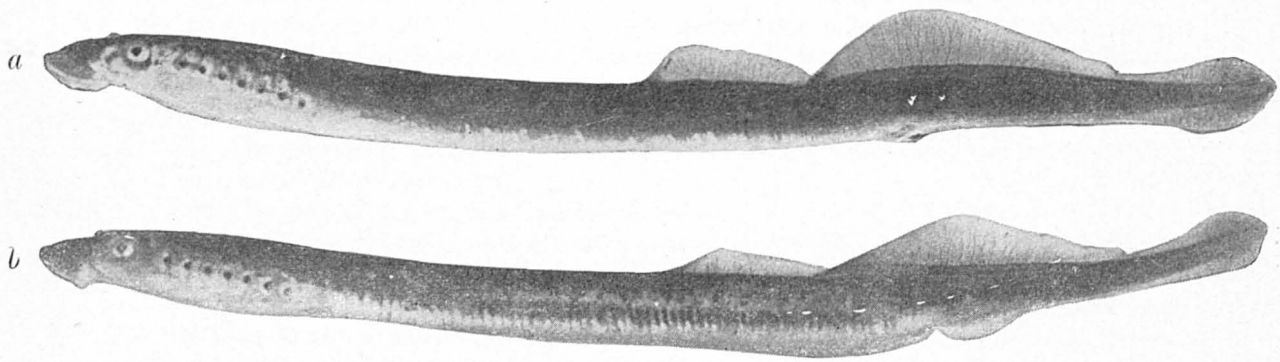
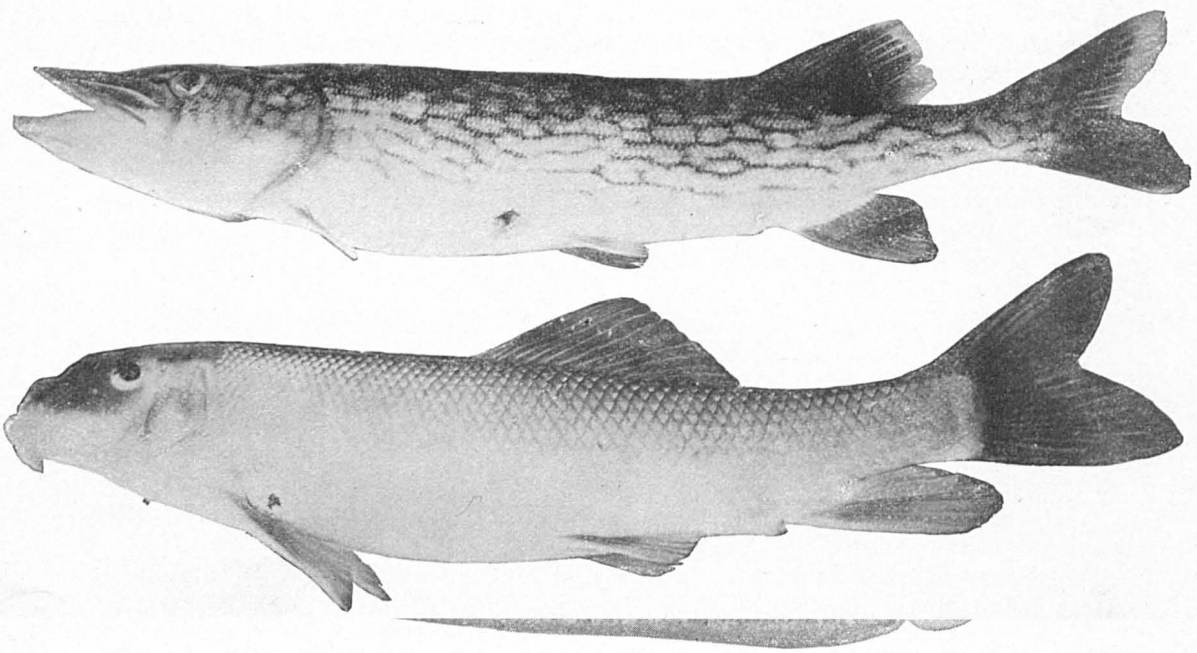
LAKE LAMPREY (*Petromyzon marinus unicolor* De Kay) FROM CAYUGA LAKE, IN WINTER. One-half natural size.



