REPORT,

MADE UNDER AUTHORITY

OF THE

LEGISLATURE OF VERMONT,

ON THE

Artificial Propagation of Fish,

BY

GEORGE P. MARSH.

BURLINGTON:
FREE PRESS PRINT.
1857.

No. 101.—JOINT RESOLUTION RELATIVE TO THE ARTIFICIAL PROPAGATION OF FISH.

Resolved, by the Senate and House of Representatives, That the Governor be requested to enquire into the present state of the discoveries which have been made in relation to the artificial propagation of fish. Also to enquire whether any, and what concurrent legislation of this and other states and provinces may be requisite in order to secure to this state the benefit of such discoveries; and the Governor is hereby authorized to draw on the Treasurer for any sum, not exceeding one hundred dollars, to defray the expenses of such enquiry and investigation.

IN HOUSE OF REPRESENTATIVES, November 15, 1856.
Read and adopted.

NORMAN WILLIAMS, JR., *Assistant Clerk.*

IN SENATE, November 17, 1856.
Read and adopted in concurrence.

C. H. CHAPMAN, *Secretary.*

HON. GEO. F. EDMUNDS,

SPEAKER OF THE HOUSE OF REPRESENTATIVES.

Sir :—In conformity with a Joint Resolution adopted at the last annual session of the General Assembly, directing inquiries to be made into the present state of the discoveries relating to the artificial propagation of fish, and also into the necessity of concurrent legislation of this and other States upon that subject, I requested Hon. George P. Marsh, of Burlington to make such inquiries.

I have the honor to transmit herewith to the House of Representatives for the use of the General Assembly, the Report of Mr. Marsh upon this subject, to which I invite the careful attention of the Legislature, relating as it does, in my opinion, to a valuable branch of the public economy of the State.

RYLAND FLETCHER.

EXECUTIVE CHAMBER,
October 13, 1857.

IN HOUSE OF REPRESENTATIVES, October 13, 1857.

Read and referred together with accompanying documents to Committee under Fourth Joint Rule.

GEO. R. THOMPSON, *Clerk.*

In House of Representatives,
October 22, 1857.

Mr. Bradley from the Committee under the Fourth Joint Rule, made the following report :

To the House of Representatives now in session.

The Committee under the Fourth Joint Rule, to whom was referred the communication of His Excellency, the Governor, concerning the artificial propagation of fish, beg leave respectfully to report that they have considered the matter, and do not find it expedient, in the present state of information upon the subject, to *now* legislate in relation thereto. At the same time your Committee are of opinion that the interests involved are of a magnitude which will require protection at some future day, when the wants of the people shall have been fully ascertained; and that in the mean time the diffusion of full and authentic information in relation to this interest will make us sure that whatever shall be done hereafter will be done wisely and considerately. Your Committee therefore offer a resolution providing for the printing of the said communication of His Excellency, with the accompanying Report, and the thorough circulation thereof in the State.

J. D. BRADLEY, *for Committee.*

Resolved, by the Senate and House of Representatives : That fifteen hundred copies of the Governor's communication on the subject of the artificial propagation of fish, with its accompanying documents, be printed, and that three copies thereof be distributed to each Senator, and Representative; and that the remainder be distributed among the people by the Secretary of State in the manner which he shall judge will secure the widest knowledge of of the subject; and the Secretary of the Senate and the Clerk of the House are directed to procure the printing of said communication and documents.

In House of Representatives, October 22, 1857.

Read and adopted.

GEO. R. THOMPSON, *Clerk*.

In Senate, October 22, 1857.

Read and adopted in concurrence.

C. H. CHAPMAN, *Secretary*.

REPORT.

TO HIS EXCELLENCY, RYLAND FLETCHER,
GOVERNOR OF VERMONT:

The Resolution of the General Assembly, in pursuance of which the following Report has been prepared, does not appear to contemplate experiment or original observation upon the natural or artificial breeding of fish, and the report will therefore present such facts only as have been gathered from foreign and American publications on the subject, together with some considerations of a general nature, which may be thought to have a bearing on the proper action of the Legislature in reference thereto.

Man, whether savage or civilized, has a strong passion for the exciting and exhilarating pleasures of the chase, and an irresistible predilection for pursuits which involve the elements of variety, uncertainty, and chance, over the tamer occupations which demand the exercise of regular industry, and offer to their followers not brilliant prizes, but fixed and humble rewards. Many might, therefore, be disposed to question whether the advantages to be derived from the restoration of the quadrupeds, the fowls, and the fish, that once filled the forests, the atmosphere, and the waters, would not be more than counterbalanced by the mischievous influence, which the opportunity of indulging in pleasures so seductive as those of the sportsman would exert upon the habits of our population.

But aside from the obvious impossibility of so multiplying the wild animals of our territory as to affect seriously the habitual pursuits, or the graver interests of our people, it is believed that any possible evil from this source would be more than compensated by collateral advantages, of a character not unlikely in the present state of American society, to be quite overlooked. The people of New-England are suffering, both physically and morally, from a too close and absorbing attention to pecuniary interests, and occupations of mere routine. We have notoriously less physical hardihood and endurance than the generation which preceded our own, our habits are those of less bodily activity, the sports of the field, and the athletic games with which the village green formerly rung upon every military and civil holiday, are now abandoned, and we have become not merely a more thoughtful and earnest, but, it is to be feared, a duller, as well as a more effeminate, and less bold and spirited nation. The chase is a healthful and invigorating recreation, and its effects on the character of the sportsman, the hardy physical habits, the quickness of eye, hand, and general movement, the dexterity in the arts of pursuit and destruction, the fertility of expedient, the courage and self-reliance, the half-military spirit, in short, which it infuses, are important elements of prosperity and strength in the bodily and mental constitution of a people; nor is there anything in our political condition, which justifies the hope, that any other qualities than these will long maintain inviolate our rights and our liberties.

The training acquired in the sports of the chase, as exercised in England, has been of great value and importance to those classes of English society which are possessed of the means of participating in it, and in the severe crisis through which the British troops passed in the late Russian war, it proved to be the best preparation for the field and the camp, which it is possible for civil life and an age of peace to afford. In a country like ours, of small landed estates, narrow enclosures, and rugged surface, the chase could never be pursued upon the great scale, which makes it so attractive, and so imposing a sport in England; and it must be admitted that angling and other modes of fishing are under few circumstances attended with as great moral and physical benefits as the pursuit of the larger quadrupeds, but they are nevertheless analogous in their nature and influences, and as a means of innocent and healthful recreation at least, they deserve to be promoted rather than discouraged by public and even legislative patronage.

But however desirable it might be, in these and other points of view, to repeople the woods and the streams with their original flocks and herds of birds and beasts, and shoals of fish, it is for obvious reasons, impracticable to restore a condition of things incompatible with the necessities and the habits of cultivated social life. The final extinction of the larger wild quadrupeds and birds, as well as the diminution of fish, and other aquatic animals, is everywhere a condition of advanced civilization and the increase and spread of a rural and industrial population. The number of wild animals which have been thus altogether or nearly extirpated in quite recent times is by no means inconsiderable. Within a few centuries, the wolf and the bear, as well as some large animals of the deer family, have utterly disappeared from the British Islands; the wild ox exists only in the parks of one or two great landed proprietors, and the cock of the woods, a magnificent bird of the grouse tribe scarcely smaller than the turkey, formerly abundant in Scotland, had become totally extinct in Great Britain, and has only lately been re-introduced from Sweeden; and the fox has been preserved from extirpation only by a public opinion which exempts him from ordinary agents of destruction, and spares him as the object of a manly sport.

So on the continent of Europe, the beaver is now so rare that he has been forced to relinquish his habits of associated life and action, and has become a solitary animal; the gigantic wild ox of the German and Slavonic states is confined to a single forest in Lithuania, and other large quadrupeds, which abounded in central Europe but four or five centuries since, are now only known by history and tradition.

In like manner the moose, the deer, the catamount, the wolf, the lynx, the beaver, the vast flocks of pigeons and water fowl, and other birds of passage, which bore so important a relation to the nutrition and the sports of our fathers,are now almost unknown to the natural history of Vermont, and zoologists observe that the clearing of the woods and the complete change in the vegetable products of the soil and the insects that feed upon them, have produced corresponding changes in the kinds and numbers of those smaller animals which being neither valuable for their flesh or their peltry, nor obnoxious for their destructive propensities, are regarded with interest by few but the scientific naturalist.

It should be observed, however, that the partial or total disappearance of many of the smaller birds and land animals is not to be ascribed altogether to a diminished supply of their natural food, but in no small degree to the wanton cruelty of youth, which finds pleasure in the torture and death of innocent and defenceless creatures, and to a mistaken prejudice which often ascribes mischievous propensities to particular birds, quadrupeds, and reptiles that in reality, by the destruction of vast numbers of noxious insects, much more than compensate the little injury they inflict upon the crops. The insect in all stages, egg, larva, chrysalis, and winged imago, enters largely into the nutriment of birds and the small quadrupeds, and many of those which are popularly supposed to be destructive to grass and grain, in fact depend for their sustenance almost wholly upon insect life, and are accordingly useful as protectors, not injurious as destroyers, of the food of man.

But although we must, with respect to our land animals, be content to accept nature in the shorn and crippled condition to which human progress has reduced her, we may still do something to recover at least a share of the abundance which, in a more primitive state, the watery kingdom afforded.

The luxurious and extravagant habits of imperial Rome first introduced the artificial breeding, or at least feeding and fattening of fish, in both salt and fresh water ponds. With the overthrow of that empire, its civilization and its industry, this practice was discontinued, and the art forgotten. But it was revived in the middle ages by the religious observances of the Papal church, which, by determining that fish and certain favorite species of water fowl were not *flesh*, and accordingly not forbidden food at seasons of fasting and mortification, ingeniously contrived to reconcile the indulgence of the palate with the discipline of

Lent. To every favorably situated monastic establishment was attached a fish-pond, which not only supplied the tables of the professed during the prescribed fasts, but often yielded a considerable revenue from the sale of fish to worldly penitents. The success of the monks led to the extension of this branch of industry, and large ponds were constructed by laymen, so that in the sixteenth century fish-ponds were an appurtenance of most great estates whether lay or ecclesiastical.

It is well known that in the earlier periods of the history of Vermont, the abundance of fish in the running waters, and more especially in the ponds and lakes of our interior and our borders, was such as to furnish a very important contribution to the nutrition of a population which the cultivated products of the soil were scarcely adequate to sustain. Lake Champlain and the Connecticut, as well as those of their larger tributaries whose course was not obstructed by cascades, abounded in salmon, and after the disappearance of that fish, those important waters, and all the streams and ponds of the interior, long continued to furnish a liberal supply of different species of the trout family, and of other kinds hardly inferior in value. At present, the numbers of the fish in all our waters, as well as of the otter, the mink, the muskrat and the water-fowl that fed on them, are so much reduced, that this branch of the animal kingdom has ceased to possess any pecuniary value in Vermont ; and on the contrary the few that remain are popularly regarded as, in an economical point of view, rather a detriment than an advantage, as furnishing a temptation to idleness, not a reward to regular industry. The diminution of the fish is generally ascribed mainly to the improvidence of fishermen in taking them at the spawning season, or in greater numbers at other times than the natural increase can supply. It is believed moreover, and doubtless with good reason, that the erection of sawmills, factories and other industrial establishments on all our considerable streams, has tended to destroy or drive away fish, partly by the obstruction which dams present to their migration, and partly by filling the water with saw dust, vegetable and mineral coloring matter from factories, and other refuse which render it less suitable as a habitation for aquatic life.

It is however probable that other and more obscure causes have had a very important influence in producing the same result. Much must doubtless be ascribed to the general physical changes produced by the clearing and cultivation of the soil. Although we cannot confidently affirm that the total quantity of water flowing over the beds of our streams in a year is greater or less than it was a century since, or that the annual mean temperature has been raised or lowered, yet it is certain that while the spring and autumnal freshets are more violent, the volume of water in the dry season is less in all our water courses than it formerly was, and there is no doubt that the summer temperature of the brooks has been elevated. The clearing of the woods has been attended with the removal of many obstructions to the flow of water over the general surface, as well as in the beds of the streams, and the consequently more rapid drainage of our territory has not been checked in a corresponding degree by the numerous dams which have been erected in every suitable locality. The waters which fall from the clouds in the shape of rain and snow find their way more quickly to the channels of the brooks, and the brooks themselves run with a swifter current in high water. Many brooks and rivulets, which once flowed with a clear, gentle, and equable stream through the year, are now dry or nearly so in the summer, but turbid with mud and swollen to the size of a river after heavy rains or sudden thaws. The general character of our water courses has become in fact more *torrential*, and this revolution has been accompanied with great changes in the configuration of their beds, as well as in the fluctuating rapidity of their streams. In inundations, not only does the mechanical violence of the current destroy or sweep down fish and their eggs, and fill the water with mud and other impurities, but it continually changes the beds and banks of the streams, and thus renders it difficult and often impossible for fish to fulfil that law of their nature which impels them annually to return to their breeding place to deposit their spawn.

The gravelly reach which this year forms an appropriate place of deposit for eggs, and for the nutriment and growth of the fry, may be converted the next season into dry land, or on the other hand, into a deep and slimy eddy. The fish are therefore constantly disturbed and annoyed in the function of reproduction, precisely the function which of all others is most likely to be impeded and thwarted by great changes in the external conditions under which it is performed. Besides this, the changes in the surface of our soil and the character of our waters involve great changes also in the nutriment which nature supplies to the fish, and while the food appropriate for one species may be greatly increased, that suited to another may be as much diminished. Forests and streams flowing through them, are inhabited by different insects, or at least by a greater or less abundance of the same insects, than open grounds and unshaded waters. The young of fish feed in an important measure on the larvæ of species which, like the musquito, pass one stage of their existence in the water, another on the land or in the air. The numbers of many such insects have diminished with the extent of the forests, while other tribes, which, like the grasshopper, are suited to the nourishment of full grown fish, have multiplied in proportion to the increase of cleared and cultivated ground. Without citing further examples, which might be indefinitely multiplied, it is enough to say that human *improvements* have produced an almost total change in all the external conditions of piscatorial life, whether as respects reproduction, nutriment, or causes of destruction, and we must of course expect that the number of our fish will be greatly affected by these revolutions.

The unfavorable influences which have been alluded to are, for the most part, of a kind which cannot be removed or controlled. We cannot destroy our dams, or provide artificial water-ways for the migration of fish, which shall fully supply the place of the natural channels ; we cannot wholly prevent the discharge of deleterious substances from our industrial establishments into our running waters ; we cannot check the violence of our freshets or restore the flow of our brooks in the dry season ; and we cannot repeal or modify the laws by which nature regulates the quantity of food she spontaneously supplies to her humbler creatures.

It is therefore not probable that the absolute prevention of taking fish at improper seasons, or with destructive implements, or indeed that any mere protective legislation, however faithfully obeyed, would restore the ancient abundance of our public fisheries, though such measures might no doubt do much to render them somewhat more productive than they at present are, if the legal and moral power of the legislature to enact and enforce appropriate laws on this subject were somewhat greater.

Although the fortieth section of the Constitution of Vermont, which secures to the people of the State certain rights of hunting and fishing, entrusts the General Assembly with a large discretion in the regulation of those rights, yet is it not clear that the Legislature possesses *all* the power required for the complete protection even of an experimental public fish-breeding establishment, and the State certainly at present has title to no suitable localities for such a purpose. Besides this, the habits of our people are so adverse to the restraints of game-laws, which have been found peculiarily obnoxious in all countries that have adopted them, that any *general* legislation of this character would probably be found an inadequate safeguard. But however this may be, the difficulties of a co-operation with other States by concurrent legislation seem, for the present at least, insuperable. The subject is by no means well enough understood to enable us to determine the proper character of a code so comprehensive as to embrace the territory of three or four states, and there is such a difference of local conditions between States, one of which controls the outlet of a great river as well as the entire course of many of its tributaries, and another whose jurisdiction extends but to the water's edge of the upper portion of its current, that the provisions applicable to one could have little adaptation to the circumstances of the other. The State of Connecticut is in all respects very favorably situated for experimenting upon the restoration of salmon and shad, and whenever that State and Massachusetts shall have adopted protective or promotive systems suited to their respective conditions, it will be the duty and interest of Vermont to resort to such co-operative measures as the interests and circumstances of the State shall seem to require.

It is believed that our main reliance in this, as in all other matters of economical interest, must be upon the enterprise and ingenuity of private citizens, and that until States more advantageously situated for experimentation than Vermont, shall have taken the initiative, our legislative action should be limited to such further protective laws as private establishments may require, and (which is earnestly recommended,) the granting of liberal premiums for judicious and successful private efforts in the restoration and improvement of the fisheries.

In many European countries, where restrictive and prohibitory laws of all sorts are much more rigidly enforced than with us, the preservation of land and aquatic game has been an object of legislation for centuries, but none of these systems have ever been attended with *general* success, and the possessors of great forests and fisheries, whether royal or private, every where depend rather upon guards and enclosures than upon the terror of the law, for the protection of the objects of the chase or the fishery.

Nor does it sufficiently appear that the governmental establishments for fish-breeding in France and elsewhere in Europe have yet accomplished any very important results beyond the supply of spawn to private operators, and, what is of more consequence, the furnishing of satisfactory experimental evidence that the artificial breeding of fish is not only practicable, but may be pursued with advantage as a branch of private industry, requiring less labor, and not more care or skill, than most other rural employments, by any person who possesses a sufficient extent of appropriate territory and water.

There is little which is new in the methods now followed in France, and they are substantially the same as those originally proposed in Germany by Jacobi, and successfully pursued by him and his successors for a century, though it is but lately that they have received the attention their importance merits. That, with such modifications as difference of climate, species, and natural facilities shall require, they will be equally successful with us, there is no ground for doubt, and the effort to introduce them is well worthy of public encouragement.

As has been already remarked, the fattening, and to some extent, the breeding of fish wholly in artificial reservoirs, has been long and widely practiced in Europe, and not unfrequently in this country, but it is not believed that methods, which leave so little to nature can be advantageously pursued on a larger scale. Trout thus grown are so inferior in flavor to fish caught in brooks and mountain lakes, that they can scarcely be recognized as belonging to the same species, but if hatched, protected, and fed during the first year or two in artificial waters, and then dismissed to seek such food as nature provides, they equal in all respects naturally bred fish, and may be greatly multiplied in number, without any diminution in size, or deterioration in quality. The introduction of fish from distant waters, and their naturalization in their new homes is also practicable to an indefinite extent. Thus the gold fish of China, accidentally escaping from artificial reservoirs in this country, breeds and thrives in American rivers; many fish have found their way from the Hudson to the Great Lakes, and from the lakes to the river, since the opening of the New

York Canal, and multiplied in both, and it is even said that a gentleman in New York has succeeded in so far changing the natural habits of the shad, that they pass the whole year and freely breed in his fresh water ponds, without returning to the ocean, or having otherwise access to salt water.

The subject of artificial fishbreeding has attracted much attention in other States, and many interesting experiments have been already tried, or are now in progress, in different parts of the Union. Printed accounts of these are readily accessible, and they are therefore not here detailed, but it has been thought expedient to append to this report an abridged translation of an excellent essay by Professor Vogt, of Geneva, in Switzerland, together with extracts from a Report to the Legislature of Massachusetts, and from the Transactions of the Connecticut State Agricultural Society.

It is recommended that a sufficient number of these documents be printed for general distribution in all parts of the State, and it is thought that they, with Fry's complete treatise on Artificial Fish-breeding, published in New York in 1854, and Garlick's Treatise on the artificial propagation of fish, published at Cleveland, Ohio, in 1857, both of which may be easily obtained, together with such experience as a few trials cannot fail to give, will furnish all information necessary to enable any person of ordinary intelligence and possessed of the requisite local facilities, (such as clear ponds, or a sufficient extent of the course of a perennial brook), to prosecute this branch of industry with advantage.* The amount of care, time and

* Note.—It deserves to be noticed, by way of suggesting a caution which it may be important for us to observe, that the forming of large artificial reservoirs, and damming up or otherwise obstructing and diverting the

money required for commencing and continuing a moderate breeding establishment in favorable situations, is altogether insignificant, and would not perceptibly increase the labor or the expense of an ordinary farm, while on the other hand, our supply of healthy and agreeable diet might be greatly augmented, and the general prosperity proportionally advanced.

If private persons undertake experiments in the breeding and rearing of fish, whether for scientific investigation or purposes of profit, there is no good reason why industry and capital thus employed should not receive the same protection as the breeding of any other animal, and it is believed that some legislation should be adopted, prescribing the same penalties for the taking of fish in waters which the proprietor has publicly signified his intention of appropriating to his own exclusive use, as for a trespass or a theft committed upon any other personal property.

It is probably too early to attempt the adoption of legislative measures for restoring the primitive abundance of the public waters of Lake Champlain, but when private observation and experiment shall have made the subject more familiar, it is to be hoped that means may be devised for again peopling them with the lake shad (white-fish,) the

natural flow of water, has in many instances been found injurious to the health of the vicinity by promoting miasmatic exhalations, and that these works have in Europe often seriously impeded the drainage of the so'l, and other modes of physical improvement. The tenacity with which the monks adhered to their privileged fisheries, long delayed the execution of that most interesting and remarkable enterprise, the draining and elevation of the bed of the Val di Chiana in Tuscany; and extensive tracts of the richest soil in Sicily are at this moment kept in the condition of barren and pestilential wastes by similar causes.

salmon, the salmon-trout, and numerous other species of fish, which formerly furnished so acceptable a luxury to the rich, and so cheap a nutriment to the poor of Western Vermont, but which now are become almost as nearly extinct as the game that once enlivened our forests.

GEO. P. MARSH.

Montpelier, Oct. 10, 1857.

ARTIFICIAL FISH-BREEDING.

ABRIDGED FROM AN ESSAY BY PROFESSOR KARL VOGT, OF GENEVA, SWITZERLAND.

The most general condition of sexual reproduction is the concurrent action of the male and female generative elements, the former being the spermatic fluid or milt, the latter the egg or spawn. With fresh water fish, impregnation is effected externally, or after the deposit of the spawn, no actual copulation taking place. The female deposits the eggs, and the male emits the spermatic fluid upon them. The contact of the two generative materials therefore occurs in the water.

Modern investigations have shown that the mere contact of spawn and milt does not alone suffice to effect fecundation. To ensure 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

NOTE.—It should be observed that the fish mentioned in this essay are all *European species.* These in general bear a considerable, and in some instances, as in the trout family, a pretty close resemblance to American fish of the same name, in character and habits, but like names are sometimes applied to fish of totally different families.

TRANSLATOR.

of the egg, and there unite with its substance. The entrance of a seminal animalcule into the egg is accordingly an essential condition of the development of the latter, and every egg is infallibly lost, unless it has thus absorbed this constituent of the male generative fluid.

