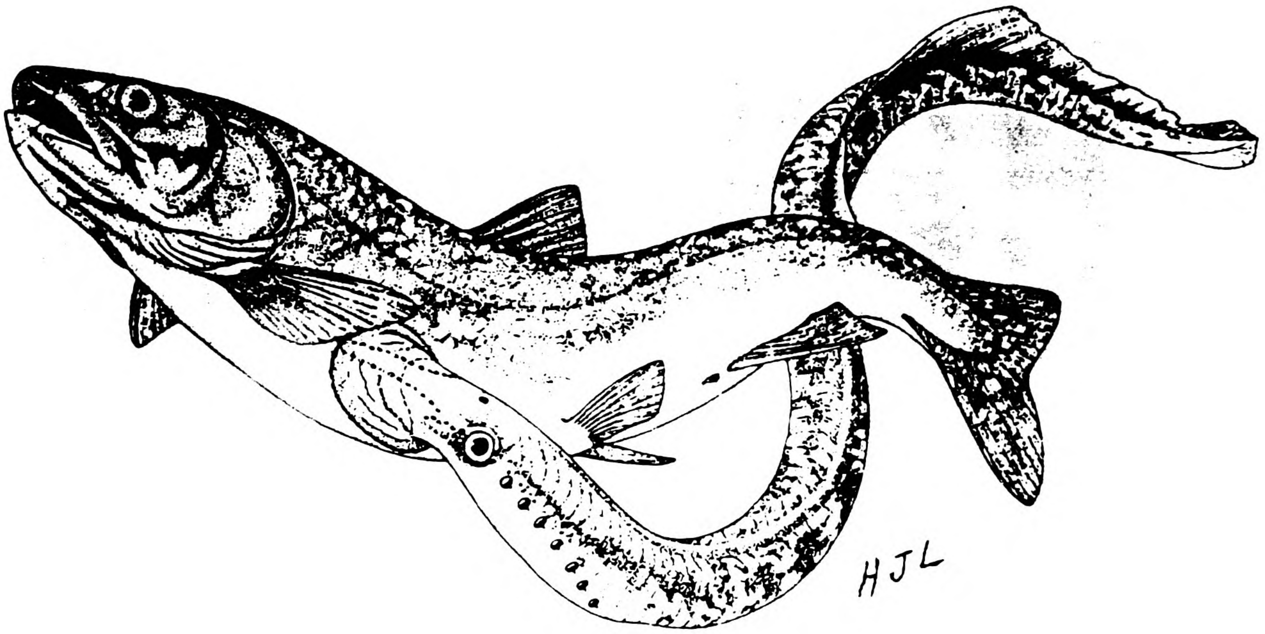
GLFC Annual Meeting
5-7 June, 1995

INTEGRATED MANAGEMENT OF SEA LAMPREYS IN THE GREAT LAKES 1994

ANNUAL REPORT
TO
GREAT LAKES FISHERY COMMISSION



by
Gerald T. Klar
United States Fish and Wildlife Service
Marquette, Michigan
U.S.A.

and

Larry P. Schleen and Robert J. Young
Department of Fisheries and Oceans
Sault Ste. Marie, Ontario
Canada

Dedicated To:

GARY A. STEINBACH (1943-1994)
Fishery Biologist, U.S. Fish and Wildlife Service
Friend and Co-Worker

On September 23, 1994 a tragic accident claimed the life of Gary while he was working on streams near Lake Champlain New York. This report is dedicated to Gary who spent 25 years working to protect the fishery in the Great Lakes.

GARY, A TRIBUTE

He was a quiet man
with a contagious grin
and a gentleness
which came from within.

His dedication to work
and the contributions he gave
were as great as the Lakes
he struggled to save.

Fond memories of Gary
are ours to hold,
a legacy of life
and accomplishments told.

Contents

INTEGRATED MANAGEMENT OF SEA LAMPREYS IN THE GREAT LAKES 1994

Gerald T. Klar
United States Fish and Wildlife Service
Marquette, Michigan 49855

Larry P. Schleen and Robert J. Young
Department of Fisheries and Oceans
Sault Ste. Marie, Ontario P6A 6W4

Executive Summary

This report summarizes integrated management of sea lamprey activities by the U.S. Fish and Wildlife Service and the Department of Fisheries and Oceans Canada in the Great Lakes in 1994. Larval assessment crews surveyed 378 Great Lakes tributaries, inland lakes, and lentic areas to assess TFM treatment or barrier effectiveness, plan future TFM treatments, and establish production capacity of streams. Lampricide treatments were conducted on 57 tributaries (Table 1). Assessment traps were operated in 72 tributaries and captured 55,203 spawning-phase sea lampreys (Table 2).

Fish community objectives for sea lamprey populations as set by the Lake Committees were met in Lakes Superior, Erie, and Ontario in 1994. The uncontrolled population of sea lamprey larvae in the St. Marys River continues to produce an unacceptably high population of parasitic lampreys in Lake Huron that are compromising lake trout rehabilitation in that lake. In addition, parasitic sea lampreys are more abundant in the northern part of Lake Michigan than in the south and likely are a threat to lake trout survival in the rehabilitation refuges and zones.

We continued to monitor the long-term effect of lampricide treatments to macroinvertebrate communities in index rivers as part of our risk assessment of the integrated management program. The priority of protection of lake sturgeon during sea lamprey management activities was ensured by studies in partnership with cooperators to determine distribution of juvenile lake sturgeon and sensitivity of the fish to TFM.

Substantial progress was achieved in advancement of the strategy to control sea lampreys in the St. Marys River. The Task Force delivered the third year of the larval and habitat mapping, the flow patterns and simulated lampricide treatments model, and designs for adult lamprey traps.

Implementation of the sterile male release technique continued in Lake Superior and the St. Marys River. The sterilization facility continues to meet the needs of the program and 17,579 male lampreys were sterilized and released into streams in 1994. A short-term assessment of the technique was conducted on seven streams. Data suggested the sterile males are competitive as far as building and occupying nests, and there were demonstrable effects from sterile males on egg viability. Studies also were conducted for quality assurance and to determine minimum effective dose of bisazir.

The Barrier Task Force held a barrier research workshop, and had drafts accepted in principle of a barrier research strategy as well as an implementation strategy and decision protocol for 171 barrier projects.

We conducted 717 outreach activities that required 245 staff days.

Table 1. Summary of lampricide treatments in streams of the Great Lakes in 1994.

Lake	Number of Streams	Discharge m^3/s	TFM[1,2] kg	Bayer 73[1] kg	Distance km
Superior	20	89.7	9,068	24.0	340.6
Michigan	9	77.3	14,161	114.0	387.7
Huron	17	142.5	12,226	15.1	305.1
Erie	1	14.4	4,337	0	40.2
Ontario	10	26.9	3,187	7.4	176.7
Total	57	350.7	42,979	160.5	1,250.3

[1]Lampricides are in kg of active ingredient.
[2]Includes 571.3 TFM bars (111.8 kg) applied in 24 streams.

Table 2. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of the Great Lakes in 1994.

Lake	Number of Streams	Total captured	Number sampled	Percent males	Mean Length (mm)		Mean Weight (g)	
					Males	Females	Males	Females
Superior	20	969	196	53	412	414	193	193
Michigan	13	14,669	1,415	38	474	482	229	244
Huron	16	34,820	311	46	426	464	247	274
Erie	8	427	235	54	508	502	305	303
Ontario	15	4,318	792	60	477	478	258	268
Total	72	55,203	2,949	48	469	476	242	253

INTRODUCTION

Sea lamprey control is a critical fishery management action delivered to support the fish community objectives developed by the Lake Committees as part of the Strategic Plan for Great Lakes Fishery Management. Objectives for acceptable levels of mortality that allow the establishment and maintenance of self-sustaining stocks of lake trout and other salmonids have been established on all of the lakes. In some cases, the Lake Committees have established specific targets for sea lamprey populations in the Fish Community Objectives or the lake trout rehabilitation plans. The current control program reflects actions by the U.S. Fish and Wildlife Service (Service) and Department of Fisheries and Oceans Canada (Department) as contract agents of the Great Lakes Fishery Commission (Commission) to meet these targets.

The Commission is working in partnership with the Lake Committees through their Lake Technical Committees to refine the current target statements and to develop common target formats for each of the lakes. These targets will consider the costs of control along with the benefits to define the control program that supports the Fish Community Objectives and is ecologically and economically sound and socially acceptable (GLFC 1992). The target for each lake will define the abundance of sea lampreys that can be tolerated and the economically viable level of control (Greig et al. 1991; Greig et al. 1992; Koonce et al. 1993) required to reach the desired suppression.

This report presents the actions of the Service and Department in the sea lamprey management and Task Force areas during 1994. Also, we relate recent trends in sea lamprey abundance to Fish Community Objectives and the Commission vision (GLFC 1992).

COMMISSION VISION

The Commission (GLFC 1992) identified milestones in relation to the "Integrated Management of Sea Lamprey Vision Statement" that included:

Development and use of alternative control techniques to reduce reliance on lampricides to 50% of current levels.

Since the beginning of the use of lampricides in the management program, the Service and Department continuously have increased their efficiency in the use of TFM. The combination of improved analytical, application, and assessment techniques and construction of barriers has reduced TFM use for the period of 1990-94 when compared to 1980-89 (Fig. 1). This decrease has occurred despite the addition of streams with higher TFM requirements (e.g., Michigan and Ontario) because of higher total alkalinity in their tributaries.

LAKE SUPERIOR

TRIBUTARY INFORMATION

- 1,566 (733 United States, 833 Canada) tributaries to Lake Superior.
- 136 (89 United States, 47 Canada) tributaries have historical records of production of sea lamprey larvae.
- 81 (50 United States, 31 Canada) tributaries have been treated with lampricide at least once during 1985-94.
- Of these, 53 (32 United States, 21 Canada) tributaries are treated on a regular (3-5 year) cycle.

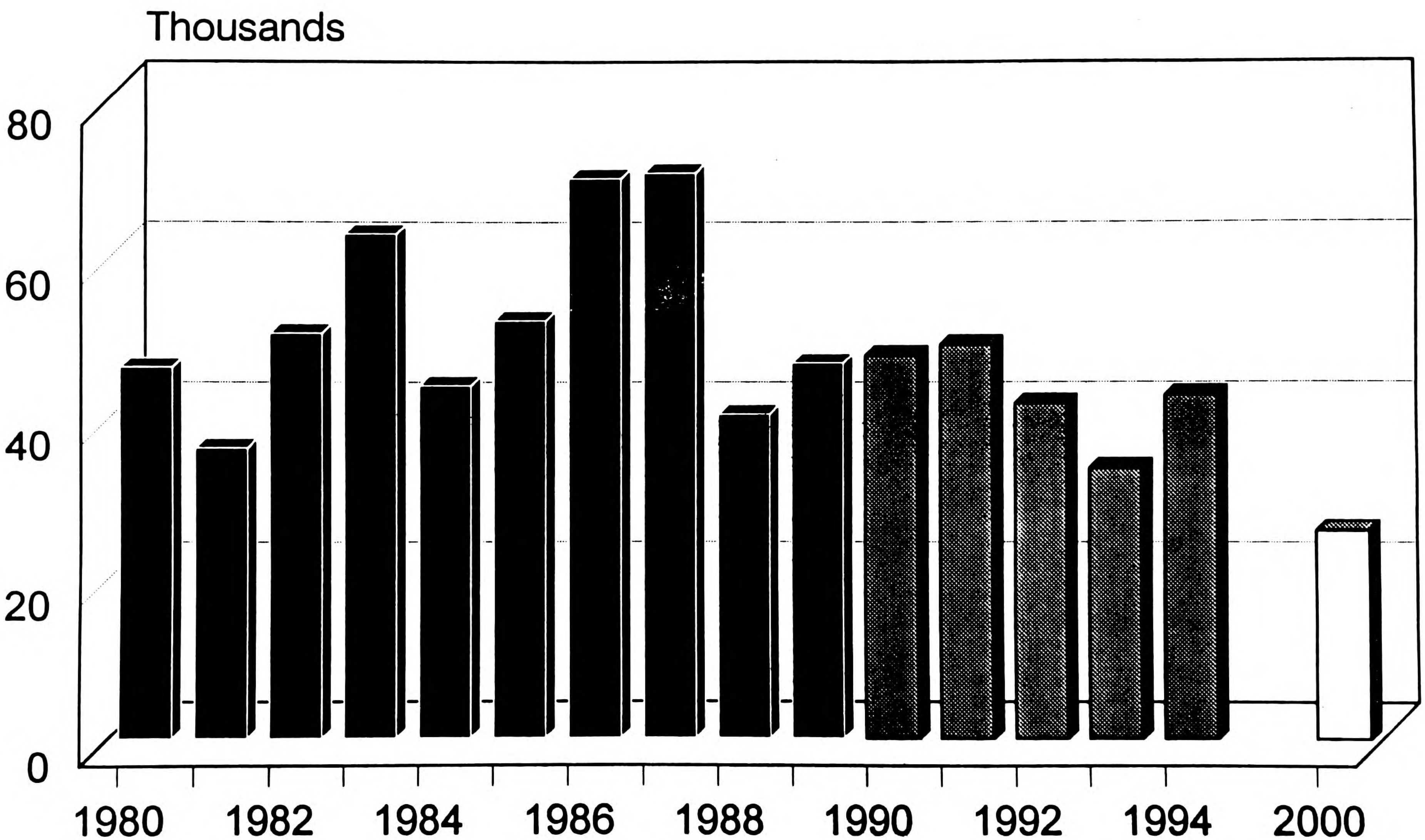


Fig. 1. Average annual use of TFM (active ingredient) during 1980-89 was 52,000 kg and for 1990-94 was 43,000 kg. Target use for 2000 is 26,000 kg.

SEA LAMPREY AND FISH COMMUNITY OBJECTIVES

The Lake Superior Committee established the following specific targets for sea lamprey populations in their Fish Community Objectives (Busiahn 1990):

Achieve a 50% reduction in parasitic-phase sea lamprey abundance by 2000, and a 90% reduction in parasitic-phase sea lamprey abundance by 2010.

Based on estimates of the damage caused by the parasitic-phase population in the mid-1980s, these reductions were established to reflect the need for enhanced control on Lake Superior, with full recognition of the need for further evaluation of the costs of suppressing lamprey to these levels.

This sea lamprey target was developed to support the following objective for the community of lake trout and other salmonids.

Achieve a sustained annual yield of 4 million pounds of lake trout from naturally reproducing stocks, and an unspecified yield of other salmonid predators, while maintaining a predator/prey balance which allows normal growth of lake trout.

Naturally reproducing stocks of lake trout can only be maintained with a total annual mortality of less than 45% (Lake Superior Lake Trout Technical Committee 1986; Lake Superior Technical Committee 1994). Reaching this objective for total mortality requires a combination of regulation of fishery exploitation and control of sea lamprey abundance.

The Service maintains an extensive trapping network for spawning-phase sea lampreys in index streams of the south shore of Lake Superior and annually estimates populations east and west of the Keweenaw Peninsula (Fig. 2). Populations east of the Peninsula generally remained stable during 1987-93 and declined substantially in 1994, while populations to the west generally declined during 1989-93 and continued with a substantial drop in abundance in 1994. The program has achieved the sea lamprey target for Lake Superior (50% decline by 2000) in 1994, but population estimates for all previous years are within historical limits. Continued measurement of the long-term trend will determine if the current situation is the bottom in cyclical abundance in Lake Superior.

LARVAL ASSESSMENT

United States

Surveys were conducted to prepare for lampricide treatments, assess the success of past treatments, monitor reestablished populations of larval sea lampreys, and search for new infestations of larvae in 94 Lake Superior tributaries. Surveys to schedule lampricide applications were conducted in 26 streams. Of these, 6 were successfully treated, 4 were scheduled for treatment in 1995, and the remaining 16 were deferred. Sea lamprey larvae that remained from past treatments were found in 19 streams, but comprised less than 5% of the total number of larvae collected in all streams. Larvae had reestablished in 36 of the streams that were surveyed. An estuarine survey was conducted in one stream, and an offshore survey was conducted near another. Original surveys to search for new infestations were conducted in 39 streams and no larvae were found.

Surveys to assess recruitment of the 1994 year class were conducted in 50 streams (41 streams examined annually and 9 streams on a triennial schedule). Young-of-the-year larvae were recovered in 26 of the 41 streams surveyed annually. Larvae have not been detected for 6 or more years in the other 9 streams.

The population of larval sea lampreys was estimated in the Huron River using two techniques (Table 3). The first technique used the established random transects habitat-based method and the second compared a computer based model that employs habitat suitability indices to predict abundance.

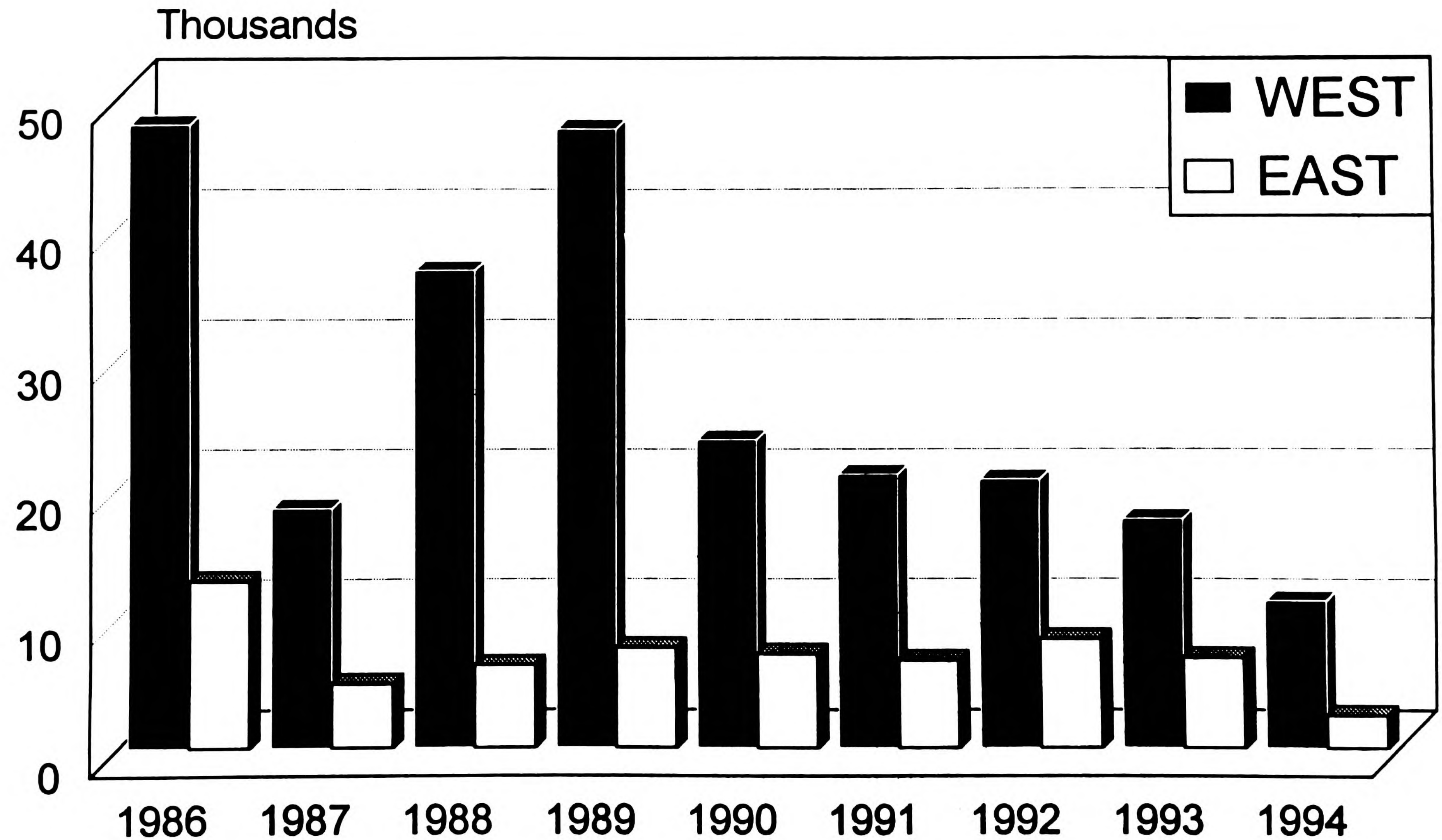


Fig. 2. Estimated number of spawning-phase sea lampreys in U.S. waters (west and east of Keweenaw Peninsula) of Lake Superior, 1986-94.

ble 3. The estimated amount of habitat (m^2) for sea lamprey larvae, density (larvae/m^2), total number of year classes in the population, total larvae, number 120 mm, and the number of transformers in the Huron River of Lake Superior, 1994. (This table is a continuation of account for estimates of production capacity larvae for all major lamprey producing tributaries in U.S. waters of the lake. The work began in 1988 and is conducted in the year of a lampricide treatment.)

iver	Method of Estimation	Area of Habitat Types[1] I	II	III	Density of Larvae[2] I	II	Year Classes[3]	Total Larvae and transformers[4]	Number > 120 mm	Number of transformers[5]
ron River	Random transects[6]	34,158	144,225	11,386	2.72	0.01	4	106,815	6,218	684

ype I habitat is considered preferred for sea lampreys, type II is acceptable though not preferred, and type III is uninhabitable.
he density of larvae in type III habitat is 0.
he 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 (≤ 25 mm) are t included as a year class. Some residuals also are present in almost all populations, but these also are not included in the year classes because exact measurement of age of each residual is beyond the scope of this study.
[4]The total is a summation of type I and II estimates and does not include young of the year.
[5]The number of transformers was estimated by taking a percentage of the larvae ≥ 120 mm. The percentage is based upon the ratio of the number of transformed larvae to those ≥ 120 mm in fall treatment collections.
[6]The random transect method is a measurement of the amounts of habitat on randomly selected 1.5 m wide transects across the river at predetermined intervals, and the amounts are expanded to include the unmeasured area.

The random transects population estimate was obtained by measuring area of larval habitat within 1.5 m wide transects spaced every 110 m along the stream. Stream bottom was categorized based on potential for habitation by larval lamprey: type I habitat is preferred, type II is acceptable though not preferred, and type III is uninhabitable.

Lamprey densities on a transect were determined by a depletion method using electrofishing units. Delineated areas of type I and II habitat in a transect were sampled one or more times. The number of lampreys captured in each sample in successive passes estimated larval density. All lampreys were identified, counted, measured for total length, and removed from the stream.

The total infested area of the stream and the estimated area and the estimated mean larval density in each habitat type were combined to estimate the total number of larvae (excluding young of the year, $\leq$ 25 mm) in the river. The number of larvae $\geq$ 120 mm (minimum length at which transformation occurs) also was estimated. The number of transformers was calculated by applying a percentage specific for the Huron River to the total number of larvae $\geq$ 120 mm. This percentage was based upon previous collections of larvae during fall lampricide treatments.

The habitat suitability method includes physical measurements of suitable habitat to predict larval lamprey numbers. The model is a modification of the Instream Flow Incremental Methodology and Physical Habitat Simulation techniques developed by Bovee (1982). The stream channel component of the model predicts habitat distribution throughout the stream and a biological component of the model (Ferrari 1990) then predicts larval lamprey abundance, growth, and survival.

Data inputs for the model include annual number of spawning-phase lampreys, stream width, average depth, and total discharge. The estimated number of spawners (644) was obtained from an approximation of 46 spawners per cfs based on a regression of stream flow to the number of spawners ascending a stream. Stream width and depth were measured at each transect. Total discharge was measured a short distance upstream from the stream mouth.

The random transects estimate of larval lampreys in type I habitat was 92,909 (53,371-136,150) and in type II was 13,906 (9,471-23,467) for a total stream estimate of 106,815 (Table 3). The estimated number of transformers was 684.

The estimated number of larval lampreys obtained by the habitat suitability indices method was 35,615 of which an estimated 106 were transformers. The habitat suitability model inaccurately placed a significant amount of spawning habitat a short distance upstream from the estuary and measurements failed to predict spawning habitat in the upper reaches of the river. Consequently, the model virtually eliminated 8.5 km of larval habitat that the random transects method demonstrated was present in the river and was the result of the wide difference in the 2 estimates. While habitat suitability indices show potential to predict available habitat for sea lamprey larvae, this test demonstrated a substantial under estimation when applied to the Huron River.

