INTEGRATED MANAGEMENT OF SEA LAMPREYS IN LAKE MICHIGAN 2002

Report to

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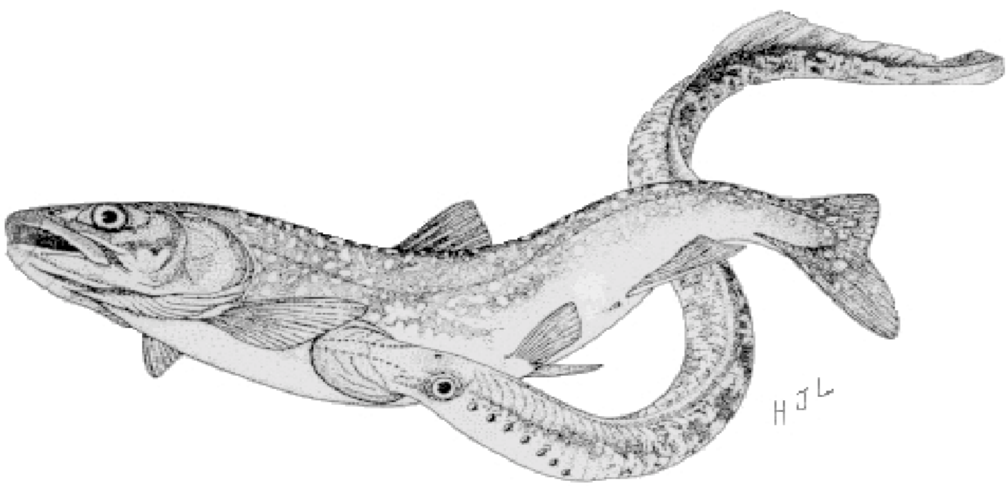

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INTRODUCTION

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 the contracted control agents of the Great Lakes Fishery Commission (Commission) to meet these targets.

The Commission is working 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. The Commission and cooperators will consider the costs of control along with the benefits to define an optimum control program. The program must support the fish community objectives, be ecologically and economically sound, and be socially acceptable. These targets for each lake will define the abundance of sea lampreys that can be tolerated and the economically viable level of control required to reach the desired suppression.

The cooperation of state, provincial, and tribal agencies continues to be critical to the success of all aspects of the control program. For example, in collaboration with the State of Michigan, the agents employed stream treatment methods that provided the best possible suppression of sea lampreys while protecting critical lake sturgeon populations.

This report presents the actions of the Service and Department in the integrated management of sea lampreys in Lake Michigan during 2002. Also presented are actions to meet milestones of the Commission Vision and trends in sea lamprey abundance as related to Fish Community Objectives**.**

COMMISSION VISION

The Commission, in its "Strategic Vision for the First Decade of the New Millennium," identified milestones that included:

> *Accomplish at least 50% of sea lamprey suppression with alternative technologies while reducing TFM use by 20%.*

The pesticide TFM has been used as a management tool to control larval sea lampreys in the Great Lakes since 1958. In the past decade the Service and Department have reduced the dependency on TFM through the development and implementation of alternative controls, the refinement of assessment procedures, and improvement of application techniques to more efficiently treat tributaries. The use of TFM has decreased 35% from an annual average of 55,169 kg active ingredient from 1986-1990 to an annual average of 35,687 kg active ingredient from 1998-2002.

FISH COMMUNITY OBJECTIVES

During 1995, the Lake Michigan Committee established the following specific targets for sea lamprey populations in their Fish Community Objectives:

> *Suppress the sea lamprey to allow the achievement of other fish-community objectives.*

In general, treatment of Lake Michigan tributaries over the years has provided sufficient control of sea lampreys, yet increases in lamprey wounding rates on lake trout in northern waters of the lake are a concern.

The sea lamprey objective was developed to support the other fish community objectives for Lake Michigan, specifically those for lake trout and other salmonids.

> *Establish a diverse salmonine community capable of sustaining an annual harvest of 2.7 to 6.8 million kilograms (6 to 15 million pounds), of which 20-25% is lake trout. Establish self-sustaining lake trout populations.*

Control of sea lamprey populations and fishery exploitation is necessary to meet these objectives. The lake-wide management plan specifies four areas where the chances of successful lake trout rehabilitation exist: refuges, primary, secondary, and deferred rehabilitation zones. The refuges and primary zones where priority should be given to control sea lamprey populations 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.

TRIBUTARY INFORMATION

- Lake Michigan has 511 tributaries.