The perfect eggs of fresh-water fish consist in general of an external shell or skin, which sometimes, as in the trout family is more firm and elastic, sometimes, as in the European perch and the white fish (*cyprinoids*,) more resembles coagulated albumen and is viscous upon the surface. In this external coating is contained the usually spherically formed yolk, enveloped in a thin simple membrane called the *vitelline membrane*. The yolk itself is always bright and clear, sometimes quite transparent and colorless, like water; sometimes of a more yellowish hue, as for example, in the eggs of the trout and salmon families, which are of an amber or orange-yellow color. The yolk consists of two rather thick fluids, one more albuminous, which upon contact with water coagulates and becomes white, like milk, the other of an oily consistence, at first appearing in minute particles, but in the course of development usually coalescing into a single fatty drop, which on account of its lightness keeps always uppermost when the egg is turned. In the trouts, the single oil-drops unite in a stratum or disk from which the young is developed, and this upper portion of the egg corresponds to the back of the fry. All perfect and productive eggs are uniformly bright, clear and transparent; milky turbidness in the interior always indicates the disorganization of the yolk, and consequently the incapacity of further development.

The outer coat of the egg and the vitelline membrane lie in close contact so long as the spawn remains in the body or the ovarium ; 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 distends itself, thus leaving a space between it and the vitelline membrane in which the yolk floats. This absorption of water is facilitated by fine pores or vessels, which traverse the shell or outer coat of the egg, and give the surface, under the microscope, a shagreened appearance. By mixing with the water coloring matter, which is held in suspension by it, it may be shown, that every egg, as soon as it is deposited in water, becomes, by means of these pores, a centre of attraction towards which very slender currents of the fluid are directed from every quarter. The absorption is soon effected, the egg-shell fully distended, and the space between it and the vitelline membrane filled with water.— This 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, which is an infallible proof of the unsoundness of the egg.

Besides these absorbent vessels, which are sometimes more, sometimes less, developed, there has been discovered in the egg of most fresh-water fish a simple orifice, which is certainly connected with the reception of the seminal animalcule into the egg. Karl Ernst Von Baer observed in the egg of a species of white fish (*cyprinus blicca*) a funnel shaped canal, the function of which he did not detect, but which is obvious since Professor Bruch has discovered in the egg of the trout and salmon a small aperture, which upon a careful scrutiny is visible to the naked eye as a shadowy point, and under the microscope appears as a small canal opening funnel-wise upon the surface. A similar orifice has since been observed in the eggs of other fish, and investigation has shown, that it is by this passage alone that the seminal animalcule penetrates to the interior of the egg.

The seminal animalcule which occurs so abundantly in the milt, is pin-shaped, having a round head and a slender hair-like tail, and it is by the vibrations of this latter organ that it moves in its native fluid. The spawn can be impregnated only by the reception of the animalcule, and 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 is retained for hours and even days, *if the milt remains in the organs by which it is secreted.* In the lake of Neufchatel, the *Palee*, a fish of the trout family, is taken during the winter months, by night or at sunset. I have often received these fish stiff-frozen, and succeeded perfectly in impregnating spawn with the milt taken from the genitals of the male the day after. But, when once placed in the water, the case is far different, and after a very short immersion the power of motion is lost, and the form of the animalcule is changed. It deserves to be remarked, however, that though simple water kills the milt in a few minutes, the addition of a seventieth part of sulphate of magnesia to the water maintains its vitality for hours.

Since then the egg completes its absorption rapidly, and the currents attracted by it very soon cease, and since the seminal animalcules speedily lose their vitality in water, it is a matter of great practical importance to perform the processes for facilitating impregnation with as little loss of time as possible. The best method is doubtless to mix the milt with water, and then immediately drop the spawn into the mixture, as the attraction arising from the absorp-

4

tion of water by the egg serves to direct and facilitate the movement of the animalcule toward the orifice, and this conclusion is abundantly established by observation. It has been found that the number of barren eggs is proportioned to the length of time the spawn lies unimpregnated, and wherever two or more operators work together, so that the male and female can be manipulated *at the same time*, and the whole process completed in a minute or thereabouts, that method is to be preferred.

To the objection that the process of first emitting the milt reverses the order of nature, according to which the spawn is first deposited and afterwards fecundated by the milt, it is sufficient to reply, that nature compensates the hazards and imperfections of this process by providing so vast a multitude of eggs, that the failure of a large proportion of them is unimportant. It appears that at least one third of the spawn fails of impregnation by natural methods, but as man's supply is limited, and every healthy egg may be fecundated, sound economy requires him to take such measures as experience has shown effectual in producing the largest proportion of young fry. The salmon lays 25,000 eggs, the pike 100,000, the tench 70,000, the perch 200,000, the eel-pout 100,000, in a single season, and these numbers increase much in proportion to the bulk of the fish, so that the sturgeon and other large fish may produce millions at one spawning.

The migrations of fish are prompted solely by the impulse to find proper localities for spawning, and for the breeding of the young. To deposit their eggs on shallow coasts, the herring and the tunny fish annually migrate from the deep sea, and a like instinct draws the salmon and the shad from the sea into fresh-water rivers, and the trout from the lakes to the brooks. The fish, which before widely scattered in pursuit of their prey, now assemble in great shoals, and proceed to their place of destination, the females leading the column, the males following. The whole attention of the fish is absorbed by the function of reproduction and they run blindly into the nets, which at other times they shun. The spawning season therefore furnishes the greatest facilities for catching them, and all great fisheries of commercial importance, such as those of the sturgeon, the salmon, the herring, the cod, the tunny, and the shad, are prosecuted almost exclusively at this period. With each parent, if taken before spawning or emission of the milt, perish countless multitudes of the young, and we may justly fear the gradual exhaustion even of the abundance of the sea.

The processes of reproduction are somewhat different in the different species of fresh-water fish. The European brook trout spawns in the latter part of September or in October, according to the season. The female seeks for a suitable place, generally in shallow water, on a gravelly bottom, and behind some large stone, to deposit her eggs. She is generally followed by several males, and she appears specially to favor one of these, which tries to drive away the others. The eggs are generally laid only by night, and especially by moonlight. By a movement of the tail, the female scoops out a shallow hollow, and deposits the eggs within it, and the male immediately emits the milt upon them. In the course of these movements the spawn becomes usually covered with sand, and it is now left to itself. The great trout of the Lake of Geneva, which sometimes weighs forty pounds, proceeds in the same way. The shallow spots in the Rhone below Geneva, where this trout spawns are known to all the fishermen. One of these is before my door, and at the spawning season it is easy to observe the process. Each female is usually following by several males. They play with each other, splashing the water, and a deposit of spawn is made from time to time, and immediately fecundated by the male. The *Palee* in the Lake of Neufchatel spawns in December. The fish collect in shallow places, keeping in pairs, and at the moment of spawning, spring together some feet out of water, belly to belly, dropping eggs and milt at the same moment. In moonlight nights, when many are spawning, the sudden shooting of these silvery fish out of the water is a very curious spectacle.

Rusconi, an Italian Naturalist, thus describes the spawning of the gudgeon: "As I was admiring a group of trees on the shores of the little lake at the Villa Traversi,my attention was arrested by a noise resembling the strokes of a stick or the blade of an oar upon the surface of the water. Looking in the direction whence the sound proceeded, I discovered that it was caused by fish in the act of spawning. I approached the spot, and, concealing myself in the shrubbery, was able to observe the process. It was at the mouth of a little brooklet of clear, cold water, but so shallow, that the gravel in its bed was left almost dry. The spawning fish swam so swiftly from the lake towards the outlet of the brook, that the impetus carried them two or three feet up the channel, not leaping, but sliding over the gravel. They now, lying on the bottom, where only the belly and lower part of the head were covered by the water, wriggled the body and tail right and left, thus pressing the belly against the gravel. They continued this movement seven or eight seconds, then struck the bottom smartly with the tail, turning at the same moment and springing back into the lake, and soon again repeated the process. Some naturalists have maintained that in the act of spawning the fish lie upon their sides, so that the belly of the male is in contact with, or at least near, that of the female, but in the instance I witnessed, there was no such conjunction. Each fish entered the rivulet by itself, and deposited spawn or milt separately."

The stickle-back even resorts to nidification. The male constructs a round nest of fragments of plants and little pebbles, in which the female lays the eggs. Argelander gives the following account of the spawning of the pike.—"The male or milter swims by the female or spawner in such a way as to keep the ventral orifices of both near together. They rub against each other's sides for some time, and alternately bend the lower half of the body, still keeping near each other, with the tails apparently in closer proximity than the heads. After some time spent in this manner, they bring their bellies into contact by a sudden movement, and at the same moment splashing the water with their tails, they start forward a short distance, and become separated. All this takes place very rapidly, and is accompanied with an emission of spawn and milt. As soon as the female stops, the male resumes his position by her side, and the spawning process is repeated for ten or twelve times."

Most fresh-water fish lay their spawn loose upon the ground, covering it with a little sand or gravel. But some, as the perch, the sand-eel, and the gudgeon, attach the eggs to waterplants or stones, and those of the perch family form considerable agglomerations like frog spawn. Perch spawn may be readily obtained by sinking willow basketwork in the spawning places at the proper season, and it will be found the next morning covered with spawn usually fecundated.

Much depends on the temperature of the water, both as respects the period of spawning and the development of the egg. Spawning may be delayed from a week to a fortnight, by transferring the fish to colder water, and the hatching of the fry may be accelerated or deferred in like manner. The development of the cyprinoids, which takes Place in the warmest summer weather, is completed in as many days, as that of the trout, which occurs in winter, occupies weeks. In the fresh waters of Europe, the spawning seasons of different fish take place from March to December, and the young are hatched generally in one or two weeks in the warm season, and in from four to six in the cold.

The reproduction of the eel is not well understood. It is probably oviparous, but the eggs are microscopic. The young make their appearance in March or April and at this period are found in prodigious numbers at the mouths of many rivers in western France and Northern Italy. At night fall, immense multitudes of the transparent pin-like fry rise to the surface of the water, and swim up stream.

They are scooped up in fine nets or sieves, and employed for pancakes and similar dishes, and thus many millions are destroyed every year.

In considering the processes of nature which take place before our eyes, we find numerous causes of destruction which may be obviated by human care. I have already adverted to the failure of impregnation, and pointed out the means of remedying this evil. But the spawn once fecundated is still exposed to the depredations of many enemies, of which the eel pout is the most destructive.— This flat broad-headed fish which always creeps along the bottom, feeds chiefly on the eggs of other species. I have never taken the eel-pout in the Rhone at the spawning time of the trout family, without finding its stomach full of fish eggs. But it is not other species alone that prey on the spawn. The male trout, if caught at spawning time, will always be found with trout-eggs in the intestines, and the fishermen and millers of the Rhone affirm that the young males follow the larger females, and greedily swallow the eggs at the instant of emission, though they do not appear to prey upon them when once fairly deposited, as the eel pout and groundling do.

Not less mischievous are the crab, the larvæ of some insects, the crawfish (*Gammarus*) and the carp-louse (*Argulus*). It is seldom that we can take a mass of perch-spawn from the water without finding upon it carp-lice, which perforate the eggs and devour the contents. So the water-rat and water-shrew, and all aquatic birds that habitually *muddle* the bottom, as geese, ducks, and swans, are very dangerous to fish-eggs, especially to those which cling to waterplants or are deposited in masses.

The vegetable kingdom, too, contributes an enemy to fish spawn, in a parasitic mildew or fungus, whose sporules attach themselves to the external coat of the egg, and soon throw out long fibres which envelop the egg as with a radiating net-work and choke the germ. This fungus multiplies with such rapidity that in a short time an entire brood is destroyed, and its progress can be checked only by the immediate removal of every infected egg. Equally injurious are certain microscopic vegetables of the family of the *Diatomaceæ*, as the *bacillariæ* and the *gomphonemæ*, of which the familiar brownish slippery slime that coats the stones at the bottom of the water is composed. These spread only where light penetrates, and hence it is that some fish protect their spawn by covering it, or attaching it to the under surface of water-plants. These microscopic vegetables are so minute that no sieve is fine enough to exclude them, and it is consequently important to keep the eggs in absolute darkness during hatching.

If the spawn escapes these many dangers, and is duly supplied with water, air, and a proper degree of warmth, the fry is soon hatched. The egg must be kept so moist, that the outer skin is constantly distended, and the space between it and the yolk quite filled with water. This is best effected by complete immersion, but this condition is not indispensably necessary. A friend of mine had chanced to leave some trout-spawn on a coarse woolen cloth, which was kept constantly wet by the water that dropped from a filtering-stone. To his surprise, the eggs developed themselves as perfectly as those in the hatching apparatus, the supply of air and moisture being adequate.

Air, or rather the oxygen contained in water, is essential. The egg in the process of development respires in the same way as the fish in water. It absorbs from the air dissolved in the water its oxygen, and gives out carbonic acid, and accordingly well water, which contains less oxygen than river-water, is less favorable to the development of the young. For the like reason eggs immersed in water which has flowed over other spawn, and thus been deprived of some of its oxygen, hatch less rapidly. Whenever, therefore, the water is not constantly renewed from a running stream, a fresh supply of oxygen must be secured by frequently changing the water during the hatching.

Different species require different degrees of warmth.—Thus the eggs of the trout are not destroyed by a freezing temperature, whereas they would probably perish at a temperature above 12 degrees (centigrade, equal to about 54 degrees Fahrenheit,) while those of the carp, which require greater warmth, would develop very slowly at that degree. Upon these points however, precise observation is wanting.

In practical fish-breeding, two periods are of special importance in the life of the hatching egg; one immediately after impregnation, the other when the eyes of the young begin to be visible through the egg-shell. The first of these periods is the most critical, for in spite of every precaution, and under circumstances apparently the most favorable, there will always be a considerable number of eggs whose milky turbidness indicates that they are unsound. It is during this period that the foundation of all the organic processes, and of the whole structure of the fish, is laid, and the slightest disturbance suffices to defeat success. Great care must therefore be observed, and as all agitation is dangerous, the spawn ought not to be moved during the first days of development.

The black pigment in the eyes, which shows these organs through the egg-shell as two disproportionately large dots, makes its appearance in the latter half of the process of hatching, and at this period the egg, with the young it contains, will bear rough treatment without injury. While observing the developement of an egg under the microscope, I accidentally dropped the glass capsule containing it upon the floor. The egg rolled out of my sight, and was found, hours afterwards, in a crack in the floor. It was then thrown into the vessel with others, and was the second of the whole number that hatched, having been quite uninjured by the fall, and by lying dry at least an hour. If then, eggs are to be transported to a distance, or otherwise disturbed, they should be moved only during the early part, of this period. This power of resistance depends of course on the firmness and elasticity of the skin, which diminishes before hatching in order to permit the escape of the fry, and the appearance of the eyes is important as indicating the period of the greatest strength of the envelope and the ability to bear transportation or other manipulation.

As soon as the embryo has attained a certain degree of development, it bursts the egg shell, which has now become weaker and less elastic. It now appears in the form of a lengthened perfectly transparent animalcule, which would be almost imperceptible in water but for a large sac attached to the belly, sometimes of a round figure, and sometimes, as in the salmon and trouts, drawn to a point posteriorly. This sac, which is the yolk, contains the material not employed in the growth of the embryo, and which is to supply nutriment to the fry during its earliest periods of independent life. So long as the yolk-sac remains thus attached, which is usually about as long as the period of development *within* the egg, the young lie for the most part stationary at the bottom of the water, actively fanning with the large pectoral fins, in order to bring a fresh supply of water to the organs of respiration. Occasionally, they shoot forth, turn round once or twice, sink quietly again to the bottom, and hide under the stones and in the sand. At this time they take no food. The yolk-sac communicates with the intestinal canal by a short passage, through which the remainder of the yolk is gradually absorbed by the fish and digested. When the sac is completely exhausted, and the belly of the fish has become smooth, the appetite for food first appears. The young fry now become active in the pursuit of prey and nourishment, and feed greedily on the smaller aquatic animals, the minute larvæ of insects, worms and the like, which inhabit the water in multitudes.

The young fish are exposed to a great number of enemies, especially during the period of repose, immediately after their exclusion from the egg. Besides the fish and the crabs which have been already mentioned, they are preyed upon by numerous carnivorous larvæ of insects, water-salamanders, and aquatic birds, and but a small proportion of the fry escape these multiplied dangers.

What then is the proper object of artificial fish-breeding? Not indeed to provide new material, for this nature abundantly supplies, but to make this material available, to avert the dangers which threaten it, and to furnish to it plentifully the elements it requires for its full development. It is absurd to say that we ought to follow the processes of nature, and them only. Nature loses more than ninety per cent. of the material capable of development which she provides, and all her economy is calculated for this proportion of loss; the population of the waters, if undisturbed by man, would still remain at the same average level, notwithstanding this enormous waste. It should be our aim to preserve this superabundance of material, and to adopt such methods as will secure development and growth to the largest possible proportion of it.

The process of impregnation is simple and obvious. If, at the spawning season, fish are simply lifted by the gills, eggs or milt will be emitted, but if gentle pressure is applied from the head towards the tail, these substances will be thrown out in a continuous stream. The finest males and females should be selected for breeding, and in the case of brook-trout, they should weigh from three fourths of a pound to a pound. The eggs and milt should be received in a shallow vessel containing barely water enough to cover the eggs expected to be obtained, and a little experience will enable the operator to estimate the quantity accurately enough. An excess of water is injurious, because it dilutes the milt, disperses the seminal animalcules, and diminishes the chances of impregnation.

Success depends much on rapidity of manipulation. The fish is seized by the head and held in or over the vessel, and the belly is gently squeezed or pressed downwards from the head to the ventral orifice. One male will yield milt enough to fecundate the spawn of four or five females.—If several operators work together, it is best to squeeze the milt and eggs into the water at the same time. If there be but one operator, and he has acquired such dexterity that the process can be very rapidly gone through with, he should, for reasons given above, first squeeze the milt and then the spawn into the water, but if, from the size and weight of the fish, or want of practice in manipulation, the process is more slowly performed, it is better to squeeze the spawn first into the water. The milt and spawn having both been received in the vessel, the water should be stirred a little with the hand, in order to effect a more perfect contact between the milt and the eggs, and the vessel should then be left to stand for an hour in a temperature about equal to that of the running waters in which the fish naturally spawn. The impregnation is now completed, more thoroughly than by mere natural processes, and the probability is that the greater part of the eggs will hatch.

Next comes the hatching, which requires the close attention of the breeder. The essential points are the conditions above mentioned of an abundant supply of well aerated water at a proper temperature, removal of unsound eggs, and protection against the dangers which have been adverted to. Fish of the trout family are the most susceptible and delicate of all. They require the purest water, as well aerated as possible, and to this end it should be frequently changed. The current of a running spring, a stream from a brook or a river, or pure water from a lake or pond, if often changed and kept in motion, will serve.—The more abundant the supply, and the more constant the change of water full of pure air, the better.

With respect to protection from external enemies, it may be remarked, that ravenous fish, crabs, and spawn-eating insects may be excluded by a wire net work or sieve, or other similar contrivance, but the microscopic sporules of the parasitic mildew, which so soon destroy the egg and spread so rapidly through the spawn, cannot be kept out by the finest sieve or even by a filter. The spawn must therefore be so placed that it it can be very frequently examined, and infected eggs at once extracted. This is most conveniently done with a pair of tweezers or small forceps. The eggs should be carefully inspected twice a day, and every one that shows the best sign of disease, the least degree of whitish turbidness forthwith removed. The purest unfiltered water, when left at rest, deposits fine particles, and it is well to free the spawn daily from any accumulation of such particles by passing over it a soft hair pencil, because the sporules of mildew, the most dangerous of all enemies, often lurk in these deposits.

As to the hatching apparatus, it may be said that any is good which admits a free circulation of water, excludes rapacious enemies, and permits ready access to the eggs, and the easy removal of such as are infected. The method of Mr. Knoche, of Coverden in the Electorate of Hesse is as follows:

"For a breeding chest I employ a stone trough seven feet long, two feet broad, and one foot deep, and provided with a wooden cover fitting into a rabbet and secured by a lock. To one end of the cover is nailed a frame whose length is equal to the breadth of the cover, namely two feet, and which is four inches wide and four inches deep. Within the frame several holes are bored through the cover to receive the water which is supplied from above. To exclude impurities, insects, and other small animals of prey, a piece of coarse linen cloth is nailed over the frame, and all the water which enters the trough is, of course, strained through this cloth. Within the breeding trough there is a perforated box, which distributes the water received from the frame evenly and quietly through the trough. At the opposite end of the trough, six inches above the bottom, are two square holes covered with finely perforated tin plate and so adjusted as to permit the escape of the same quantity of water as is admitted through the frame. The trough is sunk in the ground near a spring, which is raised by a dam to the height of a foot, and the water is conducted directly to the middle of the frame on the cover of the trough through a pipe about an inch and a half in diameter. The bottom of the trough is filled up to the depth of three inches with clean washed sand or gravel, and the water always stands three inches deep on the sand. When the eggs are introduced the flow of water from the spring is shut off, and the impregnated spawn, after standing three hours, is carefully poured into the trough, and so distributed that the eggs are not in contact with each other. The distribution is affected, *without touching the eggs*, by agitating the water over them with the bearded end of a quill. The trough is now closed and left undisturbed for twelve hours,after which the water from the spring is admitted again and kept regularly flowing for six weeks."

The sand or gravel which Jacobi and his successors employ as a bedding for the spawn, is altogether superfluous, and is moreover objectionable, because it obstructs the examination of the eggs and the removal of unsound or mildewed ones. A stone or other hard bottom is to be preferred.

In order to show how much the process may be varied in conformity to conditions of necessity or convenience, I will mention two methods employed by Drs. Mayor and Duchosal of Geneva. In some of their experiments they used the common drinking water which is raised from the Rhone into a great reservoir by machinery, and then distributed through the city in pipes. A frame resembling the stepped stands used for flower pots, was placed under a lead aqueduct pipe with a stream a finger's breadth in diameter. The eggs were deposited in square earthen pots, which were arranged on the steps of the frame. Each pot had a small aperture in front, into which was introduced a pipe to convey the water to the pots of the next tier below, and in all the pots the water was kept one inch deep. The aqueduct pipe was pierced with holes corresponding to each pot of the upper tier. These pots, which were about a foot square, received a constant stream of about a line in diameter directly from the aqueduct pipe, and the lower pots received their supply from the tier next above, respectively. The eggs hatched equally well in all, but from the partial exhaustion of the air in the water in passing through the upper tiers, the eggs in the lower tiers were somewhat longer in hatching.

In another case, they employed a different process in the current of the Rhone. The eggs were deposited in deep, flat-bottomed earthen pots, with holes in the sides an inch above the bottom, which admitted a free circulation of river water. The pots were inserted in small floats or rafts made of a couple of boards, covered lightly, and left to float in the river. The floats were secured by a cord, and the pots could thus be drawn to the bank at any time for examination and the removal of mildewed eggs. The success of the experiment was perfect. The boxes proposed by Jacobi, and the wicker-work of willow or wire recommended by others, have been employed with equally favorable results, but they are not so easily handled as pots with smooth, yellow-glazed bottoms, which enable the operator readily to see and remove defective eggs.

During hatching, the breeder has nothing to do but to see that water is regularly supplied and the mildewed eggs picked out ; and if the apparatus is conveniently arranged, it will not require more than an hour daily, at the commencement of the process, to inspect 100,000 eggs, and remove the infected ones. At a later stage, even less time is demanded.