Canada

The Department conducts larval sea lamprey surveys annually in Lake Superior tributaries to estimate population abundance and establish range distribution to schedule TFM treatments in the following year. The standard techniques normally used in larval assessment include backpack electrofishing (shallow streams) and Bayer 73 surveys (deep water). In 1994, 31 streams were surveyed to assess larval sea lamprey populations.

Distribution Surveys:

Distribution surveys were completed on nine streams in anticipation of possible treatment in 1995 (Goulais, Chippewa, Gargantua, Michipicoten, Pic, Steel, and Little Gravel rivers and Cash and Polly creeks). No significant change was observed in larval distribution within these streams.

Treatment Evaluation and Larval Reestablishment:

Treatment evaluation surveys were completed on the five tributaries treated in 1993 (Big and Little Carp, Goulais, Pancake, and Pays Plat rivers). Low densities of the 1992 and 1993 year classes were collected from the Pays Plat, and a moderate population was observed in the Goulais (see "Quantitative Assessment"). No residual larvae were collected from the remaining streams.

Spring/summer surveys showed re-established populations of the 1993 cohort in Big Carp, Pancake, Jackfish, and Kaministiqua rivers. Fall surveys collected the 1994 cohort in the Goulais, Chippewa, and Pancake rivers.

Larval sea lampreys were found for the first time in almost 30 years in Westman Creek, which was last treated in 1966. Both the 1992 and 1993 year class are present in this small Batchawana Bay tributary.

No larval sea lampreys were found in re-establishment surveys of West Davignon, Cranberry, and Stokely creeks or the Little Carp and Harmony rivers.

Barrier Evaluation:

a) Low-head barriers

Barrier dams on Stokely, Sheppard, and Gimlet creeks and on Carp, Wolf, and Neebing rivers were all effective at blocking the 1993 spawning run.

b) Velocity barrier

Assessment of the experimental velocity barrier, built on the McIntyre River in August 1993, continued with the sampling of larval lamprey index sites located both above and below the structure. We completed surveys in early July before the lampricide treatment (July 18-21) and again following treatment in September.

Before treatment, catch per hour of electrofishing (CPUE's) for sea lamprey larvae were 28 above and 39 below the barrier. No sea lamprey larvae were collected in the September surveys.

Quantitative Assessment:

a) Index surveys

Department staff surveyed index sites on most sea lamprey producing tributaries to determine year class structure and predict abundance of metamorphosing larvae in 1995. Population estimates based on the index surveys were used to schedule stream treatments in 1995 and provide baseline data to evaluate the sterile male release technique.

b) Little Pic River population estimate

The Little Pic River is a medium sized (15 m^3/s) sea lamprey producing stream located on the north shore of Lake Superior. The stream is characterized by highly erosive and unstable silt, sand, and clay banks which result in high turbidity year round. Sea lamprey spawn in the Little Pic River annually but larval density is low in the 35.5 km of main stem distribution. However, an abundance of marginal habitat, deep and turbid water, and very difficult access make for poor survey conditions. The combination of large potential habitat, poor collecting conditions, and relatively large use of TFM has resulted in uncertainty in scheduling the stream for treatment. In 1994, we initiated a mark and recapture study to more precisely quantify the larval population.

We subjectively classified larval habitat as type I (preferred), II (possible but not preferred), or III (unsuitable) throughout the distribution along transects spaced 1000 m apart. Sampling crews were unable to consistently differentiate between type I and II habitat and consequently were lumped for this analysis. Type I & II habitat in the main stem of the Little Pic totalled 400,746 m^2 and comprised 43.4% of the total substrate.

Larval densities were estimated at 5 sites of approximately 500 m each in length. Approximately 450 larvae were tail clipped and released into each study area. During the lampricide treatment larval lampreys were collected using scap and fyke nets. Distribution was limited to the uppermost 11 km and lowermost 3.5 km of stream. Larval densities were low in the upstream and downstream regions, ranging from 0.21/m^2 to 0.28/m^2 in type I/II habitat, respectively. We estimated the population of the upstream reach at 34,820 larvae. Similarly, the population of the downstream reach was estimated at 16,680, for a total river estimate of 51,500. The size of the sea lamprey larvae collected throughout the river was, on average, very large (121.7 mm) with 119 of the 224 collected (53%) being ≥ 120 mm in length. We found the average length of recaptured larvae to be 79.2 mm (n = 40) whereas the length of released larvae averaged 67.2 mm (n = 1,844). Despite the large average size, no metamorphosing larvae were collected. We suspect high discharge flushed the metamorphosing larvae to the lake before the treatment.

c) Goulais River residual estimate

The Goulais River is a highly productive stream, complicated by numerous tributaries, lagoons, and ground water pick up. Our treatment evaluation in 1993 suggested a significant residual population existed, based on a relatively small sampling effort. In 1994, we increased our sampling effort to more precisely define the size of the residual population in order to assess the need for retreatment.

Habitat was subjectively classified (see Little Pic River above) at 0.5 km intervals along the main stem, totalling 80.5 km and those parts of the eight tributary streams historically infested, totalling 28.2 km. We estimated 2.38 X 10^6 m^2 of suitable habitat of which 3.1 X 10^5 m^2 (12.8 %) was type I. Most (~60%) type I habitat is concentrated in the upstream reach (upper 48.5 km).

Larval densities were determined by sampling 36 randomly selected sites using electrofishers. Sampling efficiency, determined by mark-recapture in six of the survey sites, averaged 12.81% (range 3.1 - 24.5%). Our estimate of residuals in type I habitat in the upstream reach was 99,900 larvae of which 18,200 were ≥ 120 mm in length. The extent of type II habitat use in this reach is unknown but may be 10% of type I, based on past sampling. Sampling results suggest that the tributary streams and the downstream reach do not have significant residual populations.

The Goulais River has been scheduled for treatment in late 1995, at which time we intend to verify the findings of this study.

LAMPRICIDE MANAGEMENT

United States

Lampricide treatments were conducted in 10 Lake Superior tributaries with a combined discharge of 26.5 m^3/s (Table 4, Fig. 3). All treatments successfully removed sea lamprey populations, however marginally effective TFM concentrations were recorded on a few short distances on Red Cliff Creek and the Traverse and Huron rivers. Sea lamprey larvae were most abundant in the Chocolay, Traverse, Huron, Sturgeon, and Amnicon rivers; significant numbers of transformed larvae also were collected in each of these streams. The Falls River was treated to prevent development of a lentic population off the stream mouth. Nontarget mortality was insignificant on all treatments.

Less than optimal stream discharges caused minor problems during two treatments. The Traverse River and Red Cliff Creek were treated during low stream discharge, and beaver dams in the streams caused lampricide concentrations to be lower than desired in downstream areas. High stream discharge delayed completion of treatments in the Huron and Amnicon rivers.

Treatment of the Bad River, scheduled for August, was deferred when access permission was denied by the Bad River Band of Lake Superior Chippewa Indians.

Municipal water systems at L'Anse and Marquette, Michigan were monitored for TFM contamination after treatments of the Falls and Chocolay rivers. No TFM was detected in either water supply.

The Kinetics TFM formulation was field tested during treatments of the Chocolay, Amnicon, and Sturgeon rivers. Although sediment was found in the Kinetics TFM containers the formulation was usable in normal summer temperatures. Cold air temperatures late in the treatment season caused crystallization which rendered the formulation unusable.

Canada

A total of eleven (11) streams were scheduled for treatment in 1994. Successful treatments were completed on the Carp, Batchawana, Little Pic, Prairie, Gravel, Cypress, Wolf, Cloud, and Pigeon Rivers and Neebing/McIntyre Floodway (Table 4, Fig. 3). The Black Sturgeon River treatment was postponed for the second consecutive year due to high discharge. Sea lamprey larvae were abundant in the Batchawana and Wolf Rivers and less abundant in the remaining treated watersheds. Non-target mortality was insignificant in all treatments.

Application of lampricide for the first time from the low-head barrier dam site on the Wolf River reduced treatment distance approximately 50% and lampricide quantities by approximately 10% compared to previous treatments of the system.

Table 4. Details on the application of lampricide to streams of Lake Superior, 1994. (Number in parentheses corresponds to location of stream in Fig. 3.)

Stream	Date	Discharge m³/s	TFM[1,2] kg	Bayer 73[1] kg	Distance km
UNITED STATES					
Red Cliff Cr. (8)	Jun 4	0.1	3	-	1.6
Sucker R. (2)	Jul 16	2.4	347	-	54.7
Traverse R. (7)	Aug 12	0.1	36	-	14.5
Betsy R. (1)	Aug 12	1.3	93	-	16.1
Chocolay R. (3)	Aug 27	3.8	606	-	38.6
Falls R. (5)	Sep 23	0.7	70	-	1.6
Huron R. (4)	Sep 25	0.9	126	-	14.5
Middle R. (9)	Sep 26	2.3	142	-	8.0
Sturgeon R. (6)	Oct 9	12.7	1,354	-	66.0
Amnicon R. (10)	Oct 19	2.2	188	-	16.1
Total		26.5	2,965	-	231.7
CANADA					
Carp R. (19)	Jun 15	1.3	86	-	11.3
Batchawana R. (20)	Jul 5	6.6	507	-	13.0
Cloud R. (12)	Jul 14	0.2	30	-	7.4
Neebing/McIntyre Floodway (13)	Jul 18	3.7	448	-	10.6
Cypress R. (15)	Jul 21	4.0	109	-	5.5
Pigeon R. (11)	Jul 22	14.7	803	11.9	4.9
Gravel R. (16)	Jul 23	9.0	445	6.9	16.1
Wolf R. (14)	Jul 25	8.3	1,215	-	5.5
Prairie R. (17)	Jul 27	5.3	341	5.2	3.9
Little Pic R. (18)	Sep 8	10.1	2,119	-	30.7
Total		63.2	6,103	24.0	108.9
GRAND TOTAL		89.7	9,068	24.0	340.6

[1]Lampricides are in kg of active ingredient.
[2]Includes a total of 280 TFM bars (54.5 kg) applied in 10 streams.

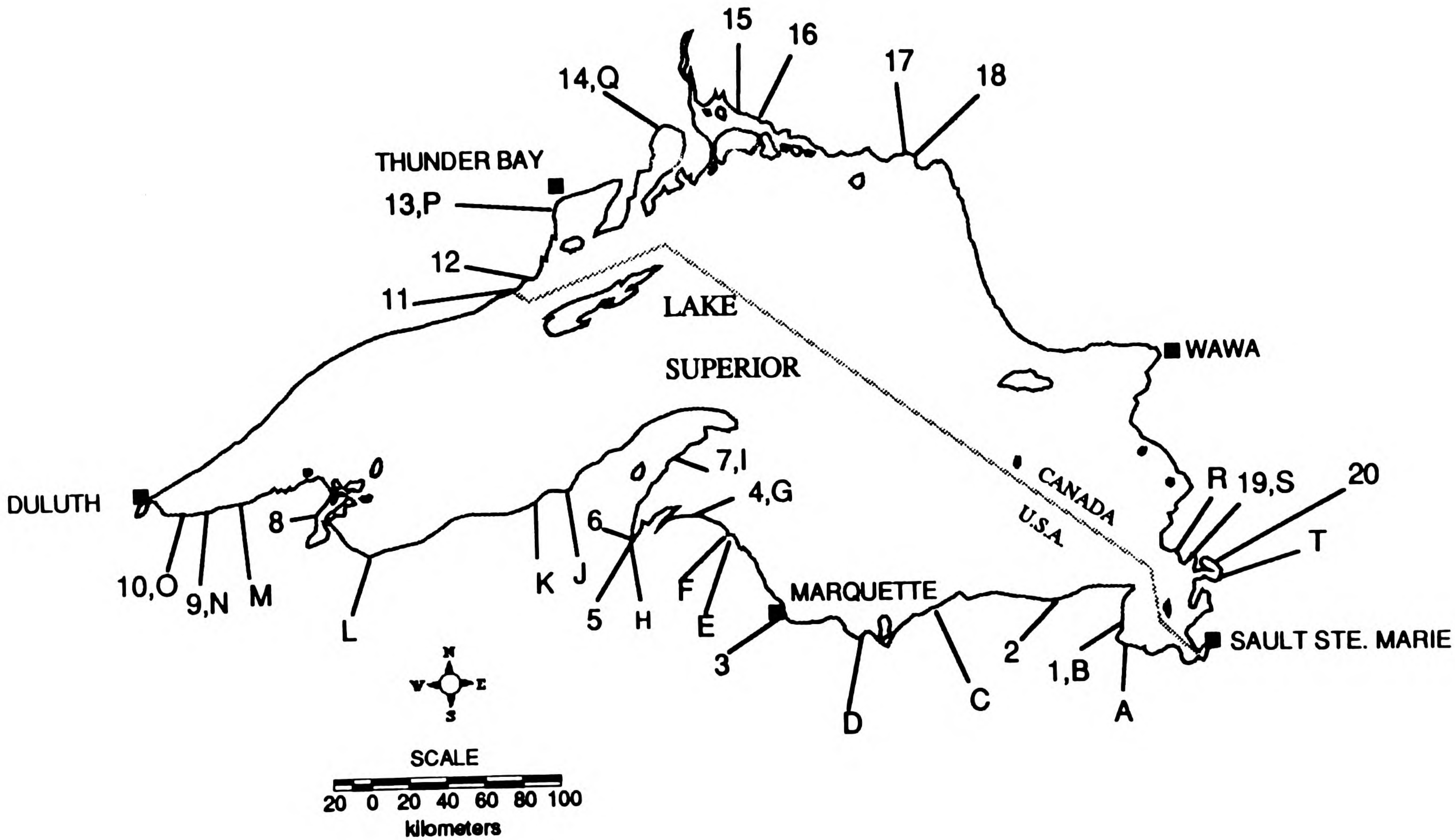


Fig. 3. Location of Lake Superior tributaries treated with lampricides (Numerals, see table 4 for names of streams) and of streams where assessment traps were operated (Letters, see table 5 for names of streams) in 1994.

SPAWNING-PHASE ASSESSMENT

United States

Assessment traps placed in 15 tributaries of Lake Superior captured 789 spawning-phase sea lampreys (Table 5, Fig. 3). This is significantly less than the 5-year average (1989-1993) of 4,715 (2,681-6,910) in the same streams. The Brule River trap which captured an average of 2,058 (780-3,705) lampreys during 1989-1992 captured only 133 in 1993 and 5 in 1994.

Spawning runs were monitored through cooperative agreements in eight streams with the Great Lakes Indian Fish and Wildlife Commission (Amnicon, Middle, Bad, Firesteel, Misery, Traverse, Silver, and Huron rivers), and in the Brule River with the Wisconsin Department of Natural Resources.

The total number of spawning-phase sea lampreys was estimated in U.S. waters of Lake Superior based on a relation of average stream discharge (x) and the estimated number of adult lampreys that enter tributaries (y) (Table 6). The estimated number of lampreys that enter tributaries is determined from mark/recapture studies, predictive linear regressions relating past years trap catch to mark/recapture estimates, or trap efficiencies from past years mark/recapture studies. The relation between discharge and population estimates was calculated separately for streams west and east of the Keweenaw Peninsula. In western waters, an estimated 11,199 lampreys were present ($y=148.25x$; $r^2=0.55$; $P<0.50$), while 2,489 lampreys were estimated ($y=34.85x$; $r^2=0.91$; $P<0.05$) east of the Keweenaw Peninsula. The total estimate of 13,688 sea lampreys was calculated using a combined flow of 171.73 m^3/s (96.31 m^3/s west and 75.42 m^3/s east). This is less than the Lake Superior 5-year average (1989-1993) of 33,230 (24,239-55,032).

Canada

We collected spawners from 5 streams (Table 6, Fig. 3) using barrier traps (4 streams) and hoop nets (1 stream) to assess long term trends in population abundance. Spawners from the Pancake and Wolf rivers were used in short-term studies of the sterile male programme and a telemetry study carried out by the Great Lakes Laboratory for Fisheries and Aquatic Sciences to estimate the spawning runs by stratified mark-and-recapture. Biological information (sex ratio, length, weight) was obtained from the Wolf River.

No catch was made in Stokely Creek. We estimated the Carp River run at 106, with an efficiency of 31% based on catch to estimate ratios. Results from the new McIntyre permanent trap yielded a stratified estimate of 378 spawners with a trapping efficiency of 17%. We suspect that lake seiche effects reduced catchability at this location.

The Pancake River was sampled at 3 locations: 1) the estuary, 2) Gimlet Creek, and 3) 5 km above the mouth on the main stem, at a site known as the "ford," using Susquehanna hoop nets.

Despite the more intensive effort we did not capture sufficient lampreys for a stratified population estimate. A Petersen estimate, incorporating the males used in the telemetry study, suggested a run of 221 spawners and a combined trapping efficiency of 10%.

The Wolf River barrier trap collected 61 spawners. Ten males were provided to the Great Lakes Laboratory for Fisheries and Aquatic Sciences for their telemetry study, 17 adults were sampled for biological information, and another 17 adults were used for the instream mark-recapture study.

We did not recapture sufficient adults for a stratified population estimate. A simple Petersen estimate yielded a run of 519 and an efficiency of 12%.

Table 5. Number, estimated spawning population, and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Superior, 1994. (Letter in parentheses corresponds to location of stream in Fig. 3.)

	Number captured	Estimated spawners	Number sampled[1]	Percent Males[2]	Mean Length (mm)		Mean Weight (g)	
					Males	Females	Males	Females
UNITED STATES								
Tahquamenon R. (A)	216	See	57	68	431	429	202	194
Betsy R. (B)	9	Table 6	0	-	-	-	-	-
Miners R. (C)	5		1	100	348	-	208	-
Rock R. (D)	87		11	54[2]	257	275	147	162
Big Garlic R. (E)	0		0	-	-	-	-	-
Iron R. (F)	10		0	-	-	-	-	-
Huron R. (G)	2		0	-	-	-	-	-
Silver R. (H)	5		0	-	-	-	-	-
Traverse R. (I)	0		0	-	-	-	-	-
Misery R. (J)	283		86	49[2]	425	414	186	188
Firesteel R. (K)	10		0	-	-	-	-	-
Bad R. (L)	110		8	38	434	406	205	156
Brule R. (M)	5		5	80	407	442	247	225
Middle R. (N)	11		1	100	367	-	187	-
Amnicon R. (O)	36		10	60	396	418	153	184
Total or average	789		179	53[2]	413	410	191	186
CANADA								
McIntyre R. (P)	65	378	0	-	-	-	-	-
Wolf R. (Q)	61	519	17	41	393	443	226	240
Pancake R. (R)	21	221	0	71[2]	-	-	-	-
Carp R. (S)	33	106	0	-	-	-	-	-
Stokely Cr. (T)	0	-	0	-	-	-	-	-
Total or average	180		17	58	393	443	226	240
GRAND TOTAL OR AVERAGE	969		196	53[2]	412	414	193	193

[1]The number of lampreys from which all length and weight measurements were determined.
[2]Percent males generally was determined from internal body examination of the number sampled. In 4 rivers, additional lampreys were examined externally for secondary sexually characteristics to determine percent males. The rivers and total or average, the number examined externally, and (in parentheses) the combined number sampled are: United States, Rock-71 (82), Misery-194 (280), Total or average-265 (444); Canada, Pancake-22 (22); Grand total or average-287 (466).

PARASITIC-PHASE ASSESSMENT

United States

A total of 12 parasitic-phase sea lampreys were collected from Lake Superior commercial operators in 1994 (Table 7). All of these were collected in management unit MI-8 (Brimley, Michigan area). The lampreys were attached to fish captured in gill nets and primarily were attached to lake trout.

Sport anglers captured 13 parasitic-phase sea lampreys in 1994 (Table 8). Charterboat anglers captured 11 lampreys and noncharter anglers captured 2. Anglers in management unit WI-2 (Bayfield, Wisconsin) contributed the largest number of lampreys. Lampreys primarily were attached to lake trout (Table 9).

Table 6. **Mean discharge for U.S. streams east and west of Keweenaw Bay in Lake Superior from May 6-June 30, 1986-1990, ra as primary and secondary producers of sea lampreys, and the estimated number of spawning phase sea lampreys in 1994.**

[Population estimates were calculated from results of stratified multiple mark/recapture studies, predictive regressions rela past years trap catch to mark/recapture estimates, or trap efficiencies from mark recapture studies conducted from 1986-9 7 of 15 streams with traps. A simple linear regression estimates populations for all streams by the relation of mean st discharge to the number of lampreys entering the 7 tributaries.]

PRIMARY STREAMS			
STREAM	DISCHARGE m^3/s	POPULATION ESTIMATE MARK/RECAP.	POPULATION ESTIMATE REGRESSION
WEST			
Nemadji River	13.87	-	2,056
Amnicon River	6.80	-	1,008
Middle River	1.42	-	211
Brule River	5.52	7	818
Red Cliff River	0.03	-	4
Bad River	12.37	2,135	1,834
Ontonagon River	29.18	-	4,326
East Sleeping River	0.74	-	110
Firesteel River	1.90	-	282
Misery River	1.39	748	206
Subtotal (West)	73.22	2,890	10,855
(w/traps)	29.40	2,890	4,359
(w/o traps)	43.82	-	6,496
EAST			
Traverse River	0.59	-	21
Sturgeon River	17.18	-	599
Falls River	1.73	-	60
Silver River	1.95	24	68
Slate River	0.54	-	19
Ravine River	0.59	-	21
Huron River	3.08	-	107
Salmon Trout River	1.58	-	55
Iron River	2.80	-	98
Big Garlic River	0.42	-	15
Little Garlic River	0.31	-	11
Harlow Creek	0.57	-	20
Chocolay River	2.91	-	101
Rock River	0.93	175	32
Au Train River	3.03	-	106
Furnace Creek	0.17	-	6
Miners River	1.08	10	38
Sucker River	2.12	-	74
Two Hearted River	6.14	-	214
Little Two Hearted River	0.96	-	33
Betsy River	2.09	-	73
Tahquamenon River	18.65	649	650
Waiska River	1.53	-	53
Subtotal (East)	70.95	858	2,474
(w/traps)	31.59	858	1,102
(w/o traps)	39.36	-	1,372
Primary Lake Total	144.17	3,748	13,329

SECONDARY STREAMS		
STREAM	DISCHARGE m^3/s	POPULATION ESTI REGRESSI
WEST		
Washington Creek	0.82	12
Arrowhead River	9.82	146
Poplar River	1.27	19
Gooseberry River	0.08	1
Split Rock River	0.28	4
Sand River	0.31	5
Black River	2.75	41
Cranberry River	1.70	25
Potato River	1.02	15
Elm River	0.59	9
Salmon Trout River	1.25	19
Fish Creek	2.21	33
Poplar River	0.99	15
Subtotal (West)	23.09	344
EAST		
Big Gratiot River	0.34	1
Eliza Creek	0.03	0
Dead River	1.42	5
Sand River	0.45	2
Five Mile Creek	0.06	0
Beaver Lake Outlet	0.48	2
Sable Creek	0.28	1
Galloway Creek	0.11	0
Pendills Creek	0.59	2
Laughing Whitefish River	0.71	2
Subtotal (East)	4.47	15
Secondary Lake Total	27.56	359

TOTAL SOUTH SHORE DISCHARGE: 171.73 m^3/s

TOTAL SOUTH SHORE POPULATION ESTIMATE: 13,688

Table 7. Number[1] of parasitic-phase sea lampreys collected in commercial fisheries in U.S. waters of the Upper Great Lakes in 1994.

Lake Superior		Lake Michigan		Lake Huron	
Unit	Number	Unit	Number	Unit	Number
MN-1	-	MM-1	-	MH-1	833
MN-2	-	MM-2	-	MH-2	27
MN-3	-	MM-3	3	MH-3	-
WI-1	-	MM-4	-	MH-4	27
WI-2	0	MM-5	18	MH-5	-
MI-1	-	MM-6	-	MH-6	-
MI-2	-	MM-7	0		
MI-3	0	MM-8	0		
MI-4	0	WM-1	-		
MI-5	0	WM-2	3		
MI-6	0	WM-3	14		
MI-7	-	WM-4	-		
MI-8	12	WM-5	-		
		WM-6	-		
		Ill.	-		
		Ind.	-		
Total	12		38		887

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

Table 8. Number[1] of parasitic-phase sea lampreys collected in sport fisheries in U.S. waters of the Upper Great Lakes in 1994.