BROOK LAMPREYS (*Lampetra wilderi* Gage). Natural size.
(*a*) male, and *b*) female, taken at spawning season and photographed under water with a vertical camera.
(From Plate IV, in the Wilder Quarter Century Book, by S H. Gage)



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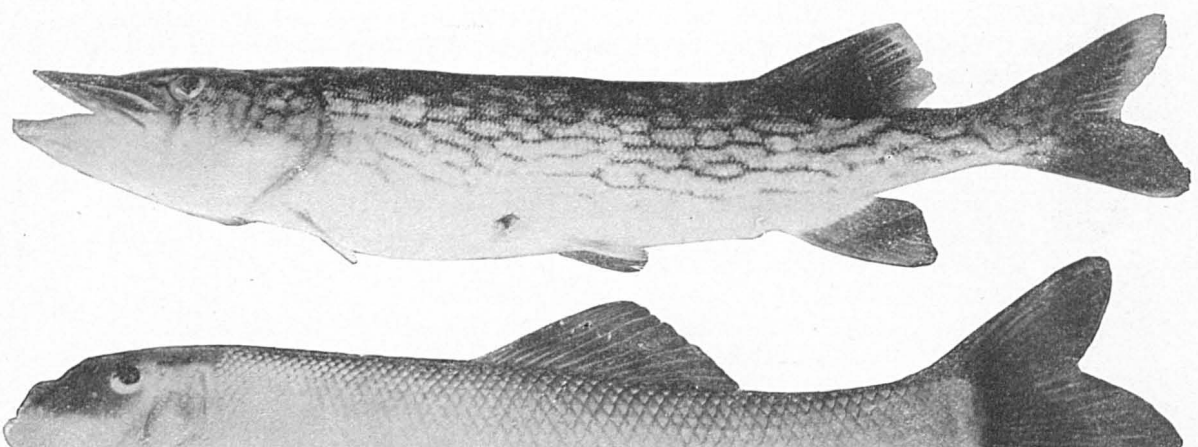


THE LAMPREYS OF CENTRAL NEW YORK.

By H. A. SURFACE, M. S.,

Fellow in Vertebrate Zoology, Cornell University.

The greatest enemy of the fish of Cayuga Lake, New York, is a fish-like animal commonly known as the lake lamprey or lamprey eel (*Petromyzon marinus unicolor*). The name lamprey eel, however, conveys an erroneous idea, as the lamprey is not an eel and resembles the eel only in general external appearance. The name lamper eel is also applied to the mutton-fish or ling (*Zoarces anguillaris*) of the Atlantic coast. It is possibly from the habits of young lampreys that the authors of our old First Readers justified themselves in the statement: "Eels live in mud." Although this animal is altogether too well known to the fishermen of this region, to most persons it is an unfamiliar object.

The generic name, *Petromyzon*, signifies a "rock sucker," because it is sometimes found clinging by its mouth to stones. The specific name *marinus* indicates the fact that its primary or normal home is the ocean; but the variety *unicolor*, of which the type is found in Cayuga, Seneca, and the other "finger lakes" of this region, is a land-locked form which has been able to adapt itself to the inland fresh-water conditions throughout the entire year. This variety, now known as the lake lamprey, has become smaller and more uniform in color (hence the varietal name, *unicolor*) than its probable ancestor, the sea or marine lamprey.

There are about 20 species of lampreys known to science, mostly inhabitants of temperate regions. Two species are found in the Cayuga Lake Basin, of which the lake lamprey is very injurious to our best fishes. The brook lamprey, *Lampetra wilderi* Gage, named in honor of Dr. B. G. Wilder, professor of vertebrate zoology in Cornell University, is much smaller than the former, is not known to be injurious to fishes, and does not occur in the lake. It receives its common name from its constant occurrence in streams. It is not known in the lake, and no reference has been found indicating that it has even been collected in any lake. In the adult state it has never been known (by us, at least) to take any kind of food, and the assumption will doubtless be confirmed that this vertebrate, like some insects, does all of its feeding in the larval stage, and remains in its mature stage or condition only long enough to reproduce its own kind. Its very long larval period (two or three years) and short adult period (a very few months) would appear to give weight to this assumption.

This species of lamprey has never been known here in the adult state except during the spring and summer months, and if it has been collected at any other time in other localities particulars of its occurrence are desired. If there is any reference to

this species attacking fish, or taking other food in the adult state, the information will be very acceptable. Professor Gage has found transforming larvæ the last of October, and full adults on the spawning-beds as early as the 26th of April. Their transformation is doubtless completed before midwinter.