So, after the exclusion of the young from the eggs, so long as the yolk-sac still remains attached to the abdomen of the fry, little attention is required of the breeder. It is well to remove the brood to a larger receptacle, as for example a long trough with one or two feet of water, to allow them space for their occasional movements. If the number of fish is large, as in a governmental establishment, a system of shallow canals should be employed, supplied with water from a running stream and lined and paved with flat tiles, brick or other materials, so as to prevent the growth of water-plants, and keep the bottom smooth and clean ; for such plants are lurking places for all the insects, and other small animals which prey on the young fry. While the yolk-sac holds out, the young subsist in the pots, troughs, or canals, without other food. In large rivers, ponds or lakes, where the flow of the water cannot be controlled, and of course floating apparatus must be resorted to, the breeding trough of Jacobi is to be recommended. This is a box of convenient length and breadth, and about a foot in depth, provided with a strong cover made removable for the inspection of the fry, and with a fine wire net-work at each end to admit water without allowing the escape of the young. The bottom of the box is loaded, so that it floats horizontally in the water, and it is so anchored or moored that the current may enter at one end and pass out at the other. A box six feet long and two wide allows space enough for 6000 young fish. In still or slowly flowing ponds or rivers, the dimensions should be greater and the water may be changed, and made to circulate through the box by drawing it occasionally to and fro by the mooring cord.

The most laborious period for the breeder begins when the young fish have exhausted the yolk-sac, which with the brook-trout is about four weeks after hatching, with the salmon about six. The fry must now be fed, and their food must be furnished in portions so small that these minute creatures can master it, and it should, moreover, be in a form that has the appearance of life or at least motion. They also require increased space for motion and feeding, for every one appropriates to himself certain limits, within which he usually remains and hunts for prey. Shell-crabs, and crab-fleas, the larvæ of small insects, as snails, musquitoes and water-flies, form their principal natural nutriment. Such food may indeed be supplied to artificially bred fish, for every brook and pond abounds with it, but when some thousands are to be fed, it is obvious that a method which might succeed with a small number is im-

6

practicable. Where however, all the natural conditions are favorable, the young may be left to feed themselves in suitable reservoirs. Knoche admits the young fry into a carefully cleansed pond supplied by a spring, and at the end of a year, when they have attained the length of six inches, he finds half the original number, the rest having perished or escaped. The fish in this case are left quite to themselves, unfed, and exposed to all the dangers which beset them in natural ponds. For trout, a winding brook would be better than a pond, and the loss of fifty per cent. would be more than compensated by the saving of time, cost, and labor.

But where the natural facilities do not exist, where the breeder can command but little water, and artificial ponds or canals only, feeding becomes necessary, and for this the refuse from slaughter-houses is particularly well suited. Small salmon and trout devour coagulated blood with avidity, particularly if it is forced through a syringe, so as to give it a worm-like appearance. Fragments of meat, the flesh of animals which die from disease or accident, or of white fish, which can sometimes be had in great abundance, are also greedily consumed, especially if the fibres are well separated by boiling, and then the whole beaten fine in a mortar, or grated. Boiled or dried flesh thus prepared, and scattered on the water, divides, in sinking, into fine threads resembling worms, which are eagerly swallowed by the fry.

It has also been proposed to breed fish of inferior sorts, to supply food for the more valuable kinds, particularly the trout. But this method is sometimes attended with unforeseen difficulties. It is true that young salmon and trout greedily seize upon freshly hatched pike, and easily swallow them. As the pike spawns in March, and hatches its young in April, and the trout have then just dropped the yolk-sac, and are beginning to seek for prey, this method furnishes them with a suitable and natural diet. It may therefore be employed on a small scale with advantage.—But in larger operations, some of the pike will be sure to escape their pursuers, and, the next year will prey in their turn on the trout. In our experiments in the Rhone, it sometimes happened that a few yearling perch found their way into the feeding basin, which was about six feet deep, twelve wide, and twenty long, and they committed great ravages on the young fry before they were discovered and caught. The breeding of white-fish for food the first year is objectionable because they do not spawn early enough to furnish nutriment to the young salmon and trout at the period when it is most wanted; and in fact the only fish which spawn at the right season for this purpose are those which, like the pike and the eel-pout, become dangerous enemies the second season. In large establishments, however, the smaller kinds of white-fish, which do little injury to the eggs or the young of other species, may be advantageously bred as food for trout which have reached their second year.

Very erroneous opinions have been maintained with respect to the growth of young fish. The author of an essay on artificial fish-breeding in Cotta's Quarterly (1856 No. 1) cites from a Scotch source some very fabulous observations, according to which, salmon hatched in the Tay, marked and allowed to escape to sea when they had grown to the weight of an ounce, had been caught on their return to the river two months afterwards, and found to weigh from five to five and a half pounds. The author of the article in question is quite right in hesitating to swallow so palpable a humbug as this. The absurdity of such statements will more clearly appear from the experiments of my friend, Dr. Mayor, on sea-trout. The fish in this case were kept and abundantly fed in a spacious basin communicating with the Rhone, and it was established by sufficient observation that their growth corresponded to that of salmon bred naturally in the river itself. Dr. Mayor observes :

"Sixty eggs of the sea-trout weigh a quarter of an ounce, and accordingly a single egg weighs two grains and two fifths, and a pound contains 3,840. The spawn of a sea-trout of sixteen pounds weighs about four pounds, and contains of course, 15360 eggs. The fish are taken at the wier at Geneva, only on their return to the sea after spawning (when they still retain their fine flavor,) and from the known number of those so taken we may estimate the total number of the eggs deposited at about three millions. A newly hatched sea-trout weighs two grains and one third, rather more than the egg, and the weight remains stationary during the gradual absorption of the yolk-sac, which occupies six weeks. The subsequent growth will appear from the following table.

Date of weighing.	Period after hatching.	Weight in grains.	Length.
May 28	77 days	8	9-10 of an inch.
June 6	86 "	15	
" 18	98 "	18	
August 13	154 "	66	
September 1	173 "	67	
" 21	193 "	95	3 inches.
October 15	217 "	146	
November 24	257 "	151	
December 3	268 "	160	5 inches.

"In the autumn of 1854, sea-trout were taken in the open Rhone measuring seven inches in length and weighing two ounces, which were evidently hatched in the spring of the preceding year, and of course were eighteen months old.

" Sea-trout of two years, caught in the Rhone at the same point in the spring of 1855, measured about eight inches in length, and weighed from two and one third to three and one third ounces.

" The natural bred trout taken in the open Rhone are neither longer nor heavier than those bred in basins ; but there are great discrepancies in the growth of these fish, according to the abundance or scarcity of their food. A trout was taken on the 24th of November weighing 40 grains only, but which belonged to a brood that generally weighed 150 grains."

It is not necessary to speak further of the care of the fry after the age of a year, but whenever the breeding of fish shall be carried on upon a large scale, it will be necessary to have a series of ponds, or artificial divisions of running streams, for keeping the broods of each year by themselves, until they are of a proper age for market, because the fish which it is most desirable to breed, as the pike and the trout prey upon the younger and weaker of their own species.

It is important to determine what particular species should be selected for artificial breeding. If it is considered as a question of profit, it is obvious that we should breed the kinds most valued in the particular market for which they are bred, which command the best price, and which are best accommodated to the natural or artificial conditions at the disposal of the breeder. If fish from distant localities promise a better return than the native species, they should be introduced, but on this point no precise rules can be laid down, and experience alone can be a safe guide. The fishermen of Comacchio, who breed with advantage millions of eels in their lagoons, would greatly err in exchanging them for sea-trout, as would the inhabitants of the shores of the Lakes of Geneva, and Neufchatel, in abandoning the trout for the eel, which there is almost valueless. So it would be a mistake to attempt the breeding of eel-pouts or sheat-fish (cat-fish) which indeed grow rapidly, but whose value would by no means compensate the mischief they do by destroying the eggs and young of other species. In fact artificial breeding must be confined to a few species which combine the necessary advantages.

First of all, rank the fish of the trout-family; as the salmon, the sea, the river, brook and lake trouts and the grayling. Trouts require clear shaded water, with a sandy or gravelly bottom, and of low mean temperature. Brooks, rivulets and clear mountain lakes are particularly well suited to them. A muddy bottom is particularly obnoxious, and they are more readily affected than any other fish by impurities in the water, such as salts, dye-stuffs and other refuse from factories, and the sooty dust and acrid fluids from gas works.

For still waters, deep and clear ponds, the lamprey is well adapted, particularly as some of the varieties of this fish may be advantageously pickled or smoked. Some of the species preserved by these methods are important articles of commerce in all the German States. Indeed almost every climate and every locality has fish which may be multiplied and bred with profit, and experience alone can decide what native or foreign species best reward the care and cost bestowed upon their propagation.

The introduction of new fish from remote localities, is, with the present rapidity of communication, extremely easy. As before observed, the proper period is when the eyes of the embryo first become visible through the egg-shell. At this time, the young fish occupies in the egg the smallest space into which it can be compressed; the tough outer skin or egg-shell which encloses it, is a much better protection against external violence than the tender skin of the newly hatched fry, and the development of the embryo has already progressed so far that it is not likely to be checked by the ordinary accidents of transportation. The only special precautions required are those which secure a due supply of air and moisture. The eggs might be transported in vessels filled with water but for the necessity of frequently changing the water, which can dissolve but a small proportion of air. The simplest and most convenient method is to pack the spawn in alternate layers with substances which retain moisture long, such as fine sand, aquatic plants, or shaggy woollen cloths, in wooden or tin boxes with covers perforated for the admission of air. The bottom of the box being covered with a layer of such material properly moistened, the eggs should be spread over it in such manner as not to touch each other, then another layer of moistened cloth, weeds or sand, and then eggs again, and so on till the box is full, taking care to cover the whole with a layer of the moist substance. For distances not exceeding forty eight hours, soft aquatic plants form the best bedding, but if a longer time is required, batting or cloth is preferable, because the commencement of decomposition in the water-plants might, in that case, be injurious to the spawn. During the journey, eggs thus packed require no attention, and as salmon spawn kept for two months, in a box of wet sand, in a cold chamber but with a temperature above freezing, still retains its capacity of development, it is evident that it may be transported not only throughout Europe, but to North America. It must be observed, however, that this applies only to fish, which, like the trout family, spawn in the winter, and require a long period for hatching, and it should be particularly remembered that after a long transportation by this method, the eggs must be gradually admitted to a full supply of water, as they will otherwise be injured by a too rapid absorption of that fluid.

The governmental establishments of Huningen in France, and Munich in Bavaria—furnish fish-eggs at the following rates per thousand.

	Hüningen.	Munich.
Ombre chevalier, (salmlet,)	$1,37	$1,20.
Danube salmon,	1,	,80.
Rhine "	1,	1,00.
Lake "	1,17	1,00.
Trout,	,75	,80.
Graylings,	,75	,40.
Sturgeon,	1,17	

The transportation of living fish, young or full-grown, should not be attempted. Not that with a sufficient expenditure of cost and labor it is impracticable, but the expense and trouble are out of all proportion to the results. Monsieur Valenciennes contrived by great effort to send a dozen living fish from Germany to Paris, but they were of species no way superior to kinds already abundant in France, and it appears that they perished at last without leaving any progeny behind them.

That the acclimation of fish is practicable, the ancients proved by introducing upon the coasts of Italy new species from the Black Sea and the Ægean, and there are modern examples of similar success. To what extent the naturalization of foreign fish can be carried, time and experiment alone can determine, but in any case success is much more likely to be attained by transporting the spawn than by transferring living and especially full grown, fish which have already become accustomed to the peculiar conditions of their native locality.

But what has already been accomplished in artificial breeding, and what further important results remain to be hoped for?

As to the success of private operations, where the breeding is artificially conducted from the spawning to the market, an opinion may be formed from the following statement by Mr. Knoche.

"For the last six years, I have hatched annually about eight hundred fish from a thousand or twelve hundred eggs. At the end of a year from hatching, I seldom find more then half that number in the pond, the rest having perished or escaped, most probably the latter, because it is very difficult to make a pond so tight, that the fry cannot sometimes pass out at either the inlet or the outlet of the water. My fish in general thrive well, and for the last three years my ponds have supplied annually from three to four hundred three and four year old artificially bred trout, those of the latter age weighing from three quarters of a pound to a pound."

But a much wider application of the process of artificial breeding is suggested, and it is proposed to extend it to species which require great space, which annually migrate, and like the salmon the sturgeon, and the shad, alternately inhabit salt water and fresh. For this purpose private enterprise can only be made available in the few cases where individuals control large fisheries, like those of some British proprietors. To Lord Grey, whose salmon-fishery in the river Tay, yielding an income of four thousand pounds sterling in 1830, but in 1853 had fallen to less than two thousand pounds, it was a matter of very serious interest to find some means of bringing up his revenue to its former amount, and the expense of impregnating some millions of eggs every year bore no proportion to the expected profits. In fact many proprietors in England and Scotland have succeeded by artificial breeding, in bringing salmon to spawn in rivers and brooks which they had never frequented before, for the salmon, like the rest of the trout tribe, return to spawn in the waters where they were bred.

The most important advantage to be hoped from artificial breeding is the re-stocking of rivers or shores where the fishery is public, and here only governments or public associations can act. The French government has set the example by founding an establishment at Huningen, the practical working of which it is not easy to ascertain.—While M. Coste considers it in all respects successful, and affirms that it not only can, but actually does, breed millions of fish every year, others describe it as little more than a miserable *shanty*, with a few boxes of eggs and a couple of dozen of miniature fish, an object of ridicule to its very managers. The truth doubtless lies between these extremes of exaggeration. The arrangements themselves are unquestionably excellent, and perfectly adapted to the natural conditions of the locality, as is also the establishment of Count Curzay near Paris for those of that region. But as a curse seems to rest on all governmental industrial undertakings, especially in France, we may well imagine that the establishment at Huningen will fail to add the expected millions to the national resources of the French Empire.

From the similar attempts which are making elsewhere there seems no ground to expect great *immediate* results.—Fish are of slow growth, and fisheries in open and public waters are exposed to many fluctuations and contingencies, the causes of which are not well understood, and it is hence obvious that the fruits of a general system of artificial breeding can be estimated only after the lapse of a considerable period. As an illustration of the extent of these fluctuations, I may mention that the great city weir at Geneva furnishes during the three months from November to January inclusive, in average years, twelve hundred pounds of sea-trout. In the year 1853 not one hundred weight was taken. There was naturally a general complaint of the decay of this fishery and the increasing scarcity of fish in both the lake of Geneva and the river Rhone, but the abundant fishery of the following year showed that the supposition of a permanent decrease of fish was without foundation. We cannot then, so long as such unexplained fluctuations exist, draw any safe conclusions from the experience of a few years.

In conclusion, we can only recommend perseverance in experiment, and especially a sound discretion in the selection of the species to be bred, whether native or foreign, with reference to the ultimate profit to be derived from their multiplication or naturalization. The general duty of governments is plain. The mere prohibition of particular implements of destruction at particular seasons effects little. The more severe the penal restrictions are, the more unpopular they become, and the more likely they are to be disregarded. Governments should found breeding establishments under the direction of competent scientific men, in order that their experiments may be conducted with due precision, and liberal measures should be adopted for the general diffusion of the fullest information on the subject among the people. The public establishments should furnish at reasonable rates eggs of the best species for breeding, and should keep always on hand a sufficient stock of young fish of different ages to illustrate the processes of breeding and rearing in all their different stages. With such measures, there can be no doubt that results will follow analogous in character and importance to those which have been accomplished in the breeding of domestic land animals and in other branches of rural industry.

APPENDIX.

DOCUMENTS REFERRED TO IN THE PRECEDING REPORT.

Extract from a Report to the Legislature of Massachusetts. May, 1857.

*   *   *   *   *   *   *

For further information contained in books on the subject, the Commissioners would refer to various numbers of Silliman's Journal of Science; especially to the numbers for May, July and September, 1853, May and July, 1855, and March and May, 1856. The Scientific Annual by D. A. Wells, also contains, in several of the volumes, brief articles on the subject. We also found an article on Pisciculture in the Revue des Deux Mondes for June 15, 1854, by Jules Haimes, containing an excellent history of the subject, with many valuable observations. Not having leisure to translate it, the task was kindly undertaken and performed by Mr Gamaliel Bradford. As the publication of this article appears to us to be desirable in order that full information may be spread before the public, we transmit it herewith, in order that the Legislature may make such use of it as they may think proper.

Several years since, a work was published in France by M. Coste, from which the American writers have derived much of their information. A new and improved edition of that work was published in 1856, but we believe it has not been translated. It can be easily obtained through importing booksellers. Its instructions, in respect to the transportation of fish for breeding, the transportation of spawn, the preparation of spawning beds, and the keeping of fish in inclosures, deserve attention.

The report of M. Millet to the Société Impériale Zoologique d'acclimatation, in March, 1856, contains valuable suggestions in respect to the planting of trees on the borders of streams where fish are raised.

In France, the artificial propagation of fish was commenced by two illiterate fishermen a few years ago. Their wonderful success soon attracted the notice of men of science, and afterwards of the government; and it is now regarded as a matter of great public concern. Information has been collected and experiments have been made at the public expense in respect to every variety of valuable fish, to be found in their fresh waters, and very recently, attention has been directed to the multiplication of various species of marine fish, on and near the sea shore. It is found that the supply of food from this source can be greatly increased.

In this country, the supply of food is so abundant, that the preservation and improvement of the fisheries in our fresh waters has been much neglected. The increase of our population for half a century or a century to come, will be likely to give to them a new importance. Even now, we have found a much greater interest in them than we had supposed to exist.

Massachusetts abounds in streams suitable for trout; and from many of them, large quantities are taken every year. But there are very few instances, where the owners of the lands over which the streams flow, take any pains to preserve or to multiply their stock of fish, or even to claim them as their property. An implied license is given to all persons to fish at their pleasure. Hence the stock of fish is greatly diminished and very few fishes grow to their full size. They are not regarded by their owners as valuable property, and fishing is pursued as a mere pastime.

But this state of things cannot last long. As wealth increases, trout are sought as a luxury, and they have already acquired a market value so great that the proprietors of streams might profitably raise them for market. There are many persons who need rural exercise, and who would cheerfully pay a liberal rent to the proprietors of a stream, well stocked with trout, for the exclusive right of fishing. We believe there are many farms on the hilly and mountainous parts of Massachusetts, containing trout streams, that, with a little pains, might be made to yield a greater income in this way than the land itself. Much might be done to increase their value without resorting to artificial breeding. The preparation of suitable ponds or pools of deep water, and of gravelly beds, suitable for spawning, with slight guards to prevent the destruction of the fish by freshets, would greatly increase the stock. But the process of artificial propagation is so simple and easy, that when trout become an object of care, we cannot doubt that they will be multiplied and protected by this method. Many millions of fine trout may thus be produced annually, and what is now regarded as a mere temptation to waste time, may be made, not only to minister to luxury and health, but become an important branch of productive industry. In addition to this, fish ponds with borders of trees and shrubbery add to the beauty of a landscape, and must increase the value of a farm.

The spawn of fish are so numerous, that the stock can be increased with immense rapidity; and by the exercise of proper skill, a large proportion of the spawn can be hatched. In England, out of 300,000 salmon spawn, 275,000 were hatched by artificial means.

Our large streams, and especially those whose current is comparatively sluggish, and which, on that account, are unsuitable for trout, might be made to yield a large stock of various other species of marketable fish, such as are adapted to their waters. Those large ponds and reservoirs, which have been created to supply water-power to our numerous manufacturing establishments, might all be turned to a profitable use in this way. It has been suggested that some of the species of excellent fish that are found in our western lakes, would thrive in these waters. The variety might also be increased by the importation of eggs from Europe. In many of them, nothing needs to be done but to increase the quantity of fish they already contain, by artificial propagation, and by protecting the young fishes from destruction till they become sufficiently large to protect themselves against their enemies.

The fisheries of the Merrimack River having been made the subject of investigation during the present session, we need not refer to them particularly. An intelligent gentleman has estimated their value at $16,000 annually; the fish consisting principally of bass, shad, and alewives.

In the Connecticut River, shad and salmon were formerly very abundant. The salmon disappeared many years since. The shad still continue to ascend the river, as far as the artificial obstructions will permit them to go. When the dam of the Hadley Falls Company was erected at Holyoke, a few years since, the company purchased and extinguished all the fishing rights above that point. But the shad still continue to ascend to the foot of the dam, where they are taken in considerable numbers, and they are said to have numerous spawning beds between that point and the head of Enfield Falls. But the proprietors of the locks and canals at Enfield, have so far obstructed their ascent within two or three years past, that it is believed they will soon leave the river entirely, unless something is done for their preservation. This obstruction may be obviated without much expense, and it is believed that, by means of artificial propagation, the river below Hadley Falls, might be vastly better stocked with shad than it has ever yet been. An establishment for this purpose might be erected in this State, and the mouth of the Agawam River has been spoken of as a very suitable place. It is believed that these fish always return from the sea to the river where they were hatched. The ascent is at their spawning season, and they are then in the best condition for use.

Those which are taken for market within the limits of this State, are generally in such a condition that their spawn and milt may be used for artificial fecundation. It has been estimated by persons who are acquainted with the shad fishery of this river, that by means of artificial propagation the number of shad taken in the river might be increased by one or more millions annually; and as the fish are sold for about twenty cents each at the landing places, the value of such an increase would be very great. This improvement in the fishery cannot be made without joint legislation on the subject in this State and Connecticut. Probably a general Act of incorporation which should give a fair proportion of the profits to all persons engaged in the fisheries, from the mouth of the river upwards, would be the most effectual encouragement that these fisheries could obtain from legislation. It would not be difficult to frame an Act which would be just to all persons interested, and which would enable them to maintain an establishment for the artificial increase of the fish at the expense of all in proportion to the value of their respective rights of fishing.

It is also believed by many intelligent persons, that the river might be again stocked with salmon by such a company. But legislation would be of no avail unless it were sought for by the proprietors of the fisheries, and concurred in by both States.

One branch of the inquiries to which our duty has directed us, relates to the necessity of further legislation. In considering this subject, we could not fail to remark the contrast that exists between the policy of our own government and that of France. There the government extends its supervision of property and business to the most minute particulars, while here every thing is left, as far as possible, to individual enterprise; and our policy is to protect and promote industry with the least possible amount of legislation. And therefore, while the legislation of France, in respect to fisheries, exhibits great learning and skill, it is not at all adapted to our circumstances.

So far as trout streams are concerned, no legislation appears to us to be necessary. Each proprietor of land is also proprietor of the fisheries upon it. The law protects him against trespassers and thieves, and so soon as it is understood that the owners of the fisheries consider them valuable and intend to exclude other persons from the use of them, their rights will undoubtedly be respected. We cannot recommend any addition to our penal laws till it is called for and found to be necessary.

In respect to extensive ponds, bordering on a great number of proprietors, and also in respect to large streams flowing through the lands of a great number of proprietors, and in which the passage of fish from one portion of the stream to another cannot be prevented, some legislation would doubtless be proper. It occurs to us that Acts incorporating the proprietors of fisheries, somewhat resembling the Acts incorporating the proprietors of general fields, may be suitable. These acts might confer exclusive right of fishing upon the riparian proprietors, giving to all of them an opportunity to become members of the corporation. If a part of the riparian proprietors decline to avail themselves of the privilege, they should not be permitted to prevent the use of the waters by the others. The laws which justify the flowing of lands for mills, and the taking of lands for aqueducts and other similar purposes, will justify such an appropriation of our fisheries. There is no other method of securing to those who engage in the labor of stocking our waters with fish, the benefit to which they are entitled.

