, while none were found in the Carp Lake River.

Surveys were conducted in the Pere Marquette and Jordan rivers to evaluate the effectiveness of electric barriers operated during 1990 by the Michigan Department of Natural Resources. Operation of the Pere Marquette River barrier was discontinued after an initial 3-week period because an instream fish passage device did not work. As a result, the 1990 year class are present throughout the river (along with the year classes of 1987, 1988, and 1989). The Pere Marquette River is scheduled for treatment in 1991. The barrier on the Jordan River was operated during the full spawning season for lampreys. Surveys conducted in the fall above the barrier found 14 young-of-the-year sea lampreys at 2 of 4 of the examined locations. Also, 6 larvae of the 1989 year class were recovered at 3 of the 4 sites (barrier also was operated in 1989).

Examination of all tributaries to Lake Michigan that previously had no history of sea lamprey infestation continued in 1990. A total of 48 streams were examined in Brown, Door, Kewaunee, Manitowoc, Sheboygan, Milwaukee, and Racine counties in Wisconsin. No populations were found although some streams appear to have favorable environmental conditions for sea lampreys.

The Milwaukee River was surveyed to assess the potential for sea lamprey production above existing dams. Several locations were examined from a dam (proposed for removal) near North Avenue, Milwaukee, upstream to Grafton, Wisconsin (about 25 miles). Suitable larval habitat was sparse in the area, and no native lampreys were found. There are three other dams between North Avenue and Grafton and each would be a barrier to migrating sea lampreys. Removal of the North Avenue Dam unlikely would result in additional production of sea lampreys to Lake Michigan because of the combination of other dams, absence of larval native lampreys, and lack of suitable habitat. Also, sea lampreys never have established in other streams of southwestern Lake Michigan.

Chemical treatment

Lampricide treatments were completed in 10 streams (Table 10, Fig. 2) with a combined discharge of 99.7 m^3/s (3,522 f^3/s). A total of 31 toxicity tests were conducted on 8 streams prior to treatment. Larvae were abundant in the Ford, Manistee, and Whitefish rivers and less common in the remaining streams. Bayer 73 wettable powder was used to reduce use of TFM by a combined 26% during treatments of the Boyne, Little Manistee, and Manistee rivers. Larvae were distributed less widely in the tributaries of the Ford River than during past treatments, and resulted in a savings of about $45,000 (lampricides and labor). A few nontarget species were killed in some complex treatments.

Table 10. Details on the application of lampricides to streams of Lake Michigan, 1990.
[Number in parentheses corresponds to location of stream in Fig. 2. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM[1] kg	TFM[1] lbs	Bayer 73 kg	Bayer 73 lbs	Distance km	Distance miles
Days R. (3)	May 4	0.9	32	141	310	-	-	8.0	5
Hudson Cr. (6)	May 5	0.1	5	6	13	-	-	3.2	2
Milakokia R. (5)	May 7	0.9	32	242	534	-	-	20.9	13
Carp Lake R. (7)	May 19	2.8	100	418	922	-	-	14.5	9
Ford R. (2)	June 2	9.2	325	2,606	5,745	-	-	145.0	90
Cedar R. (1)	June 17	18.4	650	4,486	9,890	-	-	80.0	50
Lincoln R. (10)	June 20	2.3	80	589	1,298	-	-	27.2	17
Manistee R. (9)									
Mainstream	July 11	53.9	1,903	9,949	21,934	69.2	152.3	119.1	74
Little Manistee R.	July 12	7.4	260	1,003	2,211	11.1	24.5	9.7	6
Whitefish R. (4)									
East Branch	July 14	1.7	60	535	1,179	-	-	22.5	14
Boyne R. (8)	Aug. 2	2.1	75	399	880	3.6	8.0	6.4	4
Total		99.7	3,522	20,374	44,916	83.9	184.8	456.5	284

[1]Includes 335 TFM bars (70 kg, 154.1 lbs.) applied in 3 streams.

able 11. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan, 1990.
[Letter in parentheses corresponds to location of stream in Fig. 2.]

tream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
est Shore							
East Twin River (A)	9	7	28	505	502	283	246
Fox River (B)	0	0	-	-	-	-	-
Oconto River (C)	32	30	27	510	508	315	301
Peshtigo River (D)	329	328	48	496	495	287	298
Menominee River (E)	71	70	50	482	485	271	278
Ford River (F)	5	0	-	-	-	-	-
Manistique R. (G)	14,967	556	50	478	477	249	261
st Shore							
Carp Lake River (H)	493	0	-	-	-	-	-
Jordan River							
Deer Creek (I)	88	88	36	484	494	244	264
Boardman River (J)	68	68	47	465	469	223	233
Betsie River (K)	573	463	42	471	472	225	237
St. Joseph River (L)	291	289	41	489	486	260	264
tal or average	16,926	1,899	45	482	482	252	262

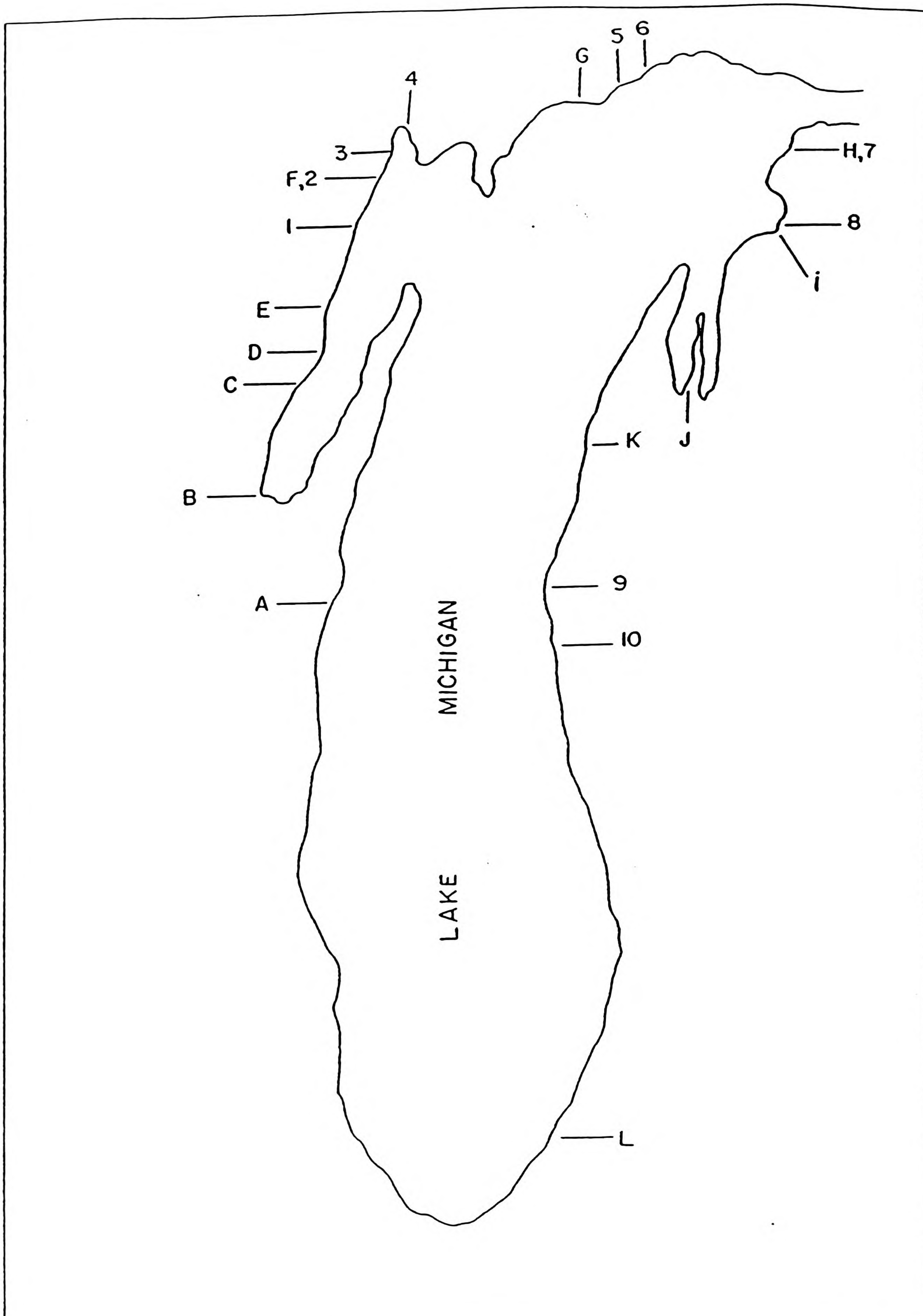


Figure 2. Location of Lake Michigan tributaries treated with lampricides (numerals; see Table 10 for names of streams), and of streams where assessment traps were fished (letters; see Table 11 for names of streams) in 1990.

Spawning-phase Assessment

A total of 16,926 sea lampreys were captured in assessment traps placed in 7 west shore and 5 east shore tributaries of Lake Michigan in 1990 (Table 11, Fig. 2), about the same as the number taken in 1989 (17,094). There was no significant change in percentage of males in samples from Lake Michigan tributaries in 1990 than from those taken in 1989 (44% vs. 45%), and the average length and weight for both sexes also remained about the same.

Along the west shore, catches in the East Twin and Fox rivers remained the same as in 1989, decreased from 59 to 5 in the Ford River due to decreased effort, and increased in the remaining 4 streams. The difference in catch in the Peshtigo River (from 48 in 1989 to 329 in 1990) was due to construction in 1989 that delayed trap placement until after the peak of the spawning run. A stratified mark and recovery system used for the seventh consecutive year to estimate the number of spawning-phase sea lampreys in the Manistique River indicated a larger population in 1990 than in 1989 (28,463 vs. 18,769).