	Lake Superior			Lake Michigan			Lake Huron	
Unit	Charter[2]	Noncharter	Unit	Charter[2]	Noncharter	Unit	Charter[2]	Noncharter
MN-1	0	0	MM-1	-	-	MH-1	99	10
MN-2	-	-	MM-2	-	-	MH-2	106	55
MN-3	-	-	MM-3	13	1	MH-3	80	178
WI-1	0	0	MM-4	7	-	MH-4	6	0
WI-2	5	1	MM-5	71	0	MH-5	54	0
MI-1	2	0	MM-6	51	4	MH-6	3	1
MI-2	0	0	MM-7	24	2			
MI-3	0	0	MM-8	47	6			
MI-4	-	-	WM-1	0	8			
MI-5	4	1	WM-2	1	2			
MI-6	-	-	WM-3	5	5			
MI-7	-	-	WM-4	9	3			
MI-8	-	-	WM-5	12	19			
			WM-6	14	3			
			Ill.	2	-			
			Ind.	-	-			
Total	11	2		256	53		348	244

[1]A zero (0) indicates sampling effort with negative results and a dash (-) indicates no effort.
[2]The Michigan and Wisconsin Departments of Natural Resources provided data on the occurrence of parasitic-phase sea lampreys in charterboat catches.

Table 9. Incidence of sea lampreys and numbers of lake trout and chinook salmon[1] taken by operators in the Michigan and Wisconsin charterboat fishery, 1994.[2]

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

Lake and District[3]	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-1	0.9	1,122	0.0	6
MI-2	0.6	1,610	0.0	3
MI-4	5.1	275	0.0	0
MI-5	0.1	1,951	0.0	12
MI-6	1.4	947	0.0	2
MI-7	1.1	184	0.0	0
All Units	0.8	6,089	0.0	23
Michigan				
MM-1	0.0	0	0.0	0
MM-3	0.8	1,598	0.0	45
MM-4	0.7	1,018	0.0	153
MM-5	0.9	7,421	0.6	984
MM-6	0.8	3,731	0.4	3,846
MM-7	0.4	3,836	0.3	3,076
MM-8	0.3	12,351	0.1	3,416
WM-2	0.0	77	0.0	3,145
WM-3	0.4	555	0.0	3,020
WM-4	0.1	2,846	0.1	5,849
WM-5	0.1	3,789	0.0	5,412
WM-6	0.3	5,008	0.0	527
Ill.	0.1	1,937	0.2	439
All Units	0.2	44,167	0.1	29,912
Huron				
MH-1	5.8	86	8.3	909
MH-2	3.5	145	13.3	708
MH-3	12.1	390	6.3	928
MH-4	2.5	79	5.5	73
MH-5	1.7	1,913	3.1	669
MH-6	0.0	69	1.1	276
All Units	3.4	2,682	7.2	3,563

[1]Lake trout and chinook salmon are the primary target species of the charter fishery of the Upper Great Lakes.
[2]The Michigan and Wisconsin Departments of Natural Resources provided data on the occurrence of parasitic-phase sea lampreys in charterboat catches.
[3]Data were not obtained from units MI-3, MI-8, WI-1, WI-2, MM-2, WM-1 and Indiana.

BARRIER PROGRAM

Canada

McIntyre River Velocity Barrier:

Evaluation of the new velocity barrier took place in 1994. The work included compiling stage-discharge and stage-velocity profiles of the barrier at six different discharges, observing, timing and gathering fish passage information, and evaluating performance of the material used to prevent lamprey attachment.

The barrier functioned quite well in 1994, blocking all sea lamprey other than a few that were able to pass during a flood on June 17, estimated at 32 m^3/s. Three nests were found upstream shortly after the flood. No sea lamprey larvae were found in late summer surveys in the river. One of the goals of the barrier was that of passing non-jumping fish. This was achieved since the barrier appeared to provide very little impediment to the passage of white suckers.

Big Carp Creek:

Engineering planning, an environmental assessment document, and development of innovative plans for a modular automatic-adjusting inflatable crest were carried out in 1994. Construction is planned for February of 1995.

Nipigon River:

Preliminary engineering and planning work for a built-in lamprey trap with attractant flow was carried out. Site soil boring will be required and the earliest possible construction will be summer 1995.

Pays Plat River:

Correspondence and photos describing sea lamprey barriers were sent to Chief Aime Bouchard and the council of Pays Plat Reserve in response to the Band's request for alternative control techniques for the Pays Plat River.

Cash Creek:

Discharges and water levels were taken in May near the proposed barrier site. Cash Creek is one of the higher ranked barrier possibilities.

Barrier Maintenance:

Maintenance work was carried out at lamprey barriers on Gimlet, Carp, and Stokely creeks and on the Wolf and McIntyre rivers. This work included addition of steel sheet piling, lowering the crest elevation, and adding a built-in trap to the Gimlet Creek barrier and placing rip-rap and mortar on parts of the banks at the McIntyre barrier where vandals often removed stone on the site.

LAKE MICHIGAN

TRIBUTARY INFORMATION

- 511 United States tributaries to lake.
- 121 United States tributaries have records of production of sea lamprey larvae.
- 70 United States tributaries have been treated with lampricide at least once during 1985-94.
- Of these, 36 United States tributaries are treated on a regular (3-5 year) cycle.

SEA LAMPREY AND FISH COMMUNITY OBJECTIVES

The Lake Michigan Committee currently is revising the draft Fish Community Objectives it developed in 1990. The 1990 draft does not have an explicit target for sea lampreys, instead the Lake Michigan Committee recommends the general strategy of "reducing residual lamprey populations further" with an integrated program of new technologies in addition to lampricide control. Current drafts being considered by the Lake Michigan Committee maintain a general objective that sea lampreys must be "suppressed to tolerable levels" to "restore and maintain the biological integrity of the fish community so that production of desirable fish is sustainable and ecologically efficient."

The original and current drafts of the Fish Community Objectives have explicit expectations for the establishment of self-sustaining lake trout populations capable of sustaining yields comparable to those experienced in the sustained historic fishery. To achieve and maintain a suitable spawning population a target total annual mortality of less than 40% must be met (Lake Michigan Lake Trout Technical Committee 1985). Control of sea lamprey populations and fishery exploitation will be necessary to meet this mortality objective. The lake-wide management plan specifies four different areas: refuges, primary, secondary, and deferred rehabilitation zones in order to focus rehabilitation actions to the areas where the chances of success are best. The primary zones and refuges where priority should be given to reducing mortality caused by sea lampreys include the mid-northern region of the lake, the mid-lake reef zone, and an offshore reef area in the southwest portion of the lake.

The Service annually has operated an assessment network for spawning-phase sea lampreys on 11-13 streams in Lake Michigan, and we present this information as total catch in all other rivers and estimated spawning population in the Manistique River, 1986-94 (Fig. 4). This index shows the population in the lake has been relatively stable during the time period, but our assessments also show lampreys are more abundant in the northern part of the lake than in the south.

LARVAL ASSESSMENT

United States

Surveys were conducted to prepare for lampricide treatments, assess the success of past treatments, monitor reestablished populations of larval sea lampreys, and search for new infestations of larvae in 105 Lake Michigan tributaries. Surveys to schedule lampricide applications were conducted in 40 streams. Of these, 6 were successfully treated, 11 were scheduled for treatment in 1995, and the remaining 23 were deferred. Sea lamprey larvae that remained from past treatments were found in 16 streams, but comprised less than 5% of the total number of larvae collected in all streams. Larvae had reestablished in 59 of the streams that were surveyed. No estuarine or offshore surveys were conducted in 1994. Original surveys to search for new infestations were conducted in 24 streams. Sea lamprey larvae were recovered from two of these streams.

Surveys above the electrical barrier on the Jordan River produced 10 larvae from the 1994 year class and 2 from the 1993 year class. Supply of electric power to the barrier failed during a short period of operation in 1994.

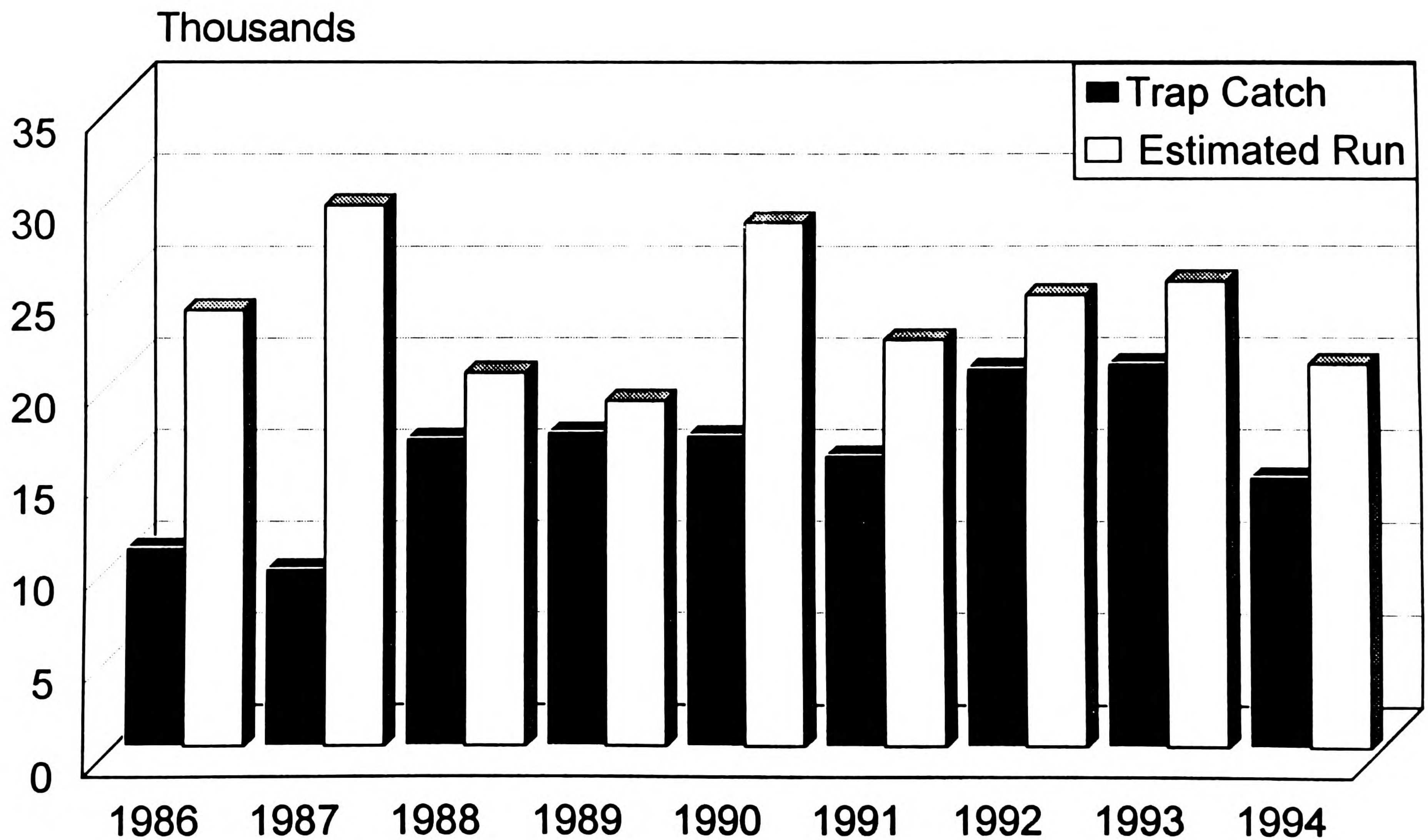


Fig. 4 . Number of spawning-phase sea lampreys captured in assessment traps in an annual average of 12 streams (range, 11-13) in Lake Michigan, and estimated population of spawning lampreys in the Manistique River, 1986-94.

Surveys to assess recruitment of the 1994 year class were conducted in 69 streams (64 streams examined annually and 5 streams on a triennial schedule). Young-of-the-year larvae were recovered in 32 of the 64 streams surveyed annually. Larvae have not been detected for 6 or more years in the other 5 streams.

LAMPRICIDE MANAGEMENT

United States

Lampricide treatments were conducted on 9 Lake Michigan tributaries with a combined discharge of 77.3 m^3/s (Table 10, Fig. 5). Sea lamprey larvae were abundant in the Big Manistee River system and less abundant in the others rivers. Larval distribution was more extensive than during some recent previous treatments in all streams except the Sturgeon and Days rivers and Porter Creek. Porter Creek is treated annually to prevent development of a lentic population off the stream mouth. No significant mortality occurred during treatments.

Minor problems that delayed treatments included beaver dams on the Carp Lake River and tributaries of the Big Manistee River and difficult access to remote sites on the Milakokia and Sturgeon rivers.

Ludington and Marquette control crews coordinated treatment of the Big Manistee River mainstream. Consumers Power Company provided outstanding assistance and cooperation which resulted in a smooth and successful lampricide application.

The mainstreams of the Little Manistee and Big Manistee rivers were treated with a combination of TFM and Bayer 73 wettable powder. Newly modified Bayer 73 application equipment worked well and eliminated applicator exposure, however further modification is planned.

Table 10. Details on the application of lampricide to streams of Lake Michigan, 1994. (Number in parentheses corresponds to location of stream in Fig. 5.)

Stream	Date	Discharge m^3/s	TFM[1,2] kg	Bayer 73[1] kg	Distance km
UNITED STATES					
Sturgeon R. (8)	May 21	4.2	689	-	96.5
Milakokia R. (9)	Jun 4	0.8	351	-	27.4
Lincoln R. (6)	Jun 4	1.4	477	-	33.8
Mitchell Cr. (3)	Jun 16	0.3	113	-	8.0
Days R. (7)	Jun 17	0.7	189	-	6.4
Big Manistee R. (5)	Jul 9	62.3	10,660	103	133.5
Little Manistee R. (4)	Jul 25	6.2	1,412	11	66.0
Porter Cr. (2)	Aug 18	0.3	55	-	1.6
Carp Lake R. (1)	Sep 18	1.1	215	-	14.5
Total		77.3	14,161	114	387.7

[1]Lampricides are in kg of active ingredient.
[2]Includes a total of 180 TFM bars (35.1 kg) applied in 3 streams.

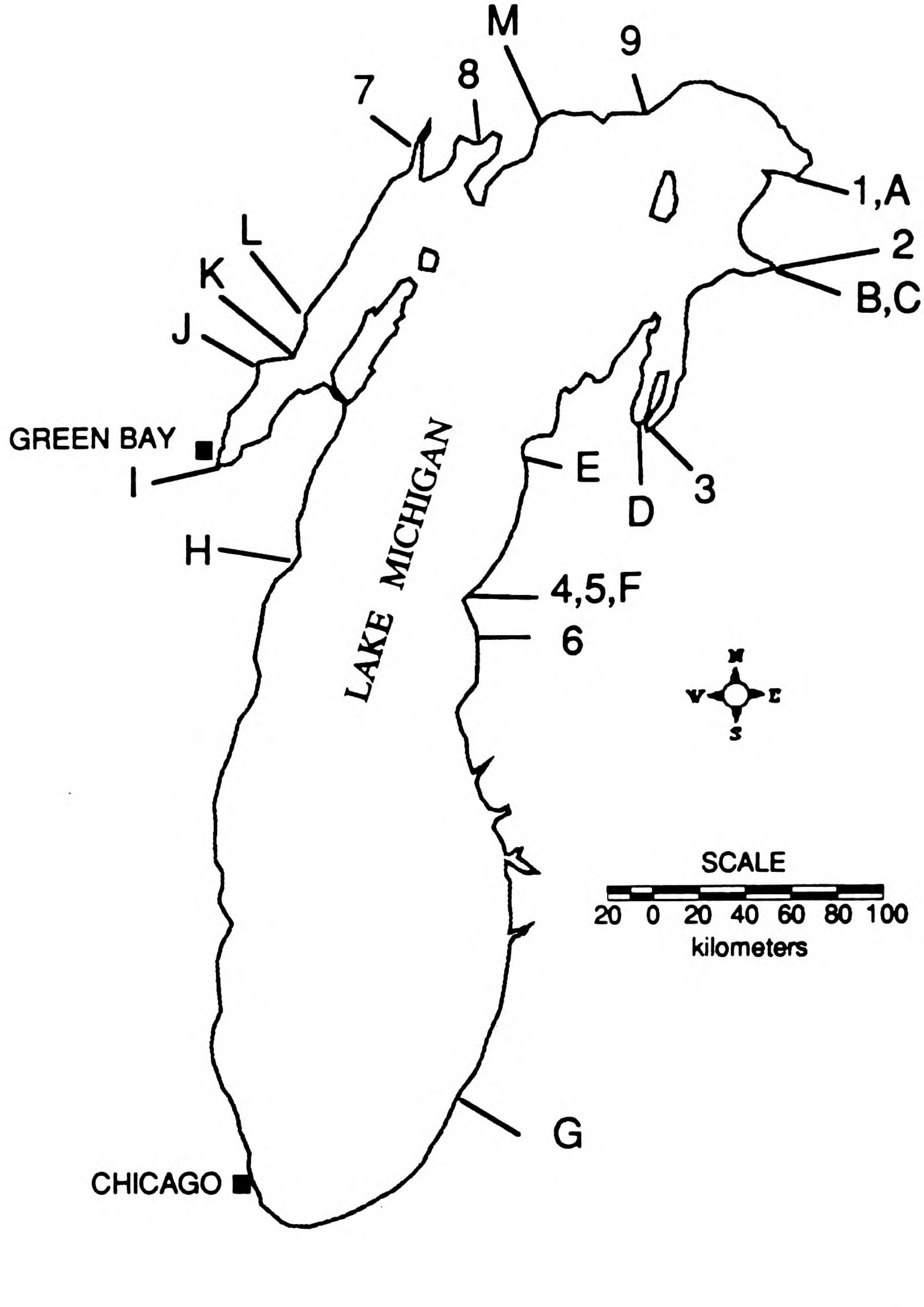


Fig. 5. Location of Lake Michigan tributaries treated with lampricides (Numerals, see ta
10 for names of streams) and of streams where assessment traps were operated (Letter
see table 11 for names of streams) in 1994.

SPAWNING-PHASE ASSESSMENT

United States

A total of 14,669 sea lampreys were captured in assessment traps in 13 tributaries of Lake Michigan in 1994 (Table 11, Fig. 5). Traps set in the Little Manistee River for the first time captured 43 lampreys. The trap catch of 14,626 in 1994 in 12 streams (excluding Little Manistee River, first year of operation was 1994) is less than the 5-year average (1989-1993) catch of 18,112 (15,454-20,854) in the same streams. The estimated number of spawning-phase sea lampreys in the Manistique River was 20,758 in 1994, compared to 25,267 in 1993.

The Betsie and Boardman rivers were monitored for the second year by the Grand Traverse Band of Ottawa and Chippewa Indians. Traps in the mainstream of the Jordan River were serviced by personnel from the Michigan Department of Natural Resources and on the Little Manistee River by volunteers.

PARASITIC-PHASE ASSESSMENT

United States

Lake Michigan commercial operators captured 38 parasitic-phase sea lampreys in 1994 (Table 7). Operators in management unit MM-5 (Leland, Michigan) contributed the largest number of sea lampreys. Lampreys primarily were attached to lake trout.

A total of 309 parasitic-phase sea lampreys were collected from the Lake Michigan sport fishery (256 charter, 53 noncharter) (Table 8). Anglers in management unit MM-5 (Leland, Michigan) contributed the largest number. Lampreys primarily were attached to lake trout (Table 9).

Table 11. Number, estimated spawning population, and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan 1994. (Letter in parentheses corresponds to location of stream in Fig. 5.)

	Number captured	Estimated spawners	Number sampled[1]	Percent Males[2]	Mean Length Males	Mean Length Females	Mean Weight Males	Mean Weight Females
UNITED STATES								
Carp Lake R. (A)	238	-	238	37	429	447	179	206
Jordan R. (B)	7	-	3	0	-	465	-	295
Deer Cr. (C)	62	-	60	38	466	455	274	296
Boardman R. (D)	55	-	55	49	479	465	243	242
Betsie R. (E)	370	-	359	36	464	464	230	239
Little Manistee R. (F)	43	-	40	65	476	473	249	243
St. Joseph R. (G)	335	-	335	35	474	482	229	244
East Twin R.(H)	31	-	31	39	422	440	187	196
Fox R. (I)	0	-	0	-	-	-	-	-
Oconto R. (J)	75	-	75	31	528	545	231	257
Peshtigo R. (K)	213	-	213	31	536	535	254	257
Menominee R. (L)	5	-	6	17	507	546	258	265
Manistique R. (M)	13,235	20,758	0	42[2]	-	-	-	-
Total or average	14,669		1,415	38[2]	474	482	229	244

[1]The number of lampreys from which all length and weight measurements were determined.
[2]Percent males generally was determined from internal body examination of the number sampled. In 1 river, additional lampreys were examined externally for secondary sexually characteristics to determine percent males. The river and total or average, the number examined externally, and (in parentheses) the combined number sampled are: Manistique-652 (652), Total or average-652 (2,067).

LAKE HURON

TRIBUTARY INFORMATION

- 1,761 (427 United States, 1,334 Canada) tributaries to lake.
- 116 (62 United States, 54 Canada) tributaries have records of production of sea lamprey larvae.
- 66 (33 United States, 33 Canada) tributaries have been treated with lampricide at least once during 1985-94.
- Of these, 50 (23 United States, 27 Canada) tributaries are treated on a regular (3-5 year) cycle.

SEA LAMPREY AND FISH COMMUNITY OBJECTIVES

The Lake Huron Committee (1993) has established a specific objective for sea lamprey abundance as part of its Fish Community Objectives:

> *Reduce sea lamprey abundance to allow the achievement of other fish community objectives; obtain a 75% reduction in parasitic sea lamprey by the year 2000 and a 90% reduction by the year 2010 from present levels.*

The progress toward this objective will be monitored by the abundance of spawning sea lampreys in four index streams in northern Lake Huron: the Thessalon, St. Marys, Cheboygan and Ocqueoc rivers (Lake Huron Technical Committee 1991).

This sea lamprey target is in support of the objectives for the other species groups in the fish community including, for example, the Salmonine community objective to:

> *Establish a diverse salmonine community which can sustain an annual harvest of 5.3 million pounds, with lake trout the dominant species and anadromous species also having a prominent place.*

To attain and maintain a self-sustaining lake trout population capable of supporting 3-4 million pounds of this overall yield objective the total annual mortality should not exceed 45% (Lake Huron Technical Committee 1991). The plan calls for management of exploitation and control of lampreys to reach this objective. The lake-wide management plan identifies refuges and special rehabilitation zones in which rehabilitation is most likely to succeed. These priority zones are distributed throughout the lake, including the northern section and the North Channel. The plan states these areas should be priority areas for the suppression of lampreys and control of fishery exploitation.

The Service and Department annually have trapped an average of 12 streams during 1986-94 to monitor abundance of sea lampreys in northern Lake Huron. During this period, lamprey abundance generally increased but declined substantially in 1994 (Fig. 6). These trap catches still represent an excessive number of sea lampreys in Lake Huron and the data is further substantiated by similar patterns in indices of parasitic sea lamprey abundance and fish wounding. We suggest that without continued substantive action to manage the uncontrolled population of larvae in the St. Marys River we will fail to make progress in achieving sea lamprey objectives for lake trout rehabilitation in Lake Huron.