But we do not think it proper that any general law should be passed on this subject. We are without experience to guide us, and probably it would be necessary that legislation should be adapted to each particular case, in order to secure the rights of all concerned. Whatever charters are granted should also be subject to modification, so that if errors are committed, they may be corrected. And no legislation can be of any avail until private enterprise shall ascertain its own wants.

If the State shall be disposed to encourage this branch of industry while it is new, by means of legislative bounties, we would suggest that the agricultural societies of the several counties may be very suitable agencies to be entrusted with the business.

In view of all the information that we have been able to obtain, we have arrived at the following conclusions, viz.: that the artificial propagation of fish is not only practicable, but may be made very profitable, and that our fresh water may thus be made to produce a vast amount of excellent food; that a small outlay of capital and a moderate degree of skill, aided by such information as can be derived from books that any man can procure, will enable the proprietors of our smaller streams and ponds to stock their own waters; that in respect to the larger streams and ponds, a combination of individuals may be necessary, with special legislation adapted to each particular case, and guarding the rights of all persons interested in the waters, especially when they have been applied to mechanical purposes; and that in all other respects, so far as the Commissioners can see, our laws afford to this branch of industry all the protection that can be necessary. If, indeed, any legislation were supposed to be necessary, it would be premature at present. Hasty and inconsiderate legislation is more likely to be mischievous than useful. All laws should be based upon practical knowledge; and, in our opinion, there is too little practical knowledge on this subject in the Commonwealth to authorize any changes in our existing laws.

There is a kindred subject in respect to which legislative inquiry may be useful, and the Commissioners are indebted to Prof. Agassiz for suggesting it. The suggestion is based on the fact that some kinds of fish are brought to market at seasons when they are unfit for use. Trout and salmon, for example, are sent to Boston market, from Maine and elsewhere, as mentioned in Captain Atwood's report, at their spawning season in autumn, when they ought to be left undisturbed, and when they are unfit for food. The same practice is said to exist in respect to some other species of fish. Such sales in market ought to be prohibited by penal laws; but as a preliminary step, a careful inquiry should be instituted into the facts by competent persons. The Commissioners have not considered such an inquiry as being within the range of their duties.

R. A. CHAPMAN,
HENRY WHEATLAND,
N. E. ATWOOD,
Commissioners.

Commonwealth of Massachusetts.

To the Hon. R. A. Chapman, *Chairman of the Commissioners.*

At the time of receiving the appointment of Commissioner for the Artificial Propagation of Fish, the season had so f r advanced that nearly all the fresh water fish had deposited their spawn, with the exception of tne trout and the allied species. Under these circumstances, it was deemed advisable that I should direct my inquiries to the trout,—respecting the habits, time of depositing spawn, localities where found most plentiful, &c. From the best information which I could obtain, Barnstable county was selected as containing the best trout streams.

On the 13th of September, (with the advice, consent and approval of my colleagues in this commission,) I went to Sandwich, and located there, for the purpose of observing the habits and experimenting on the artificial propagation of this fish. On the 15th of September I obtained four specimens —two males, two females—and found that the eggs were not mature; carefuly observing the condition of those that were taken from that date, no mature eggs were noted till the third of November, when some were obtained and fecundated by artificial means. This was effected in the following manner. I took a zinc vessel and put into it about one pint of clear water; then taking the female fish whose eggs were mature, holding her over the vessel and gently passing the hand over the abdomen, the eggs freely pas ed from the fish into the water. I then took the male fish whose milt was mature, holding him over the vesse in the same manner, pressed the milt into the water containing the eggs; the water was stirred gently with the hand so that every part of the egg came in contact with the milt; after the lapse of two or three minutes, the water was poured off, and some fresh water added; the eggs, by this means, were successfully fecundated.

By careful observation, I have ascertained that the trout commence to deposit their spawn about the first of November, and as late as the middle of December I have found the females with spawn. I think that the spawning season continues at least two months. I have observed in the Boston market, trout shipped from the State of Maine, in November, and their eggs were mature. At this season of the year this fish is exceedingly poor and lean, and consequently, as an article of food, it is considered of little value; when in good condition, they are very excellent, and find a ready sale at high prices. The common salmon also finds a ready sale at very high prices in the spring and early summer; at that time they are in excellent condition, and, like the trout, as the spawning season approaches, they become very poor, and remain so until long after they have deposited their spawn; during this time they are of little value as an article of food. In November last, some ten thousand pounds of salmon were shipped to the Boston market from the British Provinces, and sold at a low price. These were the first which I have ever noticed to be shipped to Boston at the time of spawning; they were full of mature eggs.

The trout, at the time of spawning, will not bite at the hook as well as at other times, but are taken with difficulty. Their habits, at this season, are to repair to the small brooks and streams where they can find a gravelly bottom, in order to deposit their spawn; at that time I could obtain a few with nets, and in no other manner; they were exceedingly scarce. I went to Plymouth, Barnstable, Marshpee, and the various streams and brooks in Sandwich to procure them, and finally, after much exertion, I succeeded in collecting some 15,000 eggs.

These, after having been fecundated by artificial means, were placed into small tanks or tubs, which had been partially filled with sand and gravel, and so arranged that a small continuous stream of water flowed in on one side, and passed over at the other, thus a constant gradual change of the water was preserved. At the expiration of twelve days, some of the eggs were examined under the microscope, and it was perceived that the embryo had formed, and that the eggs were progressing hopefully. Soon after this time I noticed that some of the eggs began to rot; these were daily removed, as they were easily detected by becoming opaque—the healthy eggs being perfectly transparent. The rotting of the eggs continued to an alarming extent, so that at the expiration of fifty-five days only a few remained.

The embryo had at that time become so far developed as to be distinctly seen by the unaided eye. I thought that a few of them might be saved by being put into still water. I accordingly brought to Boston the few that remanied, and with them a quantity of water into which they had been deposited, deeming it not advisable to change suddenly, but gradually, to replace it with the Cochituate. I also tried the experiment of placing some of the eggs into all Cochituate water, and they soon died.

The rotting, however, continued, and those that continued healthy appeared to be progresing hopefully until about the first of February; after that time I could not see any further developement of the embryo; they had been deposited about ninety days, and the embryo seemed to be far advanced toward maturity. The cause of their final decay and loss must have been owing to the water not possessing their natures required. At Sandwich, where I made my experiments, there were two ponds, an upper and a lower pond, with springs running into the former; between the two ponds was a dam, that prevented the fish from passing from one to another. In the upper one I found trout apparently of all ages, both young and old: but in the lower, below which I made my experiment, I found only a few trout, and they all had the appearance of extreme old age. In this pond I took five specimens, and they were females with mature eggs. I took the milt of males taken in other localities and put with the eggs, and fecundation did not appear to have taken place. I came to the conclusion that the trout in this (the lower) did not multiply, but that they were the fish that were in the pond when the dam was built.

After I found that the eggs which I had collected were fast decaying, I then (when it was too late to apply a remedy, or to adopt a different course,) concluded that the water was not suitable for their development, and although a large quantity of water was flowing out of the pond where I was located, and from which I took the water, yet the bottom being covered with mud, which was constantly accumulating from year to year by the falling leaves, &c., might tend to render the water unsuitable for the development of the eggs of the fish.

In conclusion, I must be permitted to express my sincere thanks to Prof. Agassiz and to Prof. Wyman, of Cambridge, for their kindness in imparting information and advice in respect to the most suitable manner of conducting my experiment.

N. E. ATWOOD.

PISCICULTURE.

Fisheries have often been called the agriculture of the waters, as if seas, lakes, and rivers were inexhaustible store-houses of food, where, without fear of ever impoverishing them, man might continue to take and destroy forever, bounded only by his wants and his desires. This definition is false, because founded on a false view of the case. Fishery is not the agriculture of the waters; it is only the harvesting. The waters are a source of production extremely powerful, but by no means infinite, and that the harvest may be always certain and abundant, it should be prepared by regular sowing, if it is true, according to the expression of M. de Quatrefages, that fish may be multiplied by sowing in the same manner as grain.

This would appear unnecessary pains, if we were to consider only the very great fecundity of almost all the aquatic tribes. A perch of moderate size contains 28,320 eggs, and a herring 36,960.

Thomas Harmer * and C. F. Lund † have obtained by untiring researches, still higher numbers from other species, e. g., 80,388 and 272,160 for the pike; 100,369 for the sole; 71,820 and 113,840 for the roach; 137,800 for the bream; 383,250 for the tench; 546,680 for the mackerel. A carp, weighing three kilogrammes (66 pounds) contained, according to Petit, 342,140 eggs. A flounder has given the enormous figure of 1,357,400. There have been counted in a sturgeon as many as 7,635,200, and Leuvenhock has found 9,344,000 in a codfish. Finally, M. Valenciennes ‡ has just calculated that there are 9,000,000 in a turbot of fifty centimmetres, (19 1-2 inches,) and as many as 13,000,000 in a thick lipped mullet.

If only the tenth part of the germs inclosed in the body of each fish arrived at maturity, there would be little to fear from the devastation of our coasts, or the depopulation of our fresh waters; but numerous causes of destruction tend to reduce considerably the multiplication thus richly provided for. These arise partly from natural causes, but in great part also, from the act of man. We are to point them all out, if possible, and weigh

* Philosophical Trans. Royal Society of London, Vol. lvii., p. 280. 1768.

† Memoirs of the Swedish R. A. of Sciences, Vol. xxiii., German Ed., p. 192. 1761.

‡ Valenciennes and Fremy. Researches on the Composition of Eggs in the Series of Animals. Academy of Sciences, March 20, 1854.

them successively before discussing the means of preventing their action, which will form the chief object of this article.

In the first place, we must not forget, that in the general harmony of nature, as Mr. Milne Edwards has justly remarked, the productiveness of animals is regulated with a view not only to the dangers to which the young are exposed before arriving at the age of reproduction themselves, but also to the uncertainty of fecundation of the eggs. It is well known that the immense majority of fishes are oviparous, and that the fecundation is effected by the operation of the male element upon the female element separate from the body of the animals, and in the midst of the waters where they live. This action is the condition necessary to the development of the embryo, and all the eggs, which have not experienced the contact with the animalcules of the milt, change and soon decay. Now it is never the case that all the spawn receives this action, and from this cause alone a portion, more or less considerable, is always lost. The portion which remains is in turn exposed to a host of pernicious influences. It may be left dry by a decline in the level of the water, or spoiled by the slimy substances which a rise of the waters always causes and carries with it. The spawn has also numerous enemies; many fish devour it, many crustacea, many insects attack it in like manner; it may be carried off by sea-weed and byssus, and almost all aquatic birds are very fond of it.

All these chances of mortality and destruction prevent the fish from increasing as fast as the great number of eggs would at first lead us to suppose, but they are still in a measure subject to the laws of the animal creation, and would seldom suffice for the depopulation of the waters, unless supported by causes of another nature. Among these should be mentioned, first of all, the inadequacy of the legislation on the fisheries, and the violation with impunity of all the protecting ordinances which it has provided. At the end of the last century Duhamel pointed out the depredations of the fishermen, who cast their lines with impunity at all seasons of the year, and daily suffer numbers of fishes, too small to be sold, to perish upon the banks. He saw, with natural indignation, the inhabitants of the coast fill baskets with the spawn to manure their land or feed their swine. This culpable improvidence has still further increased, and we can almost say that at the present time all injuries are authorized, and all abuses are practiced, without limit. In vain the best grounded complaints are raised against the poachers upon fisheries; the devastations have continued on all sides.

The necessity has been felt, however, for a long time, of taking repressive measures against the destruction of spawn, and the historians of fishery have collected numerous ordinances, which have been successively issued with this view at different times and in different countries. Without citing them all, it will be sufficient to recall those which have had the greatest influence upon the legislation of the present time. In the year 966, Ethelred II., king of the Anglo Saxons, interdicted the sale of young fishes. Malcolm II., in 1030, fixed the time of the year when the salmon fishery should be permitted. Several other kings of Scotland have confirmed these decrees. Under Robert I., the willows of the bow-nets were to be separated by at least two inches of interval, to leave a passage for the young fry. In 1400, Robert III. carried severity so far as to punish capitally every person convicted of having taken a salmon in the forbidden season. This cruel law was abolished by James I., but this prince kept up the interdict during the same season, and every infraction still remained the object of severe penalties. The kings of France were at great pains also to insure the free development of the young fishes. A great number of ordinances were issued by them, to determine the nature of the nets, of which the use should be permitted, and the length of the fishes which might be sold in the market places. At length, in 1669, Colbert placed upon a new footing the legislation of the coasts and rivers. He prohibited river fishing during the night and during the spawning season, under penalty of a fine of twenty livres and a months's imprisonment for the first offence, of a fine double in amount and two months' imprisonment for the second, and of the pillory and the scourge for the third. The only exceptions were in the fisheries of salmon, shad, and lampreys. Colbert also prohibited the placing basket work at the end of the drag nets during the spawning season, under penalty of twenty livres fine, and after having determined the kinds of snares to be forbidden, he directed that the fishermen should return to the streams the trouts, carps, barbels, breams and millers, which they should take having less than six inches between the eye and the tail, and the tenches, perches and mullets having less than five inches, under a penalty of one hundred livres fine.

The legislation which governs us at present is based upon the previous dispositions; unfortunately, it has disregarded the information offered by natural history, and thus but imperfectly attains the object proposed. The regulations relative to marine fishing, permit, for example, the taking of a given fish on shores where it has never been found, and give, for the limits of the crustacea, indications contrary to the most simple common sense. The code of river fishing, which principally interests us here, is no better protected against criticism." The ordinance of November 15, 1830, supplementary to that of April 16, 1829, leaves to the prefect of each department the care of determining, with the advice of the general council, and after having consulted the foresters, the times, seasons and hours when fishing shall be prohibited in the rivers and water-courses. Now how many times must the prefects, little skilled in natural science, or ill advised by those whose duty it is to enlighten them, have committed errors like those of Colbert, when he interdicted trout fishing from the first of February to the middle of March, that is to say, at a time when they had nearly all already finished spawning! The same ordinance prohibits certain specified nets and snares, thus intimating that all others are authorized, and permitting changes of form and name in the first, without rendering them less formidable or destructive. Article 30 of the fishery code punishes, with a fine of 20 to 50 francs, whoever shall catch, offer for sale, or sell fishes of less than the prescribed size, but it excepts from this provision sales of fish coming from ponds or reservoirs. It will at once be perceived how easy it is, through this exception, to catch and sell fish of all sizes. Article 24 forbids the placing of any gate, structure or fishing establishment whatever, calculated to prevent entirely the passage of fish, but it tacitly authorizes dikes and mill dams, which produce the same effect.

We will carry carry criticism no farther. It would be as easy for us to show that no efficacious measures insure the action of the fish police, and that the law is as badly executed as conceived. This state of things is deplorable, and has, without doubt, powerfully contributed to bring on the decay which has fallen upon the aquatic industry of France.*

Some figures, taken from the archives of the ministry of finance, will show clearly the importance of the evil. The water-courses of France have a total length of 197,255 kilometres (122,500 miles.) Its lakes, reservoirs and fish ponds occupy a superficies of 220,000 hectares (900 square miles.) Now the rent of all the waters directed by the commissioners of forests, and those of dikes and bridges, yields to the State a revenue of 650,000 francs. The

*The evil has been further increased by the encroachments of manufacturing industry, as well as by the processes which they have involved. The mills throw off into the water-courses their acids and salts, which have become useless, and the bleachers do the same with their chlorides. The beds of streams have often to be laid dry to execute dragging and cleansing. Finally, steamboats, by their violent movements of the water, raise and cast up the young fishes upon the river banks, and these are often retained and perish there. These last causes of destruction are still more fatal to the development of the fry than the culpable practices of the poachers.

former alone give fishing privileges in 7,570 kilometres (4,750 miles) of navigable and floating water-courses, producing the annual sum of 521,395 francs; that is, an average of 69 francs to the kilometre. The insignificance of this sum is very striking, when compared with what it ought to be, or even with that still furnished by some rivers more favored than others. Thus the Doubs, in the Jura, is still let out at the rate of 159 francs the kilometre. The Moselle, in the department of La Meurthe, at the rate of 182 francs. For a similar length, the Loire brings in 252 francs in La Loire Inferieure, (department,) the Sarthe 297 francs in Le Mairie et Loire, and the Loiret 309. La Mayenne produces 339 francs, and the Seine 498. As for the Mairie, it produces the exceptional sum of 1,378 francs. By the side of these figures, more or less satisfactory, many others attest, on the contrary, the extreme scarcity of fish. The Ain, in the Jura, produces only 14 francs to the kilometre; the Dordogne, in the department of La Corrèze, 10 francs, the Isère 8 francs, the Drôme 4, and the Durance 2. Finally, 219 kilometres have been depopulated to that point, that they cannot be let at any price.

This marked inequality in the revenues of several rivers, which offer in general similar conditions to the fish, or whose different conditions can be differently improved, seems to indicate that the evil, even where greatest, is not irreparable. The proprietors, injured by the impoverishment of the fisheries, and the government itself, more interested than any body in the products of the rivers, have yet remained a long time inactive under the laws which they are sustaining. The remedy has been decided upon only after the reiterated solicitations of naturalists, who, long since masters of a process of artificial multiplication, have felt that it might be usefully applied to the repopulating of rivers and ponds. The first experiments have given results sufficiently remarkable not to discourage farther attempts. The practical methods have been promptly developed, and scientific researches, skillfully conducted, have impressed a new character upon pisciculture—that is, the branch of rural economy which is occupied with the improvement of waters. A very general interest is now felt in this important question of the artificial multiplication of fish, which belongs at once to the natural sciences, to agriculture and to political economy. The result of the experiments which, since the end of the last century, have had for their object the re-stocking of rivers, already forms a curious chapter of zoological history, and while awaiting its increase by some new pages, it appears to us desirable to reunite its scattered elements.

I.

The first attempts at pisciculture were made by the Chinese and the ancient Romans, and it is probable that they were preceded by their elders in civilization. We have no positive data as to the epoch in which the Chinese commenced these experiments; but every thing tends to show that they reach back to the most remote antiquity. We find in the "*Histoire Generale des Voyages*" (1748) in Grosier, in Davis, as M. Chevreul has already pointed out, and in most of the works which treat of Chinese customs, some curious details on the transport of the spawn of fish. According to the missionaries who have visited China, a multitude of salmon, trout, and sturgeons mount into the rivers of Kiang-si and into the ditches which are dug in the middle of the field to preserve the water necessary to the production of rice. The jesuit father, John Baptiste Duhalde, is the first French author who has shown the manner in which this traffic is effected.* We give his account, which most historians have copied with alterations; "In the great river Yang-tse-kiang, not far from the city Kieon-king-fou, in the province Kiang-si, at certain times of the year, are assembled a prodigious number of boats for the purchase there of the eggs of fish. Towards the month of May, the country people bar the river in various places with mats and hurdles, for a length of about nine or ten leagues, leaving only sufficient space for the passage of the boats; the eggs of the fish are stopped by these hurdles. They can distinguish them by the eye, where other persons see nothing in the water; they draw out this water mixed with eggs, and fill several vases with it for sale, which causes at this season, numbers of merchants to come with their boats to buy it, and transport it into different provinces, taking care to agitate it from time to time. They succeed one another in this operation. The water is sold in measures to all those who have fish preserves and domestic ponds. After some days there are seen in the impregnated water, as it were, little heaps of fishes' eggs, without its being yet possible to distinguish the species. It is only with time that this appears. The profit is often a hundred fold more than the outlay, as the people live in great part upon fish." To these very simple, but successful means of replenishing their ponds, the Chinese are said to have joined others which travellers have only very imperfectly indicated; they assert that when the young fish begins to eat, they give him marsh lentils mixed with yellow of eggs.

The Romans had nearly similar customs, at a very early epoch. "The

*History of the Chinese Empire, Vol. i., p. 35. 1735.

descendants of Romulus and Remus," says Columella,* "rustics as they were, had much at heart the procuring upon their farms a sort of abundance in every thing like that which reigns among the inhabitants of the city; thus they were not satisfied with stocking with fish the ponds which they had constructed for this purpose, but carried their foresight to the point of filling lakes formed by nature with the spawn of fish which they threw into them. In this way the lakes Velinus and Sabatinus, as well as the Vulsmensis and Ciminus, have, in the end, abundantly furnished, not only cat-fish and gold fish, but, moreover, all other sorts of fish which are able to live in fresh water." These practices were early abandoned, and it is a matter of surprise, when we consider the strange infatuation of which fish became the object in ancient Italy during the following centuries, that no measures were then taken to insure their reproduction and free development. It is well known that the ancients had a remarkable predilection for this species of food. The principal luxury of the Roman banquets consisted of fish, and the poets speak of sumptuous tables spread with these exclusively. In the period between the taking of Carthage and the reign of Vespasian, this taste became a perfect passion, and for its gratification the senators and patricians, enriched by spoils of Asia and Africa, incurred the most foolish expense. Thus Licinius Murena, Quintus Hortensius, Lucius Philippus, constructed immense basins, which they filled with the most rare species, and Lucullus, like a new Xerxes, caused a mountain to be pierced to introduce sea water into his fish ponds. Varro† relates that Hirrius received twelve millions of sesterces ($675,000) from the numerous buildings which he possessed, and that he employed the entire sum in the care of his fishes. The rich patricians, says the same author, were not satisfied with a single pond; their fish preserves were divided into compartments where they kept shut up, apart from each other, fishes of different kinds; they retained a great number of fishermen solely to take care of these animals. They tended their fish as carefully as their own slaves, during sickness. It is even added that a naval expedition, commanded by an admiral, had for its object to introduce upon the coast of Tuscany a sort of scar peculiar to the waters of Greece.‡

This extravagant fashion, which spread through the various classes of

*De Re Rustica, Book viii., Section 16.

†De Re Rustica, Book viii., Section 17.

‡For further details, see Noel de la Morimiere History of Fishes, Vol. i., 1815; Cuvier and Valenciennes Natural History of Fishes, Vol, i., 1828, and Dureau de la Malle, Political Economy of the Romans, Vol. ii., 1840.

society, and brought on the ruin of entire families, had also the effect of impoverishing the coasts of the Mediterranean. Ismeral complained that time was no longer given to the fish of the Tyrrhenian sea to come to maturity. The scandalous luxury displayed in fish preserves, and the unwearied attention then directed to marine animals, have furnished no other result useful to pisciculture. The only fact worthy of remark at this epoch of sterile extravagance, is the introduction of gold fish into artificial ponds, where shell fish were also placed for their nourishment.