The total catch of sea lampreys in streams along the east shore of Lake Michigan decreased in 1990. This primarily was due to the decreased catch in the Carp Lake River (1,379 vs. 493) where high water levels prevented trap placement during the peak of the spawning run. The east shore decrease also reflects the exclusion of the Pere Marquette River from spawning-phase lamprey assessment in 1990 (catch of 296 in 1989 and operated by the Michigan Department of Natural Resources in conjunction with their experimental use of an electric barrier).

Parasitic-Phase Assessment

Lake Michigan commercial fishermen captured 312 parasitic-phase sea lampreys in 1990 (Table 7), compared with 298 in 1989. Of the total, 175 were collected from Lake Michigan and 137 from Green Bay, compared with 222 and 76 respectively in 1989. Most lampreys were collected by trapnet fishermen (63%) during July-September (50%), and the lampreys primarily were attached to lake trout (72%) and lake whitefish (19%).

Spawning year was determined for the 312 parasitic-phase sea lampreys. Of these, 160 would have spawned in 1990 and 152 in 1991. A total of 381 of the 1990 spawning year class have been collected (221 in 1989 and 160 in 1990) and represent an increase when compared to the number of the 1989 spawning year class (249) captured by commercial fishermen.

A total of 873 sea lampreys were collected or reported from the Lake Michigan sportfishery, 664 from charter and 209 from noncharter fishermen (Table 8). (Variation in the collection of sea lamprey data from Michigan and Wisconsin requires that the assessment data be treated separately.) The Michigan management unit which contributed the largest number of sea lampreys was MM-6 (Arcadia to Little Sable Point, Michigan; 196), while the Wisconsin management unit of WM-5 (Sheboygan-Milwaukee, Wisconsin area) contributed the largest number (54). Most lampreys were collected or reported by fishermen during June-August (82%), and primarily were attached to lake trout (81%).

Information on the incidence of sea lampreys was reported by the charterboat fisheries for 7 of the 8 management units of Michigan (Table 9). Fishermen reported 1.8 and 0.4 lampreys attached per 100 lake trout and chinook salmon respectively.

LAKE HURON

Larval Assessment

United States

A total of 31 Lake Huron tributaries were surveyed to prepare streams for lampricide treatments and assess annual recruitment and residual populations. Sea lampreys are reestablished in at least 24 streams. Surveys to assess the recruitment of the 1990 year class were conducted on 23 streams. Young-of-the-year larvae were found in 11 streams. Pretreatment surveys to schedule treatments were completed on 12 streams; 3 later were treated in 1990, and the others either are scheduled for treatment in 1991 or postponed indefinitely.

Residual sea lampreys were collected from 2 streams during posttreatment surveys to evaluate treatment effectiveness and from 3 other streams during surveys to assess annual recruitment. Residual lampreys comprised less than 5% of the larvae collected in each stream except Albany Creek (about 38%) and the North Branch of the Pine River (75%). Additional surveys are required to determine the residual population in the Pine River.

Surveys continued in 1990 to monitor populations of larval sea lampreys in the St. Marys River. A total of 10 index locations of 0.2 ha. (0.5 acre) each were surveyed with Bayer 73 granules, and 466 larval and 13 transformed sea lampreys were collected. An additional 6 locations were sampled in the Little Rapids Cut area and 457 larval and 2 transformed sea lampreys were collected.

Canada

Surveys were conducted on 43 Lake Huron tributaries, two instream lakes and the deltas of five streams in 1990. Larval sea lamprey distribution was determined in the Garden and Echo Rivers before their 1990 treatments. Although the upstream distributional limits in the Echo River were near the historical maximum, larval sea lamprey densities were low in most branches. The sea lamprey population of the upper Echo River (above the barrier dam) consisted primarily of the 1987 year class along with some residuals of the last (1987) treatment. Distribution surveys were also completed on two streams (Boyne and Mississagi Rivers) scheduled for treatment in 1991.

Treatment evaluation surveys on the 10 streams treated in 1989 found a small number of residuals in only one, Timber Bay Creek. Evaluation surveys on three of the streams treated in 1990, Manitou River, Blue Jay and Silver Creeks, found a single residual in Blue Jay Creek.

Of the 10 streams treated in 1989, five have re-established with the 1989 year class of sea lamprey larvae (Koshkawong, Serpent, Spanish, Mindemoya Rivers and Timber Bay Creek).

Surveys were done on the St. Marys and French Rivers to monitor untreated larval sea lamprey populations. Sixteen index stations on the St. Marys River were surveyed using granular Bayer 73. Although larval catches from individual stations tend to be inconsistent from year to year, overall catches suggest a fairly stable population in the St. Marys River.

The French River is a large complex river system with a highly dendritic mouth. One tributary, the Wanapitei River, located about 25 km upstream, is treated on a regular basis. Another small channel near the western mouth was treated with TFM in 1976 and was partially treated with Bayer 73 granules in 1987. A scarcity of spawning habitat (gravel) is likely a major factor preventing the French River from being a significant sea lamprey producer. Survey effort in 1990 was concentrated on the lower reaches of the Western Channel which includes the small channel treated in 1976 and 1987. Larval sea lamprey densities are moderately high again in this small channel. Survey results also indicate successful sea lamprey spawning at two other locations in the Western Channel. At both sites larval densities appear low, but more work needs to be done to confirm this as well as to determine their spatial distribution. Additional work is also needed in other parts of the French River, which is undoubtedly the most difficult area to survey on the Canadian side of the Great.

Surveys were done to check the effectiveness of the four low head barrier dams on Lake Huron streams. The dams on the Sturgeon, Koshkawong and Still Rivers appear to have been effective since their construction. The dam on the Echo River appears to have blocked spawning runs since remedial work was completed in 1987.

Routine surveys of 11 streams with no previous history of larval sea lamprey found one with a larval population. Spragge Creek, a small North Channel tributary, was found to have a multiyear-class population, some of which were undergoing transformation to the parasitic stage. Spragge Creek was subsequently treated in late 1990.

Lentic populations of sea lamprey larvae were sampled in seven locations. None of these populations are currently thought to be significant contributors to the parasitic stocks of Lake Huron.

Chemical treatment

United States

Lampricide treatments were completed on 4 streams (Table 12, Fig. 3) with a combined discharge of 6.6 m^3/s (237 f^3/s). A total of 14 toxicity tests were conducted on the streams prior to treatment. Sea lamprey larvae were abundant in the East Au Gres River and less common in the remaining streams. The East Au Gres River was treated for the first time since the sea lamprey barrier was constructed in 1985. This effective barrier has eliminated the need to treat 25 miles of river and reduced lampricides by 50%. Low stream flows complicated treatments of the Au Gres and Munuscong rivers and McKay Creek. Treatment of the Devils River was deferred to 1991 to accommodate cooperative studies with the Hammond Bay Station. Treatment of the Au Sable River was postponed until 1991 and treatment of the Black Mallard River was postponed indefinitely due to low numbers of lamprey larvae. A few steelhead trout and suckers were killed in about four miles of Johnson Creek (Au Gres River), but no mortality of nontarget species occurred in the other treatments.

Canada

Nine Lake Huron streams (7 North Channel, 2 main basin) received treatment with lampricide in 1990 (Table 12, Fig. 3). Unsatisfactory treatment discharge resulted in the deferral of three treatments: the Pine River, a tributary to the Nottawasaga River in southern Georgian Bay; La Cloche Creek, a Spanish River tributary; and the majority of the upper Thessalon River, a North Channel tributary. One section of the upper Thessalon River, between Rock and Gordon Lakes, and a small tributary were successfully treated in 1990.

All treatments were deemed effective in killing the resident larval sea lamprey populations. Ammocoetes were very abundant in the Garden and Echo Rivers and Blue Jay Creek, whereas moderate numbers were observed in the remainder of the treated streams.

Mortality of non-target fish species was insignificant in all treatments.

Spawning-phase Assessment

United States

During the 1990 spawning season, 36,837 sea lampreys were captured in assessment traps placed in 6 tributaries of Lake Huron (Table 13, Fig. 3) compared to 30,604 in 1989. More lampreys were caught in the Cheboygan (32,696 vs. 28,224), the Ocqueoc (1,555 vs. 530), and the Au Sable (983 vs. 76) rivers in 1990 than 1989. A stratified mark and recovery system was used to estimate the number of spawning-phase sea lampreys in the Cheboygan River for the seventh consecutive year. An estimated 52,414 sea lampreys comprised the spawning run in 1990 compared to 38,907 in 1989. Trap efficiency decreased from about 70% (1987-1989) to 60% in 1990 probably because of lower water levels in 1990 than previous years. An estimated 2,806 spawning-phase sea lampreys were present in the Ocqueoc River. A population estimate conducted in the St. Marys River in cooperation with the Department of Fisheries and Oceans, Canada, shows a slight decrease in the estimated number of lampreys in 1990 compared to 1989 (23,052 vs. 26,919). The average length and weight of sea lampreys sampled from Lake Huron tributaries in 1990 remained about the same as those taken in 1989 whereas the percentage of males increased from 47 to 52%.

Canada

Trap devices in five Lake Huron streams collected 14,881 adults (Table 13, Fig. 3). Excepting the Echo River, where a surprisingly large run was experienced, the other St. Marys/North Channel sites reported average counts. The dam at the Still River in Georgian Bay collected only nine adults this year (as opposed to 0 in 1989), but there are some concerns about its effectiveness as a barrier. On two occasions during the season, high water practically nullified the drop, and the operator observed suckers swimming over the dam.

Table 12. Details on the application of lampricides to streams of Lake Huron, 1990.