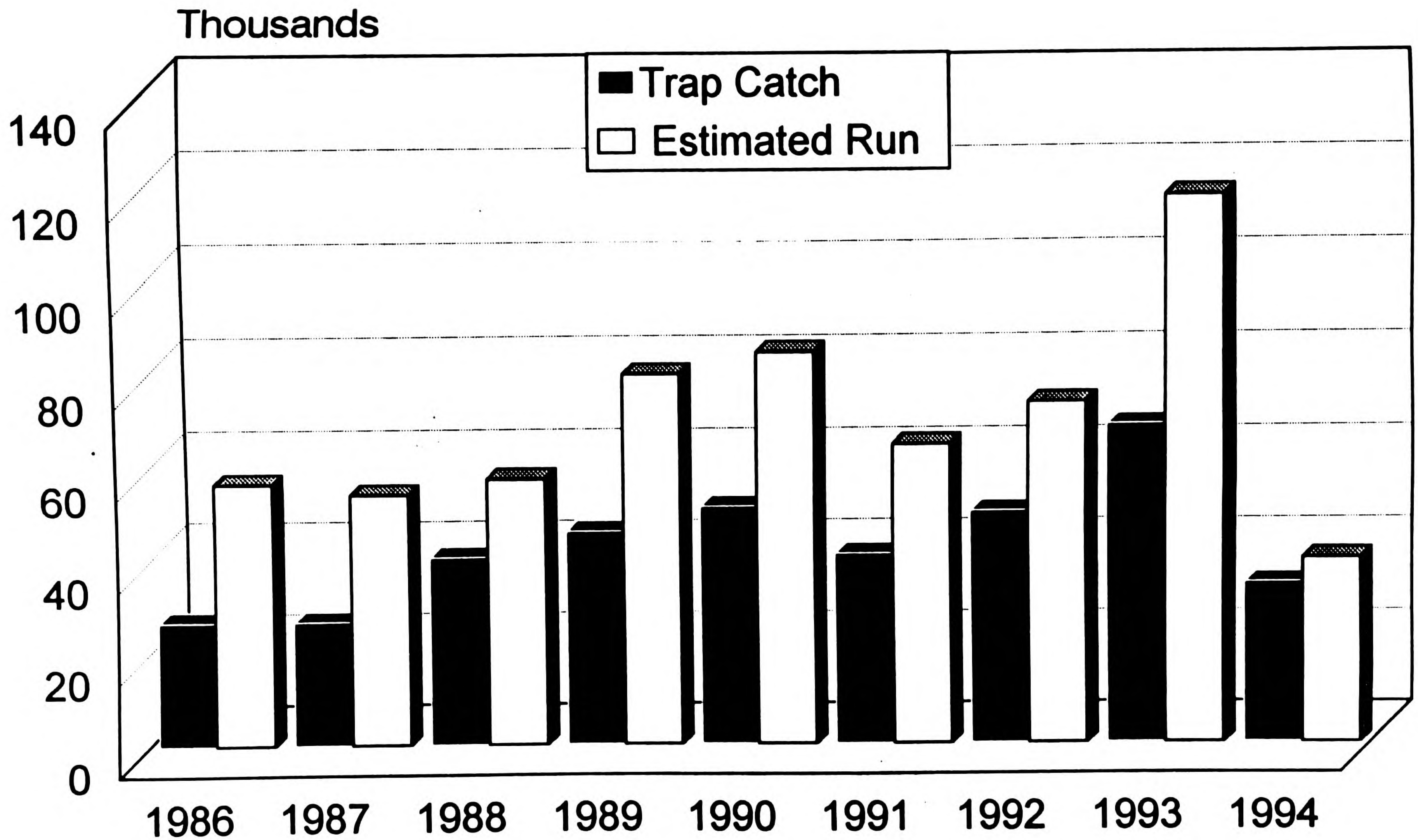


Fig. 6 . Number of spawning-phase sea lampreys captured in assessment traps in an annual average of 12 streams (range, 10-16) in Lake Huron, and estimated population of spawning lampreys in the Cheboygan, St. Marys and Thessalon rivers, 1986-94 (population in Thessalon River not estimated in 1988 and 1991).

LARVAL ASSESSMENT

United States

Surveys were conducted to prepare for lampricide treatments, assess the success of past treatments, monitor reestablished populations of larval sea lampreys, and search for new infestations of larvae in 49 Lake Huron tributaries. Surveys to schedule lampricide applications were conducted in 14 streams. Of these, 2 were successfully treated, 5 were scheduled for treatment in 1995, and the remaining 7 were deferred. Sea lamprey larvae that remained from past treatments were found in 3 streams, but comprised less than 5% of the total number of larvae collected in all streams. Larvae had reestablished in 33 of the streams that were surveyed. No estuarine or offshore surveys were conducted in 1994. Original surveys to search for new infestations were conducted in 9 streams. Sea lamprey larvae were recovered from three of these streams.

Surveys to assess recruitment of the 1994 year class were conducted in 36 streams (33 streams examined annually and 3 streams on a triennial schedule). Young-of-the-year larvae were recovered in 21 of the 33 streams examined annually. Larvae have not been detected for 6 or more years in the other 3 streams.

Canada

The Department surveyed 44 streams in 1994 to estimate population abundance and determine the potential for transformation in the following year to schedule treatments. The standard techniques used in larval assessment include backpack electrofishing (shallow streams), deep water electrofishing, and Bayer 73 surveys (deep water).

Distribution Surveys:

Distribution surveys were completed on 4 streams in preparation for treatment in 1994, (Garden and Manitou rivers, Blue Jay, and Sand creeks) and on 9 streams in anticipation of possible treatment in 1995 (Root, Mississagi, Boyne, Musquash, Sturgeon, and Sauble rivers and Richardson, Sucker, and Spragge creeks). No significant change in larval distribution was observed within these streams.

Treatment Evaluation and Larval Reestablishment:

Treatment evaluation surveys were completed on the 8 Lake Huron tributaries treated in 1993 (Koshkawong, Serpent, Mindemoya, Magnetawan, Naiscoot, and Nottawasaga rivers, Lauzon and Timber Bay creeks) and on 8 of the 10 tributaries treated in 1994 (Garden, Echo, Spanish, and Manitou rivers and Watson, Livingstone, Blue Jay, and Silver creeks). Moderate numbers of residual larvae were collected from the Echo, Serpent, and Magnetawan rivers; low numbers from the Blue Jay, Naiscoot, and Spanish rivers; and none from the other streams.

Reestablished populations of the 1993 cohort of larval sea lampreys were found in Two Tree, Koshkawong, Serpent, Mindemoya, Naiscoot, and Nottawasaga rivers and Lauzon and Timber Bay creeks. The 1994 cohort was found in fall surveys of the Garden, Echo, Manitou, and Magnetawan rivers.

No larval sea lampreys were found in fall reestablishment surveys of the Spanish River or Watson, Livingstone, Blue Jay, and Silver creeks.

Barrier Evaluation:

Low head barrier dams on the Echo, Still, and Sturgeon rivers were all effective at blocking the 1994 spawning run. Extensive surveys done above Denny's dam on the Saugeen River indicate that it remains effective as a lamprey barrier.

Quantitative Assessment:

a) Index surveys

Index sites established on most sea lamprey producing tributaries were assessed for year class structure and abundance of larvae large enough to metamorphose in 1995. By expanding the densities in the index sites to the total stream habitat infested, whole stream estimates of potential transformers were made. These were used to determine which streams warranted treatment in 1995.

b) Spanish River population estimate

The Spanish River is a large tributary (mean annual discharge 155 m^3/s) to the North Channel of Lake Huron with a drainage area of 13,500 km^2. The river has a long history of industrial use that includes hydro-electric power dams, mining, logging, saw mills, pulp, and paper making. Numerous tributaries of varying size join the main river below Espanola, with the three largest, the Aux Sables River and Birch and La Cloche creeks being sea lamprey producers.

Larval abundance in the heavily polluted main river was considered very low in 1967 and 1972 with average treatment collecting CUEs [no. larvae/person hr.] at 4.7 and 1.7, respectively. After a major improvement in water quality in the 1980s, larval numbers increased considerably. Surveys done with granular Bayer showed much higher larval densities, particularly in the upper half of the river. When treated in 1989 abundance was rated extremely high throughout the river (average treatment CUE was 49.1).

Following the 1989 treatment, estimates of larval abundance were inconclusive resulting in uncertainty in scheduling the 1994 treatment.

The proposed late summer treatment provided us with an opportunity to estimate the abundance of larval lamprey by mark and recapture, particularly those undergoing transformation.

Unfortunately, the last minute moratorium on the use of Bayer this year prevented the completion of that component of the proposed study.

i) Main stem estimate methodology

The main stem of the river was divided into two reaches, Espanola to the confluence of the Aux Sables at the village of Massey (27.5 km) and Massey to Spanish (26.5 km). Within each reach, three 600 m study areas were selected that were thought to be both representative of the reach and where the TFM block was expected to arrive during daylight hours. For each of the six study areas, length, average width, and depth were determined. Habitat was subjectively classified and quantified as type I - preferred, type II - suitable but not preferred, or type III unsuitable.

Modified Petersen type estimates were made of the larval sea lamprey population in each of the six study areas. Two days prior to the treatment, sea lamprey larvae (n= ~500) that had been electrofished from the Garden River near Sault Ste Marie, marked with a tail clip, and measured to length were randomly released in the upper half of each study area.

During the lampricide treatment we collected as many larval lamprey as practical from the study areas, both by hand and with fyke nets. The population of each study area was estimated and average densities determined. The population of the treated portion of the main river was calculated by averaging estimated densities of the three study areas in each reach and applying the result to the total amount of habitat in each reach. Extensive observations were also made on larval distribution and relative abundance between study sites.

Caged larvae were placed in the river at each of the six study sites in order to evaluate treatment effectiveness.

ii) Tributary estimate methodology

Larval habitat was quantified in the reaches of the three tributaries using a systematic transect approach. On Birch and La Cloche creeks, which had 18 and 14 km infested respectively, transect spacing was 500 m, whereas for the Aux Sables River, with only 2.3 km infested, transect spacing was 100 m.

Modified Petersen type estimates were made of the larval sea lamprey population in two 500 m study areas in Birch Creek and of one 400 m study site in the Aux Sables River.

Marked larvae also were released in a proposed study site on LaCloche Creek but unfortunately, due to water use conflicts, the treatment commenced just downstream of that section of the river. A subsequent attempt to estimate larval density using electrofishers at the site was unsuccessful due primarily to poor survey conditions.

Index stations on all three tributaries were electrofished prior to treatment in order to evaluate electrofisher efficiency.

iii) Results and discussion

Suitable larval habitat in the Spanish River was abundant (Table 12). Although we classed habitat as type I, II, or III in the field, we could not consistently distinguish between types I and II, and have combined them as "suitable" habitat.

Larval densities in the main river averaged $0.21/m^2$ of suitable habitat, ranging from 0.05 to 0.54 in the 6 study plots. The main stem was estimated to have 1.67 million larvae of which 42,300 were undergoing transformation. We found the highest density of larvae near the confluence of LaCloche Creek below an obvious spawning area about 20 km from the mouth.

Birch Creek, with a density of $1.3/m^2$ of suitable habitat, also had a substantial sized population of 226,000 larvae and nearly 5,000 transformers.

Although no estimate was made of the LaCloche Creek population, observations and collections made during the treatment indicated low densities and spotty distribution. The LaCloche collections indicated an unusually high proportion of large larvae (75% ≥ 120 mm) of which 28% were undergoing transformation. This is probably in part due to the fact that it had not been treated for 22 years as well as to sampling bias resulting from the high turbidity of LaCloche Creek.

Electrofishing index sampling on Birch Creek and AuxSables River caught 0.94 and 0.30 larvae/m^2 respectively. This compares favourably to the mark-recapture estimated densities of 1.3 and 0.25, suggesting either high electrofisher efficiency or selection for the better (type I) habitat.

Caged larval lampreys in each of the study areas as well as in an additional eight sites in the delta area of the river experienced complete mortality, indicating an effective treatment.

Table 12. Spanish River population estimate data.

	Main River Espanola to Massey	Main River Massey to mouth	Birch Creek	Aux Sables River	LaCloche Creek	Totals
Length infested portion (km)	27.5	26.5	18	2.4	14	88.4
Area type I & II Habitat (Ha)	227.2367	563.5497	17.2117	7.5812	8.9444	824.5237
Mean Larval Density, age 1+	0.16	0.232	1.314	0.248	unknown	0.243[1]
Population estimate (larvae + trans)	363,578	1,306,107	226,162	18,838	unknown	1,914,685[1]
Transformer estimate	18,320	23,980	4,749	253	unknown	47,302[1]
% larvae => 120 mm	20.2	15.9	13.7	19.1	unknown	16.37[1]

[1]Totals are exclusive of LaCloche Creek.

c) **Sand Creek population estimate**

Sand Creek is a small stream located on Cockburn Island at the west end of Lake Huron. In conjunction with the early October 1994 treatment we estimated the habitat and larval abundance in the infested part of Sand Creek.

Using a systematic transect method we found 1,971 m^2 (23.7%) of type I and 3,342 m^2 (40.2%) of type II habitat in the 1.47 km of stream infested. Prior to the treatment we released 318 tail clipped age 1+ larval sea lampreys randomly throughout the type I and type II habitat.

During the treatment we collected 1,093 unmarked age 1+ larvae, 10 transformed larvae and 41 marked larvae. The 1994 year class was abundant but their small size, < 30 mm, made them difficult to collect without bias. We estimated the age 1+ population at 8,477 larvae and 78 transformers.

LAMPRICIDE MANAGEMENT

United States

Lampricide treatments were conducted on 7 Lake Huron tributaries (Table 13, Fig. 7) with a combined discharge of 12.8 m^3/s. Sea lamprey distribution was more extensive in 1994 than during recent previous treatments of the Black, Sturgeon, and Ocqueoc rivers. Larval densities were abundant in the Black River and Albany and Trout creeks. Mortality of nontarget species was insignificant during all treatments.

Minor problems were encountered during six treatments. A boost application in Mulligan Creek was necessary due to low discharge. Treatment of the Sturgeon River was delayed three days due to high water. Beaver dams cause difficulty during treatments of Mulligan and Albany creeks and the Black and Ocqueoc rivers.

The new Kinetics TFM formulation was used in early September during treatment of Silver Creek (Ocqueoc River) and worked well. In addition, a comparative static toxicity test was conducted with the Kinetics and Hoescht formulations and showed toxicity to sea lamprey larvae of both formulations is similar.

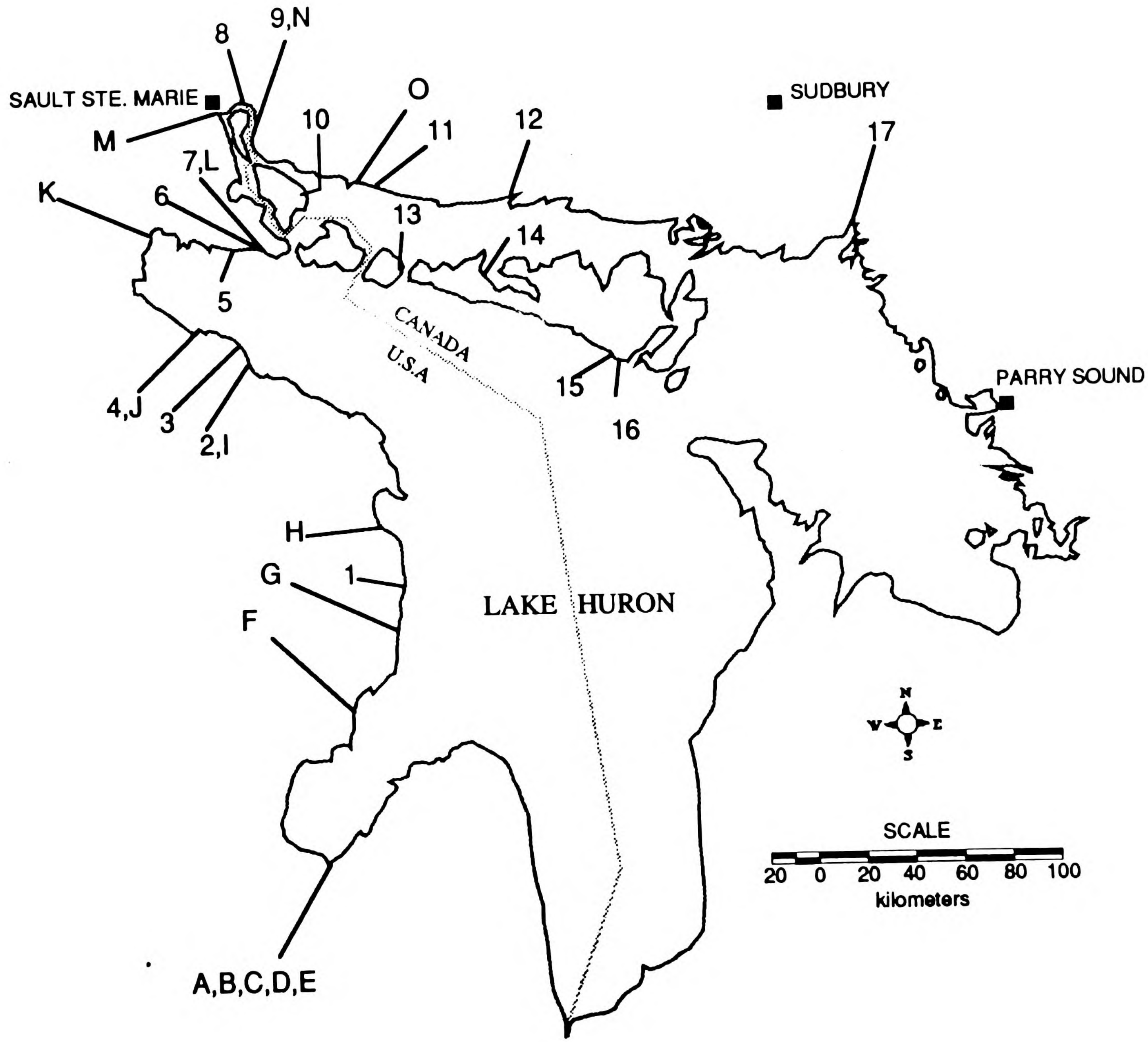


Fig. 7. Location of Lake Huron tributaries treated with lampricides (Numerals, see table 13 for names of streams) and of streams where assessment traps were operated (Letters, see table 14 for names of streams) in 1994.

Canada

Six North Channel, 3 Main Basin, and 1 Georgian Bay tributary were successfully treated with lampricide in 1994 (Table 13, Fig. 7). Stream discharges were within projected ranges on the majority of rivers, thus allowing for treatment completion without significant cost overrun.

On the Spanish River, The International Nickel Company historically has lowered and controlled the discharge during lampricide application, thus substantially reducing treatment costs. In 1994 we requested a controlled discharge of 55 - 58 cms, however flow during the lampricide application averaged 71 cms. Although costs were increased by approximately 12%, treatment effectiveness was greatly enhanced throughout the lengthy estuary. Anticipated reduction in erosion of the lampricide block also allowed the application concentration to be lowered slightly, thus reducing the impact on nontarget organisms.

Sea lamprey larvae were very abundant in the Spanish and Garden Rivers, two of the largest North Channel rivers treated, while moderate to low numbers of ammocoetes were observed in the remainder of the streams. A substantial number of metamorphosing larvae appeared to be present in the Spanish River, last treated in 1989. All treatments conducted appeared to have minimal impact on nontarget organisms.

Table 13. Details on the application of lampricide to streams of Lake Huron, 1994. (Number in parentheses corresponds to location of stream in Fig. 7.)

Stream	Date	Discharge m^3/s	TFM[1,2] kg	Bayer 73[1] kg	Distance km
UNITED STATES					
Trout Cr. (6)	May 7	0.3	32	-	1.6
Ceville Cr. (5)	May 8	0.1	20	-	1.6
Black R. (1)	May 8	1.8	359	-	12.9
Albany Cr. (7)	May 9	0.3	54	-	9.7
Mulligan Cr. (3)	May 21	0.1	7	-	3.2
Cheboygan R.					
Sturgeon R. (4)	Aug 23	6.1	2,141	-	56.3
Ocqueoc R. (2)	Sep 4	4.1	975	-	29.0
Total		12.8	3,588	-	114.3
CANADA					
Silver Cr. (14)	May 26	0.8	161	-	5.6
Manitou R. (15)	May 28	2.8	390	-	3.8
Blue Jay Cr. (16)	May 31	1.0	169	-	7.9
Watson Cr. (10)	Jun 2	0.3	16	-	1.9
Garden R. (8)	Jun 20	12.5	634	-	58.1
Lower Echo R. (9)	Jun 21	1.7	87	-	12.7
Spanish R. (12)	Aug 9	94.0	6,146	-	89.8
Wanapitei R. (17)	Aug 10	16.2	973	15.1	6.3
Livingstone Cr. (11)	Aug 29	0.1	12	-	3.2
Sand Cr. (13)	Oct 4	0.3	50	-	1.5
Total		129.7	8,638	15.1	190.8
GRAND TOTAL		142.5	12,226	15.1	305.1

[1]Lampricides are in kg of active ingredient.
[2]Includes a total of 111.3 TFM bars (22.16 kg) applied in 11 streams.

SPAWNING-PHASE ASSESSMENT

United States

During the 1994 spawning season, 28,031 sea lampreys were captured in assessment traps placed in 13 tributaries of Lake Huron (Table 14, Fig. 7). The Pine and Big Salt rivers were new trap sites in 1994. The trap catch in 6 streams (Cheboygan, Ocqueoc, Albany, Au Sable, East Au Gres, and St. Marys rivers) trapped annually from 1989-1993 averaged 36,628 (24,267-50,734) lampreys. The catch in these same rivers in 1994 was 27,233.

A catch of 17,568 in the Cheboygan River was a dramatic drop from the 1993 record catch of 38,831. The spawning run in the Cheboygan River in 1994 was an estimated 26,912 sea lampreys. Population estimates also were conducted in the Carp (964), Devils (381), Cass (778), Tittabawassee (3,597), and Pine (271) rivers and cooperatively with the Department in the St. Marys River (10,624).

Spawning runs were monitored in two rivers through cooperative agreements. The Carp River trap was operated by the Chippewa/Ottawa Treaty Fishery Management Authority and the Tittabawassee River trap was managed by Dow Chemical U.S.A.

Canada

To assess long-term trends in abundance of spawning phase lampreys in the North Channel and northern Lake Huron, we trapped at our three standard index streams (Table 14, Fig. 7). We used portable spawning-phase traps at all locations except the Echo River where a trap built into a low head lamprey barrier is used. Spawning run estimates were determined using the modified Shaefer (Ricker 1975) stratified mark and recapture method.

In general, spawning runs were significantly lower across all Great Lakes during 1994. Our catch in Lake Huron index streams was below the 10-year average but within the long term range (Table 14). We fish at two locations on the Thessalon River. However, we recaptured adequate numbers of spawners to estimate the run only at the Bridgeland Creek location. In past studies, the Rydal Bank traps have ranged between 4 - 14% efficiency. The capture of 17 specimens implies a run of 500 adults. Thus, we estimated the total run in the Thessalon River at 2,500 based on our estimate of 2,009 in Bridgeland Creek and 500 at Rydal Bank. A joint study by the Department and Service in the St. Marys River estimated a spawning run of 10,624 into the Sault Basin. In addition, 1,031 sterile males were captured and released from DFO traps with only one dying in the traps. Trapping efficiency (catch/spawning run estimate) in all streams continued to be high ranging from 33.6% in Bridgeland Creek to 56.2% in the St. Marys River.

PARASITIC-PHASE ASSESSMENT

United States

A total of 887 parasitic-phase sea lampreys were collected by commercial operators in U.S. waters of Lake Huron (Table 7). Operators from management unit MH-1 (Detour-Rogers City, Michigan) collected the largest number of sea lampreys.

Sport anglers on the U.S. side of Lake Huron captured 592 parasitic-phase sea lampreys (348 charter, 244 noncharter) (Table 8). Anglers from management district MH-3 (Harrisville-Oscoda, Michigan) contributed the largest number of sea lampreys. Lampreys primarily were attached to chinook salmon (Table 9).

Six sites in northern Lake Huron were monitored by personnel from the National Biological Service Lake Huron Biological Station in conjunction with a coded wire tag study. These sites accounted for 187 of the parasitic-phase sea lampreys captured by the noncharter sport fishery and 860 by the commercial fishery.

Table 14. **Number, estimated spawning population, and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1994.** (Letter in parentheses corresponds to location of stream in Fig. 7).