We may pass rapidly over the immense interval which separates the Roman Empire from the eighteenth century, without remarking any important progress in the husbandry of the waters. The fisherman's art was, however, extended and perfected during the middle ages, and fish preserves became extremely numerous in France and Italy. Kings and princes all had artificial ponds in their domains, and we behold Charlemagne himself taking great pains to keep his own in repair, causing new ones to be dug, and giving order that the fish produced should be sold. The religious communities exacted enormous duties upon almost all fisheries, and had considerable preserves in which multitudes of fish grew fat. The maintenance of these preserves required many precautions, and the restorer of agriculture in the thirteenth century, (Peter of Crescenza,) pointed out the manner of getting the greatest result from the lakes of fresh, as well as salt water. There appears in his work, however, no method worthy of being noticed here, and the treatise does not appear to us to have rendered any more service to pisciculture than that of Florentinus, in the third century, at least as far as we can judge of the latter by the extracts which Cassianus Bassus has preserved for us. It appears, nevertheless, that towards the end of the middle ages, new methods were sought for, which might serve to increase the production of fish; a monk of the abbey of Réome, near Montbara, named Dom Pinchon, conceived the idea of artificially fecundating the eggs of trout, by pressing out in turn the products of a male and female of this species into water, which he afterwards agitated with his finger. After this operation, he placed the eggs in a wooden box having a layer of fine sand on the bottom, and a willow grating above and at the two ends. The apparatus remained plunged up to the moment of hatching, in water flowing with a gentle stream. This process is described in a manuscript dated 1420, and belonging to the Baron of Montgandry, grand nephew of our celebrated Buffon. It has never been published, and had remained secret till a recent time.* Dom Pinchon

*M. De Montgandry explained the hatching box of Dom Pinchon at one of the last sessions of the Zoological Society of Acclimation, and was kind enough to inform us also of the manner in which the monk of Reome effected the fecundation of the eggs.

is then, in all probability, the first inventor of artificial fecundation, but his experiments must be looked upon as not having occurred, since they were not made public. They have of course had no influence on the progress of pisciculture, and are only interesting in a historical point of view.

The fishery of Commachio, on the Adriatic, of which the origin is probably very ancient, presents some natural features, which may, perhaps, be imitated with advantage on other parts of the Mediterranean shore. Already described at length by Bonaveri, then by Spallanzani, this lagoon still merits that we should say some words with regard to it. It is, perhaps, one hundred and thirty miles in circumference, according to Spallanzani, and is divided into forty basins surrounded with dikes, and all in communication with the sea. Eels abound there to such an extent, that the inhabitants sell them through all Italy. During the months of February, March and April, they leave the gates open and all the passages free; the young eels enter of their own accord, and the more abundantly in proportion as the weather is stormy. This they call the "*mounting*." Once in the basins, the fishes find nourishment so abundant and so well suited to their wants, that they do not attempt to leave until full grown, that is, after about five or six years. The eels emigrate and are taken in the greatest number during the months of October, November and December. For this purpose, the fishermen open at the bottom of the basins little passages bordered with reeds, which the eels follow from choice, and are conducted into a sort of narrow chamber, where they accumulate without being able to get out. On the average, the crop amounts annually to a million of kilogrammes, (2,204,737 pounds,) and M. Corte informs us that it produces, according to the estimate of M. Cuppari, a net revenue of 80,000 Roman crowns, that is, about $88,000.

The fishers of Commachio profit, as we see, by the advantages which nature offers, and they have but few precautions to take to insure the development of the fish in this great preserve. The less favorable circumstances in which the fisheries of the Swedish lakes were carried on, induced investigation, towards the middle of the last century, of the means of preventing the considerable loss which the spawn had there to undergo. Already great care was taken in that country not to trouble the fish at the times of their reproduction, so that it was even forbidden to ring the bells during the spawning season of the bream. A counsellor of Linkoeping, Charles Frederick Lund,* remarked that the three species most esteemed among those which inhabit the Lakes of that country, the bream the perch and the mul-

*Of the Planting of Fishes in Inland Lakes. Memoirs of the Swedish Academy of Sciences, Vol. 23, 1761. German Translation of Kartner, p. 184.

let, attach their eggs near the banks, either to the rocks, or by preference, to the twigs of pine and to the willow cages placed in the water to catch them. The eggs are thus destroyed by the fishermen, or devoured by insects, birds, and especially by the fishes of prey, so that hardly one out of ten finally escapes. He well understood that the prohibition of fishing during the spawning season would very imperfectly prevent this enormous destruction. He devised another means of protecting the multiplication of the fish, which accords completely, as he himself remarks, with the habits of these animals, the mode and the laws of their reproduction, as well as with the rules of logic and of our own duty. He caused large wooden boxes to be made without covers, but pierced with little holes, and furnished with rollers to allow of their descending easily into the water. He placed twigs of pine in them, and introduced a certain quantity of males and females, taken at the time of spawning, taking care to separate them by their kinds and to give them space enough. After having left them there two or three days,—that is, during the time necessary for laying the eggs, he drew out all the fishes with the help of a small net, and arranged the boughs so as not to press too much against one another. The eggs arrived at maturity after a fortnight, or a little more, according to the degree of heat, and a multitude of young fishes came forth. This simple process included all the conditions necessary to success, and doubtless great advantages may be found in it for the propagation of fishes whose eggs are adherent. Lund succeeded in transporting from one lake to another, boughs covered with spawn, which he placed in a vase of water, taking care merely not to expose them to contact with the air. In making a first application of his process, he had put separately into three large boxes, with a small number of males, fifty female breams, which gave him 3,100,000 of the fry; one hundred perch of the large species produced 3,215,000 of the fry; and one hundred mullets gave 4,000,000 of little ones. He obtained then in this manner more than ten millions of young fishes, which were dispersed in the Lake of Raexen. If this process had been employed on a large scale in all the lakes of Sweden, there would have resulted, says he, a real blessing for the country.

The favorable circumstances of the arrangement adopted by Lund enabled him to observe some particulars of the development of the embryo. A German naturalist, Bloch,* advanced somewhat farther in this direction by employing a similar means. He took from the Spree some aquatic plants

*Marc Eliezer Bloch. General and particular Ichthyology, Part ii, p. 94. 1795.

covered with eggs of perch, bream, rotengle, &c., and kept them in a wooden box of fresh water, renewed daily. At the end of a week he obtained many thousands of little fish; observing, however, that only a small part of the eggs were fecundated, and that those which were so, remained transparent and yellow, while those which failed, became daily more disturbed and opaque. Bloch concluded that by transporting spawn upon plants, as he had done, lakes and ponds might be easily and cheaply stocked with fish; but he made no experiment, and as we see, only imperfectly imitated Lund.

While the ingenious predecessor of Bloch was seeking the means of increasing the inhabitants of the Swedish lakes, a lieutenant of militia of Lippe Demold, in Westphalia, J. L. Jacobi, conceived the idea of artificially fecundating the eggs of fish, and of applying this process to the repopulating of ponds and rivers. The curious results of his experiments were indeed embodied in a letter which the *Magazine of Hanover* only published in 1763;* but as early as 1758 Jacobi had addressed manuscript notes upon the subject to the illustrious Buffon, which Lacépéde has mentioned in the first volume of his *Natural History of Fishes*, and in the course of the same year he had intrusted another account of his labors to the Count de Goldstein, grand chancellor of Berg and Juliers. Goldstein caused a Latin translation of it to be made, which he sent M. de Fourcroy, director of fortification at Corsica, and an ancestor of the celebrated chemist. This version was published for the first time in French in 1773, in Vol. iii. of the *General History of the Fisheries* by Duhamel-Dumonceau. Duhamel does not mention Jacobi, but the facts in both memoirs being perfectly identical and set forth in similar terms, it is impossible not to perceive that both writings emanate from the same author. The date of the first communication entirely secures the claims of Jacobi, which are besides confirmed by the quotations of Lacépéde, and by a communication made in 1764 by Gleditsch, to the academy of sciences at Berlin. We give the details, because the name of Goldstein alone having been printed in the *History of the Fisheries*, many naturalists have wrongly attributed to him the merit of the discovery of artificial fecundations.

The experiments of Jacobi were upon the two most esteemed species of fish, the trout and the salmon. He tells us himself that, before arriving at good results, he had to employ sixteen years in preparatory researches and incomplete experiments. He remarked, in the first place, that from the

* It is to be found also, *in extenso*, in Wm. Yarrell, History of British Fishes, Vol. ii., p. 87, 1841, and at the end of Practical Instructions upon Pisiculture, by M. Coste, 1853.

of November to the beginning of February the trout come together in the brooks and fix themselves upon the gravel, where they rub their bellies in a way which leaves large tracks. The females then deposit their eggs, upon which the males drop their milt. He caused some trout, then, to be taken at this season, when ready to spawn; taking by turns a female and a male, he pressed their abdomens lightly over a vase half filled with water, and let fall into it the mature products of both sexes, and then stirred up the whole with his hand in order to render the mixture more complete and thus to ensure the fecundation of all the eggs. These eggs being once fecundated, it was necessary to combine the circumstances proper for their development, and for this purpose Jacobi thought of placing them in a grated box, across a little brook of running water. He constructed a large chest, at one extremity of which, and on the upper surface, he left a square opening, barred by a metallic grating of which the threads were separated by a space of only about four lines; this opening served to let in the water. Another, grated in like manner, and placed in the vertical face of the other extremity, allowed it to flow out. The bottom was overlaid with an inch of sand or gravel. Jacobi placed this apparatus in a trench prepared for it by the side of a brook, or, better still, a pond fed by good springs, from which he could cause, by a canal, an uninterrupted stream of water to flow through the box.

These dispositions, very simple and judiciously combined, completely resolved the problem which he had proposed to himself, viz: To protect the fecundated eggs against their natural enemies, and yet to leave them in circumstances similar to those in which they would naturally have been placed. The experiment succeeded. After about three weeks, Jacobi saw appearing through the thick envelope of the egg two black points corresponding to the eyes of the animal, and eight days later he began to distinguish the body itself which moved and turned in the interior. Finally, after five weeks, the young fishes broke from their shells, and soon separated themselves completely from it, retaining on y, under their bellies, a hanging yellow pouch, which is the umbilical vesicule. During nearly a month the young were nourished by the substance of this pouch, which disappears as they increase in size; but then th y had need of other nourishment, and to obtain it, they left the box by passing through the grating, and fell into a reservoir filled with sand and fitted to receive them. Jacobi adds, that in a basin of sufficient size, they grew wonderfully in the space of six months, and that then they had arrived at a suitable growth for stocking the ponds; but he does not say in what way he nourished them during all this time.

The inventor of artificial fecundation appears to have often repeated the experiments which he describes, and took great pains to insure the success of them. He perceived that the eggs are easily spoiled when they get into heaps, and recommends, to avoid this danger, the separating them frequently by means of a switch. Care should be taken also, that they do not stick together, when the milt is poured over them. Finally, the dirt which the water deposits should, from time to time, be carefully removed from them, and this may be readily done with the feather of a quill.

The question now is, whether Jacobi, by neglecting no precautions, and guarding himself against the various chances of failure, did arrive at a final result which is completely satisfactory in a practical point of view? Did he succeed, by means of his process, in advantageously re-stocking water-courses which had become unproductive, or increasing production, to any extent, in those where fish were already abundant? We have not the requisite documents for answering this question positively; but we can scarcely doubt that he obtained at least partial results, since England recompensed his services with a pension, and in a little state of Germany, his operations have been continued with success by M. Schmittger.*

Physiology soon turned to account the discovery of Jacobi, and artificial fecundations have since been frequently reproduced in laboratories. There is no need of recalling the results which Spallanzani, Prevost of Geneva, and Dumas, have drawn from them. They have been also a great help to embryological studies, and by employing this means two contemporaneous zoologists, Rusconi and C. Vogt, have been able to follow all the phases of development of the tench and the palie; but this discovery especially marked a great progress in pisciculture, and while science availed itself skilfully of this new mode of investigation, the practical results obtained by Jacobi were carried out in Germany and Scotland.

In the *Treatise on the Economy of Ponds* (by Ernst Friedrick Hartig, p. 411, 1831,) there is given a description of the process of Jacobi, with the remark that this method has been successfully employed by the forester Franke, at Steinburg, in the principality of Lippe Schaumburg, as well as by M. de Kaas, at Bückeburg. The same facts are confirmed by M. Knoche,† who asserts that he has himself also completely succeeded upon

*This fact is proved by a letter of Dr. Schutt, of Frankfort, recently written to Mr. Milne Edwards. The experiments of M. Schmittger have been made in the principality of Lippe Detmold.

† Journal of the Agricultural Union of the Grand Duchy of Hesse, No. 37, p. 407. 1840.

the estate called Oelbergen. The last writer placed the young fish at first in a little reservoir, and the following year transported them into a larger basin. "I have obtained by this process," says he, "in the eight years that I have been employed, 800 young fishes out of 1,000 to 1,200 eggs. After a year I found in the smaller pond only about half the fish, the others having either died or escaped. Apart from this loss they succeeded very well, and I have obtained in three years, out of the fish, in this manner, a crop of three to four hundred trouts a year, of three to four years of age, and of which the largest weighed three-quarters of a pound." M. Vogt, in a letter recently published, which reproduces this passage of M. Knoche, informs us at the same time that a decree of the government of Neufchatel, issued in 1842, gave complete instructions to the fishermen as to the method of artificially fecundating the eggs of fish.

Some experiments have also been made in England and Scotland. After having studied during several years the manner in which the salmon spawn naturally, Mr. John Shaw* attempted to combine the conditions, which appeared to him most essential, in some preserves which he caused to be made near the river Nith. These reservoirs were only two feet in depth, and spread with a thick bed of gravel. They were fed directly by the water of a spring which abounded with the larvae of insects. A close grating was placed before the conduits, by which the surplus of this water had to flow out to gain the river. These dispositions once made, Mr. Shaw fecundated the eggs just below the point where the water fell into his basins, and left them to develop at the same spot. This plan succeeded, and he was able to bring up a certain number of young salmon during two years, and even more. He took advantage of them to make observations upon their growth and change of color. At the age of six months the young salmon had a length of two inches; of a year, three inches and three quarters; of sixteen months, six inches; and of two years, six inches and a half. At this last period, when they had put on the livery of emigration, and when they are called in Great Britain by the name of *parr*, the milt of the males had arrived at a sufficient state of maturity to be able to fecundate the eggs of adult females. We owe also to M. Shaw, as well as to Mr. Andrew Young† and Dr. Knox, our increased knowledge of various particulars relative to the monogamy of salmons, and to the manœuvres which the female performs on the spawning place, but these researches do not appear to have had any practical result worthy of attention.

* Transactions of the Royal Society of Edinburg, Vol. xiv., p. 517. 1840.

†Natural History of the Salmon. Wick. 1848.

An engineer of Hammersmith, named Gotlieb Boccius, published in 1848 a short treatise on the management of fish in rivers and streams. He extols in it the method of artificial fecundation, but without producing any positive fact to prove that he himself experimented with success. Since that time he has assured Mr. Milne Edwards that he had operated in 1841 upon the water-courses belonging to Mr. Drummond, near Uxbridge, then upon the estate of the Duke of Devonshire at Chatsworth, upon that of Mr. Gurnie at Carsalton, and that of Mr. Hibberts at Chalfort. Mr. Boccius must have raised already about two millions of little trout.

The discovery of Jacobi had passed successfully, as we have seen, the trial and application in England, as in Germany. Up to 1848, nevertheless, France had remained very much behind in experiments of this sort. Although she, perhaps more than any other country, had need of effectual means for remedying the impoverishment of the waters, the French economists had scarcely given any attention to this question. A single one, the Baron of Riviére, presented, in 1840, to the Central Society of Agriculture, some very learned and sensible reflections upon ichthyology regarded in its relations to the wants of man, and the profits of agriculture.* He insisted especially on the advantages which would result from taking in the Spring the *bourons* or little eels which abound at the mouths of rivers, and dispersing them in the lakes, ponds, pools, and even muddy ditches, where they live very well. He satisfied himself that they might be transported alive in casks full of water, without appearing to suffer much from it; but wherever it should be possible to use rivers or canals, he thought it better to make use of boats pierced with holes in communication with the water, such as are frequently used for keeping fish. In this memoir of M. de Riviére, the word Pisciculture is used for the first time; he employs it with hesitation to indicate this new branch of rural economy, which, says he, is still to be created.

II.

The year 1848 saw a new era commence in France for the economy of the waters. We believe it is just to say, that if the application of artificial fecundation to the repopulating of rivers is owing to a German naturalist, it is in our country that pisciculture has grown, has been perfected, and has finally come to constitute an actual branch of industry. All the progress which has been made within six years in this department of the science, is the work of French inquirers.

*Memoirs of the Central Society of Agriculture, Vol. xlviii., p. 171. 1840.

The first, M. de Quatrefages,* was led by purely scientific researches to occupy himself with the multiplication of fish. This zoologist, convinced that artificial fecundation would do away with the various causes which prevent the development of the eggs, advised the employment of the hatching box of Goldstein (or rather of Jacobi) for fish of running water. For those of ponds or lakes he recommended depositing the fecundated eggs on a layer of aquatic plants in a spot where the water should be tranquil and shallow, and protecting them by lattice work against the attacks of their enemies. He showed how the employment of the process discovered by Jacobi would facilitate the domesticating of foreign fish in our waters. Finally, he pointed out the possibility of rendering annual the triennial and irregular product of the ponds by dividing them into three or four unequal compartments. In the smallest the eggs might be hatched and the fry raised. Each year the fish might be driven from one compartment to another, and the last basin might be fished every year.

The memoir of M. de Quatrefages made a good deal of noise, because it met one of the wants of rural economy, and gave a glimpse of a quite new prosperity for the industry of ponds and water-courses. Drawing from oblivion the results obtained in Germany during the last century, it recalled the attention of naturalists and husbandmen to a question too long neglected, and of which it would be now superfluous to dwell upon the importance. The author was, doubtless, far from thinking that the conclusions to which he had brought his studies would be almost immediately justified and confirmed by the experiments undertaken some years before, but which had not yet been made public. However, in the first days of March, 1849, the Academy of Sciences learned by a letter of Dr. Haxo,† Secretary of the Society of Emulation of the Vosges, that this society had, in the year 1844, given a premium to two fishermen of La Bresse, M. M. Rémy and Géhin, for having fecundated and artificially hatched some eggs of trout. M. Haxo added that Rémy and Géhin then possessed a piece of water containing five or six thousand trout, of one to three years old, all raised by this process. It is impossible not to admire the sagacity and perseverance of these fishermen, who, quite unlettered and ignorant of the progress of the natural sciences, have found the means, of themselves, of remedying the decay of their industry, and of giving it a new impetus. Not only have they repeated,

*Comptes rendues of the Academy of Sciences, Vol. xxvii., p. 413. 1848. See also the Revue des Deux Mondes. Jan. 1, 1849.

†Comptes Rendus of the Academy of Sciences, Vol. xxviii., p. 351. 1849.

with great pains, the observations and experiments which occupied Jacobi's whole life, but they have gone much farther in the practical application, and have almost entirely resolved the problem.

Although they have both greatly contributed to the success of the undertaking, we now know that the first efforts were solely owing to Joseph Rémy, and that he associated Antoine Géhin with himself only after having already half succeeded. Rémy first studied the habits of the female trouts ready to spawn. He saw them remove the gravel with their tails, and rub their bellies to assist the laying of the eggs. Having caught many of them in this state he perceived that by pressing them a little with his hand, he could easily force out the mature eggs, and that the same thing occurred with the milt of the males. He next suspended a female above a vase full of water, and by means of a light pressure applied from above downwards, he caused the eggs to fall out, upon which he afterwards poured, in like manner, the fecundating liquid of the male until the water was white. Next depositing the eggs in a tin box pierced with numerous holes, and spread with a layer of coarse sand, he placed the box in a fountain of pure water, or in the bed of a brook; after a certain time he saw the young hatched, and freeing their tails first.

These facts, which Rémy relates himself in a letter addressed in 1843, to the prefect of the Vosges, are, as we see, almost identical with those which Jacobi has embodied in his memoir, as these last were with the experiments of Dom Pinchon; but the two fishermen of La Bresse did not stop there.* It was not enough to have guarded the eggs against the chances of destruction, which menace them when abandoned to themselves. It was necessary also to insure the development of the young, and to find for them a nourishment suited to the wants of their age. This, Rémy and Géhin succeeded in doing. After two or three weeks of a diet adapted to these wants, they opened the boxes which contained the fry, and allowed them to run freely into a water chamber or a portion of the stream prepared to receive them. There they had taken care before-hand to raise a great number of frogs, of which the spawn is eagerly devoured by the young trout. Somewhat later, they had recourse to the method already employed for the support, in preserves, of adult carnivorous fishes.†

*Haxo d'Espinal on the Artificial Fecundating and Hatching of the Eggs of Fish, 2d edition, p. 22, 1853, and Guide of the Pisciculturist, 1854.

† "To nourish their young trout," says M. de Quatrefages, "they hatched with them, other smaller species of fish, smaller and herbivorous. These are raised and

Rémy and Géhin first stocked two ponds near La Bresse, several brooks of their canton, the water-courses of the commune of Waldenstein, and have thrown about fifty thousand young trout into the Moselotte, one of the affluents of the Moselle. These results were too important, and promised too great advantages in the economy of our waters, not to draw the attention of the public, and even of the government. In 1850, M. Milne Edwards was officially charged by the minister of agriculture, to make sure of the accuracy of the facts published, and to ascertain their value. After having procured some information in England, as to similar experiments, he went into the Vosges, and visited the little establishment of the fishers of La Bresse. In a very remarkable report,* he gave an account of the interesting labors of Rémy and Géhin, and, while pointing out that the discovery of artificial fecundation dated back into the last century, he proclaimed that the fishermen of La Bresse were the first to make application of it among us, and that they have the merit of having thus created a new branch of industry in France. The learned Dean of the Faculty of Sciences of Paris resolved upon a grand experiment of stocking the waters of France with fish, and regarded the success of it as probable, if the processes were judiciously arranged. It appeared to him that the best recompense which the government could make to the fishermen of Bresse, would be to give them the direction of the enterprise. The Philomatic Society did not hesitate to put forth a similar wish by the organ of M. de Quatrefages.

The first notice of M. de Quatrefages, the promulgation of the success obtained at La Bresse, and the favorable report of M. Milne Edwards, gave a powerful impulse to pisciculture, and induced varied applications of it on all sides. Under the influence of these first labors, commenced, in many parts of France, the grand trial which is now going on. Its value will not be fully known till it is completed; but it is already sufficiently advanced to permit us to hope that in the majority of cases, the method of artificial fecundation will produce important results. A certain number, both of emi-

nourished upon aquatic vegetables. In their turn they serve for food to the trout, who are nourished by flesh. These fishermen have thus succeeded in applying to their industry, one of the most general laws, upon which are based the natural harmonies of the animal creation." In view of the necessity of their carnivorous diet, it is important to put together only trout of the same age, otherwise the smaller become the food of the large; and even with this precaution, it is not always possible to avoid the fatal effects of their voracity.

*Annals of the Natural Sciences. Third Series, vol. [illegible]

†Journal of Practical Agriculture, [illegible]

nent men of learning, and of men of practical skill, have taken part in this movement, which, far from slackening, increases on the contrary, and is extending daily more and more. Among those who have contributed most by their writings or their practical studies to the continually increasing progress of pisciculture, besides Rémy and Géhin, besides M. Milne Edwards and M. de Quatrefages, we must mention M. Valenciennes, whose knowledge of ichthyology is so extensive and profound; M. Millet, inspector of waters and forests; M. Coste, professor in the College of France; Messrs. Berthol & Detzem, engineers of bridges and causeways; Mr. Paul Gervias,* at Montpellier, Mr. J. Fonmet,† at Lyons, Mr. F. Defilippi,‡ at Turin.

