AUTUMN AND WINTER.

Sea salmon, (*Salmo salar.*)
Brook trout, (*Salmo fontinalis.*)
Lake trout, (*Salmo confinis,* &c.)
Lake white fish, (*Ceregonus albus,* &c.)

SPRING AND SUMMER.

Pickerel, (*Esox reticulatus.*)
Mascalonge, (*Esox estor.*)
Perch, (*Perca flavescens.*)
Pike-perch, &c., (*Lucioperca Americana.*)
Striped bass, (*Labrax lineatus.*)
Black bass, (*Grystes nigricans,* &c.)
Rock bass, &c., (*Centrarchus œneus.*)
Shad, (*Alosa præstabilis.*)

The number of eggs deposited by a single salmon in one season has been estimated at from ten thousand to twenty-five thousand; by the perch, two hundred thousand; the pike, one hundred thousand. Of these, it is supposed that at least three quarters fail to become productive, being devoured by other fishes, washed down and buried in the mud by freshets, and exposed to many other casualties. Countless millions of the young also are destroyed before they become capable of propagating their species, and still greater numbers of the ova are never deposited at all, being destroyed while yet immotive, in the body of the parent fish, which, in most cases, is most readily captured at the season when it seeks its spawning grounds. The object of artificial breeding, then, is to secure the spawn of valuable fishes against the operation of these untoward contingencies, to place it in those conditions where a larger comparative proportion may become productive, and to preserve the young fishes from the dangers which surround them in their natural element.

The processes of artificial breeding are simple and easy, but, at some stages, they require care and experience. The mode of impregnating the eggs is readily learned, with a little practice. The female fish is taken at a time when the spawn is mature, and is held over a shallow vessel containing a quart or so of pure water. A very slight pressure along the abdomen will cause the eggs, if sufficiently mature, to fall into the water. If they do not come away readily, the indication is that they are not yet mature, and the fish should be preserved for a few days, when the trial may be repeated. The object is to procure the eggs in the exact state when they will most readily receive the fecundating influence of the milt of the male fish. This must be judged of by experience. After the female fish has been thus treated, the milt is obtained from the male in the same manner. If mature, the milt will flow readily from the fish, and will give the water a whitish and turbid appearance. The water should be slightly agitated—as well by the tail of the male fish as in any other way—while

the emission of the milt is taking place, so as to insure the thorough contact of the two elements. A little practice will enable the operator to perform this manipulation without injury to the fishes, which, after their supply of eggs and milt is exhausted, may be replaced in the pond or stream from which they were taken, and thus reserved for breeding a second year. The milt from a single male will be found sufficient to impregnate the ova of numerous females, but the mixture of it with the eggs must be effected as soon as possible after their extension.

The eggs, after being thus impregnated, are placed in hatching boxes prepared to receive them. These may be constructed in several different methods. Those used by Jacobi were wooden troughs, with a wire grating at either end, to keep out destructive fishes and insects, the bottom being covered with a layer of gravel. The eggs were strewed on the gravel, care being taken to place them so as not to lie in heaps, and the water of a running stream was conducted through the gratings. The apparatus of Gehin and Rémy consisted of a tin box, the cover and sides being pierced with holes to admit the water, and the bottom in like manner covered with gravel. The box and its contents were placed in the bed of a stream. The French savans have invented several improvements in the hatching apparatus, one of the best of which is said to be the use of willow or fine wire gratings, on which the eggs are placed, and which are suspended in the water by means of sliding rods, thus dispensing entirely with the gravel bottom, and retaining the eggs in a position where they can be more readily examined, and are not so liable to be injured by being piled together by the flow of water.

During incubation the eggs should be inspected daily, and those which prove to be unimpregnated removed. These are readily distinguished from the others by their greater opacity, and, if allowed to remain in contact with the rest, would soon spoil them. There is also a minute species of parasitic mildew, which is very injurious to the eggs, and difficult to exclude, as its spores are deposited with the sediment of the water. In order to prevent its ravages as far as possible, the eggs should be daily cleansed, and the sediment prevented from settling on them by means of a soft hair pencil. Where it is practicable to do so, it is recommended to filter the water, in order to obviate this difficulty.

