

XXXVI.—ON THE REASON FOR AN EXTRAORDINARILY RICH PRODUCTION OF OYSTERS IN A NATURAL BASIN.*

By Prof. H. H. RASCH.

After repeated requests from many persons living in the counties of Stavanger, North and South Bergenhus and Romsdal, who, because of the great diminution of the oyster fisheries, had in the space of the last year invested considerable sums to re-establish them by the method employed on the west coast of France, but always with unfortunate result, in the summer of 1878 I undertook a journey along the coasts of the above-mentioned districts. The object of my journey was made known through the newspapers. Shortly after my arrival at Stavanger, H. Gundersen, a custom-house officer in Egersund, told me that he knew a little lake (tarn), rich in oysters, which lies a few feet higher than the open sea close outside of it, which could convey salt water into the lake only during severe southwest storms combined with spring tides; the lake receives through a brook the surplus fresh water from two lakes situated higher. In the lake mentioned, which, because of its wealth of oysters, had from time immemorial received its name, Oyster Lake, is found, according to the informant's statement, the same abundance of oysters fastened on the perpendicular banks descending into the lake and on the bowlders which have fallen down from them. The truthfulness of the informant was established by the large number of living oysters which he brought with him. Most of them had grown together in clusters or clumps a foot long, but they were easily separated from one another. Specimens of such oysters were to be seen among the individuals exhibited by me in Berlin, which ought to call attention to the development of oysters in Oyster Lake.

That I should, as quickly as possible, devote myself to this much-favored lake is a matter of course, and, after I had a boat brought into it, I was able, with the help of a water telescope brought along, to satisfy myself that Gundersen's report was not exaggerated. Because of a continued drought which had prevailed for a long time previous to my arrival, the quantity of water in the two higher lakes had diminished, the brook flowing therefrom was entirely dried up, while at the same time the great evaporation from the surface of Oyster Lake itself had

* Translated from *Nordisk Tidsskrift for Fiskeri*, 1880, pp. 49-58, by Tarleton H. Bean.

caused it to fall about 6 inches lower than its outlet to the sea. The fresh-water layer was therefore evaporated so that the surface water had a salt taste. This condition was favorable in the respect that it had given the young oysters swarming about an opportunity to come up into the uppermost layer of water, where they had found points of contact on the branches of our common dog rose, *Rosa canina* L., which, being cut off, were accidentally thrown into the water. This was for me a hint as to how the gathering of young oysters in this basin ought to be managed.

The lake is surrounded on three sides by steep walls of rock 300 to 400 feet high, and only on the western side facing toward the open sea does the middle portion of the mountain slope on both sides down to the level of the lake. Through the southeastern depression, when the basin is full, fresh water flows out into the sea, while on the contrary during westerly storms sea-water presses in more easily through the north-western depression, the bottom of which, however, lies nearly one-half foot higher than the southeastern.

A couple of fathoms from the shores the lake has nearly everywhere a depth of 6 meters, and slopes therefrom uniformly down towards the middle, where the depth is nearly 12 meters. In summer great masses of floating confervæ are found crowded together both on the surface and in the deeper strata of water. This conferva, the only aquatic plant in the lake, according to the determination of our algologist, N. Willes, is *Cladophora crispata* (Roth) Kuts.

In spring, when it begins to sprout, it is bright green, and develops, by the influence of the sun, a quantity of oxygen in the form of small bladders, which collect in masses in the closely entangled web which results from the extraordinary branching of this species. Through this quantity of air-bladders the cohering mass becomes so much lighter than the water that it frees itself from the bottom and rises toward the surface, where, little by little, it becomes darker—brownish—and at last quite black, whereupon it breaks up into minute fragments which fall to the bottom in the form of the finest dust, and communicate to it a jet black color. What part this black bottom-color plays in the singular thermal conditions of this lake I will attempt to show farther on.

Upon and in these masses of confervæ live two species of gastropods both belonging to the genus *Rissoa* and three or four *Acephalæ* of which especially a dwarf fish form of *Cardium edule* is exceedingly numerous. The shells of these three species are black because of the fine confervæ dust mentioned, but by being transferred to sea-water, which is free from this black powder, they become gradually lighter and finally altogether white. At the same time, however, the black color has so penetrated into the shells that they cannot be made much lighter by rubbing. The young oysters of from one to two inches diameter always have black-striped shells, which can hardly be explained in any other way than that the black particles of confervæ have been taken up with

their food and afterwards secreted in connection with the calcareous matter of which the shells are formed.

Besides the part which the conferva plays with regard to the temperature and oxygenation of the water, it probably furnishes the chief food of the oyster in the enormous masses of spores which it gives off. A similar but less important role as a means of nourishment is taken by the young of *Medusa aurita*, which occurs in the lake in enormous quantities and of all sizes. The young of the species of mollusks mentioned and of the crustacea living in the lake are less important in this respect. A little *Gammarid*, probably a variety of *G. pulex*, and the common shrimp, *Palaemon squilla* L., notably the last named, are exceedingly numerous.

