Original: Am. Fish. Society
cc: Fish Division
Education-Game
Institute for Fisheries Research
D. S. Shetter
V. C. Applegate

January 28, 1947

Report No, 1086

# A brief history of the sea lamprey problem in Michigan waters[1]

[1] Contribution from the Institute for Fisheries Research

David S. Shetter

Michigan Department of Conservation

Lewiston, Michigan

## Abstract

The sea lamprey, Petromyzon marinus, usually spends almost all of its adult life in the ocean, entering fresh-water streams only to spawn. Since 1921 it has spread into the Great Lakes and certain large inland lakes where it has become sufficiently adapted to spend its adult life. It enters streams to spawn, between April and August, in specially prepared nests in gravel riffles. The adults die after spawning. Within 3 weeks the viable eggs hatch into the larval or ammocoete stage. The ammocoetes are free-living in the stream for 4-5 years, when they become adult by undergoing a metamorphosis, move down into large lakes or the sea, and spend the balance of their 5-8-year total life span as parasites, sucking the blood and juices of fish.

In 1921 the sea lamprey was taken in western Lake Erie. By 1930 it had appeared in the St. Clair River and by 1936 had been found in Lake Michigan near Milwaukee. Recent reports of its occurrence in Lake Superior have not been confirmed by actual specimens.

Commercial fishermen of the Great Lakes have complained of increasing damage to their catch by sea lampreys, especially in the northern halves of Lakes Huron and Michigan. In interviews with Michigan conservation officers during the summer of 1946, commercial fishermen reported that an average of roughly one-third of their catch was damaged, and that sometimes every fish in a given haul would bear sea lamprey scars. Lake trout were most heavily victimized but whitefish, suckers, yellow pike-perch, yellow perch, and carp also showed signs of attack according to these reports.

In 1944 and 1945 a weir was operated on the Ocqueoc River in northeastern Michigan throughout heavy spawning runs. Although the weir traps did not catch all lampreys in the runs because of faulty construction, in the first year 3,366 and in the second 4,608 lampreys were caught and killed. It was estimated that 90 or more percent of the migrants were sea lampreys.

It is shown that attempts to trap and destroy all lamprey spawning runs would be very expensive and, to be effective, would have to be prosecuted vigorously and simultaneously by all states and provinces bordering the Great Lakes.

Practically, complete eradication of the sea lamprey from the Great Lakes appears impossible. The trapping method, however, might result in significant reduction in sea lamprey abundance and should be tested further.

## Introduction

The sea lampreys (Petromyzon marinus), like the smelt (Osmerus mordax), originally existed during their adult life only in marine

waters, and returned to fresh-water streams to reproduce. That they are a very adaptable form is demonstrated by their present distribution in several inland lakes in New York State and Michigan, and in all the Great Lakes.[2]

---

[2] Although reported from Lake Superior, no specimens taken in the Lake Superior drainage have been examined and positively identified.

---

The sea lampreys of the smaller inland lakes are considered by Hubbs and Pope (1937) to be a dwarf form of the marine species, as they seldom exceed 15 inches in total length when mature. Gage (1893) gave total length measurements of mature ocean-run lampreys from Massachusetts which averaged about 26 inches, whereas the "lake" form studied by him in New York averaged 12.6 inches. Michigan specimens of the sea lamprey range in size from 12.5 inches to 30.0 inches, and individuals as large as 40 inches in total length have been reported by commercial fishermen. With the exception of the size differences noted, it appears that the form now present in all the waters mentioned is one and the same.

Previous workers (Hubbs and Lagler, 1941) have published taxonomic keys which aid in separating the sea lamprey from the four other species of lampreys present in Michigan waters. The life history of the "lake" form of the sea lamprey has been minutely described by Gage (1893-1928). The adult portion of the sea lamprey's life cycle, during which it is parasitic on almost any species of fish available to it, has drawn attention to this primitive vertebrate since 1875.

This paper contains a brief account of the life cycle of the sea lamprey, the known history of its spread into Michigan waters,

observations on certain spawning runs in Michigan streams and a discussion of control measures attempted, as well as the results of interviews by conservation officers with commercial fishermen. The implications of control and eradication procedures suggested by interested parties are also discussed.

## Life history

The important details of the life history of the sea lamprey in Michigan are as follows:

1. The mature adults migrate into running water between April and August. The peak of the spawning run occurs after the water temperature reaches 50° F., usually in late May and early June.

2. The eggs are laid in specially-prepared nests on gravel or rubble riffles in from 4 to 36 inches of water.

3. After spawning is completed, the adults die[3].

---

[3] This point still seems to be held in some doubt by various researchers and numerous commercial fishermen. However, the evidence on the matter, as presented by Gage (1928, pp. 169-171) strongly supports the conclusion that the adult sea lamprey dies after spawning is completed.

On June 26, 1945, after spawning had passed its peak on the Ocqueoc River about half (52 of 107) of the sea lampreys seen were dead or dying. Many were in an advanced state of decomposition, and were lodged on the pool edges out of the current. Others had been caught on overhanging branches, and some were barely able to wriggle from the author's grasp.

4. Within 3 weeks, the viable eggs develop into larval lampreys called ammocoetes. The ammocoete stage of the sea lamprey corresponds roughly to the tadpole stage of the frog or toad, which differs greatly from the adult stage in morphological structure and mode of life.

5. The ammocoetes live for 4 to 5 years in sand and mud banks in the vicinity (usually slightly downstream) of the spawning site. During this period they are not parasitic.

6. When a length of 6-8 inches has been attained, a metamorphosis occurs. The immature sea lamprey takes on morphological characters which fit it for parasitic life, including horny teeth, a rasping tongue, and functional anti-coagulant-secreting buccal glands. It remains in the sand and mud banks during this transformation.

