XXII.—THE ECONOMIC VALUE OF THE NORWEGIAN LAKES AND RIVERS AS A FIELD FOR FISH CULTURE.

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[Translated by Tarleton H. Bean.]

INTRODUCTION.

At the public meeting of the Imperial Acclimatization Society, held in Paris February 20, 1862, M. de Quatrefages, vice secretary of the society, delivered the following address:

From Hesiod to Virgil and from Virgil to our day the poets have vied with one another in praising the boundless munificence and maternal goodness of the goddess which watches over the harvest. But, without offense to the beautiful spirit, their commendations have been wrongly bestowed. Ceres is but a nurse, and that a severe one. She resembles Hercules, in that she helps only those who first help themselves. Before she makes the furrow fruitful she insists that the laborer shall water it with his sweat as an offering, and does not always protect it from the scorching or freezing breath of Æolus's children, nor from Jupiter's thunder-showers.

There is on ancient Olympus a much less exacting and a very differently liberal goddess. I refer to Tethys, the old ocean's bride and mother of springs and streams; in other words, the goddess of the water. She proves always a tender mother, gives always without numbering, and without ever requiring a return. Of him who cultivates her domain she demands neither plowing nor harrowing; she excuses him from all labor save that which is necessary to the harvest. It is perhaps on this ground alone that she has been neglected; because mankind has sometimes a strange heart which is inclined to ingratitude. It easily disregards what is acquired without trouble; it forgets a benefactor whose always open hand and heart have anticipated its desires, but holds better in remembrance and higher in esteem one whose benefactions must be extorted. This is doubtless the reason why the ancient Grecian priests lavished upon Ceres the expressions of filial gratitude which rightfully belonged to Tethys.

But one fine morning, as if overtaken with regret, they suffered Venus to be born from the foam of the ocean; Venus the goddess of love, fruitfulness made corporeal. This was at once to repair an injustice and to

* Meddelelser fra Norsk Jæger—og Fisker—Forening, 7de Aargang, 1 ste Hefte, Kristiania, 1878, pp. 1–47; 2 de Hefte, pp. 101–172.

acknowledge the eternal truths which the somewhat obscure, somewhat graceful, myths of antiquity so often conceal.

Fruitfulness is, according to universal experience as well as according to the highest apprehensions of science, the chief attribute of water. Without water the richest soil would remain absolutely barren, while the water appears to be sufficient in itself alone to bring forth all kinds of living beings. Wherever it collects and remains, even in small quantity, life manifests itself in a thousand forms; before the spring sun has dried up the water in the ruts of our roads each of these has witnessed generations of microscopic algæ, rotatores, and lower crustacea to be born, grow, and die; the smallest pond is a whole world wherein representatives of the two organic realms and of the four principal divisions of the animal kingdom contend together; but what is this in comparison with the picture which presents itself to our sight when we direct it towards our brooks and rivers?

To see this organizing, life-producing energy which appears to be assigned to water in all its might, one must, however, turn his gaze toward the sea; one will then not merely feel surprise but overpowering amazement. To produce the marvel, one need not go to the tropical zone, concerning whose inconceivable fertility the sea-faring ones can narrate; our own coasts are sufficient for the inquirer.

He will immediately be surprised by a striking fact. In the sea it is not the loose bottom which corresponds to our arable land which proves itself most fruitful, it is the *rock*. The harder and firmer it is, the more impenetrable it is to all that can be called roots, the more living beings of both kingdoms it nourishes. From Belgium to Spain, Brittany's rocky coast is incontestably the richest. It is on its unalterable, impenetrable granite that the uninterrupted belt of sea-weed extends densest and broadest, which gives the soda industry and agriculture an importance sufficient to make up for all others; it is here that all depresions, all little creeks with their bottoms covered with loose stones transform themselves into shady valleys, where algæ of all kinds and all sizes represent the mainland's moss, greensward, thicket, and forest; it is here also where the grass-eating animals, which find the most abundant nourishment in the most luxuriant vegetation, are most numerous and most fruitful, and thereby themselves give the richest nourishment to the greatest number of flesh-eating kinds. But all takes place in the water, all is produced thereby and returns thereto. The soil amounts to nothing, because the starting point in the circle in which life and death follow each other is always *a simple plant fastened on the naked rock*.

This evidence of Creative Power which the water displays in itself, even to its smallest molecule, and which increases with the fluid masses, must kindle the human soul. With this evidence stand in closest relation the cosmogenic speculations of different nations, likewise all the theories of spontaneous generation which different men, of considerable

merit in other respects, have attempted to put forward contrary to what experience has established.

When the existing continents rose up from the seas in which they were born, the greatest portion of the soluble substances which could serve for the support of living beings collected with the water in the sea. After this time thousands, perhaps myriads, of cycles elapsed, and the land without cessation was washed away by rain. That is to say, distilled water has not ceased to furnish this immense reservoir with materials of the same nature, with organic detritus.

Hereby it becomes explicable how the river water flowing over a great expanse becomes enriched, how the sea water becomes a nourishing bath for the beings which it contains. In this manner is explained the abundance of the products of all kinds which the waters possess, and whose existence seems a paradox; plants without roots nourish themselves solely through their branches or leaves; stationary animals wait for the occurrence of their food, which is never wanting: free-moving animals, which float almost passively, a ball for the wind and waves, which scatter them everywhere, find everywhere that which is required for their nourishment.

But, on the other hand, it holds good in the ocean, also, that where no washing off of the solid land can reach, there also life ceases and death reigns. The fluid plain has its deserts just as the dry land.

Such an one is an enormous area in the southern part of the Pacific Ocean, separated by Humboldt's Stream from the coast of South America, which has been rightly called the Desert Sea. Here the waves rise and fall without moving anything but water; the billow is never traversed by any fish, nor the air by the pinions of any bird. That the sea, at a certain distance from the coast where the organized matter washed down from the dry land sinks to the bottom or is consumed by the multitude of living beings, does not everywhere show this unusual barrenness, which has so greatly astonished the seafaring ones who crossed this region, is so because, by the universal laws which govern our planet, there goes on an incessant mixing of all its parts. Even the revolution of the land produces streams which flow from the equator to the poles and from the poles to the equator, and which carry the waters which have washed the Old World over to the new continent, and the waves which have washed America's coasts back again to Europe. These streams carry, just as our great rivers, with which we have long compared them, elements of all kinds, which are plundered from the dry land; furrowing, in a manner, the ocean in all directions, they distribute, wherever they extend, fertility and life.

As the soil is not fruitful unless it is regularly watered, so also is the water fruitful only by virtue of the elements which it receives and transforms from the mainland. The sea sends the mainland rain and dew which are indispensable, to it; the mainland sends the sea the nourishing materials which it needs. Each of them expects a return for

what it gives, and neither the one nor the other has ever refused its return. In this manner, receiving and giving without ceasing, both contribute to nature's wonderful harmony.

When men appeared at last upon the earth, and entered into the great circle of mutual influences, originated conditions which were produced by the nature of the surroundings. In the beginning of communities were found everywhere hunters and fishermen exclusively. They desired of the earth as of the water only what it produced of itself, and as a consequence they required enormous room in which the not numerous tribes might find the uncultivated fruits, the fish, and wild animals which were necessary for their support, and which often failed. In our day still some tribes are in the same condition, and we call them savage.

Mankind became at length herdsmen; that is to say, they collected some useful animals about them; they were raised thereby a round in the ladder of civilization. Less exposed to the cravings of hunger, these tribes increased and became hordes. But to support the animals which they had procured for themselves, men were obliged to move from pasture to pasture. They remained, therefore, nomadic and barbarous.

Finally, they learned how to cultivate vegetables, and trees, and plants, and soon thereafter how to improve them; they abode also in one place, and became agriculturists. But with the new work which they had assumed they were obliged from the first partly to strive against nature, partly to call her to their help. To procure a place for rice, wheat, corn, or potatoes, the weeds had to be removed; to increase the crops and renew the exhausted ground's fertility, manuring became necessary. Agriculture was called to life; it secured a steadily increasing population its daily bread. They performed their labors through centuries, and the experience gained secured steady production; civilized men live plentifully, by the million, in a space where a few thousand nomads, a few hundred hunters, would starve to death.

We all see what has been effected in this direction; but what always escapes the attention of many is that human industry is directed only to the soil, and has forsaken the water. With regard to culture, the hunter has altered his condition; the fisherman has become a savage. In this respect the most refined European races find themselves, with few exceptions, exactly in the same condition as the tribes of the Orinoco or of Australia; the white does not in any respect excel the negro. As his colored brethren have fished he fishes everywhere, always carelessly and without judgment; more numerous and equipped with better implements, the civilized white has fished more than the worse equipped black, and has wound up by exhausting the brooks, lakes, and rivers, as well as the sea, of both small and great fishes. But good is often produced from evil in its climax, and necessity has seldom failed to teach mankind wisdom. The diminution of wild animals led undoubtedly to the taming of our domestic animals; agriculture was instituted, perhaps, in the midst of the pangs of hunger. The decrease of the abundance

of fish has brought fish-culture to mind; and at present *aquaculture*, that is, the cultivation of the waters with reference to fish-propagation, is about to win its way to recognition and practice as *agriculture* did thousands of years ago.

I.

GENERAL CONSIDERATIONS.

Few countries possess such a wealth of lakes and rivers of all sizes as Norway. In his work, "The Kingdom of Norway," Dr. O. J. Broch gives the combined areas of these waters as 7,600 square kilometers, or 2.4 per cent. of the whole area of the country. Their situation with regard to elevation above the sea, in connection with the climate and the topographical relations, causes by far the greater portion to be especially adapted as a place of residence for the kinds of fishes which are universally considered the choicest and most valuable, because they contain clear and cool water, in which these fishes thrive best and acquire the finest flavor. Of the waters, only a small portion, lying in the lowest regions, are unsuited to these better kinds, because of their sluggishness and higher temperature; these are, however, well adapted to other less esteemed, but at the same time valuable, species of fishes. Most of these waters, in earlier times, when the population was smaller, were very rich in fish, and the greater ones were therefore regarded as manorial rights, which, as such, were separately liable to taxation. Forty or fifty years ago the greatest portion of the waters situated in the mountain regions proper, and the rivers generally, were what one might call rich in fish, although the abundance, according to the statements of the inhabitants, was even at this time considerably diminished; but latterly the quantity of fish is steadily and rapidly being diminished by the constantly increasing fishery of the growing population, which in this country, as everywhere in Europe, urges on the pursuit, and especially at a time when it is the most injurious to the continuance of the fish supply—the spawning time—because the fish is most readily caught on the spawning-grounds. The steadily diminishing abundance only increases the demand instead of putting a check thereon. Fishing implements were gradually constructed in such manner that the smallest edible fish could never escape, and brooks which were the natural haunt of young fish were swept systematically from one end to the other by fine-meshed nets with careful search, so that only an insignificantly small number could reach the age of reproduction. This was, of course, not so everywhere in like degree; but over a large part of the country, by this mode of proceeding, prosecuted more or less eagerly, has been established a scarcity which in places approaches complete absence of fish of the better kinds, which were the chief object of pursuit, just as in many other European countries.

The sad result brought about in this manner, which in those places had reached its culmination more than thirty years ago, is naturally

universally regretted; but the primitive consolation, that the Lord will constantly take care of the continuance of the abundance of fish, and that this gift was inexhaustible, was so rooted in their apprehension that men ascribed the diminution of the fish to the most marvelous causes instead of the real one.* Precisely the same thing occurred with the most valuable of all our fishes, the salmon, which, however, is indigenous in only a small part of the course of our great rivers. In the beginning of the century down to the end of its first twenty years, this abundance was so great that in many places the servants stipulated that they should eat salmon only three days in a week. But this abundance, by the same mode of procedure as was employed for the freshwater fishes, and owing to other causes arising with the gradually developed industry, diminished to such a degree that the capture of a single salmon had become in many places in Southeastern Norway a rare occurrence, and it fell off to such an extent in many localities that the merchants did not think it worth while to keep the implements of capture, whereas formerly, when the price of the fish was only $\frac{1}{3}$ to $\frac{1}{5}$ of what it had in the mean time advanced to, good and even rich fisheries were a yearly experience.

Such was the state of things in this country, as well as in many other parts of Europe, when in this portion of the world it finally dawned afresh upon the consciousness that man's care, by bringing nature's powers into activity in an intelligent manner, might win from the waters a considerable production of fish, a production which, when the business is prosecuted with the requisite energy and care, might become very considerably greater than one could have any conception of from previous experience. Influenced by his own observation, it occurred to a farmer in the year 1842, in the Vosges, in France, to attempt to hatch out young trout in order to restore them to a depleted river.† The

*I have twice in Aal, in Hallingdal, received the explanation that the sea-worm was the cause of the scarcity. The first time, in 1840, Vatsfjord was the scene of its ravages, and it is said that they had procured castor, with which the water was sprinkled around to poison or drive off the worm, but without avail; the fish were absent and remained away. I have since had a good opportunity to see who does the work attributed to the sea-worm. Near sunset every evening the people assembled from every house in the neighborhood, and swept the water with fine-meshed nets, and they caught therefore only very few fish in the water, whereas the same little flowing river was rich in trout weighing three-eighths of a pound to one-half pound. The last time, in 1872, I heard that Buvandet, below Rensfjeld, had been the scene. A clergyman, one of his assistants, and a couple of farmers, owners of the water, had in partnership sprinkled castor to drive off the sea-worm, naturally with the same success as before.

†It is singular how seldom it happens that men avail themselves of accidental experience. The indication of artificial fish culture is not of rare occurrence here, since in many places the same experience is had as in the following case: In 1841, a perfectly trustworthy man told me that he, some years before, had been fishing and hunting late in the autumn at Gjendinsoset. Impending storms drove the fishermen in the greatest haste away to their country district, 5 to 6 miles distant; the nets were pulled up in the greatest haste, and the boat placed in the boat-house, while they

attempt succeeded, and aroused general attention in France, and thereby an impulse was given to a new industry, which, wherever the natural fundamental conditions are present or can be procured, will bear fruit of particularly great value.

Although, in the last century, this industry has received so little attention in Europe that it might be regarded as entirety forgotten, it has, notwithstanding, been known and practiced for a very long time. The most ancient civilized people of the East, the Chinese, practiced it steadily to a great extent, and have practiced it from time immemorial. One of their proverbs reads, "The more fish a country produces, the more men it produces." Artificial culture is so ancient here that it is considered to have been always prosecuted, and they have many species of fish which are cultivated in every house, in every pond, and which are regarded as belonging as much to the household as other domestic animals. They belong to the great cyprinoid family, are vegetable feeders, and are fed just as regularly as cattle and other quadrupeds. The stock is procured by collecting annually the naturally deposited spawn or naturally hatched young, and this collecting is a distinct industry. In the central provinces, which are drained by the Yangtse-kiang, near Kieow-Kiang, in the province Kiangri, in the month of April, more than 150 junks of a very considerable tonnage are occupied in bringing in cargoes of young, which they transport to and distribute in the interior of the country.

Just as fish culture is carried on everywhere, to a great extent, so the provisions of law have constantly received attention, in order that the abundance of fish in the natural waters may not be diminished by making them the subject of stringent legislation. It is said that 1,222 years before the Christian era, an emperor of the Tscheou dynasty, together with his consort, wished to go fishing; it was in the fourth month, during the spawning season. One of the prime ministers, Tschangsype, cast himself on his knees before him, and submissively called his attention to the fact that he was about to violate one of the most stringent laws of his empire, and that by acting thus he might bring destruction upon one of the most important of the common means of subsistence, whilst he would thereby incur a great responsibility before the tribunal of history. The emperor admitted that the minister was right, and desisted from his intention.

Fishing in all lakes, channels, and brooks which do not immediately

forgot to take out the plug, so that the boat might empty itself. On the following spring, when the boat again was put in the water, little young trout swarmed in the water remaining in the boat, hatched out from the spawn and milt which the imprisoned ripe fish had liberated when they were taken from the nets. Hatching may also occur under peculiarly unfavorable circumstances, for it cannot be doubted that the water must have been entirely frozen for a long time. To be sure, the boat was in the boat-house, which, during the winter, was covered by snow; but the place lies over three thousand feet above the sea, and at this height the cold is considerable and protracted.

flow out of or into a great river rich in fish is absolutely prohibited during six months of the year, from March to September, in order to secure the fishes against the rapacity of their pursuers and to insure propagation. The maintenance of these provisions and political inspection of the waters is presided over by specially selected mandarins and private citizens, to which last the state leases fishing privileges by cantonments. These general lessees, called konau-ho, pay a yearly tax to the state, and are pledged, 1, to appoint times for planting a quantity of young fish in the waters leased by them, corresponding with the extent of these waters; 2, to see that communication between their waters and the rivers rich in fish is always open at the spawning season, so that the fish may come into them to spawn; 3, with a stringent watchfulness to see that no one fishes during the time from March to September, and that nothing is done which can work injury to the thriving of the fish. In compensation, no one is allowed to fish in their cantonments without written permission, which they furnish to companies who carry on fishing according to the regulations created by the lessees. In rivers of medium size the close season is reduced to three months, and in the largest rivers which empty into the sea every one is allowed to fish during the whole year.

Owing to these provisions and the universal household fish-culture, fresh-water fish constitute a very large part of the accustomed food of the people, and so it has been from time immemorial without this source of nourishment ever having threatened to be exhausted.* The ancient Romans likewise carried on systematic fish-culture to a considerable extent, and their methods have not in the flight of time gone entirely into oblivion; but this cultivation was in the main only the enterprise of private individuals in inclosed fish-ponds. Universal legal provisions having in view the preservation of the abundance of fish in the open, generally accessible and public waters, scarcely existed; because if this had been the case it would, like the rest of the Roman laws, without doubt have been observed, at least to some extent, through the lapse of time, and would also doubtless have prevented the universal diminution of the abundance of fish, which in all the most civilized countries of Europe exists even down to the present time. The practice of the Romans is, however, as remarked, not entirely forgotten; they have in most countries continued to a greater or less extent to maintain fish-ponds, and to supply them with young in a manner which may be called artificial, in so far as this supplying goes on under direct human supervision, and is not left entirely to nature's care. It has similarly also been prosecuted here in Norway, at one time or another, by certain rich men; they say, also, that the monks at Storhammer have attempted it. It is presumably this circumstance alone which explains the occurrence in a couple of places of a species of fish, the carp, which does not belong to our northern fauna, and of another which is indigenous in the eastern

* Dabry de Thiersant, French consul-general in China, 1871.

part of the peninsula, the pike, so far as is known in a single place in western Norway, where it ordinarily does not exist. In a single place systematic and artificial fish-culture has been carried on extensively for centuries as the sole means of subsistence of a community consisting of many thousand individuals, namely, in Laguna di Comachio, near the Adriatic Sea south of Venice. But no one thought about imitating this business before last year, though the same or a similar opportunity for such industry is found in many places in France as well as in Italy. The objects of culture here are fish which do not, like the salmon, spawn in fresh water, and afterwards reach their greatest development in the sea, but which, on the contrary, spawn in the sea, while their young at stated times frequent the streams in the shallow lagoons, there to reach their full development, chief among them being the eel, which has the same habit here in the North as in the South.