It is not possible, within the limits of this paper, to give particular directions as to the construction of hatching apparatus. The ingenuity of almost any country gentleman or farmer will point out to him some contrivance which will fulfill the conditions necessary for the purpose. A constant stream of pure water bathing the eggs is all that is necessary, in addition to the other precautions mentioned.

The progressive development of the embryo, as watched from day to day under the microscope, becomes very interesting, and is fully described in the works which will be hereafter mentioned.

After the young fishes are hatched, they should be removed to a larger receptacle; they need little care, however, until the yolk-sac is exhausted, and they begin to require food. This may be supplied in the form of finely-comminuted flesh or fish, the fibres of which have

been separated by boiling. Care should be taken not to place so much of this in the box in which the young fish are kept as to corrupt the water.

Well cared for, young trout will attain the length of about three inches the first year. They should then be turned into a pond, and allowed to provide for themselves. It would be well, however, to have for this purpose two or three separate ponds, to contain the broods of each successive year. This precaution is required in consequence of the predatory nature of these fishes, and the liability of the younger to be devoured by the older. Some other species of fish, of a smaller and inferior kind, may, with advantage, be placed and permitted to breed in the pond, for the purpose of supplying food to the trout.

In a region where trout are abundant, of course much of the trouble of artificial breeding may be dispensed with, provided a pond can be constructed by damming the course of a stream already populated by them. They may then be left to their natural instinct, and, if the stream affords suitable spawning places, they will maintain the supply of young needed each year, with no further care. But it is absolutely necessary, for the reproduction of trout, that their eggs should be deposited, during incubation, in running water, highly aerated; and hence it is that they will never increase in number while confined to the still waters of a pond. They will neither grow well nor become of good flavor in water rendered turbid by vegetable matter, nor where the bottom is muddy. Clear, cool, spring water, resting on a sandy and gravelly bottom, is indispensable to the full development of their good qualities. In constructing a pond for the reception of this most valuable and beautiful of all fishes, these conditions should be recollected.

After the ova of fishes have been fecundated, they may be transported to considerable distances, provided they be kept moist and cool. The simplest method is to pack them in alternate layers (taking care that the eggs do not touch each other) with fine sand, shaggy woolen clothes, or aquatic plants, in small boxes. The boxes for this purpose may be six or eight inches square by three or four deep, and care should be taken that the contents be thoroughly moistened before they are closed. The eggs of the lake trout, the lake white-fish, and the pike-perch have thus been brought from Ohio and Lake Ontario to Connecticut, in perfect condition. Indeed, eggs of the salmon and trout thus packed will retain their capacity of development for several weeks. The eggs of those fishes which spawn in summer, however, would not probably bear transportation so easily, but would be much more likely to prove unproductive, after being carried long distances. Care must be taken to admit water gradually to the eggs thus procured, especially if they have been for several days on their journey they are liable to be spoiled by too rapid absorption of fluid.

The introduction of fishes peculiar to one country, or to one section of a country, into distant waters, is by this means readily effected, suitable breeding places being provided in advance for the reception of the ova.

The most extensive and important operation of this kind yet undertaken in this country has been attempted for the purpose of introducing

some of the fishes of the great lakes into waters which they did not previously inhabit. A brief account of the measures taken for this purpose, and which are believed to have resulted in at least partial success, will not be out of place here.

Saltonstall lake is a very beautiful body of water, almost three miles in length, situated a few miles from the city of New Haven, Connecticut. It was selected as the locality of the intended experiments, because, in position, size, quality of water and of shores, and in all other respects, it was believed to combine the conditions most favorable to success. Like most of the New England lakes of its class, it was already populated with pickerel, perch, eels, and other common species. In the spring of 1857, an act was passed by the legislature of Connecticut affording ample protection to the enterprise, and the gentlemen concerned also procured from the riparian proprietors grants of their fishing rights in the lake, so that they thus acquired complete control of its waters. A small, but constantly flowing stream, one of the feeders of the lake, was prepared for the reception of the ova, by forming it into a series of shallow pools, and strewing the bed with a layer of clean gravel and small stones. The intention, in this case, was to procure so large a quantity of ova as to be able to allow them to run the hazard of being hatched in the open stream.