7. After metamorphosis is completed, the transformed sea lampreys migrate into the larger inland lakes or the Great Lakes. Here their food consists entirely of the blood (and to a small extent the flesh) of fishes. Their parasitic life is thought by Gage (1928) to last from 1-1/2 to 3-1/2 years. On reaching maturity the adults return to flowing streams to reproduce and die. Although the evidence given in the literature is of an indirect nature, it appears that the life cycle is no less than 5 years and possibly as long as 8 years in duration.

The parasitic portion of the life cycle has caused great concern in recent years, particularly since the sea lampreys have increased in Lakes Huron and Michigan, and more and more of the choice marketable species of Great Lakes fish are found scarred, wounded, or dead. This

large parasite attaches itself to the chosen host fish at any convenient point on the fish's body, utilizing the oral sucking disc. The horny circumoral teeth aid in penetrating the scales, and the finely-toothed tongue soon drills a hole in the flesh. If a blood vessel is not found immediately, the position of the oral disc can be shifted without losing its hold until blood is found. Once the blood flow is started the secretion of the buccal glands prevents coagulation. The parasite will hold to the fish until death of the host or satiation of the lamprey occurs. Gage (1928, p. 185) makes the following statements, based on experiments with sea lampreys (the dwarfed New York State form) and bullheads in confinement: ".....if the fish was relatively large, the lamprey does not usually kill it, but if the fish is small, the lamprey may kill it. Several examples with large and with small fish showed this over and over."

From these experiments he concluded also that about 1 meal every 36 days was the usual rate of feeding, and that the sea lamprey (of the sizes he studied) took about 1 ounce of blood per feeding.

The end results on fish which have suffered sea lamprey attacks run the gamut from completely healed, scaled-over scars about the size of a quarter (Fig. 1) which are rather inconspicuous, to specimens which have been observed with as high as nine fresh, livid wounds, some of them through the entire flesh of the body wall. Fish attacked shortly before being captured in the nets of commercial fishermen are usually paler than undamaged specimens in the same catch.

## Spread of the sea lamprey into Michigan waters

Previous to 1921, the sea lamprey had penetrated only as far as Lake Ontario, where it had existed as the dwarfed form already

Figure 1.--Sea lampreys, and lake trout showing characteristic healed scar. (Photo by Michigan Department of Conservation)

mentioned. In that year, Dymond (1922) reported the capture of specimens of the sea lamprey at Merlin, Ontario, in central Lake Erie[4]. The spread thereafter was as follows: 1927, near West

---

[4] A. E. Crewe also captured a specimen in the same year and at the same locality according to Gage (1928)

---

Sister Island (Osborn, Wickliff and Trautman, 1930); 1927, near Sandusky, American shore (Hubbs and Brown, 1929); 1928, near Rondeau, Canadian shore (Hubbs and Brown, 1929); 1930, St. Clair River, Michigan (Hubbs and Pope, 1937); 1932, Huron River, Michigan, from spawning run (Creaser, 1932); 1934, Swan Creek, Ohio, spawning run (Hubbs and Pope, 1937); 1936, 15 miles east of Milwaukee, Wisconsin (Hubbs and Pope, 1937); Elk Rapids, Michigan, (Hubbs and Pope, 1937); 1937, Ocqueoc River, Michigan (Conservation Officer Marvin Norton's semi-monthly report).

Since that time the author has observed sea lamprey spawning runs in the Clinton River (1938), the Au Gres River (1941), the Platte River (1943), the Ocqueoc River (1944), and the Rifle River (1944). They are reported to run in great numbers in the Cheboygan River. Other streams where the sea lampreys were reported to spawn during the spring of 1946 were located in 26 of the 41 Michigan counties bordering on Great Lakes waters. It is obvious that the sea lamprey has penetrated to and become well established in the Great Lakes waters of Michigan.

Research on sea lamprey control in Michigan

In May 1938, Conservation Officer Earl Goff reported a run of spawning sea lampreys in the Clinton River, a tributary of Lake St.

Clair in the vicinity of Yates' Cider Mill, near Rochester, Michigan. A similar run occurred there in 1939. Trautman and Deason (1938)[5]

---

[5] Trautman, Milton B., and Hilary J. Deason, 1938. Observations of the spawning of the sea lamprey, (Petromyzon marinus) in the Clinton River, Oakland and Macomb Counties, Michigan, with suggestions for control. (Unpublished MS).

---

and Deason (1939)[6] made observations on these runs and on the spawning

---

[6] Deason, Hilary J. 1939. A second report on observations of the sea lamprey, Petromyzon marinus, in the Clinton River, Oakland and Macomb Counties, Michigan. (Unpublished MS).

---

activities. Interviews with Harry Yates of Rochester, Michigan, indicated that sea lampreys were first observed in that locality in 1934, had returned yearly thereafter in slightly increasing numbers, and were reported to spawn in a rather limited riffle area about a half-mile below a dam with a 4-foot head. In 1938, four specimens captured ranged from 14.2 inches to 17.4 inches. A search for eggs and ammocoetes was unsuccessful, except that 1 egg was observed attached to a stone in a nest where spawning took place. In the 1938 report (op. cit.) five methods of manual control were suggested: by hand, minnow seine, long-handled knife, spear, and gaff, and plans for the construction of the last three items were given.

Recommendations were made concerning investigation of other possible spawning areas, and the 1939 report (op. cit.) recommended the construction of an experimental weir in conjunction with Mr. Yates' water wheel as the most likely means of controlling the Clinton River run.

In March 1944, a cooperative plan for an experimental study of possible methods for controlling the sea lampreys in the Ocqueoc River was drawn up by representatives of the East Presque Isle Sportsmen's Club, the Field Administration Division and the Fish Division of the Michigan Department of Conservation. The club contributed materials and labor to erect a weir, while the Conservation Department paid the salary of a weir attendant.