[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		Distance	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles
UNITED STATES									
Au Gres River (1)	Apr. 27	4.2	150	933	2,057	-	-	77.2	48
East Au Gres R. (2)	May 9	1.8	65	349	770	-	-	16.1	10
McKay Creek (3)	June 2	0.1	4	54	119	-	-	6.4	4
Little Munuscong (4)	June 5	0.5	18	234	516	-	-	17.7	11
Total		6.6	237	1,570	3,462			117.4	73
CANADA									
Two Tree R. (7)	May 29	0.40	14	127	280	0.1	0.2	9.6	6
Echo R. (5)	May 29	2.19	77	226	498	-	-	33.4	20
Watson Cr. (8)	May 31	0.06	2	11	24	0.2	0.4	1.9	1
Blue Jay Cr. (13)	June 6	0.72	25	142	313	-	-	7.9	5
Silver Cr. (11)	June 8	0.39	14	136	300	-	-	5.6	4
Manitou R. (12)	June 9	3.51	124	346	763	-	-	1.0	<1
Garden R. (6)	June 19	17.88	631	1,185	2,612	0.5	1.1	58.1	36
Thessalon R. (9)	Aug. 8	3.06	108	206	454	-	-	6.1	4
Spragge Cr. (10)	Oct. 17	0.58	20	18	40	-	-	0.6	<1
Total		28.79	1,015	2,397	5,284	0.8	1.7	124.2	78
GRAND TOTALS		35.39	1,252	3,967	8,746	0.8	1.7	241.6	151

[a]Includes 184.8 TFM bars (38.7 kg, 85.2 lbs.) applied in 6 streams.

Table 13. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1990.

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

Stream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
UNITED STATES							
St. Marys River (F)	1,424	813	55	480	478	249	254
East Au Gres River (A)	48	48	52	448	461	189	210
Au Sable River (B)	983	963	55	459	465	210	223
Ocqueoc River (C)	1,555	0	-	-	-	-	-
Cheboygan River (D)	32,696	617	46	468	478	219	241
Albany Creek (E)	131	131	43	451	441	204	201
Total or average	36,837	2,572	52	467	471	224	235
CANADA							
St. Marys River (F)	9,054	913	56	489	491	245	261
Echo River (G)	2,494	476	51	486	490	245	260
Koshkawong River (H)	357	81	27	484	490	250	253
Thessalon River (I)	2,967	597	53	495	500	252	264
Still River (J)	[illegible]	6	50	359	460	107	233
Total or average	14,881	2,073	53	490	493	247	261
GRAND TOTAL OR AVERAGE	51,718	4,645	52	477	480	234	246

Stratified population estimates and trap efficiencies based on the ratio of released to recovered were:

St. Marys River (U.S./Canada combined data)	23,052	41%
Echo River	3,731	59%
Thessalon River (Bridgeland/Rydal Bank combined)	9,641	30%
Koshkawong River	623	28%

Spawning Ground Observations/Nest Surveys

These activities, initiated in 1987 as a requirement of the pending Sterile Male Release Technique (SMRT), were continued in the St. Marys River. The spawning season was quite late, with the first nest located on July 16 and the first adult observed on July 20.

All 34 sightings of adults occurred in July, and 10 (5 male) were collected. All were unmarked. This poor recovery rate continues a trend in which recapture rates on the Rapids spawning grounds have been subtly but persistently lower than those from the traps (5% versus 9% over five years). The implication that the marked adults appear on the Rapids spawning facilities in fewer relative numbers than at the traps is important to any sterile male release which relies on trap data to set sterile male requirements or to subsequently measure impact.

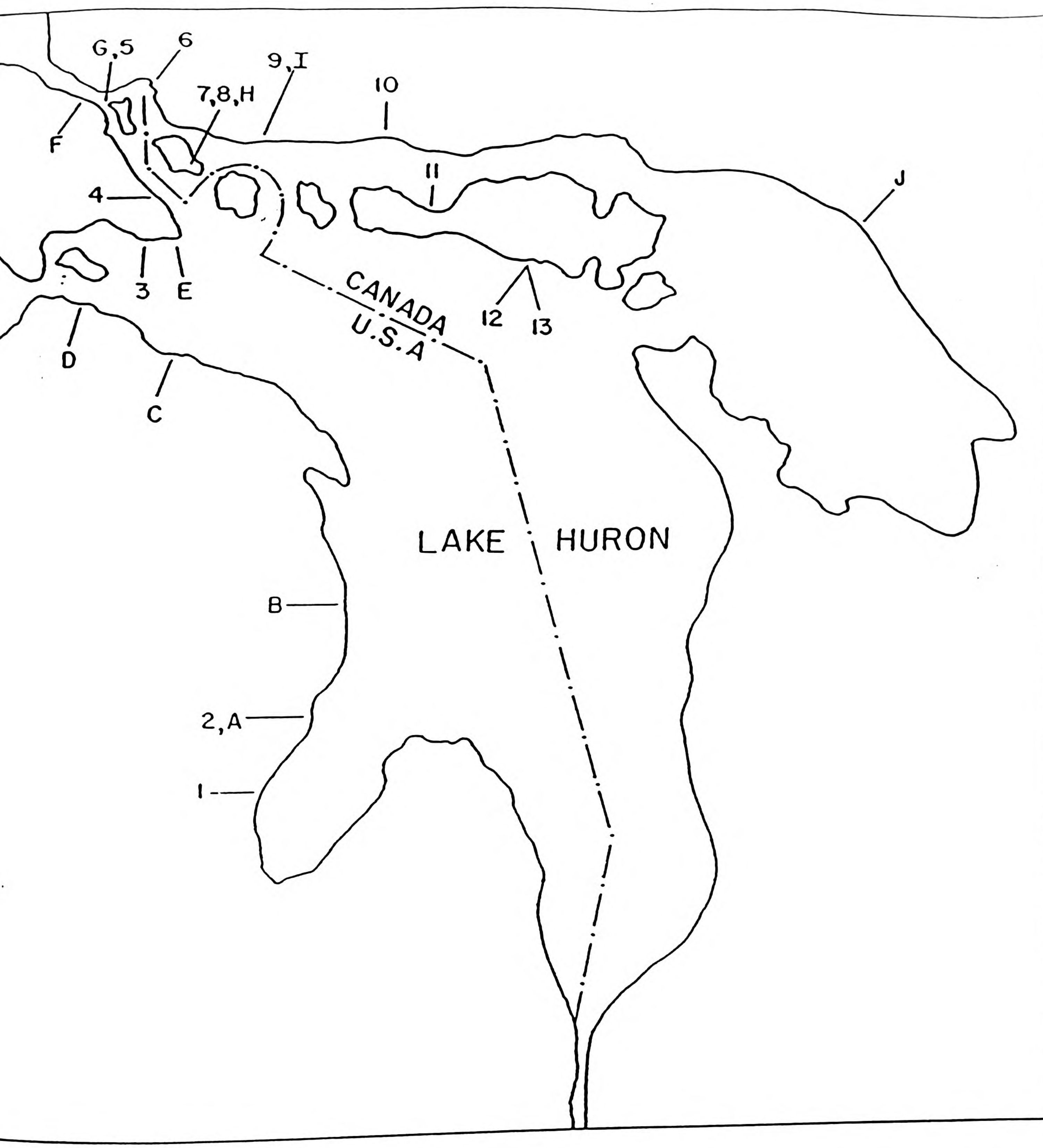


Figure 3. Location of Lake Huron tributaries treated with lampricides (numerals; see Table 12 for names of streams), and of streams where assessment traps were fished (letters; see Table 13 for names of streams) in 1990.

Eighteen positive nests were identified, but four of these were lost because of tampering by individuals or excessive siltation. Nine (64%) of the remainder experienced successful hatches, with eight of these eventually yielding final stage prolarvae. This hatching success rate is low in relation to past years. In conjunction with the reduced number of nests and adults observed, and the lateness of spawning activity, a generally poor spawning year is suggested. Year-to-year variability in hatching success may hinder this technique in providing a valid index of success.

SCUBA observations by contracted underwater video divers, and volunteer club divers, continue to reveal extensive spawning in areas of the Sault basin other than the Rapids. A reach of gravel downstream from, but within, the immediate influence of the Great Lakes Power tailrace, is heavily utilized. Other areas that were initially identified some eight years earlier, i.e., the Corps of Engineers tailrace and along the upstream edge of Sugar Island, are still in use. Evidence of spawning was also located above the compensating gates. The contribution of the Rapids to the overall spawning occurrence within the River is unknown.

Parasitic-phase Assessment

A total of 1,326 parasitic-phase sea lampreys were collected by commercial fishermen in Lake Huron in 1990 (Table 7), compared with 1,295 taken in 1989. Fishermen from management unit MH-1 (DeTour-Rogers City, Michigan area) contributed the largest number of sea lampreys (1,190), an increase from the number taken in 1989 (1,072). The number of sea lampreys collected by commercial fishermen in the management units of MH-2 (Alpena, Michigan area) and MH-4 (Tawas City-Bay Port, Michigan area) decreased from 112 and 110 respectively in 1989, to 44 and 92 respectively in 1990. Most lampreys were collected by trapnet fishermen (77%) during August-October (42%), and the lampreys primarily were attached to lake whitefish (36%), salmon species (28%), and lake trout (23%).

Spawning year was determined for the 1,326 parasitic-phase sea lampreys. Of these, 200 would have spawned in 1990, and 1,126 in 1991. A total of 1,440 of the 1990 spawning year class have been collected (1,240 in 1989 and 200 in 1990), and represent an increase when compared to the number of the 1989 spawning year class (994) captured by commercial fishermen.

Anglers on the U.S. side of Lake Huron captured or reported 3,165 parasitic-phase sea lampreys (1,450 from charter and 1,715 from noncharter fishermen) (Table 8). Fishermen from management unit MH-1 (Rogers City, Michigan area) contributed the largest number of sea lampreys (897). Most lampreys were collected or reported by fishermen during July-September (87%) and primarily were attached to chinook salmon (76%).

Occurrence of sea lampreys on fish was reported by charterboat captains in all six management units of Michigan (Table 9). The operators reported 6.6 and 18.7 lampreys attached per 100 lake trout and chinook salmon, respectively. The management unit of MH-1 reported the largest number of lampreys per 100 chinook salmon (30.7), whereas the management unit of MH-6 reported the largest number of lampreys per 100 lake trout (46.7).