M. Valenciennes‖ has at least in part, realized the hope which has often been indulged, of transporting and domesticating in the waters of France the most esteemed fish of foreign countries. He has succeeded in bringing alive from the Spree to the reservoirs of Marly, five different kinds, each represented by a certain number of individuals. There are the *sander*, (*perca lucioperca*, *of Linne*,) the *wels* or *silure* (*silurus glanis*, *of Linne*,) the *alandt*, (*cyprinus jeses*, *of Bloch*,) the German *lotte*, (*gradus lotta*, *of Bloch*,) and the *pitzker* (*cobites fossilis*, *of Linne*.) This trial has only been made on a small scale, but it is none the less important on that account, since it proves that, in ordinary circumstances, difference of waters would not be an absolute obstacle to the acclimating of foreign fish.

The same gentleman was afterwards charged by the Minister of Marine with the duty of inspecting the fisheries of our coasts. The report, in which were embodied the observations made in the course of this mission, has remained unpublished, and it is to be regretted that the learned ichthyologist was not able to continue and extend these researches, to which his previous studies so naturally called him.

It is worthy of notice what wise circumspection Messrs. de Quatrefages and Milne Edwards have employed in presenting the advantages which rural economy might derive from the method of artificial fecundation. They have incited the proprietors to attempts which appeared likely to be advantageous, but without always promising them certain results. M. Coste has proceeded with less reserve.

*Bulletin of of the Society of Agriculture de l'Herault, July, 1852.

†Memoirs of the Society of Agriculture of Lyons, May, 1853.

‡Importanza economica dei pesci e del Coro allevamento artificiale.

‖Report on the Species of Fish in Prussia, which might be imported and acclimated in the fresh waters of France.

With unlimited confidence in the future of pisciculture, he has allowed no occasion to pass without exalting the benefits which it will confer. In his first report, at the close of the year 1850, he declared already "that there is no branch of industry or husbandry, which, with less chance of loss, offers an easier certainty of profit."* Later he speaks with enthusiasm of the means, tried during a century, of providing for the repopulating of the waters. Most certainly it is with excellent intentions, and, doubtless, in the hope of sustaining the efforts of experimenters, that M. Coste thus undertakes to guarantee future results; but is it not rather to be feared that, in magnifying too greatly some partial successes, he may compromise the general success of the undertaking. Meanwhile, though these absolute affirmations seem to justify, to some extent, some critisms of which the learned Professor has been the object, they cannot diminish his share in the improvements recently made in the method of Jacobi.

M. Coste first put in practice the means proposed by the Baron de Riviere for transporting the "*mounting*" or the young eels, and raising them in confined spaces.* After having brought this mounting from the mouth of the Orne to the College of France, in flat paniers, overlaid with aquatic plants, he gave them for nourishment a hash composed of the flesh of animals, which do not serve for food, and of that of molluscs and earth insects. The little eels which, on arriving, had an average length of six and seven centimétres, (two and one-half to three inches,) and a circumference of one centimétre, had arrived, after twenty-eight months of this diet, at thirty-three centimétres of length, and seven of circumference. M. Coste remarks with reason, that the corpses of the vertebrated animals, which are not fit for the food of man, might be made useful in this manner. He adds that the noxious insects would serve quite as well to fatten the fish. "Thus a great service would be rendered to agriculture, since it would, in the end, be delivered of one of its scourges." It is to be regretted that the learned Professor has not entered into any details upon the best method of capturing these insects, which the cultivators have so great an interest in getting rid of, even if they could not make a profitable use of them.

The author of the Practical Instructions upon Pisciculture has been at length induced to take charge of the organization of a vast establishment of artificial fecundation. In 1850 the two engineers of the canal from the Rhone to the Rhine, Messrs. Detzern and Berthol, after having visited La Bresse on the invitation of the Prefect of the Doubs, had applied at Huningue the method of Rémy and Géhin. Upon the basis of their first

*Practical Instructions upon Pisciculture, p. 34.

experiments they had undertaken hypothetical calculations, from which it appeared that the present population of the waters of France does not exceed twenty-five millions of fish, producing annually less than six millions of francs ($1,200,000)—which figure is really much too large—while, if the process of artificial fecundation every were where introduced, the number of fish would be raised, after four years, to three thousand one hundred and seventy-seven millions, and would produce a revenue of nine hundred millions of francs ($180,000,000.*) At Lochlebrunn, some kilometres from Huningue, Messrs. Detzern and Berthol had established the foundations of a large preserve, where in 1852 they operated numerous fecundations, by means of a hatching box, which in no respect differs from that of Jacobi. They assert they have there obtained a cross of the trout and salmon.†

The minister of agriculture directed M. Coste to visit the new establishment. In a report, favorable to the labors of Messrs. Berthol and Detzern,‡ the professor of the College of France asked for and he succeeded in obtaining a considerable development of the fish preserve or *piscifactory*, as he proposed to call it. He brought into use on a large scale a hatching apparatus which we shall have to describe, adopted all the measures which he thought most fit, and in his memoir upon the means of restocking the waters of France, he undertook, before the Academy of Sciences, to make a delivery in June, 1853, of six hundred thousand trout and salmon, large enough to be thrown into our rivers. We have not visited the establishment of Huningue, and know not whether it is organized in a way to fulfil a part of the promises which its founders have often put forward; but from the information which has reached us from several quarters, it would seem that their success has not always been as complete as was hoped for at first. It is then much to be feared that after four years, and even more, the establishment of Huningue will not have succeeded in alone restocking with fish all the waters of France, and in making them produce the nine hundred millions of francs promised by Messrs. Berthol and Detzern.

However this may be, the relations established between this *piscifactory* and the College of France have furnished to M. Coste an opportunity of making some curious observations on the transport of the eggs, and the duration of their vitality after having been taken from the water. Some eggs of salmon and trout, sent from Mulhousen by the diligence, were hatched in great numbers at the College of France. The precaution had simply been

*Artificial Fecundation of Fish. Society of Emulation of the Doubs, p. 18. 1851.
†Report upon the facts proved at Huningue from May 8, 1851, to May 7, 1852.
‡Practical Instructions in Pisiculture, p. 96.

taken of surrounding them with moist aquatic herbs in a tin box pierced with holeson the upper side.* Other eggs, artificially fecundated, arranged in layers with wet sand in a pine box, remained thus two months in a cold chamber. At the end of this time, they were only corrugated; but having placed the box in water to moisten them through the sand, M. Coste saw them soon resume their natural appearance, and they hatched son after.

To render possible in his laboratory the experiments which he had undertaken, M. Coste had to adopt an apparatus occupying but little space, and for which a simple thread of water would suffice. The arrangements which he chose, are very simple. This apparatus, which, by the way, we have often seen in operation, is an assemblage of little troughs, arranged like steps on each side of an uppe rtrough which serves to supply all the others. The bottom of each trough is covered with a bed of gravel. A stop-cock lets fall a continuous thread of water into one end of the upper trough. A current is thus created towards the other end, and there an opening at the sides giving it passage to right and left, it breaks into two falls of water which go to feed the two troughs placed immediately below. These last have also openings by which the water falls into the lower troughs, the number of which may be increased at pleasure.

After the hatching obtained by this apparatus, M. Coste was able to inclose two thousand young salmon into a canal of baked earth, having fifty-five centimetres in length, (twenty-one inches,) fifteen in breadth, and eight in depth, where, says he, the current is kept up by a simple thread of water of the size of a straw. He gave them for nourishment a *paste formed of muscular flesh reduced to fine fibres*, in preference to the boiled blood of which Rémy and Géhin made use. A salmon raised in this manner in an artificial pond, two metres in length, (eighty inches,) and fifty centimetres in breadth, (nineteen and one-half inches,) was, at the age of six months, larger than those of the same age taken in Scottish rivers, and represented in the work published under the assumed name of Ephemera.† Such are the principal results to be ascribed to M. Coste. He has recently collected his memoirs and reports into a volume, under the title of *Practical Instructions upon Pisciculture.* He sets forth in these instructions the knowledge previously acquired, and those which he has drawn from his personal experience, and he adopts some of the improvements introduced by M. Millet in the practice of the new industry. We regret that the author of this little

*Comptes Rendus of the Academy of Sciences, Vol. xxxiii., p, 124. 1852.

†The Book of the Salmon, by Ephemera assisted by Arthur Young. See also the Agronomic Annals, Vol. i., p. 234. 1851.

work written with much elegance and clearness, has not oftener cited the sources from which his information is taken.

The same day upon which M. Coste presented his work to the Academy of Sciences, M. de Quatrefages read before this learned body some researches, upon the milt of certain fresh water fish.* The question here treated of is fundamental, and before it had been resolved, it was impossible to use the necessary precision in artificial fecundations. This labor is then of great importance in the double point of view of comparative physiology and the application of zoology. We know by the experiments of Prevost of Geneva, and M. Dumas, that the milt owes its physiological properties to the presence of animalcules, which move in a manner very peculiar, and that all the fecundating power disappears the moment that these animalcules die. Now, M. de Quatrefages shows that the duration of these movements is extremely short in the case of fish, even in the most favorable circumstances. Thus in the milt of the brochet, diluted with water, all vitality ceases after eight minutes and ten seconds. The animalcules of the mullet are all dead after three minutes and ten seconds, and those of the carp after only three minutes. This period of activity is still more limited for the perch and barbel, since it only reaches two minutes and forty seconds for the former, and two minutes ten seconds for the latter. Neither is it equal for all the animalcules of the same fish, and half of them perish in much less time. Besides, the preceding figures are taken at a degree of heat most favorable to the duration of these movements, and even slight variations above or below this point destroy them with great rapidity. The temperature which maintains longest the vitality of the animalcules is, for winter fish, like the trout, forty-one to forty-eight degrees, of Fahrenheit; for those of the early spring, fifty to fifty-five degrees; for those of the later spring, as the carp and the perch, sixty-three to sixty-eight; and for the summer kinds, seventy-seven to eighty-seven. When the temperature somewhat exceeds these limits, the increase of energy on the part of the animalcules, compensates, to a certain extent, for the shorter duration of their vitality. These results apply to those which are disseminated through the water; when they remain united in small masses, they die much more slowly. The peculiarities of the milt may thus be preserved for a much longer time, when it is not diluted, and especially when it is kept at a very low temperature. It may even be frozen without causing, in all cases, the death of the animalcules. " M. Millet, who has aided me in all these researches," says M. de

*Comptes Rendus of the Academy of Sciences, Session of May 30, 1853, Vol. xxxvi. p. 936; Annals of Natural Sciences, Third Series, Vol. xix, p. 341, 1853.

Quatrefages, "has thought of putting the milt with ice into a tin box, so that the water may run out as the ice melts, and then to arrange this box in a second wooden one, pierced with very small holes, and itself filled with ice." Thanks to these precautions, the learned academician has been able to preserve the milt in a serviceable condition during sixty-four hours. It is worthy of remark that the fecundating property disappears first in that part of the male organ where the liquid is most completely elaborated, and endures some time longer in the deeper parts.

These facts, taken together, will explain most of the failures resulting from operations apparently well conducted. They show that the manipulations must be accomplished with great quickness, and careful attention must be paid to the temperature of the water. We may conclude from them also that the season of spawning in certain localities, must vary in accordance with the atmospheric phenomena—that the short vitality of the milt is one of the causes which oppose the crossing of the different species in nature, and that the hitherto unexplained instinct which leads the trout and salmon to mount to the sources of water-courses, is owing to the need felt by these animals of finding a degree of temperature suitable to the fecundation and development of their eggs. M. de Quatrefages has also deduced from his researches, data of great value for practice, and eminently suited to regulating the methods of artificial fecundation.* The results contained in the memoir of M. de Quatrefages give to these methods a scientific regularity, which they have wanted hitherto, and tend to endow pisciculture with fixed and precise rules.

To complete the summary picture of the progress which pisciculture has made from antiquity to our time, and to show its present condition, it remains to point out the numerous and important improvements which are owing to M. Millet, inspector of waters and forests.†

*Since the male liquid, completely elaborated, loses first its fecundating properties, only that should be used in doubtful cases which is pressed from the milt itself. The vitality of the animalcules not being destroyed by cold in the male organ, the frozen milt is not to be rejected as useless. If the fecundation cannot be made till after the death of the animal, it is well to take out the milt and preserve it in a wet cloth. In view of the extreme shortness of life of the animalcules, and of the obstacles which the swelling of the envelope may oppose to fecundation, it is useful in the case of certain species to pour the eggs and the male product simultaneously into the same vessel, and thus to render the contact instantaneous. Of course the water must never be first impregnated with the milt.

†Report to the Director General of Waters and Forests, upon the repopulating of the navigable and floating water-courses, by M. de Saint Ouen, Administrator of the

It is a well known fact that fish do not deposit all their spawn at once. The eggs do not all arrive together at a state of maturity. When left to herself the female returns several times to the place of spawning where the male always follows her, and it is only after a certain number of days that the delivery of the eggs is complete. Although it has been already remarked that only the ripe eggs leave the ovary and find their way into the abdominal cavity, yet the advice was always given to effect the artificial fecundation at once, by forcing out the spawn by pressure on the sides of the belly of the female. Without doubt, this practice in many cases was attended with a violence as injurious to the development of a great number of the products as to the health of the animal thus operated upon.

Struck with these inconveniences, and convinced of the advantages always following from a strict imitation of nature, M. Millet took pains to gather the eggs only in portions and in several days, as they became completely ripe, and to let them fall into the water simultaneously with the milt of the male. As captivity has often a bad effect upon the generative functions of fishes, M. Millet only takes them at the moment of making the fecundations, and restores them to the river immediately after, at the same time tethering them with a pack-thread passed through the gills. They ive very well in this condition, and do not perceptibly suffer from it. M. Millet has also sometimes made use of artificial spawning holes which call to mind those of Lund, but are more perfect. These are a kind of double-bottomed cages, the first consisting of an open frame-work of bars, the second of a movable sieve of metallic cloth. The females, by rubbing against the bars, let fall their eggs which drop upon the sieve. The males being introduced into the apparatus at the same time, it generally happens that the fecundation is effected naturally. This method of gathering has the advantage of losing

Forests. March, 1853. Annals of the Forests, pp. 272 and 420. July and August, 1853. Independently of the various memoirs upon pisciculture, which we have hitherto cited, it may be useful to consult the report of a commission of the king of Holland, having for title, Handlielung tol de Kumtmatige Veremenigouldigen var Vischen, 1853; some notes of M. de Caumont in the Norman Annual for 1850, and in the same collection an Essay upon the Multiplication of Fish in the department of La Manchi, by M. G. Sward de Beculieu, 1854; as well as some letters of the Marquis of Wibraye and the Count of Port Gebard, 1854; in the Analytic sketch of the Labors of the Academy of Rouen a note by M. Bergasse on Artificial Fecundation applied to the Salmon, 1853; and some Researches into the Natural History of the Salmon, by M. A de Bignon, 1853; finally, various observations of M. M. Gehin, Richard de Behagne in the Bulletin of the Agricultural Society of Paris, Vol. vi. p. 461 and 469, 1851; of M. Noblet, *ibidem*, Vol. vii., p. 403, 1852, and of M. Quenard *ibidem* Vol. viii,, p. 95, 1853.

no portion of the eggs, while there is a risk of this in holding the female by a cord in rivers.

The hatching apparatus used by M. Millet varies a little with circumstances, but remains always simple, convenient and economical. If the development of the egg is to take place out of the water in which the parents live, whether in an apartment or under a shed, a vessel of any description is taken, having a capacity of thirty to thirty-five litres, (eight to nine gallons,) and on the bottom of this, gravel, sand and charcoal are heaped up so as to constitute a filter. A purified water runs from this reservoir by a stop-cock situated underneath it, and falls into troughs placed like steps, which may be multiplied at pleasure. This arrangement is entirely similar, as we see, to that which M. Coste had already chosen, but M. Millet has added an improvement, which, we hasten to say, the learned professor of the College of France has at once adopted in his turn.

However pure running water may be, it always bears with it and deposits at the bottom, which it covers, foreign particles, which, if they rested upon the eggs, would finally surround them with a sort of slime favorable to the development of byssus and mould. To meet this objection, M. Millet thought of suspending the eggs a little below the surface of the water. M. Vogt* had already taken the precaution to place them in a muslin bag, permeable on all sides, which he threw into the lake after having fastened it to a stake or kept it in place by a large stone. Starting upon the same principle, M. Millet has arrived at a surer and more complete result. He places the eggs upon sieves, which little rods, sliding on the edges of the tubs, hold at the desired height. This skillful experimenter has successively employed sieves of various substances, of hair, of silk, of willow, &c., and has finally given the preference to galvanized metallic cloth, which have more solidity and durability, do not spoil, are easily cleaned by the help of a brush, and are only very rarely attacked by sea-weed.

The expense of outfit of such an apparatus is quite insignificant. The working consists merely in filling the reservoir every morning and evening, in moving the sieves once a day, and taking away the eggs which may become opaque. For many years the eggs of trout, of salmon, of the umber, &c., have been developed in this way, and hatched in considerable quantities in the same apartment which the experimenter occupies at Paris, in the middle of the rue Castiglione.

When the process can be carried on in the water of a stream itself, of a lake or of a pond, M. Millet recommends the employment of double sieves

*Embryology of the Salmon, Natural History of Fresh Water Fish, by L. Agassiz, p. 16, 1842.

of metallic cloth, which may be kept at a suitable height by the help of floaters, and which follow all the changes of the level water. For the species which spawn in sleeping water, he lines the double sieve with aquatic plants, or limits himself to placing the eggs in large shallow tubs with plants which prevent the water from corruption. When the fecundated eggs are to be transported to great distances, M. Millet advises placing them in a flat box, in quite thin layers, between two wet cloths. In this state he has sent them to Florence, where they have reached the hands of M. Vaj and the Professor Cozzi, after a journey of twenty or twenty-five days, and have not failed to hatch soon after. The use of moist linen is preferable to that of aquatic plants; the linen dries less rapidly, and facilitates the unpacking, which, in the other cases, requires much time and care. The Marquis of Vibraye, to whom the Sologue owes so many useful improvements, and who has already introduced on his estates numerous trout produced by artificial fecundation, has also made use, with advantage, of small wadded cushions. When the eggs to be dealt with are very delicate, and are to be transported during the summer, M. Millet sometimes employs the little portable ice box, of which we have already given the description.

As soon as the young fish have completely absorbed their umbilical vesicule, that is to say, some weeks after the hatching, the author of these curious experiments is of opinion that it is best not to try to nourish them in captivity, but to dismiss them at once into the waters where they will have to live, taking care, however, to place them suitably where they will find the spawn of frogs, lymnites, planorbes, &c. They should commence at once to seek for their prey, and thus avoid the suffering from change of water, of nourishment, and of habits, to which they will necessarily be subject, if raised artificially in basins not communicating with the waters which they must inhabit.

It is principally in the department of the Eure, the Aisne and the Oise, that M. Millet has put in practice these various methods. Affidavits emating from the local authorities, bear witness to the important results which he has obtained. M. Millet has conducted, at the same time, a series of delicate observations, which have already led to some happy applications.* He has examined the action of salt or brackish water on the eggs of fish, which leave the sea to spawn in fresh water, and he has seen that it is injurious to their development in ordinary cases, which gives the practical reason of the emigration of these animals. Nevertheless, salt, which would destroy the healthy eggs, has the singular property of healing them,

*Comptes Rendus of the Academy of Sciences, Vol. xxxviii., session of December 26, 1853.

when attacked by white spots. These spots, which probably spread from the surace to the centre, and would lead to the destruction of the eggs, if allewed to allowed to increase, disappear in water very slightly salted, and when they are taken in time, the young fish may thus be saved. It results also, from the observations of M. Millet, that the mortality of the eggs always reaches its maximum at the epoch when the embryo begins to form; accordingly, he advises transporting them only when the eyes become visible, or rather immediately after the fecundation. He has remarked finally, that the white spots on the one hand, and the sea-weed and byssus on the other, at tack much more rarely the eggs of trout and salmon, at a low temperature, than in one which exceeds fifty-four degrees.

Here terminates the rapid exposition of the applications furnished by zoology to the economy of ponds and water-courses, and of the progress which this branch of industry has made of late years. The labors of Rémy and Géhin, and those of M. de Quatrefages, of M. Coste and M. Millet, represent the present state of this department of agricultural science. To them belongs the honor of having regulated and perfected the methods, and of having determined the basis of a cultivation, before very vague and precarious.

III.

The processes which we have analyzed are not all equally adapted for easy and profitable application. It remains then to compare the respective advantages of them, to determine the combined measures which pisciculturists ought to adopt.

The first care to be taken, when it is desired to stock a river or pond, is to learn what species of fish will best adapt themselves to the circumstances which happen to be united there. To escape the danger of certain failure, it is first of all necessary that the nature, the ordinary temperature, the depth, and the various qualities of the waters to be enriched, should agree with the instincts, habits and way of life of the animals to be developed there. These recommendations are found in all books upon the subject, but cannot be too often repeated. It is most certainly from the neglect of these proprieties, and want of appreciation of them, that certain pisciculturists have seen their attempts miscarry, when they were otherwise skilfully executed.

When, therefore, the ground, as it were, has been studied in advance, and it has been determined what sort of fish has the best chance of prospering there, the individuals necessary for the multiplication of the chosen species should not be procured except at the very season of spawning, since very often the products are spoiled in the bodies of fishes which are condemned to close captivity. This inconvenience does not present itself if the animals can be placed in reserve in inclosures near the rivers or ponds in which they have been caught. Otherwise they may be held by a cord in the same places where they have lived. It is important, before effecting the fecundation, to pay attention to to the temperature of the water, which has so great an influence upon the properties of the milt, as M. de Quatrefages has so clearly shown, and probably also upon the vitality of the egg itself. Although M. Vogt has seen the eggs of the palee* prosper after they had been taken in ice, this extreme cold is generally sufficient to destroy them.

The gathering of the male and female elements should be made on different occasions and in several days. It seems useful, in many cases, to guard the products from all exterior influences, and not to take them from their natural medium. For this purpose a male and female are taken and inclined near each other, at the surface of the water. They are then bent gently upward, which produces a strong contraction, and generally serves to create a flow of the ripe products. If the exit offers any difficulty, it may be assisted by passing the finger under the belly, but without any effort. The simultaneous or almost simultaneous mixture of the eggs and the milt, is necessary in most cases, since with certain fish, as the trout, the animalcules of the milt do not live even a moment, and with others, as the carp, the mucilaginous envelope of the egg swells rapidly in the water, and then opposes itself to the impregnation. For the last reason, it is important always to refrain from washing the eggs before fecundation, as some persons had advised doing.