The weir was installed about 2-1/2 miles upstream from Lake Huron, just below the outlet of Ocqueoc Lake. Here the river has steep banks approximately 35 feet high. At low water the width of the river is about 50 feet, and the depth does not exceed 2 feet. The bottom is hard clay and rubble with a surface covering of gravel and clam shells.

The weir was of the conventional "double-V" type with the traps in midcurrent. Material for the structure, donated by the Michigan Limestone and Chemical Company of Rogers City, consisted of used stone screening. These screens were 15 feet long by 3 feet wide, and were of 3/4-inch or 1-inch mesh. To form the blocking arms, these sections were overlapped about 1 foot, and were supported by and wired to steel stakes, of the type used to support snow fencing, driven firmly into the bottom by a sledge. Irregularities in the bottom were filled with gravel and rubble.

The traps proper, prefabricated in a single unit from the used screening, were approximately 6 by 8 by 3 feet. A funnel-type lead-in sloped up from the mouth on the bottom side. In 1945, 1/4-inch mesh hardware cloth was used to line the downstream blocking arms and the entire trap, and to make an overhanging apron on these parts of the weir. This addition was prompted by the observation that many small lampreys were able to "tail" through the 3/4-inch mesh, and that the larger ones might "jump and fall" over the blocking arms when the water level was high.

In 1944, the weir was operated between May 22 and July 24. A total of 3,366 lampreys was destroyed as follows: May, 2,000; June, 1,225; July, 141. Daily catch records were not kept. The mesh size of the blocking arms and trap was too large, the weir was over-topped on several occasions, and undercut at several points. Hundreds of spawning sea lampreys were observed to reach the spawning grounds below Ocqueoc Falls.

In 1945, the weir was re-installed at the same point on April 22, and was removed from the stream on July 16. Trap records and temperature data are more complete than for 1944. However, as in 1944, the weir was not 100 percent efficient in blocking the run because of faults inherent in its construction. The blocking arms were undercut because they were not sealed by sheet-piling, and high water caused by rains of flood proportions completely overtopped the 3-foot sections during the periods April 25-28, and May 28-June 6. After the last period, spawning sea lampreys increased very noticeably on the riffles below Ocqueoc Falls.

In 1945, the traps caught 9,911 individuals. All were upstream migrants except for 29 sea lampreys and 1 rainbow trout taken in the downstream trap. The total was made up of 4 species of lampreys, 15 species of fresh-water fish, 2 turtles and 5 water snakes. The trap catches, listed by 2-week periods except for the first period, will be found in Table 1.

The four species of lampreys trapped were the sea lamprey (Petromyzon marinus) and the silver lamprey (Ichthyomyzon unicuspis), both of which are parasitic on fish in Lake Huron; the Michigan brook lamprey (Ichthyomyzon fossor) and the American brook lamprey (Entosphenus lamottenii), the latter two species being non-parasitic. The weir attendant, who dipped the lampreys chiefly at night and destroyed them after passing on the game fish and rough fish, was not able to distinguish between the species of lampreys, so the exact numbers of each species present cannot be stated. Observations on the spawning beds, however, indicated that 90 percent or higher of the run was composed of sea lampreys. A total of 4,608 lampreys was trapped and destroyed.

The species of fish and the numbers of each taken in the traps were as follows: Common sucker (Catostomus c. commersonnii), 1,555; redhorse (Moxostoma aureolum), 649; rainbow trout (Salmo gairdnerii irideus), 10; brook trout (Salvelinus f. fontinalis), 3; yellow pike-perch (Stizostedion v. vitreum), 6; northern pike (Esox lucius), 1; yellow perch fingerlings (Perca flavescens), 1,586; smallmouth bass (Micropterus d. dolomieu), 250; common shiner (Notropis cornutus frontalis, 857; carp (Cyprinus carpio), 17; dogfish (Amia calva), 2;

Table 1.--Trap catch at the Ocqueoc Weir, season of 1945. Figures in parentheses show numbers of individuals taken in downstream traps. The peak run for each species is shown in italics.

| Species | Duration of period | | | | | | Totals | Size range (inches or pounds)[1] |
|---|---|---|---|---|---|---|---|---|
| | April 22-April 30 | May 1-May 15 | May 16-May 31 | June 1-June 15 | June 16-June 30 | July 1-July 15 | | |
| Sea lamprey[2] | 9 | 893 | *2,688* | 491 | 460(18) | 67 (11) | 4,608(29) | 8 - 30 inches |
| Common sucker | *1,196* | 174 | 74 | 79 | 21 | 11 | 1,555 | 14 - 20 inches |
| Red horse | 309 | *340* | ... | ... | ... | ... | 649 | 14 - 20 inches |
| Rainbow trout | ... | ... | *9* | ... | ... | 1 (1) | 10(1) | 18 - 30 inches |
| Brook trout | ... | 1 | ... | ... | ... | *2* | 3 | ... |
| Walleyed pike | 1 | 2 | *3* | ... | ... | ... | 6 | 2 - 5 pounds |
| Northern pike | ... | 1 | ... | ... | ... | ... | 1 | ... |
| Yellow perch | ... | *1,450* | 114 | 22 | ... | ... | 1,586 | 3 - 6 inches |
| Smallmouth bass | 2 | 20 | *99* | 25 | 96 | 8 | 250 | 4 - 7 inches |
| Common shiner | ... | 243 | 50 | 132 | *372* | 40 | 837 | 4 - 8 inches |
| Carp | ... | 2 | 3 | 3 | 3 | *6* | 17 | 3 - 8 pounds |
| Dogfish | ... | ... | 1 | 1 | ... | ... | 2 | 3 - 5 pounds |
| Rock bass | ... | *22* | ... | 6 | 13 | 3 | 44 | 4 - 8 inches |
| Bullhead | ... | ... | 1 | 29 | 27 | *50* | 107 | 5 - 10 inches |
| Smelt | 3 | ... | ... | ... | ... | ... | 3 | ... |
| Creek chubs | ... | ... | ... | 82 | *144* | ... | 226 | 4 - 7 inches |
| Turtle (sp?) | ... | ... | ... | ... | ... | *2* | 2 | ... |
| Water snake | ... | ... | ... | ... | ... | *5* | 5 | ... |
| Totals | 1,520 | 3,148 | 3,042 | 870 | 1,136(18) | 195(12) | 9,911(30) | |