Some very interesting "Notes on the spawning habits of the brook lamprey (*Petromyzon wilderi*)" have been contributed by Bashford Dean and F. B. Sumner (N. Y. Ac. Sci., vol. XVI, December 9, 1897). The authors compare their dates with recorded dates for this region, and conclude that "the spawning season of our local (New York City) lamprey is thus found to be nearly a month earlier than at Cayuga Lake," but to draw accurate conclusions dates in the same year should be compared. In 1897 the brook lamprey was found on beds here on April 30. This makes a difference of 14 days instead of 30 days between New York City and this region. These two species of lampreys are apparently identical in places of spawning, habitat of larvæ, and observed external appearances (*i. e., specific determinations in the ammocœtes stage* are impossible), but the brook lamprey spawns from one to two weeks earlier than the lake lamprey.

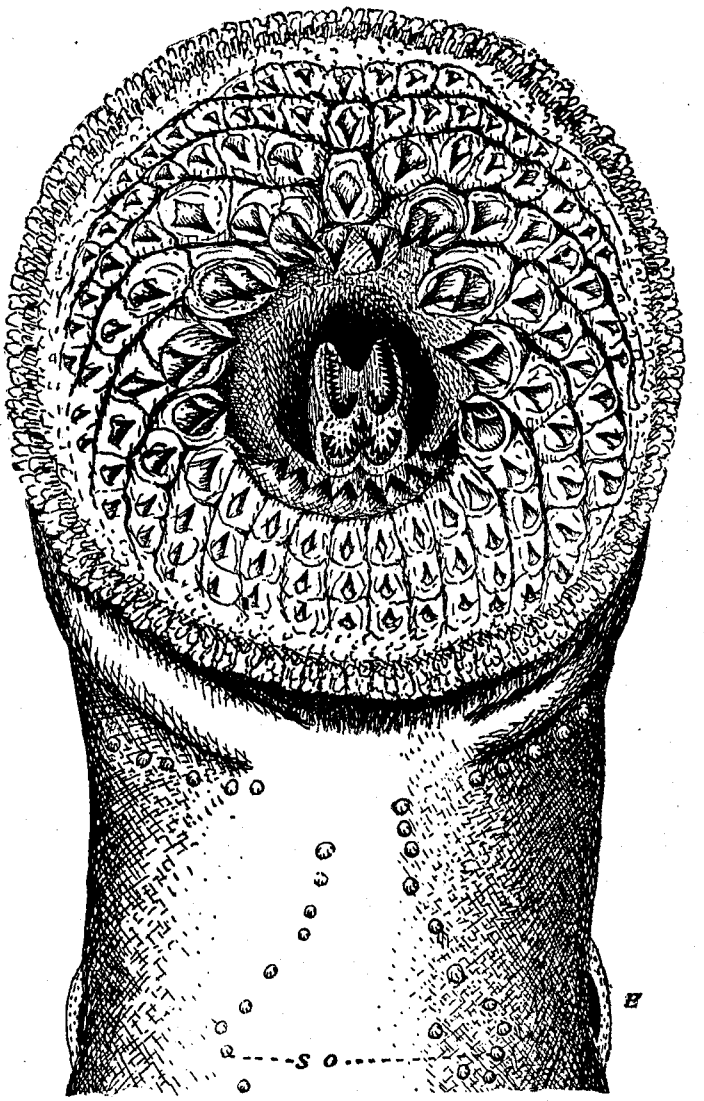
Plate 10 shows one of the lake lampreys attached to a common white sucker (*Catostomus commersonii*), which is also pierced by lamprey marks near both its ventral and pelvic fins, the body-wall being entirely cut through by these blood-suckers, and the abdominal cavity penetrated. This illustration is from a photograph of fresh specimens, under water, taken with a vertical camera, by Prof. S. H. Gage, at Cornell University. Professor Gage and Dr. Wilder have done more work with the lampreys of this region than have any other persons, and it is from Professor Gage's article on "The lake and brook lampreys of New York," in the Wilder Quarter Century Book, 1893, that much information is taken for the present paper. The other illustrations are from photographs of specimens collected in Cayuga Lake or its inlet by persons at Cornell University, and were made for the purpose of showing some special features of the habits of this enemy of our fishes.