- 120 tributaries have historical records of sea lamprey larvae production.
- 63 tributaries have been treated with lampricide at least once during 1993-2002.
- Of these, 32 tributaries are treated on a regular 3-5 year cycle.

LAMPRICIDE CONTROL

Tributaries harboring larval sea lampreys are treated periodically with lampricides to eliminate or reduce the populations of larvae before they recruit parasitic juveniles to the lake. Service and Department treatment units administer and monitor doses of the lampricide TFM, sometimes augmented with 70% wettable powder formulation of Bayluscide, to scheduled tributaries. Specialized equipment and techniques are employed to provide concentrations of TFM that eliminate about 95% or more of the lamprey larvae and minimize the risk to nontarget organisms. During recent years the combination of improved analytical and predictive techniques has allowed treatment personnel to reduce the amount of lampricide used (kg/yr) in the Great Lakes by more than about 35%.

The following statements highlight the lampricide control program for Lake Michigan during 2002. Table 1 provides details on the application of lampricide to tributaries treated during 2002 and Fig. 1 shows the locations of the tributaries.

- Treatments were completed successfully in all 15 scheduled tributaries. Annual treatments of Porter and Horton Creeks were deferred when larval assessment surveys did not detect recruitment of sea lampreys.

- 70% wettable powder formulation of Bayluscide was applied during four Lake Michigan treatments to reduce the use of TFM.

- The interim protocol for application of lampricides to streams with populations of young-of-year lake sturgeons was followed in treatment of the Muskegon River. The protocol limits the concentrations of TFM and 70% wettable powder formulation of Bayluscide to 1.2 times minimum lethal concentration (MLC; concentration of lampricide necessary to kill 99.9% of sea lampreys in a 12-hour treatment) to protect young-of-year lake sturgeons. Conversely, the Ford River, treated during 2000 under the interim protocol, was treated by standard application methods.

- The Days River was treated for the fifth consecutive year to prevent recruitment of larval sea lampreys into offshore areas in Lake Michigan.

- Bayluscide 3.2% Granular Sea Lamprey Larvicide was applied by boat during lentic treatments to 14.2 hectares in the Manistique harbor. Numerous large (>120 mm) sea lamprey larvae were observed following the applications.

- Cold, wet weather during the spring and fall produced higher than normal stream discharge and required the use of more TFM to provide effective treatment of the Ford River and Hibbards and Bailey Creeks.

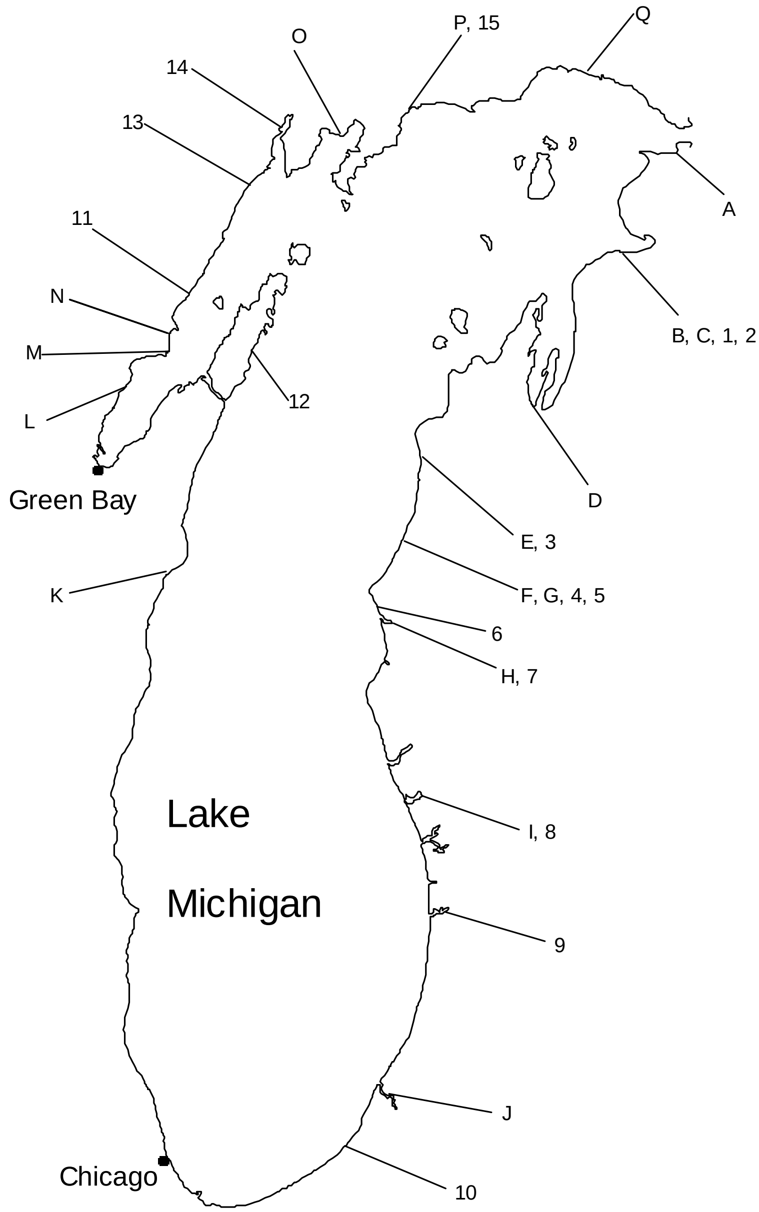
- Voluntary Adverse Effects 6(a)(2) reports were submitted to the Environmental Protection