The peculiarities above communicated with regard to the plant and animal life of this remarkable basin I did not of course discover during my first short visit, but the existence of a greater quantity of oysters than I had heretofore seen collected in one place, combined with the discovery of the branches of the dog rose covered with young oysters and the peculiar situation of the lake, were sufficient facts to warrant me, after my return to Stavanger, in advising my acquaintances living there to form a joint stock company, as soon as they could agree with the three owners of the lake as to the terms of the lease, to carry on oyster culture with combined forces, and I promised to support such an association in this matter by word and deed. A sufficient number of share-holders in such a company was quickly found, and they intrusted to the well-known customs-officer H. Guundersen the task of negotiating with the owners of the lake and agreeing with them about the terms of the lease. When this business was settled fourteen experimental collectors were set out by Guundersen on the 31st of July. These experimental collectors consisted partly of willow twigs fastened with nails to a wooden frame of laths, and partly of boards covered with cement. By means of stones fastened with ropes to the lower ends of the collectors these were held under the surface of the water in a vertical position. On the 17th of October, these were examined by some members of the company, among them the young pharmacist Buch, curator of the Stavanger Museum, and school principal A. Olsen, both of whom had been my companions in the examination of Oyster Lake. Mr. Buch communicated to me the result of this preliminary trial, which was certainly surprising because of the rapid growth of the oysters deposited—to particularize, some examples in the course of two months and seventeen days had reached a diameter of 35 millimeters—and because, also, of the unexpected fact that swarms of young had been emitted, since they found a great quantity of attached young so small that they could hardly be seen by the eye alone, and so could not have been more than a couple of days old.

On taking up the collectors Guundersen observed that the stones which were fastened to them to hold them under the water were quite warm to the touch, which was so much the more remarkable because cold

weather had set in. Later in the autumn a thermometer was sent to the superintendent (one of the owners of the lake), who was requested to observe here and there in the course of the winter the temperature of the water at the bottom. The winter cold, which set in early in November, before he had received a thermometer, was unusually severe up to the end of March, so that a layer of ice a foot thick was formed over the lake. In the beginning of April he reported that the temperature at the bottom, in a depth of 28 feet, was 10° R. (54.5° F.), though the water was not yet free from ice. They believed in Stavanger that he had read incorrectly, but repeated examinations gave the same result. When Gundersen visited the lake in May, to place new collectors and examine the old, he found the temperature of the water 14° R. (63.5° F.), at a depth of 33 feet. This seemed incomprehensible to the members of the company, and gave occasion for many guesses as to the cause which could possibly produce the high temperature of the bottom water. The flowing out of warm springs in the bottom of the lake was regarded by some as the most probable, while others attributed it to the heat developed by the putrefaction (fermentation) of the masses of confervæ.

When they asked my opinion as to the explanation of this curious circumstance, I reserved it until, by a longer stay in the place, I had carefully examined the conditions which probably in connection with one another would give a better basis of explanation for the unquestionable fact than those propounded above, both of which seemed to me inadmissible. Last summer and fall I remained twice for a long time at the lake, and after my return to Christiania, I stated at one of the meetings of the scientific society my explanation of the causes of the exceptionally high temperature of this basin, both in summer and winter, a temperature which makes this lake, scarcely two hectares in area, with an average depth of 26 feet, a tropical water oasis in our cold north, and thereby a forcing-house for oysters. I hope that my explanation will be satisfactory to the scientific public since it has been sanctioned by our well-known hydrologist, Professor Mohn.

I suppose the causes to be the following:

1. *Its situation, protected from all cold winds*; because only the milder westerly winds coming from the sea can affect the surface of the lake, and that but slightly. Through the valley, which leads up to the lake from the north, from which originates the brook spoken of, a portion of Oyster Lake, it is true, can be affected by cold northerly wind, but the cooling effect of this wind, taken altogether, is comparatively slight, and when the lake becomes ice-bound and afterwards snow-covered, the cooling off will be reduced to a minimum.

2. *The black color of the bottom* is, according to my opinion, compared with the remaining reasons, the chief cause of the high temperature of the lake water; to this also the dark color of the mountain sides mentioned contributes in no small degree, in that, being illumined by the sun, they radiate a heat, which in the stratum of air saturated with

vapor, which rests over the lower portion of the mountain base, becomes very oppressive and sudorific, under a temperature which during my stay in Skyggen sometimes rose to 27° R. (92.75° F.). At a height of a little over 150 feet above the surface of the lake, this strong and oppressive heat diminished more rapidly than it had done during the ascent, notwithstanding the fact that one had not reached the edge of the depression which is found in the mountain wall which surrounds the lake upon the north and east, and through which the newly constructed road leads down to North Fjord.