But the commonly-practiced fish-culture of the Chinese, Romans, and modern Europeans is restricted chiefly to species of fish of particularly great fecundity, which live in sluggish waters of an average higher temperature, which spawn in spring or summer, and whose eggs are hatched without difficulty of any kind in the space of a few days, namely, carp and its kindred genera, together with the pike and perch, to which may be added the eel, whose young may be easily collected in their migrations up the river courses. The choicer species of fish belonging to the many different species of the salmon family, the most of which spawn late in the autumn or in the winter, have been the subjects of artificial culture in very few places.

The artificial fertilization of the spawn of the nobler species of fishes, the salmon, in the manner in which it has been practiced for the last twenty or thirty years, was not, however, entirely unknown; for there are found printed works which describe it dating from the middle of the preceding century and later; but these aroused general attention as little as the practical performance of the operation, which took place here and there. About the year 1842, when, as before remarked, a peasant, Remy, in the Vosges, concluded to attempt the artificial fertilization and hatching of trout-eggs, the affair first was fortunately brought to the knowledge of French scientific men who appreciated its great economical importance to the nation, and many of these have since that time with the greatest zeal labored to bring, and have also succeeded in bringing, the mode of operation to the desired perfection. Among these many scientific men Mr. Coste, professor of embryology in the College of France in Paris, a member of the French academy, is generally regarded as the one who has labored the most and the most successfully for the advancement of this thing, in which duty he was strongly supported by the Emperor Napoleon. Since the year 1852, one may regard the plan of operation to have been brought to perfection, and since that time the business, so far as the salmon-like fishes are concerned, had been carried on to a steadily increasing extent everywhere in Europe and America, where the opportunity is presented.

About the same time the matter awakened attention among us where already in many places the abundance of fish was reduced to a minimum, a reduction which, moreover, has continued for many years with unabated zeal in many places in this country, and even now is continued here and there on no small scale.

Since the year 1848 the legislature has taken into consideration the destruction of salmon-fishing, and has sought by more stringent provisions to control the instinct of prey. Since 1863 the way has likewise been open by it for restraining this mode of procedure in the lakes and rivers, since the necessary increase ought to be gained in all the places interested. For about the same length of time, by the contribution of public funds, artificial hatching has been carried on over the whole country, and public attention has been directed to the matter, while instruction in the art has been given wherever it has been sought.

These measures have borne evident fruit, and the country therefore owes great gratitude to Prof. H. Rasch, who chiefly gave it the impulse, as well as to his indefatigable assistants in its practical execution. But the result has not yet by far reached the extent which it can and ought to reach, and which it probably will reach when the matter is taken hold of with the energy and care which it deserves. That it is not at present greater cannot depreciate the man's services, which hitherto have borne the matter forward; one must much rather wonder that he has succeeded in winning so great victories over deeply rooted prejudices, and the universal reluctance among people to submit to previously unknown restrictions against habitual unrestrained free fishing, the use of which they must first see before they can, perhaps rather will, comprehend them.

But the experience gained through more than twenty years' practice in many countries in America, as well as in Europe, has shown that we now stand very far from the goal which we can and, therefore, ought to seek to reach. We have hitherto in this country confined our operations to placing little barriers against improper rapacity; these barriers ought to be given the necessary dimensions which are required for the attainment of the object in the well-understood interests of all. Having, besides, to some extent provided for the sowing of the field, they will win therefrom increased production; but this care has not been sufficiently great by far, partly because it is limited to the salmon by ill-advised provisions of law, which render difficult, often impossible, that which has the claim of the first requisite, the desired abundance of mature spawn; partly because they have placed their trust in, and, therefore, to an unreasonable degree given their attention to the advancement of, natural culture. Moreover, they considered only the production of the delicate young, and have liberated these, which cannot be regarded as in much better condition to escape the multitudes of enemies than the spawned eggs, in the rivers, to be eaten up in masses before they reach any size. Finally, they have, for the lake fisheries concerned, not at all considered

that, just as the farmer by manuring can multiply his crops, so by a suitable mode of procedure one may also increase the maintaining capacity of the water by looking after the increase of the nourishment from which the fish, which are made the object of especial care, get their subsistence. The opinion has been much more generally held that this food is injurious to the rearing of the cultivated fishes, as it consists chiefly of living fish of smaller and commoner kinds, which are regarded as enemies of natural culture, as spawn-eating, in competition with all other fishes, small and great, and with a multitude of other living animals, four-footed as well as winged, and insects of a multitude of species, which culture, as remarked, has attributed to it an importance which by no means can or ought to be attached to it if one wishes speedily to reach the goal, a considerable increase of the abundance of fish.

Since I have chiefly in view to show the value of the lakes and rivers as a field for fish-culture, I shall next take these into consideration by showing what ought to be done, so that the kinds of fishes which should be the objects of cultivation in them may be produced in the greatest possible abundance; and next, what should be done for the fish which belong to both the sea and the fresh water, although these last have already obtained, and probably by more thorough modes of proceeding will further retain, superiority over those in economical respects, and, therefore, ought to stand in the first place. Thus I pass on to—

II.

WHAT FURTHER SHOULD BE DONE AND WHEREFORE.

It is known that in natural fish-culture only a very small fraction of the quantity of eggs deposited are developed; therefore, the Lord of nature has made their fruitfulness great in proportion to the danger of destruction to which the eggs and the young are exposed. I shall here confine myself solely to the chief representative of the fishes, which will certainly be the especial object of culture—the trout. What percentage of naturally spawned trout eggs reach their full development as young it has been found impossible to learn with certainty, just as little as to what age the multitude which come to life as tiny young ones under natural conditions live. Men who have closely studied this matter believe that one out of ten or one out of a hundred eggs develop into young fish. The rest go to ruin, are buried up, destroyed, or eaten up; perhaps the greatest portion disappear in the last mode, for everything that lives in the water, large and small, even the fish that lay the eggs, eat them as the greatest delicacy.* Trout or salmon roe is the most irre-

* An experienced American fish-culturist thus describes what happens at the spawning-place:

"When the spawning time approaches the trout seek a suitable place on a gravelly bottom in shallow flowing water, especially that originating from springs. When they have paired themselves, which takes place only after violent, often deadly battles between the males, both go to the chosen place and lie still there if they are not

sistible lure (bait) for trout and salmon, as well as other fishes. Such is the case in countries with much milder winters than we have. How great a portion of the young are eaten in the space of the first year, when they stay unprotected in their native place, we have naturally no certain knowledge of; it is probable that at least half are eaten or destroyed by the above-named causes under the water, as may frequently happen. With us, at all events, over the greatest portion of the country, we have cold winters, which produce bottom ice, and at least spring drifting of the ice to a considerable degree, which as a rule always comes in contact with and traverses the best spawning places of the trout or other salmonoid fishes, which are besides readily laid bare in the course of the winter.

But suppose that the eggs and the young fish endure being locked up in the ice without dying, they will by no means endure the drifting of the ice or lying bare in the frost. In this way the profit or product of natural culture becomes so uncertain that it cannot be depended upon to give any result which in any way can or ought to be taken into consideration. It seems to me that the confidence in the rapid increase of the abundance of fish through natural culture fully corresponds with the confidence of the farmer who thinks that the garnering of premature corn will be sufficient provision of seed for the coming year's harvest. On the other hand, a long experience has now established that one, if he manages things with proper care in all necessary directions, may safely count upon about ninety-five young from a hundred eggs, and that one can rear these young ones under proper conditions through a year with a loss of only five per cent. The artificial culture also is as safe, the natural as unsafe, as possible.

Since this is the case, one has it also in his power by labor and outlay, which are inconsiderable, to procure all the young that he considers necessary for stocking a fishing-stream with perfect certainty, provided one can procure the necessary quantity of eggs; all regard for

disturbed; but the males are for the most part occupied in driving away rivals, who pry around. It is curious to see a little male by the side of a large female. Under ordinary circumstances the smaller male respectfully gives way to the larger, but at the pairing time the smaller will in an instant attack one three times as large as himself, should he approach to within a few feet of the female; as a rule the male is fully occupied in driving away rivals. When these are numerous the female will often come to the help of her chosen mate. But after the female has selected a consort there is no longer any contest; the disappointed males fly as soon as the consort makes a show of attack; they appear to respect the intimate union. The female meanwhile forms a nest, which consists simply of a shallow depression 6 to 8 inches in diameter and 2 to 3 inches deep. It is constructed in this way: the female thrusts her nose down in the gravel and pushes it aside with her tail as she raises her head again. This work goes on many days until the cavity is large enough for her. After they have laid over the nest for some time the female is ready to deposit a portion of her eggs. The male seems to know this instinctively, because whereas he had been busy expelling rivals, he is then always at the female's side, and the instant she lays her eggs he allows his milt to flow over them.

"When the eggs are deposited the male forsakes the female, who thereupon covers

the natural culture becomes superfluous for the fish species concerned, which ought to be the object of cultivation, and absolutely injurious in so far as one, from his anxiety to advance this culture, seeks to eradicate or omit to stock the water with other kinds of fishes which might serve the cultivated fishes as food, even if they in any degree concur with this about other means of food, for the fishes which one cultivates will chiefly be fish of prey, which will develope with a desired rapidity only when they have an abundance of other fishes as food.

The essential condition for abundant production of fish, next to the possession of water, is ability to be able to get fish-spawn in the desired quantity. This ability will always be present in all well-stocked fishing waters if no injurious law regulation places an artificial barrier by prohibiting the capture of spawning fish at the right season, that is, at the spawning time itself. Every trout or salmon yields 2,000 eggs per kilogram (two pounds) of its weight. To procure 1,000,000 eggs there will thus be required fish of the united weight of about 500 kilograms, but few males being required in proportion to the females. After the lapse of a year, one will have at least 800,000 young fishes of one-twentieth to one-tenth of a kilogram each, or 60,000 kilograms in place of 500 kilograms. If, therefore, the mothers and fathers which are taken as spawning fish must be consumed and a portion more are taken under the same pretext, this signifies nothing in the face of the certainty of having brought back the necessary young which, even as yearlings, will weigh fully one hundred times as much.

It was just to prevent the loss of profit in fishing at the close-season that the existing legal enactment for salmon was made. This misunderstanding of real interest, this injurious prohibition will probably disappear when the pending new proposition for a change in the fish law obtains legal validity. Besides, the spawning-fish are always poor food in comparison with what they are at other times of the year. In England such spawning fish are considered inedible, and such will also be the case in this country when a greater abundance of fish no longer

the eggs with gravel by sweeping over them with her tail all that is found near the nest. If the female is not satisfied with the covering she will go into the stream and push suitable stones backward with her ventral fins over the nest until it is completely covered. After a few minutes the male returns to see how the work progresses, eats some eggs if he can find any, and departs again. The female, on the contrary, does not go away, but remains at the place and does not forsake it until all the eggs are spawned, which occurs in many installments and occupies a long time, often as much as three days. The female, as well as the male and all the hangers-on swimming around, have meanwhile eaten as many as they could of the eggs. When the first pair has left the place another comes on the same errand. The female finds a suitable place and begins to prepare a nest. As soon as the first-spawned eggs appear this business is given up and female and male vie with the lookers-on in eating all the roe before they again resume work. If one next takes into account that all kinds of water fowl seek after the spawn with great eagerness, that the tender young fish coming to life in the spring serve in great portion as food for the larger fishes, it is no wonder that there are so few trout in our streams, but a great wonder that any are left."—(Trout-culture, by Seth Green. 1870.)

tempts one to take them as food just at the time when they are the poorest.

When no such prohibition exists there will generally be no difficulty in finding as many spawning fish as may be necessary, provided the water contains the requisite quantity. By proper forming of spawning places one can regularly take on them every fish which makes its appearance for spawning; if it is not quite ready for that when it is taken, it can be set free in the water again; it will again make its appearance at the place when the proper time comes. Or one can in the American manner construct the spawning places so that one without touching the fish, leisurely and at ease in the daytime can collect all the spawn deposited and fertilized the evening before.

That there will be fish in abundance to supply all the spawn which is considered necessary for planting in a stream when it has become properly stocked is certain; that natural culture will take place by the side of the artificial is thus self-evident. But whether this gives any yield of any living fish or not is a matter of entire indifference, excepting in so far that the quantity of spawn deposited in this manner, and the possibly small number of young arising therefrom, plainly increases the nourishing capacity, since, as remarked, the spawn as well as the young will serve as food for a whole multitude of all kinds of fishes.

After—

1. *Artificial hatching* of the multitude of eggs, which is considered necessary for the proper yearly recruiting of the water, or filling up the decrease caused by steady fishing for the fish which have reached a suitable size, is required also—

2. Rearing of the young in an inclosure until they are at least six months old, when they will have reached such a size that they themselves may appear as enemies among a host of enemies whose prey they would have become at an earlier age; there is required in aquaculture, as in agriculture, *proper inclosing of the ground.* This must, in the scheme here proposed, provide for the hindering or destruction of enemies which will divide the harvest with the breeder, and take the lion's share or the whole if they are able. Among these, man stands first. It is, therefore, a matter of course that the laws must secure for the fish-culturist, as well as the farmer, the indisputable right to the fruit of his labor, and thus make the proprietorship and right of fishing in the water of every condition just as clear and fixed as the corresponding right to the ground in question.

As long as the right to free and unrestricted fishing in brooks and rivers is recognized fish-culture cannot pay, because our brooks and rivers are just as important for the rearing of young fishes as they are also chosen waters in which they may nourish themselves until they become full-grown or mature products, which will be indiscriminately fished for, and thereby the result of every effort for the increase of the fish will be brought to naught. What is needed in this direction this is not the

place to develop more fully; I suppose it will be done when the realization of the necessity is sufficiently clear to the public. But even if legal enactments contain all the necessary provisions, this will not be enough. Law alone is inoperative; it must have living supporters, particularly when the temptation to break it is especially great, as will be the case when the fishing-streams, rivers and brooks, receive the complete supply of fish which they can accommodate and sustain. Constant and active watchfulness must supplement the protection of the law, and the business will with the greatest ease be able to meet the expense which must herewith be associated. Where a single individual commands an isolated field for fish-culture, the matter is very simple; where the culture must be carried on in partnership by more than one, or by many interested parties, watchfulness becomes necessary over a greater area than for the isolated proprietor's district. He who cultivates for himself alone, independent of others, will see to carrying on the business in the manner most profitable for himself, and act in accordance with that object, and, if he does not do this he must blame himself for the possible damage or loss. Where many persons are interested, the temptation to undertake to feather one's own nest at the expense of the rest is very great, and not every one is able to resist it. In such case the custody must be open for inspection, that even the interested parties observe the rules of the business, namely, that the catching of fish be judicious, so that no improper division may be made, nor the business be injured. But in this case it is not sufficient as hitherto to depend chiefly upon the men seperately appointed for such inspection. If it is important to have fixed legal enactments, or agreements respected, then should every means auxiliary thereto, which costs nothing, be brought also into the greatest activity, and this activity should not as generally hitherto, be paralyzed to the greatest possible degree.

Where numerous keepers of the law or established custom are appointed it is clear that many and very improper advantages can and must escape their observation, which, however unavoidable, must become generally known to other persons among the people more or less interested in the matter. Why not seek to invoke such assistance for the support of the law when it can be procured without cost? In nearly all hitherto established laws of such a nature they have, as it appears, made it possible to prevent the public from interesting themselves in any way for their support. The specially-appointed inspector was to have a share in the fines which were imposed for transgressions; the discoverer and informant, who had no such position, received, on the contrary, nothing. It appears now as if they, with full knowledge, wished to relax the operation of the law to the utmost extent in which, with a little appearance of decency, it could exist. That such maintenance of the law will be secured to a considerable degree by allotting to every informant the same compensation can be subjected to no doubt, and by such a plan alone can such laws fully acquire their intended strength.

The mode of proceeding hitherto followed made the law almost inoperative, and encouraged a license in treating it, which it is, or should be, the design of the law to destroy. "No receiver of stolen goods, no thieves," says the old proverb. No fracture of such a law of any importance can occur without the participation of assistants, since the law itself now does its best to help the receivers by depriving them of that encouragement to the announcement of irregularities which it grants to the specially-appointed inspectors, for whom such encouragement would appear less necessary, since they are paid especially to see that the law is respected. Were such encouragement granted to those who are not inspectors, the transgressions of the law would on that account alone become exceedingly rare, as no one could be certain that a transgression occurring would not be reported, which in ninety-nine out of a hundred cases must come to the knowledge of many persons whose silence could not be depended upon. The objection against encouraging a system of informants, which we have heard mentioned as an argument against the institution of such a reward, will signify nothing, because an occasion for information will then never, or very seldom, arise.

But, besides the encroachment of men, there is no little multitude of animals which will tax the abundance of fishes in somewhat the same degree as beasts of prey on the land and in the air reduce the abundance of game, and this taxation is in reality very much more considerable than people generally have any conception of. *Otters, loons, ducks*—especially fish ducks—destroy a considerable quantity of fish, and should therefore be persecuted with all means one is in possession of. In the same class must be included fish of prey, not merely of the kinds which are not objects of culture, but also those of the cultivated species which have become so old that they increase annually in size but slightly in proportion to the nourishment which they require. The most profitable yield from fish culture will clearly be obtained when the fish is regularly caught as soon as it has reached the age and size at which the quick increase begins to fall off. This size will differ in the different species of fish, likewise in different waters, according to the greater or less wealth of nourishment, and its quality. No general rule in this direction can be given; it can only be acquired through experience in each separate locality.

According to experience, a trout consumes daily animal food equal to $\frac{1}{100}$ of its weight; this has at all events proved fully sufficient feeding for fish maintained in the same way as stalled cattle. They have thrived upon it, grown quickly, and become fat. They could of course have consumed more; but this quantity may be regarded as a proper medium, especially if one does not include very large ones. A common lake-trout which, for example, has reached a size of five kilograms, will thus in the space of a year consume of food of all kinds 365 times $0.05 = 18.25$ kilograms, while at the same size and age it will increase scarcely more than one-half in the space of a year, or 2.5 kilograms, In the first three

or four years its own weight doubles yearly with the same amount of food; thus, for instance, a trout during the fourth year which at the beginning weighs about 0.75 kilogram, consumes about 365 times 0.0075= 1.85 kilograms, while it will have gained in weight 0.75 kilogram; the ratio between the food consumed and the increase of weight is also at this age quite particularly more profitable than at a later age, because the increase of weight in the last case bears the proportion to the nourishment consumed of 75 to 185, or 1 to 2.4, and in the first case of 2.5 to 18.25, or 1 to 7. Even if the increase were the same at this age as earlier, the proportion would become as 5 to 18.25, or as 1 to 3.6, or in a considerable degree less profitable than in the younger stages.

One must also strive to catch the older fish as completely as possible, and for this end the spawning time will furnish the best opportunity. Whether one will then eat them or put them into a separate smaller pond, where they will be easy to catch at any time, for preserving and feeding them until they are in better condition, is a matter of taste. That fish of prey of other species which possibly may occur ought to be exterminated by all means is self-evident.