	Number captured	Estimated spawners	Number sampled[1]	Percent Males[2]	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
UNITED STATES								
Big Salt R. (A)	8	-	0	-	-	-	-	-
Pine R. (B)	44	271	2	50	491	432	225	253
Chippewa R. (C)	1	-	1	0	-	-	-	-
Tittabawassee R. (D)	328	3,597	22	50	445	439	179	198
Cass R. (E)	116	778	116	62	394	497	250	325
East Au Gres R. (F)	26	-	0	-	-	-	-	-
Au Sable R. (G)	51	-	0	-	-	-	-	-
Devils R. (H)	198	381	105	48	432	434	259	267
Ocqueoc R. (I)	8,775	-	0	44[2]	-	-	-	-
Cheboygan R. (J)	17,568	26,912	0	42[2]	-	-	-	-
Carp R. (K)	103	964	42	43	489	485	241	247
Albany Cr. (L)	17	-	3	100	423	-	184	-
St. Marys R. (M)	796	See Canada (M)	20	65[2]	494	462	260	238
Total or average	28,031		311	43[2]	426	464	247	274
CANADA								
St. Marys R. (M)	5,175	10,624	0	56[2]	-	-	-	-
Echo R. (N)	922	2,200	0	54[2]	-	-	-	-
Thessalon R. (O)	692	2,500	0	57[2]		-	-	-
Total or average	6,789		0	56[2]	-	-	-	-
GRAND TOTAL OR AVERAGE	34,820		311	46[2]	426	464	247	274

[1]The number of lampreys from which all length and weight measurements were determined.
[2]Percent males generally was determined from internal body examination of the number sampled. In 5 rivers, additional lampreys were examined externally for secondary sexually characteristics to determine percent males. The rivers and total or average, the number examined externally, and (in parentheses) the combined number sampled are: United States, Cheboygan-17,568 (17,568), Ocqueoc-8,743 (8,743), St. Marys-776 (796), Total or average-27,087 (27,398); Canada, St. Marys-5,175 (5,175), Echo-922 (922), Thessalon-692 (692), Total or average-6,789 (6,789); Grand total or average-33,876 (34,187).

Canada

The 1994 cooperator programme collected parasitic lampreys by-catch from eight Lake Huron fisheries. Seven fisheries collected lampreys from the North Channel/northern main basin area and one fishery collected in the southern main basin. No fisheries collected lampreys from the central main basin.

Six lampreys were collected from the southern main basin, suggesting low lamprey activity in that portion of the lake. A total of 1,971 specimens were reported from the North Channel/northern basin area (1,035 from the northern main basin and 936 from the North Channel fisheries). The combined catch is considerably down from the peak catch in 1992, but the count from the northern main basin is the highest since the late 1960s. About 250 lampreys were collected by two fisheries after mid-November, once most of the fisheries had terminated operations for the season. These data suggest continued high wounding in the northern portion of Lake Huron and predict increased spawning runs in the index network for 1995.

The Lake Huron Biological Station is conducting a mark/recapture study to estimate the parasitic lamprey population in Lake Huron and Lake Michigan. As part of this study, we coded-wire tagged and released 531 juvenile lampreys collected from the commercial fishery. To date, we have recovered six and will be monitoring the spawning run catch for coded-wire tagged lamprey in 1995.

BARRIER PROGRAM

Canada

St. Marys River Powerhouse Trap:

The Barrier Coordinator has been involved in the design process of the adult trap project at the U.S. Army Corps of Engineer (Corps) No. 10 powerhouse. This project is planned for joint funding by the Corps and the GLFC.

Barrier Maintenance:

Required maintenance work was carried out at the low-head barriers on the Echo, Koshkawong and Still rivers.

LAKE ERIE

TRIBUTARY INFORMATION

- 842 (317 United States, 525 Canada) tributaries to Lake Erie.
- 19 (8 United States, 11 Canada) tributaries have records of production of sea lamprey larvae.
- 18 (8 United States, 10 Canada) tributaries have been treated with lampricide at least once during 1985-94.
- Of these, 7 (4 United States, 3 Canada) tributaries are treated on a regular (3-5 year) cycle.

SEA LAMPREY AND FISH COMMUNITY OBJECTIVES

The Lake Erie Committee is currently developing Fish Community Goals and Objectives for the lake. The Committee is considering the previous management plans and will define objectives for the eastern basin salmonid community. The current draft in development recognizes the need for continuing control but does not set specific objectives for sea lamprey (Lake Erie Committee 1993).

A specific management plan for sea lampreys in Lake Erie was developed prior to the implementation of stream treatments in 1986 (Lake Erie Lake Trout Task Group 1985a). The plan defined an "experimental program" of control to reduce sea lamprey populations to levels where wounding on lake trout would be less than 5%, assessment trap catches of lamprey would be less than 10% of pre-treatment levels, and nest densities would be less than 2 nests per km of spawning habitat. By 1989 the first 2 of these objectives had been met in the eastern basin of Lake Erie. Based on the success of the experimental control program, in 1992 the Great Lakes Fishery Commission declared the control program on Lake Erie to be an ongoing program like the stream treatment programs in the other lakes.

The lake trout management plan for rehabilitation of self-sustaining stocks in the eastern basin of Lake Erie prescribed a maximum annual mortality rate of less than 40% be achieved to permit the establishment and maintenance of suitable stock of spawning adults (Lake Erie Lake Trout Task Group 1985b). Mortality would be controlled through management of fishery exploitation and continued suppression of sea lampreys.

The Service and Department annually have trapped spawning-phase sea lampreys in an average of 6 tributaries since 1986 and estimated the number of spawning lampreys in Cattaraugus Creek during 1992-94 (Fig. 8). Current catches are significantly less than those prior to the start of lampricide management (started in 1986 and showed effect in spawner population in 1989) but are greater than 10% of pretreatment catches. Since lake trout wounding remains at less than 5%, we are achieving sea lamprey objectives in the lake.

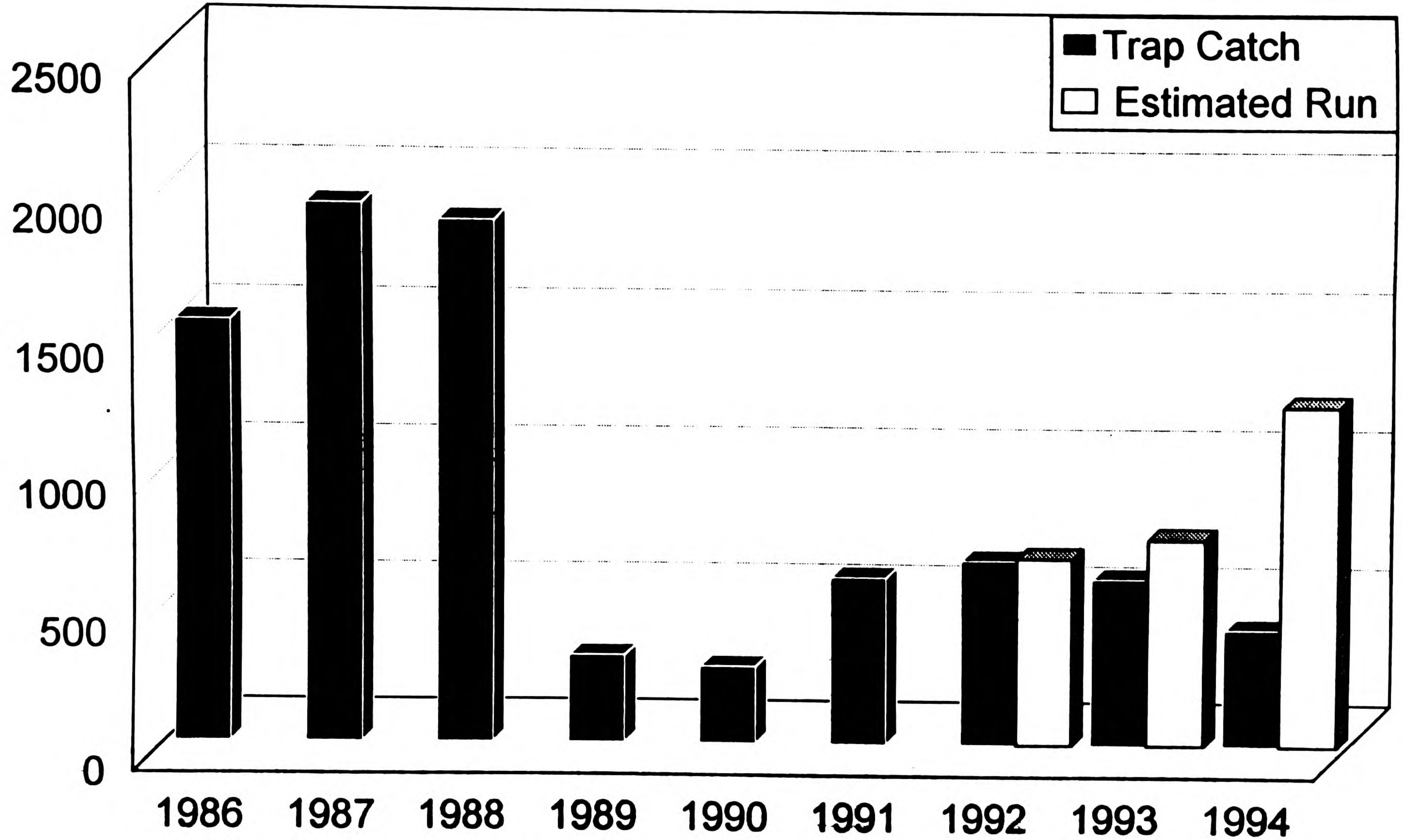


Fig. 8 . Number of spawning-phase sea lampreys captured in assessment traps in an annual average of 6 streams (range, 3-8) in Lake Erie,1986-94, and estimated population of spawning lampreys in Cattaraugus Creek, 1992-94.

LARVAL ASSESSMENT

United States and Canada

The Service and Department jointly staff an office in Amherst, New York and the larval assessment reported here is a result of that team of people working as partners in waters of both countries.

Surveys were conducted to prepare for lampricide treatments, assess the success of past treatments, monitor reestablished populations of larval sea lampreys, and determine barrier effectiveness in nine Lake Erie tributaries. Surveys conducted to prepare for 1994 treatment of Cattaraugus Creek indicated that lamprey distribution remained unchanged. Surveys to schedule lampricide applications were conducted in six streams. Of these, 2 were scheduled for treatment in 1995, 1 was scheduled for treatment in 1996, and the remaining 3 were deferred. Surveys to determine barrier effectiveness were conducted on Little Otter and Big creeks, Canada. Both barriers have been effective at blocking spawning runs of adult sea lampreys.

LAMPRICIDE MANAGEMENT

United States

Treatment was conducted on Cattaraugus Creek with a discharge of 14.4 m^3/s. A total of 4,337 kg active ingredient TFM was applied to 40.2 km of stream (Fig. 9, stream 1). Sea lamprey larvae were abundant and many large larvae were collected. An attempt was made to treat Clear Creek (tributary of Cattaraugus Creek) with the new Kinetics formulation of TFM, but cold temperatures caused the lampricide to gel rendering it impossible to use.

SPAWNING-PHASE ASSESSMENT

United States

A total of 417 sea lampreys were captured in assessment traps placed in 6 tributaries of Lake Erie in 1994 (Table 15, Fig. 9). This compares with the 5-year (1989-1993) average of 465 (235-622). The population in Cattaraugus Creek was estimated at 682.

Canada

We collected spawning phase lampreys at Little Otter Creek (a major tributary of Big Otter Creek) and Young's Creek (Table 15, Fig. 9) to monitor trends in lamprey abundance. Spawning runs are estimated using mark and recapture, when possible. No spawning-phase adults were collected at Little Otter this year. We collected 10 adults at Young's Creek. These data are consistent with catches since 1990, implying continued low parasitic lamprey activity in Lake Erie.

BARRIER PROGRAM

Canada

Big Creek:

Survey, hydrology, and some preliminary design work was carried out at the proposed Big Creek barrier site. First contacts were made with the property owner and OMNR regarding the project.

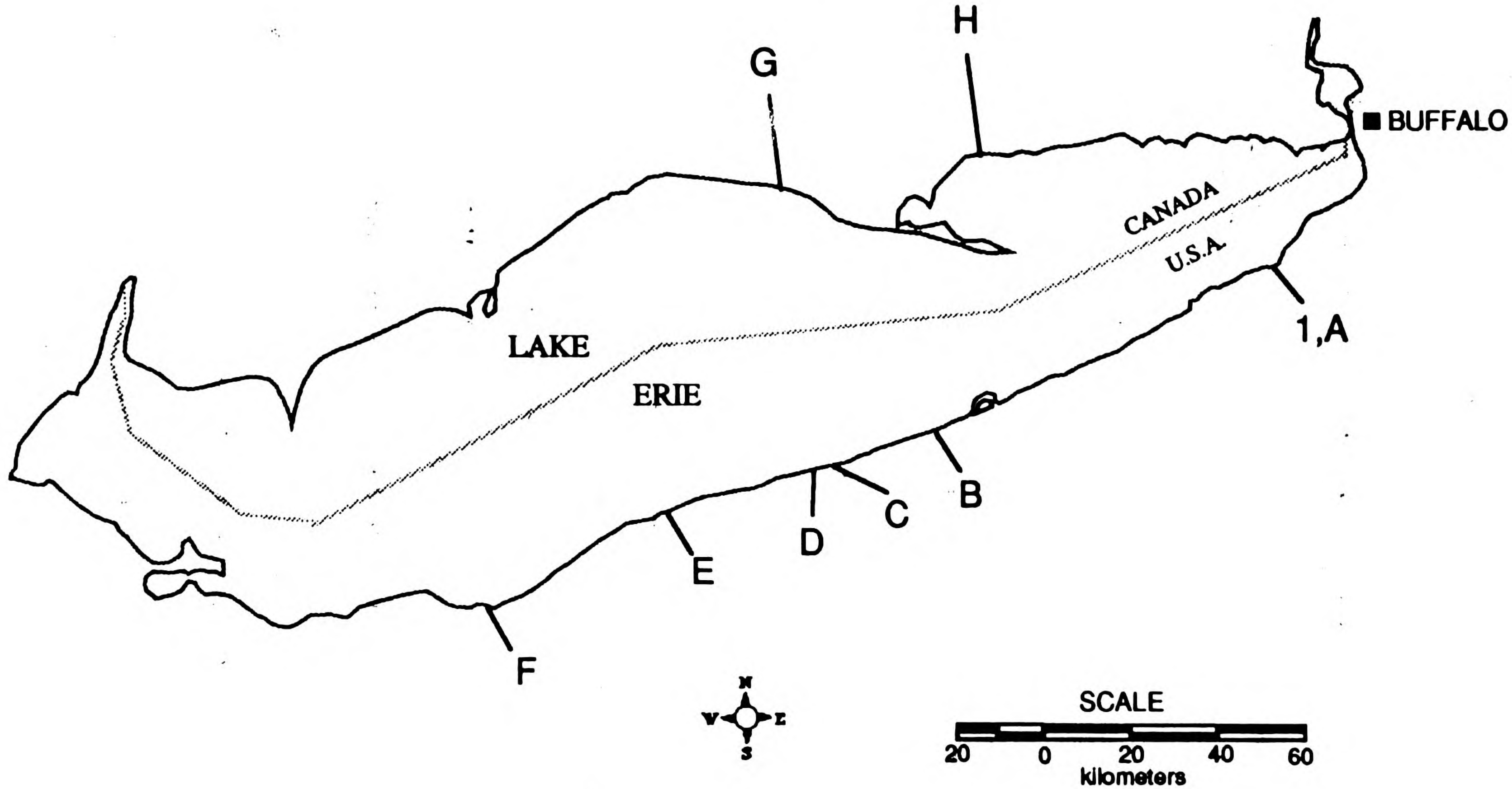


Fig. 9. Location of Lake Erie tributary treated with lampricide (Numerals, see Lampricide Managment section for stream names) and of streams where assessment traps were operated (Letters, see table 15 for names of streams) in 1994.

Barrier Maintenance:

Maintenance work was carried out at the five existing Lake Erie barriers. This work included addition of rip-rap and mortar at several barriers. Steel plates were added to the crest of the existing small dam on Young's Creek for the purpose of stopping lamprey passage.

Table 15. Number, estimated spawning population, and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Erie, 1994. (Letter in parentheses corresponds to location of stream in Fig. 9.)

	Number captured	Estimated spawners	Number sampled	Percent Males	Mean Length (mm)		Mean Weight (g)	
					Males	Females	Males	Females
UNITED STATES								
Cattaraugus Cr. (A)	410	682	234	54	508	502	305	303
Crooked Cr. (B)	0	-	0	-	-	-	-	-
Raccoon Cr. (C)	0	-	0	-	-	-	-	-
Conneaut Cr. (D)	0	-	0	-	-	-	-	-
Grand R. (E)	3	-	0	-	-	-	-	-
Chagrin R. (F)	4	-	1	0	-	470	-	280
Total or average	417		235	54	508	502	305	303
CANADA								
Big Otter Cr. (G)	0	-	0	-	-	-	-	
Young's Cr. (H)	10	-	0	-	-	-	-	
Total or average	10		0	-	-	-	-	
GRAND TOTAL OR AVERAGE	427		235	54	508	502	305	303

LAKE ONTARIO

TRIBUTARY INFORMATION

- 659 (254 United States, 405 Canada) tributaries to Lake Ontario.
- 57 (28 United States, 29 Canada) tributaries have records of production of sea lamprey larvae. (All Oswego River tributaries counted as one tributary.)
- 40 (19 United States, 21 Canada) tributaries have been treated with lampricide at least once during 1985-94.
- Of these, 34 (17 United States, 17 Canada) tributaries are treated on a regular (3-5 year) cycle.

SEA LAMPREY AND FISH COMMUNITY OBJECTIVES

The Lake Ontario Committee (1988) in the Lake Ontario Fish Community Objectives supported continuing sea lamprey control and defined a specific objective for lampreys in terms of mortality to lake trout:

Limit the size of the sea lamprey population to a level that will not cause mortality in excess of 90,000 lake trout annually.

This specific objective was developed to support the productive salmonine community including a lake trout population that shows significant reproduction in the near term.

The Lake Ontario Committee has revised its Lake Ontario Lake Trout Rehabilitation Plan (Schneider et al 1991) from the original plan developed in 1983 (Schneider et al 1983). The goal of the plan is to rehabilitate a self-sustaining population of lake trout as defined in the Fish Community Objectives. The plan includes the fundamental premise that continued control of sea lamprey induced mortality is necessary for lake trout rehabilitation. The plan includes a specific objective for sea lampreys of:

Controlling sea lamprey so that fresh wounding rates (A1) of lake trout larger than 431 mm is less than 2 marks/100 fish.

This specific objective is meant to maintain the annual survival rate of 60% or greater in order to maintain a target adult spawning stock of 0.5 to 1.0 million adults of multiple year classes. Along with sea lamprey mortality, angler, and commercial exploitation also shall be controlled so that annual harvest does not exceed 120,000 fish in the near term.

The Service and Department annually have operated traps in 15 index streams for spawning-phase sea lampreys in Lake Ontario since 1986. During that period, spawning catches have remained relatively stable, ranging from 4,000 to 8,000 annually (Fig. 10). Lake wide wounding rates average about 2 marks/100 fish, with annual survival between 50-70% (Schneider et al. 1994). As well, lake trout deaths from sea lampreys were about 30,000. Thus, the control program is achieving the current sea lamprey objectives for Lake Ontario.

LARVAL ASSESSMENT

United States and Canada

The Service and Department jointly staff an office in Amherst, New York and the larval assessment reported here is a result of that team of people working as partners in waters of both countries. The section titled: Larval Population Dynamics Study was conducted only by staff from the Department office in Sault Ste. Marie, Ontario.

Distribution Surveys:

Sea lamprey larval distribution was determined in 18 Lake Ontario tributaries, 10 in Canada (Bronte, Sixteen Mile, Lynde, Colborne, Proctor, Bowmanville, Farewell, and Port Britain creeks and the Credit and Rouge rivers), and 8 in the United States (Carpenters Brook, Little Sandy, Deer, Snake, Ninemile, Sodus, and First creeks, and Salmon River). Carpenters Brook and the Rouge River were treated in 1994, while the remaining streams were surveyed to schedule 1995 treatments. Sixteen Mile, Port Britain, and Ninemile creeks and Credit River had low densities of larvae and were deferred from the 1995 treatment schedule. Colborne and Proctor creeks were added to the 1995 treatment schedule.

Larval Reestablishment:

Surveys to identify reestablished populations of larval sea lampreys were conducted in 9 of 10 streams treated in 1994. Larvae were found only in the following four United States streams: Lindsey, Grindstone, and Sterling creeks and Little Salmon River. Proctor Creek (Canada), last treated in 1986, annually was surveyed from 1987-92 with no larvae collected. For this reason no surveys were conducted in 1993. In 1994 surveys showed the presence of the 1992-94 classes.

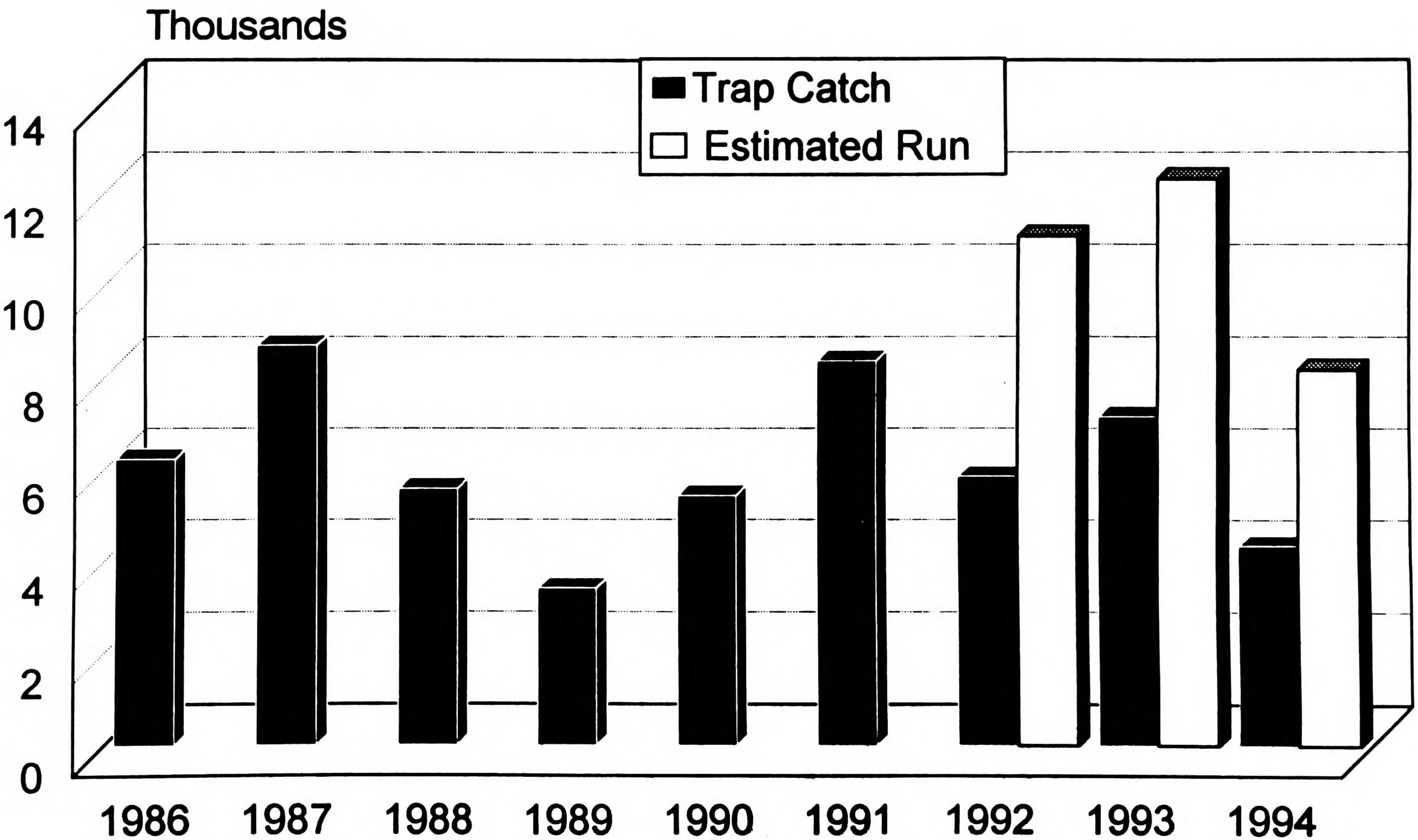


Fig. 10. Number of spawning-phase sea lampreys captured in assessment traps in an annual average of 15 streams (range, 13-16) in Lake Ontario, 1986-94, and estimated population of spawning lampreys in the Black and Humber rivers, and Duffin, Port Britain and Shelter Valley creeks, 1992-94.