Agency after significant numbers of spawning chinook salmon were killed during treatments of Bear Creek and the Little Manistee River. Numbers of nontarget fish killed in all other treatments were minimal.

Table 1. Details on the application of lampricides to tributaries of Lake Michigan, 2002. (Number in parentheses corresponds to location of stream in Fig. 1.)

Stream	Date	Flow (m^3/s)	TFM (kg)[1,2]	Bayluscide (kg)[1]	Distance treated (km)
Ford R. (26)	May-9	12.7	1,600.0	12.8	104.6
Hibbards Cr. (24)	May-11	1.4	191.3	0	4.8
Bailey Cr. (25)	May-14	0.6	33.8	0	1.6
Galien R. (23)	May-24	3.2	780.4	0	34.1
Lincoln R. (19)	Jun-23	1.6	412.9	0	37.8
Kalamazoo R.					
Mann Cr. (22)	Jul-2	0.1	19.5	0	1.6
Betsie R. (17)	Jul-10	7.8	1,076.9	13.7	18.6
Jordan R. (16)	Jul-23	6.8	2,467.1	0	26.7
Muskegon R. (21)	Aug-5	33.3	5,479.7	50.2	63.1
Pere Marquette R. (20)	Aug-18	15.6	2,291.6	20.0	271.6
Boyne R. (15)	Sep-2	2.3	694.9	0	6.4
Manistique R (28)	Sep-11	-	-	79.8[2]	-
Big Manistee R.					
Bear Cr. (18)	Sep-13	2.3	977.1	0	75.9
Days R. (27)	Oct-11	0.2	83.3	0	6.4
L. Manistee R. (5)	Oct-27	4.2	799.4	4.6	73.8
Total		**92.1**	**16,907.9**	**181.1[2]**	**727.0**

[1]Lampricide quantities are in kg of active ingredient.
[2]Includes 79.8 kg active ingredient applied as Bayluscide 3.2% Granular Sea Lamprey Larvicide applied to 14.2 ha.



TRIBUTARIES TRAPPED

A. Carp Lake R.
B. Jordan R.
C. Deer Cr.
D. Boardman R.
E. Betsie R.
F. Big Manistee R.
G. Little Manistee R.
H. Pere Marquette R.
I. Muskegon R.
J. St. Joseph R.
K. East Twin R.
L. Oconto R.
M. Peshtigo R.
N. Menominee R.
O. Ogontz R.
P. Manistique R.
Q. Hog Island Cr.

TRIBUTARIES TREATED

1. Jordan R.
2. Boyne R.
3. Betsie R.
4. Bear Cr.
5. Little Manistee R.
6. Lincoln R.
7. Pere Marquette R.
8. Muskegon R.
9. Mann Cr.
10. Galien R.
11. Bailey Cr.
12. Hibbards Cr.
13. Ford R.
14. Days R.

ALTERNATIVE CONTROL

Sterile Male Release Technique

Research into the sterile male release technique (technique) for sea lamprey control began during 1971. The technique was experimentally implemented in Lake Superior tributaries and the St. Marys River during 1991-1996. During 1997 the technique was refocused and lampreys are now released exclusively in the St. Marys River to enhance control.

Male sea lampreys are captured during their spawning migrations in 20 tributaries to lakes Superior, Michigan, Huron, and Ontario and the St. Marys River and transported to the sterilization facility (facility) at the Hammond Bay Biological Station. At the facility, sea lampreys are sterilized with the chemosterilant bisazir, decontaminated, and released into the St. Marys River. Laboratory and field studies have shown that treated male sea lampreys were sterile and sexually competitive, and that the number of eggs that hatch was reduced.