For the attainment of a reasonably large profit it is, moreover, as before mentioned, necessary, in the greatest possible extent, to improve (gjöde) the water which is the object of cultivation. This may occur in different ways, depending on how the circumstances may be varied. It applies to the whole circle of creation that the lower organisms live upon plants, and in their turn serve as food for the more highly organized flesh-eating animals; and it is a settled thing that men, by assisting the operation of nature, can, to a very considerable extent, and in many, if even not in all, directions, promote this activity toward a very considerably increased production. It will everywhere be in the power of the fish culturist, in the same way as is employed for the fishes in question, which are the peculiar object of the breeder's care, to promote the hatching of species of fish which feed chiefly on vegetables, in order that subsequently, when they have reached the proper development, they may serve as food for the choicer fishes.

In the same way one may promote the increase of crustaceans and mollusks, which likewise, to a great extent, serve as food for the nobler fishes. It will, moreover, in many places be an easy matter, by the employment of vegetables, which, in comparison with meat, cost little, such as carrots, peas, meal, and potatoes, to feed a greater multitude of the vegetable-eating fishes and other aquatic animals than the waters of themselves could support. Moreover, one can, if the opportunity offers, to a greater or less extent, provide directly for the nourishment and food of the cultivated fish by the use of all kinds of animal offal, the flesh and entrails of all sorts of fish, birds, and four-footed beasts, which have little or no value.*

By the use of such means, among which cod-roe might, perhaps, be

*Mr. Seth Green says: "It is more profitable to raise trout than hogs."

used with profit, it is in the power of the fish-culturist to eke out the stock of his water to a very considerable degree, which is limited only by the existing access to fresh, running water, or, more properly, on the renewal of the quantity of oxygen absorbed by the water; by an adequate renewal thereof, the number of fish may be increased until the space becomes as closely packed in proportion as a saufjös (sheepfold) usually is. How far one ought to go in this direction experience will in every place quickly teach. If more fishes are placed in the water than it can support, the leanness of the fish will soon attract attention; this, however, will not occur, because in case of need they will mutually eat one another. If the supply of oxygen becomes too small in proportion to the need of the abundance of fish, this will quickly and plainly show itself also in this, that the fish will seek at the surface of the water the wanting vital air and that many will die. Probably only a few waters can be found in this country where it will be possible to carry fish-production to this last extremity, since one observes that the superfluity with regard to the means of nourishment does not exist except in winter and after continued intense cold, which dries up the tributary brooks. The difficulty, and in most cases the impossibility, of furnishing the fishes an extra food-supply during the winter will restrict stocking far below these extremes, which can be reached only by wholly artificial breeding in smaller especially constructed ponds, where the fish may be supported in the manner which may be most closely compared with the permanent stall-feeding of cattle. But even if one, as will generally be the case, finds it most profitable to restrict the stocking of the waters far below this measure, they may still receive and support a quantity of fish which will considerably exceed what would be considered a great abundance.

Further, it is important *to carry on the collecting in an intelligent manner.* This will not be done until one constructs his fishing-implements in such a way that he reaps only the mature fruit; that is to say, that he catches all the fish which have reached the size shown by experience to be the most profitable, which, as before remarked, may, however, be very different, according to the species of the fish which one attempts to produce, and the food one may be able to procure for them. To permit a portion to escape again, in order to reach a greater size, causes, as shown, a greater or less loss in proportion to the shorter or longer time one permits them to live after reaching the most profitable size; to catch them earlier also causes a loss, though of less importance.

But it is important also to harvest the crop at the time of year when it is most fully mature, most savory, and of the greatest value, not merely on account of its flavor but on account of its greater weight; that is to say, in summer from April until the middle of August at the latest for all the autumn and winter spawning fishes. The difference of quality and weight between the summer and winter is remarkably great; it may, in the salmon-like fishes, amount to over the half the weight of the fish in its best condition, and so far as the flavor is concerned the proportion

is precisely similar. Professor Rasch states in his book on "The means of improving the salmon and fresh-water fisheries of Norway, 1857," that the Duke of Athole has related the following:

"By consulting my journal I find that I caught this fish marked as a spawner (kelt) on the 31st March, with a rod, two miles above Dunkeld-Broen, and it then weighed exactly ten pounds. Five weeks and two days later I caught it again, and it had, in the short time specified, gained the almost incredible increase of 11¼ pounds, for on its return it weighed 21¼ pounds. The salmon here mentioned was caught and marked nearly 40 English (6 Norwegian) miles from the sea. It had thus in this time wandered this way back and forth, and still had time to obtain the quantity of food which it consumed to produce such an increase of weight. There can be no doubt of the trustworthiness of this fact, because his grace was extremely precise with regard to his marking experiment, and carried for this purpose with him small zinc tags numbered and furnished with the means of fastening them. Thus we find this fish marked number 129, and the date entered in his grace's journal."

This observation refers of course to the salmon and not to the trout, but there can be no doubt that the last species of fish is subject to the same laws as the first, even if not to the same degree.

Hitherto there has at the same time obtruded itself an important hinderance in the way of extensive catching of late fishes in summer, namely the difficulty of preserving them in the best condition for any length of time. To transport them fresh has been possible only for short distances; to salt them so that they will be preserved has also its difficulties; in every case the lake fish loses thereby a good portion of its value as a salable article. These circumstances have certainly had varying influence in restricting the fishery to the spawning time, since the frost has already to some extent made its appearance, although the greater ease then of capturing the fish at the spawning places has of course been the essential motive of the common people for deferring the fishing chiefly to this time.

If the means cannot be found for preserving fish unspoiled in the fresh state for a long time, the profit of systematically prosecuted fish culture will be diminished in no small degree in all places some distance away from the chief means of transit and the trade centers, and the most and best of our fishing streams are thus situated. This is, however, fortunately the state of things; it is in our power to preserve fish perfectly fresh for a long time by a very simple means which is everywhere in this country at hand in more than the necessary quantity, namely, ice. The plan which has hitherto been employed in shipping fresh fish over to England, packing in boxes with loose pieces of ice and sawdust, permits, according to the statement of Americans, the transportation of fish fresh and unspoiled on the railroads to a distance of 800 kilometers, about 490 miles—that is to say, preserves them during

such transportation for twenty-four hours; but this will not be sufficient. If one, on the contrary, employs a plan recently introduced into Canada, and freezes the fish in the proper quantity safe and sound in blocks of ice, so that the fish and ice form a compact mass with two to three inches of pure ice between the fish and open air, an operation which can easily be performed in tin boxes of suitable form by packing in a mixture of ice and salt, which gives a cold of 31.45° Fahr., then, if placed in an ice-house, or during shipment packed with care in pieces of ice and bad conductors of heat—moss, which is found everywhere, or sawdust, if this can be had—they will probably be preserved for a long time unspoiled, just as safely as the mammoth which for many thousand years has lain buried in Siberia's ice-fields, and which now and then comes to light in a perfectly unspoiled condition.

There is thus nothing that prevents or discourages fishing—harvesting—from occurring chiefly in summer, when this is associated with the least trouble and the least discomfort from cold and bad weather, and nothing in the way of preserving fish in the most valuable condition—perfectly fresh—as long as it may be found profitable. One has it then fully in his power to bring them to market at the time and the places when and where it will pay best, even if these are far distant and many days are required to reach them. The preservation of the harvest is also just as simple as the preservation of corn and hay.

I shall next briefly mention the habits of the salmon, which in certain particulars differ from those of the lake fishes.

Ancient, fully trustworthy experience has shown that the salmon, like the birds of passage, seek and, with unerring instinct, return to the place where they were born, and equally well whether their birthplace is a mighty stream or a little brook which the salmon in many places cannot penetrate without lying flat on their sides or employing accidental floods in order to traverse the shallower places between the pools where they can find water deep enough. This last phenomenon one has nowadays rarely an opportunity to observe, since nearly all these brooks have long since been fished out, so that for many years no salmon have been born in them. I have, however, personally had the opportunity of observing this fact in the little river or, more properly, brook, which forms the boundary between us and Russia on the south side of Varanger Fjord. It may be forded dry-shod, when it is lowest, at many places, yet salmon are found in most of the pools quite up to the lake in which it has its origin. Every brook, which at least now and then has a supply of water so far uniform that the salmon can swim over the shallow places, can be made a collecting-place for the salmon in any quantity, because one has it in his power to make each of them the point of departure for young salmon in every case with little trouble. The hatching of eggs may take place wherever a spring, or even a brook, supplied with water only in the winter half of the year, is found—in the last event, of course, with a little greater cost of construction, which at

the same time will signify nothing compared with the profit. The roe which one gets to begin with he must procure from other places, and from places where good salmon are found; for there are many, sometimes considerably different varieties of the greatest difference in value. After the lapse of two or three years one will be able to get more at a place that he can manage to hatch—under the condition previously mentioned as now existing, the absurd opposition against removal—which it cannot be doubted will occur.

The hatching of salmon-roe is in all respects just as certain as the hatching of trout-eggs; of which it is not necessary further to speak. Only in one direction is the case of the salmon different from that which applies to lake fish. The salmon goes, one or two years after it has been hatched, out to sea, and the nourishing capacity of this is unbounded.* One does not need, so far as the salmon are concerned, in any way to limit the abundance of the eggs which are taken for hatching for fear that the fish will not be able to find food enough for their full and complete development.

But it is not sufficient, as hitherto, to take care of the young till they can scarcely be regarded as fully hatched; one must further protect them until they assume the wandering habit, and instinctively seek the sea. The older method in reality results in destroying at least half, perhaps three-fourths, of the young which one has with care hatched out. Of course the care of the young long continued will involve an outlay for suitable ponds and for the food as well as the tending of the fish; but this outlay will amount to nothing compared with the increased abundance of fish which will spring from it. The mode of procedure heretofore adopted is perhaps the principal reason why the profit of the work hitherto done is so inconsiderable.

It applies to salmon, without doubt, in a still higher degree than to the lake fishes that every attempt to assist natural culture, in order to increase the abundance of fish thereby, and escape the labor of hatching, is perfectly idle work. For the salmon it is evidently the largest rivers that have any importance in this direction; for the lake fish it is essentially small brooks. But it is just in the largest rivers that the unfavorable conditions peculiar to our climate appear most plentifully and with the most destructive power, along with all unfavorable circumstances which in more propitious climates bring it to pass that natural

*Capt. John Ross, who . . . . . undertook a voyage of discovery to the arctic regions, to find the so-called northwest passage, states, in his report on this expedition, the following: "When spring finally arrived after the first winter, came in sight from the ship a great river, on whose shore Esquimaux gathered, to fish. They thrust unwearicdly the whole day their spears at random down in the turbid river, and at every third cast they usually got a salmon. On the vessel there was a fishing-net made of coarse materials, brought along for such a case; this was thrown out, but was broken by the weight of the fish. A new net of coarser material was then quickly knit, and with this 5,500 salmon were taken at one haul. All the empty vessels on the ship were salted full, and a large portion, which could not be accommodated, were presented to the Esquimaux. This describes plainly enough the unbounded nourishing capacity of the sea.

culture in all proportions yields an inconsiderable and even in many cases no profit at all.

It is attempted now, chiefly with the object mentioned, to clear the path through the long extent of our large rivers, to which, partly by nature, partly by art, their approach is obstructed, by the construction of salmon ladders in different places; however, curiously enough, not in the place most important of all in this respect in the whole country, a place which by itself is more important than most of the other rivers combined, namely Sarpen. It might appear that since no increase of the abundance of salmon has been gained by the introduction of such ladders, and the larger field thereby found for the salmon, owing to the increased natural culture, it will be useless to continue such a scheme. This is, however, by no means the case. Such a plan must on many accounts be considered in a high degree profitable, even if it should cost what one might regard a large sum of money.

Access to the hatching of eggs is nowhere unbounded, while common interest demands that it should be prosecuted on as large a scale as possible. The waters of springs, which may be used for such hatching—and it is only those which have pure water, in the greatest possible degree free from minerals of all kinds in solution—limit the quantity of spawn which can be hatched out, and their occurrence is not particularly frequent. One may, of course, by appropriate arrangement of apparatus, provide for the replacing in the spring-water the oxygen which was gradually consumed during the hatching of the embryos, but one has no means of removing from the water the carbonic acid generated in the place of the oxygen consumed. This will steadily increase by the continued use of the water, and quickly reach such a point that the water will become deadly for the embryos and the young. Long before such a point has been reached the water must be regarded unsuitable for hatching. One cannot generally calculate that people who never see, as adult salmon, any young which they may have hatched out will interest themselves in such hatching. It is vain to expect that the springs which must occur along the upper courses of our rivers will ever be employed for the hatching of salmon to the desired extent as long as the way is not cleared for them to return to their birthplace and they are retained near the mouth of the river for the advantage alone of those who live there.

If one wishes to advance the hatching of salmon in the greatest possible degree, he must, by means of ladders, clear the way to the upper sources of the river, and then hatching on a large scale will not fail to take place along the extent of the rivers wherever the necessary conditions are present. The profit hereof will of course substantially fall to the residents along the lower portion of the river and along the coast outside of its mouth; but some profit will accrue to those resident on the upper waters, and this probably sufficiently great to incline them to regular hatching. This would especially apply to the men on whose rivers sportsmen will be required to buy permission from the owners to

catch salmon, a privilege which usually commands a high price. Inland residents have probably a legitimate claim* that they should not be cut off from permission which probably might be granted them to enjoy a portion of the blessing which the sea can give in the form of the best fish which find their way from it up through the streams as far as they are able to advance, and this so much the more since the lower residents under all circumstances will skim the stream and have absolutely the greatest profit from the abundance of salmon which the increased hatching must produce. There is also ample reason for building salmon-ladders wherever it will be practicable to place them, even if regard for the promotion of natural culture can or ought to have no weight. Should it fortunately happen that natural culture in some peculiarly favorable place produce a yield worthy of mention, so much the better, provided only that the dependence upon such a yield do not cripple the work of artificial hatching—the only mode that is perfectly certain—and the work of caring for the young in their tender youth.

In parenthesis I shall here say a few words about the attempt to hatch salmon in lakes, with a view to keeping them there. This is, in my estimation, a complete misconception of the problem. In the first place, one cannot, according to my belief, destroy the wandering instinct of the true salmon (*Salmo salar*) by placing it in a lake. It will certainly find its way out of this into the sea just as surely as out of a river; the one is just as easy as the other, and one cannot destroy instinct. Only by keeping them confined in a basin from which they cannot possibly escape can this instinct probably be controlled, and this is attended with a danger of their leaping out on land and perishing. In the next place, the nourishing capacity of every lake, even the largest, is limited in comparison with that of the sea. To confine sea salmon—wandering salmon—there, even if it were practicable, would also be to subject them to comparative starvation instead of plenty. As regards the Venern salmon, which persons have attempted to introduce into our country, it is, in practical and economical respects, precisely the same as our female trout. The fact that some have been pleased to call it a salmon does not by any means make it a sea salmon, or a true salmon in any respect. So far as flavor and weight are concerned it differs in nothing from the female trout in Mjösen, and the corresponding large trout in our other larger lakes, and it is therefore in my opinion both unnecessary and unprofitable work to introduce it into our waters.

Salmon are born in the river, live there a short time in their tender youth, and then seek the sea, where they grow with astonishing rapidity.

* Already the Norwegian parliament has recognized the legality of such a claim as fully as it could be done at the time, as it prohibits the barring the way of the fish from the beach to the river source. This law, however, in a space of time was forgotten, and industry has been allowed without complaint here and there to block the way of the salmon where it was open before. That this happened without complaint was probably only because the abundance of fish was already diminished to such an extent that this barring of their way made no difference.

When, driven by instinct, they again retrace their way to their birthplace they become on their way along the coast, which they always follow, the object of a fishery of the greatest economical importance, because they are then in the best condition, which they quickly lose after their entrance into the river, where, according to experience, they take little or no nourishment. Residents on the sea-coast are thus in all respects at least as much interested in the hatching of salmon in the greatest possible quantity as the dwellers along the river courses. This community of interest is not yet comprehended in its full extent. Since the coast-dwellers as a rule are cut off from the opportunity of working personally for the production, or even for the preservation, of the salmon supply, they harvest what others have sown, and ought therefore rightfully to be obliged, in proportion to their catch, to share in the expenses which the hatching of the young salmon in the river-courses involves. A law of this kind would be eminently just, and would doubtless in a high degree advance the profit for all, but first and to the greatest extent for the coast-dwellers themselves.

Law has now established a certain size of mesh for the implements for catching salmon. This should gradually be increased so that only full-grown salmon of twelve Danish pounds weight, 6 kilograms, and upwards, can be caught. The salmon is then four years old. It will doubtless be urged as an objection to this that they will thereby lose permission to catch the sea-trout. This will certainly become true so far as the salmon-nets are concerned. But since the sea-trout are of inferior value compared with salmon, and one will gain more by allowing the salmon to become mature than by catching the small ones, the loss of the sea-trout in the salmon-nets cannot be taken into consideration. One must resign the capture to the common set-nets. At the same time the now legal sale of young salmon 8 inches long should be absolutely forbidden; under a size of 16 marks (8 Danish pounds), four kilograms, should no salmon be allowed to be sold. Moreover, the necessary active attention must be exercised in order that such a provision of law, as all others, may be properly respected; because only in this way will all persons interested be able to reap the full share, which, according to the circumstances existing on their soil, rightfully belongs to them. It is evident that the coast population have it in their power to capture nearly all the fish which come into the rivers, just as the residents on the river banks are able to omit the hatching of the young, the plain result of which will be that the coast people can get no salmon, since after a shorter or longer time no salmon will be found in the sea along the adjacent coast-extent. Both categories of proprietors' interests are thus closely dependent each upon the other. It would therefore seem that it would be to the greatest advantage of all the fishery-owners in the naturally-united districts whose interests are thus consolidated, if the whole matter within the district were carried on in partnership, as well with regard to the planting as the harvesting. Without the aid of suitable legislation

such an agreement could not be rendered feasible; a majority should have the right to control the minority; because one or more perverse ones are found everywhere, and such associations serving the common use should not be checked by a single person or a few persons, whose interests probably may be of little importance compared with those of most of the others.