The Lake Huron commercial fisheries submitted 1,565 sea lamprey in 1990 (1,059 North Channel, 506 main basin). This is down from the 1989 count by nearly 20 percent. Although the downturn in numbers from the North Channel is slight, the fisheries operating in the eastern end expressed the belief that lamprey abundance was below recent levels, perhaps hinting at the positive influence of the August, 1989 treatment of the Spanish River.

Sport Fisheries

The project continued to monitor two fishing derbies centred on the St. Marys River. The first, the Coor's King Salmon Derby, was held from August 25 to September 8. Despite having been reduced by one week, the derby was highly successful. Of 429 chinook examined, 28 percent carried seasonal (A1-A3) wounds, with a wounding rate of 37.8 wounds/100 fish. These values are down from 1988 and 1989, but comparable to 1987 results.

The Can-Am Tournament, held September 14-16, indicated 39 percent wounded and 58.5 wounds/100 fish for 135 chinook sampled. While the "wounds/100" rate follows the 4-year trend noted from the Coor's Derby, the "percent wounded" rate was actually up slightly suggesting that attacks leading to wounding were more dispersed across the chinook population. The number of lamprey observed attached to the chinook during the Can-Am averaged 12.1/100 fish, similar to rates from the past two years and decidedly below those of 1987 and 1988.

Lamprey-trapping in a Denil Fishway

A denil fishway was constructed and set up with a gravity water feed at Little Rapids on Bridgeland Creek, a tributary to the Thessalon River to observe adult spawning-phase sea lamprey behaviour and to evaluate trapping potential.

Four trap entrances conveying attractant water were added to a 3.7 m long standard denil (30 cm wide) with a slope of 13% (Fig. 4). Groups of lamprey (20+/-) were placed in a footbox below the structure and given about 24 hours to attempt upstream passage. Yellow walleye (<u>Stizostedion vitreum</u>), and common white suckers (<u>Catostomus commersoni</u>) were also tested. Testing was conducted at several controlled flow rates and various water temperatures. Velocities in the fishway ranged from 0.5 to 1.2 m/s.

Following initial testing, the fishway was lined with outdoor carpet in stages and testing was repeated.

The traps captured 37% to 44% of the lamprey attempting to migrate through the fishway (Table 14). The balance of the migrant lamprey made it to the funnelled trap at the top end of the fishway. The trap whose entrance was just beside the fishway entrance took more lamprey than all three inter-fishway traps. In the first series of tests lamprey appeared to have problems negotiating the fishway. They would usually attach three or more times and those succeeding took between 7 and 24 minutes to do so, almost all of which was attached resting time. Three walleye (40-50 cm) swam the fishway in less than 15 s (11.4°C) and three adult common white suckers swam it in 3 - 7.5 s, (14.5°C). It was assumed that lamprey would not be able to make it through the fishway if they could not attach. When the fishway and baffles were fully lined with outdoor carpet, a non-attachable material, 63% of the 131 lamprey attempting the structure passed all the way through. They swam in the lowest velocity water near the bottom of the baffles and did not attach. Water temperatures at this time of 18.5 to 19°C are within the optimum range for sea lamprey's swimming performance.

It is assumed that at temperatures under 12°C, because of lower metabolic rates and swimming endurance, similar (no-attach) denil fishways would not pass lamprey. Such structures could pass the bulk of walleye runs and other early non-jumping fish but would require the installation of a drop when stream water temperatures reach about 9°C.

It is recommended that testing be done in the lower temperature ranges with both denil and vertical slot fishways. The latter holds even more promise for stopping and trapping lamprey because of the higher velocities between pools, more desirable multiple trapping sites and simple pool morphology. A stream-durable material to which lamprey cannot attach would be important to the sea lamprey barrier program.

Velocity Chute

Lamprey burst swimming endurance was tested by removing the fishway baffles and increasing the slope to 16%.

Lamprey from the St. Marys River were acclimated a minimum of 24 hours and then placed in the introduction box where they could attempt the chute.

Lamprey swimming bursts were observed in the chute and a number of them were timed (Table 15). Lengths of lamprey ranged from 40 to 56 cm with a mean of 47.6 cm. Water in the chute was flowing at 2.75 m/s (Ottmeter, Pitot tube) with depths of 8-10 cm and temperatures of 21° to 22°C. Since lamprey could not attach when fatigued, the swift laminar current would wash them back into the introductory box. Although some lamprey were able to make more than one attempt, there was no apparent decrease in burst distances over the approximate hour of observation each day.

The greatest distance attained out of 49 timed bursts was 1.85 m. Mean burst length was 0.87 m, and mean duration was 5.2 s.

A current of 2.75 m/s over a distance of 2.5 m should constitute a barrier for migrating sea lamprey if they cannot attach.

Figure 4. Denil fishway modified to trap sea lamprey, 1990 study.

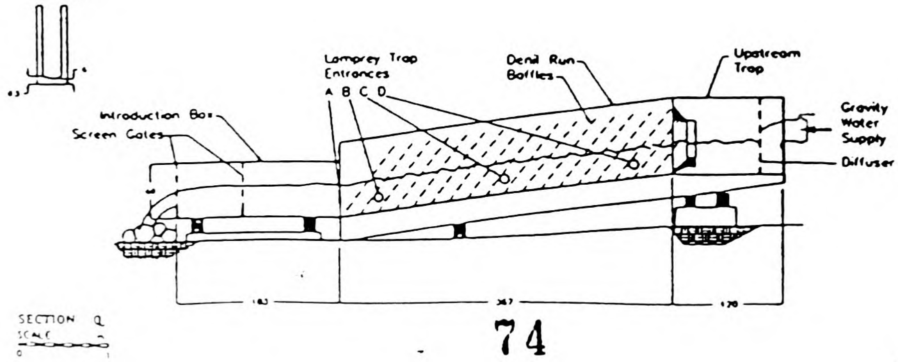


Table 14. Lamprey Trapping Denil Fishway
Summary - Percent Lamprey Trapped

Date	Total n	Lamprey No. runs	No. of Attempts	Total trapped A	B	C	D	Percent Trapped
May 8 to May 24 (7° - 14.5°)	96	7	59	-	19	15	8	42
May 25 to June 21 (12.5° - 19°)	434	19	344	26	6	6	6	44
Fishway Partly Non-Attachable								
June 28 to July 6 (18° - 21°)	160	6	128	20	9	5	5	39
Fishway Fully Non-Attachable								
July 10 to July 16 (18.5° - 19°)	151	5	131	24	5	4	5	37

A: Beside Entrance Fishway
B–D: Within Fishway
D: Farthest Upstream

Table 15. Velocity Chute Summary

WATER VELOCITY 2.75 m/s   CHUTE SLOPE 16%   WATER TEMPERATURE 21 - 22°C

Date	No. Lamprey	No. Attempts	Burst Duration s Mean	Range	Burst Distance m Mean	Range	Mean Swimming Vel. m/s
July 26	20	10	4.81	(2.0-7.8)	0.85	(0.20-1.80)	2.92
July 27	20	26	5.77	(3.0-9.9)	1.00	(0.40-1.85)	2.92
July 30	15	13	4.34	(1.7-6.1)	0.65	(0.25-1.15)	2.90
TOTAL/MEAN		49	5.2		0.87		2.92

LAKE ERIE

Larval Assessment

United States

A total of five Lake Erie tributaries were surveyed in 1990 to assess sea lamprey populations and to search for new infestations. Pretreatment surveys were conducted in 4 streams along the south shore in preparation for chemical treatment in 1990. Upstream distribution limits and proposed chemical application points were examined in Conneaut, Raccoon, Crooked, and Cattaraugus creeks. All of the streams later were treated in 1990. A pretreatment survey of the Grand River was deferred until 1991 because of high water at the scheduled time of survey.

During an October 1989 fish survey in the North Branch of the Clinton River (a Lake St. Clair tributary), Michigan Department of Natural Resources personnel captured three recently transformed sea lampreys. Subsequently, 5 sites in the stream were surveyed for larvae and spawning potential. Habitat for larvae was scarce at all sites; 1 sea lamprey (153 mm) and 5 Ichthyomyzon sp. larvae were found at 1 site.

Index surveys scheduled after October 1 to assess recruitment of the 1990 year class on the Buffalo River and Delaware, Halfway, Canadaway, and Wheeler creeks were cancelled because of uncertainty of funding levels for fiscal year 1991.

Canada

Surveys were conducted on 10 Lake Erie tributaries in preparation for chemical treatments in 1991, to monitor re-established and residual populations and to evaluate barrier dams.

Distribution surveys were done on the three streams recommended for treatment in 1991. Upstream distribution in Big Otter and Clear Creeks appears to be considerably reduced over that observed during their first treatments in October, 1986. Distribution in Young's Creek is basically the same as it was in the 1987 treatment.

Treatment evaluation surveys on Big and Forestville Creeks, both treated in May 1989, were negative. A small number of sea lamprey larvae were collected from both North and South Creeks, tributary to Big Creek. Neither of these small streams have been treated with lampricide as both feed the municipal water reservoir for the town of Delhi.

Barrier dams on Normandale and Forestville Creeks appear to have blocked the 1989 run of sea lamprey. As well, there is no evidence of successful spawning below either barrier.

To date, there is no evidence of reestablished larval sea lamprey populations in East, Catfish, South Otter, Normandale and Fishers Creeks, since their initial treatments.

Chemical Treatment

United States

Lampricide treatments were completed on 4 streams (Table 16, Fig. 5), which showed reinfestation with sea lamprey since the initial treatment of 8 streams in 1986-87. Sea lampreys were abundant in Conneaut Creek and relatively scarce in the remaining streams. Transformed larvae were found in Cattaraugus and Conneaut creeks and indicate rapid larval growth.

The treatments were conducted during periods of intermittent rain storms which created fluctuations in discharges, frequent schedule changes, and additional lampricide applications. Toxicity tests were conducted on Cattaraugus Creek only as high water levels on the other streams precluded collection of sufficient test animals. Nontarget mortality was low in all treatments.

Table 16. Details on the application of lampricides to streams of Lake Erie, 1990.