Technique-related highlights for 2002:

- A total of 12,270 spawning-phase sea lampreys were transported to the sterilization facility during May 10-June 23 from trapping operations on the Manistique (11,317) and Peshtigo (953) rivers.

Barriers

In its "Strategic Vision for the First Decade of the New Millennium", the Commission committed to implementation of an integrated control program that relies on alternative control methods to achieve 50 percent of lamprey suppression. Barriers are currently the only proven alternative control method. Presently, there are 12 purpose-built sea lamprey barriers on Lake Michigan tributaries (Fig. 2).

The Sea Lamprey Management Program benefits substantially from a number of dams built and operated for other purposes. A GIS inventory of these "de-facto" barriers is nearly complete for Lake Michigan. This will be an essential tool in identifying dams of value to sea lamprey management and tracking a growing number of barrier mitigation proposals that have potentially serious consequences to the Great Lakes fishery.

Barrier-related highlights for 2002:

- White River – Hesperia Dam is now functioning as a sea lamprey barrier after several Commission-initiated modifications, the most recent during 1999. Collections since 1999 show abundant recruitment downstream of the dam and none upstream.

- Paw Paw River – The barrier project with the U.S. Army Corps of Engineers (Corps) entered the Plans and Specifications stage. The Corps is proposing that Berrien County serve as the local sponsor in partnership with the Commission.

- Kids Creek (Hospital Creek) - The site has been finalized for the Corps barrier, and landowners are being contacted for flowage easements. The City of Traverse City has tentatively agreed to be the local sponsor in partnership with the Commission.

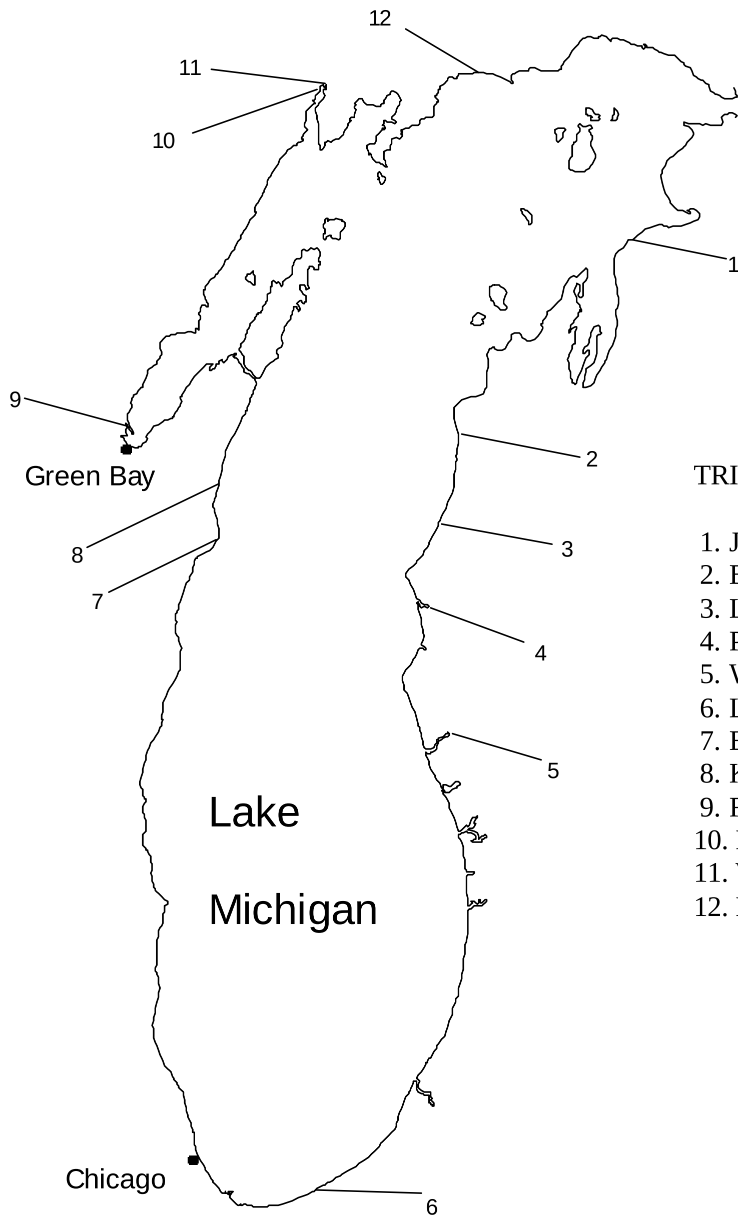
- Cedar River - Site surveys, hydrology studies, and soil borings were nearly completed by Barr Engineering under contract by the Service's Division of Engineering. A minor revision to the hydrology study remains to be finished.