In comparison with the cultivation of the kinds of fishes related to the trout, whether they be in the sea or fresh water, the cultivation of the salmon will always be beyond comparison the most profitable, taken as a whole, for all the interested persons in partnership, or for the individual who can secure for himself the greater portion of the profit of the planting of the young which he must hatch and rear and then liberate into the sea. There is of course an important difference in the rapidity of growth between different species of lake as well as salt-water trout; but if one institute a comparison between the species of both kinds of trout, which may be considered to represent the middle class, and salmon, the relation will show itself to be as follows: After being hatched out in the spring the young salmon remain in the river where they are born until the next spring; then about half of them change their markings and go to sea. Whether these are stronger individuals or one of the sexes is not known. The other half remain in the river until the spring following this, then change their dress and go to sea. By continued culture also after the first year a portion of the whole quantity of the young hatched out in the course of the winter will always go to sea. It is also unnecessary to take account as to which year's fish they represent. Those which forsake the fresh water have a length of 6 to 7 inches and a weight of 125 to 350 grams. These young have been marked to find out their subsequent growth, and thereby it has been found that even in the autumn of the same year in the spring of which they went to sea at least a portion of them returned to the river, and had then a weight of 1 to 3 kilograms, an average of 2 kilograms. When they next return from the sea they weigh from 3 to 6, or on the average of 4 kilograms, and are then in their third year. The next or fourth year they reach an average weight of 8 kilograms, and so on, but in a diminishing scale. According to the experience in many different fish-culturists' establishments in Europe and America the increase of the trout with a good supply of food may be estimated for corresponding ages, respectively, at 0.275, 0.650, and 1.500 kilograms. Comparing these numbers, the proportion shows itself to be, for the salmon and trout in question, at the close of—

	Salmon.	Trout.
The second year, average weight.....	2 kilograms.	0.375 kilograms.
The third year, average weight.....	4.5	0.750
The fourth year, average weight.....	8	1.500

This shows what a considerable value salmon culture has compared with trout culture. The yield from the first is, after the fourth year,

more than five times as much as the last; and even this will yield a good profit, as will be shown later. As is well known, the export of ice has in the last ten years steadily increased in extent and economical importance in this country. In many places along the coast where, naturally, fitting opportunity has offered, ponds are constructed with considerable expense for the production of ice alone for export. Nothing is more natural than to use these ponds for fish culture along with ice production, to which they are all, to a greater or less degree, adapted, according as the supply of running water and its quality may be. The expenses which fish culture will occasion are nothing in comparison with the cost of procuring ponds by means of damming brook-courses; but the yield from fish culture, carried on with care, may be of very great importance, especially if circumstances allow one to select salmon as the object of culture. It will, at all events, give a very good return for the outlay which the apparatus for fish culture and the labor upon it demand.

In the same way as one has found it to answer a good purpose to procure ice-ponds at considerable expense, will one in many places where the opportunity offers be able, with profit, by damming, to construct larger and smaller fish-ponds at such a distance from the sea that the production of ice will have no other importance than as a means of preservation for the harvested fish. Such an opportunity is offered in many places in our mountain districts, where the ground which must be sacrificed to transform it to a lake bottom instead of solid land cannot be considered to have any value in comparison with that which it will acquire by being transformed into a field for fish culture. One has it thus in his power, to an extent which perhaps must be called very considerable, to enlarge the field for this culture, already very great in proportion to other countries, which, as shall be shown later, has a more varied economical importance than agriculture on good ground of corresponding extent.

I shall next briefly mention—

III.

THE FISHES WHICH SHOULD BE THE OBJECTS OF CULTURE; ALSO THE KINDS OF FISHES AND OTHER AQUATIC ANIMALS WHICH SHOULD BE REARED AS FOOD FOR THESE.

Since I, as before remarked, have our lakes and rivers specially in mind, I shall first treat of the species which live exclusively in fresh water, and then of those which live both in fresh and salt water.

Following the prevailing taste among us, as also to a great extent in other countries, the genera and species of fresh-water fishes should probably be taken into consideration in the following order: Trout, red char, gwiniad, grayling, perch, perch-pike, pike, and crawfish, besides those improperly included with the fishes in familiar language. To

these some persons would add the bream and lake, which, however, for a reason which I shall mention hereafter, I place out of consideration.

TROUT (*Salmo ogla, ferox, fario, punctatus*) are the most widely distributed of all our fresh-water fishes. They are found from near the level of the sea up to the snow limit, and at elevations over 1,000 metres above the sea they are the only indigenous fish. Just as the localities differ in which they occur with regard to temperature and quantity of water, its mobility, and the nature of the bottom, so the trout, which are considered by naturalists as belonging to the same species, differ in form, size, color of the skin and of the flesh, and in flavor. Although especially well-flavored in places which are suitable for its thriving, in less favorable and turbid rivers it may be of very inferior value compared with other fish, and it suffers at all events from a circumstance produced by its characteristic taste, that one can scarcely find another fish from the sea or the fresh water of which one becomes weary more quickly. In order that the trout may acquire their flavor, clear cold water and a stony bottom are necessary. They thrive of course in streams with a muddy bottom, especially when these have a steady and tolerably strong influx of fresh cold water; but then they seldom have the same flavor if they should become very fat and large. If the influx of water is smaller, and is liable to cease entirely in the summer, so that the water in the lakes is considerably heated, they are not suitable for trout; and this condition is fulfilled as a rule in all regions of country which are situated lower than 250 to 350 metres above the sea-level; also in all smaller lakes. It applies even to the largest rivers rising in the mountain-tops—more especially, though, at an elevation less than 100 metres above the sea-level. Fresh-water trout should, therefore, scarcely be made an object of culture in small streams lower than 150 metres above the sea-level, or at all events only where the water-course is pretty uniformly supplied with cold water the whole year round by inflowing brooks or springs. It may of course live, and through bountiful feeding reach a considerable size, in comparatively small streams or artificial basins in a low country near the sea-level, but it acquires there a flavor far inferior to that which it has in elevated regions.

What particularly influences the flavor of the trout naturalists have not with certainty fathomed. It is assumed generally that cold water with more stone than mud bottom, and rich in insect larvae, and especially in the smaller crustaceans, offers the most favorable conditions for this species of fish, especially when the supply of this kind of food, as is the case in many places, is so great that the rapacity of the fish is either not at all developed or but little developed, as is plainly shown to be the case in various waters by the whole form of the fish, and as the vain fishing, with baiting arrangements of the most tempting kind in other waters, appears fully to confirm. But even where the supply of food from the insect world is smaller, and where thus the preying instinct manifests itself, the trout becomes very well flavored if there is only a sufficient sup-

ply of food and the water is clear and especially cold. The best-flavored trout are found therefore in the waters situated the highest, even up to the snow-fields; but where a certain water contains trout of particular appearance and flavor, scarcely two are found alike. The trout spawn, as it appears, exclusively in running water, especially in brooks which empty into a lake or larger river in which they stay, and then press towards the head-waters as far as they are able to advance. There is, however, a theory that they also spawn in still water; but about this there is no positive knowledge.

The RED CHAR (*Salmo salvelinus* and *alpinus*) lives in fresh water from the level of the sea up to a height of about 600 metres above it. In southeastern Norway it is a rare fish, since it seldom appears at the surface of the water, and is not easily caught with the implement usually employed to catch the trout—the artificial fly. In western Norway, on the contrary, it appears to be much more common, shows itself more plentifully, and is caught by the fly in greater numbers, than the trout. How far north this applies is unknown to me, but it is at any rate the case as far as Trondhjen. With regard to flavor the chars vary as much as the trout. In southeastern Norway they have as a rule a finer flavor than the trout; especially in certain waters in western and northern Norway it falls far below this in flavor.

How far the char can thrive is at present, so far as is known, not determined. They appear to thrive best in deep, cool waters, with the uniform afflux from bottom springs or brooks. It is strictly a lake fish; it spawns in the same water and does not ascend the brooks which empty into or flow out from it; at any rate not here in southeastern Norway.

It is a common assumption that the char and the trout do not agree well in the same water. The statement has been made that when the char is introduced into water where only trout were found before, the abundance of these was diminished. Although the char certainly may be regarded as a voracious fish like the trout, it appears, however, to judge from its whole structure, to be so in a less degree than the trout. The theory of a direct war between the adult fishes of both races mutually is thus untenable, neither can this reputed opinion be explained. It has been supposed that the char destroys the trout eggs and young with greater voracity than the trout consumes the char's. This statement appears to me entirely untenable. The trout spawns in brooks wherever it can reach them, and its young remain in them in their tender youth; while the char never frequents the brooks. It can thus not do any harm to these eggs or young of the trout. The char, on the contrary, spawns in the very water where its eggs and young are entirely exposed to the attack of the trout, and it refuses them certainly just as little as other fish eggs and young, its own included. The relation is thus rather the opposite of what is supposed. But whatever may be the relation in this respect, and even if the supposition were well founded, the admitted

relation cannot be taken into consideration where energetic cultivation is in question, which does not rely upon natural culture for the preservation or the increase of the abundance of fish. In reality it may possibly be that the perfectly innocent char has been blamed for that for which the sea-worm is held responsible elsewhere, while the real culprit has been man and him alone, who has fished with stupidity and rapacity, and will not comprehend and confess that he has done his utmost to kill both the goose and the goslings, in which he has finally succeeded; because with this explanation it is clear that the more easily accessible trout will be captured and diminished in numbers more rapidly than the less accessible char.

If in possession of water in which it is admitted that the char will thrive and acquire a desirable flavor, this and the trout may unquestionably be raised together. That they will fight for the food at hand is certain and unavoidable; but that the char should diminish the abundance of the trout is plainly inconceivable if the supply of both kinds is regulated by artificial hatching and protection of the tender young in the quantity which may be found suitable for the proper stocking of the water in proportion to its nourishing capacity. It may, of course, happen that one of these kinds of fish will find better conditions for natural culture than the other, and thus increase proportionally more in number, but in such a case one will have it in his power, by limiting the artificial culture of the favorably situated species, to restore the desired proportion.

The char is considered not only here in South-eastern Norway as the finest, best flavored fresh-water fish, but the same value is attached to it also in England, France, and Southern Germany, where it occurs in the natural or cultivated state.

GWINIAD (*Coregonus oxyrhynchus*, *lavaretus*, *fera*, *vimba*) make their home in the less-elevated larger lakes and streams, where they, presumably because of strong persecution alone, for the present reach but a small size. Experience in the attempt of introduction shows that it thrives particularly well in our more elevated mountain lakes, where it reaches considerable size, fatness, and flavor. While it nowadays in this country, where it occurs most generally, seldom reaches a size of two to three kilograms, in Finland it grows to six kilograms and over. It is generally known as one of our best fishes, which one can eat more freely without becoming tired of it than trout or salmon. It is not, like the trout, what is called a gluttonous fish, or a fish of prey, since its mouth is small and not so armed with teeth that it can seize a somewhat developed fish, even though of small size. It lives, therefore, on water-insects of different kinds, but also, like all the others, on spawn and young fishes. Its spawning-time is late in the autumn, and for a spawning-place it chooses a stony bottom in shallow water. It is comparatively more fruitful than the trout, since its eggs are of somewhat smaller size.

This fish is admirably adapted for rearing along with the trout and the

char in the same water, since it not merely on its own account is well worth cultivation, but also because its young are excellent food for the larger trout, which the char on its part cannot injure. How high it will thrive we have no experience of; the highest place known to me, where it is planted and thrives remarkably, lies about 900 metres above the sea. It appears thus not absurd to suppose that it will also thrive under conditions otherwise favorable. But if one does not wish to make this a special object of cultivation, and will regularly hatch out and raise a proper number of young in proportion to the area of water which he may have control of, he should, however, not neglect to stock the water with it as a contribution to the food of other fishes. It will in this respect possibly prove to be a kind of fish that will thrive highest above its hitherto common place of resort.

It might, perhaps, be supposed that the planting of the gwiniad in such places where the already indigenous fish, the trout, finds so rich a supply of food that it does not devour all of it, and thus does not need any kinds of smaller fish or young fish as additional food, would effect an unnecessary competition about food between the gwiniad and the trout, and thereby a diminished profit from the fishery as a whole. That this possibly might become so by thickly stocking with both species together cannot be contested. In such a case one obtains restricted planting in the aggregate. But I should, however, think that rearing the gwiniad by the side of the trout, whereby a variety in fish-food becomes possible in places where they have hitherto been confined exclusively to trout, will prove a source of real profit.

The GRAYLING (*Thymallus vulgaris*) has hitherto been confined to the same localities as the red char in the eastern part of the country. It is not found westward of the rivers of Laugen, Vormen, and Glommen, and the tributaries falling into these. It resembles the red char more closely than the trout in form, color, and flavor. It thrives particularly in cold clear waters with afflux of larger brooks or rivulets, with a strong or even rapid current, against which it at certain times of the year advances, on which account also it is called, in certain places, current-grayling. There appears to be good ground for supposing that it will thrive in suitable places as well as the red char; but as far as is known no attempt has been made to introduce it into other lakes or rivers than those in which it naturally exists, neither has it, so far as is known, hitherto been the object of hatching. It has, upon the whole, been less noticed, just as it is comparatively rarer, than the red char, wherefore I have taken it into consideration after this. The flesh of the fish is savory and very wholesome; it takes the artificial fly readily; and, finally, it spawns in the spring, while the fishes previously named spawn in autumn and winter. The first-named quality recommends it as an article of food for cultivation in the same degree as the red char; the other recommends the grayling as a game fish for every one who, along with the profit of fish cultivation, also prizes fly-fishing as a pastime; and the last-named

quality makes it just as worthy of recommendation to be bred along with the red char where circumstances permit, since it naturally lays its eggs in the open water, and the fry proceeding therefrom will serve as food for the whole planting of fishes at a time of the year when neither trout or char eggs or young are present; while the artificial hatching which is necessary for the regular stocking, without requiring special apparatus, may take place in May to June in the empty apparatus used for the hatching of trout and char eggs. For the nourishing of the young in their tenderest youth only is required a particular apparatus of little extent and expense. It is just as little a fish of prey as the red char, and possesses nearly the same fecundity.

With these four kinds of fishes the list is complete of the salmonoids, or salmon-like fishes, which ought to be special objects of cultivation as articles of food. There are still a couple small fishes belonging to the same principal division, which also deserve to be taken into consideration as objects for cultivation; but since they are supposed to deserve to be considered as a natural food for the larger and more valuable fishes rather than as food for men, for which, however, to some extent they are used in the places where they now occur in any quantity, and since they, as it appears, will thrive and reproduce only in larger lakes with bottoms of a certain quality, I will refer to them under the kinds of fishes that ought to be hatched as food for the larger and more valuable fishes. Should it happen that by such cultivation they will become so numerous that they might also be considered as food for people, so much the better.

Of another chief division of fishes, the spiny-finned, which inhabit our fresh waters, I have next cited two kinds to be considered above all others, although it is generally supposed that they cannot be compared with the preceding in flavor. About this, opinion may be, and is much divided.

Of these I have placed the PERCH (*Perca fluviatilis*) first, since this species is most widely distributed. It is found generally more or less numerous in nearly all rivers, brooks, and lakes, even up to the spruce limit. Whether it will live and thrive at greater elevations is, so far as is known, not determined, probably because it is readily eaten by the common people in the mountain districts, but is not regarded particularly by the side of the trout, which is more generally distributed there. It bears very different names in the different parts of the country where it occurs: Abor, tryte, skjebbe, &c. It lives and thrives in all kinds of lakes, small and great, with or without constant afflux, and is just adapted, therefore, for cultivation in such lakes in which the previously-mentioned kinds of fishes will not thrive properly. It is decidedly a rapacious fish, and it is supposed, therefore, by fish breeders in Southern Europe that it ought to be excluded from the lakes in which the *salmonidæ* are cultivated. Experience in our country seems, at the same time, to show that it cannot be very dangerous to the trout or the red char,

since it occurs up to their present limits, as well as in all waters along with both of these, and without, as far as is known, doing them any serious injury. It is a slothful, sluggish fish, while the trout is lively and particularly quick in its movements. I assume, therefore, that there should be no hesitation in raising the perch along with trout and other salmonoids, if one cares to cultivate this kind of fish and the opportunity to treat it by itself is wanting. The flesh is found by many, when properly prepared, to be peculiarly well flavored, especially as a change from other fish, and it is highly nourishing. With the necessary supply of food the perch reaches a considerable size, up to one and a half and two kilograms; but if one wishes to gain this size, care must be taken that the fish obtain abundant nourishment from other smaller fishes of different kinds. It spawns in spring, May to June, and is peculiarly fruitful.

The genus of fish most closely related to this is the PERCH PIKE (*Lucioperca sandra*), one of our largest lake-fishes, and also one of the most savory; it grows to a size of 12 kilograms and upwards. It is found at present in only a few of our larger, least elevated lakes; it is not found in this country north of Öieren. As far as known, no one has attempted to introduce it to other lakes, although there are a great number of such in which it doubtless would thrive well. Since the fish is very little known, I shall state that its flesh is as white as the cod's, likewise just as free from bones, and it is, although of a somewhat more decided flavor most nearly like that of the turbot—rated by most persons who know it just as highly as the best cod. Its natural place of resort shows that this fish is not adapted to the colder, more elevated lakes, and that on this account it cannot be expected to thrive where the conditions are particularly favorable for the thriving of the trout. Since it is, besides, a predaceous fish, which is considered more voracious than the perch, it should not be bred together with trout or red char. While, on the contrary, the gwiniad remains more at the surface of the lake, while the perch-pike, by preference, remains at the bottom, there can be no objection against planting them in the same lake. That care must be taken to supply sufficient food, if one desires a rapid development of this fish to a suitable size, is self-evident. It spawns in spring, and is very fruitful.

Of the soft-finned fishes, I will state that only one species will be taken into consideration for cultivation, namely, the PIKE (*Esox lucius*), the most voracious of all our fresh-water predaceous fishes. It is comparatively little distributed in our country; generally it can be said to be only in the eastern parts, where, it is true, it ascends in the great rivers to a height of 250 to 300 metres above the sea in the Glommen; but in smaller lakes and in the larger western rivers it occurs scarcely higher than 200 meters above the sea. In the whole southern and western part of Norway it occurs in only a few places, where it appears to have been introduced, while in the eastern and northern portions of the Scandinavian peninsula it is generally distributed far into

the interior; it is found thus in many lakes on the boundary between East Finmark and Finland. In the region of the country where the pike is indigenous it is a well-esteemed fish, though, of course, not so highly esteemed as the trout or the gwiniad. In the portions of the country, on the contrary, where it has been introduced, and this applies to the region to the west and north of the valley of the river Drammen, and to this valley itself, in which last it was introduced not many years ago, it is less prized as a means of food. It is, taken on the whole, an indolent fish, which, however, when it sets out to seize a victim, can move itself very quickly. It is thus a dangerous enemy of the trout, and annihilates this wherever they are found in the same lake, in the regions which are favorable for its thriving, namely, the stiller, shallower, and thus warmer portions of the same. Syrifjord, at Ringeriket, offers a good illustration in this connection. In its tributary, Stensfjord, and the shallower portions of Tyrifjord itself, the pike rules, and it is a rare thing to get a trout without much walking. In Holtsfjord branch, on the contrary, it is much deeper and colder, and in its immediate vicinity the trout is the presiding fish; and here it is just as great a rarity to capture a pike as it is to catch a trout in the other places.

With abundant supply of food the pike grows rapidly, and it may reach a very considerable size, 12 to 18 kilograms and more. In all lakes of lower elevation, for instance such as are liable to want supplies in the great drought of summer, the pike may profitably be cultivated along with the perch, which is its usual associate wherever it occurs, and the pike-perch, which is very nearly as voracious a fish of prey. It spawns from February to midsummer, and is, like the preceding species, particularly fruitful; its own offspring, therefore, constitute a large part of its food.

The CRAWFISH, like the pike-perch and the pike, frequents the less elevated watercourses in the eastern portion of the country. Up to a few years ago it was not found west of the valley of the Glommen, and in this region not higher than a hundred metres above the sea, in the smaller and warmer rivulets, brooks, and lakes. In the Glommen proper, it is very rare and does not extend up to Mjösen, probably because of the greater coldness of the water than in the tributaries. About twenty years ago it was transported to Stensfjord. It appears that it has not distributed itself there very much. Although comparatively little distributed, and thus little known in this country, it is liked by many where it is found. It might with ease be transported to many localities on the western low-lying rivers and lakes, and its cultivation and fattening are very easy.