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

Stream	Date	Discharge		TFM[a]		Bayer 73		Distance	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles
UNITED STATES									
Cattaraugus Cr.(1)	Sept. 9	13.9	491	4,734	10,437	0	0	45.1	28
Raccoon Cr. (3)	Oct. 7	0.3	9	49	108	0	0	6.4	4
Crooked Cr. (2)	Oct. 15	1.4	50	198	436	0	0	12.9	8
Conneaut Cr. (4)	Oct. 18	12.8	450	1,183	2,609	0	0	98.2	61
Total		28.4	1,000	6,164	13,590	0	0	162.6	101

[a]Includes 4 lbs. of bars applied in Conneaut Creek.

Spawning-phase Assessment

United States

A total of 279 sea lampreys were captured in assessment traps placed in 3 tributaries of Lake Erie in 1990 (Table 15, Fig. 5) compared to 235 in 1989 and 1,903 in 1988. The reduction in catch from 1988 to 1989 is due to the first-time lampricide applications to sea lamprey producing streams in 1986-87. The mean length and weight of lampreys and percentage of males remained about the same in 1990 as in 1989.

Canada

The two streams fished with assessment traps in 1990 (Fig. 5, Streams D,E) captured a total of 62 spawning-phase adults. This was the first year of operati[illegible] incorporated into the low-head dam on Clear

Creek, constructed in 1989. Although only one adult was captured in this initial attempt, this may not be indicative of the actual run, as operational problems persisted throughout the trapping period. The traditional operation of portable traps on Young's Creek provided 61 adults, although efficiency of these traps fell to 21% from 29% in 1989. The stratified estimate indicated a total run of 175, up from the 129 estimated for 1989. This estimate is still about one-half the mean trap catch for three years of trapping prior to the initiation of lampricide treatments on Lake Erie tributaries in 1986.

Table 17. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Erie, 1990.

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

Stream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
UNITED STATES							
Cattaraugus Creek (A)	222	220	60	493	493	267	272
Grand River (B)	54	54	68	491	466	260	234
Chagrin River (C)	3	3	100	513	-	260	-
Total or average	279	277	62	493	489	266	266

Parasitic-phase Assessment

Canada

The Lake Erie fisheries submitted only 17 parasitic stage sea lamprey. For the third year, submissions from the eastern and central basins fell. Where 1986 and 1987 counts provided by the Port Dover Observer programme averaged 329, he three-year mean for 1988 to 1990 is 21. The east-central basin has shown a continual decline, while the waters of the western half of the lake continue to show a low but persistent level. Although the much reduced numbers offer less incentive for the commercial fisheries to turn in boated specimens, most continue to cooperate, and the fleets are repeatedly reminded of our continued interest in submissions.

Barrier Dams

Canada

A low-head lamprey barrier dam was constructed during July and August on Little Otter Creek, 1.5 km upstream from its confluence with Big Otter Creek. Site property was leased from a private landowner.

The gabion structure has a concrete grout cap, an overhanging steel lip, a prefab steel jumping pool and a built-in lamprey trap. It was built at a cost of $24,703. It should reduce the difficult treatment of 28 km to 1.5 km or less and provide an assessment site to monitor adult spawning-phase sea lamprey running the Big Otter Creek system.

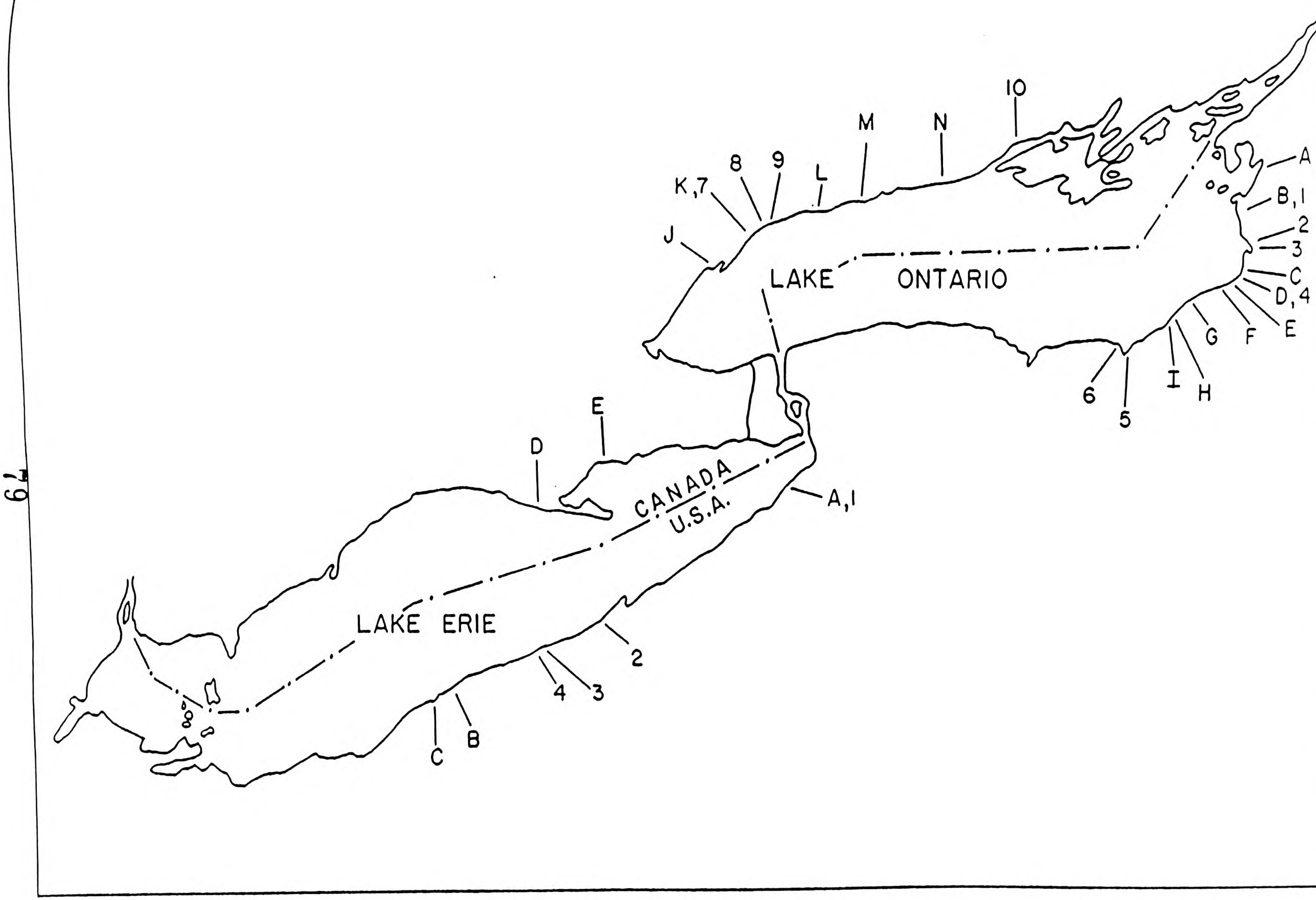


Figure 5. Location of Lake Erie and Lake Ontario tributaries where lampricides were applied (numerals; see Table 16 for Lake Erie streams and Table 18 for Lake Ontario streams), and assessment traps were fished (letters; see Table 17 for Lake Erie streams and Table 19 for Lake Ontario streams).

LAKE ONTARIO

Larval Assessment

United States

Surveys scheduled in October to assess recruitment of the 1990 year class, monitor existing populations of sea lamprey larvae, and search for new infestations were cancelled because of uncertainty of funding levels for fiscal year 1991.

Canada

Surveys were conducted on 44 Lake Ontario tributaries in 1990 in preparation for chemical treatment, to monitor re-established, residual and untreated populations, and to look for new infestations.

Distribution surveys were completed on five streams scheduled for treatment in 1990, all of which were subsequently treated. Population and distribution surveys were also done on 13 streams recommended for treatment in 1991. One of these, Sodus Creek, was treated in the fall of 1990. A major change in distribution was found in the Salmon River (Canada). Sea lamprey are now spawning 12 km above an old mill dam that had been repaired and modified in 1974 to act as a lamprey barrier.

Treatment evaluation surveys on the 12 Lake Ontario tributaries treated in 1989 found moderate numbers of residual sea lamprey larvae in Little Sandy, Fish and Deer Creeks, and in the Salmon River (New York). Low numbers of residuals were found in Bronte, Bowmanville and Wilmot Creeks. No residuals were collected from Farewell, Salem and Snake Creeks, Cobourg Brook or the Little Salmon River.

Post treatment surveys done on Lynde Creek following the 1990 treatment confirmed an observation made during the treatment, that sea lamprey larvae were likely inhabiting a section of stream above the main chemical application point. Approximately 1.5 km of stream were found to have a low density larval population, comprised largely of the 1989 year class.

Treatment evaluation surveys conducted on three other streams treated in 1990 found a few residuals in Lindsey Creek and none in Skinner or Mayhew Creeks.

All eight streams treated in the spring of 1989 are reestablished with the 1989 year class of sea lamprey larvae, whereas the four treated in August and September of 1989 are not.

Surveys done above the low head barrier dams on Graham, Colborne, Grafton and Shelter Valley Creeks indicate that all are effective. As mentioned earlier, the mill dam on the Salmon River has not been fully effective for several years. Small numbers of spawning sea lamprey also appear to be getting past the repaired and modified mill dam on the Credit River near Streetsville.

Chemical Treatments

United States

Six tributaries to the New York side of Lake Ontario received applications f lampricide in 1990 (Table 18, Fig. 5). South Sandy, Skinner, Lindsey, and irst Creeks were successfully completed in the spring, whereas Grindstone and odus Creek treatments were performed in the fall.

