Eels in Water Pipes and Their Migration.—By Watson L. Bishop, Superintendent of the Dartmouth Water Works, Halifax Co., Nova Scotia.

(Read 9th. April, 1906.)

The early history of the eel (*Anguilla vulgaris*) is involved in mystery. No other common fish has so completely baffled scientific investigators. The Greek poets jocosely remarked "that since all children whose paternity was doubtful were ascribed to Jupiter, he must be considered the progenitor of the eel." Aristotle emphatically stated that eels are spontaneously produced from the mud and moist earth. About sixty years ago, Martens, a famous naturalist stated, "Among all the animals that surround us, the eel is the only one which has never unveiled the secret of its propagation, even to the most perservering investigators." From that time to the present the most persistent efforts have been made to solve the mystery of the sexual characteristics of this fish and its reproduction.

In 1896, G. B. Grassi, a professor in Rome, after four years devoted exclusively to the study of this fish, and years of previous inquiry, communicated a paper to the Royal Society of London, which practically solved this mystery. He established the fact that the eel reproduced itself only in very deep water, at least 1500 feet in depth; that the eggs deposited, float there in these great depths; that the young when hatched take a form not recognized previously as the young of the eel, but described under the name *Leptocephalus brevirostris,* which proves to be its larval form; that this fish passes through a metamorphosis in a few weeks, and then becomes the eel known to all when about two inches in length; that in a very short time it seeks the fresh water to acquire sexual maturity and go on with the work of reproduction; that the parent eel then dies, and

therefore the mature eel never returns again to the fresh water. He also shows with others, that the female eel grows to a much greater size than the male eel, while the latter rarely exceeds a foot or fourteen inches in length, although the female frequently attains a length of six feet, and a weight of from twelve to fifteen pounds.

The fact that the eel has to seek such great depths in the open ocean in order to become sexually developed, and has to remove itself far from the usual haunts of man, and the further facts that special ships and apparatus had to be fitted out for its capture, and that but very few localities on the globe are available for the study of the mature fish and its young, were the causes which prevented scientists from learning sooner the secrets of its life history.

As there is still a great deal left to be learned, from the fact that this fish is noctural and secretive in its habit, I thought it might be of some interest to place before you the result of some investigations I have made during the past few years regarding its habits.

Since the water system was installed in Dartmouth in 1892, until 1904, eels caused considerable trouble by getting into the main pipe at the intake, and thence finding their way through the mains to the service pipes in the town, and plugging them up. The lakes from which we draw our supply are about eight miles from the sea by following the stream. This stream passes through other small lakes before reaching the salt water.

The time of year when eels gave us most trouble was during the months of September and October. At this season men were constantly employed in digging up the service pipes to take out these obstructions. It almost invariably happened that the services which were troubled most by them were the ones having leaky fixtures. The eel imprisoned in the pipes would be constantly feeling for any current whereby it might escape, and would thus get into the services. Digging up so many pipes being so expensive, and also damaging to a well finished

street surface, as well as being annoying to householders, I eventually discovered a plan which proved more satisfactory and economical. I found that by attaching a strong pump to the service pipe into the house, by means of which the eel could be easily forced back into the main, (which we frequently did against a pressure of 90 pounds), the eel being dead, or nearly so, was easily carried along with the current and taken out of a hydrant opened for this purpose. It was sometimes necessary to shut a valve to divert the flow of water in the direction of the hydrant.

During the above-mentioned migatory season, there had been no water going over the waste weir. The only water going from the lakes was by way of the water pipes. From the above facts, and from noting that after heavy rains occurred, many eels would be taken from the water pipes, I came to the conclusion that at such times they must gather about the intake in great numbers, trying to follow the current of the water to reach the sea.