- The proposed Rapid River barrier project was dropped after surveys and hydrology analysis by the Corps. Due to unstable spring flows and low banks, a barrier site could not be found far enough downstream to be cost-effective.

- Pere Marquette River – The electrical weir and fishway were operated successfully, with lampreys blocked and more than 25,000 fish passed. The video system for fish counting was installed by the MDNR for operation during 2003.

- Corps Design Documentation Reports (including hydrology and hydraulics analysis, topographic surveys, real estate and the final Preliminary Restoration Report) were completed for new barrier projects at the South Branch Galien River and Trail Creek.

- Manistique River - A proposal to improve lamprey blockage at the Manistique Papers Inc. dam was accepted by the Corps under Section 1135 of the Water Resources Development Act. The project will examine the feasibility of either repairing the present structure or removing it and replacing it with a lamprey barrier.



TRIBUTA

1. Jordan
2. Betsie
3. Little M
4. Pere Ma
5. White
6. Little C
7. East Tw
8. Kewaun
9. Fox R.
10. Days
11. Whitefi
12. Manisti

ASSESSMENT

Larval

Tributaries to the Great Lakes systematically are assessed for abundance and distribution of sea lamprey larvae. Sampling information is used to determine when and where lampricide treatments are required and to measure the effectiveness of past treatments. Surveys are conducted with backpack electrofishers in waters that are <1m deep. Waters >1m in depth are surveyed with deepwater electrofishers or the granular formulation of Bayluscide. Data collected from these surveys are used to estimate the number of metamorphosed sea lampreys that will leave individual tributaries the following year and to define the upstream and downstream distribution of the larvae.

Tributaries considered for lampricide treatment during 2003 were surveyed during 2002 to estimate larval density and habitat. Survey plots were randomly selected in each stream, catches of larvae were adjusted for gear efficiency, and the lengths of larvae were standardized to the end of the growing season. The population of larvae in each tributary was estimated by multiplying the mean density of larvae (number per m^2) by an estimated area of suitable habitat (m^2). The estimated number of larvae that would metamorphose into parasitic sea lampreys during 2002 was developed from historical relations of the proportion of metamorphosed to larval sea lampreys collected during previous lampricide applications. After processing the data, streams were ranked for treatment during 2002 based on an estimated cost per kill of metamorphosed sea lampreys.

Larval assessment highlights for 2002:

- Assessments of populations of sea lamprey larvae were conducted in 55 tributaries and offshore of 5 tributaries. The status of larval sea lamprey populations in streams treated during the past 10 years is presented in Table 2.

- Larval populations were estimated in 34 tributaries (Table 2).

Table 2. Status of Lake Michigan tributaries that have been treated for sea lamprey larvae during 1993-2002 , and sea lamprey population estimates for tributaries surveyed during 2002.