Sea lamprey larvae were abundant in South Sandy, Grindstone and First reeks while lesser numbers were observed in Skinner, Lindsey, and Sodus Creeks. ow discharge, the necessity to treat the extreme upper reach of a tributary, eaver impoundments and high pH levels complicated the September treatment of rindstone Creek (deferred from the spring because of very high discharge). reatment effectiveness on the latter's tributaries was facilitated by beaver am removal and the application of numerous lampricide blocks. However high pH evels and attenuation of the lampricide block caused incomplete mortality of ea lamprey in the lower reach of the main Grindstone. Fortunately ammocoete ensity has been historically low in this area. Sporadic mortality of common ite suckers, brown bullheads and darters occurred throughout the Grindstone ributaries.

Canada

Lampricide treatments were conducted on four Canadian Lake Ontario ibutaries in 1990, all during the month of May (Table 18, Fig. 5).

All treatments were considered effective and, with the exception of Mayhew eek, were treated under seasonable flows. Rainshowers immediately prior to eatment of Mayhew Creek increased flows to high but tolerable levels.

Treatment collections indicated that successful annual sea lamprey spawning curred in each stream, although year class strength varied. Larval abundance s ranked as scarce in Duffins and Lynde Creeks, and moderate in Oshawa and yhew Creeks.

Non-target fish mortality was light in Duffins, Oshawa and Mayhew Creeks l was primarily restricted to the more susceptible logperch, stonecat and icknose dace. An unexplained dramatic flow reduction resulting in higher ipricide concentrations, and a sudden pH decrease, which increased lampricide 'icacy, resulted in higher non-target mortality in Lynde Creek (primarily mon white suckers).

Spawning-phase Assessment

United States

A total of 1,981 sea lampreys were captured in assessment traps placed in ributaries of Lake Ontario in 1990 (Table 19, Fig. 5). This was a significant rease from the catch of 139 in 1989, largely due to the initial trapping on Black River and large increases in catch on Sterling Valley Creek (578 vs. Sterling Creek (176 vs. 75), and Grindstone Creek (293 vs. 10). Traps were ced on t[illegible] for the first time, but no lampreys were caught.

Three sea lampreys were captured in the Oswego River, the first catch since trapping began in 1987.

Efforts continued for the third consecutive year to estimate the total number of spawning-phase sea lampreys in U.S. waters of Lake Ontario using the method developed in Lake Superior. The method is based on the relation between average stream discharge and the number of adult lampreys that enter tributaries to spawn. While all the flow data necessary to conduct the estimate was collected, corresponding in-stream population estimates required to establish the mathematical relation proved statistically unreliable in most streams due to few or no recaptures.

Table 18. Details on the application of lampricides to streams of Lake Ontario, 1990.

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

Stream	Date	Discharge		TFM[a]		Bayer 73		Distance	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles
CANADA									
Duffins Cr. (7)	May 2	1.77	63	757	1,669	-	-	6.2	4
Lynde Cr. (8)	May 5	0.77	27	358	789	-	-	11.9	7
Oshawa Cr. (9)	May 8	0.79	28	382	842	-	-	19.7	12
Mayhew Cr. (10)	May 12	0.69	24	175	386	-	-	3.5	2
Total		4.02	142	1,672	3,686			41.3	25
UNITED STATES									
South Sandy Cr.(1)	May 3	3.10	109	488	1,076	-	-	11.4	7
Skinner Cr. (2)	May 6	1.47	52	189	417	-	-	12.6	8
Lindsey Cr. (3)	May 9	1.16	41	169	373	-	-	24.1	15
First Cr. (6)	May 12	0.12	4	20	44	-	-	1.6	1
Grindstone Cr. (4)	Sept. 19	0.61	22	134	295	.05	.11	27.9	17
Sodus Cr. (5)	Sept. 23	0.07	2	26	57	0.25	0.55	1.8	1
Total		6.53	230	1,026	2,262	.30	.66	79.4	49
Totals		10.55	372	2,698	5,948	0.30	.66	120.7	74

[a]Includes 67 TFM bars (14.1 kg, 31.2 lbs.) applied in 2 streams.

ıble 19. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Ontario, 1990.

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

:ream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Females	Mean Weight (g) Males	Females
IITED STATES							
:erling Creek (I)	176	23	61	467	451	230	216
:erling Valley Creek (H)	578	159	67	483	485	265	274
;wego River (G)	3	0	-	-	-	-	-
ıtfish Creek (F)	0	0	-	-	-	-	-
.ttle Salmon River (E)	18	0	-	-	-	-	-
:indstone Creek (D)	293	14	71	490	459	275	219
ılmon River (C)	0	0	-	-	-	-	-
ıuth Sandy Creek (B)	4	0	-	-	-	-	0
.ack River (A)	909	148	59	479	483	252	271
ıtal or average	1,981	344	64	481	481	258	266
NADA							
ımber R. (J)	1,295	247	46	471	456	257	242
ıffins Cr. (K)	1,291	211	56	491	486	273	286
ıwmanville Cr. (L)	123	27	67	499	478	299	251
ırt Britain Cr. (M)	180	40	70	501	497	207	325
ıelter Valley Cr. (N)	545	110	61	499	484	288	278
ıtal or Average	3,434	635	54	487	472	273	265
AND TOTALS	5,415	979	118	968	953	531	531

Canada

Five streams fished in Canadian waters of the lake yielded 3,434 spawning adults (Table 19, Fig. 5). Although traditional operations on Wilmot and Graham creeks were omitted from the network this year, a new barrier dam and trap on Port Britain Creek was serviced during the season. Modifications made to the recent permanent trap installed at the Bowmanville Creek site were considered successful in improving trap efficiency.

Measure of trap efficiency and concurrent population estimates were:

Humber River	31%	4,097
Duffins Creek	81%	1,517
Bowmanville Creek	14%'	509
Port Britain Creek	41%	341
Shelter Valley Creek	48%	1,033

Changes in efficiency at individual trap sites, reflected in the resulting estimates, is clearly an important consideration this year. While the Humber count dropped appreciably this year over last, efficiency was down as well, and the estimate of the run was virtually the same as in 1989. On Duffins, the catch was up, but so was the efficiency, and the run estimate was actually down. The Shelter Valley trap efficiency was considerably down, and the estimate correspondingly up, despite an essentially duplicate count. Despite this, both the catches and run estimates suggest no substantive change in spawner abundance from 1989. The sex ratio continues to hover above 50% male, while the size of the spawners holds at peak levels.

Nest Surveys

Nest building observations on the Humber River were first made on May 17. However, the presence of several hundred suckers appeared to frustrate efforts at nest building. By the following day, the suckers had disappeared and five nests were located. Eventually 35 positive nests were identified, but several, with early through late stage eggs, were lost (likely due to tampering by the public. Others with low numbers of developing, well-advanced eggs were scoured by heavy rainwaters, with no embryos subsequently found. One nest yielded a few advanced prolarvae (Stage 16) but the next was empty on a follow-up check. The rains may have washed them free. This represents the most advanced level of development of embryos encountered in four years of next sampling on the Humber River. This may suggest an improvement in water quality and could lead to eventual survival of larval sea lamprey in this urban stream.

Biological Studies

In 1990, population estimates were made on the Rouge River and Grindstone Creek, both tributary to Lake Ontario. The effort on Grindstone was schedule din late July to allow the collection of any transformers that might be present. In addition, estimates of residual sea lamprey escaping treatment were conducted in Wilmot and Salem creeks. Bronte Creek also had residual/YOY (young-of-the-year) estimates conducted during 1990.

The results were:

Stream	Date Surveyed	Type of Survey	Population Estimate x 10^3	Transformer Estimation x 10^3
Rouge River	May	Population	0.5	0.01
Grindstone Creek	July	Population	1,884.0	4.6
Wilmot Creek	May	Residual	0.0	0.0
Salem Creek	May	Residual	0.0	0.0
Bronte Creek	August	Residual	0.0	0.0
		YOY	6.5	N.A.

All population estimates, except Grindstone Creek, were adjusted for electrofishing efficiency based on a regression of observed density (during treatment) vs. calculated density (using the depletion estimates). It was impossible to get observed densities from Grindstone Creek during treatment and therefore only estimated densities were used to calculate the population. The reported populations are considered low for Grindstone, particularly the transformer estimate.

Previous data from Grindstone Creek treatments indicates that about 35% of all larvae over 120 mm should be transforming. During the 1990 treatment, 9.5% of the total collection (55% of all larvae over 120 mm) were transforming. Treatment collections are normally biased toward the larger animals and the number of transformers should be similar to Salem Creek's population in 1989, i.e., 2% of the total population. This value would suggest that approximately 40 x 10^3 transformers were present in Grindstone Creek in 1990.

The IMSL (Integrated Management of Sea Lamprey) model for Lake Ontario predicts that 31-36 x 10^3 parasitic sea lamprey would be feeding in 1990-1991, corresponding to this time frame. The model applies a 50% mortality to transformers before they begin feeding on lake trout and this would equate to a transformer production of 62-72 x 10^3 from the streams. It is obvious that a missed treatment of a stream with the production capabilities of Grindstone or Salem creeks could greatly increase the parasitic sea lamprey population in the lake and significantly impact fish mortality.

LAKES SUPERIOR, MICHIGAN, AND HURON

Treatment Effects on Nontarget Organisms (short-term test)

Mayflies--Hexagenia nymphs were collected in the Pere Marquette River (Lake Michigan) to determine recovery of the population following a lampricide treatment of August 1987. Total abundance of nymphs in 1987 declined 69% from pretreatment ($754/m^2$) to posttreatment ($230/m^2$) samples. The majority of the decline occurred within the 1986 year class of nymphs, while the 1987 year class exhibited little decline. The 1987 year class of nymphs was strong and has contributed to a steady increase in population abundance since treatment. Abundance in 1990 averaged $925/m^2$ or 23% above pretreatment levels, and the percent composition of the 1988 and 1989 year classes is similar to that observed in 2 year classes before the 1987 treatment. Apparently, the population of nymphs was not impacted significantly by the 1987 treatment and has recovered fully in 3 years. The Pere Marquette River is scheduled for treatment in 1991 and further sampling will determine effects on the Hexagenia population.

