SEA LAMPREY

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INTRODUCTION

In 1829 when the engineers finished the Welland Canal which connects Lake Ontario with Lake Erie they thought they were providing a passage for ships only. They could not know they were letting in a "monster" from the Atlantic Ocean, the sea lamprey, which about a hundred years later was to destroy the 10-million-pound lake trout fishery of the Great Lakes.

The sea lamprey, Petromyzon marinus, is found in the North Atlantic Ocean from Iceland and northern Europe to northwestern Africa and from the Grand Banks and Gulf of St. Lawrence to northern Florida. The adult lamprey, once found in marine waters only, has become well established in the lakes of western and northern New York and in the Great Lakes.

No one knows when the lampreys, members of the family Petromyzonidae, first moved into the Finger Lakes of New York State, where they abound. They probably came from Lake Ontario through the canals between Oswego and Buffalo.

Sea lampreys move each spring from the Atlantic Ocean into the coastal streams of Europe and North America to build nests, deposit eggs, and die. Some, however, deserted the Atlantic Ocean to live in the fresh water of Lake Ontario, feeding on its fish, spawning, and dying in its tributary streams. Niagara Falls prevented the lampreys from migrating into the other Great Lakes. However, in 1829 the Canadian Government finished the Welland Ship Canal, which provided the lampreys a route around Niagara Falls.

Even after the canal was completed, the lampreys seem to have been slow in establishing themselves in Lake Erie. The first lamprey was caught there in 1921. They did not thrive in Lake Erie as the waters were too warm and the spawning conditions poor. By the 1930's they reached Lakes Huron and Michigan, where the food supply, cold waters, and clear, gravel-bottomed tributary streams were ideal for growth and survival. Then they moved toward Lake Superior, but the dam and the navigation locks at the head of St. Mary's River slowed the rate of invasion into this lake. However, enough lampreys arrived in the lake to establish a rapidly growing population. The first specimens were taken off Isle Royale and Whitefish Point in 1946.

EFFECT OF LAMPREY ATTACKS ON THE FISHERY

The effect of the lamprey attacks on the lake trout, the most prized food fish and the backbone of the fishing industry of the Great Lakes, was devastating. For the 10-year period of 1930-39 fishermen took annually about 5 million pounds of lake trout from Lake Huron and the same amount from Lake Michigan. By 1950 the total catch in both lakes was only about 0.5 million pounds--a decline of 95 percent. By 1960 the catch amounted to less than 2,000 pounds. In Lake Superior catches declined rapidly commencing in 1953. By 1960 the catch amounted to only 10 percent of the average for the 10-year period 1941-50.

The lampreys not only brought havoc to the large, plentiful lake trout of Lakes Huron, Michigan, and Superior, but they preyed heavily on the larger chubs and whitefish. These species, like the lake trout, inhabit the deep water environment which is also the lampreys' domain.

As a result of the lamprey invasion, the commercial fishermen of the three upper lakes lost an annual income of more than $8 million. Losses to other channels in the trade and to sport fisheries cannot be estimated.

COOPERATIVE RESEARCH TO CONTROL THE LAMPREY

The Great Lakes States (New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, and Minnesota), the Province of Ontario and the Federal Governments of Canada and the United States have joined in efforts to save the lake trout from lamprey destruction. In 1946 the United States and Canada began a cooperative research program to find means to control the lamprey. On September 10, 1954, they signed a treaty for joint action and the Great Lakes Fishery Commission was set up in 1956 to direct this action.

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Effective methods for controlling the lamprey in the Great Lakes could not be developed until scientists learned more about its life cycle. They thought that during certain periods of its life it might be vulnerable to methods of control. From studies they found that lampreys spend 12 to 20 months in the lakes and in late winter congregate in bays and estuaries of rivers to mature their sex products. Prior to spawning, the sex glands grow enormously while the muscles, skin, and eyes degenerate. The digestive tract shrinks, and the lampreys do not feed but live on their stored fats and body tissues.

NATURAL HISTORY

Spawning

After the streams warm to about 40° Fahrenheit the lampreys ascend those that contain gravel, clear water, and a moderately strong current. The spawning migration may last 20 weeks.