Treatment Evaluation:

Treatment evaluation surveys were conducted in 11 streams. Four United States streams (Lindsey, Big Bay, and Grindstone creeks and Little Salmon River) were found to harbor small numbers of residuals. A significant number of residual lampreys from the 1993 treatment was found in Fish Creek (United States) and it has been scheduled for retreatment in 1995.

Barrier Evaluation:

High lake levels in 1993 caused inundation of barriers at Shelter Valley and Graham creeks (Canada). Surveys in 1993 showed that the 1993 year class had established in Graham Creek. Spawning lampreys were observed in Shelter Valley Creek in 1993 and surveys in 1994 confirmed the presence of the 1993 year class. The barriers on Shelter Valley and Graham creeks successfully prevented spawning in 1994. No larvae were found above barriers in four other Canadian streams that included Bowmanville, Port Britain, Grafton, and Colborne creeks.

Black River Larval Population Study:

Observations during the 1991 Black River (United States) treatment and larval assessment surveys in 1992-93 showed the presence of a significant population of residual larvae. We conducted a study using the technique developed for the St. Marys River by the St. Marys River Control Task Force with the objective for the Black River of estimation of the abundance and distribution of larvae prior to a TFM treatment and amount of habitat suitable for larvae. The study area extended upstream from the mouth for 4.3 km. Substrate samples from 239 stations were classified as types I, II, or III habitats. A total of 104 stations were sampled with the deep water electroshocker and no sea lamprey larvae were collected, which results in an estimate of 0. Estimated area (m^2) of habitat is: types I-462,000, II-328,000, and III-586,000.

To verify the equipment and procedure, we used the ABP II backpack shocker in 20 shoreline areas of types I and II habitat and collected only 1 larvae. As a further verification of the deep water shocker, we sampled an index site in the Salmon River and captured 20 larvae. Based on the study results, the lampricide treatment of the Black River scheduled for 1994 was deferred.

Larval Population Dynamics Study:

A four-year study of larval sea lamprey population dynamics in Salem Creek was completed in 1994. The study stream was similar to other small Lake Ontario tributaries having relatively high growth rates and densities of larval sea lamprey. TFM treatment crews effectively eliminate larval populations in Salem Creek on a three to four year treatment rotation. The study was to examine the rates of growth, mortality, and biomass among the four year classes (YC) that established since 1990. Lamprey were collected with backpack electrofishers each spring at 12 randomly selected sites. Year classes were separated based on length frequency distributions using a maximum likelihood algorithm (MacDonald and Pitcher 1979).

The 1990 YC was the first to reestablish after the 1989 treatment and its rate of growth and survival was significantly greater than all other YCs. The length at age of larvae was negatively correlated with the number of YCs present in the population. The 1990 YC increased in length from 44.6 mm at 1^+ to 103.1 mm at 4^+. We observed relatively high density at age and survival for the 1990 YC compared to later YCs. Density of larvae at 1^+ average $71.2 \cdot m^{-2}$ declining to $42.2 \cdot m^{-2}$ at age 4^+ with mean annual survival of 85%. Like length, density at age was negatively correlated with the number of YCs present in the population. Consequently, a significant ($p=.02$, $R^2=0.97$) linear increase in the biomass of the 1990 YC from $12.7\ g \cdot m^{-2}$ in 1991 to $71.1\ g \cdot m^{-2}$ in 1994 was noted. The biomass of the remaining YCs remained relatively stable year to year and was negatively correlated with the number of year classes present in the population.

These data suggest density dependant suppression of growth and survival of sea lamprey larvae. Transformer production was estimated to be 3,000 and 8,000 in 1993 and 1994, respectively. Based on size it is reasonable to believe all transformer production came from the 1990 YC.

LAMPRICIDE MANAGEMENT

Canada

New York:

The Little Salmon River, Grindstone, Lindsey, Sterling, and Red creeks and Carpenter Brook (treated for the first time) received lampricide treatment in April and May (Table 16, Fig. 11). All treatments provided adequate mortality of larval sea lamprey with minimal impact on nontarget organisms. The Little Salmon River and Grindstone Creek continue to be prolific larval sea lamprey producers while moderate to low numbers of ammocoetes were observed in the remaining streams.

The absence of several historically impounded areas on Grindstone Creek allowed for an effective treatment throughout the entire watershed.

The recent failure of the dam located in the town of Mexico, New York to stop the upstream migration of spawning adults on the Little Salmon River necessitated treatment of an additional 23 km of watershed and increased treatment complexity. Although spawning sea lampreys were observed in the river during the treatment, none were sighted above the Mexico dam. The dam appears to intermittently halt the upstream movement of spawning adults.

Canada

Ontario

Lampricide treatments were completed on the Rouge and Salmon rivers and Covert and Salem creeks (Table 16, Fig. 11).

Treatment concentrations on the Rouge River were kept purposely low to reduce the mortality risk to spawning phase white suckers. Incomplete larval sea lamprey mortality was recorded in a cage study conducted during the treatment, however treatment evaluation surveys failed to confirm the presence of residual larvae in the system.

The barrier-dam located on the Salmon River, which had for a period of years eliminated access to spawning phase sea lamprey and hence the need to treat from 1978 to 1990, is not a barrier at the present time. Treatment of the system in 1994 included the same distance treated during the initial 1971 treatment.

Covert Creek, a very small stream, was treated for the first time in 1994 following the first documentation of larval sea lamprey in 1993. Low flows may eliminate spawning opportunities on a regular basis.

Treatment of Salem Creek was scheduled for September to permit a late summer population study to be completed.

Sea lamprey larvae were abundant in Salem Creek and moderate in the remaining streams. Non-target mortality was insignificant in all streams treated.

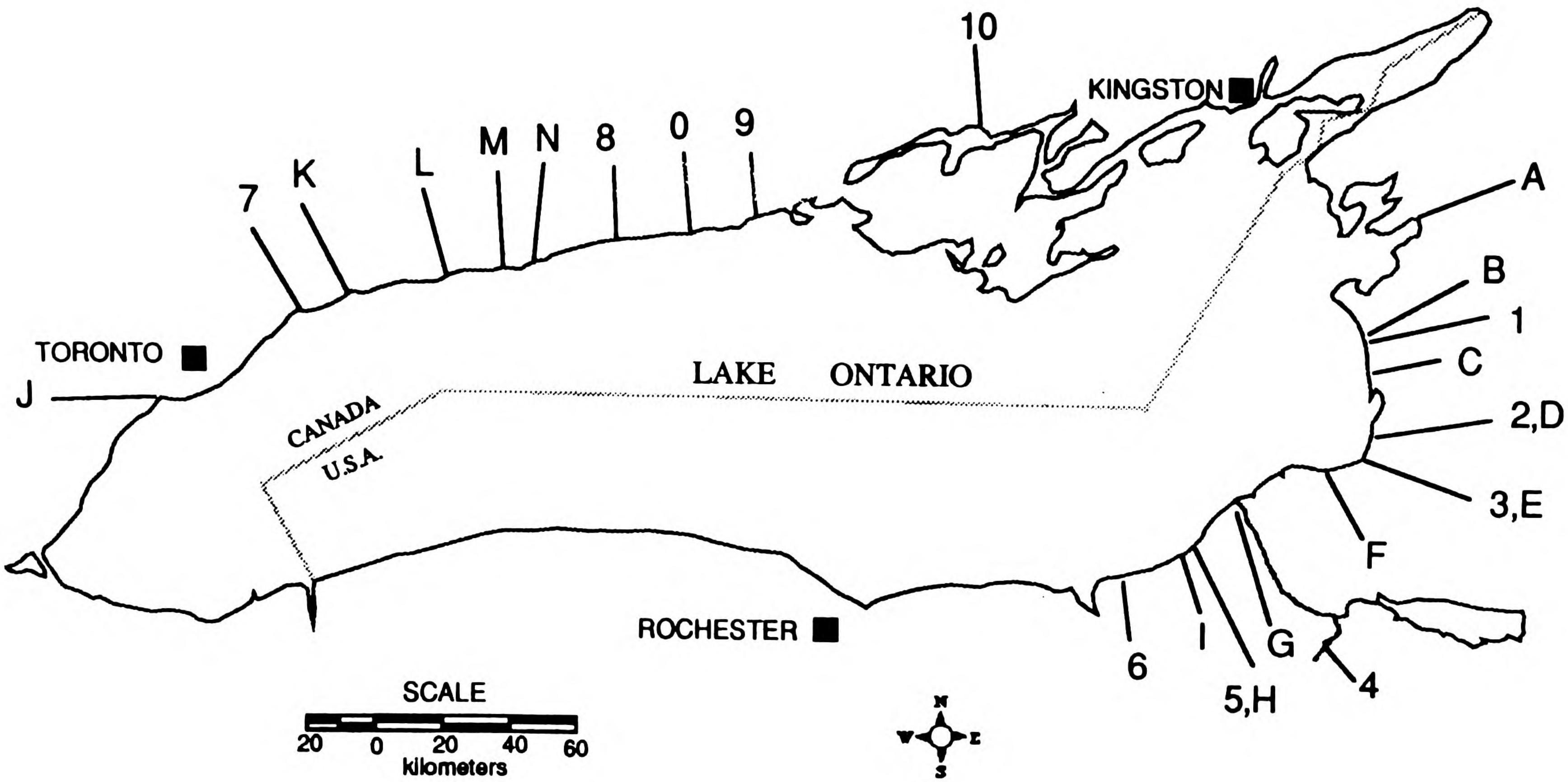


Fig. 11. Location of Lake Ontario tributaries treated with lampricides (Numerals, see table 16 for names of streams) and of streams where assessment traps were operated (Letters, see table 17 for names of streams) in 1994.

SPAWNING-PHASE ASSESSMENT

United States

A total of 1,873 sea lampreys were captured in assessment traps placed in 9 tributaries of Lake Ontario in 1994 (Table 17, Fig. 11). The 1994 trap catch of 271 lampreys in 6 consistently trapped streams (South Sandy, Grindstone, Catfish, Sterling, and Sterling Valley creeks and Little Salmon River) was lower than the 5-year (1989-1993) average of 542 (139-1,069) in the same streams. However, the Black River which was not included in the 6 streams had a significant increase from 241 lampreys in 1993 to 1,598 in 1994. The Black River catch accounted for 85% of the total Lake Ontario catch in 1994. Mark and recapture studies to estimate populations of spawning-phase sea lampreys were conducted in the Black River (4,439) and Sterling Creek (406).

Canada

To assess long-term trends in abundance of spawning phase lamprey in Lake Ontario, six standard index streams were trapped (Table 17, Fig. 11). Permanent traps are installed at all locations. Spawning run estimates were determined using a modification of the Schaefer stratified mark and recapture method (Ricker 1975). In addition, the catch was subsampled to determine sex ratio and size of lamprey as an index of lamprey stock size (Heinrich et al. 1980).

Spawning run catches at our most easterly index sites located in the central portion of the lake declined 38% from 1993. This result is consistent with the trend of decreasing spawner abundance in this region of the lake since 1986. In the western section of the lake, spawner catch declined 65% from 1993 catches. However, long term trends in the western section of the lake suggests a stable population which fluctuates in a cyclical pattern that may be related to TFM treatment effort. Trap efficiency (catch/run estimate) at most streams remains relatively high, ranging from 57% to 76% (Table 17).

Our index of size and sex ratio has remained relatively stable since 1990. The percent males declined slightly to 54% from 58% in 1993. Length and weight (Table 17), averaged for both sexes also declined marginally to 483 mm and 263g, respectively.

BARRIER PROGRAM

Canada

Black River (New York):

The Dexter dam was examined and a telemetry study was arranged to identify lamprey passage areas at the dam. The study was carried out by A. Schiavone of New York Department of Environmental Conservation in May and June. A conceptual drawing for remedial works to stop lamprey passage at the dam was designed by Department personnel and a contract was let with the Hydro Development Group to perform the work. The first part of the work, a steel lip, was finished in October 1994. High water levels necessitated putting off construction of a small concrete wall until 1995.

Fish Creek (New York):

Planning and designing were done for remedial work to stop lampreys at the McConnelsville dam. Construction could not proceed due to a funding technicality.

Barrier Maintenance:

Maintenance work was carried out at the existing Lake Ontario barriers and built-in traps and included Humber River, and Duffins, Graham, Lakeport, Shelter Valley, Grafton, Port Britain, Bowmanville, and Colborne Creeks.

Table 16. Details on the application of lampricide to streams of Lake Ontario, 1994. (Number in parentheses corresponds to location of stream in Fig. 11.)

Stream	Date	Discharge m^3/s	TFM[1] kg	Bayer 73[1] kg	Distance km
UNITED STATES					
Grindstone Cr. (2)	Apr 30	2.3	281	-	60.6
Red Cr. (6)	Apr 30	0.9	186	-	8.8
Oswego R.					
Carpenter Br. (4)	May 4	1.2	281	-	6.8
Little Salmon R. (3)	May 6	7.1	444	-	35.9
Lindsey Cr. (1)	May 10	1.4	126	-	11.1
Sterling Cr. (5)	May 28	1.8	357	-	7.5
Total		14.7	1,675	0.0	130.7
CANADA					
Covert Cr. (8)	Apr 27	0.2	47	-	1.3
Rouge R. (7)	May 10	2.4	437	-	19.7
Salmon R. (10)	Jun 15	9.5	989	7.4	22.9
Salem Cr. (9)	Sep 9	0.1	39	-	2.1
Total		12.2	1,512	7.4	46.0
GRAND TOTAL		26.9	3,187	7.4	176.7

[1]Lampricides are in kg of active ingredient.

Table 17. Number, estimated spawning population, and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Ontario, 1994. (Letter in parentheses corresponds to location of stream in Fig. 11.)

	Number captured	Estimated spawners	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
UNITED STATES								
Black R. (A)	1,598	4,439	304	70	468	471	255	275
South Sandy R. (B)	9	-	0	-	-	-	-	-
Beaverdam Br. (C)	2	-	0	-	-	-	-	-
Grindstone Cr. (D)	6	-	0	-	-	-	-	-
Little Salmon R. (E)	126	-	0	-	-	-	-	-
Catfish Cr. (F)	3	-	0	-	-	-	-	-
Oswego R. (G)	2	-	0	-	-	-	-	-
Sterling Cr. (H)	67	406	0	-	-	-	-	-
Sterling Valley Cr. (I)	60	-	0	-	-	-	-	-
Total or average	1,873		304	70	468	471	255	275
CANADA								
Humber R. (J)	1,353	2,387	258	58	477	468	251	250
Duffin Cr. (K)	706	937	148	52	489	489	270	281
Bowmanville Cr. (L)	63	-	15	47	495	482	275	250
Graham Cr. (M)	39	-	10	40	523	488	329	247
Port Britain Cr. (N)	17	30	3	33	448	493	210	275
Shelter Valley Cr. (O)	267	357	54	50	505	507	279	294
Total or average	2,445		488	54	484	481	261	265
GRAND T			792	60	477	478	258	268

LAKES SUPERIOR, MICHIGAN AND HURON

RISK ASSESSMENT

United States

Riffle community index:

Index areas of macroinvertebrate riffle communities were established in the Brule (Lake Superior) and West Branch of the Whitefish (Lake Michigan) rivers in 1985 and Sturgeon (Lake Huron) River in 1986. Samples have been collected in the spring and fall and before and after lampricide treatments using a standardized traveling kick method. Samples were taken up (control) and downstream (treated) of lamprey barriers in the Brule and Whitefish rivers. Samples were collected from a treated area of the Sturegon River. Due to problems with comparability of control and treated areas in the Sturgeon River a control area was selected in an untreated portion upstream of a barrier in the Boardman River (Lake Michigan). Field collection of specimens was concluded in the Brule and Whitefish rivers in 1993, and will be concluded at the other sites in 1995. We report results of laboratory analysis of samples collected in the Whitefish river in 1991 (Tables 18-19). Results of 1985-90 for the Whitefish River and 1985-91 for the Brule, Sturgeon, and Boardman rivers have been listed in tables in previous annual reports. Laboratory analysis of all remaining years will be reported in 1995.

Lake sturgeon studies:

Protection of lake sturgeon during sea lamprey management activities is a priority. The lake sturgeon is listed in the federal register as a candidate species (C2) and is being considered for threatened or endangered status. We monitored the potential impacts of sea lamprey management to lake sturegon in two studies. Our primary rivers of concern are the Sturgeon and Bad rivers (Lake Superior).

Lake sturgeon were subjected to various concentrations of TFM in flow-through and static toxicity tests conducted at the Sturgeon River (Houghton County, Michigan) in October. Lake sturgeon are sensitive to TFM, but are not harmed if minimum lethal concentrations (MLC) of TFM is 1.3 times MLC necessary to kill larval sea lampreys. These results were consistent with the results obtained in similar toxicity tests conducted at the Sturgeon River in 1989 and 1993. To lessen the risk to lake sturgeon populations in the Sturgeon and Bad rivers, we treated these rivers with concentrations of TFM $\leq$ 1.3 times MLC and after August 1 when adult and juvenile sturgeon are not likely to be in the rivers.

In partnership with the Service Fishery Resources Office in Ashland, Wisconsin, Michigan Technological University in Houghton, Michigan, and the Great Lakes Indian Fish and Wildlife Commission in Odanah, Wisconsin, we participated in gill net and bottom trawl surveys in the mouths of the two rivers and near offshore waters of the lake. A total of 37 juvenile sturgeon (range, 209-858 mm) were captured. The Service Office in Ashland had the lead on this work and they report this study in detail in their annual report.

Project completion reports:

Reports were completed in 1994 on several studies conducted during the 1980s. The project completion reports include: 1) Effects of three applications of a lampricide (3-trifluoromethyl-4-nitrophenol) upon a Hexagenia population in a Michigan River; 2) Mortality of nontarget organisms confined to cages during TFM applications to the Great Lakes 1983-1989; 3) Effects of the 1984 TFM lampricide (3-trifluoromethyl-4-nitrophenol) application on benthos in the Fish Creek system, Oneida County, New York; 4) Effects of the 1987 TFM lampricide (3-trifluoromethyl-4-nitrophenol) application on fish, aquatic insects, and an amphibian in the Grand River, Lake County, Ohio; and 5) Effects of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) on macroinvertebrate drift in 6 tributaries of the Great Lakes, 1984-1988.

Table 18. Mean number of organisms from 5 samples taken by kick nets in riffle communities in the Whitefish River in spring 1991 in areas that are periodically treated and in areas that are not treated (control).

	Whitefish River	
Taxa	Treated Area Spring 1991	Control Area Spring 1991
Arthropoda		
Hexapoda (Insecta)		
Ephemeroptera		
Baetidae		
Baetis	16.6	5.0
Pseudocloeon	0.0	0.2
Oligoneuriidae		
Isonychia	2.2	2.2
Heptageniidae		
Epeorus	15.0	31.4
Leurocuta	9.2	10.4
Stenonema	18.2	11.0
Ephemerellidae	0.2	0.0
Drunella	8.2	1.6
Ephemerella	156.6	94.8
Eurylophella	3.0	0.2
Serratella	55.8	13.0
Caenidae		
Caenis	6.8	1.4
Leptophlebiidae		
Paraleptophlebia	16.4	10.0
Ephemeridae		
Ephemera	0.6	0.4
Odonata		
Gomphidae		
Ophiogomphus	6.2	3.0
Stylogomphus	5.8	1.4
Aeshnidae		
Boyeria	0.6	0.0
Plecoptera	0.2	0.0
Taeniopterygidae		
Strophopteryx	2.6	15.0
Nemouridae		
Amphinemura	0.0	0.2
Ostrocerca	8.0	8.6
Perlidae		
Neoperla	0.4	0.0
Paragnetina	1.8	1.8
Phasganophora	6.8	7.4
Acroneuria	11.4	12.6
Perlinella	2.4	0.6
Perlodidae		
Isoperla	2.6	8.0

(continued)

Table 18. Continued

Taxa	Whitefish River Treated Area Spring 1991	Whitefish River Control Area Spring 1991
Hemiptera		
Corixidae	0.0	0.2
Megaloptera		
Corydalidae		
Nigronia	3.2	1.8
Trichoptera	0.0	0.2
Philopotamidae		
Chimarra	1.4	1.4
Psychomyiidae		
Psychomyia	1.6	1.0
Hydropsychidae		
Ceratopsyche	38.4	21.0
Cheumatopsyche	8.2	2.6
Rhyacophilidae		
Rhyacophila	0.0	1.2
Glossosomatidae		
Glossosoma	28.6	13.0
Hydroptilidae		
Agraylea	2.0	0.0
Dibusa	1.2	0.0
Hydroptila	0.4	0.2
Stactobiella	0.6	0.0
Leucotrichia	1.0	0.2
Protoptila	0.2	0.6
Brachycentridae		
Brachycentrus	1.4	0.4
Micrasema	0.2	0.0
Lepidostomatidae		
Lepidostoma	8.6	3.8
Limnephilidae		
Neophylax	17.0	27.4
Pycnopsyche	0.6	0.0
Odontoceridae		
Psilotreta	6.2	5.8
Helicopsychidae		
Helicopsyche	3.4	5.6
Leptoceridae		
Ceraclea	4.6	1.4
Mystacides	0.6	0.2
Setodes	0.0	0.2
Pupae	0.4	0.8

(continued)

Table 18. Continued

	Whitefish River	
Taxa	Treated Area Spring 1991	Control Area Spring 1991
Coleoptera		
Psephenidae		
Psephenus	1.0	2.6
Ectopria	0.0	0.4
Dryopidae		
Helichus	0.2	0.0
Elmidae		
Macronychus larvae	0.0	0.2
Macronychus adult	0.2	0.2
Optioservus larvae	15.4	15.4
Optioservus adult	7.6	1.8
Stenelmis larvae	0.0	0.2
Stenelmis adult	3.2	1.8
Diptera		
Tipulidae		
Antocha	17.4	6.2
Hexatoma	0.8	1.8
Ceratopogonidae	0.0	0.2
Simuliidae		
Ectemnia	0.0	0.4
Prosimulium	28.8	174.4
Simulium	0.4	0.0
Chironomidae	189.8	39.6
Athericidae		
Atherix	10.8	1.8
Empididae		
Chelifera	0.4	0.0
Hemerodromia	1.6	1.0
Pupae	5.0	1.0
Platyhelminthes		
Turbellaria		
Planaria	0.6	0.0
Annelida		
Oligochaeta	2.8	2.2
Arthropoda		
Amphipoda		
Gammarus	0.2	0.0
Decapoda		
Astacidae	0.6	0.0
Arachnoidea (Arachnida)		
Hydracarina	3.2	0.2

(continued)

Table 18. Continued

Taxa	Whitefish River Treated Area Spring 1991	Control Area Spring 1991
Mollusca		
Gastropoda		
Physidae		
Physa	2.2	2.0
Ferrisia	0.6	0.0
Pelecypoda		
Sphaeriidae		
Sphaerium	1.0	0.4
Pisces	0.4	0.0
Total	781.6	583.0
Total Taxa	71	65

Table 19. Mean number of organisms from 5 samples taken by kick nets in riffle communities in the Whitefish River in fall 1991 in areas that are periodically treated and in areas that are not treated (control).