Riffle invertebrate communities--The Rifle River (Lake Huron) typically is treated with lampricide in segments over a period of a few weeks because of the overall complexity of the system. In 1989, the eastern headwater tributaries were treated first (August 25), followed by treatment of a large western tributary (Houghton Creek) and the mainstream (August 27). As a result, the mainstream Rifle River immediately downstream of the Houghton Creek junction received a dose of lampricide sublethal to sea lamprey two days prior to application of a dose lethal to sea lamprey. To determine effect by the successive doses of lampricide on macroinvertebrate riffle communities, a study area was established in the mainstream about 0.5 mile downstream of the Houghton Creek junction. Communities were sampled randomly with a circular depletion sampler the day before exposure to lampricide (control) and immediately following passage of the sublethal TFM dose, and again following the lethal dose. Also, invertebrate drift was sampled before and during the two lampricide applications using standard drift nets.

A total of 64 invertebrate taxa were represented in the circular depletion samples. Of these, 29 were scarce in all sample periods, 30 were common and showed no significant change through both treatment dosages, and 5 were common and significantly decreased only after the lethal dose. Heptageniidae (Stenonema), Leptophlebiidae, Hydroptilidae, Chironomidae, and Oligochaeta declined 51-83% after passage of the lethal concentration of TFM.

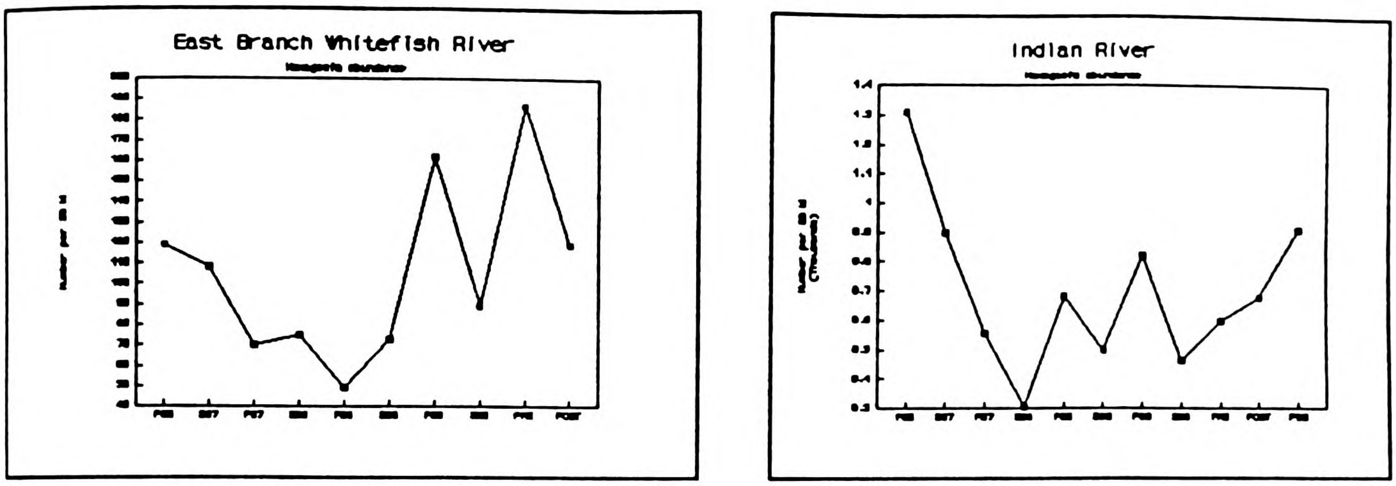
About the same number of macroinvertebrate taxa were found in the drift net samples (58), and most of these were scarce (45). Of the 13 taxa that were common, Oligochaeta and Simuliidae substantially increased during the lethal dose of TFM.

Macroinvertebrate density at the community level did not differ significantly from pretreatment to posttreatment (sublethal and lethal) periods (ANOVA; $p<0.05$). Most of the changes in abundance of macroinvertebrate taxa (decreases in circular samples and increases in drift nets) occurred when those taxa left their burrows or places of attachment as an avoidance response to TFM and drifted downstream. Changes in density of macroinvertebrates (at the community and individual taxa levels) in the present study are similar to those observed in the Whitefish River (Lake Michigan) which is treated with a single lethal dose of lampricide (GLFC Annual Report 1986), and show that successive doses of TFM do not have an additive effect. This study was conducted in cooperation with Central Michigan University as partial fulfillment of a Master of Science degree of a student enrolled in the Fish and Wildlife Service Cooperative Education Program.

Treatment Effects on Nontarget Organisms (long-term test)

Hexagenia--Since 1984, samples of Hexagenia have been collected in the spring and fall in the East Branch of the Whitefish River (Lake Michigan) to determine effects of lampricides on the population. Random samples (3 from each of 10 silt beds at a control and a treated area, or 60 samples) were collected with an Eckman dredge. Scott Creek (Whitefish River tributary) was selected as the control area in 1984 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 fall 1986. In 1989, total abundance of Hexagenia nymphs in both the East Branch of the Whitefish and Indian rivers reversed a downward trend exhibited since 1986 (Figure 1). The number of nymphs in the East Branch increased 231% from $49/m^2$ in October 1988 to $162/m^2$ in October 1989. At that time, the abundance of Hexagenia nymphs was about the same as that of October 1985 (prior to a 1986 treatment of the river and 2 years since the previous treatment in 1983) and suggested a four-year treatment cycle rather than three-year may enhance further repopulation of the nymphs. As a result, the East Branch was deferred from treatment until 1990 (the balance of the river was treated in 1989) to determine if lengthening the interval between treatments (from three to four years) would improve abundance of the Hexagenia population.

Figure 6. Abundance of Hexagenia nymphs in the East Branch of the Whitefish River and at a control site in the Indian River, 1986-1990. Samples were taken in the fall and spring and before and after a 1990 lampricide application in the East Branch.



Abundance of Hexagenia nymphs increased to an average $187/m^2$ prior to treatment in 1990. These samples, taken in late June, contained many large nymphs of the 1988 cohort indicating that emergence apparently was prolonged in 1990. The treatment was conducted in mid-July and abundance of Hexagenia nymphs declined to $119/m^2$ following treatment. Some of this decline resulted from emergence of nymphs between pretreatment and posttreatment sampling, but mortality of larger nymphs also occurred (no 1988 cohort nymphs were found and abundance of the 1989 cohort was reduced). Interestingly, posttreatment abundance in 1990 (mean $119.2/m^2$, std.dev. 99.8) was nearly identical to that in October samples following the 1986 treatment (mean $119.4/m^2$, std.dev. 118.1). Lengthening the treatment cycle apparently had little effect. Because Hexagenia population trends in the treated and control sites were similar from 1986 to 1990, environmental conditions rather than lampricide treatments appear to be a more significant factor than lampricide treatments in determining the strength of Hexagenia populations in the East Branch of the Whitefish River.

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

Samples have been collected in the spring and fall at areas using the standard travelling kick method. Collections were taken before and after lampricide treatments of the index streams (Whitefish River 1989 and Sturgeon River 1988). Samples from the Whitefish River have been sorted and identified through 1988 and from the Sturgeon River through spring 1989. These long-term studies in invertebrate community structure require the establishment of several years of data to draw conclusions that relate to stream treatments. Thus far, the results have shown little difference in changes in invertebrate populations between control and treatment areas (Tables 17 and 18).

The construction of a lamprey barrier on the Brule River in 1985 provided the opportunity to design a study on invertebrate communities that included index sites upstream and downstream of the barrier in a regularly treated stream. Initial samples were collected in fall 1985 (the sampling schedule includes spring and fall collections through a minimum of two treatment cycles). Collections were taken from each site before and immediately after lampricide treatment in 1986 that included both areas of the river. The river again was treated in 1989 but included only the area downstream of the barrier. Samples have been sorted, identified, and reported through the 1988 collection (GLFC Annual Report 1988). Samples collected in 1989 and 1990 will be presented upon completion of processing in later annual reports.

Table 20. Mean number of organisms from five samples taken by kick nets in riffle communities in the Sturgeon River in 1989 in areas that are periodically treated and in areas that are not treated (control).[a]
[The Sturgeon River, a tributary of the Cheboygan River on Lake Huron, was treated in October 1988; the control area is in the Boardman River on Lake Michigan.]

Taxa	Treated Area (Sturgeon River) Fall	Control Area (Boardman River) Fall
Ephemeroptera		
Baetidae		
Baetis	21.4	100.4
Pseudocloeon	5.8	7.2
Oligoneuriidae		
Isonychia	2	
Heptageniidae		
Rhithrogena	36	0.8
Stenomena	40	0.4
Ephemerellidae		
Ephemerella	43.2	78.4
Seratella	25	
Leptophlebiidae		
Paraleptophlebia	2.8	4.2
Odonata		
Anisoptera		
Gomphidae		
Ophiogomphus	0.2	1
Plecoptera		
Pteronarcyidae		
Pteronarcys	2.8	0.2
Taeniopterygidae		
Taniopteryx	0.6	0.2
Strophopteryx		0.6
Capniidae		
Paracapnia	0.2	0.4
Perlidae		
Paragnetina	1.4	
Acroneuria	6.2	0.4
Perlinella		0.2
Perlodidae		
Isogenoides	14	0.4
Isoperla	19.8	4.8
Hemiptera		
Corixidae	0.2	

(continued)

Table 20. Continued.