Tributary	Last Treated	Last Surveyed	Residuals Found	Oldest Reestablished Year Class	Estimate of 2002 Larval Population	2003 Metamorphosing Estimate	On 2003 Treatment Schedule
Brevort R. (lower)[1]	May-89	2002	-	1998	653	267	No
Hog Island Cr.	Jun-96	2002	-	1998	8,789	61	No
Black R.	Jun-99	2001	No	1999	-	-	No
Millecoquins R.[2]	May-00	2001	Yes	2000	647	32	No
Rock R.	Aug-00	2000[6]	Yes	None	-	-	No
Crow R.	Aug-00	2000[6]	-	-	-	-	No
Cataract R.[1]	Sep-75	2002	-	1998	5,040	8	No
Hudson Cr.	May-98	2002	Yes	1998	963	7	No
Milakokia R.	Jun-99	2002	Yes	1999	152,293	6359	Yes
Bulldog Cr.	Jun-97	2000[6]	No	None	-	-	No
Gulliver Lake Outlet	May-00	1999[6]	-	-	-	-	No
Marblehead Cr.	May-00	1999[6]	-	-	-	-	No
Manistique R. (Above dam)[1]	Aug-74	2002	-	1998	734,450	10,892	No
Manistique R. (Below dam)	Sep-01	1999	-	1998	-	-	No
Manistique R. (Lentic)[2,3]	Sep-02	2000	-	1998	0	2,082	Yes
Johnson Cr.[1]	Aug-81	2002	-	1999	162	0	No
Deadhorse Cr.[1]	May-91	2002	-	1998	753	14	No
Bursaw Cr.	May-97	2002	-	1998	1,256	38	No
Parent Cr.[1]	Jun-91	2002	-	1998	626	3	No
Poodle Pete Cr.[2]	May-01	2000[6]	-	-	145	15	No
Valentine Cr.[2]	Jun-97	2001	No	1998	13	8	No
Little Fishdam R.	May-01	2002[6]	No	None	-	-	No
Big Fishdam R.	May-99	2002	No	1999	64,445	6	No
Sturgeon R.	Oct-98	2002	Yes	1998	379,160	2939	Yes
Ogontz R.	Oct-96	2002	-	1998	40,872	1458	Yes
Squaw Cr.	Aug-00	2001[6]	Yes	None	-	-	No
Whitefish R.[2]	Aug-01	2001[6]	-	-	3,891	760	No
Rapid R.	May-99	2002	Yes	1999	90,728	8021	Yes
Tacoosh R.	May-00	2001[6]	No	None	-	-	No
Days R.[3]	Oct-01	2002[4]	Yes	2001	0	0	Yes (Lentic)
Portage Cr.[1]	Jun-97	2000	-	None	-	-	No
Ford R.	May-02	2002[6]	Yes	2002	2,933	567	No
Bark R.	May-99	2002	Yes	1999	30,970	1973	Yes
Cedar R.	Oct-01	2002	Yes	2001	26,806	852	No
Sugar Cr.	Aug-77	2002[6]	-	None	-	-	No
Bailey Cr.	May-02	2002[5]	-	-	2	1	No
Beattie Cr.[2]	Oct-01	2001[6]	-	-	22	12	No
Springer Cr.	May-99	2002	No	None	0	0	No
Peshtigo R.[2]	Jul-01	2001[6]	Yes	2001	102	81	No
Oconto R.[2]	Jul-01	2001[6]	No	None	76	75	No
Hibbards Cr.[2]	May-02	2001[6]	-	-	444	125	No
Door Co. #23[1,2]	May-79	2001	-	1998	16	11	No
East Twin R.	Jul-00	2000[6]	-	-	-	-	No

Table 2. continued

Tributary	Last Treated	Last Surveyed	Residuals Found	Oldest Reestablished Year Class	Estimate of 2002 Larval Population	2003 Metamorphosing Estimate	On 2003 Treatment Schedule
Carp Lake R.	Sep-94	2002	-	1998	65,612	181	No
Big Stone Cr.	May-97	2001[6]	No	-	-	-	No
Wycamp Lake Outlet	May-00	2002[6]	No	None	-	-	No
Horton Cr.[3,4]	Oct-01	2002[6]	No	None	-	-	Yes
Boyne R.[3,4]	Sep-02	2002	No	-	0	0	Yes (Lentic)
Porter Cr.[3,4]	Oct-01	2002[6]	No	None	-	-	Yes
Jordan R. [2]	Jul-02	2002[6]	-	-	1,184	452	No
Monroe Cr.[1]	Oct-72	2002	No	1999	630	22	No
McGeach Cr.	Oct-99	2002[6]	No	None	-	-	No
Elk Lake Outlet	May-97	2002	-	1999	4,875	123	No
Mitchell Cr.	May-99	2002	Yes	1999	29,295	1,390	Yes
Boardman R. [3,4]	Aug-01	2002[6,8]	-	-	-	-	No
Goodharbor Cr.	Oct-01	2000[6]	-	-	-	-	No
Platte R.	Jul-01	2002[9]	Yes	2001	35,682	1,359	Yes [9]
Betsie R. [2]	Jul-02	2002[6]	-	-	7,509	145	No
Big Manistee R.	Aug-98	2002	Yes	1999	2,119,572	129,348	Yes
Bear Cr.	Jun-02	2002	Yes	-	-	-	No
L. Manistee R. [2]	Oct-02	2002[6]	-	-	5,369	398	No
Gurney Cr.[2]	Jul-01	2001[6]	-	-	2	1	No
Lincoln R.	Jun-02	2002	No	None	0	0	No
Pere Marquette R.	Aug-02	2002	Yes	-	525	0	No
Pentwater R.	Jul-01	2002	Yes	2001	15,120	1,430	Yes
White R.[2]	Aug-01	2001[6]	Yes	-	388	350	No
Muskegon R. [2]	Aug-02	2001[6]	-	-	585	157	No
Brooks Cr.	Aug-00	1999[6]	-	-	-	-	No
Cedar Cr.	Aug-00	1999[6]	-	-	-	-	No
Bridgeton Cr.	May-95	2002[6]	-	2000	-	-	No
Minnie Cr.	Aug-00	1999[6]	-	-	-	-	No
Bigelow Cr.[5]	Aug-02	2002[6]	-	-	-	-	No
Black Cr.[1,2]	Aug-70	2001	-	1999	2,364	40	No
Grand R.							
Norris Cr.	Jun-00	2002[6]	No	-	-	-	No
Sand Cr.	Sep-96	2002	No	1999	41	0	No
Crockery Cr.	Jun-00	2002[6]	No	2000	-	-	No
Kalamazoo R.							
Bear Cr.	Jun-98	2002	No	1998	1,331	5	No
Sand Cr.	May-00	2002[6]	Yes	2000	-	-	No
Mann Cr.	Jul-02	2002	No	2002	0	0	No
Black R.	Jun-01	2002	No	2001	960	0	No
Brandywine Cr.	Jun-85	2002	-	1998	62	61	No
Rogers Cr.	May-98	2000[6]	No	-	-	-	No
St. Joseph R.							
Paw Paw R. [2]	May-01	2002[6]	No	None	34	33	No
Mill Cr.[2]	May-01	2000[6]	-	-	183	167	No