[1] Only sea lampreys and rainbow trout were actually measured. All other sizes were either estimated or not given

[2] Some American, Michigan brook, and silver lampreys are included in the catch records.

rock bass (Ambloplites rupestris), 44; bullhead (sp. ?), 107; smelt (Osmerus mordax), 3; creek chubs (Semotilus a. atromaculatus), 226. The identity of the turtles captured is not known; the water snakes were Natrix s. sipedon.

The daily trap catches of lampreys, the average daily water temperatures, the water level and the average size of the lampreys trapped are given in Table 2. The number of lampreys moving from midnight-6 a.m., 6 a.m.-noon, noon-6 p.m., and 6 p.m.-midnight of each day is listed also for the period May 4-June 30.

It may be concluded that 95 percent or more of the migrants moved between the hours of midnight and noon; slightly more than half of the movement occurred between midnight and 6 a.m. The hours of greatest activity were during complete darkness.

The length of mature sea lampreys in the Ocqueoc River varied from 14.1 inches to 30 inches. Eighteen females taken during the first 10 days of July ranged in size from 14.1 to 21.7 inches, average length 17.9 inches. Twelve males taken at the same time varied from 15.5 to 19.6 inches and averaged 17.6 inches in total length. Sea lampreys inhabiting the Ocqueoc River appear therefore to be larger than those described by Gage (1928) for New York State, but smaller than those commonly running from the Atlantic Ocean.

From examinations on May 19 and 20 (before the peak of the run) and on June 15 (after the peak) of a limited number of specimens by the weir attendant, the sex ratio was determined to be 70 percent males to 30 percent females before the peak of the run, and 80 percent females to 20 percent males after the peak had passed. It might be inferred from this that the males run somewhat earlier than the females.

Table 2.--Daily catch of sea lampreys,[1] and data on water temperature and water level at Ocqueoc weir, 1945. Figures in parentheses indicate numbers of downstream migrants trapped.

| Date | Number of sea lampreys trapped between | | | | Daily total | Average daily water temperature (degrees Fahrenheit) | Water level (inches above or below normal) | Average size or size range of lampreys (inches) |
|---|---|---|---|---|---|---|---|---|
| | Midnight-6 a.m. | 6 a.m.-Noon | Noon-6 p.m. | 6 p.m. Midnight | | | | |
| April 22 | ... | ... | ... | ... | 1 | 42 | ... | 30 |
| 23 | ... | ... | ... | ... | 1 | 42 | ... | 24 |
| 24 | ... | ... | ... | ... | ... | 42 | ... | ... |
| 25 | ... | ... | ... | ... | 1 | 44 | +14 | 7 |
| 26 | ... | ... | ... | ... | ... | 42 | +12 | ... |
| 27 | ... | ... | ... | ... | ... | 43 | +10 | ... |
| 28 | ... | ... | ... | ... | ... | 43 | + 8 | ... |
| 29 | ... | ... | ... | ... | 2 | 43 | + 6 | ... |
| 30 | ... | ... | ... | ... | 4 | 43 | + 7 | ... |
| April totals | ... | ... | ... | ... | 9 | | | |
| May 1 | ... | ... | ... | ... | 11 | 43 | + 3 | ... |
| 2 | ... | ... | ... | ... | 33 | 44 | + 2 | ... |
| 3 | ... | ... | ... | ... | 43 | 45 | + 1 | 20 |
| 4 | ... | 11 | ... | 51 | 62 | 46 | Normal | 21 |
| 5 | 31 | 23 | ... | ... | 54 | 47 | Normal | ... |
| 6 | 73 | 55 | 3 | ... | 131 | 50 | Normal | ... |
| 7 | 43 | 30 | 4 | 4 | 81 | 50 | - 1 | ... |
| 8 | 56 | 40 | ... | ... | 96 | 48.5 | + 6 | ... |
| 9 | 37 | 41 | ... | ... | 78 | 44.5 | + 8 | ... |
| 10 | 27 | 33 | ... | ... | 60 | 46 | + 7 | ... |
| 11 | 27 | 17 | ... | ... | 44 | 46 | + 5 | ... |
| 12 | 29 | 17 | ... | ... | 46 | 45 | + 5 | ... |
| 13 | ... | 21 | ... | 34 | 55 | 46 | + 5 | ... |
| 14 | 31 | 6 | ... | 1 | 38 | 46 | + 5 | ... |
| 15 | ... | 38 | 23 | ... | 61 | 47 | + 4 | ... |
| 16 | 43 | 37 | ... | ... | 80 | 48 | + 5 | 16-26 |
| 17 | 47 | 28 | ... | ... | 75 | 48 | + 4 | 24 |
| 18 | 52 | 29 | ... | ... | 81 | 48 | + 4 | ... |
| 19 | 172 | 40 | ... | ... | 212 | 51 | + 3 | 14-26 |
| 20 | 42 | 186 | ... | ... | 228 | 52 | - 1 | 14-26 |
| 21 | 200 | 141 | ... | ... | 341 | 52 | - 1 | 14-21 |
| 22 | 186 | 71 | ... | ... | 257 | 58 | - 2 | 12-26 |
| 23 | 212 | 76 | ... | ... | 288 | 56 | + 2.5 | 12-26 |
| 24 | 20 | 105 | ... | ... | 125 | 52.5 | + 2 | ... |
| 25 | 46 | 142 | ... | ... | 188 | 57 | + 2 | 14-20 |
| 26 | 177 | 108 | ... | ... | 285 | 58 | + 2 | ... |
| 27 | 105 | 186 | ... | ... | 291 | 59 | + 3 | 12-26 |
| 28 | 163 | 74 | ... | ... | 237 | 60.5 | + 7 | 14-24 |
| 29 | ... | ... | ... | ... | ... | 62 | + 9 | ... |
| 30 | ... | ... | ... | ... | ... | 60 | +16 | ... |
| 31 | ... | ... | ... | ... | ... | 60 | +14 | ... |
| May totals | 1,918 | 1,555 | 30 | 56 | 3,581 | | | |