The lamprey is similar to the frog and most other amphibians in the fact that from the young stage to the adult it passes through a metamorphosis slightly comparable with the change of a tadpole into a mature frog. Its full life-history, as determined by Professor Gage, is, briefly, as follows:

The adult passes about three years in the lake, living exclusively by sucking the blood from living fishes, most of which are good food-fish. In the springtime, about the middle of April, apparently, they start out independently from the various points of the lake, each one forsaking its prey and swimming vigorously or stealing a ride by attaching to the bottom of some boat moving in the right direction. On they go until the current of the inlet gives them the clue, and they follow it. Frequently, also, ordinary fishes bound on the same errand throng the streams, and then the lampreys, with their inherent desire to be taken care of by the labor of others, fasten to the larger fishes and are carried along up the stream. It not infrequently occurs that from the natural inclination of the stream, or from some of man's obstructions, there are rapids or dams to be surmounted. Nothing daunted, the lamprey swims up just as far as possible by a tremendous effort, grasping a stone or other object so that he can not be carried downstream again, rests for a while, and then, by a powerful bending and straightening of the serpentine body, a leap is made in the right direction, and what is gained is saved by again fastening the mouth to a fixed object.

This goes on until the obstacle is surmounted, if it is not too great. Then, without delay, the lamprey pushes on upstream, sometimes 8 or 10 kilometers, until clear water and numerous ripples are found. Just above some ripple the lamprey begins to make ready a secure place for a new generation.

The male arrives first and begins the nest building by removing and placing stones with his suctorial mouth. In a few days he is joined by a female, and together they labor away until they have made a basin, or in some cases a ditch across the bed of the stream. Now they fasten themselves with their mouths to stones at the upper edge of this basin, and their bodies swing downstream and sway in the current.



Mouth of lake lamprey (*Petromyzon marinus unicolor*). Reproduced from a drawing by Mrs. S. H. Gage. E, eye; S O, sense organs.

Many hundreds of lampreys have been actually counted on beds in the inlet in a single season by observers at Cornell University, and in 1891 Professor Gage saw there fully 1,200. In these nests the eggs, after being fertilized, sink to the bottom and adhere firmly to the sand and stones, being covered by the lampreys stirring up the sand with their tails. After some days the eggs are hatched and the young lampreys, very much like small angle-worms, burrow into the sand. At first they live in the sand at the bottom of the nests, but soon make their way to the sand along the banks of the stream. Here they remain for perhaps two years or longer, with their eyes only rudimentary and their mouths valvular, feeding on very minute organisms that live in the mud and sand.

It is said that the adult lampreys die soon after spawning, but this is not fully determined. It is also believed that some may return to the lake. When the young

are sufficiently developed they metamorphose into adults, find their way down the inlet into the lake, and begin the same kind of parasitic bloodsucking life that their parents led. Thus is the cycle of life completed for these creatures.

