

XVIII.—HOW CAN THE CULTIVATION OF THE OYSTER, ESPECIALLY ON THE GERMAN COASTS, BE MADE PERMANENTLY PROFITABLE?*

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The first condition of successful oyster cultivation on our coasts is a knowledge of the character of our natural oyster-beds. The majority and the best of them are near the islands of Sylt, Amrum, and Föhr. At the northern boundary of our oyster territory, near the island of Röm, and at its southern boundary, near the islands of Pellworn and Nordstrand, not far from the city of Husum, there are but few and small beds. Farther south, near the mouths of the Eider and the Elbe, there are none.

As the oyster-beds share the character of that portion of the sea in which they are located, it is necessary to cast a glance at the character of the Schleswig-Holstein Archipelago.

Compared with the open German Ocean it is a shallow sea. In the whole southern portion of the open German Ocean between Germany, Holland, and England the average depth varies from 35 to 45 meters. In the Schleswig-Holstein Archipelago no such depth is found. The greatest depth of the channels by which it is connected with the open sea averages 15 to 20 meters. The bottom of the archipelago, therefore, rises like a plateau above the deeper ground of the German Ocean. The plateau is intersected by valleys of varying depth and breadth. When the tide is in, the plateau is entirely covered with water, but when the tide is out, large spaces are dry; and these are called "Watten," from which this whole sea is also called the "Watten Sea."

When the tide goes out, the water flows through these valleys (called "deeps" by the sailors) both in a northerly and a southerly direction into the open German Ocean, until the tide when it comes in, which occurs twice a day from two sides, makes the water flow back. It rises and the valleys can no longer contain the water. It overflows the banks and inundates the "Watten" to such an extent that small vessels can sail over the same place where a few hours ago men could walk and drive wagons. For at high tide the water in the "Watten Sea" stands 6 feet higher in the north and 9 feet higher in the south than when the tide is low. The current of the water is therefore in

* Address made at the meeting of the German Fishery Association at Berlin, March 16, 1876, by Dr. Karl Möbius, of Kiel. [From Circular No. 3 of the Deutsche Fischerei-Verein, Berlin, March 21, 1877.] Translated by Herman Jacobson.

many places as rapid as the Rhine near Bonn, its rapidity being $1\frac{1}{2}$ to 2 meters a second.

The bottom of this turbulent ocean is mainly composed of quartz-sand. Farther away from the strong currents the so-called "*schlick*" is deposited a clayey mud containing organic matter; this is the case at many points of the eastern coast of Sylt and on the coast of the mainland. On the slopes between the "*Watten*" and the deep channels the bottom is for great distances covered with coarse gravel, small and large stones, and shells. In such places we find, besides many other marine animals, colonies of oysters, so-called oyster-beds. As the water is full of little floating particles of clayey mud, these oyster-beds cannot be seen; their location, however, has been known to the fishers for centuries; and they find them by steering their vessels toward high points of the coast and of the islands. The oysters are caught with drag-nets, consisting of an iron frame from which depends a bag composed of iron rings and coarse yarn, with an opening measuring about 1 meter. The whole net weighs about 60 pounds. It is generally drawn along for 5 to 7 minutes; then two or three men draw it up and throw its contents on the deck of the vessel. This consists of old oyster-shells, different animals and plants, and live oysters, which are picked out, freed from all animal or vegetable matter adhering to the shells, and then shipped to the markets.

In no part of the "*Watten Sea*" do the oysters lie on rocky bottom. The best bottom for them is that which is composed of old oyster-shells. It is an erroneous idea that the oysters stick to the bottom of the sea, or that they lie close together or in layers. In good Schleswig-Holstein oyster-beds the net has to be drawn over a space of 1 to 3 meters square and even larger in order to get a single full-sized oyster.