3. The cooling off of the surface water produced by the radiation in clear nights counteracts in part the formation of the fog which originates by the shifting of the layer of vapor resting over the mountain base, when this is cooled after sunset. This is, however, the case only in perfectly calm weather; for when a brisk wind blew over the mountain surrounding the lake, I did not observe the formation of any fog. Thus, radiation deprived the water of far less heat than it had received during the day through the influence of the sun's rays.

There is no doubt that the black color of the bottom of the lake is the chief cause of the high temperature of the water; for when the sun's rays through the crystal clear water meet the black bottom, this absorbs the light rays, whereby the heat rays combined with these are set free in the same way as in the air, and every one has felt sensibly enough how strong this can be when he wears black clothing on a clear, sunshiny day. The heat given off from the sun-illuminated bottom diffuses itself in accordance with physical law quickly upward to the overlying water stratum and communicates its temperature to the whole mass of water. When a body of water 26 feet deep and 2 hectares in area is heated up to 20° R. (77° F.) it certainly takes a long time before this will cool to 10° R. (54.5° F.), especially when half the water mass—the lowermost—is at perfect rest, which is the case here; for the current which is caused by the issue of the brook into the lake certainly does not reach very deep, all the more as this water is fresh and lighter than salt water, and consequently remains at the surface.

In the deepest part of the lake—12 meters, or 40 feet—the saltness of the water is greater than in the North Sea at a depth of 4 feet. On the 17th of October, 1878, Candidate Buch examined the saltness of the water in depths from 2 to 27 feet. In the latter the saltness was 3.90 per cent., and in the former 0.20.

In sinking the collectors at different depths they have been convinced that the depositing of the young does not take place below a depth of 18 or 19 feet, and that the size and number of the young diminish in from 14 to 18 or 19 feet. As to the cause of this I will not venture to express an opinion, but the fact is fully established.

The stratum of water in which oysters thrive best is between 3 and 14 or 15 feet, and I have called this stratum the oyster belt of Oyster Lake. In this belt the swarms of young appear to congregate in at least nine

months of the year. The shoaling young retain their swimming power far longer than is stated by the authors who have attempted an explanation of this question. Gundersen and Prof. G. O. Sars have kept them living as long as eleven days, while the authors known to me state the duration of their swimming power to be four days at the most.

That all the conditions for a vigorous oyster growth are present in the above-described basin to an extent hitherto unknown is best shown by the rapid growth of the oysters living therein, their fatness, and the quick development of their reproductive function; to give details, individuals of eleven months old had already emitted broods of young. With reference to the question of the fertility of the oyster I will venture to remark that according to my opinion this is placed too low by many late writers when they estimate the number of young which an adult oyster will emit as only 1,000,000 or even fewer; for I am convinced that Leuwenhœck is correct in putting the number at many millions, yes, so far as I recollect, at 9,000,000.

From an oyster eleven months old taken from one of the collectors, which probably had scarcely begun to emit young, since many of the embryos had not yet broken through the egg-membrane, I preserved by estimate half of the number of young, and I am greatly at fault if this number does not considerably exceed 1,000,000.

The plan of suspending receptacles for the young, made of birch wood, on telegraph wires stretched in many directions across the lake and fastened to iron bolts which are fixed in holes made just at the margin of the water, was carried out this year. Last year only a couple of receptacles were placed; these were rather heavy collectors, consisting partly of old crab-traps and baskets filled with sticks, broken crockery, shells of blue mussels, *Mytilus edulis* L. and *modiolus*, were suspended on heavy, well-tarred ropes. Many of these ropes, however, became so rotten in the tepid fresh water that they parted and the collectors sometimes sunk in water so deep that they could not be found; but the collectors which were hung up and fell down in a less depth of water were found to be thickly covered with vigorous young oysters. The receptacles built by Groom, the merchant, of pieces of boards joined together in the form of book-cases showed themselves to be next best to those made of birch. They were, however, covered with young only on the under side of the pieces. On the same area the birch collectors yielded a much larger result, and the young on them could be easily gathered without injury. The young, which are intended for shipment or to be placed in the fattening grounds leased by the stock company, are taken from the lake down to North Fjord, where they are put into boxes with holes bored in them until they are sent away. In the latter part of July 65,000 young oysters averaging $2\frac{1}{2}$ inches in size, packed in 43 boxes, were transported 10 miles and deposited in a fattening-place $1\frac{1}{2}$ miles from Stavanger. Of this number less than 100 were found dead when de-

posited, and those that were dead had been greatly injured in removing them from the collectors.

When they have placed many hundred receptacles for the young in Oyster Lake they will without doubt be able to harvest an extraordinary number of such young oysters.

From the description here given by me it is to be hoped that people will admit that the discovery of Oyster Lake may become a matter of great importance for oyster culture in Norway; regarding it both as a nursery for this highly esteemed mollusk wherefrom many of the oyster beds which were formerly rich may again be supplied with parent oysters, and as a school for the study of oyster culture.