Table 2. continued

Tributary	Last Treated	Last Surveyed	Residuals Found	Oldest Reestablished Year Class	Estimate of 2002 Larval Population	2003 Metamorphosing Estimate	On 2003 Treatment Schedule
Brandywine Cr.[2]	May-97	2000	-	None	-	-	No
Brush Cr.[2]	May-01	2001[6]	-	-	9	9	No
Pipestone Cr.	May-88	2002	-	1997	25,419	23,741	Yes
Blue Cr.[2]	May-01	2001[6]	-	-	20	20	No
Galien R.							
South Br. Spring Creek	May-02	2002[6]	-	-	-	-	No
Upper Galien and E.Branch	May-02	2002	No	2002	25,997	0	No
S. Br. Gallien & Galina Cr.	Jun-99	2002	No	1999	597	49	No
Trail Cr.	Apr-00	2000[6]	-	-	-	-	No
Burns Ditch	Jul-99	2001[6]	-	-	-	-	No

[1]Not treated during the past 10 years, but quantitative larval surveys were conducted during 2000-2002.
[2]Estimates of larvae and transformers developed from 2000 or 2001 data.
[3]Stream has a known lentic population.
[4]Lentic population was assessed during 2002.
[5]Quantitative assessment conducted prior to treatment during 2002.
[6]Not quantitatively assessed since last treatment.
[7]Estimate is for Paw Paw R. tributaries (Mill Cr., Brandywine Cr., and Brush Cr.)
[8]Lentic surveys only during 2002.
[9]Upper Platte R. only.

Spawning-Phase

The long-term effectiveness of the control program is measured by the annual estimation of the lake-wide abundance of spawning-phase and parasitic-phase sea lampreys. Traps and nets are used to capture migrating spawning-phase sea lampreys during the spring and early summer. Trap catch began to provide a measure of relative abundance as early as 1975 (varied by lake). Lake-wide abundance has been estimated since 1986 from a combination of mark-recapture estimates in streams with traps and model-predicted estimates in streams without traps.

Spawning-phase highlights for 2002:

- 33,349 sea lampreys were trapped at 17 sites in 15 tributaries during 2002 (Fig. 1, Table 3).

- Estimated population of spawning-phase sea lampreys in Lake Michigan for 2002 was 94,037 (65,286 north and 28,751 south; $r^2 = 0.86$).

- A significant positive trend (Fig. 3) was detected from a linear regression of spawner abundance during 1983–2002 ($p=0.004$, $r^2=0.38$).

- Spawning runs were monitored in the Boardman and Betsie rivers through a cooperative agreement with the Grand Traverse Band of Ottawa and Chippewa Indians; in the Little Manistee River with the Little River Band of Ottawa Indians; and in the Carp Lake Outlet with the Little Traverse Bay Bands of Odawa Indians.

Parasitic-Phase

The Michigan and Wisconsin Departments of Natural Resources provided data on the frequency of parasitic-phase sea lampreys attached to fish caught by sport charter boats during 2002.

- 887 sea lampreys were collected from 10 management districts; 298 were attached to lake trout and 589 were attached to chinook salmon.