The number of our oyster-beds is 47, and their extent varies very much. The largest extends one-half German mile (about $2\frac{1}{2}$ English miles) in length. Most of them, however, are not so long, and only a few hundred feet broad. Although all the beds are located within a territory 10 German miles long and 3 German miles broad, the quality of the oysters varies very much. If all the 47 beds were put together, they would not cover the hundredth part of that portion of the "*Watten Sea*" which always remains under water. What is the cause of this? Is there a lack of young oysters to occupy all the vacant spaces between the beds? I cannot suppose that this is the case, and my reasons are the following:

The total number of full-grown oysters in our beds may be about 5,000,000. According to investigations made by me in 1869, at least 44 per cent. of all the full-grown oysters produce young ones; and as every full-grown, pregnant oyster produces at least 1,000,000 young ones, the number of young oysters produced during the breeding season, which generally lasts from June till August, would be 2,200,000,000,000, sufficient to make the whole "*Watten Sea*" one continuous oyster-bed;

for if this number of oysters is spread over a space 30 German miles square, there would be 1,332 to every square meter.*

If, in spite of this, the oyster-beds have not extended over the whole "Watten Sea," the reason cannot be that the quality of the water is less favorable to the oyster in some places than in others; for throughout this whole sea it has the same quantity of salt, viz, 3 to 3.2 per cent. The temperature is likewise the same everywhere, for both in the oyster-beds and in other places it varies in the course of the year 20° above to 2° below zero (Celsius). Want of food cannot be the cause why the oyster-beds have for centuries kept within certain limits, for the water of this sea is full of microscopic plants and animals and decaying organic matter, all of which might serve as food for the oysters. The only remaining natural cause which could hinder the oyster-beds from extending and increasing is the unfavorable character of the bottom in the greater portion of the "Watten Sea." *Oysters do not flourish on bottom consisting of quicksand or deposits of clayey mud mixed with organic matter.* And one of the two is found in the greater portion of the bottom of the "Watten Sea." The size and number of those places where, in spite of the tide, the bottom remains firm and free from deposits, is very limited, and only in these limited spaces oyster-beds can be formed. In order to explain this I must say a few words on the structure and development of the oyster.

The mother-oyster does not lay her eggs immediately in the water, but keeps them in the so-called beard (the gills of the oyster) until the little creatures are able to swim. These young oysters, of a bluish color and 0.15 to 0.18^{mm} long; swarm about in the water and finally settle on the bottom.

If this young oyster gets to a place where there are clean stones or shells on which it can grow, there is a prospect of its reaching its full size, but if it gets on quicksands or muddy deposits, it is lost; for, as it has no feet, like some other shell-fish, it cannot work itself out of the sand and clay.

Most of these young oysters doubtless die very soon, because they find no clean places on which to grow. This circumstance has led to the artificial cultivation of the oyster in France, whose author is Professor Coste, of Paris. In the spring of 1858 he distributed in the bay of St. Brioux shells and heavy fagots over a space of 1,000 hectares (1 hectare = 2.4711 acres), and on these spread 3,000,000 mother-oysters. In autumn all the fagots were of course covered with young oysters; for, if these oysters were as fruitful as the Holstein oysters, there were 132,000 young oysters to every square meter. The boldest expectations were exceeded. It was thought that now the means had been found to surround every French coast with oyster-beds, and people already com-

* In a work on "The Oyster and its Cultivation," which I intend to publish very soon, I shall give the data on which these figures are based. I feel convinced that they are not exaggerated, but are rather below the actual figures.

menced to calculate, according to the price which oysters had at that time, how many millions of francs would be yielded by this harvest of the sea. Capitalists went into partnership with fishermen and started artificial oyster-beds; but the rich harvest of marketable oysters failed everywhere, because the greater portion of the young oysters had been destroyed by quicksand or clayey deposit, by want of food, or by enemies.

At present the catching and raising of young oysters is only successfully carried on in a few places on the French coast which are favorable for this cultivation; on a large scale in the bay of Arcachon, south of Bordeaux. In this bay the young oysters produced by mother-oysters on natural beds are caught on fagots, separated from these in October, and then placed in boxes, and finally in artificial ponds. In these they are protected against their enemies by wires or nets. Once or twice every year they are placed in other clean ponds, and care is taken that both during the coldest and the warmest season they are covered by at least 20 centimeters of water.

By this improved method 196,000,000 marketable oysters have, in 1875-'76, been raised in the bay of Arcachon, and the price of oysters fell in consequence. While in 1873 a thousand oysters cost 43 francs, they could be bought for 25 francs in 1876. Compared with the considerable expense of starting and running the oyster establishments, this price is so low that only those oyster-raisers made money who, as I know from good authority, worked with their own hands and were assisted by their families.

Who would not like to see this improved method of raising oysters, in spite of its expense, introduced on our coasts? I will therefore endeavor to answer the question whether the essential conditions of its success are found in the German seas.