The eggs once fecundated are placed in an apparatus like those of M. Coste and M. Millet, but it appears to us preferable in all cases, when possible, to employ the double sieve or floating incubator of the last experimenter. The fecundation is then effected in the lower part of the sieve, placed in a tub full of water, and after the cover is put on, the whole is transported to the river which is to be furnished; in this way, the spawn undergoes no change of water, from its exit from the belly of the female to the period of its development. If the eggs are unencumbered, they are allowed to fall to the bottom of the sieve. If they are adherent, like those of the carp, the tench, or the barbel, care is taken to introduce beforehand into the sieve some aquatic plants or twigs. The little apparatus is furnished with floaters, fastened to stakes by a cord, by which it is easy to draw it to the bank,

* A kind allied to the salmon.

when it is to be examined. After the young fish are hatched, and their umbilical vesicule is completely absorbed, the sieve is opened, and they are thus dispersed in the very places where they are to live. With this view, shallow places are chosen, which the fry generally prefer, and which are not frequented by the large fish, or rather inclosures near the water-courses. The fish of this early age have great agility, and commonly escape the pursuit of their enemies by squatting among the pebbles, and concealing themselves in the grass or roots of trees. They then feed naturally upon lymnites, planorbes, small worms, or the spawn of frogs, but it soon becomes useful to throw them the refuse of the shambles or the kitchen, and, generally, as M. Coste has advised, all animal substances which are not made use of. It would seem, however, that some of these substances may become injurious to the fish, and M. Sivard de Beaulieu has remarked that his trout always died after eating earth salamanders. The putrefaction of the substances which are not eaten, offers no inconvenience in a mass of water frequently renewed like that of a brook, while for this reason, and many others the artificial nourishment of young fish in narrow reservoirs is almost impracticable. They should, therefore, always be dispersed after the absorption of their vesicules, without attempts to raise them painfully in small apparatus.

These various operations are, as we see, very simple and easy, and may be brought to a good result by any body with little outlay of time and expense; but it is evident that success depends greatly upon the tact and foresight of the operator, and that here, as in all branches of industry, individual skill will always have great influence upon the result. Without doubt, also, a prolonged and sufficiently extensive experience will soon attain to further improvements in the application of the new methods, and reduce greatly the chances of failure. Every thing, then, gives reason to hope that at an early period pisciculture will be naturalized among the useful sciences, and that it is destined to solve one of the important terms of the great problem of cheap living.

This result, so desirable, would be greatly expedited if the government should decide to take some energetic measures. It should cause to be completely revised, by competent men, the legislation of the fluvial and marine fisheries, and should bring the system of artificial fecundation into operation in all the fresh waters of France, at the same time that a service of observation and vigilance should be organized upon our coasts. In uttering this wish, we are only the echo of all the learned men and economists who have touched upon this question.

Already, indeed, the state has made a first step in the path where we should like to see it wholly enter. It has decreed the piscifactory of Huningue. We are far from denying the services which this establishment may render by its consequences; but it is clearly proved that it will never suffice for entirely restocking the waters of France, and meets very imperfectly the present wants of pisciculture. If there are too great obstacles to putting this vast trial in practice over the whole surface of the country, it would at least be easy for the state to undertake it in more limited, though still considerable proportions, and without charging the budget with any new burden. For this purpose it need only profit by the resources offered by the administration of waters and forests. In fact, this administration disposes of a surface of canals and brooks which reaches nearly 8,000 kilométres, (5,000 miles,) and has a personal force quite ready and trained to the various practices for the husbandry of the waters. The number of its simple fisheries police amount to 427, without counting the general police, sub-inspectors, and inspectors which direct the others, and who are all prepared by their previous studies for applications of this kind. Here is a service extensively organized, which would be admirably adapted to experiments of pisciculture on a large scale, and which would not even thereby be turned from its legitimate functions.

It is to be hoped that those who are interested will not fail to be struck with these easy advantages, and that they will try to attain to at least a part of the results promised by the new industry. Relying upon their own resources, the proprietors have not hesitated to undergo the risks of the trial; but apart from their isolated and limited efforts, does it not belong to the State to give prosperity and extension to the methods devised by Jacobi, and already carried, by men of science in France, to so high a degree of perfection.

JULES HAIME.

Revue des Deux Mondes, June, 1854.

Extracts from the transactions of the Connecticut State Agricultural Society, for the year 1856.

EXPERIMENTS IN ARTIFICIAL FISH-BREEDING.

BY E. C. KELLOGG.

So much has been written by savans upon artificial fish-breeding, it is with no little delicacy that I attempt a compliance with your request, to furnish a paper upon that interesting subject. We are apt to hear of transactions in a foreign land, or of events which take place in a remote section of our own country even, with far less interest, than when similar occurrences fall within the range of our immediate observation. The more remote the scene of some wonderful achievement, the more doubt of its reality will be entertained. Distance, instead of lending enchantment to the mental view, especially when the *dollar* is the object to be discovered, seems rather to blur the vision, and we desire something more tangible whereon to rest our gaze. If the man of science regards the statement of any novel occurrence which is contrary to the ordinary course of nature, with doubts, and will not be convinced of its truth until the fact is demonstrated before his eyes, how much more will the casual observer doubt the practicability of so extraordinary an idea as that of raising fish by an artificial process, and especially of its one day becoming a matter of immense public importance, and perhaps a source of wealth to himself! That fish may be artificially bred, the scientific world is well aware.

The discovery, a century ago, by Jacobi, a skillful German naturalist; the writings of many since his day; experiments for multiplying salmon in the waters of Great Britain, as pursued by Shaw in 1837, and Boccius in 1841; and above all, the re-discovery by Géhin and Rémy, two illiterate fishermen of the Vosges of France, with the practical result of their labors since 1842, render it unnecessary to say anything to establish the fact in the scientific mind.

But we, the common people, also, are slow to believe and slower to act. It is only necessary to consider for a moment the agricultural department, in a single particular, to prove the correctness of the assertion. When we observe so many decayed orchards around us, and farms almost or entirely destitute of choice fruit, the position is established. People are unwilling to engage in any new routine of industry, until it can be clearly demonstrated that by so doing, a large profit will ensue. There is, perhaps, no class of community so slow of improvement as the agriculturist. No, not that, the old fashioned "*farmer.*" Of course, there are many noble exceptions, worthy of emulation. But if a barren stream, once alive with salmon and trout, flows through the fair fields of the enterprising tiller of the soil, it serves well to water his stock, and by a little trouble he constructs a dam and has a fine place wherein to wash his sheep. This is all he wants or expects of his sparkling stream except, perhaps, once a year a "*mess of suckers.*" If he will have a treat of fresh fish, he must content himself with these, wait the arrival of alewives and shad, or pay his dollar for a pound of salmon or trout. He will not think of raising upon his own premises either of these delicate fish. He little dreams that the dam already constructed would make a reservoir for more trout than his necessities would require, and that it is possible, with an outlay of ten or twenty dollars, the little pond would yield a greater annual income than the acre of ground which surrounds it. Perhaps he has heard his father tell of the time when salmon were abundant in his ancient pasture lot, but he scarcely dreams that they might again be seen leaping the cascade over the little dam Talk to him of raising fish artificially, and he will laugh at the idea. He would look upon the undertaking as utterly futile. Nor do I wonder. Such enterprises with favorable results, are so recent, and the necessity of legislative enactments, preparing the way and protecting him in his efforts, is so apparent, it is no marvel that he is faithless or slow.

My object is, to give a brief history of what has been done in our mids t in the way of breeding fish by the artificial process. Learning what has been accomplished in Europe, and also by Dr. Garlick and Professor Ackley, of Cleveland Ohio, I determined, in connection with my friend, D. W. Chapman of the city of New York, to make an experiment, Accordingly, in the summer of 1855, visiting the town of Simsbury, the scene of sport for anglers, far and near, we found upon the grounds of a friend, a fine spring running through a deep ravine, and emptying into the Farmington river. Near the source of the spring we built a slight dam, raising a pond of some three feet head. Farther down, we threw across the ravine a second and larger dam, making a tolerably capacious reservoir, intended for the parent stock. Several times during the season, we visited the neighboring streams, and after considerable toil, we managed to secure a goodly number of trout, mostly, however, of small size, which we placed in the pond.

As we pushed our way through the dense alders along the margin of Stratton Brook, we found the exercise of transporting each a pail of water, wherein to keep alive the fish, rather more troublesome than when our only encumbrance was the rod and simple creel; and as limb-weary at night, we discharged our meager plunder, we began to realize that we were prosecuting a work of labor, as well as enjoying sport. But like Géhin and Rémy, the fishermen of Bresse, by our poor success we were the more convinced of the necessity of doing something for the restoration of our favorite fish, which were so rapidly diminishing in every stream. At length, having secured our little stock, we erected a temporary shanty at the lower side of the upper dam, to serve as a hatching house. A small stream of water was conducted by a pipe and flowed continuously into a box partly filled with gravel. In November, my friend made a visit to the works and conducted the process of spawning a number of the larger fish, and fecundating their eggs after the prescribed method. The eggs were then placed upon the box and left to abide their time for hatching. A particular description of the process of manipulation will be given further along.

In the course of a few weeks it was apparent that embryo fish were being developed in some of the eggs, and in nine or ten weeks about seventy-five trout were hatched.

The fry were kept in the box a month or two and then were allowed to run into the pond, below. The next fall, we found them with the old fish, and apparently doing well.

Last summer, I was induced by the convenience of the Connecticut river water on my premises, to make the experiment of artificial fish-breeding on a small scale, at home. During the season I placed a number of trout in a little pond which I had excavated in the garden. In the cellar I arranged a box with several partitions, filled it partly with gravel, and laid it in a slanting position, so that the partings formed a series of steps, and water from the public reservoir was conducted to it through a lead pipe. November, the time for spawning, having arrived, I took a female trout, holding it firmly in my left hand, the back of the fish in the palm, and with the right hand, gently pressed upon the abdomen from top to bottom. If the eggs are fully matured, by this operation they will readily be forced from the ovary and spirt out like a stream of water. After collecting the eggs of several fish in a vessel containing about a quart of water, taking a male fish in the same manner and by the same process, I expressed the milt into the vessel with the eggs. The milt communicating with the water, immediately changed it to a milky hue, and after stirring the eggs so that they would be sure to come in contact with the milt, and letting them remain a few minutes, the process of fecundation was completed. I then placed the eggs upon the gravel in the several apartments of the hatching-box, where a small stream of water was running, and they were left to hatch. In spawning the fish I found some that were not mature, and it was with difficulty that the eggs were expressed; others I found that would not yield at all. Such were kept several days or weeks, until their full time should arrive. Of some two thousand eggs that were expressed, I am now convinced that comparatively few were in a mature state, and, consequently, most of them were unfecun lated and died in a short time.

I found the process of expressing the ova and the milt at first somewhat difficult, the fish in its struggles would so easily squirm through my hands; but by a little practice I soon was able to perform the delicate operation, I fancy, equal to the most skillful practitioner; for of a dozen or more that were subjected to the manipulating operation, not one seemed to have suffered from its effects.

The process of incubation went on very slow; the temperature of the water being some 10 degrees below that of spring water. In about four weeks, however, eye-spots began to appear, and in about eleven weeks a few fish were hatched. Those first out, were from eggs spawned in November. Others spawned in December, now more than one hundred days in the water, are just beginning to hatch. Of all the eggs deposited in the box, only some sixty seem to have been fecundated, or at least to have shown signs of development. The reason for so small a yield must be attributed in a great degree, to the immature condition of the egg, and somewhat, perhaps, to the excessive coldness of the river water. On testing the temperature, I found the mercury frequently as low as about 35 degrees.

In both experiments we labored under disadvantages, which, doubtless, another trial would in a great measure overcome. Had the attempt in the cellar, proved wholly ineffectual, I should have been less surprised, than I am at the present success. What with inexperience, a dearth of mature eggs, the most unfavorable arrangements for water, and the lack of other important accessories, I am entirely satisfied with the result. We were not aware that it was so absolutely imperative to observe the precise conditions, in order to insure success; and although the conditions are, for the most part, carefully laid down and are apparent to the understanding, still, a little practical experience, in order to *know them*, must prove extremely advantageous. An account of recent experiments in Europe states, that out of forty thousand eggs, unfavorably conditioned, twenty thousand were successfully hatched. On another occasion two hundred and sixty thousand ova were deposited and all, with trifling exception, were hatched. Again, of several thousand ova taken from a single salmon, every one produced a fish in fifty-seven days. In an interesting "Treatise on artificial Fish-Breeding," translated and edited by W. H. Fry, of New York, after describing Mr. Géhin's process of fecundation and incubation of trout's eggs, the description continues with his observations of the phenomena of hatching; thus, "The tail comes first from the eggs, and the pieces of the fine skin or shell torn by it, form the two hinder fins. The head next appears at the other end, and the torn shell there forms the forward fins. The lower part of the egg forms the belly, and the upper part next is broken and the back appears. The shell or skin which enveloped the embryo is not detached from the newly born fish, but becomes a part of, and is absorbed by it."

My observations of the same phenomena differ most essentially from those of Mr. Géhin; I do not discover any uniformity in the manner which the young fish emerges from the shell. Sometimes the tail first appears, and sometimes the head, and not unfrequently the belly is first seen protruding; and instead of the shell becoming a part of the fish and forming the fins, I have invariably observed the entire shell completely detached. A few days since, I was examining an egg, when only the head of the fish was out, and taking it between my thumb and finger, by a gentle pressure, forced the fish completely from the shell. Again, I was examining with a magnifying glass another egg, and while pressing it slightly, saw it burst and the entire fish except the head appeared. In this state it remained a day or so, when it became wholly free.

Possibly the trout which Mr. Géhin observed, were of a different species, and it is possible their manner of hatching is also different. The young fish are extremely delicate, and for many days by the aid of a magnifying glass, the motion of the blood from the pulsations of the heart can be distinctly seen through the transparent tissues.

The newly hatched fish vary in size according to the size of the egg, and are from three to five eighths of an inch long. Their growth is quite perceptible from week to week and it is interesting to observe how soon they practice the habits of shyness, so natural to older fish. Those which were hatched about the beginning of February, are now nearly an inch in length. The umbilical bladder which has furnished their sustenance for weeks is nearly absorbed and it is almost time for them to show signs of hunger. They are growing finely, are lively and seem in perfect health.

It may not be inappropriate, here, to state, that the experiment in the cellar has been a double one; that is, I have tested the practicability of artificial fecundation and incubation, and also that of keeping a large numb. r of fish in circumscribed quarters, and with a small supply of water. In the fall I removed from the pond in the garden, the old stock, about forty in number, some of the largest of which were those manipulated, to a half hogshead in the cellar. After the operations of spawning, they were lank and poor, and although supplied with a stream of water a good share of the time no larger than a str w, they all lived, fed readily, and are now plump and in excellent condition. I can see no reason why fish may not be stall-fed, so to speak, and fattened as well as other animals.

The experiments which I have been interested in, prove to my mind, most conclusively, and independent of the glowing accounts of success in France and England, that artificial Pisciculture may be prosecuted on an extensive scale and to immense advantage to community at large. I am also persuaded that 't will be of little avail to attempt such an experiment without knowing and regarding all the important conditions, so necessary to success. That those conditions may be well understood, and that each year's experience will demonstrate rapid progress in the art, I have no reason to doubt.

What practical result will accrue to our community from this scientific development which has awakened the attention of governments in Europe, remains to be proved. I should like to see the enterprising Yankee, who would venture an investment, sufficient to carry on a fish-breeding establishment successfully. There are enough ready to purchase mill-sites and erect manufactories, because they are pretty sure of a profitable return. This they understand; but fish-breeding, as a source of profit, would be a new business and they will be cautious. They are not censurable. I think, as in France, the State should first lend a patronizing hand. Some sort of commission should be instituted. The subject should be investigated and if found worthy, an appropriation should be granted, works established, wholesome protective enactments passed, and suitable encouragement given to all who might venture in the enterprise.

From what has been done in Europe, prophetic vision is unnecessary to see that at no distant period, with proper legislative care, our rivers and streams, now impoverished or barren, will teem with salmon and trout, as well as with delicate fish from foreign waters, affording food and luxury to all. Is there a country that possesses greater facilities for such an enterprize? What beautiful rivers, lakes and mountain streams! Let the spindle whirl and be protected, and let the salmon and the trout also come in for a consideration at least.

The man who would make two dollars out of one, would hail the opportunity. The epicure would smack his lips at the thought of a pound of salmon or trout at a quarter of the present value,—the day laborer would rejoice that he could obtain his money's worth for a shilling, and every true lover of the angle, at the first favorable expression of the wisdom of the state, would shout for joy.

What benefits might not imagination fancy, in store for the varied interests of community! Religiously considered, the mere observer of outward forms as well as the true Christian would be enabled to keep more rigidly the Lenten days. Morally, man would have less occasion to wrong his fellow man; and physically, the inner man would be less a slave to outer conditions.

As a learned writer informs us, that fish should enter more largely into the culinary department, as an article of diet, so soon as the novel art will allow us to adopt the suggestion, we may indulge the hope that instead of the many Calvin Edsons, who now mope around, ghostly, gaunt and grim, there will be more who will approximate the Daniel Lambert school of *solid men*, each like Shakespeare's justice,

"In fair round belly with good *salmon* lined."

It is gratifying to know that some of our sister states are manifesting an interest in the subject, and when the practicability of success is rendered more apparent and its vast importance as a matter of public economy is considered, I feel confident that something will be done by way of encouragement, by the legislature of our own State.

Respectfully yours,

E. C. KELLOGG.

H. A. Dyer, Esq., *Secretary State Agricultural Society.*
Hartford, March 27th, 1857.

Mr. Dyer,

Dear Sir:—The greater portion of the following article was contained in a paper read by me several months ago before the Natural History Society of Hartford. It has been prepared hastily, at moments stolen from an avocation by no means congenial to the spirit of the subject,—and I am quite sensible of its imperfections.

The art of artificial fish breeding has for several years occupied my thoughts. In 1853, I attempted, in a report on a kindred subject, to attract the attention of our Legislature to the developments which had then been made, and to awaken a sense of their importance in reference to the re-establishment of salmon in our waters. At that time, however, so far as I know, little had been written or effected in this country, and I was not prepared to demonstrate the practicability of what I proposed. Four years have elapsed, and Pisciculture has attained such a rank among the economic arts, that an apology can no longer exist for neglecting its claims.

Yours truly, &c ,

J. C. COMSTOCK.

HARTFORD, March, 1857.

PISCICULTURE.

SALMON BREEDING.

Although it is at a quite recent date that the art of Pisciculture, or the Artificial Breeding of Fish, has attracted, to any great extent, the notice of scientific men, and has been extensively applied to economic purposes, yet the main facts upon which it is founded, as well as the principal processes for carrying it into effect, were understood many years ago. In this as in many other instances, we find only another illustration of the truth of the verb, "there is nothing new under the sun!" The ancient Romans undoubtedly knew something of this art, and their epicurean tastes led them to invent many processes for preserving and fattening fish. The Chinese also are said to have paid considerable attention to fish-raising, and some knowledge of the art of breeding fish from the egg would appear still to exist among them. Something of this art was also probably known to those priestly epicures, the monks of the middle ages. Whether they understood the mode of artificial impregnation, as at present practiced, may admit of a doubt, but it seems certain that they effected, on a large scale, introduction of foreign fishes into the ponds and streams, which always formed an appendage to great monastic houses. There are good grounds for supposing that the carp, the grayling, the charr, and several other species, were thus introduced into English waters, when England was Catholic, and when the great number of fast days rendered a corresponding supply of fish necessary. But it is not as a matter of antiquarian curiosity that I desire now to present the subject in question, but rather to consider it in its modern and utilitarian aspect. The credit of the modern discovery of this long neglected art, unquestionably belongs to M. Jacobi, a German gentleman, who, in the year 1763, communicated to the Hanover Magazine, an interesting account of his plan for the breeding of trout by artificial impregnation of their ova; and it is not a little remarkable, that this plan contains the substance of nearly all that has since been discovered in relation to the art, though Jacobi does not seem to have been aware of the extent to which it may be applied. His invention, as he states, was the result of experiments made during a period or no less than forty years. Though the process of Jacobi attracted some attention among the scientific men of the time, and was the means of stocking many streams in Holland, yet it appears to have fallen into disuse, and to have slumbered a long time among those forgotten inventions which are so often claimed as new discoveries by a succeding age.

Sir Humphrey Davy, in his delightful "*Salmonia*," alludes to Jacobi's experiments, of which he gives a short account, and recommends a trial of Jacobi's method to those who propose to stock ponds with trout. He also dilates upon the practicability of introducing by these means, various foreign species of fish into the waters of England. Sir Humphrey also appears to have tested some of Jacobi's experiments, and to have entirely satisfied himself of their correctness and value.

About fifty years later than the time of Jacobi, that is to say, from 1830 to 1835, a series of really accurate and scientific observations were made in regard to the peculiar habits of fish at the spawning season,—habits upon which the whole science of artificial propagation is founded. These observations would appear to have been originally instituted by Dr. Knox, of Edinburgh, who published a paper on the subject in the Transactions of the Royal Society. He watched the process of spawning, in the the case of the salmon, and observed the progressive development of the ova, and of the young fishes after exclusion. His hints were followed up, at about the same period, by a most acute and patient observer, Mr. John Shaw, who devoted himself for several years to a series of well-manag d observations of the natural history of the salmon; and it is to him that the world is indebted for the most interesting information it possesses on this interesting subject. Mr. Shaw does not appear, however, to have been aware of the importance of these experiments of his, as connected with the re-stocking of rivers with fish,—by far the most important purpose to which they can be applied. There had been a long and bitter dispute going on among British naturalists and anglers, as to the identity of a small fish abounding in many of the English and Scotch streams, and usually called parr or pink, with the true salmon,—some contending that the parr was the young of the salmon, and others that it was a full grown species of the salmon family, separate and distinct from any other. It was principally for the purpose of settling this vexed question, that Mr. Shaw's experiments were undertaken,—and he succeeded most satisfactorily in demonstrating the truth of the assertion, that the parr is the young of the salmon. But he did a great deal more than this; and the facts, thoroughly proved, and clearly stated, which he details in regard to the mode of spawning, time of hatching, progressive growth, migration to and from the sea, and other peculiar habits of the salmon, will always possess the greatest value as a foundation for the entire practicability of restoring that splendid fish to waters from which it has been exterminated. At about the same time, experiments were also made by Mr. Andrew Young, of Scotland, and by Mr. Boccius, an engineer, at Harrowsmith, England.

It is to France, however, that the honor must be awarded, of having first carried into practical effect, and applied to a useful purpose and on an extensive scale, the information afforded by the observations of the British naturalists. There is no government in the world which has always been so ready to encourage and protect inventions which tend to a development of the economical resources of the country, as that of France. It is not surprising therefore, that when it was announced, something more than ten years ago, that two poor but ingenious fishermen of the department of Vosges, M. M. Géhin, and Réme, had acquired the art of breeding fishes, in any quantity, and had actually caused the salmon, trout, perch, and other species, to abound in waters which had long been deserted by them, the Natural Academy of Sciences and the government, should have taken these benefactors of mankind under their especial patronage, and afforded them the means of porsecuting their experiments on a large scale, in various portions of the country.

From this time forward Pisciculture has taken its place as a well founded and most important science—and it is now thoroughly understood in most of the civilized countries of Europe. In Germany, France, England, Scotland, it has already proved of the utmost importance to the well-being of society. It has furnished a supply of wholesome, agreeable, and cheap food, to a class of persons, and in districts, where want and poverty have heretofore prevailed. It has given rise to a lucrative and extensive branch of industry, and has afforded occupation to thousands of persons. It has, in fact, particularly in many portions of France, opened up a new and inexhaustible source of wealth and prosperity. Let us hope that the United States—and especially the New England States, (for to them it is of perhaps greater necessity than to any of the others)—will not long be found to lag in the rear of a development of social industry so exceedingly important, and so easily attained.

Having thus very briefly touched upon the history of Pisciculture, it is time to recur to those facts upon which is founded its application to the restoration of fish to those waters which are destitute of them, or from which certain species have gradually disappeared. To illustrate this branch of our subject, I shall refer, sufficiently at length, to the results of the observations of Mr. Shaw and Mr. Young on the salmon, since it is to this particular species that I desire to direct the attention of those into whose hands the work which contains these observations may fall.