- Lampreys were attached at a rate of 1.44 per 100 lake trout (n = 20,625) and 0.56 per 100 chinook salmon (n = 104,564).

Table 3. Stream, number caught, estimated population, trap efficiency, number sampled, percent males, and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan, 2002. (Letter in parentheses corresponds to stream location in Fig. 1)

						Mean Length (mm)		Mean Weight (g)	
Stream	Number Caught	Spawner Estimate	Trap Efficiency	Number Sampled[1]	Percent Males	Males	Females	Males	Females
Carp Lake Outlet (A)	893	3,884	23	49	60	445	468	187	237
Jordan R. (B)	168	666	25	28	48	462	469	209	241
Deer Cr. (C)	111	313	35	18	59	452	487	224	282
Boardman R. (D)	244	646	38	73	44	465	448	219	206
Betsie R. (E)	2,133	7,922	27	565	49	474	478	248	243
Big Manistee R. (F)	342	4,700	7	16	69	471	455	231	239
Little Manistee R. (G)	119	746	16	7	46	443	474	223	272
Pere Marquette R. (H)	757	1,331	57	341	50	496	501	291	281
Muskegon R. (I)	879	2,570	34	347	62	487	486	274	276
St. Joseph R. (J)	461	1,604	29	54	69	483	490	257	254
East Twin R. (K)	89	313	28	12	51	434	469	209	251
Oconto R. (L)	18	49	--	1	72	511	---	280	---
Peshtigo R. (M)	2,687	3,024	89	311	54	493	493	257	278
Menominee R. (N)	109	1,316	8	4	86	510	---	260	---
Ogontz R. (O)	178	489	36	51	47	500	489	305	302
Manistique R. (P)	24,035	38,290	63	4	49	484	524	266	308
Hog Island Cr. (Q)	126	1,533	8	39	--	---	---	---	---
Total or Mean	**33,349**	**69,396**		**1,910**	**51**	**483**	**485**	**265**	**268**

[1]The number of sea lampreys from which all length and weight measurements were determined.

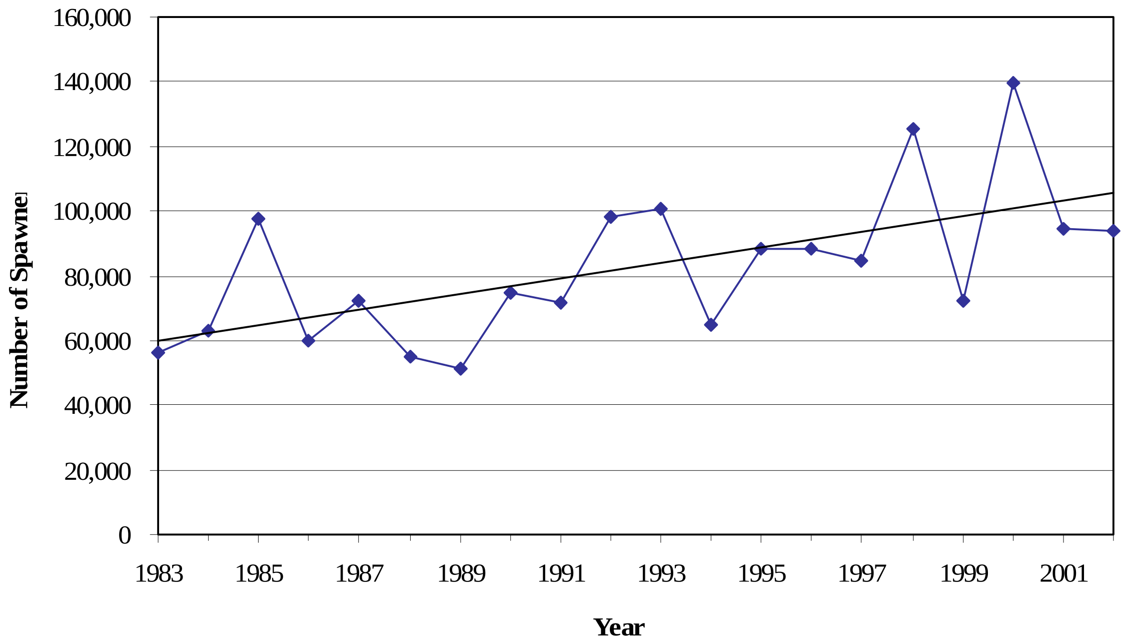


Fig. 3. Trend line of the linear regression of spawner abundance for Lake Michigan during 1983–2002.