The lake trout (*Salmo confinis*) and the white-fish (*Ceregonus albus*) were the species chosen as those most likely to become readily acclimated, and as otherwise most valuable to the breeder. In November of the same year the first supply of the eggs of these species was procured at a fishing station on Lake Ontario; the trout and white-fish being taken alive from the fishermen's nets, and the ova artificially fecundated on the spot, in the manner heretofore described. They were then packed in alternate layers with fine wet sand, in wooden boxes, and the proper precautions taken to insure safe transportation. On the 17th of November, 1857, the previous cargo, estimated at about five millions of the eggs of the trout, and one million of those of the white-fish, arrived at the place for which they were destined, apparently in good condition. They were unpacked with great care, and those of the trout were partly deposited in the bed of the stream, and partly along the gravelly shores near its embouchure, in water of two or three feet deep. Those of the white-fish were placed upon a smooth, sandy shoal, in water of somewhat less depth, the intention, in both cases, being to place the eggs in positions, as nearly as possible, similar to those in which the fish themselves deposit them. During the winter the eggs in the stream were repeatedly examined, and many of them found to be progressing favorably toward their development; and in March and April, 1858, the young made their appearance in great numbers. They were allowed to take care of themselves, and in due time they proceeded down into the lake. It was impossible to ascertain the probable proportion of the eggs which were hatched, but if one out of every thousand produced a living fish, the result of the experiment may be considered satisfactory.

In the month of May of the same year, about twenty millions of the eggs of the pike-perch, (*Lucioperca americana*,) which inhabits the same waters with the lake trout and other white-fish, were collected

and transmitted to the same breeding-place. Two thirds of them were placed in the stream, and the remainder on the gravel of the lake bottom. Some of those in the stream, after having been deposited about two weeks, were found to be developing properly, and an enormous crop of young fishes was expected; but, unfortunately, a sudden freshet shortly afterward tore up the bed of the rivulet, and swept away and destroyed a great proportion of the ova. What number, if any, survived this disaster, is not known, but it is believed that some of those deposited in the lake, and thus so situated as to have escaped the effects of the freshet, must have arrived at their full development.

In the autumn of 1858 another collection of about ten millions of the ova of the lake trout and white-fish was deposited in the same places, and, from observations made in the spring and summer of 1859, considerable numbers are believed to have been hatched. Several young trout of this brood have been taken in the lake, and also a few of larger size, weighing nearly a pound each, supposed to be the produce of the first deposit of eggs. As the white-fish does not take the hook, its actual presence in the lake has not yet been detected. Measures will be taken, however, in the course of the next summer, to ascertain positively the result of the experiment as regards that species. So confident are the gentlemen concerned, in the entire feasibility of their project, that they intend to continue their operations until assured of full success. They will also introduce other species of lake fish.

It is not yet time to speak confidently upon the prospect of future pecuniary profit, as the ultimate result of these operations; but if the trout, white-fish, and pike-perch do become acclimated and grow to the size which they attain in their native waters, the supply furnished by Saltonstall lake cannot fail, in a few years, largely to repay the parties concerned for their labor and expenses. The writer of this article has felt a very deep interest in these experiments from their inception, has been personally conversant with their progress, and has derived much valuable information respecting practical fish breeding from the two principal conductors of the enterprise, Messrs. Carl Muller, of New York, and Henry Brown, of New Haven.

TRANSPORTATION OF LIVING FISHES.

In some cases it may be desirable to transport living fishes from a distance. Whenever this is to be effected, the chances of success will be greatly increased by the observation of a few simple precautions. Small fishes are much more easily transported than those of full size. To save the trouble of changing the water often, its temperature should be reduced by placing in it pieces of ice so fixed as not to injure the fish. A large tin can, holding from twelve to twenty gallons, with a wide mouth, similar to those used by milk-men, is as convenient as anything. The lump of ice may be suspended in a netting from the mouth, the cover of which should be pierced with holes for the admission of air. If such vessels cannot be obtained, barrels, or even tubs, may be used, care being taken to cover them with some kind of cloth of loose texture, to prevent the water from being thrown out by the jolting of the carriage or rail-car in which the journey is performed.