(Continued on next page)

Table 2 (Continued)

| Date | Number of sea lampreys trapped between: Midnight-6 a.m. | 6 a.m. Noon | Noon-6 p.m. | 6 p.m. Midnight | Daily total | Average daily water temperature (degrees Fahrenheit) | Water level (inches above or below normal) | Average size or size range of lampreys (inches) |
|---|---|---|---|---|---|---|---|---|
| June 1 | ... | ... | ... | ... | ... | 60 | +10 | ... |
| 2 | ... | ... | ... | ... | ... | 55 | +10 | ... |
| 3 | ... | ... | ... | ... | ... | 50.8 | + 9 | ... |
| 4 | ... | ... | ... | ... | ... | 50 | + 7 | ... |
| 5 | ... | ... | ... | ... | ... | 48 | + 8 | ... |
| 6 | 6 | 63 | ... | ... | 69 | 48 | + 8 | 12-20 |
| 7 | 74 | 35 | ... | ... | 109 | 50.8 | + 6 | ... |
| 8 | 46 | 6 | ... | ... | 52 | 52.5 | + 4 | ... |
| 9 | 39 | 40 | ... | ... | 79 | 56.5 | + 3 | 12-18 |
| 10 | 8 | 1 | ... | ... | 9 | 60 | + 2 | ... |
| 11 | 21 | ... | ... | ... | 21 | 61 | + 5 | 18 |
| 12 | 12 | 11 | ... | ... | 23 | 60 | + 4 | ... |
| 13 | 21 | 17 | ... | ... | 38 | 62 | + 3 | 20 |
| 14 | 28 | 21 | ... | ... | 49 | 62 | + 3 | 24 |
| 15 | 14 | 28 | ... | ... | 42 | 62 | + 6 | 22 |
| 16 | 21 | 20 | ... | ... | 41 | 62 | + 7 | 22 |
| 17 | 17 | 21 | ... | ... | 38 | 63 | + 8 | 22 |
| 18 | 26 | 21 | ... | ... | 47 | 64 | + 8 | 12-24 |
| 19 | 26 | 11 | ... | ... | 37 | 64 | + 6 | 22 |
| 20 | 7 | 1 | ... | ... | 8 | 66 | + 4 | ... |
| 21 | 17 | 29 | ... | ... | 46 | 66 | + 3 | ... |
| 22 | 6 | 32(8) | ... | ... | 38(8) | 66 | + 3 | ... |
| 23 | 18 | 17(2) | ... | ... | 35(2) | 66 | + 3 | ... |
| 24 | 17 | 11 | ... | 3(3) | 31(3) | 68 | Normal | ... |
| 25 | 23 | 14(2) | ... | ... | 37(2) | 68.5 | Normal | 22 |
| 26 | 13 | ... | 11 | ... | 24 | 69 | Normal | ... |
| 27 | 16 | ... | 11 | ... | 27 | 69 | Normal | ... |
| 28 | 16 | ... | 1(1) | ... | 17(1) | 70 | Normal | ... |
| 29 | 17 | ... | 2(2) | ... | 19(2) | 70 | Normal | ... |
| 30 | 11 | ... | 4 | ... | 15 | 70 | Normal | ... |
| June totals | 520 | 399(12) | 29(3) | 3(3) | 951(18) | | | |
| July 1 | 3 | ... | 3(1) | ... | 6(1) | 70 | + 2 | ... |
| 2[2] | 12 | ... | ... | ... | 12 | 69.5 | + 2 | ... |
| 3 | 6 | ... | ... | ... | 6 | 71 | + 2 | ... |
| 4 | 8 | ... | ... | ... | 8 | 71 | + 2 | ... |
| 5 | 7(1) | ... | ... | ... | 7(1) | 71.5 | + 1 | ... |
| 6 | 8(5) | ... | ... | ... | 8(5) | 72 | Normal | 10-18 |
| 7 | 1 | ... | ... | ... | 1 | 72 | Normal | 20 |
| 8 | 3 | ... | ... | ... | 3 | 72 | Normal | 16 |
| 9 | 3 | ... | ... | ... | 3 | 70 | Normal | 18 |
| 10 | 1 | ... | ... | ... | 1 | 68 | + 2 | ... |
| 11 | 3 | ... | ... | ... | 3 | 68 | Normal | ... |
| 12 | 1 | ... | ... | ... | 1 | 64 | Normal | ... |
| 13 | 3(2) | ... | ... | ... | 3(2) | 64 | Normal | ... |
| 14 | 3(1) | ... | ... | ... | 3(1) | 64 | Normal | ... |
| 15 | 2(1) | ... | ... | ... | 2(1) | 65 | Normal | ... |
| July totals | ... | ... | ... | ... | 67(11) | | | |
| Grand totals | ... | ... | ... | ... | 4608 (29)[1] | | | |

[1] Some American, Michigan brook, and silver lampreys are included here.

[2] From July 2-July 15, traps were checked only at midnight and noon.