When a satisfactory spawning site in the stream has been chosen, a male lamprey starts building a nest and is joined by a female, who helps in the construction. They clear a small area, picking up stones with their mouths and piling them in a crescent-shaped mound on the downstream side of the nest.

After the nest is finished and the water is warm enough (over 50°) spawning begins. The female, which lays an average of 61,500 eggs, deposits a few eggs at first, and the male at once fertilizes them. The current carries the eggs to the rim of the nest, where they lodge in the spaces among the stones. Then the female lays another batch of eggs and the process is repeated. The pair continue laying and fertilizing eggs until they are spent--spawning may take from 1 to 3 days--and then both die within a few hours and decompose rapidly. The lampreys that have no opportunity to spawn die also.

Larval Lampreys

Less than 1 percent of these heavy, small eggs hatch. Depending on the water temperature, hatching occurs in 2 to 3 weeks.

The newly hatched larvae remain in the nest until about the 20th day. Then, about a quarter of an inch long, they drift downstream to quiet waters. In the soft bottom each larva digs a burrow that will be its home for about 5 years unless erosion washes it away. Throughout their larval life the young lampreys, termed ammocetes (fig. 1), are blind and harmless. They

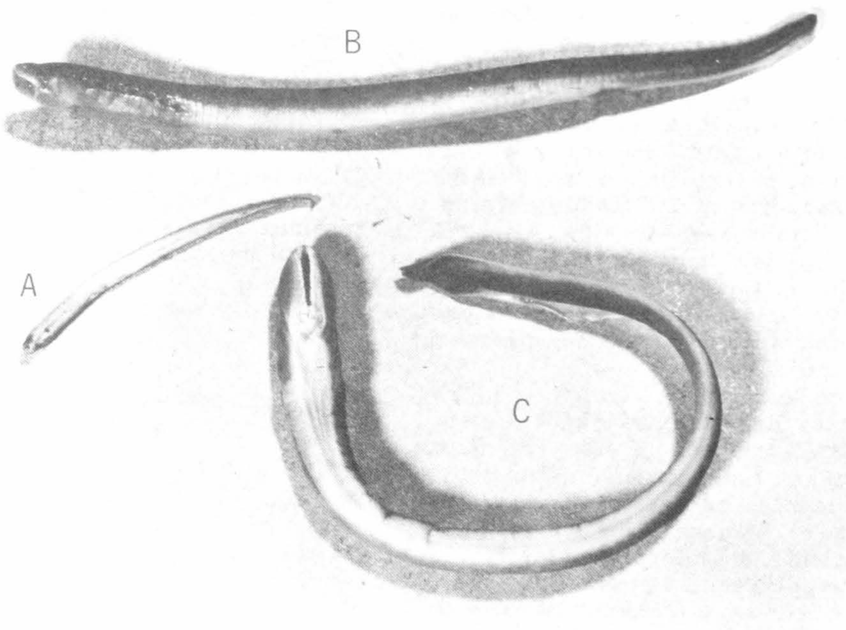

Figure 1.--Stages of development in the sea lamprey of the Great Lakes. A. An eyeless larva 1 3/4" long and about 1 year old. B. A 3-year-old larva 4 1/2" long in the nonparasitic life history stage. C. A juvenile parasitic lamprey which recently metamorphosed from the nonparasitic form.

suck food, mainly microscopic organisms, from the water passing the mouth of the burrow. A filtering apparatus in the throat keeps out debris and passes food organisms to the digestive tract.

After about 5 years each larva develops large prominent eyes, a round mouth lined with horny teeth, a filelike tongue, and enlarged and unpaired fins. Its slim body, with a soft skeleton of cartilage rather than bone, becomes dark blue above and silvery white beneath. Now 4 to 7 inches long, it may emerge from its burrow when late fall rains raise the stream level, but usually it waits until the spring ice breakup and high water before migrating downstream to the lakes. It will feed there upon the blood, body fluids, and dissolved flesh of fish, its sole food.

Adult Lampreys

This jawless predator, which does not school, attaches its suckerlike mouth (fig. 2) to almost any part of a fish. Sometimes several lampreys feed upon one fish at the same time.

Figure 2.--Mouth of the sea lamprey which is lined with horny teeth. In the center of the mouth is the rasping tongue.

