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# *Sea Lamprey in the Great Lakes*

The sea lamprey is an invading nonindigenous species that has had an immense impact on fish communities, fisheries, and fishery management in the St. Lawrence River and the Great Lakes of North America. Native to the Atlantic Ocean, sea lampreys probably entered the Great Lakes via the Hudson River and its artificial extension, the Erie Canal, which was opened to Lake Ontario in 1819 (Fig. 1).


**Fig. 1.** Jurisdictional boundaries in the Great Lakes. The boundary between Ontario and various states is also the international boundary between Canada and the United States. The natural and artificial waterways between the lower lakes and the Atlantic Ocean are also shown.

Adult sea lampreys, which are shaped like eels, feed by attaching on other fish with their suctorial mouths and extracting blood and other body fluids from the fish. Each sea lamprey may kill as much as 18 kilograms of fish during the 12-20 months of its adult life. The sea lamprey gained access to Lake Erie when the Welland Canal around Niagara Falls was completed in 1829, but they were not noted in Lake Erie until 1921, almost a century later. Thereafter, the invasion quickened; sea lampreys were found in Lake

Huron in 1932, in Lake Michigan in 1936, and in Lake Superior in 1946.

# Life Cycle

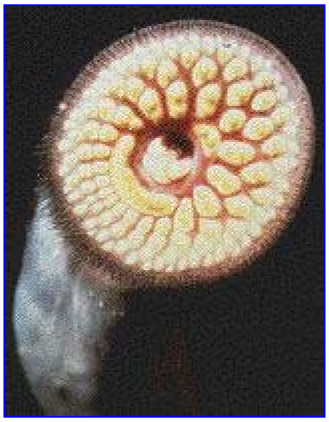

**Fig. 2.** The mouth of an adult sea lamprey.


Sexually mature sea lampreys, which are about 46 centimeters long, ascend the tributaries of the Great Lakes in the spring and summer to seek stony, gravelly riffles where they excavate redds, saucerlike depressions that serve as nests. Mating takes place on the redd, where individual females deposit up to 60,000 eggs each. Luckily for the lamprey's prey, the adult dies after spawning. The eggs hatch into larvae, barely visible to the naked eye. These larvae are blind, toothless, and have a fleshy hood overhanging the mouth. For several years the larvae live as filter feeders in burrows they construct in soft sediments of the tributaries. Larvae later transform (metamorphose) into free-swimming juveniles. Transformation involves the disappearance of the hood, the emergence of eyes, and the development of teeth on the tongue and the sucking disk, which surrounds the mouth (Fig. 2).

**Fig. 3.** Sea lampreys attached to a lake trout.
Courtesy USGS

These *transformers*, silvery in color and about the size of a 13- to 15-centimeter-long pencil, move downstream to the Great Lakes, where they quickly attach to prey fish. The duration of attachment varies, but the site of attachment on the fish's body, the time of year, and the size of the sea lamprey relative to the size of its prey determine whether the attack will be fatal to the prey fish. Captured lake trout sometimes bear wounds and scars indicating that they have survived several attacks by small sea lampreys (Fig. 3). Over their 12-20 months of predatory existence, sea lampreys mature sexually and then repeat the life cycle.

# Effects on the Fisheries

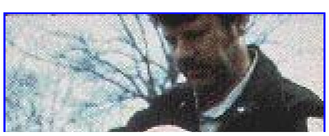

**Fig. 4.** Lake trout with wounds caused by sea lamprey attacks.
Courtesy U.S. Fish and Wildlife

Commercial fishermen on Lakes Huron and Michigan went

Service

through the grim experience of
seeing increasing numbers of sea lamprey wounds on their catch (Fig. 4). Storms also rolled growing numbers of lamprey-killed lake trout into bottom net sets. At the same time the combined annual catch of lake trout, which had averaged 5.9 million kilograms, declined sharply. Despite this alarming decline in lake trout abundance, fishermen tried to maintain the level of their catch because of the food shortage created by World War II and because of their fear that sea lamprey would kill all the lake trout anyway.