A study of the temperature data and the number of lampreys trapped each day reveals an increase in the run as the water temperature approaches 50°-60° F. Slightly more than 53 percent of the total upstream migrants trapped (2,452 of 4,579) were taken in the period May 19-28, when the average daily water temperatures ranged from 51.0°-60.5° F. Sea lampreys were taken by the trap every day it was in place and could be examined. Average daily water temperatures ranged from a low of 42° to a high of 72° F. during the period of operation. Figure 2 has been prepared to show more readily the relationship between water temperature and lamprey migration in the Ocqueoc River. The data are taken from Table 2.

Observations on the spawning grounds below Ocqueoc Falls about 10 miles upstream from the weir, in both 1944 and 1945, indicated that numerous mature individuals were escaping the traps and reproducing. A part of these mature lampreys may have been resident in Ocqueoc Lake above the weir. It did appear that the weir was fairly efficient in 1945 until overtopped by flood waters during the period May 28-June 6.

## Present effect of the sea lamprey on the Great Lakes fishery

In an effort to gain more information which might be of use in controlling the sea lamprey, the conservation officers of the Division of Field Administration in the counties bordering the Great Lakes were instructed by the Conservation Commission at the June, 1946 meeting to interview commercial fishermen, and report on the following points:

Figure 2.--Daily water temperatures and catch of lampreys, Ocqueoc River weir, 1945.

(1) number of known spawning streams; (2) percent of total fish taken that are scarred; and (3) the effect of scars on the marketability of the fish.

Results of the conservation officers' interviews with commercial fishermen are summarized in Table 3. The Michigan waters of the Great Lakes have been divided into seven geographical areas, and the reports pertaining to each briefly presented, including the number of reports, number of spawning streams reported, percentage of fish marked by lampreys, species marked, and the effect of scars on the marketability of the fish.

If the reports are correct, the sea lamprey is now present in all the Great Lakes, since it was reported to spawn in at least 10 streams flowing into Lake Superior. The Lake Superior localities must be accepted provisionally until specimens from there are obtained and identified. Judging from the conservation officers' reports, the greatest number of spawning streams are tributaries of northern Lake Huron (17) and northern Lake Michigan (30). Locations of the 68 reported spawning streams are given on the map in Figure 3.

The percentage of the commercial catch that was reported to be scarred or marked by sea lamprey parasitism varied considerably between the geographical areas and within the several areas. Owing to the extremely wide variation in range of damage reported to conservation officers by commercial fishermen, a statistically accurate figure of the percentage of fish bearing lamprey marks cannot be obtained from these data. For example, a fisherman might report that during a given period from 10 to 100 percent of the fish in his catches were marked. Without knowing the number and percentage of marked fish in each catch, and the total number of catches, one cannot be sure whether the overall average for the period

Table 3.--Summary of conservation officers' reports on sea lamprey spawning streams, the percentage of scarred or wounded fish taken in commercial gear, and the effect of scars on marketability, for Michigan waters of the Great Lakes, June, 1946.

| Lake | Number of officers reporting | Spawning streams reported | Percentage of commercial catches reported scarred[1] | | Species affected | Reports on marketability of scarred fish | | |
|---|---|---|---|---|---|---|---|---|
| | | | Range | Average less than | | Number making no report of loss | Number reporting no loss | Number reporting some loss |
| Superior | 15 | 13 | 0-100 | 1 | Lake trout | 3 | 10 | 2 reported scarred fish difficult to sell or unmarketable. |
| Michigan (Northern Half) | 21 | 30 | 0-100 | 50 | Lake trout<br>Whitefish<br>Suckers | 7 | 6 | 8 reported 5 to 75 percent loss on scarred fish. |
| Michigan (Southern Half) | 5 | 2 | 30-90 | 60 | Lake trout | ... | 4 | 1 reported most fish salable, half-price for scarred fish. |
| Huron (Northern Half) | 6 | 17 | 0-100 | 50 | Lake trout<br>Whitefish<br>Suckers | 2 | ... | 4 reported 5 to 75 percent loss on fresh, wounded fish, no loss on fish with healed scars. |
| Huron (Saginaw Bay) | 3 | 2 | 1 | 1 | Walleye<br>Sucker<br>Carp | ... | 3 | ..... |
| Huron (Southern Half) | 4 | 2 | 1-95 | 50 | Lake trout<br>Whitefish<br>Yellow perch<br>Suckers | 1 | 3 | ..... |
| Erie and St. Clair | 5 | 2 | 1-80 | 20 | Whitefish<br>Carp<br>Unstated | ... | 5 | ..... |
| Totals | 59 | 68 | 0-100 | 31 | Lake trout<br>Whitefish<br>Suckers<br>Walleyes<br>Yellow perch<br>Carp | 13 | 31 | 15 reported detailed varying losses on the scarred and wounded fish. |

[1] Averages determined by totalling maximum percentages given for all species from all reports.

Figure 3.--Map of Michigan showing distribution of the sea lamprey as reported by employees of the Michigan Department of Conservation and by commercial fishermen. Streams shown are those where adult lamprey migrations were noted by departmental field employees. Solid circles with arrow = sea lamprey spawning runs verified by Fish Division personnel, 1932-1946; open circles with arrow = sea lamprey spawning runs reported by conservation officers, 1946; solid squares = sea lamprey spawning sites observed by Fish Division personnel or other technical workers; solid triangles = fishing ports or fishing grounds where commercial fishermen have reported lamprey damage.

would be midway of the range reported, or closer to the upper or lower limits of the range.

In the Michigan waters of Lake Superior, from 0 to 10 percent of the lake trout were reported to be scarred, with the average less than 1 percent. Of the 15 reports, 10 indicated no loss in marketability of scarred fish, 2 that scarred fish were difficult to sell or unmarketable. Obviously, the economic loss to the Lake Superior fishermen so far has been of minor consequence. Three reports did not discuss effects of scars on sales value.