	Whitefish River	
Taxa	Treated Area Fall 1991	Control Area Fall 1991
Arthropoda		
Hexapoda (Insecta)		
Ephemeroptera		
Baetidae		
Baetis	12.4	4.2
Pseudocloeon	21.0	16.0
Oligoneuriidae		
Isonychia	26.0	21.6
Heptageniidae	2.6	0.0
Epeorus	21.8	10.2
Leurocuta	25.6	16.6
Rhithrogena	3.6	0.0
Stenacron	0.4	0.0
Stenonema	50.4	30.4
Ephemerellidae		
Drunella	1.4	0.0
Ephemerella	104.2	19.8
Eurylophella	2.2	4.2
Serratella	69.0	61.4
Caenidae		
Caenis	1.6	0.8
Leptophlebiidae		
Paraleptophlebia	43.8	25.4
Ephemeridae		
Ephemera	0.6	0.0
Odonata		
Gomphidae		
Ophiogomphus	5.6	6.4
Stylogomphus	3.2	3.8
Aeshnidae		
Boyeria	0.8	0.0
	0.2	0.0
Plecoptera		
Taeniopterygidae		
Taeniopteryx	0.2	0.0
Strophopteryx	0.4	0.0
Nemouridae		
Ostrocerca	1.0	0.0
Capniidae		
Paracapnia	1.0	0.2

(continued)

Table 19. Continued

	Whitefish River	
	Treated Area	Control Area
	Fall	Fall
Taxa	1991	1991
Plecoptera (continued)		
Perlidae	3.2	0.2
Neoperla	0.6	0.0
Paragnetina	0.4	3.8
Phasganophora	10.0	1.6
Acroneuria	6.2	5.2
Perlinella	3.0	0.0
Perlodidae		
Isoperla	7.4	1.4
Megaloptera		
Corydalidae		
Nigronia	5.6	1.6
Trichoptera		
Philopotamidae		
Chimarra	11.4	1.0
Dolophilodes	1.0	1.6
Polycentropodidae		
Neureclipsis	0.2	0.0
Polycentropus	0.0	0.2
Psychomyiidae		
Psychomyia	2.2	1.4
Hydropsychidae		
Ceratopsyche	75.8	130.0
Cheumatopsyche	2.2	0.0
Rhyacophilidae		
Rhyacophila	0.4	2.4
Glossosomatidae		
Glossosoma	16.2	1.0
Hydroptilidae		
Agraylea	0.8	0.0
Dibusa	0.2	0.0
Hydroptila	0.2	3.4
Stactobiella	1.0	0.0
Leucotrichia	9.6	5.8
Brachycentridae		
Brachycentrus	1.6	8.4
Lepidostomatidae		
Lepidostoma	3.0	4.6
Limnephilidae		
Neophylax	0.8	0.0
Odontoceridae		
Psilotreta	1.2	0.4
Helicopsychidae		
Helicopsyche	4.2	1.8

(continued)

Table 19. Continued

Taxa	Whitefish River Treated Area Fall 1991	Whitefish River Control Area Fall 1991
Leptoceridae		
Ceraclea	0.4	0.2
Pupae	1.6	1.4
Coleoptera		
Psephenidae		
Psephenus	4.4	4.6
Ectopria	0.4	0.0
Elmidae		
Optioservus larvae	97.0	46.4
Optioservus adult	28.6	7.6
Stenelmis larvae	0.4	0.2
Stenelmis adult	2.2	2.4
Diptera		
Tipulidae		
Tipula	1.4	0.0
Antocha	50.4	20.8
Hexatoma	6.2	4.6
Ceratopogonidae	1.8	0.4
Simuliidae		
Prosimulium	8.0	0.6
Simulium	2.0	0.8
Chironomidae	73.6	108.4
Athericidae		
Atherix	11.2	19.8
Empididae		
Clinocera	0.2	0.0
Hemerodromia	1.8	4.0
Pupae	2.2	1.0
Adult	0.6	0.0
Platyhelminthes		
Turbellaria		
Planaria	1.2	0.0
Nematoda	0.4	0.0
Nematomorpha	0.2	0.0
Annelida		
Oligochaeta	7.6	2.4
Branchiobdellida	0.2	1.8
Arthropoda		
Decapoda	0.8	1.2

Table 19. Continued

	Whitefish River	
	Treated Area Fall 1991	Control Area Fall 1991
Taxa		
Arachnoidea (Arachnida)		
Hydracarina	0.4	0.0
Mollusca		
Gastropoda		
Physidae		
Physa	1.4	0.6
Pelecypoda		
Sphaeriidae		
Sphaerium	0.6	0.0
Terrestrials	0.6	0.0
Pisces	0.4	0.4
Total	875.6	626.4
Total Taxa	81	54

TASK FORCE REPORTS

The Great Lakes Fishery Commission has established Task Forces to recommend direction and coordinate actions in three focus areas: St. Marys River Control, Sterile Male Release Technique, and Barriers. The following outlines the progress and major actions of the Task Forces for 1994.

ST. MARYS RIVER CONTROL

- Task Force established January 1992

- Charge is:

  a) Define scope of problem in terms of size and distribution of larval sea lamprey population and production of parasitic phase animals

  b) For all recommended control options determine:

     - Feasibility
     - Effectiveness (% reduction in transformer contribution)
     - Costs
     - Information needs to estimate effectiveness and costs
     - Environmental assessment requirements
     - Evaluation plans

  c) If effectiveness of control options cannot be predicted, develop experimental or adaptive design that does not conflict with other options and includes evaluation.

- Members are: Larry Schleen (Chair) and Robert Young from Department of Fisheries and Oceans Canada; John Heinrich, Dennis Lavis, and Terry Morse from U.S. Fish and Wildlife Service; Roger Bergstedt from National Biological Service; James Johnson (Lake Technical Committee Representative) from Michgian Department of Natural Resources; Richard Fleming (Outside Expert) from Forestry Canada; and Gavin Christie from Great Lakes Fishery Commission Secretariat.

- Meetings held: January 20 and June 28-29

- Progress on the charge in 1994:

During 1994, the Task Force provided considerable information on larval distribution and densities, habitat classification, flow patterns, and adult trap designs. Table 20 provides the Task Force's current recommended timeline and cost estimates for the various control options and information needs. This timeline will be continually revised as the information needs are met. The status of each item in the timeline table is as follows:

I. Control Options

A. Reduce Reproduction

1 and 2) Adult trapping and sterile male release

Trapping of spawning phase sea lampreys and the release of sterilized males into the St. Marys River continued in 1994 (detailed reports of these activities are found in the sections titled spawning-phase assessment

Table 20. St. Marys River control strategy-timeline/cost estimates.

Action/Yr	93	94	95	96	97
I. Control Options					
A. Reduce Reproduction					
1. Adult Trapping	41 K	41 K	41 K	99 K	99 K
2. Sterile Male Release	55 K	55 K	55 K	90 K	90 K
3. Enhanced GLP Trapping	-----	20 K (Design)	100 K (const.)		
4. Enhanced COE Trapping	-----	-------------	-------------	10 K of total 40K	
B. Reduce Larval Population					
1. Section Bayer	-----	-------------	test formulation 36K (8 Ha)	360 K (65 Ha)	1,012 K (182 Ha)
2. Section Animycin	-----	-------------	1 K (0.8 Ha)	? K	? K
3. Section TFM	-----	-------------	-------------	-------------	?
4. Whole River TFM	-----	-------------	-------------	Decision Year	-------------
II. Information Needs					
1. Trapping Eff. Study (GLP)	-----	8.4 K			
2. Larval & Habitat Mapping	200 K	320 K (80% of pop n)	240 K (90% of pop n)	155.4 K (100% of pop n)	
3. Index of Larval Abundance	-----	20 K	100 K	200 K	200 K
4. Ageing/trans. Rates	-----	included in	larval & habitat	mapping above	
5. TFM Transport Model	-----	20 K	10 K		
6. Dye Study	-----	-------------	-------------	100 -150 K?	
7. Toxicity Assays TFM	-----	-------------	10 K	10 K	10 K
8. Appl'n Techniques TFM	-----	-------------	-------------	? K	? K
9. Bayer Efficacy Testing	-----	-------------	62 K	? K	? K
10. Stock Recruitment Workshop	-----	-------------	15 K		
III. Environmental Assessment					
1. Envir. Assess. Process	-----	-------------	-------------	100 K	? K
2. Non-Target Impacts	-----	-------------	-------------	? K	? K

and sterile male release technique in this report). The timeline shows a similar effort planned for 1995, but if enhanced trapping at the Great Lakes Power facility begins (see below), the costs of these programs would increase accordingly because of the larger number of adults involved.

3) Enhanced Great Lakes Power trap

Construction of an enhanced adult trap at the Great Lakes Power facility could occur in 1995 if the contracted engineering firm completes the design in time and the construction costs do not exceed $100,000. Trials in July 1994 to move lampreys with a fish pump proved encouraging. A fish pump to facilitate emptying lampreys from the new larger trap is an integral and innovative part of the trap design, as is a pumped water outflow to attract adults to the trap.

It is unknown at this time whether the trap could be constructed early enough in 1995 to be operational for the 1995 spawning run. If not, the trap could still be constructed in early fall of 1995.

4) Enhanced Corps of Engineers trap

Enhanced adult trapping at the United States Army Corps of Engineer (Corps) facility also has been recommended by the Task Force. During earlier consultations with the Corps a joint fish/lamprey trap was conceived. However because of concerns by the Corps about the location of this joint trap, the project would now consist only of a lamprey trapping facility. Two semi-permanent lamprey traps would be located against the upstream end of the tailrace abutments. These would be supplied with attractant water from upstream. The project is estimated to cost about $40,000 with the Commission paying 25% of the cost ($10,000). The earliest possible construction date is likely 1996.

B. Reduce Larval Population

1) Section treatments - Bayer

Tests are planned for 1995 to assess the feasibility of treating sections of the St. Marys River with a new formulation of granular Bayer. Up to 8 ha will be experimentally treated with the new product at a cost of $20,000. Larval assessment results to date (see below) have shown that there are a number of discrete areas with relatively dense concentrations of larval sea lampreys. If tests prove encouraging and flows permit, the areas treated would be substantially increased in future years. Up to 65 ha would be treated in 1996, and the Task Force has suggested that beginning in 1997, 182 ha could be treated annually. A treatment of 182 ha annually would allow the estimated 1,214 ha with high larval density to be treated in 7 years. This figure may be modified as more information on larval distribution and flow velocities is gathered. These potential treatments also rely on the registration and availibility of the new Bayer formulation.

2) Section treatments - Antimycin

A small (0.8 ha) plot(s) will be experimentally treated with antimycin in 1995 to evaluate this product as a potential bottom toxicant for use in the St. Marys River.

3) Section treatments - TFM

Section TFM treatments have been identified as a possible control option, but cost estimates have not been included in the timeline, pending results of the TFM transport model and possible dye study, which are required to determine the feasibility of this option.

4) Whole river treatment - TFM

A whole river TFM treatment, if deemed to be effective and funds were available, would not appear in the timeline until 1998 at the earliest. The larval assessment work must be completed and flow information gathered and analyzed before a full scale TFM treatment could be recommended. Also, a realistic cost estimate of a TFM treatment cannot be made until the information needs are met. By 1996 sufficient information should be available to determine if a full-scale TFM treatment is feasible and at what cost.

II. Information Needs

1) Trapping efficiency study at Great Lakes Power

A trapping efficiency study of the present portable GLP plant traps was conducted in 1994 to assess the results of extra trap lifts (weekends and evenings).

Background: The Department has fished two portable assessment traps annually in the St. Marys River at the Great Lakes Power tailrace since 1983. Trap efficiency ranged between 30-40%, the highest efficiency for passive, portable traps in our network. However, permanent dam traps with attractant water have a mean efficiency >60%. The Task Force recommended the construction of a permanent trap with attractant water as part of an integrated program to reduce lamprey abundance in the St. Marys River. The Lake Huron Technical Committee suggested that as an alternative to construction of a permanent trap, catch efficiency of the existing traps might be improved. Our data indicated that traps approached the maximum capacity for holding lamprey during the peak of the spawning, which may reduce the overall trap efficiency. We tested the hypothesis that increasing the frequency of lamprey removal from traps increases catchability.

Procedure: The two large, portable traps used at the tailrace fish along the downstream face of the turbine draft tubes. We check the traps daily, Monday to Friday, during the spawning run. The traps are inefficient when the catch equals the trap's holding capacity (~1,300). This capacity is usually reached over weekends and daily during the peak of the run.

We operated both traps in 1994, but serviced the north trap daily on weekends during the peak of the run, and usually twice daily (morning and evening) two days a week. The south trap served as a control. To avoid confounding results from the weekend morning checks, night checks were confined to a Tuesday-Wednesday set, or a Wednesday-Thursday set.

Results (Comparisons of total catch/efficiency): The total 1994 catch of 5,175 lamprey was significantly lower than the previous eleven-year (1983-93) average of 7,215. Trap efficiency in 1994 was estimated to be 49% compared to the long term average of 34% (29-39%).

Results (Comparisons of the two traps): The impact of additional lifts at the north trap versus the south (reference) was tested by developing the "ratio-of-catch" between the two traps (ie. N:S). In 1994, enhanced checking at the north trap increased the N:S to 3.6:1 compared to the 11 year average of 2.1:1 (1.4-3.1:1).

Our data suggests that weekend and evening trap checking increased trap efficiency by approximately 24%. However, enhanced checking of portable traps did not approach the trapping efficiency of permanent traps (> 60%), and therefore, does not represent a viable control alternative in the St. Marys River.

2) Larval and habitat mapping

The extensive larval and habitat mapping effort needed to plan and predict the effectiveness and costs of the options to control the larval population continued in 1994. The effort (cost) was increased from $200,000 in 1993 to $340,000 in 1994.

From the analysis of 1993 data, several observations indicated modifications to the sampling scheme were needed for 1994. Because only 8% of the stations in Lake Nicolet and 15% of the stations in the North Channel had catches of sea lampreys associated with them and local concentrations of larvae are important, an adaptive sampling approach has been developed for better efficiency. The adaptive sampling technique can be defined as a process to geographically distribute second round sampling effort proportional to larval densities determined from first round sampling. The following recommendations were implemented in 1994:

a. The systematic grid of 65 m in 1993 was expanded only slightly to a 70 m grid, maintaining continued high-quality mapping. Effort made available by this 15% relaxation was used for adaptive sampling in 1994.

b. Adaptive sampling was carried out in two ways:

   i) As boats sampled stations along a transect, if the sum of two adjacent stations yielded four sea lamprey larvae or more, then an additional station was sampled at the midpoint betweenthose two sampling stations. If a single station yielded four or more larvae, then the boat sampled ahead one half step (35 m) as well.

   ii) The Survey Designer Software System was then used to analyze data from the first round of sampling and to plan additional adaptive sampling. Additional stations (not on transects) were sampled near areas of local high concentrations for better delineation of those areas. This was done after sampling the 70 m systematic grid.

c. The remainder of the 1993 sampling protocol was maintained in 1994, except velocity measurements were eliminated.

As a required component of the Survey Designer Software System to perform adaptive sampling, a detailed electronic bathymetry map over the known sea lamprey distribution was needed prior to the start of sampling in 1994. After a data search of most federal agencies from both countries had been conducted, bathymetric data was secured for about 60% of the area. The remainder of the data was gathered by the U.S. agent using real-time, differentially corrected Global Positioning System (GPS), and an echosounder. This data (59,243 points), along with bathymetry data from National Oceanographic and Atmospheric Administration surveys (60,701 points) and sea lamprey larval surveys (4,167 points) were corrected and assembled into an electronic bathymetry map by the Survey Designer developer, Dr. Dimitri Stolyarenko. This map forms the basis for multidimensional spatial modeling. Dr. Stolyarenko's anaylsis can be found in the document submitted to the Commission in August, 1994.

The main emphasis was to complete areas so that at the conclusion of 1994 the total surveyed area would be continuous. The areas were surveyed in the following priority order:

a. Side Channel area (from the head of Lake Nicolet upstream to the Sugar Islander Ferry crossing including the side channels adjacent to the Sault Ste. Marie Municipal Marina).

b. Turning basin (from the western end of Sugar Island upstream to the navigational locks and the foot of the St. Marys River rapids).

c. Remainder of the North Channel (1993 ending point downstream through Little Lake George to the head of Lake George).

A total of 3,801 stations were examined over an area of 16.04 km^2 in 1994: 1,743 stations over 7.12 km^2 in priority areas 1 and 2 and 2,058 stations over 8.92 km^2 in priority area 3 (Table 21). A total of 629 sea lamprey larvae (range 14 - 169 mm) were captured. Adaptive sampling accounted for about 9% of the total number of samples. In the 22.56 km^2 surveyed to date, a population of 2,232,000 larval sea lamprey is estimated (Table 21).

Table 21. Estimated stock abundance (corrected for gear efficiency) of larval sea lampreys in surveyed areas of the St. Marys River, 1993-94.

River Segment	Area (km²)	Population Estimate
1993		
Upper Lake Nicolet	3.94	535,000
North Channel	2.58	472,000
1994		
<u>Priority areas 1 and 2</u>		
Head of Lake Nicolet to navigational locks	7.12	1,025,000
<u>Priority area 3</u>		
Partridge Point to outflow of Little Lake George	8.92	200,000
Total	22.56	2,232,000

In an effort to determine the sampling intensity required in 1995, seven transects were completed to examine the level of catches to be expected in lower Lake Nicolet. Only two stations were positive and density appeared low. The sampling grid likely can be relaxed in 1995.

The assessment effort will continue in 1995 and 1996. By the end of 1996, it is expected that 100% of the larval population will have been mapped.

3) Index of larval abundance

Efforts to establish index sites to estimate larval abundance and evaluate any implemented control options began in 1994 ($20,000). A total of 5 small areas sampled in 1993 were selected as index areas to sample in 1994; 4 were located in Lake Nicolet and 1 in the North Channel. Using geographic information software, a sampling grid with cells measuring 22 m^2 was created over these areas in an electronic map. Then using GPS, the boats were navigated to visit each cell. Four samples were taken per cell with the deepwater electroshocker. This technique proved reliable and it will be easy to return to the areas covered by these cells in future index sampling. An increasingly large portion of the total larval assessment effort is planned for the establishment and use of these index sites as control options are initiated.

4) Larvae age and transformation rates

Information on larval ageing and transformation is being collected during the larval assessment work.

Of the 1,188 lamprey collected from the St. Marys River during the 1993 and 1994 deepwater electrofishing surveys, 119 were dissected and had their statoliths removed for age determination. There was a positive correlation between age and length ($r^2=0.66$). Eight statoliths were too ambiguous to determine an age with confidence.

Table 22. Age, length, and distribution of 119 larvae from the St. Marys River from which statoliths were examined.

Age	Length (mm) Min	Max	No. Sampled
1	27	66	14
2	39	91	32
3	60	146	24
4	79	127	27
5	83	153	12
6	128	139	1
7	-	164	1

Ages were assigned to each individual with an average error of 8.9%. This means that the same statolith would be assigned the same age 91.1% of the time. The discrepancies in age never varied by more than one year.

A disproportionate number (42 of 111) of the larvae assigned ages were 120 mm or larger. Effort was increased in the larger size classes in order to determine the age at potential transformation in the St. Marys River. Of the 42 sampled, 16% (7 of 42) and 50% (21 of 42) were aged as 3 and 4 years old, respectively. This is an indication that the duration of the larval life stage may be less than previously suspected. Weights were not recorded so no measure of condition factor was possible.

An age validation study was initiated in June, 1994 to determine age and growth of larvae in the St. Marys River. Sea lamprey ammocoetes (n = 325) from the 1994 electrofishing surveys were injected with oxytetracycline (OTC), a calciphilic biomarker, which will be incorporated into the structure of the statolith during ammocoete growth. When viewed under ultraviolet light, the OTC uptake will be observed as a fluorescent line within the statolith. One complete annulus should form in the area beyond that marked with OTC 12 months after the date of injection. This would verify that the number of dark bands present within statoliths is equivalent to the age of the ammocoete in years.

The 1994 work is being treated as a pilot study. All of the larvae marked in 1994 are being held in the lab and most will be sacrificed over the next year to see if the mark takes. Assuming that the mark does take and that Bayer 73 can be used, we intend to expand this work to the field in 1995, where we plan to follow both growth and age in the St. Marys for a minimum of three years.

5) TFM transport model

Work progressed favourably in 1994 on the contracted lampricide transport model which is being developed to assist in predicting the effectiveness of the various lampricide options for the St. Marys River. A mid-development progress report was presented at the June Task Force meeting, at which time the Task Force made recommendations for refinement and completion. It was decided at this meeting that the flow model should be developed primarily to determine the effectiveness of a TFM treatment(s), with secondary emphasis on assisting with spot treatments with bottom toxicants.

Sea lamprey control and assessment experts met with the flow modelling project team, led by Drs. Shen and Yapa, at their laboratory at Clarkson University in Potsdam, New York on February 9-10, 1995. The function and products of the flow and lampricide application models for the St. Marys River were demonstrated. The model is adequately calibrated to the results of a dye study carried out in 1981. Initial simulations of a TFM application produced concentration maps in time and summary of lethal dose that suggested that the chemical would be initially well mixed into the system and would effectively cover larval populations in the north channel portion of the river, but would not likely be effective into Lake Nicolet. New TFM application scenarios at current flow and application conditions were defined by the group. Drs. Shen and Yapa and their students will be producing these outputs for presentation and consideration at the March 1995 meeting of the Task Force. The lampricide distribution predictions of the model will be combined with the larval distribution data to evaluate effectiveness of kill. These analyses are critical to evaluating the cost effectiveness of the TFM treatment options in the St. Marys River.

6) Dye study

A rhodamine dye study is shown in the recommended timeline for 1996 at a cost of $100-150,000. It appears that the computer flow model will enable the scope and cost of the dye study to be reduced, but it is likely that some kind of dye study will be required to calibrate the flow model and confirm its predictions..

7) Toxicity tests

The Task Force recommends that target and non-target TFM toxicity tests be conducted in 1995-97 at an annual cost of $10,000. These tests will be required to help estimate the amounts and cost of TFM treatment(s) if deemed feasible.

8) Application techniques

Specialized application techniques and equipment will likely be required for either full-scale or section treatments. An undetermined amount for these items is included in the timeline for 1996-97.

9) Bayer efficacy tests

A figure of $62,000 is included in the timeline for 1995, with undetermined amounts in 1996-97, for efficacy testing of the new granular Bayer formulation in the St. Marys River.

10) Compensatory mechanisms workshop

A figure of $15,000 is included in the timeline for 1995 to conduct a stock-recruitment and density-dependance workshop to discuss compensatory mechanisms.

III. Environmental Assessment

1) Environmental assessment process

A figure of $100,000 is shown in the timeline for 1996 to begin conducting environmental assessment work which would likely be required if a full-scale TFM treatment is recommended. The exact timing and cost of this work is difficult to predict at this time.

2) Impacts to nontarget organisms

An undetermined amount to gather special non-target impact information required for an environmental assessment is included in the timeline in 1996-97.

STERILE MALE RELEASE TECHNIQUE

- Task Force established April 1984

- Charge: to implement and assess the sterile male release technique as an experimental alternative technology of sea lamprey control (changed to a research focus at Interim Meeting in December; charge redefined in 1995).

- Members: John Heinrich (Chair) and Michael Twohey from U.S. Fish and Wildlife Service; Rob Young and Rod McDonald from Department of Fisheries and Oceans Canada; Gavin Christie from Great Lakes Fishery Commission Secretariat; Jim Smith (Outside Expert) from Mississippi State Delta Research and Extension Center; and Michael Hansen (Lake Technical Committee representative) and Roger Bergstedt from National Biological Service.

- Meetings held: April 12 and September 21-22

- Progress on the charge in 1994:

Implementation of the sterile male release technique continued in Lake Superior and the St. Marys River in 1994. Male sea lampreys were captured in six tributaries of Lakes Michigan and Huron and transported to the sterilization facility at the Lake Huron Biological Station. At the facility, lampreys were sterilized with the chemosterilant bisazir, decontaminated, and released into 25 major lamprey-producing tributaries of Lake Superior (U.S.-21, Canada-4) and the St. Marys River. In addition, interaction of sterilized males with resident female lampreys was monitored in six tributaries of Lake Superior and the St. Marys River.