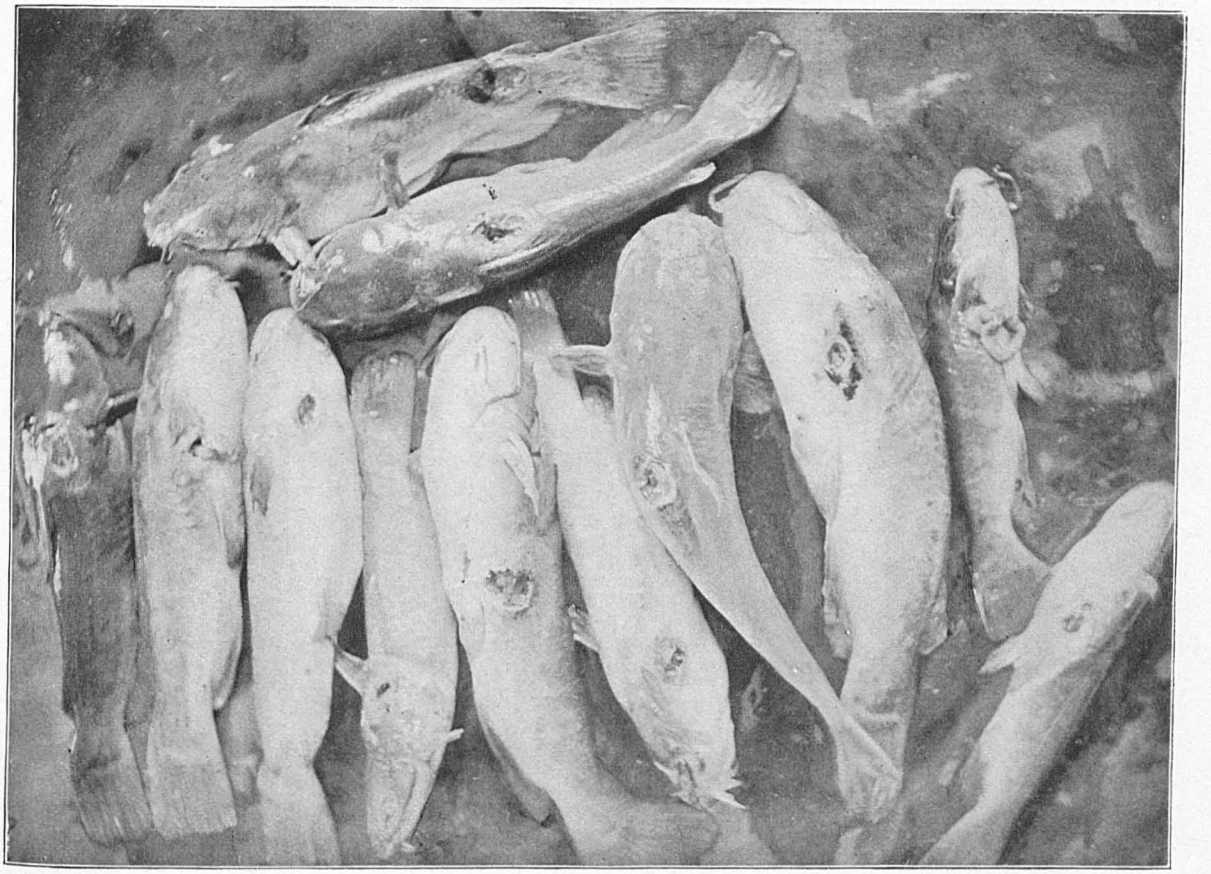
In structure and zoologic position the lampreys are the lowest vertebrates found in this region, being placed at the very foot of the list of fishes and by most recent authors they are even denied admission into the class of fishes. The class to which they belong is Marsipobranchii, or "pouch gill," because the gills form a series of pouches, seven on each side of the head. They receive their water through as many independent gill-openings.

The adult lamprey swims in the water like a fish, only with more of a wriggling or snake-like movement, but it does not have paired fins placed as in the true fishes. The only organs that it has that functionate as fins are membranous expansions on its back and on the dorsal and ventral sides of its tail.

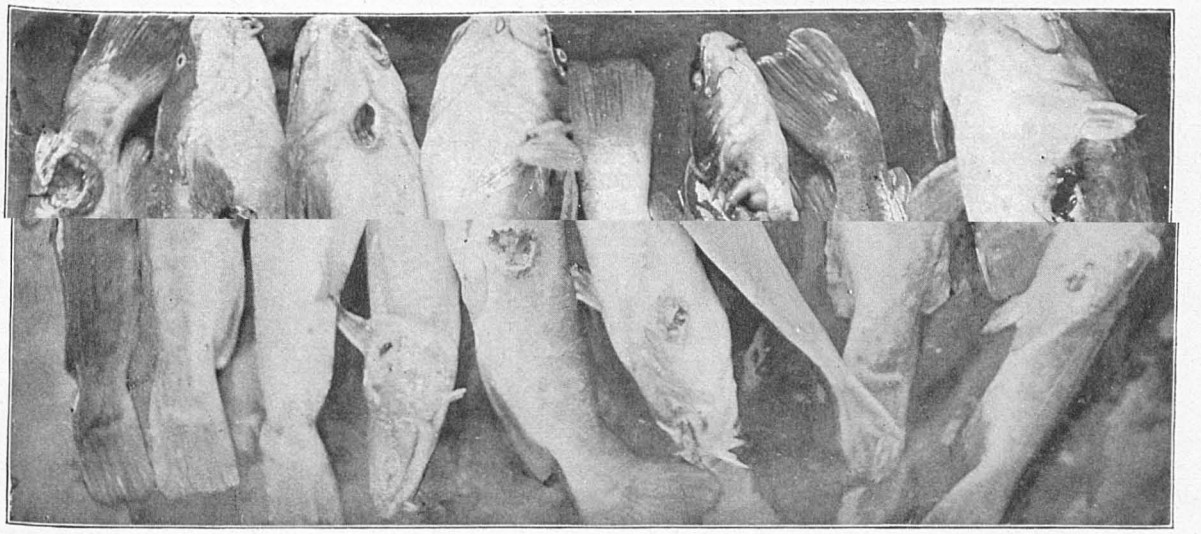
As will be seen from the figure of the mouth (p. 211), it has no jaws, but its mouth is a large circular disk, thickly studded with large, strong, chitinous spines or teeth, which enable it to more securely grasp its victim. This disk is surrounded by a softer membrane, which readily fits tightly over any surface and makes it possible for the animal to adhere quite firmly to an object by suction when the piston-like tongue in the center is drawn back. Having fastened itself by this wonderful mouth, which is larger around than its head, it rasps away with the saw-like teeth on its tongue, using nearly 150 other teeth, until it has worn through the thick skin or scales of its victim. Then it has nothing to do but to remain attached to the fish and be carried around by it, sucking blood when it is hungry, and occasionally rasping away at its raw flesh, making the hole deeper and deeper until finally the abdominal wall is completely perforated and the body cavity penetrated. Often the intestines or other organs of the fish are attacked and cut to pieces, but more frequently the lamprey fastens itself at another place if its victim has any blood left, or if not it seeks another fish.