In both northern Lake Michigan and northern Lake Huron, from 0 to 100 percent of the lake trout were reported as scarred, and up to 10 percent of the whitefish and suckers, or an average of less than 50 percent. Of 27 reports from these waters, 9 contained no mention of any effect on sales, 6 showed that marketability was not affected by the lamprey scars, and 12 indicated 5 to 75 percent loss on scarred fish.

In the southern portions of Lakes Michigan and Huron, the average percentage of commercial species marked by the sea lamprey appeared to be between 50 and 60 percent. Lake trout were the chief victims, but whitefish, suckers and yellow perch were mentioned also. Seven reports indicated that the fishermen were suffering no loss on scarred fish sent to market; one reported that most of the scarred fish were being disposed of, and that badly scarred fish sold for half-price; and one report did not discuss marketability.

The Saginaw Bay fishery in Lake Huron is not affected by the sea lamprey, according to reports from three conservation officers. Less than 1 percent of yellow pike-perch, suckers and carp taken were reported scarred.

In Lakes Erie and St. Clair, five reports indicated that 1 to 80 percent of the fish were scarred, with an average of 20 percent. Whitefish and carp were the species mentioned. No loss in marketability because of scars was reported.

The conservation officers' reports, based on interviews with an unstated number of commercial fishermen might be summarized as follows: 68 spawning streams were reported; roughly 30 percent of the commercial species were reported to be scarred or wounded from lamprey attack; lake trout appeared to be most heavily parasitized by the sea lamprey followed by the whitefish, sucker, yellow pike-perch, yellow perch, and carp; in some 52 percent (31 of 59) of the reports commercial fishermen stated that no loss in sales value resulted from lamprey scars; 22 percent of the reports did not mention the subject, so it is not unreasonable to assume that there was no loss or only light loss to the fishermen who were interviewed; and 26 percent of the reports outlined varying losses from 5 to 75 percent in value on the lamprey-scarred fish.

The financial losses are largest to fishermen operating out of ports north of Saginaw Bay in Lake Huron, and north of Muskegon in Lake Michigan. There was almost no loss reported for other regions. The amount lost depends on the severity of the wound. If it is completely healed, the fish can be marketed as easily as unscarred specimens. The actual financial loss also varies with the mode of selling. If fish are dressed or filleted, almost all the value can be obtained, but it is said that if they are sold in the round, a heavy loss is taken by the shipper. Some operators sell the lamprey-scarred fish, if badly wounded, for the smoked-fish trade.

Before the loss to the commercial fishery can be ascertained accurately, it will be necessary to obtain numerous records taken at all seasons and localities from which to determine the percentage of scarred and unscarred fish in the catches, and to keep track of the prices obtained for both scarred and unscarred fish throughout the course of such an investigation.

From the literature available, and from the limited amount of research done in Michigan, the following facts emerge:

1. After penetrating Lake Erie in the period 1921-28, the sea lamprey invaded Lakes Huron and Michigan within the next 10 years, and the species became established. From a handful of known spawning localities in 1932 in Lake Erie, the reported spawning streams have increased to a total of 68 in Michigan waters alone in 1946.

2. Unless a weir of proper construction is installed in streams used for spawning, numerous mature lampreys are able to pass through, under or over the structure and to reproduce.

3. About one-third of all commercial species in Michigan's Great Lakes waters may be marked with scars of varying degrees of severity, according to fishermen's reports to conservation officers. The lake trout is the species most severely afflicted.

4. Despite the rather high incidence of lamprey-marked fish taken in commercial gear, reports by the fishermen to the conservation officers indicate that only in northern Lake Huron and northern Lake Michigan is there at present an appreciable loss to the industry because of lamprey wounds. The exact extent of the loss cannot be determined without more accurate and detailed data on the number of scarred fish taken and prices received for them.

During the past 3 years, the commercial fishermen most affected have demanded that either the State or the Federal Government "do something" about the sea lamprey. House Joint Resolution 366 was introduced in the House of Representatives in the second session of the 79th Congress, authorizing the U. S. Fish and Wildlife Service to "investigate and eradicate" the sea lamprey, and allocated a sum not to exceed $20,000 yearly for a 10-year period. This joint resolution was passed by Congress and signed by the President.

Many individuals have proposed to eliminate the sea lampreys by trapping and destroying them on their spawning runs. One of the primary purposes of the work on the Ocqueoc River in Presque Isle County, Michigan was to test this method of control which, in the light of the experiences there in 1945, would appear feasible if the necessary funds, materials, and labor were granted.

The proper type of structure would be built on sheet-piling to prevent undercutting, and the traps and blocking arms would be constructed of no larger than 1/2-inch mesh screen. It would have to be sufficiently wide and high to remain lamprey-tight under the worst flood conditions. Engineering estimates of construction costs alone for a weir of this type on the Ocqueoc River, where an opening 80 feet long by 5 feet high must be screened, have been set at $5,000. Allowance would have to be made also for maintenance costs as well as for the expense of attendants to keep the traps and screens under constant, 24-hour observation during the peak of the run. Since 68 known lamprey spawning streams have been observed in Michigan alone, costs for weir construction, maintenance and attendants would attain a very high annual figure and might be largely wasted unless similar programs were prosecuted vigorously by other states bordering the Great Lakes and by The Province

of Ontario. Even if the attempt were made to block all spawning streams tributary to the Great Lakes, complete eradication of the lamprey would be difficult if not impossible to achieve. The possibility should not be overlooked, however, that annual operation of weirs on the more important spawning streams might at least keep the pest under control.

Further study on the life history of the sea lamprey in the Great Lakes is needed. How long is its life cycle? How much time does it spend in the lakes proper as a parasite, and where? These are just two of many questions to which answers are needed. Complete knowledge of the life history and requirements of any parasite is requisite to any effective control. Possibly some unsuspected weak link in the life cycle might be uncovered by further investigation and might offer means for control or eradication. Investigations should be pursued also to determine the possible use of the sea lamprey as food, either for human or animal consumption. Gage (1928) and Kerr (1926) indicate that in earlier days, both in the British Isles and in New England, the sea lamprey was regarded as a delicacy. Gage (1928) mentions also that the ammocoetes were a lucrative source of income to bait dealers in New York State at one time. Collection of young and adult sea lampreys for biological study in high school and college zoology courses is not unremunerative although the market is limited.