A sufficient supply of ice should be procured to maintain the water at a low temperature. In such manner Dr. Garlick, of Cleveland, tells us that he kept five hundred and twenty trout in a barrel of water for eighteen hours without changing the water; and Mr. Henry Brown recently carried twelve hundred trout from the northern part of Massachusetts to Long Island, with the loss of only two or three. The water was not changed, and the trout were thirty-six hours on the road.

When the waters from which the fish are to be brought are not too distant, this is an easy mode of procuring material for stocking ponds. As an instance of what may be effected by this method, in stocking waters of considerable extent with new species, the following may be mentioned:

In the winters of 1852–53, the black bass of the lakes (*Grystes nigricans*) was introduced into Waramang lake, situated between the towns of Washington and Warren, in Litchfield county, Connecticut. "They have in that lake," writes our informant, F. D. Beeman, Esq., of Litchfield, "multiplied very generously. Their growth is estimated to be about one pound a year, and they have been frequently caught weighing five pounds and upwards. They were originally brought from a small lake in Duchess county, New York. They are a hardy fish, and can be readily transported from one place to another in a tub of water, covered with wet canvas. There were less than an hundred bass originally placed in Waramang lake; there are now probably millions, and they appear to propagate and flourish better than any other fish in the waters of that lake."

The black bass has more recently been introduced into another lake in Litchfield county, and will soon be established as a denizen of many other of our Connecticut lakes. It is a fine fish, in every respect, and is well worthy the attention of those who have large private ponds. The ease with which it may be transported, the rapidity with which it multiplies, the sport which it affords the angler, and its excellence on the table, form a combination of qualities which render it deservedly popular with those who know its merits, and which should lead to its introduction into all such waters as are suited to its habits.

BREEDING OF MIGRATORY FISHES.

In addition to the experiments already alluded to, others of even greater interest, in some respects, are now in progress. Those which are next to be mentioned will eventually, it is hoped, afford much practical information in regard to the question whether the breeding of *migratory* fishes can be so managed as to be made a source of profit to the breeder: in other words, whether these fishes, after being reared in private waters, and allowed to follow their instincts by going to the sea at the proper age, will return when adult, at the spawning season, to the place where they are hatched, in sufficient numbers to enable the breeder to repay himself for his care of them while young, by capturing and selling them when full grown. Somewhat similar experiments have been made in other countries, for the purpose of settling the same question; but, notwithstanding the enthusiastic anticipations

of foreign fish breeders, we have, as yet, no positive and reliable accounts by which to estimate their value. The importance of the subject warrants a thorough trial, and such, we hope, it is to receive by the means now to be described.

Messrs. U. S. Treat & Son, of Eastport, Maine, have obtained the control of three large ponds, about twenty miles from Eastport. The largest of these is about three quarters of a mile long, by half a mile wide, and they all have a common outlet into the St. Croix river. The outlet has been provided with a gate, by means of which it may be closed or opened at pleasure, thus enabling the owners to retain the fish in the ponds, or to allow them to proceed to the sea. The breeding operations were commenced in the spring of 1857, at which time a number of salmon, (*S. salar*,) striped bass, (*Labrax limatus*,) shad, (*Alosa præstabilis*,) and alewives (*A. tyrannus*) were placed alive in two of the ponds, the salmon in the largest. The shad and alewives, Mr. Treat informs us, spawned about the first of June, and in about three weeks millions of their young were seen. The gate was then closed, and the growth of the young fish watched in the pond for three months, after which, a portion of them were allowed to proceed down the river to the sea. The remainder were detained for two months longer, when they also were dismissed to salt-water. The number of young produced by this first spawning was estimated at more than five millions. They had grown, when on their way to the sea, to the length of three to five inches. The salmon spawned in the November ensuing, and the eggs were hatched in the spring after. Mr. Treat did not, however, succeed in detecting any of the young until the summer of 1859, when they were above a year old. They had then grown, he says, to the length of ten or twelve inches, and were changing from the trout-like appearance which characterizes them in their first year, and were taking on the silvery coat of the parent fish. As the lake is in some places forty feet in depth, not many of these young salmon were captured; but enough were secured to enable Mr. Treat to identify them. The old salmon still appear to be in good condition, and are frequently observed. They have been in the lake two winters and two summers. Whether they continue to breed is not as yet known. The young salmon were also allowed to follow their natural instincts and to proceed to the sea at the proper season. Mr. Treat confidently expects the return of his fish—such of them as survive the dangers of the seas—as soon as they become capable of reproducing their species and feel the impulse of that instinct which induces them to seek the fresh water for the purpose of depositing their spawn. We shall await the result of his experiments with great interest, and hope to be able, in some future report, to announce the fulfillment of his anticipations. Several other important and doubtful questions, as to some of the habits and the growth of the species which are made the subjects of these experiments, will also, perhaps, be solved.