With these I think that the list of fresh-water inhabitants worthy of cultivation for food ought to end. The fishes belonging to the last-named principal division (soft-finned), the extensive family of carp-like fishes, *Cyprinidæ*, of which many kinds are found in this country, and among which the bream in particular is the principal one and the most

widely distributed of the largest of this family, I think do not deserve especial cultivation, except as food for those previously named, in places where any of the cyprinoids will thrive. They all stand—at all events those which are now at all abundant in this country—far below all of the previously mentioned in flavor, and are distinguished by an abundance of bones of the finest and most pointed kind, which make it a troublesome, sometimes painful, matter to eat them. The carp proper, which in more southerly countries has been and now is an object of breeding, is found in only two places with us, where it is introduced, although it is said that the attempt of its importation in ancient times was made in many places, but without success. What value the carp may have as a source of food in comparison with the species of fish named, I cannot decide. I am inclined to believe that it does not much surpass the bream in this respect. Should any one wish to undertake to cultivate it, places may be found, of course, where this may be done successfully, but it must take place in waters of entirely different quality than those in which it is said that such culture was attempted before. Low-lying warm waters, deep in places, with muddy bottom are their proper haunts. All carp-fishes are very prolific, and live principally on vegetables partly rotten. They are thus just suited as food for others—carnivorous fishes.

The same reason which appears to disparage undertaking the culture of any genus or species of the *Cyprinidæ** does not, on the contrary, apply to the LAKE (*Lota*), which is a rather generally favorite food in the early months of the year wherever it occurs, namely, in all the great watercourses of Southeastern Norway up to quite a considerable height; in the Glommen as far as Röros. This single fresh-water representative of the cod family is a greedy fish of prey, and is possessed of very great fertility, so that, on the one hand, it is little adapted for the stocking of waters where other more esteemed species of fish are bred, while, on the other hand, its natural fecundity is sufficient to maintain the race in proper abundance; from which it happens, furthermore, that its haunts have such an extent that individuals rarely have any particular interest in their increase. Should we ever proceed so far that systematic cultivation, for the interest of all, of the abundance of fish in the large lakes or larger divisions of our greater water-courses should be practiced, and should one then ever consider it of interest to increase the supply of this species of fish, it will be very easy, by hatching out the spawn, which can be procured with ease in great quantities, to provide for the development of great multitude of young.

It cannot be open to question that one, by artificial hatching, and by protected rearing in their tender youth of the young thus produced, as long as the nature and mode of life of each particular species of the

*If one wishes to describe this great family of fishes by the quality most apparent to people in general, one should style them the fishes crammed with fine bones and with insipid flesh.

cultivated fishes require, will be enabled to increase the abundance of fish in our lakes and rivers to a very considerable degree. All of these waters at one time were much richer in fish than they now are, and it is thus a certain thing that, without any care in this direction, they will supply nourishment for a considerable increase of a number of fishes in the future just as well as they have done in the past. But if one enters into the cultivation of fish, it will be just as unreasonable to stop at the limits which the natural fruitfulness of the water establishes as it would little reward the farmer to neglect to increase the natural fruitfulness of the soil, especially as it is just as easy, perhaps much easier, to produce an increase of the nourishing capacity of the water as to furnish to the soil the materials which are necessary to increase the crop.

Such an increase of the fertility of the water may be brought about in many ways. The simplest, as before remarked, will be, along with the fishes which are the objects of culture, to hatch out, and in the proper degree rear, other fishes, crustaceans and mollusks, as food for them, to the extent which prevailing circumstances in every place will allow; and these conditions will be found to vary to a considerable extent. Along with these means one may naturally also employ artificial—if one will unnatural—food, and thereby augment the yield in an extraordinarily high degree; but the opportunity of procuring this kind of fish-food is in a still higher degree different from increasing living organisms. I will therefore, place it out of consideration.

As fish-food are adapted, chiefly—

ÖREKJYTEN, Gorkjyte, Gorkim (*Phoxinus aphya*), which occurs as far up as 900 metres above the sea. It may be that it, like the gwiniad, will admit of being planted and thrive in still more elevated lakes and brooks than those in which it occurs now. One thousand two hundred to 1,300 metres above the sea-level should be regarded as the limit of the occurrence of the trout, and it is perhaps not impossible to introduce the Örekjyten to this height; if not everywhere, at least in certain places, where the proximity of the "*Snebrœrnes*" is not too great.

It multiplies rapidly, and since it spawns in or after midsummer, its spawn or young will supply the young cultivated fishes of all kinds at a time of the year when other spawn and young do not occur. It is at all times a cherished food for trout. Where this fish will no longer thrive, on account of the elevation above the sea, one has probably no other species of fish to plant in its place as food for the larger choicer fishes, except young gwiniad (Sik), as far as these will thrive upwards. The minnow is regarded in many places in the country, as before intimated, as injurious, since it is with reason supposed that it destroys the spawn and young of the choicer fishes in great quantities. Thereby it counteracts, just as all other fishes without exception, the natural culture of all fishes; but this circumstance will, as repeatedly stated, lose all importance when we, as a fundamental condition for fish-culture, begin by constantly providing for such a planting of fully-developed young fishes of

the kinds which one prizes as objects of especial care, as corresponds with the existing nourishing capacity of the water-area. The more minnows which under such conditions occur, and the better they thrive, the more profitable for the development of the species of fish which one desires to produce as the particular fruit of culture.

A species related to this—

The MÖRT (*Leuciscus rutilus*), occurs in the eastern and southern portion of the country in nearly all the waters and rivulets with a current not too strong and with a muddy bottom, up to a somewhat lower level than the preceding. It will probably also admit of being planted in waters more elevated than those in which it is now found. It is, as the most of the genera belonging to the great cyprinoid family, particularly fruitful. It spawns in spring, in April and May. There is no difficulty in the way of its introduction in great numbers, if it be found necessary in this way to insure that the supply of this food may not diminish too much, which may easily occur with merely natural reproduction, where the spawn as well as the tender young are the defenseless prey of every fish, small and large, of other and even the same kind. At a still lower height occurs another cyprinoid—

LAU or LÖJE (*Alburnus lucidus*), which occurs in large lakes and rivers, but resembles the mört in habits and appearance; the most evident difference is that it has a yellow iris, while the mört has a red one. It spawns on grassy bottoms, at the same time as the mört, and might perhaps be introduced to more elevated waters. Both of these species feed on aquatic plants as well as aquatic insects. It thrives thus in a less degree than other fishes of choicer kinds, if the insect world yields it nourishment.

The KARUDSEN (*Cyprinus carassius*) lives in pools and ponds with muddy bottoms, up to a height of 150 to 200 metres above the sea-level. It will probably easily admit of being transferred to more elevated places in still waters with muddy bottoms. It lives, as the two species previously named, to a great extent on vegetables, occasionally rotten ones. It spawns in May and June, and is very fruitful. The *Karudsen* may reach a very considerable size, even up to one kilogram, and are then considered well flavored.

Of the salmon family occur, as before intimated, in the great Scandinavian lakes, two species, which may be mentioned.

SLOM or NORS (*Osmerus eperlanus*) and LAKE HERRING or SIKLÖJE (*Coregonus albula*) appear abundant in very numerous schools where they are found. Both occur in Mjösen, where the last, at the spawning time in autumn, is now and then caught in great multitudes, many hundred barrels. In Sweden, also, the nors is caught in great abundance at the spawning time, which occurs in March to April. The attempt has been made to introduce the lake-herring into many of our larger lakes, but the attempts hitherto made have, so far as is known, not succeeded. If sufficient care should be exercised, it might be possible to introduce both

species to many lakes, and to greater heights than those at which they now occur; and they will then, even if one may not wish to use them as food for mankind, be particularly useful as food for other larger fishes which persecute them with eagerness.

As being closely related to fishes, must another class of animals which may serve as nourishment both for larger and smaller fishes not be left out of consideration, namely, frogs and toads. Just as the grown animals are relished by the larger fishes, so are their eggs and tender young a favored food for smaller fishes of choicer kinds. To transfer these animals from one water to another will, of course, hardly be successful, since they are just as much land animals as they are water animals; but nothing is easier than to transfer their eggs or spawn laid here and there to basins or waters where it may be of use.

As is seen from the foregoing brief representation, the ability to procure natural food for the larger fishes is all the greater and easier the lower the water-basin lies which shall be prepared or preserved for fish-culture. This is a very favorable circumstance, because the lower the level becomes, the higher the water's average temperature, and the less uniform the water supply, the more voracious, as it appears, become the species of fish which may be made the object of successful culture. Even the trout becomes in the less elevated warmer waters more of a predacious fish than at greater heights. Whether this is because of the greater wealth of insect food in the elevated regions than in the waters of the lowland, or owing to other circumstances, we have as yet scarcely any certain knowledge or conjecture about; the fact is in the meantime as stated. A commonly received opinion, especially with regard to the trout, which, with the exception of the red char, is regarded as the best of all our fresh-water fishes, perhaps because it is the most common—is at the same time that fish of the salmon family become all the fatter and more savory the greater the supply they find of insects, crustaceans, and mollusks. This supply is meanwhile, as experience teaches, very different in different waters. It shows, therefore, of itself that also in this direction one ought to provide, as far as possible, for procuring himself a supply of food by stocking the waters in which fish-culture is prosecuted with the species of these kinds of animals which admit of being transferred from one place to another.

The same opinion is stated by Prof. G. O. Sars, in a prize essay on Norwegian crustacea, issued as a publication of the university in 1865: "One will be able to form a still clearer idea of the enormous numbers of these animals if one reflects that they, notwithstanding their small size, constitute the chief food of most fresh-water fishes, a fact which is sufficiently established by Leydig, who, upon the dissection of very many different kinds of fresh-water fishes, always found the stomach's contents almost exclusively to consist of entomostraca and copepoda. It is thus most highly probable that the good quality of fish in different localities largely depends upon the greater or lesser quantity of these small

animals, wherefore, even from practical considerations, in the artificial fish-culture so zealously carried on in our time, they certainly ought not to be left entirely out of consideration. They will especially recommend themselves as wholesome and efficient nourishment for the still delicate young fishes, just as, also, certain species deserve to be planted in larger fish-ponds. These small animals play a still more important role in the great economy of nature by filling all the stagnant pools and swamps with their countless multitudes."

The recommendation suggested by the professor concerning the cultivation of these crustaceans as food for fish-fry was about the same, practically, as that attempted by Mr. Sanvedon in the vicinity of Paris in 1864, '65, '66, and '67, and has completely answered the purpose.*

The aquatic insects which, after passing through the larval condition in the water, take on a winged form, it will perhaps be difficult to transport from one place to another; it will, however, be worth the trouble to attempt it. The animals of the extensive crustacean or crawfish family, which live in mud or among the stones at the bottom of the water—which by common people are called Grundaat, because they destroy fishing implements placed on the bottom—easily admit, on the contrary, of being transported from one body of water to another; and since they, with little care, multiply with great rapidity, there will be no difficulty in making a supply of this nourishment ample in the basins which may serve as abiding places for the younger fishes. Since these basins must stand empty at certain intervals, it is easy to provide that a new aftergrowth of such crustaceans shall take place when the basin again is to be used, if the quantity of these should be improperly reduced by a preceding stock of fishes. How far the free-swimming crustaceans, which sometimes occur in countless quantities even in the most elevated mountain streams and throughout the larger rivers, will admit of being introduced to waters where they do not occur, is a question well worth examination. I have seen the Vormen so full of these animals that it appeared as if there were one to two animals in each cubic inch of water, at least nearest the surface.

They think they have discovered in Scotland that the fatness and the flavor of the fish in certain waters was really to be attributed to a mollusk, a *water-snail*, which lives in these waters in great abundance, and this species of snail has, therefore, already been introduced into this country, but is hardly distributed as far as it is desirable it should be. The introduction of these animals into new waters in which they can live is not difficult, and since their fecundity is very great, a great wealth of food will very quickly be produced for fish whose cultivation may be attempted by their introduction.

Of the species of fish which belong as well to salt as to fresh water there are only three, the SALMON (*Salmo salar*), the SEA-TROUT (*Salmo eriox* and *trutta*), and the EEL (*Muræna anguilla*).

* Bulletin de la Société d'Acclimatation, December, 1867.

The two first-named kinds have been previously so far mentioned that I shall in this place merely add a few remarks. Both are born in fresh running water, both remain therein during their earlier youth, and go therefrom to the sea, where they quickly develop, after which they again, driven by the instinct of reproduction, return to the places where they were born. Some have thought that this returning, at all events so far as the salmon are concerned, is also caused by the instinct of freeing themselves in fresh cold water from certain parasites which infest them in the sea in summer; but this appears scarcely probable, since the lake and river trout are also attacked in summer by similar animals. The return to fresh water takes place earlier in the case of the salmon than with the sea-trout, which last, as a rule, first enters the mouths of the rivers towards autumn. Owing to this circumstance, one has a longer fishing season for the first than for the last.

It is thought that the salmon and the trout do not agree well, but conflict with each other about the spawning-places, so that where the trout appears in any great abundance, particularly the large form, *eriox*, there the salmon decreases, and *vice versa*. It may, however, be somewhat doubtful how far this observation is founded upon any mutual antipathy between the races. It may possibly be based upon other circumstances; for instance, conditions accidentally more favorable for the propagation of one species or the other in different years, which plainly will cause one or the other species to occur in greater comparative abundance some years after than was the case earlier.

With regard to flavor, the salmon must generally be preferred to the trout, particularly salmon of the better kinds. It has already been stated that salmon, like the fresh-water trout, vary considerably in quality from one place to another; this is, however, true in a less degree with the ocean-trout. In the salmon this may be the case even in a very high degree with fish from adjacent rivers, a phenomenon which can be explained only by race differences, since fish from the different rivers get their development in the sea, where both find equal conditions for thriving and fatness. At Christiansand we have a striking example of this. While the salmon in Torisdal River is plump and beautiful in form, bright in color, and must be called excellent in fatness and flavor, the salmon of Topdal River is thin, dark in color, and can be styled nothing but indifferent or even bad in plumpness and taste.

In regular culture one has it in his power, among fish as well cattle, to select the best races which are known, and it seems to be beyond question that these, transplanted to a new locality, will retain their peculiarities; because, as remarked, the wealth of the sea is everywhere free for all, and supplies all a like abundance of food. What can produce the existing great difference in adjacent places is not easy to perceive. The only mode of explanation seems to be this, that the rivers possess very different nourishing capacity for the tender young, so that they in one in a manner are checked, while in the other they thrive greatly.

Should this supposition be well founded, which the attempt of a few years with spawn brought from another place will show, then one should, in the places which prove to be less favorable, seek to provide the remedy for the absence of nourishing capacity for the young by direct feeding, and also constantly renew the race by bringing spawn from more profitable places.

But even an inferior race of salmon grows much more rapidly than sea-trout, even the larger form, so that the relation between these with regard to yearly increase of growth will be not far from the same as previously pointed out with regard to the relation between salmon and lake-trout. If, then, the mutual antipathy mentioned between the salmon and the sea-trout may be only a baseless conjecture, this difference in growth from year to year, in connection with the salmon's returning to its birthplace earlier in the year, will cause its culture to become much more profitable than that of the sea-trout, which requires just the same labor and outlay for apparatus. It has been previously stated that salmon-fishing ought to carried on in such a way that one, at all events after hatching has been prosecuted for three or four years, will not catch any but grown fish, that is to say, of about 6 kilograms in weight. The apparatus which will be required for such fishing will be unserviceable for the capture of sea-trout, which only at a comparatively advanced age reach such a size. I should, therefore, consider it best to undertake the culture of only one of the fishes mentioned, and then preferably the more profitable one—the salmon.

For both these species of fish in question, one is clearly free from all care with regard to their nourishment, except during their earliest youth. The wealth of the sea in food which they require is certainly boundless; at all events, men are able, so far as their insight at present extends, to do nothing to increase it, even if it should be considered desirable.

As regards the EEL, it acts just the reverse of the species previously mentioned. It is born, so far as we now know, in salt water alone, and migrates from this in early youth, when of the size of a coarse darning-needle, up along the brooks and rivulets to the fresh waters, where it passes many years of its life. In migrating up into the water-courses it is not easily stopped by any obstacle; if the current is stronger than it can swim against, the young eel takes to the land, and continues its way in compact columns of many thousands on the moist bank; it winds even up the trunks of trees in dams, and thus advances where one would consider it impossible. The migration takes place, as remarked, in dense multitudes of many thousands. Whether or not eels are born in the sea we have no certain knowledge, neither do we know whether they are also born in fresh water.

The journey of the eel-fry up into the water-courses takes place in April, May, and June—in different places at different times, probably according to the condition of the weather. From midsummer and during autumn, especially during the dark autumn nights, the adult

eel goes from the fresh waters, where it has passed its preceding life, down into the sea, as commonly supposed, to propagate its species, and thereafter does not return to the fresh waters, but continues its life in the sea, where it is thought to make regular journeys from place to place. No one has ever come across adult eels migrating upwards from the sea. What causes this wandering out to the sea no one knows. The exodus includes both larger and smaller eels at the same time, which do not appear to be of the same age or degree of maturity, and so there are found simultaneously in the sea both small and large eels, as in the fresh waters from which they descend. It is a warm-water fish, and therefore is seldom found more than 500 feet above the sea-level, but thrives in all kinds of waters, large and small, with or without affluents, if they only have a muddy bottom in which they can bury themselves in winter.

It lives exclusively on animal food—insects, snails, fish, and flesh of all kinds until and after it has become putrefied. It is easily caught in many ways; the easiest, however, appears to be unknown in this country, at all events it is employed very rarely—namely, to capture it in so-called eel-traps in its migration towards the sea, which is universal over all Sweden.

It is considered by many a very well-flavored fish, and commands a high price. It grows very quickly. While 1,800 young eels are required to weigh a pound, one-half kilogram, only 30 yearling go to make up the same weight. At the age of three or four years the eel reaches a weight of one kilogram. One can cultivate it by collecting the young during the migration from the sea, and therewith stocking ponds and pools, and if one provides for a supply of food, living or dead, they will grow quickly. The mode of cultivation which, however, will presumably answer the purpose best will be to place the eels which are caught in the river or the sea, fresh or salt, and which may not have reached a suitable size, in a separate pond, and then to feed them well with all kinds of offal of flesh and fish, to which there must be easy access; if it is a little putrefied it will, as remarked, do no harm. They will then grow very quickly, and give a good return for their care and food. One must in the mean time look out that they do not escape from the pond, by surrounding them with an inclosure which the eel cannot climb over or creep through; otherwise they will in the night, during a heavy dew or rain, leave the pond and disappear. A belt of loose sand about the pond will prevent them also from escaping, if it has sufficient breadth. A pond for such purpose ought to have a muddy bottom and hollows in the sides in which fish may conceal themselves and find shelter both in warm and cold weather; if one can conduct running water through the pond, it will become so much the more profitable. In an extent of twenty square meters 150 to 200 eels can be accommodated and thrive well, if they simply obtain sufficient food.