It is to be regretted that the sea lamprey was able to enter the Great Lakes and become established in these inland waters, but rather than attempt the almost impossible task of eradication, we should explore all possibilities to turn its presence into an economic gain.

Summary

1. The life history of the sea lamprey is briefly outlined. Mature adults are anadromous, spawning chiefly in May and June and dying shortly thereafter. The larvae pass 4 to 5 years in the sand, gravel and silt banks of the spawning stream before transforming into the parasitic stage. After becoming fitted for a parasitic life, they live as free-swimming adults, parasitic on fish, from 1-1/2 to 3-1/2 years before becoming sexually mature and ready to spawn and die.

2. The sea lamprey spread into the upper Great Lakes within the period 1921-1936, and is firmly established in Michigan waters, probably including Lake Superior and possibly in some of the larger inland lakes.

3. The experiments of 1944 and 1945 on the Ocqueoc River in northeastern Michigan involving the operation of a sea lamprey trap were described. The trap failed to take a portion of the run each year because of improper and faulty construction. Nevertheless 3,366 lampreys were destroyed in 1944 and 4,608 lampreys were caught and killed in 1945.

4. Most of the upstream movement (95 percent or more) occurred between the hours of midnight and noon; over half of this movement took place between midnight and 6 a.m. The total length of the Ocqueoc River sea lampreys varied from 14.1 inches to 30 inches. Males appeared to precede the females to the spawning grounds. The peak of the run came when the average daily water temperature ranged from 51° to 60° F.

5. Conservation officers of the Michigan Department of Conservation in all counties bordering the Great Lakes questioned commercial fishermen operating in their respective territories on the following points during June and July of 1946:

(a) Number of known spawning runs of sea lampreys;

(b) Percent of lamprey-marked fish in their catches and the species of fish involved;

(c) The effect of scars on the marketability of the scarred fish.

The results can be summarized as follows:

(a) Sixty-eight spawning streams or areas were reported;

(b) Depending on the locality fished and the species of fish sought, from 0 to 100 percent of the catch was lamprey-scarred. Roughly 30 percent of the commercial species taken were reported to be scarred or wounded; lake trout were worse affected followed by whitefish, suckers, yellow pike-perch and carp;

(c) Commercial fishermen, except those fishing from ports in northern Lake Michigan and northern Lake Huron, told conservation officers that they had suffered almost no loss due to scarring of fish by sea lampreys. In the affected areas, the loss was reported to vary from 5 to 75 percent of the normal value of the fish. Catch records listing the numbers of scarred and clean fish taken in commercial gear and the prices received for each type are needed before the financial loss suffered by the industry can be determined accurately, and should be obtained from all types of gear and at different seasons of the year.

6. The possibility of eradication of sea lampreys through trapping the mature adults on their spawning runs was discussed. It was shown that attempts to block off and trap all lamprey spawning runs would be exceedingly costly. The suggestion was made that operation of traps on the more important spawning streams might control the pest, even though complete eradication might prove impossible to achieve.

7. Further research on the life history and possible economic utilization of the sea lamprey was suggested.

Acknowledgements

I wish to thank Dr. John Van Oosten of the U. S. Fish and Wildlife Service for obtaining permission to use unpublished material from the files of the U. S. Fish and Wildlife Service.

I am grateful to many employees of the Michigan Department of Conservation, especially the conservation officers and their various superiors in the Division of Field Administration who assembled the data from the recent questionings of the commercial fishermen regarding the presence of the sea lamprey and its effect on the industry, and to Mr. A. B. Cook, Assistant in charge of the Fish Division, who prepared the first draft of the map.

Literature cited

Creaser, Charles W.

1932. The lamprey Petromyzon marinus in Michigan. Copeia, 1932, No. 3, p. 157.

Dymond, John R.

1922. A provisional list of the fishes of Lake Erie. Pub. Ont. Fish. Res. Lab., No. 4, pp. 55-74.

Gage, Simon Henry

1893. The lake and brook lampreys of New York, especially those of Cayuga and Seneca Lakes. The Wilder Quarter-Century Book, pp. 421-493;

1928. The lampreys of New York State--Life history and economics. Biol. Surv. of the Oswego River System, Suppl. to 17th Ann. Rept., N. Y. State Cons. Dept., 1927, pp. 158-191.

Hubbs, Carl L., and Dugald E. S. Brown

1929. Materials for a distributional study of Ontario fishes. Trans. Roy. Can. Inst., Vol. 17, pp. 1-56.

Hubbs, Carl, and T. E. B. Pope

1937. The spread of the sea lamprey through the Great Lakes. Trans. Am. Fish. Soc., Vol. 66, 1936, pp. 172-176.

Hubbs, Carl L., and Karl F. Lagler

1941. Guide to the fishes of the Great Lakes and tributary waters. Bull. No. 18, Cranbrook Inst. of Sci., pp. 1-100.

Kerr, John G.

1926. Lamprey. In Encyclopedia Brittanica, 13th Ed., Vol. 15, p. 134.

Osborn, Raymond C., Edward L. Wickliff, and Milton B. Trautman

1930. A revised list of the fishes of Ohio. Ohio Journ. Sci., Vol. 30, pp. 169-176.

Surface, H. A.

1898. The lampreys of central New York. Bull. U. S. Fish Comm., 1897, Vol. 17., pp. 209-215.

Approved by: Dr. A. S. Hazzard
Typed by: S. E. Bommer

INSTITUTE FOR FISHERIES RESEARCH

David S. Shetter