BREEDING TROUT AT HARTFORD.

Mr. E. C. Kellogg, of Hartford, Connecticut, gives the following account of his experiments. He was among the first to attempt the

artificial breeding of trout in this country, and he has conducted his experiments with great intelligence and care. His observations in regard to the progress of development of the embryo fishes, the best and most certain methods of impregnation, the growth of the young fry, and many other points of interest, have been exceedingly patient and minute, and, when published, as they may be in the Report of next year, will materially add to the stock of knowledge already promulgated by foreign writers, and will, we are certain, prove of material benefit to those who desire to practice the art. At present, we have space only for a brief notice of what he has done and what he is now doing.

His first experiment was made in 1855, during the summer of which year he collected a number of trout, to be used as breeders, which he placed in a small pond in the town of Simsbury, Connecticut. A slight dam was made near the source of the spring by which the pond was supplied, forming a smaller pond, and at the lower side of this upper dam a temporary hatching-house was erected, in which was placed a box partly filled with gravel, and through this a small stream of water was conducted. In November, the eggs were fecundated, after the prescribed method. In the course of a few weeks it was apparent that embryo fish were being developed in some of the eggs, and in proper time about seventy-five trout were hatched. The fry were kept in the box for a month or two, and were then allowed to run into the larger pond below. In the succeeding autumn they were found with the old fish, apparently doing well.

The next year's experiments at Simsbury failed entirely, the water-pipe becoming stopped, so that the water froze in the hatching box. Mr. Kellogg, however, was induced, by the convenience of having the Connecticut river water on his premises, to make a trial of artificial breeding in the cellar of his house. He arranged a box with several partitions, filled it partly with gravel, laid it in a slanting position, so that the partings formed a series of steps, and water from the public reservoir was conducted through it. By this means he succeeded in hatching about sixty trout during the first winter, and about four hundred during the winter of 1858. He is at present directing the construction of works for artificial breeding on a more extensive scale, and on a far more convenient plan, at East Hartford. Through the liberality of Colonel Colt, upon whose grounds the work is progressing, no pains nor expense are spared to render the experiment successful. An excellent spring, running out of a gravel bank into a ravine, furnishes a good supply of water. Across the ravine a dam has been thrown, raising a pond of about sixty feet in diameter and six feet in depth. A commodious house has been built, in which are the arrangements for hatching, and a large tank, with divisions, to hold the parent fish at the time of spawning. A supply of breeding fish has recently been provided, and a considerable number of eggs, probably three or four thousand, have been impregnated and placed in the hatching boxes. Every precaution which experience and ingenuity could suggest has been used to secure successful results, and we hope, next year, to be able to make a satisfactory report of these operations.

"That there is some difficulty in breeding trout artificially," writes

Mr. Kellogg, "I think all who have experimented will allow. It is perhaps somewhat difficult to point out the causes of failure, which seem to lie principally in the uncertainty of fecundating the ova, a very large proportion of which often proves barren, in spite of every care and precaution. We must suppose that some one of the conditions necessary to thorough fecundation has been disregarded or not understood. There is no reason to doubt, however, that the careful observations of experimenters, each succeeding year, will overcome the difficulty, and will lead at last to complete success.

"The rapidity with which fish grow with good feeding is truly surprising. In the basin of a fountain in my garden a single trout has lived during this season. For some time no care was taken to feed this fish, it having been left to depend for its existence upon the few insects which chanced to fall into the water, and for several months it increased in size very slightly. After being fed daily with worms for a few weeks, its growth was remarkable. In a single month it has more than doubled in weight.