The intestines protruding and the blood escaping from the deserted wound, in a great many cases sooner or later cause the death of the fish, which are often seen swimming in the lake in the miserable condition just described. The injured fish does not always die, but in every case it is seriously weakened and reduced in flesh and blood, and in the power of fully reproducing its kind. Among some specimens recently collected for study here was a bullhead or horned-pout (*Ameiurus nebulosus*) that had been so severely attacked by a lamprey that its stomach protruded through the hole in the side. This fish was kept alive in a tank (for the purpose of observing its condition) for three weeks.

Last spring (1897), when using a collecting seine under the permission and direction of the New York Fisheries, Game, and Forest Commission, the writer found by actual experiment that it was easy to distinguish the bullheads that had been attacked by lampreys, even when they were purposely turned over so that the holes were not visible. The injured fish loses entirely its rich golden hue, and, assuming a sickly appearance, grows paler and weaker. It is not at all uncommon to find dead fish along the shores of Cayuga Lake, and upon examination the marks of the lamprey may be seen. Among such fish recently found are the bullhead or catfish (*Ameiurus nebulosus*), suckers (*Catostomus*), carp (*Cyprinus carpio*), lake herring (*Argyrosomus artedi*), and pickerel (*Lucius reticulatus*). Other species of food-fish are also injured. It is a serious enemy of the sturgeon (*Acipenser rubicundus*), one of which was caught in



A DOZEN CATFISH (*Ameiurus nebulosus*) FATALLY ATTACKED BY LAKE LAMPREY (*Petromyzon marinus unicolor*).
Collected and photographed by H. A. Surface.



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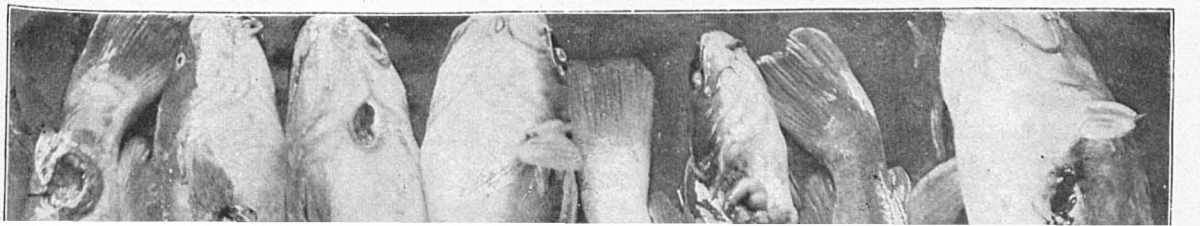

Cayuga Lake with six lampreys on it. A local fisherman claims to have captured a very large sturgeon which had 21 lampreys attached to it.

In addition to the above list other valuable fish which have been attacked are the whitefish, pike, muskellunge, bass, perch, lake trout, wall-eyed pike, redhorse or mullets (*Moxostoma macrolepidotum* and *M. aureolum*), the eel (*Anguilla chrysypa*), drum (*Aplodinotus grunniens*), white bass (*Roccus chrysops*), and others. In fact, of the 74 species of fish found in Cayuga Lake basin, none is known to be free from its attacks except those too small for its attachment and support. · Several injured specimens of the bowfin, mudfish or dogfish (*Amia calva*) have been seen; even the heavy-scaled ganoid, the gar pike or billfish (*Lepisosteus osseus*), is sometimes attacked. Fine specimens of lake trout (*Cristivomer namaycush*) with as many as five wounds on one fish have been found. With smaller fishes one attack sometimes proves fatal; often, however, the fish may survive the first attack and fall a victim to the second or even third. Only a fish of considerable size and vitality can survive five or more wounds without intervals for recuperation.