The water enters the screen-chamber through an opening two feet wide by nine feet deep. In this opening three screens were placed one above the other. In the bottom screen, which is two by three feet, I cut in the centre a hole sixteen inches in diameter and fitted to it a funnel-shaped intake of screen cloth, 8 by 8 mesh, No. 16 wire, leaving a circular opening of one and a half inches to admit eels. I then boxed off the back of the screen with the same material. It can be readily seen that eels trying to follow the flow of water would easily find their way into this trap, from which there is no escape except through the small funnel opening by which they came in. The peculiar construction of this trap makes this opening very difficult to find from the inside; therefore, eels one in, remain there until they are taken out.

The trap was put in position on the 29th of April, 1904, and on May 6th eighty-nine eels were found in it. Three were about one foot long, the remaining eight-six were small, from

four to eight inches in length, the average length being 5.96 inches.

May 13th, forty-four were taken. The four largest were about one foot, while the remainder were small, similar to the ones taken the week before.

May 30th, sixty-one were caught. Two of these were large, being about eighteen inches long, the others were small like the ones previously taken.

June 17th, twelve were caught; seven of which were small, and five quite large.

June 29th, the trap was empty.

July 19th, thirty-six were in the trap. Two were small, the others quite large.

August 5th, twenty-three were caught, measuring from twelve to eighteen inches in length.

August 19th, fifty-one were caught; all were the size of those taken from the service pipes, about one foot long.

August 26th, three hundred and eight eels were found in the trap, ranging in length from twelve to fourteen inches, except two which were much larger. By referring to the precipitation of that year it will be seen that on the 21st the rainfall was 2.44 inches, and on the 23rd 0.43 of an inch.

September	2nd,	11	were taken.
"	8th,	23	" "
"	16th,	41	" "
"	23rd,	2	" "
October	5th,	22	" "
"	14th,	46	" "
"	21st,	0	" "
"	28th,	2	" "

The trap was then taken out, the migratory season being over, with a total catch of seven hundred and eighty.

After the large catch on August 26th, as shown by the above data, few had found their way into the trap for several days.

It is likely, therefore, that nearly all the eels in the vicinity of the trap were caught, and that they were scarce about the gate-house until the few which were not in the first run had found their way to the intake. It has also been shown that nearly all the eels taken in the early spring were small, probably one year old, and during their earlier life had remained in the lakes nearer the sea.

The lakes in question being so far from the sea, and the outlet from them passing through other lakes in its course, it does not appear necessary that they should make the entire journey the first year.

What confirms me in this belief is, that several years ago I saw during the spring, at the head of the tide waters of the Cornwallis river, in King's County, N. S., many thousands of small eels working their way up the stream in the shallow water at each side of the river. These were certainly not more than two and a half to three inches long. To form an idea of the great numbers passing along I judged that there was one hundred or perhaps more in a space of two feet.

This stream of eels was continuous without a break as far as they could be seen each way. It can readily be seen that vast quantities were finding their way to the spacious still waters in the meadows about half a mile further up the stream. Unfortunately, I cannot give the exact date on which this observation was made.

I am of the opinion that the first catches in the spring, which were nearly all of small size, had just reached the lake by way of the stream, and being naturally somewhat tired, had settled in the deep water to rest, and had thus found their way into the trap at the intake which was only about one hundred feet from where they entered the lake. A subsequent experiment, which is explained later, proved the foregoing assumption to be correct.

On April 19th, 1905, the eel trap was again put in place in the gate-house, and when visited on May 9th it contained one

hundred and twenty-three small eels, the same size as the ones taken in the early spring of the previous year. On this date, May 9th, I also put a trap in the overflow with the opening facing down stream to intercept eels that might be coming up into the lake.

May 17th this trap was examined and found to contain eighty-nine small eels, thirteen small trout, one small sucker, and one minnow. On the same date only eighteen small eels were taken from the trap in the gate-house.

June 1st sixty-six small eels, ten small trout, and four suckers were taken from the trap in the overflow, and only 9 small eels were in the trap in the gate-house. This proves in two ways that my theory was correct, and that the small eels taken in the early spring of 1904 had just reached the lake. A confirmation is found in the fact that while the two traps were in use, the trap in the stream stopped nearly all that were going into the lake, so that there were only a few to get into the trap in the gate-house.