This fish is well adapted for stocking ice-ponds, which, because of a

want of a regular water supply or other circumstances, cannot be used for salmon or sea-trout. There is no difficulty in planting them. The young eels will be found in all rivulets which proceed from waters wherein the eel lives, regularly every spring, if one takes the trouble to look for them in May and June. They migrate, as remarked, not singly, but in dense masses of many thousands, and can be collected with ease. If it is necessary to bring them from a very great distance, the transportation is not difficult. The eel's tenacity to life is known, and they are able to live many days in water-plants if they are now and then moistened and kept in a cold place.

IV.

ACQUIRED EXPERIENCE.

In order that one may form an idea by any means clear concerning what profit he may expect from systematic fish-culture prosecuted to a different extent in different localities, it is necessary to know the results which have been reached from such culture in other places. I shall, therefore, communicate below a few instructive illustrations sought among a multitude of experiences in different countries and authentic sources.

In the State of New York, in the vicinity of Caledonia, Messrs. Seth Green, A. S. Collins, and S. M. Spencer, in 1865 to 1866, constructed a fish-farm nearly three-quarters of a mile (1,200 meters) from the source of the Caledonia Springs, a brook which originates from springs in the bottom of its bed, and which at the farm conveys a bulk of water of nearly 80 barrels, or about 10,500 liters,* per second, or about 9,000,000 hectoliters in twenty-four hours; a respectable body of water, which is completely at the disposition of fish-culture. The farm contains an area of about 20 hectares, which, in a length of about 800 meters, is traversed by a brook. Since the ground is quite level, there is no overflow into the brook, whose water, therefore, is perfectly clear; it contains a small portion of sulphur and chalk, but these must be well adapted to the fish, since the brook has been renowned for its trout, which are now numerous in it. The object of the construction of the farm was to rear trout for sale as food, but circumstances have caused the operations to involve chiefly the bringing in of impregnated eggs, newly-hatched young, and one to two years' old fish for sale for stocking other lakes, brooks, and ponds. Many millions of eggs are hatched out annually.†

The selling prices are: For a single thousand impregnated eggs, $10; many thousands and upwards, $5 to $8 per thousand; for newly-hatched young, $30 per thousand; yearlings, $12 per hundred; fishes two years old, $25 per hundred, or a little over the price of dead fish for food. No more old fish are kept and reared than are necessary to procure the de-

* One liter = 1.0362 quarts; one hectoliter = 103.52 quarts.

† Seth Green: Trout Culture, 1870. Leon Soubeiran: Pisciculture dans l'Amerique du Nord, 1871. Raveret Wattell Progrès de Pisciculture aux États-Unis, 1873.

sired quantity of impregnated eggs. If we estimate that only 2,000,000 eggs are sold annually at the lowest price, these yield a gross profit of $16,000, or $800 per hectare ($80 per rood) of the whole property, which can only be in part occupied by them for the necessary fish-culture ponds.

Mr. Green states that a pear-shape basin of 6.3 meters in length, 1.9 meters in breadth about the middle, and from 0.15 to 0.64 of a meter in depth, with a capacity about 3.6 cubic meters, and with a water supply of 1.6 liters of filtered spring water per second is quite sufficient for 6,000 to 8,000 young after they are completely hatched, when they begin to take food of their own accord.

That a similar pear-shape basin of 9½ meters in length, 3.15 meters in breadth at about the middle, and a depth 0.15 to 1.26 meters, with a capacity about 15½ cubic meters, and a water supply of about 37½ liters of brook water in a second, will be sufficient for 5,000 two-year-old fish; while a similar basin 15.75 meters long, 9.5 broad about the middle, and from 0.15 to 1.5 meters deep, with a capacity about 48 cubic meters, and a supply of running brook-water equal to that of the last smaller basin, is fully sufficient for 2,000 fish in the third year; observe, under the condition that the temperature of the water is not under 1° (34.25° F.) and not over 12° R. (59° F). The fish will die if the temperature of the water rises to 16° R. (68° F.), unless there are cold springs in the bottom of the basin which will cool off the water. The rule is, the colder the better down to the limit stated.

The hatching is done in a trough 20 feet long, 18 inches broad, and 6 inches deep, which is divided into compartments 18 inches long by cross-pieces 2 inches high, which are secured to the sides of the trough; other such cross-pieces are used at pleasure, or when it is necessary to make the water deeper. The bottom of the trough is covered with shingle. The spring water is filtered in a trough 6 feet long, in which are placed, at an angle of 45°, three to four screens covered with flannel, to give the greatest possible filtering surface. The loss of eggs in hatching does not exceed 6 per cent.

Later, Mr. Green was appointed superintendent of the fisheries of New York State, and he constructed a State hatching-house on the same brook—Caledonia Springs—in which are hatched out and distributed annually 4,000,000 to 5,000,000 of impregnated eggs and young.*

Count M. de Causans, on the 10th of December, 1858,† the lake be-

* One of the herring family, *Alosa sapidissima* (the shad), which in America is very highly esteemed as an article of food, and which, like the salmon, spawns in fresh water, had been for some years almost fished out. Mr. Green has in the later years annually hatched millions of young of this fish in open water—one year nearly 8,000,000—so that now the abundance in many places has become just as great as it was a hundred years ago. The young have been carried from New York State to streams in California, where they thrive well, although this fish did not before exist on the Pacific coast. A couple of genera related to this fish are found sporadic on our coast. Would it not be worth the trouble to attempt the introduction of the dainty shad to our coasts and rivers?

† Bulletin de la Société d'Acclimatation à Paris.

longing to him, Saint-Front, in the canton Fay-le-Froidi, department Haute-Loire, in France, has a surface of fully 30 hectares, a depth of up to 10 meters, and an elevation of 1,200 meters above the sea. It is fed partly by numerous springs in the bottom of the lake, partly by brooks which flow into it after first traversing the meadows which surround the lake; a larger brook, La Gagne, carries the water from the lake to the river Loire. The lake contains trout which are much esteemed, and which are sold on the spot for 2 francs 50 centimes to 3 francs per half kilogram = 1 Norwegian pound.

Until 1854 they restricted themselves to liberating in the lake a few hundred small trout caught in the brooks; but this autumn they took pains to procure 30,000 to 40,000 impregnated eggs, which were placed in an apparatus constructed for the purpose in the lake itself, to be hatched out. In subsequent years this was annually continued in an increasing scale, just as persons by cleaning out the tributary brooks have attempted the improvement of natural culture. In the space of the year 1857 by net fishing they took regularly from 25 to 30 kilograms of fish of an average size of 300 grams every time. He can now, without interfering with the abundance of the fish, sell at least 15,000 kilograms annually, and his manager, Mr. Millet, thinks that one might, without injury, take 200 kilograms per hectare annually. The lake contains also carp and other cyprinoids, together with an abundance of minnows and frogs, which serve as food for the trout.

The Marquis de Selve has constructed a fish-cultivating establishment* at Godset Villiers, in the communeCerny, in the department of the Seine and Oise, near Paris. It consists of a canal with manifold windings, which in a total extent of 12 kilometers (one Norwegian mile), traverses a nearly horizontal field of 12 hectares, and ends in a larger basin from 10 to 30 meters in diameter, and is 5 meters deep; the canal is 2 meters in breadth, and is fed by water taken from Cerny canal, which from the basin flows out again into the river Essonne. The whole inclination from the beginning of the canal to the outlet from the basin is only 80 centimeters, but the water supply is sufficient to maintain a suitably strong current; various rather strong springs increase at many points the water supply, as they furnish the hatching apparatus with the necessary water for the development of salmon and trout. At the highest portion of the field are constructed smaller canals for the rearing of the delicate young until they have reached such a size that they can be liberated in the larger canals. There is abundance of water which nourishes an endless multitude of small crustaceans, and the bottom contains lime, which is of great advantage for the development of the common large crawfish.

In the spring of 1864 was begun a project of digging a couple of kilometers of the large canal to experiment with trout and the common

*Rapport par Ch. Wallut, 15 Mars, 1867, Bulletin de la Société d'Acclimatation à Paris.

crawfish. Young trout were purchased from a hatching establishment in Paris; but even the results reached in a few months determined the marquis to give his apparatus the full extent intended. In the month of October, 1864, therefore, a multitude of workmen engaged in digging the rest of the 12 kilometers of canal; in April, 1865, the water began to traverse the whole length. The expenses of the scheme (the digging, locks and bridges, buildings, purchase of eggs, fish, crawfish) amounted to fully 150,000 francs, and the expenses of maintaining, for food, watching, repairs, instruments, &c., must be estimated at about 12,000 francs per year.

According to the report the establishment was partly three and one-half years old, and the rearing of crawfish was carried on for the same length of time. Unfortunately, crawfish grow slowly; it requires eight to ten years before they can be offered in the market of Paris. In order to shorten this time, 325,000 crawfish of three to four years old were gradually purchased and liberated in the canal. These have thrived wonderfully, and will admit of comparison, so far as flavor and size are concerned, with the best crawfish from Maas River or from Germany.* They have multiplied, and are found of all sizes from one to three years. The Marquis de Selve estimates the number at 8,000,000 to 10,000,000, which by no means appears overdrawn. Last year already he sold many thousand francs worth; this year he expects to sell over 20,000 francs worth. Since Paris is supplied for the greatest part from Holland and Germany, an interruption may easily occur in the shipping, and a cessation of nearly twenty-four hours brings up the price to double or triple what it was. The marquis, who is close by and can obtain instant information, can take advantage of these accidental pauses, and has therefore constantly a reserve on hand for such favorable opportunities. The marquis, however, cherishes no illusions; as soon as autumn approaches various sacrifices must still be made. To insure the ability to deliver a uniform supply he must still for three or four years stock his canals with crawfish to the amount of 25,000 francs yearly, in order to be properly furnished with spawners. The profit on these purchased crabs is only 12 to 15 centimes (2.2 to 2.7 cents) apiece; when those born in the establishment are grown, the case becomes entirely different. There are sold now about 1,000 crawfish daily.

Besides crawfish are cultivated also trout and other salmonoids. The first planting is nearly three years old. On the 18th of August, 1866, was caught a splendid trout; it was not weighed to avoid injuring it, but from its appearance it must have weighed between 2 and 2½ kilograms at the age of 27 to 28 months; it was sent away living as a present because of its size and beauty. Trout 20 to 24 months old weigh from 500 to 750 grams.

The hatching apparatus is placed in a separate building in connection

* Crabs are almost as necessary a constituent part of a French dinner as meat or fish; if not as a dish proper, then as a means of decoration.

with the smaller canals. Three watchmen with large dogs keep off robbers; besides, many workmen of different kinds are employed. For feeding are used two horses weekly at 25 francs apiece, together with carrots and other vegetables to the amount of 5,000 francs yearly; each adult crawfish consumes one gram of flesh or carrots daily. The marquis has full confidence that the scheme will pay when it comes into full condition and operation.

Mr. Livingston Stone, in Charlestown, North America,* arranges from his own experience the following propositions:

1. Under favorable conditions the increase in weight of a trout in the third year equals a fifth part of the food it consumes.

2. For a trout of this age the daily ration of flesh or fish offal ought to be about a hundredth part of its weight.

3. At this age the weight generally doubles in the space of a year. With care and abundant food one may reach the same result in 6 months. April to September.

4. All kinds of viscera (lungs, liver, &c.) are adapted for food for adult trout. During the first 6 months the cost of the food for the young is next to nothing.

5. Even in summer, fresh trout, packed in ice and sawdust, may be shipped a long distance. Thus treated they endure railroad transportation for a distance of 500 miles (800 kilometers).

The price of trout in the markets in New York varies from 50 cents to $2.25 (1.80 to 4.50 crowns) per pound.

At many establishments in Auvergne in North France,† the following results have been reached. Of salmon, trout, and red char have been hatched out 92 to 98 per cent. of eggs impregnated according to Professor Coste's plan. At the age of 24 to 26 months, trout and red char reach a length of .25 of a meter and a weight of 200 to 300 grams; at the age of three years they reach a length of .30 of a meter and a weight of 500 to 700 grams. Four year olds are .40 of a meter long and weigh from 800 to 1,500 gams. The average loss from different causes is only 5 per cent. yearly although the temperature of the water in many places in summer now and then rises to 24° C. = 19.2 R. (75.2° F.).

In Bayern various fish-cultural establisments have existed for many years. One of these founded in München by a fish dealer, Mr. Küffer, deserves a somewhat detailed description, since it is distinguished as much by the simplicity of its construction and the smallness of the space on which it is built, as by the profitable results which have been reached. It is situated in one of the suburbs of München, and is fed partly by water from the river Iser, partly from a strong spring which comes up on the upper side of the river in the establishment itself. Like all springs

* Rapport sur de le progrès de la pisciculture Americaine par Raveret Wattel, 1873.

† The following information is drawn from Traité de pisciculture par M. G. Bouchon Brandely, secretaire du Collége de France, 1876. (!) The book is the result of a journey made for investigations of the relations with regard to fish-culture in France, Italy, Switzerland, Austria, Bayern, Belgium, Holland, and England, 1874.

its temperature is nearly constant, 46.4° Fahr. The water of the Iser, which is brought in by a little canal, has on the contrary a very variable temperature, and just as variable clearness, as a natural consequence of the extremely changeable climate of Bayern and the river's rising in a high, partly snow-clad mountain region, and its course through easily soluble strata of earth.

The establishment is constructed on a field with little inclination, and occupies a surface of not over 150 square meters (1½ Ar. = 0.15 Maal). Highest, but lower than the spring, are placed a series of stone troughs for the salmonoids of different ages, and for the small fishes which are required for their support, in a series along the wall and covered with a movable screen, to prevent the light from shining down upon them, and at the same time to protect the fish against thieves or beasts of prey. Somewhat lower, different basins are dug out in the bottom for other salmonoids from two to four years old; however, with the exception of one which is intended for the small fry. These water-reservoirs are constructed in the simplest manner possible. The sides are formed of planks driven down into the ground; a gate for entrance and exit keeps the fish confined; and some holes made in the bottom for shelter, constitute the whole of the internal structure, while the arrangement is completed by some boards, which partially cover the basins to produce a little shade and darkness in them. These basins or bowls have a size of 18 to 20 square meters and a depth of 45 to 50 centimeters. The height of the water varies between 30 and 40 centimeters. Immediately above the basin intended for the young is a little larger basin, likewise dug out in the ground, which has been constructed for a variety of salmon peculiar to the waters of Bayern, the Donau salmon.* This basin is so constructed that about half of it is under a little house, and is there covered by a floor, which can be lifted at pleasure, to observe the fishes, catch them, or distribute food to them. In this basin are found only individuals from one to three years old. The above-mentioned basin for the young differs from the rest only in having a supply of water-plants as shelter or cover for the young fish. The bottom in all the rest of the basins is covered with larger and smaller stones, and care is taken to remove all vegetation as soon as it shows itself.

All these troughs and reservoirs are filled from the spring. The troughs receive the spring-water first, and from these it flows down in the lower basins. The basin for the young is fed, however, directly from the spring with perfectly pure water, which has not been used before. The narrowness of the space has made Mr. Küffer attempt fish culture in a manner which comes the closest to stall-feeding. To show this it

* This; the hucho, *Salmo hucho*, is a variety, which like the Venern salmon, *Salmo ogla*, never leaves fresh water; it has white flesh and reaches the enormous size of 50 kilograms and upwards. It has been attempted to transplant it in this country, but without success.

is sufficient to state that in one of the stone troughs 1.50 meters long, 75 centimeters broad, 60 centimeters deep, with a water-supply of .675 cubic meter (= 675 liters) there are six Donau salmon and common salmon together, each of which weighs from 10 to 12 kilograms. One of the Donau salmon measured 1.20 meters. Born in the establishment, it was at the age of a year placed in this little box, and in eight years it reached this enormous size. The length of its comrades varied between 85 and 110 centimeters; they were likewise born in the same establishment. The space was so narrow for them that they for many years had found it impossible to turn or to move from the place. Their long-continued captivity had made them just as tame as other household animals. They were not alarmed when one approached them but evidently expected food from his hand. Every female of this age and size lays annually 16,000 to 18,000 eggs.

This is not the only example of the stall-feeding and packing which Mr. Küffer's establishment furnishes. To the fish-hatching structure he has added an annex in one of the storehouses, where he carries on the fish trade. The fishes which he sells each day for consumption he keeps living in stone troughs, or wooden tanks lined with zinc. The reservoirs are furnished with water from the common water aqueduct of the city, which does not contain the same water as that with which the fish-culture establishment is furnished, but which, however, is perfectly serviceable. In a stone trough of the same measure as that which contains the large salmon there are over 200 trout, weighing from 350 to 450 grams. All these fish were lively, provided with a good appetite, and were apparently in the best condition. One cannot, however, conclude from this that such a packing is to be recommended as a rule.

All the salmonoids in Mr. Küffer's establishment differ in sex and age, so as to prevent them from mutually destroying one another. They are fed with the viscera of the fishes which are sold for consumption in Mr. Küffer's storeroom, and in order that they shall never hunger, the food is supplemented by commoner species of fishes, which he places in the same basin. Mr. Küffer is of the opinion that one must feed to satiety if one wishes to see the fish develop and thrive. He feeds them, therefore, twice in twenty-four hours at least, morning and evening. The fishes which are intended as food for the rest are reared in a separate basin, where they, as it were, get no other food than what they find in the water. Those of the fish which live in the same basin with the fishes whose food they are sooner or later destined to become, live on what these waste.

Mr. Küffer employs for impregnation the French, or Mr. Coste's method. The apparatus for hatching is the same as is used in many other places, but it is entirely covered, so as to completely exclude the light. Sometimes he is obliged to distribute the eggs in the basin intended for the rearing of the young. Under all circumstances he succeeds completely in the hatching. The loss during the whole hatching season is just as

little with the eggs which are placed in this basin as with those which are placed in the apparatus especially constructed for hatching. But he does not employ the basin for this purpose unless his hatching apparatus becomes too small to accommodate the whole quantity of eggs.

The reservoirs which are to contain crawfish are entirely covered like the stone troughs, and get the water directly from a spring and from the river. It is highly amazing to see the enormous quantity which Mr. Küffer has packed together in so small a space. In a division which is not longer than 2½ meters and 1½ meters broad, there were heaped upon one another more than 6,000 crawfish. They were so crowded that they lay in many layers, one above another. They were remarkable for their size and weight; some weighed 250 grams and upwards. The males are always separated from the females, and live in a reservoir by themselves. Notwithstanding the narrow space and the little care bestowed upon them, only a very small number die.

In an establishment at Salzburg, which is almost as small as Mr. Küffer's in München, fishes are fed with minced horse-flesh and the commoner kinds of fishes. They feed 30,000 large and small fishes, which are in the establishment, at a daily expense of 44 cents.