The lakewide decline of the fishery in relation to the invasion of sea lamprey was best documented in Lake Superior, where lake trout production held at 1.8 million kilograms from 1930 to 1952. In the following decade, though, production dropped 90%, while the number of sea lampreys caught in a fixed number of assessment weirs rose from 1,000 to 70,000.

Lake trout were the favorite prey of sea lampreys and were also the top predator in the Lake Superior system. As the number of lake trout dropped, the sea lamprey turned to preying on lake whitefish and other members of the whitefish family, the chubs and lake herring. As the top predator in Lakes Huron and Michigan was eliminated, the population of another invader from the salty Atlantic, the predatory alewife, exploded. Alewives became very abundant, and though they were vulnerable to massive spring die-offs, they had adverse effects on many valuable native fish species.

# Early Control Efforts

In 1948 a committee representing the governments of the United States and Canada, eight U.S. states, and Ontario--the jurisdictions bordering the Great Lakes (Fig. 1)--was established to begin a sea lamprey control program. The U.S. Fish and Wildlife Service, the state of Michigan, and the province of Ontario led research in defining the life history and distribution of sea lampreys and installing and testing physical barriers designed to prevent sea lampreys from entering streams to spawn. Very early in the program, the committee decided that a chemical selectively more toxic to sea lamprey larvae (lampricide) in streams than to nontarget fishes and other aquatic organisms would be invaluable. The U.S. Fish and Wildlife Service intensively screened some 6,000 chemicals in laboratory tests over 7 years before TFM™ (3-trifluoromethyl-4-nitrophenol) and Bayer™ 73

(2',5-dichloro-4'-nitrosalicylanilde) were chosen for field testing. These effective chemicals are still the major control agents today.

# An International Commission

Meanwhile, Canada and the United States realized that to control and manage the sea lamprey and rebuild the Great Lakes fishery, coordination and stable, adequate funding were needed. Thus, the Convention on Great Lakes Fisheries was ratified in 1955, and the Great Lakes Fishery Commission was formed and charged to improve the fisheries, develop and coordinate research, advise governments, and control the sea lamprey. The commission assumed responsibility for ongoing sea lamprey control programs and selected the U.S. Fish and Wildlife Service and the Canadian Department of Fisheries and Environment as its agents to carry out sea lamprey control and research.

# Further Control Efforts

By 1959 mechanical weirs and electrified barriers were installed in 135 Great Lakes tributaries. These devices, which contained traps, were generally effective at preventing sea lampreys from reaching spawning areas and also provided information on the number of sea lampreys in the area. During high water and power failures, though, sea lampreys could bypass these devices. Both systems were gradually phased out. The use of electricity was abandoned in the late 1970's, and research into effective electrical blocking systems was delayed by many years. The mechanical barrier program has since been refined and enlarged.

Subsequently, the commission concentrated on chemical control programs, which experienced great success following initiation of chemical treatments in all the lakes (Fig. 5). Information for Lake Michigan, where chemical treatment started in 1960, has not been summarized, but it followed a pattern similar to that of Lake Huron in the early years of treatment (1960-1982; see Lake Huron graph in Fig. 5). Lamprey numbers have increased recently in Lake Michigan, but not nearly as dramatically as in Lake Huron.

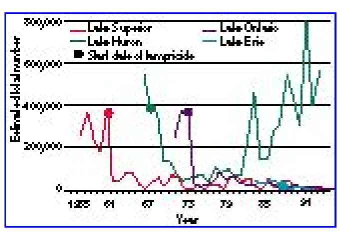


**Fig. 5.** Numbers of feeding-phase sea lamprey in Lakes Superior, Huron, Erie, and Ontario before and after initiation of lampricide applications in tributaries. Dot indicates start date of lampricide use (G. Christie, Great Lakes Fishery Commission, Ann Arbor, Michigan, unpublished data).