The trap in the overflow stream was taken out June 1st, 1905.

June 9th, six eels were in the trap in the gate-house;

June	24th,	2	were	taken.	Oct.	6th,	5	were	taken.
July	1st,	2	"	"	"	12th,	0	"	"
"	14th,	1	was	"	"	21st,	23	"	"
"	24th,	14	were	"	"	28th,	4	"	"
"	29th,	0	"	"	Nov.	4th,	6	"	"
Aug.	5th,	5	"	"	"	10th,	0	"	"
"	15th,	22	"	"	"	18th,	7	"	"
"	24th,	9	"	"	"	25th,	0	"	"
Sept.	1st,	9	"	"	"	30th,	3	"	"
"	7th,	50	"	"	Dec.	7th,	1	was	"
"	19th,	19	"	"	"	18th,	0	were	"
"	26th,	12	"	"					

On December 27th no eels were found and I took the trap out, the lake being then frozen over. The trap was kept in

several week later than the previous year. The autumn (the migratory season for eels) being unusually dry, they did not seem to be moving as in the previous year. The trap was therefore kept in to find whether they would migrate when sufficient rain had fallen to raise the lakes and streams. The rain held off, however, until about the middle of November, and it was then so late there was no noticeable movement of the eels.

Many water-works men have held that the way eels get into the water pipes is by getting through the screens when very small, and that they live in the pipes until they are about a foot long and then they find their way into the services. I cannot credit this, as they would then be giving trouble all the year round, and would not get in the pipes periodically as they now do. It has also been pointed out that if an overhanging dam were put across the stream the small eels could not reach the lake, and in a few years there would be no small eels in the lakes to get in the water pipes. This idea seems quite reasonable, but I do not think it complete enough to be entirely successful. I think the ends of the dam should be arranged so as to prevent eels passing around the end of the dam on the land, and thus reaching the stream above.

That eels are well able to pass around or over a dam, there can be no doubt. I tried an experiment with one lot taken from the trap with the following results: They were put in a box without water, and kept in a room where the temperature was fifty-six degrees (Farenheit), and at the end of twenty-seven hours two were put in water and soon became lively, and appeared as well as though they had never been taken from the lake. The others appeared to be in about the same condition. The largest one lived forty-three hours. Other experiments tried later in the summer proved that eels fifteen to eighteen inches long, will live longer than small ones. In one case I had one to live out of water for seventy-two hours.

Judging from these facts, these fish can leave the water in the night while the grass is wet with dew or rain, and remain

out of water for several hours without any inconvenience. As they can move through wet grass very readily, it is therefore evident that they can travel overland for considerable distances should occasion require it.

What would likely be the most effectual way to prevent them from getting into the lakes, would be to put lime in the stream every evening, commencing in the spring as soon as the stream is free from ice, and continuing until the migratory season is over. It is a well known fact that eels have a great dislike for lime, and it is not at all likely they would enter a stream where the water was charged with it. Lime is often used in earth dams to prevent eels from boring through and thus causing leaks or washouts.

I expect to continue catching eels both at the intake and in the overflow stream, to determine whether their numbers will be lessened in the lake, and if by taking the small ones on their way to the lake, it will decrease their numbers returning to the sea in the autumn.

Since the trap has been in use, there have only been two or three eels taken from the service pipes each year; whereas, in former years, from thirty to fifty were taken out of the water pipes each autumn during the downward migratory season. This proves conclusively that the work for which it was intended, that is, to catch the eels at the intake and thus prevent them from entering the water-mains, has been successfully accomplished by the trap.

In conclusion, I find that this troublesome fish goes up streams in the spring months in large numbers, and that during the autumn the mature fish returns to the sea. During the summer months a few are caught in the trap, but I attribute this to accident instead of migration. The eels are simply feeding around or looking for a dark spot in which to hide during the day, and thus get entrapped.

That they can be effectually stopped from getting into the service pipes is certain if sufficient care is taken.

Whether or not the quality of the water will be affected adversely by keeping all the eels out of the lake is to me an open question. The eel is well known to be a great scavenger ; but on this subject I have not secured sufficient data to form an opinion.