The records kept in field work here show that lampreys are much more injurious, or a much greater percentage of fishes are injured in the early spring (February and March) than at any other time. This season of feasting may be to strengthen them for the long period of fasting and spawning, for it is shown that they not only refuse to feed during the spawning season, but owing to the atrophy of the alimentary canal they are entirely incapacitated for taking food.

Professor Gage has estimated that the lamprey annually does as much in reducing the available food-fish in this lake as all the work of the fishermen combined. He has also shown that of the bullheads captured in the lake 12 out of every 15 have been attacked by the lamprey. From careful observations made within the past year, the writer is prepared to confirm and emphasize both of the above statements.

The attacks on the bullhead or catfish alone are of great importance. It is safe to say that hundreds of barrels (probably about 500,000 pounds) of these are placed annually upon the markets in the State of New York. In most cases they are dressed. No wonder! Who wants to buy or eat fish with great festering sores or ulcers visible? And yet the bullheads are excellent food-fish. That their value is recognized by experts is attested by the fact that last year the State Fish Commission of New York furnished the State Fish Commission of Ohio with 1,200 of them for stocking certain streams in the latter State.

From every economical standpoint it would appear to be advantageous to rid the world entirely of the lampreys. It would certainly be greatly to the advantage of the fisheries of the State of New York if all were destroyed. Naturally, however, the student of biology must mourn the loss of a form so interesting and so instructive. The questions naturally arise: "How can the fish be protected from the lampreys; and is it possible to remove the lampreys from our lakes? Thanks to the service science has rendered by the twenty-five years' study of this subject by Dr. Wilder and Professor Gage, the modus operandi becomes comparatively simple, as shown by the following quotations from the latter's paper.

> It will be seen that it [the lamprey] has one very vulnerable point, viz, leaving the lake and running up the tributaries to spawn. This seems to be the only point at which the lamprey can be attacked, and the hope of exterminating it is rendered still stronger from the fact that in Cayuga and Seneca lakes, so far as explored (during several seasons), the lampreys run up the inlet at the head of the lake only, and do not spawn in the tributaries entering the lake at intervals on each side.

Lampreys must be destroyed before spawning if they are to be exterminated. Nothing would be easier than to do this. A dam with a fishway—the fishway leading into an isolated inclosure—where the lampreys could be easily removed and disposed of, or a weir of some kind, could be constructed at slight expense. If this could be continued for three or four years in all the lakes and in the Oswego River, the race could be extinguished and the lakes wholly freed from their devastations.

In the diagram A represents perpendicular posts set in the stream and fastened, for the purpose of catching floating material that might otherwise tear or injure the weir below. B represents net wings for the capture of creatures running down the stream. C represents the main or chief net placed entirely across the stream to prevent passage either way. At D is the pocket or pen in which the fish coming up the stream will ultimately be found, being guided by the various wings of netting or wire E and F.

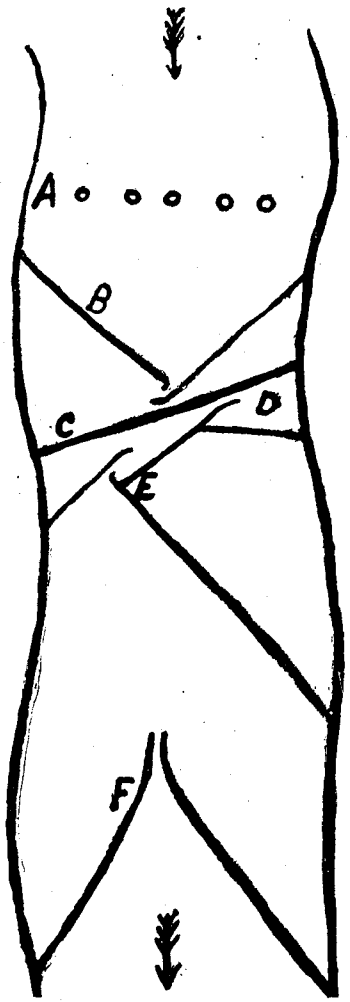

Diagram of weir for catching lampreys as they run up the stream to spawn. (Arrow indicates direction of current.)