Since 1975 the commission, concerned that the control program was overly dependent on chemicals, has emphasized that the chemical control program alone can never bring the sea lamprey under complete control. The success of the chemical applications and the development of a world-class recreational fishery, though, have led the public and the U.S. and Canadian governments to consider the lamprey problem in the Great Lakes solved. Thus, funding for research that was needed to investigate supplemental and alternative control methods, and even funding for maintenance of control programs, was curtailed. The sea lamprey control program directly benefited the fishery and therefore was better funded than the research program.

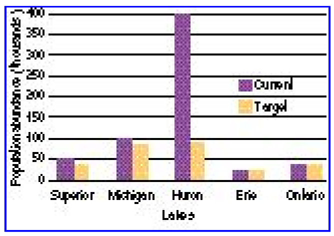


**Fig. 6.** The 1995 status of sea lamprey populations in the Great Lakes and control program targets for sea lamprey suppression (G. Christie, Great Lakes Fishery Commission, Ann Arbor, Michigan, unpublished data).

In 1982 the commission began applying integrated pest management concepts to sea lamprey management. Concern about the introduction of chemicals into the environment has led the commission to fund extensive testing of the environmental safety of lampricides. Although no long-term detrimental effects to the ecosystem have been detected, public apprehension about pesticides is a compelling reason to seek alternatives to lampricides. Therefore, the commission's integrated management of sea lamprey includes establishing target levels of sea lamprey abundance (Fig. 6) and reducing lampricide use by 50% by the year 2000 (Great Lakes Fishery Commission 1992). The sea lamprey controls now in use include low-head barrier dams, stream velocity barriers, safer and more effective electrical barriers, mechanical trapping, and the release of sterile male sea lampreys, which compete with normal males for mates but produce no offspring. The development of spawning attractants and repellents, which took a large part of the research budget for several years, has not yet yielded a useful control tool.

The St. Marys River, which connects Lake Superior and Lake Huron, contributes an estimated 400,000 sea lampreys a year to Lake Huron, with disastrous effects on the lake trout population there (Figs. 5 and 6). Although a multiphase attack program on sea lampreys spawning in the St. Marys has been developed, it may not be implemented soon.

# Rebuilding the Great Lakes Fishery

As sea lampreys became sufficiently controlled, Ontario, state, and U.S. Fish and Wildlife hatcheries produced large numbers of lake trout for stocking. These hatcheries, though, were unable to produce enough fish to fully take advantage of the carrying capacity of the lakes with their huge populations of forage fish. After evaluating the opportunity, the Michigan Department of Natural Resources introduced chinook salmon and coho salmon, which can be grown in hatcheries to stocking size in greater numbers and in shorter times than lake trout. The salmon were first stocked in Lake Michigan, where they survived in excellent numbers, grew quickly on a diet of alewives, were relatively resistant to lamprey attack, and provided an excellent offshore and inshore recreational fishery. Other states around the lakes soon followed Michigan's lead.

Thus, the fishery has been rebuilt through sea lamprey control, water-quality improvement, habitat protection, stocking, establishment of sanctuaries, and enforcement of regulations. At the fishery's peak in the mid-1980's, the annual regional economic effect of the commercial fisheries was estimated at $270 million, and that of the recreational fisheries at $2.0-$4.0 billion (Talhelm 1988). Some 55 million angler-days were spent in pursuit of Great Lakes fish annually, and the fishery-related industries provided employment for between 37,500 and 75,000 people.

The commercial catch of lake whitefish, a valuable species that was also decimated by the sea lamprey, is at historic levels. Lake trout populations have been declared recently to be self-sustaining in Lake Superior, and natural reproduction is finally occurring in the other lakes. Alewife populations are under control, and native species of forage fish are rebuilding. Keeping sea lamprey populations at levels that allow adequate survival of desirable fish communities seems to be the key to success. With adequate funding for current control strategies and further research into innovative alternative control techniques and their application, further declines in sea lamprey populations seem achievable and economically feasible.

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