The sterilization facility continued to meet the needs of the Sea Lamprey Management Program. A total of 18,965 spawning-phase male lampreys were transported to the sterilization facility during May 7 to July 25. Male lampreys were sorted from the assessment traps on the Manistique River of Lake Michigan (5,033) and the following rivers tributary to Lake Huron: Cheboygan (6,673), Ocqueoc (3,623), Echo and Thessalon (702 combined), and St. Marys (2,934). The lampreys were injected with bisazir at a dose of 100 mg/kg of body weight. After 48 hours of decontamination, lampreys were transported to streams for release. Sterilized males placed in streams with trapping operations were marked with a dorsal fin clip to distinguish them from resident lampreys. A total of 18,282 lampreys were sterilized and 17,579 were released into streams. The Lake Huron Biological Station used 199 sterilized male lampreys for quality control and dosage studies. The death of 504 (3%) sterilized lampreys occurred prior to release from unknown causes that were probably related to stress.

Water from Lake Huron was pumped continually through the facility to provide fresh water for lampreys and laboratory processes. Waste water from areas where bisazir potentially could occur was collected in a sump and pumped through carbon filters before release to Lake Huron.

Water in the facility was monitored for presence of bisazir to comply with Michigan Department of Natural Resources permit requirements, to insure safe working conditions for Service personnel, and to confirm that lampreys no longer excreted bisazir prior to release. We used two protocols to monitor for bisazir. First, the effluent was monitored daily. Each day 4 samples were drawn from filtered effluent and combined into 1 sample bottle. Second, water was randomly sampled from 7 holding tanks each week immediately prior to the removal of lampreys from the facility (sterilized lampreys were held in the facility for > 48 hours after injection to insure that all bisazir was metabolized or excreted from their bodies prior to release).

Results of the monitoring protocols showed safe operation of the facility was maintained, but we encountered one reportable incident. During routine analysis of the effluent samples on June 27 (samples taken June 14, 15, and 16), a chemical was found that had the same retention time on the high performance liquid chromatograph as bisazir. The lower detection limit for bisazir in water is 20 μg/L and trace amounts were detected at about one fourth of this limit. Sterilization of lampreys was suspended on June 27 and the Michigan Department of Natural Resources was immediately notified. A thorough review of facility protocol and a test of the carbon filters showed integrity of the process at acceptable levels. The peak on the chromatograph likely was due to contamination of monitoring equipment and sterilization resumed on July 5.

A total of 21,000 sterile male sea lampreys were predicted to be available for release in 27 Lake Superior streams, based on average spawning runs of the previous 5 years. Due to smaller than predicted spawning runs, the actual number of released sterilized males was only 14,912 (Table 22) and 2 streams in Canada (Pigeon and Nipigon rivers) did not receive any sterilized males. A ratio of sterile: resident male lampreys was predicted at 2.0:1 for 27 streams and the estimated ratio was 1.8 (includes ratio of 0.0:1 in Pigeon and Nipigon rivers). The first release of sterilized males was predicted for May 13 and occurred on May 17. The final release in Lake Superior was predicted for June 11 and the actual final release occurred on June 17.

Fewer lampreys also were captured in the St. Marys River than was predicted and resulted in fewer male lampreys available for sterilization and release. The number of sterilized males predicted for release into the St. Marys River was 5,600 and 2,667 were released. The first release of sterilized males was predicted to be on June 14 and occurred on July 8. The final release was predicted for July 22 and occurred on July 27.

The estimated resident population of spawning-phase sea lampreys in the St. Marys River was 10,624 (6,060 males). Assessment traps removed 5,971 lampreys (3,406 male lampreys; a theoretical reduction of 56% from trapping). An estimated 2,654 resident males remained in the river and the release of 2,667 sterilized males achieved a sterile:nonsterile resident male ratio of 1:1 (further theoretical reduction of 22%). The combination of removal by traps and release of sterile males resulted in a theoretical reduction of reproductive potential of 78%. The effect of the sterile male release technique to the lamprey population that was not captured in traps was a theoretical reduction of 50% of the remaining reproductive potential.

A short-term assessment of the sterile-male release technique was conducted following the study plan similar to that of 1993 but also peer reviewed by the Commissions Board of Technical Experts. In brief, we studied the release of sterile males in six Lake Superior tributaries and the St. Marys River. Observations were made of nesting males, nests with only one type of male (sterile or untreated) present were marked, and nests were excavated to determine resulting egg viability. Of the 6 streams studied on Lake Superior, we were able to make substantial numbers of observations of males in 4. Of those 4 streams, population estimates of untreated males (necessary to determine an expected ratio of sterile to untreated males) were available for 2 (Misery and Rock rivers). This was in part due to small runs of sea lampreys basin-wide and also to errors in executing the mark and recapture study of spawner run size. An estimate of the expected ratio of sterile to untreated males also was available for the St. Marys River. In the three streams, the observed ratios were higher than the expected ratios (but not significantly), suggesting that the sterile males are competitive as far as building and occupying nests. Data on egg viability in the excavated nests were encouraging in that there were demonstrable effects from sterile males, but the data also raised questions about some underlying assumptions of our approach. As an example, we use data from the Amnicon River where the largest samples were collected (Fig. 12). The egg-viability distribution for nests with unobserved male parents was shifted significantly ($P<0.05$) to the left compared to those with untreated male parents. The reduction in mean percent viability slightly exceeds the predicted reduction with the observed ratio of 0.4 sterile to 1 untreated males in the Amnicon River. Unfortunately, comparison of the results of the 1994 quality control study to the distribution of egg viability in nests on the Amnicon River with sterile male parents suggested that nests could not be reliably assumed to have just one male involved. The Task Force discussed the situation and, when considering that significant reductions in percent egg viability in the Amnicon, Bad, and Wolf rivers (comparing the distributions for nests with untreated and unobserved male parents) in spite of the potential problem, decided to proceed with egg sampling for 1995 studies.

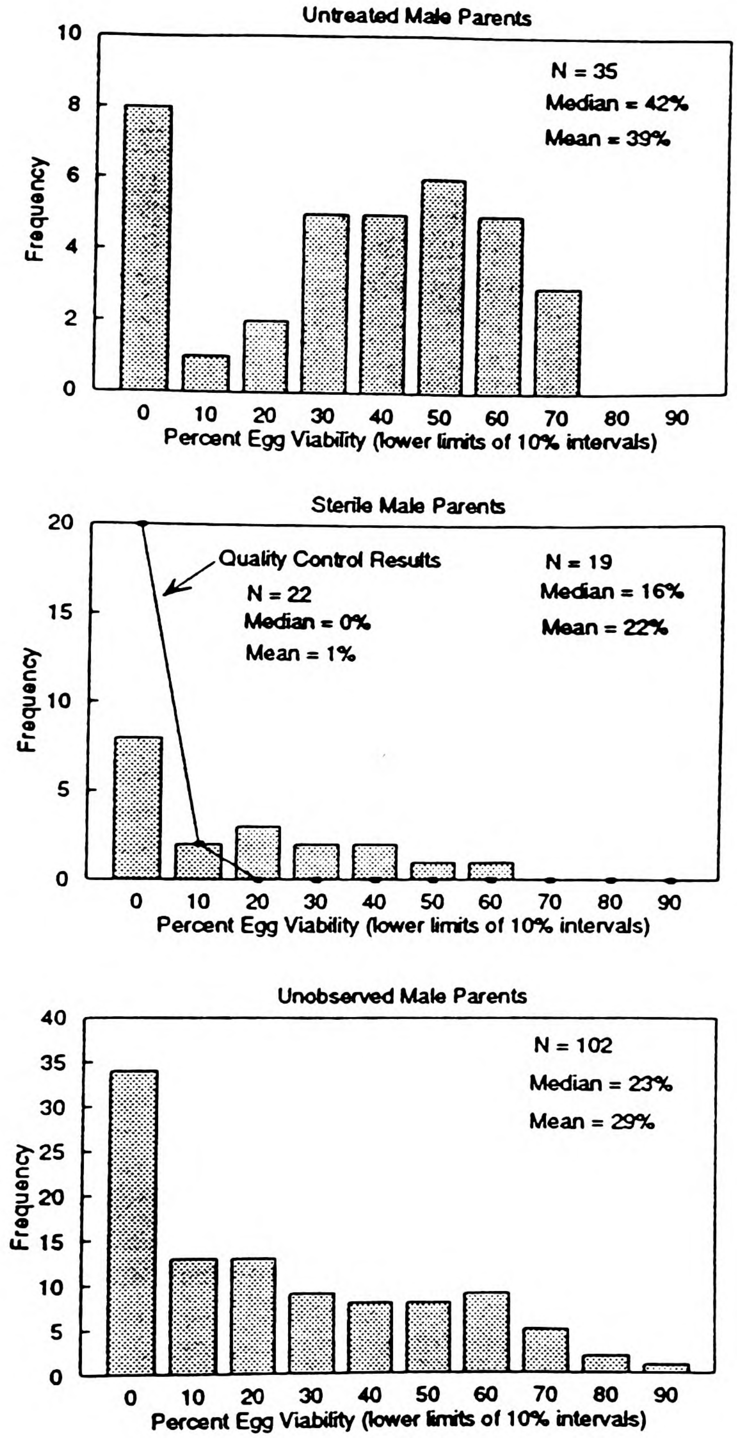


Fig. 12. Distribution of percent egg viability in sea lamprey nests of three classifications (untreated male parent, sterile male parent, and unobserved male parent) in the Amnicon River, Lake Superior, spring 1994. The line in the center panel shows results of the 1994 quality control study.

Table 23. The estimated number of resident male sea lampreys and the number of sterile male lampreys released into 27 tributaries of Lake Superior in 1994 (listed by country and ordered by location, west to east), and the theoretical reduction in sea lamprey progeny. The predicted ratio of sterile to normal males in 1994 was 2.0:1. Sterile males were scheduled for release beginning May 13 and ending June 11, and were actually released beginning May 17 and ending June 17.

	Estimated Resident Males[1]	Released Sterilized Males	Estimated Ratio	Theoretical Reduction (Percent)[2]
UNITED STATES				
Nemadji				
Black	327	969	3.0:1	75
Amnicon	528	954	1.8:1	64
Middle	111	210	1.9:1	65
Poplar	8	15	1.9:1	65
Bad	1,129	3,500	3.1:1	76
Cranberry	13	37	2.8:1	74
Potato	8	22	2.8:1	73
Ontonagon	2,293	2,452	1.1:1	52
Firesteel	149	159	1.1:1	52
East Sleeping	58	300	5.2:1	84
Misery[3]	67	1,475	19.6:1	95
Traverse	11	20	1.8:1	65
Sturgeon	317	686	2.2:1	68
Huron	57	102	1.8:1	64
Salmon Trout	10	52	5.2:1	84
Chocolay	54	96	1.8:1	64
Rock[3]	37	800	21.0:1	95
Au Train	56	100	1.8:1	64
Sucker	39	94	2.4:1	71
Two Hearted	113	93	0.8:1	45
Waiska	28	51	1.8:1	65
CANADA				
Pigeon	90	0	0.0:1	0
Wolf	319	1,349	4.2:1	81
Nipigon	1,125	0	0.0:1	0
Pancake	157	900	5.7:1	85
Batchawana	450	238	0.5:1	35
Goulais	450	238	0.5:1	35
Total	8,004	14,912	1.8:1	65

[1]Population estimates were calculated for streams using a simple linear regression of mean stream discharge to the number of lampreys estimated to enter a subset of streams (estimated by stratified multiple mark/recapture studies). The number of males was calculated using the 5-year average percent males (53%). Lampreys captured in traps and destroyed were subtracted from the estimate.

[2]Theoretical Reduction includes reduction from trapping (in parentheses) in the following streams: Amnicon River (1%), Bad River (<1%), Middle River (1%), Wolf River (5%).

[3]Emigration of sterilized males was estimated for the Misery River where 1,475 were released and 1,313 were estimated to have remained, and in the Rock River where 800 were released and 777 were estimated to have remained. The estimated ratios and theoretical reductions were calculated from the number of sterile males remaining.

Performance of the auto-injector was evaluated for accurate administration of bisazir to the lampreys. A surrogate lamprey was placed into the injector to receive a dose of saline (used in place of bisazir). After injection, the surrogate was removed and weighed to determine the actual amount of saline injected. All tests showed surrogate lampreys were over-injected by an average of 0.2 ml. The auto-injector delivered saline at less than 75% of the desired dosage in 5 out of 260 tests (2% occurance).

A study was conducted at the Lake Huron Biological Station to determine the minimum dose (mg/kg) of bisazir that produces an effective dose of 99.9 percent for male sea lampreys. Five groups of sexually mature males were injected with different doses of the chemosterilant bisazir, (0, 10, 18, 32, 56, and 100 mg/kg) and a sixth group (control) with 0.9% sodium chloride, and placed in an indoor spawning channel with fertile female sea lampreys. Spawning behavior among the males in each group was monitored between July 1 and July 15, 1994. Sea lampreys observed in the spawning act were removed from the spawning channel and eggs were stripped from the female into glass dishes. Milt from the male was used to artificially fertilize the eggs. Embryological development of each group was monitored daily until stage 17. All embryos in the 100 mg/kg group stopped developing, usually by day 5. Lower doses produced variable times to death of the embryos and variable mortality. Mortality ranged from 55% in the 10 mg/kg group to 100% in the 100 mg/kg group. Probit analysis suggests that the minimum effective concentration of bisazir is about 154 mg/kg. However, empirical data suggests that the current operational dosage of 100 mg/kg produces 100% sterility.

A second study was conducted to determine if embryos successfully develop after lamprey eggs are fertilized with sperm from male lampreys sterilized by the current automated sterilization technique. Twenty bisazir-injected males, 20 untreated males, and 20 females were placed into each of 3 recirculating streams. A total of 27 paired egg samples were obtained: 10 from stream 1, 10 from stream 2, and 7 from stream 3. Fertilization did not occur in 4 paired samples from stream 2 and 1 paired sample from stream 3. Three controls had reduced survival due to fungus. Normal appearing prolarvae occurred in 3 of the batches fertilized by milt from bisazir-injected males, but overall less than 1 percent of eggs were viable (Fig 12). The control eggs that died from fungal infection were heavily infested on day 13 and all eggs were dead by day 16. The corresponding sterile eggs were all dead by day 9; no fungus was associated with their death. An important result of the study was the successful design of a temperature-controlled, recirculating system for inducing spawning of sea lampreys held under laboratory conditions.

The Task Force shifts focus in 1995 to a coordination role of the proposed research plan and will continue to monitor the progress of the technique. Adjustments of implementation and assessment operations that were put into action for 1995 include:

Implementation

- Trap male lampreys in seven streams (added Carp River and enhanced Cheboygan River).
- Sterilize and release 24,000-28,000 male sea lampreys into 27 streams of Lake Superior and 5,800 into the St. Marys River.
- Test for sterility of males through industrial process of quality assurance (industrial process becomes routine part of sterilization facility operations).
- Monitor effluent of sterilization facility to comply with permit from Michigan Department of Natural Resources.
- Conduct and complete studies of bisazir to meet requirements of discharge permit.
- Purchase radio-labelled bisazir.
- Conduct study to analyze for bisazir in lamprey tissues.

Assessment

- Conduct short-term measurement of ratios of sterile:normal males and nest success in three streams of Lake Superior and the St. Marys River.

- Conduct routine measurements of year-class strength of larvae at index sites.

- Estimate population of spawners in U.S. waters of Lake Superior and the St. Marys River.

- Add 2 trap sites in Canadian waters of Lake Superior, estimate population of spawners in 5 streams, and begin to develop technique to estimate total spawners in streams of Canada.

- Cooperate in radio-telemetry studies to determine upstream migratory behavior of sea lampreys (including sterilized males) and fate of sterilized males that do not appear in spawning areas in streams of release (Pancake and Bad rivers). This study is conducted under contract with Dr. John Kelso of Department of Fisheries and Oceans Canada.

- Conduct workshop cooperatively with St. Marys River Control and Barrier Task Forces to design study to measure long-term effects of stock recruitment and density dependence (compensatory mechanisms).

SEA LAMPREY BARRIER TASK FORCE

- Task Force established April 1991.

- Charge is: to expand the development and use of sea lamprey barriers throughout the Convention Area.

- Members are: Dennis Lavis (Chair) and Ellie Koon from U.S. Fish and Wildlife Service; Tom McAuley and Andrew Hallett from Department of Fisheries and Oceans Canada; Bill Swink from National Biological Service; Doug Dodge from Ontario Ministry of Natural Resources; Bill Culligan from New York Department of Environmental Conservation; Bernie Ylkanen, John Trimberger, and John Schrouder from Michigan Department of Natural Resources; Les Weigum from U.S. Army Corps of Engineers; and Mike Millar from Great Lakes Fishery Commission Secretariat.

- Meetings held: February 16 and September 19-20.

- Progress on the charge in 1994:

  - Barrier research workshop held February 11-13.

  - Barrier research strategy accepted in principle by Commissions in June.

  - Draft barrier implementation strategy and decision protocol accepted in principle by Commission in December that identified 171 barrier projects on 164 streams.

  - Coordinated Corps involvement in St. Marys River trap design in concert with St. Marys River Control Task Force.

  - Met with Corps officials to facilitate their involvement in other areas of barrier program.

- **Barrier projects proposed and accepted for FY 1995 funds: Jordan River (Lake Michigan) electric barrier operations, Pere Marquette River (Lake Michigan) fish passage construction and improvement to electric barrier, Albany Creek (Lake Huron) barrier improvement, Bad River (Lake Superior) fish movement study, Big Creek (Lake Erie) barrier installation, and Black River (Lake Ontario) barrier improvement.**

- **Extensions granted for FY 1994 projects: Misery River (Lake Superior) barrier improvement and Fish Creek (Lake Ontario) barrier improvement.**

LITERATURE CITED

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper 12. U.S. Dept. of Interior, Fish and Wildlife Service, Office of Biological Services. FWS/OBS-82/26. 248 p.

Busiahn, T.R. (ed). 1990. Fish Community Objectives for Lake Superior. Great Lakes Fishery Commission, Special Publication 90-1.

Ferreri, C.P. 1990. Development of habitat suitability indices for sea lamprey (Petromyzon marinus) ammocetes in streams tributary to Lake Ontario. Thesis MS for Master of Science. August 1990. Case Western University.

Great Lakes Fishery Commission. 1992a. Strategic Vision of the Great Lakes Fishery Commission for the Decade of the 1990's. Great Lakes Fishery Commission, Ann Arbor, MI.

Great Lakes Fishery Commission. 1992b. Annual Executive Meeting Minutes, May 7-8, 1992. Arlington, VA.

Greig, L., D. Meisner, and M. Rose. 1991. Toward a management protocol for integrated management of sea lamprey (IMSL): Report of two development workshops. Great Lakes Fishery Commission. Ann Arbor, MI.

Greig, L., D. Meisner, and G.C. Christie. 1992. Manual for the management protocol for the implementation of integrated management of sea lamprey in the Great Lakes basin. Ver. II. Great Lakes Fishery Commission. Ann Arbor, MI.

Heinrich, J.W., J.G. Weise, and B.R. Smith. 1980. Changes in biological characteristics of sea lamprey (Petromyzon marinus) as related to lamprey abundance, prey abundance, and sea lamprey control. Can. J. Fish. Aquat. Sci. 37: 1861-1871.

Koonce, J.F., R.L. Eshenroder, and G.C. Christie. 1993. An economic injury level approach to establishing the intensity of sea lamprey control in the Great Lakes. North American Journal of Fisheries Management 13:1-14.

Lake Erie Committee. 1993. Draft Lake Erie Fish Community Goal and Objectives. Draft V.5 Sept. 1993. Great Lakes Fishery Commission. Ann Arbor, MI.

Lake Erie Lake Trout Task Group. 1985a. A Sea Lamprey Management Plan for Lake Erie. Report to the GLFC's Lake Erie Committee, March 1985, Ann Arbor, MI.

Lake Erie Lake Trout Task Group. 1985b. A Strategic Plan for the rehabilitation of lake trout in eastern Lake Erie. Report to the GLFC's Lake Erie Committee, March 1985, Ann Arbor, MI.

Lake Huron Committee. 1993. Fish Community Objectives for Lake Huron. In Minutes 38th Annual Meeting of the Great Lakes Fishery Commission. May 24-28, 1993. Toronto, ON.

Lake Huron Technical Committee. 1991. A Lakewide management plan for lake trout rehabilitation in Lake Huron. Great Lakes Fishery Commission manuscript.

Lake Michigan Lake Trout Technical Committee. 1985. A lakewide management plan for lake trout rehabilitation in Lake Michigan. Great Lakes Fishery Commission. Ann Arbor, MI. March 1995.

Lake Ontario Committee. 1988. Fish Community Objectives for Lake Ontario. Great Lakes Fishery Commission, Ann Arbor, MI.

Lake Superior Lake Trout Technical Committee. 1986. A lake trout restoration plan for Lake Superior. In Minutes Lake Superior Committee (1986 Annual Meeting), Ann Arbor, MI. Great Lakes Fishery Comm., March 20, 1986.

Lake Superior Technical Committee. 1994. A lake trout restoration plan for Lake Superior. In preparation for the Lake Superior Committee 1994 Annual Meeting. Ann Arbor, MI.

Macdonald, P.D.M., and T.J. Pitcher. 1979. Age-groups from size-frequency data: a versatile and efficient method of analyzing distribution mixtures. J. Fish. Res. Board Can. 36:987-1001.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191:382 p.

Schneider, C.P., D.P. Kolenosky, and D.B. Goldthwaite. 1983. A joint plan for the rehabilitation of lake trout in Lake Ontario. Great Lakes Fishery Commission. Ann Arbor, MI.

Schneider, C.P., T. Schaner, J.E. Marsden, W.D.N. Busch. 1991. Lake Ontario Lake Trout Rehabilitation Plan. Lake Ontario Committee, March 1991. Great Lakes Fishery Commission. Ann Arbor, MI.

OUTREACH

The Service and Department are routinely and heavily involved in outreach activities with the intent of providing information for a more fully informed public of the benefits and operations of the integrated management of sea lamprey program. These activities range from major group participation at sports shows in metropolitan areas to the efforts of individuals in the many media contacts and presentations at schools. A summary of these activities for 1994 includes:

	Number of Occurrences		Staff Days	
Activity or Event	U.S.	Canada	U.S.	Canada
School presentations	14	4	15	3
Sports shows	3	4	20	66
Youth fishing	3	1	64	2
Civic groups	12	2	11	5
Media interviews	30	30	6	6
Media mailings	304	180	10	8
Station public display	0	50	0	19
Miscellaneous	40	40	5	5
Total	406	311	131	114
Combined	717		245	

FISHERY BIOLOGISTS, CHEMIST, AND PROFESSIONAL ENGINEER IN THE SEA LAMPREY MANAGEMENT PROGRAM

U.S. FISH AND WILDLIFE SERVICE

Gerald T. Klar, Field Supervisor
Marquette Biological Station

Control Supervisor: Terry J. Morse

Dorance C. Brege, Treatment Supervisor
Gary A. Steinbach, Treatment Supervisor (dec.)
David G. Carie
Darrian M. Davis
David A. Johnson, Chemist

Assessment Supervisor: John W. Heinrich

Michael F. Fodale, Survey Supervisor
Michael B. Twohey, Survey Supervisor
Katherine M. Mullett, Adult Supervisor
Alex F. Gonzalez (Amherst Office)
Henry R. Quinlan
John W. Weisser
Glenn L. Barner
Joseph H. Genovese
Jennifer A. Kagel
Dale J. Ollila

Barrier Coordinator: Ellie M. Koon
(Duty stationed in Ludington)

Ludington Biological Station

Dennis S. Lavis, Station Supervisor

Hal J. Lieffers, Treatment Supervisor (ret.)
Thomas E. Hamilton (resigned)

Richard E. Beaver, Survey Supervisor (ret.)
Sidney M. Morkert

DEPARTMENT OF FISHERIES AND OCEANS

Sea Lamprey Control Centre
Sault Ste. Marie, Ontario Canada

Control Supervisor: Larry P. Schleen

R. Wayne Westman: Treatment Supervisor
Reginald J. Goold: Treatment Supervisor
Tom C. McAuley, Barrier Coordinator P. Eng.

Assessment Supervisor: Robert J. Young

Rod B. McDonald, Adult Assessment Supervisor
Douglas W. Cuddy, Larval Assessment Supervisor
Jerry G. Weise, Quantitative Assessment Supervisor
Paul Sullivan, Lower Lakes Assessment Unit Biologist