In Amsterdam, where a grand establishment is constructed for fish-hatching, chiefly for stocking the rivers of Holland with salmonoid fishes, in the winter of 1873 and 1874, from 250,000 impregnated eggs, they got 238,000 living young; the loss was under 5 per cent. All of these were liberated in the rivers Yssel and Vecht. With regard to the increase of the abundance of fish in the larger rivers by means of the hatching in this establishment during a few years, it is noticeable that the state owns 38 fisheries, which are leased, the amount of whose rental is quite considerable; thus, for example, share No. 2, which before 1873 had been leased for 10,000 florins yearly, at the auction sale of leases the same year was rented for 35,000 florins. Share No. 12, for which previously was given 8,000 florins, was leased for 47,500 florins, and so on. These figures speak for themselves; upon the whole, the rent is more than triple what it was earlier.

As universally applicable results from the observations made, M. Bouchon Brandely lays down as essential the following rules:

The depth and extent of the reservoirs and basins ought to vary according to the number and age of the fishes which are to live in them. For trout of two to three years, is required a depth of 60 centimeters; for older trout, 1 meter. A greater depth will, of course, do no harm, but that mentioned is sufficient. For the young, broad trenches of little depth are better than reservoirs. The bottom should consist of small stones with water-plants here and there, with the borders planted with bushes, which hang out over the water, partly to give shade, partly to supply nourishment, since quantities of insects and larvæ will frequent them and fall into the water, where they with greediness will be captured by the young. The young of different species of fish, even belonging to

the same genus, ought to be kept separate; likewise should the young of the same species and the same age be separated according to size. The development of different individuals is considerably different in rapidity, and the larger will quickly attack the smaller if they live together. The most important thing to observe in a structure for the culture of salmonoids is to secure a constant supply of clear water, and the colder this is the better.

For the rearing of the young newly-hatched is naturally required a larger place than for their hatching. The larger the place one gives them, and the purer, the colder the water one has for use, the more certain is one that they will thrive well, and that the loss at this most sensitive age will become the least possible.

These are a few of a great multitude of examples of more or less successful fish culture prosecuted on different scales. That there are plenty of examples of less successful or even quite unsuccessful culture is self-evident. Everything depends in this as in all other practical undertakings, on how far one properly appreciates the conditions, and does *all* that is necessary in pursuance of them, in order that the affair shall succeed; if these things are done, the examples mentioned show that the business can and will yield a good profit. It is particularly the hatching of the salmonoid fishes that is unsuccessful, and the reason is easily given. They have partly lacked a sufficient water supply, but especially the comparatively low temperature of the water in summer, which is an irremediable condition for the thriving of the salmon.

With regard to the quantity of food that fish require in comparison with what warm-blooded land animals need, the fish commissioners of New York state the following:

"The food consumed is used by all animals chiefly for the production of motion and heat, because all animals are physical machines, which must be furnished with fuel if motion is to be developed, since they will wear out with friction if this wear and tear is not compensated for by new nourishment. A man or a horse can only perform his full quantum of work when his body gets the full nourishment required, and on the other hand he can not consume the full quantity of nourishment unless he works. The dry-land animals are warm-blooded and movable; many of them, in natural state, find their food only by hunting it; while fishes are cold-blooded, and although they sometimes undertake long journeys, as a rule they keep themselves still in the same place. A trout will remain by the week in the same place in a pool or a hole. A pike will lie still like a sunken stick between the rushes, except when it between times plunges off after its prey, after which it usually returns to the same place; in the possession of all the senses except hearing, in the fullest development, it resumes its condition—that of motionless, sleepless attention.

"The consequence of this is, that while the warm-blooded animals use a considerable quantity of nourishment to produce the high tem-

perature of their blood, and compensate for the wear and tear occasioned by constant motion, the cold-blooded transform nearly all their food to an increase of their own size, and grow, therefore, in proportion thereto, without using more than a small quantity for maintaining the low temperature of their bodies, and to compensate for the small wear and tear occasioned by their little motion. It is therefore a mistake to feed fishes with the flesh of warm-blooded animals, unless it is entirely worthless offal, because it is contrary to natural economy. Cattle can be fed up and fattened only by a liberal use of the natural means of nourishment, whose procuring demands considerable employment of human labor, whereby a comparatively large portion is used without corresponding increase in growth, while fish, left to themselves or fed in a proper manner, will consume what in itself costs nothing, and what could not in any manner be utilized. They should, indirectly or directly, be fed from the water's domain, whose crop practically is left to perish, without at present being useful for men. Neither is the flesh of the inhabitants of the water, when it can be obtained, less valuable for men than that of land animals. Pound for pound, it contains the same quantity of nourishment and will sustain human life just as well, while under certain conditions it is more profitable. It gives the brain and the nerves phosphorus, which is not contained in all kinds of food, but which is just as essential to complete health as gluten or starch, while it at the same time is so much more easily digested than the flesh of land animals and birds that it is used as a modified form of fasting, and at certain times of the year is more wholesome than the last-named kinds of food. A wise economy of the means of nourishment which nature gives will, therefore, as the population increases, compel us to turn our attention to the harvest which the water can yield."

V.

ESTIMATED PROFIT AND THE ECONOMICAL VALUE OF THE WATER-AREA.

I shall next, with the guidance which the foregoing results of experience furnishes, attempt to show what profit one may expect from fish culture in our rivers and lakes, if this business in the future is attended to with the care which is now bestowed upon the prosecution of an industry of corresponding importance, and this everywhere in proportion to the opportunities offered by more or less favorable conditions for the necessary attention to the business.

From the examples cited is seen what also lies in the nature of the business, that this culture can be carried on in very different ways, alike by artificial rearing and complete feeding in apparatus and basins specially constructed therefor through the whole time which intervenes before the fish can reach the development one desires; also, by what one might call perfect stall-feeding, by inconsiderable cleanings out in the

brooks in which natural spawning occurs, and the formation of spawning places, at the time when the spawn is mature; by placing eggs in common boxes in open water, which labors, though somewhat mutually different, must be regarded as of nearly equal importance, and the least to which can be given the name of fish-culture. Between these two extremes there will be a great multitude of variations of more or less extensive cultivation, just as is the case in agriculture, produced partly by local circumstances, partly by the cultivator's greater or less ability, information, and aptness. The different waters will, besides, present just as great variations in natural fertility as the soil. Some localities will be able to be compared with rich wheat-land, while others can be considered as only equal to poor oat-land.

It is worth while also to find out a proper middle course which can be depended upon to yield a probably medium result. As a middle course for the cultivator's greater or less completeness, I will adopt a natural lake of such situation that the hatching in a regular apparatus, and the rearing of the young in separate water-basins through the first summer, will take place, which will not require greater outlay or labor than can be accomplished by any, even the most indigent, owner of fishing waters who interests himself in the business and will attend to it with the necessary care, at the same time that the natural means of nourishment are sought to be increased by the culture of commoner fishes and other aquatic animals which, likewise, any one, even the poorest fish culturist, can perform himself or with the help of his half-grown children.

As a representative of the fishes of medium value, I should select the fish most widely distributed in our country, the common trout, just as one in agriculture employs barley as a common denominator. The red char, in places where it can thrive well and reach its best development, will be the most valuable fish, and represent wheat, just as the pike and the perch will stand in the series with oats; both extremes will be cultivated in nearly corresponding quantities, and mutually balance each other.

The selected representative occurs at all elevations above the sea, even up to the uppermost limits where fish can live, and is there the only kind which occurs. It is a rule, which may be regarded as universal, notwithstanding that, as before remarked, each particular lake may be considered to have its peculiar variety of trout, in the matter of appearance as well as taste, that the higher the lake lies the better flavored are the trout which live therein. Thus it is this very species which should become the object of cultivation above all others; but against this the climate opposes, at these heights, great, in many places insurmountable, difficulties, as it will be impossible for people to establish winter residences at such elevations. It is evident, however, that people are able to live at considerable heights if they find it profitable there, especially after they have learned to use peat as fuel. There are besides

only a few lakes of any extent which are worth considering, that lie higher than the stations where, for a long time, people have had dwellings, and have thrived well. When, therefore, at some time the importance of fish-culture has become recognized, it will certainly come to pass that the necessary men for regular cultivation will remove to all lakes of any importance in elevated districts, so that fish-culture, to the extent previously supposed will be carried on, even up to the most elevated lakes which may be worth cultivating; because, even if hatching cannot take place in the lakes themselves, there is nothing to prevent obtaining satisfactory results by bringing to these lakes the required stock of young from less elevated localities in which the hatching can be done with greater ease. Such transportation will, as a rule, be an easy and simple thing, since it will not be long, and, as a rule, can go on in such a way that one, as often as he wishes, can look out for the most thorough renewal of the quantity of water in the vessel in which the transportation occurs.

The next and most difficult question to answer is, how large a planting of fish may be considered proper under such a mode of cultivation as previously provided? With regard to this I shall next consider some of the previously cited data.

Mr. Seth Green states that two basins with an area, the uppermost of 22.5 and lowermost of 55.8 square meters, and with a capacity of 15.5 and 48 cubic meters, respectively, are sufficient for 5,000 individuals of one to two years old, and 2,000 individuals of two to three years old fish, respectively, with a supply of water through both reservoirs, one after the other, of 37.6 liters per second. Since the trout, as a rule, stay on the bottom, and only rarely distribute themselves at different heights in the water, the spaciousness of the area is more to be considered than its cubic contents. To each fish in these basins is thus allotted, respectively, .0045 and .0111 square meter, and cubic space of, respectively, .005 and .024 cubic meter, with 5 and 24 liters of water. For each fish in the first basin, there is also a surface of, for example, 15 centimeters long, and 5 centimeters broad, while the fish at this age can have a length of about 10 and a breadth of about 2 centimeters, more or less; in the other basin, each fish has a space of, for example, 20 centimeters in length and 5.5 centimeters broad, and it will have a length of 15 centimeters, and a breadth of 3 centimeters or upwards. One perceives, also, that fish can live and thrive in a very small space, if the water supply and the food are sufficient. According to M. Bouchon Brandely's statement, each four-year-old fish has .3 square meter; it is, for instance, 75 centimeters long and 40 wide, and its size will be about 25 centimeters long and 5 broad, while to each fish will be allotted a quantity of .3 cubic meter, which equals 300 liters of water. The water supply he does not mention. The relation concerning the surface and cubic room each fish ought to have is thus, according to the two statements, considerably different; there can be no doubt that the larger it is the better.

But in open water, where the fish must live on what they find in it in the form of insects, mollusks, crustacea, and larger or smaller fishes of other commoner, chiefly vegetable-eating kinds, probably a considerably greater surface room and likewise cubic space should be allotted to each one. Since a natural lake, wherein fish can live in our country in winter, must have a considerably greater depth than the basins indicated, if one estimate according to the bottom alone, there will arise a much larger space for each fish; but this increase cannot be taken into consideration except in so far that the commoner fishes, which live in schools near the surface of the water, will thereby get the necessary space. Since I take it for granted that the young are preserved in the greatest possible degree from enemies in the first year only, as long as this can be done without considerable expense for building special breeding ponds, also that one has not the opportunity of procuring other kinds of reservoirs for young fishes than such as will freeze to the bottom in winter, young fishes must be liberated in the water late in the autumn when the cold commences—they are then only about one-half year old as developed fish. Because of the small size at this age, I think that the deaths in the first year become considerably more numerous than experience has shown them to be under more solicitous care, and that likewise the loss from year to year will become much greater than experience has shown it to be with proper care in ponds. I assume, therefore, that of 1,000 young about one-half year old, which are liberated in the water one autumn, the next autumn only 700 one and a half year old fish will live, and of these the following year 550 two and a half year old fish; moreover, of these the following year there will be 450 three and a half years old, while the next year will be found only 400 grown fish over four years old, which thus in the fifth year become the profit of culture. These grown fish I will on the average estimate at a weight only one kilogram, though, according to experience, the average will reach a considerably greater weight.

Experience has sufficiently shown that among the fishes, as in other classes of animals, individuals differ greatly with regard to the rapidity of growth. But this cannot be taken into consideration; one will naturally catch and sell the fish which have reached the proper size, 1 kilogram and upwards, or whatever other size and weight he may find most profitable, without the slightest regard to what age the individuals may have; it is essential that one can calculate with certainty the chosen size reached by the corresponding ages of the number of fish calculated. If this size is reached earlier or by a greater number of fish, the profit will become so much the greater. The thing is, not to calculate the probable profit too high, also the business more profitable than it is likely to become, and this is perhaps done here as well with regard to the sale from year to year, which probably is placed at too high a figure, as with regard to the increase in size and weight of the fishes surviving, which

is placed likewise at much too little; both parts in all likelihood exceed the probability.

For each fish that one will calculate to capture in the fifth year of 1 kilogram in weight I assume that one ought to find in the water (450 + 550 + 700 + 1,000) divided by 400 = 7 fishes of younger ages, as likely the fishes of the oldest class, which may be too small, will be compensated for by younger individuals of greater weight from year to year.

If one estimates now for each fish, without regard to age, a surface of 1.5 square meters or 1.5 meters long and 1 meter wide, or for each fish of every age a surface five times as great as M. Bouchon Brandely adopts for four years old, it should probably be assumed that no crowding can be expected to take place; because a lake of the size mentioned may generally be considered to have an average depth of at least 5 meters; each fish, small and great, thus obtains 7.5 cubic meters or 7,500 liters (Potter), or twenty-five times as great cubic space as that considered sufficient for adult fish by M. Bouchon Brandely. In a water area of 3 hectares, which equals 30,000 square meters, can also be estimated 20,000 fish of all ages, and of these one-eighth, or 2,500 adult fishes over four years old, of a weight of 1 kilogram and upwards. There is, as remarked, naturally nothing to prevent taking fish of younger age or smaller size. Many will perhaps even prefer fish of half this weight. I hold, however, to the size and age mentioned essentially so as not to estimate the profit too high and attainable in too short a time, at the same time, because at the age indicated the fish may be considered fully mature, as after this age the common trout, which alone I have here in mind, increases more slowly in size and weight, and also becomes less profitable.

According to the calculated decrease, from year to year, to a number of 2,500 fishes of over four years old, will correspond a number of the youngest class of about 6,500 individuals in the first year which must be liberated in the water to compensate for the decrease of the captured adult fishes. But it is not enough only to calculate on the hatching out of this number. The most delicate age from the time the hatching out can be considered completed with the absorption of the egg-sack until autumn, is, according to all experience, the most dangerous time for the young, since the death rate is greatest, and here it is assumed that the ponds or basins procured for the rearing of the young during the first summer are not likely to be of the best kind, and that the attention, at all events, at the beginning, is incomplete; as a result of this, the death rate must be estimated comparatively high. If one place this decrease at about 50 per cent., which will likely be estimating it high enough, and add at the outside about 10 per cent. for loss during the hatching itself, there will be required at the highest 10,500 eggs each year for hatching.

It is probable that this quantity of eggs will yield a larger number of fish than is necessary for obtaining the stated number of adults; but this can likely involve no harm, because if it should be evident that the

abundance of fish will thereby become too great, either with regard to the supply of food or of oxygen, it is an easy matter, by the assistance of natural means or by the capture of a larger number of fish, to remedy the difficulty. It will, probably, under all circumstances, be the best to hatch out a greater quantity of eggs than is actually necessary, if there is opportunity to retain them, and thereby gain experience as to the water's nourishing capacity in both directions, because the larger the planting which can be kept in good condition the greater the profit. To procure 10,500 impregnated eggs, are required female fish of a combined weight of 6 to 7 kilograms, and a corresponding number of male fish, weighing from 2 to 3 kilograms. This quantity of fish, with the appropriate mode of proceeding, will be easy to procure in a not altogether fished-out lake of the size mentioned, or even from far-distant lakes, in which case, however, it must be bought. After the expiration of the second year, at all events, the lake will yield the desired quantity of eggs from the best developed of the young first hatched. For the hatching of this quantity of eggs, is required 3 to 4 square meters of space in a suitable apparatus. Even if one, besides the fish which may be objects of culture, wishes to hatch out some gwiniad, chiefly as food for the trout, and therefore increases the size of the hatching apparatus to 5 square meters of surface, the structure can only become inexpensive if no unnecessary luxury is brought into use in a construction. In case of necessity the hatching may occur in an open field.

Besides this hatching apparatus, as remarked, separate places must be procured for the newly-hatched young. This will, as likewise previously remarked, everywhere be an easy thing, by the construction of canals or small ponds or damming up some little creek, which are arranged so that they may be furnished with water from some brook or spring, or both together. These ought to be prepared the year before they come into use, so that they may be sufficiently stocked with water-insects, and crustacea. This requires only a few days' work and material of small cost.

The hatching of the kinds of fishes which may serve as food for the cultivated fishes proper, and which will thrive in a lake, is not difficult, since it may take place in the lake itself with very simple and inexpensive apparatus, and in a very short time, since their spawning season is short, and the eggs are hatched in a few days. The collecting of the necessary quantity of eggs by the use of likewise very simple and inexpensive arrangements is not at all difficult if the lake only contains such fish. Neither is the transportation from other lakes associated with other difficulties than the transportation of trout eggs; it will be necessary only a couple of times. Even if this may give rise to any outlay, it will be just as well invested as the outlay for seed-corn for fertile soil or the procuring of artificial manure for the land which needs it.

In three hectares of water, should one, from the fifth year, harvest, on the average, 2,500 adult fishes, of 1 kilogram each, or 2,500 kilograms.