"During several winters I have kept in a small tank in the cellar a considerable number of trout, and although quite thin after the spawning season, they have become fat and in excellent condition before spring, by means of generous feeding. It is astonishing, also, to notice how easily fish may be domesticated. Wary trout, after only a few days' confinement, will eat readily, watch daily for their accustomed allowance, and even become so gentle as to take food from the hand, like chickens."

PRACTICAL HINTS TO FISH BREEDERS.

The following instructions, upon several points connected with the different stages of artificial fish breeding, are partly the results of our own observation, and partly condensed from an essay by Professor Vogt, of Geneva, Switzerland, translated for Mr. Marsh's report, before alluded to. This essay contains a very great amount of valuable and curious information, in respect to the reproduction of fishes, and the best methods of securing success in artificial fish breeding. It is worthy of perusal entire, by any one to whom it may be accessible.

1. The mere contact of spawn and milt does not suffice to effect fecundation. To insure the production of a living creature from the egg, the active element of the milt, which consists of moving microscopic corpuscles, provided with a thread-like tail, and called seminal animalcules, must penetrate into the interior of the egg, and there unite with its substance. Every egg is, therefore, infallibly lost, unless it has thus absorbed the constituent of the male generative fluid.

2. The perfect eggs of fresh-water fish consist of an external skin, or shell, within which, enveloped in a second thinner membrane, called the *vitelline membrane*, is the yolk. The yolk is always bright and clear, sometimes quite colorless and transparent, like water, (as in the white-fish,) sometimes of an amber or orange color, as in the trout and salmon. The outer coat of the egg and the vitelline membrane lie in close contact, so long as the spawn remains in the body of the fish; but, as soon as the eggs are deposited in the water, a rapid absorption

commences, the water penetrates through the external coating, which swells and becomes distended, thus leaving a space between itself and the vitelline membrane around the yolk, this space being filled with water. The vitelline membrane is impervious to water, so long as the egg is in a healthy state, and its contents remain perfectly clear and limpid. But the penetration of water into the yolk is at once betrayed, by its assuming a milky color; and this is an infallible proof of the unsoundness of the egg.

3. An orifice is observed in the eggs of most fresh-water fish, opening at the surface, through which the seminal animalcule penetrates to the interior of the egg.

4. Since the spawn can be impregnated only by the reception of the animalcule, it becomes of much practical importance to ascertain how long this minute being retains its power of motion and impregnation. At low temperatures, this power may be retained for hours, and even days, *if the milt remains in the organs in which it is secreted.* The eggs of trout have been impregnated by milt taken from the male after it was stiff-frozen. But, when once the milt is placed in water, the power of moisture is very soon lost. It has been found that the animalcule of the mullet perishes in three minutes and ten seconds; that of the carp in three minutes; that of the perch in two minutes and forty seconds; and this in the degree of heat most favorable to vitality. *Very slight variations, above or below this point, destroy the animalcules with great rapidity.* The temperature which seems longest to maintain their vitality is, for winter fish, like the trout, 41° to 48°; for those which spawn in early spring, 50° to 55°; for those of early summer, 63° to 68°; and for those of hot weather, 77° to 87°.

5. It becomes, therefore, a matter of the greatest practical importance to perform the processes of impregnation in the *very shortest possible time.* Some operators mix the milt first with water, and then immediately drop the spawn into it, believing that the minute currents, formed by the absorption of water by the egg, have the effect of directing the movement of the animalcule toward the orifice. It is also supposed that the swelling of the egg, in consequence of the absorption of water, tends to close the orifice, so that the animalcule cannot enter, after the envelope is full of water. However this may be, it is found, by experience, that the *simultaneous* mixture of the milt and the spawn is most likely to effect the impregnation of the greatest proportion of the eggs; and hence it is recommended, when practicable, that *two* persons should work together, one manipulating the male fish and the other the female.

6. It is absolutely necessary that the ova be *mature.* Fish do not deposit all their spawn at once, but usually through several successive days, as the eggs become ripe. The operator should, therefore, use no violence in forcing the eggs from the female; since those which are fully mature, and fit for impregnation, will fall from her with very little pressure. After she has emitted that portion which is fully ripe, she should be placed in the tank again for a day or two, when a second portion will be ready for impregnation. The milt of a single male is usually sufficient for the eggs of several females; and it may be obtained likewise in successive portions.