Discussion.

F. W. W. DOANE.—The eel nuisance has been a most perplexing problem for every superintendent of a water system. It is at times very difficult to account for their presence in pipes. There is no doubt in the mind of the writer that eels will climb over a screen projecting from eighteen inches to two feet above the water. Traces of eels have been noted on the top of the screens in the gate-houses, and on one occasion an eel was caught in an effort to surmount the obstructing screens. The carelessness of a gate-keeper sometimes permits their entrance through a small hole worn or torn in the screen or where the corner of the screen frame unprotected by metal has become worn. In the Halifax screen chambers there are two sets of grooves for screens separated only by a thin angle-iron. It was suspected that eels got in while the screens were being changed, consequently a batten was placed on the back of the lower front screen at the bottom edge so that the space between the two sets of screens was completely filled. By always putting in the new screens before removing the old set, there is no opportunity for eels to get between them.

Anguilla vulgaris is supposed to be long lived, one authentic instance being recorded of an eel which was at least thirty-one years old.

There is no doubt of the ability of eels to travel over land. On more than one occasion Halifax water department officials have seen them, when thrown out of a trench or stream (near the lakes), start for the lake.

When migrating, no ordinary obstacle seems to stop them. It is claimed that they have been known to cross from one water to another by ascending a branch of a tree hanging in the water

and dropping on the other side. They have been known to climb steep ascents also.

It is probable that the migration down stream is made at night, dark nights being chosen, and moonlight being sufficient to stop them. The young eels going up in the spring travel by day.

It is claimed that eels are peculiarly averse to cold, and that the temperature of the brackish water of estuaries is always higher than that of unmixed salt or fresh water. Eels bury themselves in winter a foot or more in the mud near the outlet of a stream, and are taken with a spear. It is uncertain whether such eels spend the summer in salt or fresh water. To the ordinary observer there is little difference in appearance between the eels taken during the summer in salt water and those taken from the lakes.

On one occasion eels filled a main on Granville Street, Halifax, so completely that when the pipe was cut it became necessary to make an auger to bore the pipe out.

The result of Mr. Bishop's study and experiments is most interesting, and further work will add equally valuable information. A better acquaintance with the habits of eels will be the means of saving much money and annoyance, and may enable superintendents to prevent entirely the entrance of eels to the pipes of water systems.

R. H. Brown.—At Sydney Mines, Cape Breton, some years ago, we made a reservoir by closing the culvert in an embankment on the colliery railway. The dry valley thus closed was converted into a lake of a few acres in extent and some ten feet deep at the middle. Its source of water supply was the drainage of the fields on the surrounding slopes, and its only outlet was by pipes of four inches diameter and about two thousand seven hundred yards in length, which conducted the water from this reservoir to the colliery engines at the Princess pits. After a few years eels were found in the pipes obstructing the flow of

water. The eels taken out were of usually good ordinary size; but on one occasion when we found the water completely stopped at a certain point, we had to break a pipe there, and found in it a living eel of about four inches in diameter (the full size of the pipe) and between three feet six inches and four feet long. The eels had no possible waterway by which to get into our reservoir, but must have travelled overland for about half a mile from a brook that runs into the Big pond. The Big pond, in which eels were plentiful, was a salt-water lake, having connection with the sea by a channel through a sand bar. These eels on their way had to pass over the railway embankment, above mentioned.

The eels in Cape Breton do not seem to migrate; they are seen in abundance, both in summer and in winter, in all the lagoons and estuaries around the coast and in the Bras d'Or lake. In summer they move about among the long eel-grass looking for food, and in winter they lie dormant in the mud in the same localities.

I once in July was watching a large shoal of smelts entering the barrasois at Indian brook, near St. Ann's, C. B., and noticed a number of large eels passing along among them. At frequent intervals an eel would be seen to turn quickly and bite a smelt; the latter at once turned on its side and floated helplessly down the channel followed by the eel, who, I presume, devoured it at his leisure.