The salmon enters the rivers from sea, during the spring and early summer. The female salmon precedes the male, entering the rivers about a month earlier than her mate. They remain for some time near the mouths of the rivers, in tide water, where they get rid of certain parasitical animals which become fixed upon them, during their stay in the salt water. During the summer months they proceed up the rivers, in search of proper places to deposit their spawn. For this purpose they seek the cool and shallow streams which are tributary to the main river, in which the water runs with a rapid motion, over a gravelly and sandy bed, and where it becomes highly charged with the oxygen taken up from the atmosphere. Here the male and female salmon pair—the male driving away with great vigor and activity, all intruders of his own sex. It is not until the season is so far advanced that the temperature of water is considerably reduced, that the operation of depositing the ova commences. This takes place in the months of October and November, and is sometimes delayed even as late as the latter part of December. The mode in which the ova are deposited is minutely described by Mr. Andrew Young, whose words I use in the following description of this interesting operation.

"The spawning bed," says Mr. Young, "which may be called a continuation of nests, is never fashioned transversely or across the water current, but straight against it. The way the bed is formed has never before been accurately described. Some have affirmed that the male fish is the sole architect; others that the female does all the work; others again, that the tail is the only delving implement employed; and others write that the bed-trenches are dug across the stream. A salmon spawning-bed is constructed thus:—The fish having paired, chosen their spot for bed-making, and being ready to lie-in, they drop down stream a little, and then rushing back with velocity toward the spot selected, they dart their heads into the gravel, burrowing with their snouts into it. This burrowing action, assisted by the powers of the fins, is performed with great force, and the water's current aiding, the upper part or roof of the excavation is removed. The burrowing process is continued until a first nest is dug sufficiently capacious for a first deposition of ova. Then the female enters this first hollow link of the bed, and deposits therein a portion of her ova. That done, she retires down stream, and the male instantly takes her place, and pouring, by emission, a certain quantity of milt over the deposited ova, impregnates them. After this the fish commence a second excavation, immediately above the first, and in a straight line with it. In making the excavations they relieve one another. When one fish grows tired of its work, it drops down stream until it is refreshed, and then, with renovated powers, resumes its labors, relieving at the same time its partner. The partner acts in the same spirit, and so their labor progresses by alternate exertion. The second bed completed, the female enters it as she did the first, again depositing a portion of ova, and drops a little down stream. The male forthwith enters the excavation and impregnates the ova in it. The different nests are not made on the same day but on different days progressively. The ova in the first are covered with gravel and sand, dug from the second, being carried into it chiefly by the action of the current. The excavating process just described is day by day continued, until the female has no more ova to deposit. The last deposition of ova is covered in by the action of the fish and water, breaking down some of the gravel crust above and over the nest. Thus is formed a complete spawning-bed, not at once, not by a single effort, but piecemeal, and at several intervals, of greater or less duration, according to the age or size of the fish, and quantity of ova to be deposited." As soon as the operation of spawning is completed, the salmon drop down into some deeper pool, where they remain quiet awhile, until they have somewhat recovered from the exhausting process of procreation. At this time they are lean, out of condition, and quite unfit for food. They mostly return slowly down the river to the sea, during the same autumn—though some probably remain in the fresh water through the whole winter.

The time required for the eggs to hatch depends upon the temperature of the water. Mr. Shaw ascertained that this time is about

114	days,	with	the water	at 36	degrees,
101	"	"	"	43	"
90	"	"	"	45	"

This was in the open air, in natural streams, and exposed to the ordinary influence of the atmosphere and weather. The length of time may be diminished, as will be shown hereafter, by artificial hatching.

When first excluded from the egg the young fish measures about half an inch in length, and for the first thirty days of its existence it is nourished by the yolk of the egg, which adheres to its belly. Their appearance and growth are thus described by Mr. Shaw: "On its first exclusion, the little fish has a very singular appearance. The head is large in proportion to the body, which is exceedingly small, and measures about five-eighths of an inch in length, of a pale blue or peach-blossom color. But the most singular part of the fish is the conical bag-like appendage which adheres by its base to the abdomen. This bag is about two-eighths of an inch in length, of a beautiful transparent red, very much resembling a light red currant, and, in consequence of its color, may be seen at the bottom of the water, when the fish itself can with difficulty be perceived. The body, also, presents another singular appearance, namely, a fin or fringe, resembling that of the tail of the tadpole, which runs from the dorsal and anal fins to the termination of the tail, and is slightly indented. This little fish does not leave the gravel immediately after its exclusion from the egg, but remains for several weeks beneath it, with the bag attached and containing a supply of nourishment, on the same principle, no doubt, as the umbilical vesicle is known to nourish other embryo animals. By the end of fifty days, the bag contracted and disappeared. The fin, or tadpole-like fringe, also disappeared, by dividing itself into the dorsal, adipose and anal fins, all of which then become perfectly developed." The fish then acquires the transverse bands which characterize it as a parr, and continues slowly to increase in size until the succeeding spring, or until it becomes a year old. It then assumes a silvery hue, loses the markings of its parr state, and becomes what is called a smolt—having grown to a length of about six inches. During the same summer, or when they are fourteen or fifteen months old, the salmon smolts proceed down the river to the sea. After this their growth is exceedingly rapid. By means of marking a large number of smolts, by twisting small pieces of wire into their dorsal fins, Mr. Shaw ascertained that the same fish, which in the spring are in a state of smolts, weighing five or six ounces, and measuring six or seven inches in length, return from the sea into the rivers the same autumn, weighing from two to eight pounds, in which state they are called grilse. In the same manner he found that the same fish which he had taken as grilse in the autumn, returned to the river the next summer as full grown salmon, weighing from eighteen to thirty pounds. These facts are also well substantiated by other observers, and Mr. Yarrell, even states that smolts marked in April or early in May, have been retaken by the end of June, weighing two or three pounds or upwards.

Those who may desire to read more than can be comprehended in this brief notice, of the natural mode of reproduction in the case of the salmon, and of the habits of that fish, I would refer to the article on salmon in Yarrell's British Fishes, Vol. ii, p. 1; as also to "Lessons on the Natural History and habits of the Salmon," by "Ephemera," reprinted in Fry's work on Artificial Fish Breeding.

It will be perceived, by the facts just stated, that the conditions favorable to the production and growth of the salmon,—and, indeed, to that of all anadromous fishes,—that is, such as run from the sea up the rivers to deposit their spawn, are as follows:

1. There must be a free passage allowed to the fish, so that they can reach, without obstruction, those places in the small streams which they naturally select as spawning beds.

2. They must also be allowed a free passage downward again to the sea, in order to complete their growth.

3. The fish should not be taken, before they arrive at such a state of maturity as to be capable of propagating their species.

4. They should not be taken at that season of the year when they are about to deposit their spawn,—nor should they be taken immediately after spawning. These conditions will be found to be of much importance in considering what legislative enactments should be required and enforced, in order to maintain a supply of this class of fishes.

Let us now turn to artificial propagation. And, in the first place, I give a short account of Jacobi's experiments, which, as I have already mentioned, are entitled to great consideration, as being the first of the kind, so far as recorded.

The mode in which the salmon and trout deposit and fecundate their spawn, in the natural state, was known to him,—and for his first experiments he collected a quantity of the impregnated ova from the spawning bed. He afterward imitated, artificially, this mode of natural propagation, by capturing a pair of salmon at their spawning bed, pressing the ova from the female into a vessel of water, and then pressing the milt from the male in the same way. "A pint of very clear water," he says, "is poured into a nice clean vessel, such as a wooden bucket, or shallow tub; a female salmon is then taken by the head and held over it; if the eggs have come to maturity they will fall into it; if not, by pressing the belly lightly with the palm of the hand, they can be made to do so. The male fish is then treated in the same manner. When from the male enough milt has been pressed out to whiten the surface of the water, the operation of fecundating the eggs is complete." But in order to make a practical application of his experiments, he prepared beforehand, to receive the fecundated eggs, long hatching boxes, in the arrangements of which were combined all the conditions with which he had observed the females to surround their spawn when deposited at the bottom of streams. His hatching apparatus he thus describes: "The box may be constructed of any suitable size,—for example, eleven feet long, a foot and a half wide, and six inches high. At one extremity should be left an opening six inches square, covered by a grating of iron or brass wire, the wires not being more than four lines apart. At the other extremity, on the side of the box, should be made a similar opening six inches wide by four inches high, similarly grated; this one will serve for the escape of the water, the other for its entrance, and the gratings will prevent water-rats, or any destructive insects, from reaching the eggs. The top of the box should be closely shut for the same reason, but a grated opening, similar to the rest, six inches square, may be left to give light to the young fish; this, however, is not absolutely necessary. A suitable place should then be chosen for the box, near a rivulet, or what is better, near a pond supplied with running water, from which may be drawn by a little canal a stream, say an inch thick, which should be made to pass continually through the gratings and through the box. Lastly, the bottom of the box to the thickness of an inch, should be covered with sand or gravel, and on this should be spread a bed of stones of the size of nuts or acorns." In this artificial brook, "the fecundated eggs are spread, in one of the boxes so placed, and the water of the little rivulet passes over them, care being taken that it does not run with such rapidity as to displace and carry away with it the eggs, for it is necessary they should remain undisturbed between the pebbles." After Jacobi had thus scattered the fecundated eggs on the bottom of this artificial rivulet, he carefully watched all the varied phases of their development, with a view of discovering any hidden obstacle to the success of the experiment. He found that the time necessary for incubation varied with the temperature,—that it required a much longer time when the water was cold than when it was moderately warm. He found, too, that a sediment is deposited on the eggs which is hurtful or destructive if allowed to remain, and to remedy this difficulty, he cleaned them by brushing them with the feather end of a quill. After the birth of the young fish, he preserved them in the breeding boxes until the umbilical bladder was absorbed, and then allowed them to run into the brook. The whole of Jacobi's experiments were characterized with great good sense, and were performed with much ingenuity. He demonstrates the practicability of stocking waters, hitherto unproductive, with all species of fish suited to them, and shows that his method, thus applied might become a source of great profit. The first trials of his plan were made near Nortelem, in the kingdom of Hanover, and he perfectly succeeded in rearing to maturity considerable numbers of trout. The English government, it is pleasant to mention, rewarded the ingenuity and perseverance of Jacobi, by granting him a pension.

As I have before stated, however, the knowledge of these experiments seems to have perished with their author,—or, at least was only preserved among the annals of science,—and no practical use was made of them, even by scientific men, until public attention was called to them by Mr. Shaw and Mr. Boccius, in special reference to the multiplication of salmon, which valuable species had begun seriously to diminish in Great Britain.

The observations of Mr. Shaw on the reproduction of salmon in their natural state have already been alluded to. He also made some experiments, on a limited scale, in artificial fecundation, and succeeded in hatching and preserving the young fish in ponds. The practical results of his experiments were carried to a considerable extent, in 1841, by Mr. Boccius an engineer at Hammersmith. He succeeded, by means of artificial propagation, in stocking the streams of gentlemen in several parts of England with trout. On the estate of Mr. Drummond, near Uxbridge, that of the Duke of Devonshire, at Chatsworth, and other places, he practised the art with success.

At about the same period, the remarkable operations of M. M. Rémy and Géhin, in artificial fish-raising attracted the attention of the scientific men of France, and led to more extensive experiments than had yet been undertaken in any other part of the world.

These two men, fishermen by occupation, succeeded, in a few years, in stocking most of the streams in their department. They had never heard of any previous experiments of the kind, but, having found that the trout, for which the streams in the neighborhood had been famous, had greatly decreased in number, they attempted to invent a remedy for the evil. They discovered that a large proportion of the spawn deposited in the bed of the streams failed to prove productive, having been devoured by other fishes, or buried in the mud. They then reflected that if they could collect the eggs, see them properly fecundated, place them in such a position as would prevent their destruction, and secure the young fishes from injury, the supply would be greatly increased. They accordingly put in operation the process which has already been described, of pressing the eggs from the female, and mixing them with the milt of the male. They then deposited the eggs on a layer of gravel, in a box pierced with holes, and fixed it in the bed of a flowing stream. After the young fish were hatched, they kept them in small reservoirs, till they were able to take care of themselves, and then turned them into their streams. They had already stocked several rivers, when the government took them into its service, and assisted them to apply their system on a large scale. Subsequently, the government made a large appropriation, and appointed agents to erect and superintend an establishment for fish culture at Hunnigen.

This establishment went into operation in 1852, and in six months had artificially fecundated 3,302,000 eggs, and produced 1,683,000 living fish—600,000 of which were trout and salmon. From this place the young fish or fecundated eggs have been sent to all parts of France, and distributed in the waters where they are needed. The eggs are packed for transportation in wooden boxes between layers of moist sand, and experience has shown that they may be carried in this way to almost any distance, without injury. Instead of the hatching boxes used by Jacobi, the eggs are deposited upon fine willow hurdles, or shallow baskets, which are placed in troughs filled with water, through which a gentle stream is constantly kept running. This process is carried on within doors, in rooms the temperature of which can be properly regulated. The young fish are turned into ponds, where they are fed until of proper age to be transported to the waters in which they are destined to find a home. The apparatus required is so simple and cheap that it can be put up on a sufficiently large scale in the conservatory, or even in the kitchen of any gentleman who desires to apply the process to the stocking of his own pond. Without occupying further space in describing the details of this process, I refer the reader who is curious to know more about it, to the "Complete Treatise on Artificial Fish Breeding," by W. H. Fry, published by Appleton & Co , which contains translations of the reports made on this subject to the French government, and the mode pursued in England. I may add, however, that I have myself seen the entire success of experiments of this kind, made by Drs. Garlick and Ackley, at Cleveland, Ohio; and that, during the past winter, Mr. E. C. Kellogg, of Hartford, had succeeded in raising a considerable number of trout in his own cellar, by means of a small stream of Connecticut River water, and a trough divided into compartments, and filled with gravel, upon which the eggs are placed.

Taking it for granted, then, that the process of artificial fish-breeding is practicable and easily applied, even on an extensive scale, I desire now to show that with proper legislation and moderate expense, our own beautiful rivers may be re-stocked in a few years with that noblest of fish, the salmon.

And, in the first place, as to the causes which have operated entirely to destroy the salmon or to drive it from our waters. It is well known that within the memory of man, that even as late as within fifty years, no river in the world was more celebrated for the numbers and the quality of its salmon, than the Connecticut. And it is equally well known that at the present time they have entirely forsaken that river. The same gradual process of extinction is going on in all the rivers to the northward. In the British Provinces, where, until quite recently, salmon have been exceedingly abundant, their great diminution in numbers within a few years past, has excited inquiry as to its causes, and has led to the enactment of laws for its prevention. Much has been written, and many speculations indulged in, as to the reasons of the desertion of our rivers by this noble fish. It has been attributed to the turmoil of the waters caused by the running of steamboats, to the building of towns on the banks, to the noise of mill-wheels, and the poisoning of the streams by saw-dust and bark. All these causes, however, have been fully proved to have had comparatively little effect upon the migration of these fishes. The limits of this paper will not allow me to state the evidence on which this assertion is founded—it is enough to say that the result complained of is now satisfactorily demonstrated to be mainly due to other circumstances. Among them, the most important of all is the erection of dams and other obstacles to the ascent of the fish to their breeding places in the smaller and clearer tributaries to the main rivers. If the fish are unable to reach those clear and gravelly streams where they find the conditions requisite to the hatching of their ova, they are compelled to deposit their spawn in the wider and more turbid waters below, where it becomes covered up with mud, is washed away, devoured by other fish, and fails to become productive. The annual supply of young fishes is thus diminished, while at the same time the capture of the adults is continued by every means which the ingenuity of the fisherman can invent. It is found, too, that salmon, after being thus repeatedly prevented from following the instincts which lead them to deposit their spawn, will cease to make the attempt, and will no more return to the same river. This process of destruction is now actually going on in the British provinces. In a most admirable report made in 1852, on the fisheries of New Brunswick, by M. H. Perley, Esq., of Saint John, instances are mentioned on almost every page where allusion is made to the salmon fisheries, of streams in which, before the erection of dams, salmon abounded, but in which at the present time, none are found.

One of the most important measures to be taken then, for the preservation of these fishes, is the opening of suitable fish-ways in all dams, across the streams which they frequent. Such fish-ways can be constructed at a small expense to the individual dam-owners, and with very little effect on the head of water maintained. In most parts of Great Britain, the construction of these fish-ways is made compulsory—and laws have been enacted for the same purpose in the British provinces. In Scotland and elsewhere a kind of fish-ladder is sometimes used, which consists of a broad trough of wood sloping down from the top of the dam to the ground below, and divided by partitions carried partly across, in such a manner as to check the impetus of the water and give the fish resting places on their ascent. To show the effect of suitable fish-ways on the supply of salmon, I quote a single case among many others, mentioned by Mr. Perley. Referring to the Saint Croix River, he says: "Up to 1825, the dams were provided with fish-ways, and while these were maintained the fisheries on the river did not diminish; but in that year the Union dam, (the lowermost,) was built without a fish-way, and the fisheries instantly fell off, continuing to diminish ever since, and now they can scarcely be said to exist. In 1846 the Union dam was swept away by a great flood, and fish got up the river; for two years after there was very good fishing, but the rebuilding of the dam again put a stop to it." In case then of an attempt to restore the salmon to the waters of Connecticut, the first requisite for success would be the opening of the dams. Other regulations, affecting the time, method and place of capture, would be also necessary. The plan which I would propose then, is briefly as follows:

1. Let the Legislature of Connecticut appoint a commissioner or commissioners, whose duty it shall be to employ suitable persons to carry out the details of the plan proposed.

2. During the present summer, and before the spawning season of salmon, let the principal rivers of the State, the Connecticut, the Thames, the Housatonic, and their tributaries, be examined, with reference to the selection of proper places for breeding the fish, and let hatching boxes, small ponds for the reception of the young fish, and all the necessary apparatus for artificial breeding be prepared.

3. At the spawning season, that is, in November and December, let the persons charged with this duty, proceed to the rivers at the northward in

Maine and the British Provinces, where salmon are still abundant, and procure as large a supply of the impregnated ova as possible, to be transported by the means already indicated, and to be deposited in the hatching boxes, the process of incubation te be watched during the winter. Or arrangements might be made with persons in the vicinity of salmon rivers, for a supply of salmon-fry in the spring, wh ch could be transported in hogsheads of water, and placed in the ponds made for the purpose. In either case, the young fishes would be kept in ponds until the spring of the succeeding year, an l then allowed to proceed into the rivers.

4. The renewal of these operations during each year for four or five years, for the purpose of keeping up a supply of the stock, until the salmon have become adult, and have commenced their migrations up the rivers.

5. An enactment compelling all proprietors of dams to construct proper fish-ways, within a certain time after the passage of the act—the fish-ways to be approved by the commissioners. Although the immediate passage of such an act would be of immense benefit to the shad and other fisheries on our rivers, yet it need not go into operation for the purposes contemplated here, until the young salmon are turned into the rivers.

6. The prohibition under a heavy penalty of t king salmon in any waters of this State for the period of four or five years, in order to give the fish an opportunity of breeding two or three times, before any are allowed to be killed.

7. The prohibition forever of taking salmon between the months of October and April, or while they are at their spawning places, or within half a mile of any dam or fish-way over which they are compelled to pass on their migrations.

8. The prohibition of the placing of permanent nets across the main channel of the rivers, or extending more than one-third of the distance from either shore.

Upon referring to the "*Act for Encouraging and Regulating Fisheries,*" Revised Statutes, Title XVII., it will be found that enactments already exist, which embody several of the most important of the above conditions, and which, if extended to all the waters of the State, and rig rously enforced, will render necessary little additional legislation, after the salmon shall be once introduced into the rivers. The regulations contained in the act referred to, regarding the construction of fish-ways in dams, the time and manner of fishing, and the penalties imposed, are entirely judicious, but are mostly restricted to certain individual rivers. Little more would be needed than to make the same regulations applicable to every stream in which salmon should be taken.

Upon conditions similar to those mentioned, the Natural History Society of New Jersey, have offered to stock with salmon the Passaic, the Hudson, and the Delaware Rivers. Whether they have actually commenced operations, I am not informed. There can however be no reasonable doubt of the success of the plan, provided the protection required is afforded. The amount to be appropriated by the State, to pay the expenses of constructing breeding places, and transporting the ova or the young fishes, would be trifling indeed, compared with the successful result which may be anticipated. Probably two or three thousand dollars would be an ample sum. Should this not be sufficient, individual subscriptions could undoubtedly be obtained to make up any deficiency, as soon as the preliminary steps are taken by the legislature. The plan which I have thus briefly indicated, presents so few difficulties, and will be productive of so much good, if carrid out, that I feel confident that it only needs to be brought to the notice of a wise legislature, in order to receive the attention which it deserves. As soon as the initiatory steps are taken by our own State, the legislatures of Massachusetts, Vermont and New Hampshire, will undoubtedly adopt measures to apply similar enactments to those portions of our rivers which are within their jurisdiction. Indeed, the legislature of Massachusetts has already appointed a commissioner to inquire into a report upon the practicability of applying the processes of fish-raising to the waters of that State. Nothing could be caiser, after our own legislature has taken the requisite action, than to have a meeting of agents from each of the four states concerned, for consultation upon the adoption of a concerted plan of operations. I need hardly add a single word in regard to the immense benefit which would follow the re-establishment of the salmon fishery in this State. It is well known to dealers in fish, that the salmon is more highly esteemed as an article of food, and brings a higher price in the market than any other—ranging from thirty cents to one dollar per pound. Suppose then, that in the course of five years, at an expense of less than two thousand dollars a year, 200,000 salmon could be made to inhabit our waters. This number would be quadrupled at least, if the operations should be even moderately successful—but taking the lowest estimate, and allowing for all contingencies, let us see what amount of pecuniary profit would result. Of those 200,000 salmon, suppose that one-fourth, or 50,000, should be taken and sold during the first year after fishing is allowed. The average weight of full grown salmon may be stated at ten pounds, which would give 500,000 pounds, which at 25 cents per pound, a lower price than they are ever sold for at present, would be worth not less than $125,000. Deducting all possible expenses, the profit could not less than $100,000. This profit would increase each succeeding year, provided the regulations for the protection of the fisheries were properly enforced. To show that the estimate of the number of salmon made in the above calculation is an exceedingly low one, I may mention that in the river Saint Croix alone, to which I have before alluded, the average number of salmon taken at a single place was for many years two hundred per day, for three months in each season, or 18,000 fish during the year. To illustrate the benefits of a proper system of protection, I may also add here, that the produce of a small river in Ireland has been, by the enforcement of Parliamentary regulations, raised in three years, from half a ton, or at most a ton every season, to eight tons for the season ending the third year; and that in the case of another Irish river, the Foyle, the annual produce has been raised from forty three tons, to nearly three hundred tons. At the end of ten years then, after the first salmon fry shall be turned into our waters, we may safely estimate the annual value of the fishery to this State, at from a quarter to half a million ot dollars, even allowing for the reduced prices which would be the consequence of such a supply. Surely the anticipation of so splendid a result ought to influence us in speedily preparing the means for its attainment.

INDEX.

INDEX.