The victim thrashes about violently, but rarely shakes off the lamprey. The strong teeth and the rasping tongue soon penetrate the fish's scales and skin. Lamphredin, a substance in the lamprey's saliva, dissolves the torn flesh and keeps the blood from clotting. Feeding stops when the host fish dies or the lamprey becomes glutted. The lamprey may remain attached to a fish for weeks, but some fish may die in as few as 4 hours. If a fish escapes, it is scarred so badly it is often unmarketable.

Feeding upon a succession of fish, the lamprey, which destroys no less than 20 pounds of fish in its life, grows rapidly, attaining a length of 12 to 24 inches and a weight of about 8 ounces. A lamprey rarely weighs more than 1 pound.

VALUE OF LAMPREYS

Efforts to find commercial uses for the lampreys to compensate for the destruction they cause were unsuccessful. They are not palatable to the people of the United States although they are eaten in many European countries. Analyses indicate that vitamin A potency and oil yield of the lamprey are much too low for commercial exploitation. Biological supply houses require only a few as study specimens.

CONTROL OF LAMPREYS

Knowledge about the lamprey, which has no known natural enemies, suggested several possibilities for control. The researchers found that the most vulnerable periods in the lamprey's life are when it is in the stream as a larva or a young migrant and later when it enters the stream as an adult to spawn. Efforts were made to prevent adult lampreys from entering streams to spawn. Mechanical weirs, installed for this purpose as physical barriers to migration, proved expensive and undependable and flash floods washed them out.

The researchers then developed a combination of mechanical traps and electrical barriers. An electrical field produced in a stream by electrical barriers was found to block the upstream migration of lampreys. These electrical barriers were superior to conventional weirs as they were less vulnerable to being washed out by floods. They did not clog with debris and they were cheaper to install and maintain. Fish and some lampreys enter traps placed at each end of the electrical barrier while others penetrate the electrical field and are killed. A different type of barrier, which is energized by pulsed, direct-current electricity, is used in streams where movements of important food fishes coincide with the lamprey migration. This device guides the fish and most of the lampreys into traps where they can be sorted and separated. The fish are passed upstream and the lampreys destroyed. An electric barrier (weir) is shown in figure 3.

Attempts were made to stop the downstream migration of juvenile lampreys. Mechanical, inclined-plane screens that strain all of the water of a stream were installed. These are extremely vulnerable to floods and accumulations of debris, which occur during the height of the downstream migration of lampreys.

Replacing this type of structure with devices designed to electrocute immediately all downstream migrants is not economically feasible. Voltages that kill fish only stun young lampreys and enough electricity to kill lampreys at this stage would cost an exorbitant amount.

The researchers next considered using selective poisons to kill juvenile lampreys. After 3 years of testing some 5,000 chemicals (fig. 4), they found that halogenated nitrophenols successfully kill larvae in streams, but do not harm fish.

One of these chemical lampricides, 3-trifluormethyl-4-nitrophenol, was used to destroy lamprey larvae in streams tributary to Lake Superior. Application of this chemical into lamprey infested streams requires great skill and precision by research teams. The procedure first involves a stream survey with portable electric shocking devices that drive buried lamprey larvae out of the bottom for capture and counting. A two-man crew makes the survey, and a record is made of the abundance and distribution of larvae. If larvae are present, other biologists map the stream, measure water flows at a number of sites, run analyses of the chemical properties of the water, and determine the points where the chemical should be introduced to provide complete coverage.

Just prior to treatment, a test is run in which lamprey larvae and game fish are placed in a series of jars containing aerated stream water at the prevailing temperature. Into the jars varying amounts of lampricide are added to determine the concentration and time of exposure that should be used to obtain a complete kill of lamprey larvae and a minimum loss of game fish.

Once this pretreatment information is collected and analyzed, lampricide is introduced by proportioning pumps into an infested stream at a rate so that the desired concentration is achieved throughout the water course. Chemical tests are made at numerous sites during the period of treatment to ensure that the concentration of lampricide is adequate.

After the treatment, biologists traverse the stream with electric shockers to check on the presence of live larvae. Seldom are live larvae

Figure 3.--Electric barrier (weir) in use on Pere Marquette River near Ludington, Mich. On the left, the alternating current electrodes are suspended upstream to prevent the passage of fish and lampreys. Downstream on the right is a suspended direct current electrode array used to guide fish and lampreys migrating upstream into the two traps.