It can be seen that if a weir for this purpose were established in the inlet of Cayuga Lake, not only would it do a great deal of good in removing the lampreys, but what is much more, it would give some vastly important absolute facts to the State authorities upon which they may be able to definitely base plans and calculations for more extensive operations at other lakes for another year. Also, one can scarcely estimate what a valuable amount of scientific information would be gained concerning our anadromous fishes as they run up the stream to spawn and return to the lake again. Important investigations could here very easily be made, and many valuable facts could be gained by such investigations properly conducted. Until trained investigators give our legislators many facts not now known, laws that will prove effectual in the protection and maintenance of fish or game can not be enacted.

For example, the laws for the protection of fish are in most cases based upon their spawning habits, and this is of course right; but no one can give or find correct answers to the following questions for even one-fourth of the number of kinds of fish found here:

Just when do they commence to spawn, and when is the spawning completed? How long before spawning do they run up the streams, and how long after do they return to the lake or sea? Just what species find it necessary to run up the streams for spawning, and what remain in the lake? What is their food, and what their enemies and diseases at this most important time in the life of the fish? What is their modification in structure, or condition of all organs, and their food before, after, and during spawning? In what numbers do they run up the streams, and what proportions are males or females? What kind of nest do they build, and do both sexes take part in its construction? Which sex cares for the eggs, and which for the young, and how? And, how long do the young need or receive parental protection?

All of these questions and many others that could be asked are of great importance, but can never be answered except through some such careful investigations as

can be made in connection with the proposed weir, the diagram of which is given. The plans have been very carefully made, and meet the hearty approval of the State fish, game, and forest commissioners. It has been placed in the inlet above the limit of navigation and below the lowest place where the lampreys spawn. Two watchmen are employed to alternate in watching this weir constantly, day and night, during the "running" season, and, empowered as deputy sheriffs, the watchmen will be able to arrest any trespassers who might otherwise seriously interfere with the success of the experiment.

A specialist from Cornell University visits the weir every morning and evening at regular intervals, and with a shallow dip net removes the lampreys and helps over the good fish and lets them go on their way. A strict count and record is made of the kinds seen and of the number of each, their condition, development, habits, and such other points as are of economic or scientific interest and help to give correct answers to the questions above asked. By conscientiously performing this work it is also possible to determine what percentage of each species migrates in the daytime and what at night.

President B. H. Davis, of the Fisheries, Game, and Forest Commission, conferred with Senator Stewart on this subject, and the latter, at the request of the former and several other interested persons, introduced a bill, as an item in the general supply bill, for $500 for this work. Last year our legislators passed a bill appropriating $1,500 for the removal of the billfish or gar pike from Black and Chautauqua lakes; and here in Cayuga Lake, the largest of the interior lakes of the State, the lamprey is fully one hundred times as injurious to the fishing industry as is the billfish, and the amount asked for and granted is only one-third of last year's specific appropriation. The appropriation was made without dissent, and the New York State fish-culturist, Hon. A. N. Cheney, now has general charge of the affair. The special investigations and experiments are to be made by the writer and the results published by the Fisheries, Game, and Forest Commission of the State of New York.

Many eminent scientists and other persons have written, expressing interest in this subject and the possible results of this experiment.

ITHACA, NEW YORK.

ADDENDUM.

APRIL 25, 1898.

At this date the weir for removing lampreys from the inlet of Cayuga Lake is constructed and in successful operation. Although it is too early in the year for any results with the lake lamprey (*Petromyzon marinus unicolor*), some interesting facts have already been obtained concerning the brook lamprey (*Lampetra wilderi*). On April 9, the first day the weir was in working order, one adult male of this species was found in it, and on the 11th two others. On the 16th it contained several adult males and females; on the 20th one male and two females, and on the 22d two more females. These were striving to swim up the stream, presumably to regain the places from which they had doubtless been washed during the past year as larvæ in the sand, since their spawning-beds are all above this. In a tank at Cornell University several specimens taken from the sand six weeks ago have not only transformed into adults, but the reproductive organs of both sexes have matured, and one female was spawning when she died. This was without having taken food, and we are still further led to believe that adults of the brook lamprey are not parasitic, and, indeed, take no food at all.

H. A. SURFACE.