The price of the kind of fish which I have chiefly in view here, the trout, was, even thirty or forty years ago, 2.7 cents per mark—which equals one-fourth of a kilogram—in the mountain regions. In the towns it is now considerably higher, especially at certain times of the year, and for fresh fish; I will, however, place it at 2.7 cents for one-fourth kilogram, which equals 11 cents per kilogram, notwithstanding that this article has something near the same nourishment as flesh, and the price of flesh must be placed at at least double. *The value of the mean profit of three hectares of water, about 2,500 kilograms, is thus calculated to be $275 annually, and for each hectare also over $82.50 gross.*

If one estimates that the careful cultivation of the water area mentioned will demand the same outlay for labor, buildings, and implements of all kinds as the cultivation of a corresponding area of land, which ought to be placing it more than high enough; and if one considers, moreover, that the profit of the first year's harvesting of the water's natural culture covers the labor necessary for the hatching, rearing, and care, then will, from the fifth year, the proportion between the yield from fish cultivation and agriculture stand as follows:

In Dr. O. J. Broch's previously-quoted work, "The Kingdom of Norway," which at present may be truly regarded as the most trustworthy statistical work, the area of the cultivated land is given as 2,700 square kilometers, or 270,000 hectares, and the value of the products of the land for the year 1865 at $13,750,000, or not quite $55 per hectare on the average. According to what experienced farmers in the most fertile tracts of our country have stated, this average profit must be considered a little higher than in reality is the average profit from land of all qualities; while, on the other hand, the estimate upon the yield from fish culture places it lower than it, at all events in many places, may be made. The proportion between agriculture and fish culture, also, should be as 2 to 3 in equal areas. But even if it must be admitted that this estimate is too high, and that some reduction ought to be made, so much, however, should be considered established, *that fish culture will yield a profit which fully equals that from agriculture over equal areas.*

As previously stated, nature has allotted to us an area covered with fresh water, more or less adapted to fish culture, of 7,600 square kilometers, which equals 760,000 hectares, which, besides, we have it in our power, with comparatively little expense, to increase considerably, by overflowing with water, districts which are and always will be worthless except in so far as they are put to such use. With the estimated yield per hectare of cultivated water should also—if some time in the perhaps not too distant future fish culture shall be prosecuted with the same perseverance and care which are now vainly bestowed on utterly poor and ungrateful soil, and in the entire extent whereto nature gives the opportunity—the total profit reach as much as $55,000,000 yearly and upwards, if the example chosen can be regarded as a proper representative of the average yield of lakes at different elevations and in

different parts of the country. Of this, however, there may be doubt, though one in the lower districts of the country, and in many places in the southern and western portion, will have it in his power, in a very considerable degree, to increase the yield by the use of other means of food for the fish besides living fish and other water-animals, which at the same time are reared in the waters. It is possible that the yield from the most elevated lakes, where cultivation to a considerable extent will be checked by local and climatic conditions which cannot be overcome, will be so far below the stated average that the greater yield of the lakes more favorably situated will not counterbalance the reduction in the total yield hereby caused. So as not to estimate too high, I will, therefore, only place the *medium yield at half of that previously calculated, or at* $27,500,000 *annually.*

But this is, however, only a portion of the profit which carefully-prosecuted fish culture will give; because the *salmon fishery*, which I here only casually and in passing have considered, can—if the opportunity for the increase of the abundance of this species of fish is unbounded, above what it is now, at all events to an extent whose measure it is impossible to indicate, and when the fishery can be prosecuted everywhere along our wide-stretched coast where fishing apparatus can be placed, when the abundance of fish has reached its greatest possible increase—in a comparatively short time by suitable modes of proceeding gain an importance and yield a profit which, in all probability, will not fall below what the lake fishery alone can yield; and possibly give considerably greater profit than this. If one estimate, therefore, the profit of the salmon fishery, like the previously-reduced value of the profit which the fresh waters probably will be able to produce, when the business at some time in the future receives the attention and the labor which it fully deserves, *the probable profit of the cultivation of fishes of the best kinds, which can be born only in fresh water, will be estimated low if placed at* $55,000,000 *gross yearly.*

This industry may also reach such a development that its gross yield may exceed the value of the whole annual import of the country, which in a good year amounts to the sum mentioned, and considerably surpass the combined profit of agriculture and grazing, which, according to Dr. O. J. Broch's tables in the work quoted, amounted in 1865 to $13,750,000 + $22,000,000 = $35,750,000.

Thus the matter presents itself when regarded in its entirety and under the supposition that the work is carried on with the greatest possible economy in the same manner nearly as the mass of farmers carry on their work.

I shall next attempt to set forth how fish culture appears when it is considered as a means of industrial speculation, as a field for the employment of capital, which seeks security and a good interest. In order that a speculation of this species may give good returns, the business must be carried on to such an extent that the necessary assistants can be

given, as far as possible, continuous employment thereat, since in the opposite event, by only employing the labor at different times of the year, it will become unnecessarily expensive. As such a size I would consider a water area of 30 to 40 hectares, combined in one or separated into many connected smaller lakes, to be tolerably suitable. I shall select the smallest size, in order to make the expenses proportionally larger than they will be when a larger area can be had for cultivation; because the expenses increase just as little in this, as in other industries, in proportion to the size of the business. According to the previously-mentioned data, should, for the stocking of such a lake, according to the same proportion as estimated earlier, be required yearly 10 × 10,500, which equals 105,000 impregnated eggs. In order to make the case as unprofitable as it is ever likely to be, I will assume that the lake is so depleted that one in the first year must buy a part of the eggs in another place, that no profit be had before the fifth year after the beginning of the business; at the same time that the price of the product in distant markets can be placed at only $3\frac{1}{2}$ cents per one-fourth kilogram, which equals 13 cents per kilogram, although the price here now is two or three times that much; wherewith I shall place the necessary expenses so high that no doubt can be entertained of their adequacy.

I will assume that the business is begun in the month of September, since one must be through handling the quantity of eggs which are to be hatched out, while at this time, also, as a rule, the harvesting of the water's crop will be past. Hereby the 1st of September becomes the proper beginning of the year with reference to fish culture. At this time I calculate as expended:

For hatching apparatus, building of spawning-places, and ponds for the young in the coming year	$412 50	
For a dwelling for two laborers' families	825 00	
Boats, implements, materials, &c	192 50	
Three-fourths of the necessary quantity of eggs, three-fourths of 105,000 = 80,000, which easily and once for all can be procured by the purchase of 60 kilograms of living fish in the course of the summer; price and expenses $2.75 per kilogram	165 00	
The outlay at the beginning of the work in round numbers		$1,650 00
In the first year I assume to be expended:		
For two permanent workmen	550 00	
Implements and materials	55 00	
Loss of interest, 5 per cent. of the previous outlay	82 50	
		687 50

For the second year:		
For two permanent workmen	$550.00	
Implements and materials, about	48.12 5	
Loss of interest, 5 per cent. of previous outlay ($2,337.50)	116.87 5	
		$715 00
For the third year:		
For two permanent workmen	550.00	
Implements and materials, about	35.75	
Loss of interest, 5 per cent. of previous outlay, ($3,052.50)	152.62 5	
		738.37 5
For the fourth year:		
For two steady workmen	550.00	
Implements and materials, about	42.62 5	
Loss of interest, 5 per cent. of previous outlay, ($3,790.875)	189.54 3	
		782.16 8
The combined outlay in advance and loss of interest		4,573.04 3

or, in round numbers, $4,675, which is to be considered as the fixed capital invested in the enterprise.

From the fifth year, when the period of preparation may be considered ended, and when the regular harvesting may first be supposed to begin—though, as repeatedly remarked previously, there is nothing to prevent it from beginning earlier, and that possibly with profit—the annual expenses at a very high estimate may be stated at:

Two permanent workmen	$660.00	
Transient labor in summer	330.00	
Implements and materials	165.00	
Stock of ice	137.50	
2½ per cent. for repairs of buildings and apparatus of a value highly estimated at $2,200	55.00	
For packing, transfer, and conveniences for selling, 20 per cent. of the gross profit, $3,437.50	687.50	
Combined annual expenses		$2,035.00
Gross profit on 30 hectares equals 2,500 × 10, which equals 25,000 kilograms × .1375		3,437.50
Estimated net profit		1,402.50,

which amount ($1,402.50), *divided by the sum of* $4,675 *invested as fixed capital, gives a yearly interest of* 30 *per cent.*

But the selling price of the article which is here treated is in the larger markets considerably higher than is here calculated, and in a business of the kind which is here in view one must assume that they will look out to sell in places where a high price can be expected without regard to a somewhat prolonged transportation, which only in a comparatively small degree will increase the expenses of transfer. The article stands, considered as a delicacy, far above meat in price, and it commands in Christiania markets 13.75 to 19.25 cents, and often more, per one-fourth kilogram, which equals 55 to 66 cents per kilogram for Venern salmon, which, as a rule, stand far below our best kinds of mountain trout in flavor and value. In France the price varies, according to circumstances and the season, between 3 and 6 francs, or 55 cents and $1.10 per one-half kilogram, which equals $1.10 to $2.20 per kilogram. Nearly the same price as in France applies in north Germany, and probably also in England. It will thus be a long time before the price, owing to increased production, will approach the amount at which it has been previously estimated, because, in order that this may happen, the prices of the necessaries of life, such as meat, must also fall to half what they now are.

In the very near future also a higher selling price than that estimated certainly will be reached, and it can hardly be doubted that the profit previously calculated upon will be obtained from capital which may be invested in such industry as is here treated of, even if the yield become considerably less than estimated; and this so much the more certainly as the business in the extent contemplated will be able to be carried on in due time with far smaller outlay than here estimated.

If one consider the estimated profit as a product equally of the area of water used and of the capital employed in its utilization, for which there is probably entire reason, since the water area is the basis of the possibility of the employment of capital in the industry here in question, the value of the capital which the water demands will advance in proportion to its extent. In such a division the net profit according to the estimate established should be $701.25 on 30 hectares, or $23.375 per hectare annually. The ratio of interest to principal, according to the lawful interest on landed property and fixed possessions, gives this hectare a capital value of $467.50. But notwithstanding that the previously-given calculation is carried out in such a way that the profit arising therefrom must be regarded as a minimum, I will, however, state that this must be considered above the average amount, because not all the waters will possess a like degree of fertility; neither will they, because of existing circumstances, be able to be cultivated as completely as stated, partly because a portion, even if not a large portion, of our fresh waters are adapted only for the culture of the kinds of fishes which are considered inferior, whose price must be estimated lower than that of trout or red char, although at present here in the chief city and the adjacent provinces it is often more than double as high as the previous stated price for the

kinds of fishes mentioned. In order to be sure not to estimate it too high, I will therefore reduce the average value per hectare to less than half of that calculated, and place it at $2.20.

But even if one, moreover, must consider this as a maximum measure for the waters in their totality, it is, in consequence of what has previously been shown, only a part of the value which must be taken as the average price when the combined fresh waters shall be taken into consideration. The salmon fishery, which is, as can be seen, smaller or larger simply as the rivers are smaller or larger which flow directly out into the sea, must also be brought into consideration. Its yield under thorough and careful management must, as previously set forth, in the future be counted upon to reach a value at least equal to that which the inland fisheries proper will give. The proper average value of our rivers and lakes in their whole extent will thus amount to at least $440 per hectare, and, for 760,000 hectares, to a sum of over $334,400,000 at such time when the people have learned, in some measure, the necessary extent and the necessary mode of using the source of prosperity which Providence has allotted to them in the rivers and seas. In this way we arrive at the conclusion, that—

The economical value of our rivers and lakes may be increased in the future to a total of over $300,000,000 *if the same labor and attention are bestowed on their cultivation as are now devoted to agriculture and grazing.*

The capital value just estimated for a hectare of water shows what outlay can be made with profit in order to put in condition our larger bodies of water for the use of fish-culture alone, by damming up in places where there may be an opportunity to secure a proper supply of running water. The share of the profit calculated per hectare is $33.375 yearly. If one starts from the standpoint, that in the employment of a sum for procuring a water supply, the half portion of the yield at the same rate—$33.375 per hectare—ought to give 5 per cent. interest on the capital invested, and besides 3 per cent. thereof for the repairs of the necessary dams, about $275 can be invested with profit per hectare of the water which thereby may be dammed up. If, for example, by the employment of a capital of $11,000 there can be dammed up a water area of suitable depth of 40 hectares or upwards, there will in this event accrue a yearly profit of $935, which sum gives $550 for the interest of the invested capital and $330 for repairs, and a surplus of $55 for the increase of the interest or the reduction of the outlay. The remainder of the invested capital for the business of fish-culture will besides obtain at least 20 per cent., since the outlay in this case will not need to be greater than for the previously-calculated work upon 30 hectares of water, or $4,675, to which in this event accrues a share of $935. If one combined both investments the whole amount becomes $15,675, on which accrues a profit of $935 plus $550, which equals $1,485, which is an average of about 10 per cent. If one assume that the same area of water can be dammed for a smaller sum, for example $5,500,

which quite frequently ought to be able to be done, the yield will be about 15 per cent. at least of the whole investment. If there is an opportunity to sell the ice which will form on a body of water thus dammed up, the profit will clearly become very large; because if one only reckons about the fourth part of the usually low price, $137.50 per hectare, this gives $5,500 in addition to the income. From this it will be seen that the time may come when comparatively worthless land to a great extent will be transformed into water-reservoirs, to prosecute fish-culture there alone.

It is truly beyond all doubt that the preceding calculations will be considered exaggerated or untrustworthy, though it must be difficult to show that the profit is estimated too high in weight or in price, or that the expenses associated with the business are placed too low in any direction. The bulk of the whole production alone—on the average of a value of $82.50 or 600 kilograms of unsorted salmon and different kinds of fresh-water fish per hectare, for 760,000 hectares equals 456,000,000 kilograms—is so great that its sale for consumption in the interior of the country and for export to foreign countries may appear to be in no small degree improbable. Upon closer reflection, however, this improbability ought to disappear.

There is here in question a means of nourishment which, everywhere in the old and the new world, is placed in the first rank with regard to flavor just as it approaches the first rank in nourishing value in proportion to its weight. With a full supply thereof at a price which is lower than that of most other far less esteemed and valuable means of nourishment, it cannot be doubted that it will be used instead of these, to a very considerable extent, by the whole population of the country of all classes. How great the consumption will become by its increased use alone throughout the country it is difficult to say, but it ought, perhaps, to advance to one-half of a kilogram daily per individual among three-fourths of the population. Without regard to its increase through time, which will be promoted no little by the facilitated access to nourishment which this business will produce, the consumption within the country should amount to one hundred and eighty times one and a quarter millions, which equals 225,000,000 kilograms yearly, or about the half of the entire production.

That there will be found sale in foreign countries at the price calculated of what may not be consumed at home, even if very considerably more than the half may be left for export, there can be no doubt. In the space of two generations Europe has become always more and more out of condition to feed its population with its own products. There have constantly been imported fertilizers and articles of food, especially grain, in large, steadily increasing quantities from other parts of the world without this satisfying the constantly growing demand, whose increase, besides, has just as steadily been counteracted by emigration on a large scale. Besides grain, meat has of late years been imported in differ-

ent forms from the most remote regions of the earth, and most recently in the fresh state and in immense quantities, without thereby causing any trace of a tendency towards a decline of the prices of articles of food, which, moreover, are advancing just as uniformly as they have been for the past decade. Under such circumstances there is probably not the remotest reason for supposing that the articles here treated of, if they, as remarked, are brought to market in a perfectly fresh state and at a lower price than is paid for other articles of food of greatly inferior value, will be unsalable even if the whole estimated quantity is marketed abroad. In north Germany alone, which can produce but few fishes of this kind and quality, there are many millions of people who would prefer them to other food if they could be had at a reasonable price, which for these millions means four to five times what is here estimated.

But this transportation in the fresh state to a distant place, which, of course, is not entirely unknown, but is practiced in a manner which can give but little security for the perfect preservation of the article during many days or weeks, may perhaps be considered both costly and troublesome. In order to remove all uncertainty in this direction, I shall state that carrying of fresh meat from America to England in steamers specially arranged for the purpose costs 30 shillings sterling per ton; that is, $7,425 per 1,000 kilograms, or seven-tenths of a cent per kilogram; an expense which is nothing in comparison with the increase in the calculated price which is to be expected in a foreign market. This is the cost of both transportation and refrigeration, which requires ice bought where it is high and the use of machinery during the whole time of transportation, together with expensive fittings of the rooms wherein the transportation goes on. The price of refrigeration alone can also not be placed higher than half—seven-twentieths of a cent per kilogram—which equals one-fifth of a cent per pound for an average period of about fourteen days. In all places where fish will be reared, the collection of the necessary quantity of ice costs nothing, as it will be done by the persons occupied in the business as a whole, and paid for it by the whole year. Salt is required for freezing, but it is only changed from a solid, dry body to pure liquid brine, and as in this form it can be used for all ordinary purposes just as well as in the solid food this article also thus costs nothing. The preserving-house and apparatus for freezing are very simple things, which can be provided once for all at an expense which must be a very small fraction of what the arrangement of a ship's room for transportation by refrigeration of fresh meat represents.

The expenses of freezing fish and their preservation for a long time in a refrigerator during a transportation of eight to fourteen days in the frozen state cannot thus possibly be more than the previously-mentioned cost of transportation across the Atlantic Ocean; and this expense, stated to be seven-twentieths of a cent per kilogram, is only a small fraction of the previously-estimated outlay for preserving, transportation, and packing, 2¾ cents per kilogram.

The necessary freezing and storing for a long time, and the refrigerating during transportation to places much more distant with the means of conveyance of the future, cannot in any way cause a remarkable increase of price of the product.

There is just as little probability that the increase of the population prevailing in the last decade will in the future become stationary, or in a remarkable degree decline, as there probably is that the prices of the necessaries of life in coming time will decline in any especially considerable degree in the markets of Europe. But even if such a decline should take place, even if it, on the average, and for this article especially, should go down to the half of what may be considered at the present a low estimate, or from 82½ cents to 41¼ cents per kilogram, the product in question must find a sure sale, since, it with an enormous profit against it, as was previously brought into consideration, can be sold far below this price, and thus, as a delicacy of the first class, must become sought in preference to articles of food of inferior account. In order that the product which is here in view may lose its rank and value as a delicacy it must become common every-day fare—that is, be able to be sold at such a price and in such quantities that the great public may have the means and the opportunity to eat it four or five times a week. If one takes into consideration only a small portion of the population of North Europe, say 15,000,000 of people, and assumes that these, on the average, when the article is to be had as cheaply as here estimated, will consume one-half kilogram twice a week, which is by no means improbable if the price becomes as stated—less than half the cost of the commonest kind of meat—for this small fraction of the population of North Europe will be required annually 780,000,000 kilograms at least; that is, ONE-HALF MORE THAN THE WHOLE ESTIMATED PRODUCTION. There is thus certainly no reason to fear that the enterprise will fail from want of sale of the portion of the product which we may be able to offer for sale. The probability is, on the contrary, that many times the quantity will find sale at considerably higher prices than those previously brought to notice, and this so much more surely since there is every reason to suppose that at the same time when an increased fish production may be secured there will be an increase of the population which may be counted on as consumers on nearly the same scale as in recent past time.

With full conviction that the labor bestowed upon the cultivation of the water will pay well, I advise every one who may have the opportunity, to take hold of this cultivation, and that with full energy; because, let it be remembered, half or quarter of the work, according to plans hitherto employed, and universal Norwegian customs, will give just as little profit as importance in this as in other directions. Moreover, I must recommend that this enterprise, with the intervention of legal provisions, be hedged around just as carefully as any other pursuit of similar importance—agriculture, grazing, or cultivation of the woods. So long as the hitherto mentioned license can go on uncensured and un-

checked, the enterprise here treated of will come into practice only to a very small extent, and to inappreciably little use for people in general; BECAUSE ONLY BY PERSONAL OWNERSHIP, INCONTESTABLE AND FULLY PROTECTED BY LAW, OF THE PROFIT WHICH CAN BE EXPECTED WILL AFFORD SUFFICIENT ENCOURAGEMENT TO PUT THE ENTERPRISE IN THE NECESSARY VIGOROUS PRACTICE IN THE EXTENT TO WHICH OPPORTUNITY IS OFFERED. THE BEST AND LARGEST FIELDS FOR FISH CULTURE, WHICH TO A GREATER OR LESS EXTENT ARE OWNED IN PARTNERSHIP, WILL, WITHOUT SUCH PROTECTION OF THE LAW, BECOME JUST AS POOR AS THEY AT PRESENT ARE UTTERLY BARREN, BECAUSE NO ENCOURAGEMENT TO ARTIFICIAL AND ENERGETIC CULTURE WILL THEN EXIST. PRODUCTION WILL THEN, AS HITHERTO, BECOME DEPENDENT ALONE ON NATURAL CULTURE; AND THE EXPERIENCE OF A THOUSAND YEARS HAS CLEARLY SHOWN *that there is no natural production, however strong and rich this may be, which can stand against the greed of men, when this is not checked by the personal consciousness of ownership.*