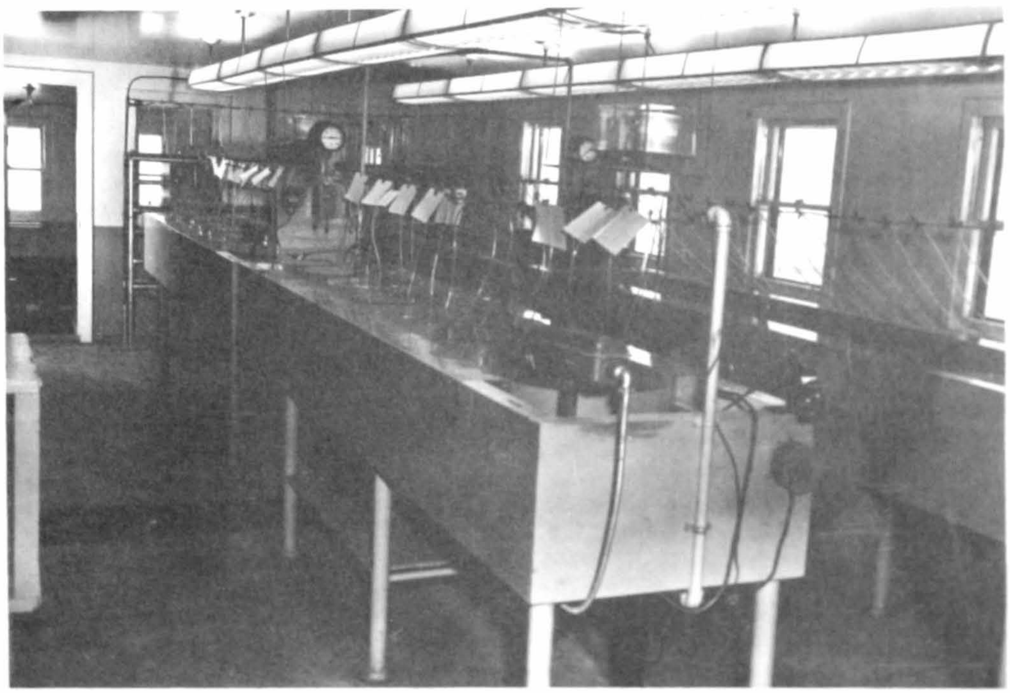

Figure 4.--A bioassay section of the laboratory at Hammond Bay, Mich., which is used to screen selective chemicals for lamprey control.

found because of the care taken in treating the stream. If many live larvae are found, the stream is re-treated.

Chemical control operations by Canadian and United States research teams began on streams tributary to Lake Superior in 1958. By the end of 1960, chemical treatments were completed on 72 streams. An additional 53 lamprey infested streams were treated, and some streams were re-treated by 1965. The result of this control effort was first evident in 1962 when the size of the adult lamprey population declined 82 percent over the 1957-61 level. In 1963 and 1964 the abundance of adult lampreys increased slightly, but remained 77 percent below that of 1957-61.

Good progress has been made in treating lamprey infested streams tributary to Lake Michigan. By the end of 1964, 78 streams had been successfully treated. It is anticipated that the remaining 21 streams will be chemically treated by the latter part of 1966. Thereafter work will commence in the Lake Huron area. In addition, biologists will chemically treat any reinfested streams tributary to Lakes Superior and Michigan before lamprey larvae are old enough to metamorphose and migrate to the lakes.

RESTORING THE LAKE TROUT

Although reduced substantially, it is not known whether the lamprey population is low enough to permit complete recovery of the lake trout population. However, since 1961 the lake trout population has responded favorably to reduced lamprey predation. Older and larger trout are more abundant, and a decline has occurred in the incidence of fresh lamprey wounds on trout.

To aid in restoring lake trout, 10.7 million hatchery-reared yearling trout, produced in State, Federal, and Provincial hatcheries, have been planted in Lake Superior since 1958. It is estimated that 3.4 million trout will be stocked in Lakes Superior and Michigan in the spring of 1965. The past plantings in Lake Superior have been successful, and these fish now comprise the bulk of the younger fish in the lake.

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