Taxa	Treated Area (Sturgeon River) Fall	Control Area (Boardman River) Fall
Megaloptera		
Corydalidae		
Nigronia	1.6	0.2
Trichoptera		
Philopotamidae		
Dolophilodes	5	0.4
Hydropsychidae		
Ceratopsyche	160.2	24
Cheumatopsyche		0.6
Rhyacophilidae		
Rhyacophila	1.6	2
Glossosomatidae		
Protoptila	105.2	118.8
Hydroptilidae		
Hydroptila	3	12.6
Brachycentridae		
Brachycentrus	19.8	5.4
Micrasema	9.4	18.4
Lepidostomatidae		
Lepidostoma	4.2	26
Limnephilidae		
Neophylax		0.2
Helocopsychidae		
Helicopsyche	251.2	
Leptoceridae		
Oecetis	0.4	0.2
Setodes	0.2	
Pupae	0.8	
Coleoptera		
Hydrophilidae		0.2
Elmidae		
Optioservus larvae	527	168.6
Optioservus adult	219.4	33.4
Diptera		
Tipulidae		
Tipula	0.2	0.4
Antocha	51	7.8
Simulidae		
Prosimulium	0.2	1.6
Simulium	2.6	15.4
Chironomidae	118	307.4
Athericidae		
Atherix	26.8	108.4
Empididae		
Chelifera	1.8	25
Hemerodromia	2.4	1.8
Pupae	7.2	11.2

(continued)

Table 20. Continued.

	Treated Area (Sturgeon River) Fall	Control Area (Boardman River) Fall
Miscellaneous		
Turbellaria		
Planaria	1.2	
Nematoda		0.6
Annelida		
Oligochaeta	79.2	92.6
Isopoda		
Asellus	24.6	
Amphipoda		
Gammarus	0.2	0.8
Hydracarina	6.4	28
Gastropoda		
Physidae		
Physa	1.4	1.8
Hydrobildae		
Amnicola	1	
Ancylidae		
Ferrisia	1.8	1
Pelecypoda		
Sphaeriidae		
Sphaerium	0.2	0.6
Terrestrials	0.4	
Pisces	0.4	0.4
Total	1,857.4	1,215.4
Total taxa	52	47

[a]Samples from the Sturgeon and Boardman rivers in 1990 will be given, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

Table 21. Mean number of organisms from five samples taken by kicknets in riffle communities in the Whitefish River in 1989 in areas that are periodically treated and in areas that are not treated (control). Samples in 1989 were taken in the spring and before and after a June lampricide application.[a]

	Whitefish River					
	Treated area			Control area		
Taxa	Spring	Before	After	Spring	Before	After
Ephemeroptera						
Baetidae						
<u>Baetis</u>	14.6	206.8	359.2	8.8	388.2	536.8
<u>Pseudocloeon</u>		24.8	46.6		49.4	46.2
Oligoneuriidae						
<u>Isonychia</u>	6.2	4.8	5.2	2.8	2.8	2.4
Heptageniidae						
<u>Epeorus</u>	19.4	15.8	33	24.2	28.6	22.6
<u>Leurocuta</u>	15.4	11.6	11.8	10.8	15.8	9.8
<u>Rhithrogena</u>				0.2		
<u>Stenacron</u>				0.6	0.4	
<u>Stenomena</u>	19.8	3.8	3.8	12.4	4.8	2.4
Ephemerellidae			0.2			
<u>Drunella</u>	22.2	2	0.6	1.8	0.8	0.2
<u>Ephemerella</u>	486.2	1.4	0.2	238		
<u>Eurylophella</u>	6.2	1.4	0.2	2.8	0.4	0.8
<u>Seratella</u>	36.4	15.6	19.6	9.6	19.6	12.2
Caenidae						
<u>Caenis</u>	16.6	1.4	2	11	2	0.4
<u>Paraleptophlebia</u>	25.4	37.4	53	7.4	39.4	33.6
Ephemeridae						
<u>Ephemera</u>		0.2		0.2	0.2	
Odonata						
Anisoptera						
Gomphidae						
<u>Ophiogomphus</u>	5.4	7.6	9	5.2	9.4	13.2
<u>Stylogomphus</u>	1.4	2	1.4	1.2	1.4	0.6
Cordulegastridae						
<u>Cordulegaster</u>	0.2					
Aeshnidae						
<u>Boyeria</u>				0.2		
Zygoptera						
Coenagrionidae						
<u>Amphiagrion</u>		0.2				
Plecoptera						
Taeniopterygidae						
<u>Strophopteryx</u>	42			64.8		
<u>Nemoura</u>			0.6			
<u>Ostrocerca</u>	181			32.8		
<u>Shipsa</u>	0.8			1		
Capniidae						
<u>Paracapnia</u>	8.2		0.2	2.6		0.2

(continued)

Table 21. Continued.

Taxa	Whitefish River: Treated area Spring	Treated area Before	Treated area After	Control area Spring	Control area Before	Control area After
Plecoptera, continued.						
Perlidae						
Neoperla	1.4	1.4	0.2	0.4	0.4	0.8
Paragnetina	2	3.2	3.4	1.6	5	6.2
Phasganophora	2.6	2.4	18.8	2.4	2	2.4
Acroneuria	12.2	7.4	8.6	8.4	13	9
Perlinella	3.4	0.8	0.2	3.4	0.8	
Perlodidae						
Isoperla	81			68.6		
Unknown			0.2			
Megaloptera						
Corydalidae						
Nigronia	7.6	2	6.4	3	2.8	2.8
Trichoptera						
Philopotamidae						
Chimarra	2.6	0.4	0.2	0.8		0.4
Dolophilodes		36.2	29.2		71.6	40.8
Psychomyiidae						
Psychomyia	1	0.6	0.2			
Polycentropodidae						
Polycentropus	0.4					
Hydropsychidae			0.6			
Ceratopsyche	38.6	13	21	25.2	30.2	23
Cheumatopsyche	8.4	0.6	1	1.4	0.4	2
Hydropsyche		1.2	0.4		0.6	2.2
Rhyacophilidae						
Rhyacophila	0.2		0.2	0.8	1	0.4
Glossosomatidae	0.6					
Glossosoma	22	4.6	5.8	12.8	6.2	4.2
Hydroptilidae					0.4	0.6
Agraylea		0.2	0.6	0.4	0.4	0.2
Hydroptila	5.2	3.8	0.2	5.2	1.2	2
Stactobiella	7.2			1		
Leucotrichia	23.2	1	0.2			
Neotrichia		1	2		2.6	2.2
Phryganeidae				0.2		
Brachycentridae						
Brachycentrus	0.4	6.4	9.2	0.4	7.8	7
Micrasema	0.6	0.2		0.2		0.4
Lepidostomatidae						
Lepidostoma	1.8	1.4	0.4	3.8	1.8	1.6
Limnephilidae						
Neophylax	29.6	0.8	1	16.4	0.6	1.2
Hydatophylax	0.6	0.2			0.2	
Pycnopsyche	0.4			0.6	0.2	
Odontoceridae						
Psilotreta	15.6	3.6	5.2	14.2	7	4.4
Helocopsychidae						
Helicopsyche	5.6	6.4	3.8	3	7.2	1.6

(continued)

Table 21. Continued.

	Whitefish River					
	Treated area			Control area		
Taxa	Spring	Before	After	Spring	Before	After
Trichoptera, continued.						
Leptoceridae						
Ceraclea	3.2			1.8		
Mystacides	0.4			0.2		
Oecetis	0.6	1	0.2	0.2	1.6	1.6
Setodes				0.8		
Triaenodes						
Pupae		31.2	12.6		12.2	8.2
Coleoptera						
Psephenidae						
Psephenus	3.6	5.4	8.8	3.4	7	8
Ectopria		0.2	0.8	0.2	0.4	0.4
Elmidae						
Dubiraphia larvae	0.4					
Macronychus adult	0.2					
Optioservus larvae	56.2	23.8	46.6	21.2	28.4	26.2
Optioservus adult	21.8	27.4	47	4.2	17.4	14.2
Stenelmis larvae	1	0.8	0.8		0.8	0.6
Stenelmis adult	2	6.8	11.2	0.4	2.2	1.6
Ptilodactylidae		0.2				
Curculionidae						
Bagous		0.4			1.6	1.2
Stenopelmus			0.4	0.2		0.2
Diptera						
Tipulidae						
Tipula				0.2		0.4
Antocha	16.4	6	2.2	2.8	4.6	2.4
Dicranota	1	0.2		0.2		
Hexatoma	5.6	14.6	24.8	0.6	25.6	25.8
Ceratopogonidae		2.2	3.2		3.4	3.8
Simulidae						
Ectemnia	0.4					
Prosimulium	1063.6			285.4		1 0.6
Simulium		1.6	3.6	0.2	12.2	8.8
Chironomidae	232.8	280	346.6	103.8	437.8	403.2
Athericidae						
Atherix	18.6	12.8	16.6	10.6	21	11
Empididae						
Chelifera	0.4					
Hemerodromia	4.4	4.8	2.4	0.8	2.4	2.4
Pupae	4.6	24.6	37.8	0.4	22.8	21
Adult		0.2			0.2	

(continued)

Table 21. Continued.

	Whitefish River					
	Treated area			Control area		
Taxa	Spring	Before	After	Spring	Before	After
Miscellaneous						
Turbellaria						
Planaria	3	1.8	1.4	0.8		
Nematoda		1.8	0.8		1.2	0.4
Annelida						
Oligochaeta	7.2	36.2	10	2.6	39.4	26.8
Branchiobdellida	0.2	1.2	0.2		0.6	1
Hirudinea			0.4			
Amphipoda						
Gammarus	0.2		0.2	0.2		
Decapoda						
Astacidae	0.6	0.6	1	0.8	0.4	0.8
Hydracarina	0.6	0.6	0.2	0.2		0.6
Gastropoda						
Physidae						
Physa	3.4	6.4	2.2	6.2	21.2	8.8
Hydrobiidae						
Amnicola	0.2					
Ancylidae						
Ferrisia		0.2				
Pelecypoda						
Sphaeriidae						
Sphaerium	2.8	3.2	2.2	1.8	1.2	0.2
Terrestrials	0.2	4.6	0.8		8.6	10.6
Pisces		0.2	0.2	0.2	0.2	
Total	2,637.8	936.4	1,250.6	1,062.8	1,400.8	1,387.6
Total taxa	56	52	45	48	48	46

[a]Samples from the Whitefish River in 1990 will be presented, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

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