The saltness of the water, the food, the currents, and the character of the bottom would make our "*Watten Sea*" as suitable a place for oyster cultivation as the bay of Arcachon; but its tide and temperature are unfavorable. In the bay of Arcachon the usual difference between high and low water is 15 to 16 feet, and, during a storm, only 3 to 4 feet more. On our North Sea coasts the water can rise during a storm twice as much and even more than at the common tide. The force of the water is therefore much greater on our coasts than in the bay of Arcachon. We would, therefore, have to give to our oyster-ponds a much greater power of resistance. But, even if they could resist the strongest floods, they could scarcely protect the oysters against the quicksands and the clayey mud. An experiment made near Norderney, in 1869, has proved this to be true. In the spring of that year a basin 10,000 feet square was constructed on the landward coast of the island; it was inclosed by protecting walls and divided into two smaller basins. In the beginning of June 20,000 full-grown oysters were placed in it, but the young oysters which had been looked for did not make their appearance; starfish and crabs attacked the oysters. In August storm-floods broke

the protecting walls, and the autumnal gales completed the work of destruction, so that soon every trace of the basins had disappeared.

If the open "*Watten Sea*" is not suitable for the construction of oyster-beds, oysters might possibly be cultivated within the dikes which shelter the fertile marshes of the North Sea coasts. For this purpose basins would have to be dug within the dikes and connected with the sea by a canal. Wherever this canal would cut a dike, a sluice would have to be constructed so as to prevent the sea from overflowing during high floods. The oyster-basins could not be constructed near the existing sluices of our marsh-dikes, because these serve to let the fresh water run off from the marshes; the oyster-basins would therefore be filled with fresh water instead of salt water.

Unless oyster-beds could be constructed within a dike, and, without endangering the surrounding country, could be filled with salt water, the oysters would have but a very scanty supply of food, much less at any rate than in the open sea, where, every day, a greater quantity of water containing food runs over every oyster than in a small basin. But the greatest danger for the basin oysters would be frosty weather, because on our coasts the lowest water is during east wind, which, at the same time, brings the greatest cold. At the very time when high water and frequent change of water would be the best means of protecting the oysters from death by freezing, this means could not be employed, and during cold winters many more oysters would die in the basins than in the natural oyster-beds.

Oysters raised artificially would, therefore, with us be a very expensive luxury; and probably they would cost us more than they cost some of the English oyster cultivators. According to an official report by Mr. Blake, inspector of fisheries, every oyster raised artificially near Reculvers, at the mouth of the Thames, cost £50; in Herne Bay, £100; and in some other places, as much as £500!

All investigations which have been made have led to the deplorable result that a profitable cultivation of the oyster according to the French method is impossible on our North Sea coasts. We are, therefore, confined in our activity to the oyster-beds, and we shall have to answer the important question whether it is possible to enlarge the existing oyster-beds and to construct new ones.

Old beds will grow naturally when the movable and clayey bottom near their boundaries becomes firm and pure, which may be occasioned by changes of the direction and force of the currents. In such cases the enlargement of the bed may be accelerated by putting shells on the firm bottom, so as to provide objects to which the young oysters may cling.

In order to construct new oyster-beds we want more extensive portions of the "*Watten Sea*," with a depth of one to four meters, and not liable to change. At my request the men best acquainted with the bottom of the "*Watten Sea*," viz, those men who have to mark the navi-

gable channels with buoys, have last year searched for such firm portions of the bottom on which there are no oysters, but could not find more than eight. There would be a risk to put at once any considerable quantity of mother-oysters in all these places, because as yet it is very doubtful whether they would there find all the conditions for the formation of new beds.

It would be more to the purpose to put, during the month of May, oyster and other shells only in one of these places, and in the beginning of June to distribute a few thousand grown oysters over this prepared bottom. Even if in autumn young oysters were found, the experiment could not yet be considered a perfect success before (besides the mother-oysters) oysters have grown there capable of propagating the species.

I consider it an impossibility to construct oyster-beds in the Baltic. Its water is too cold for oysters, has too little saltness, and is too stagnant, because there is no tide. All attempts in this direction made at the Greifswalder Oie, in the Bay of Kiel, and near the islands of Lolland and Sealand, have proved failures.

Four miles east of Kiel there is a fossil oyster-bed on a hill not far from the shores of the Baltic. Thousands of years ago oysters must, therefore, have lived in the Baltic, when it was connected with the North Sea by broader and deeper channels, and therefore shared its saltness, temperature, and tide. If at the present day oysters could live in the Baltic, they would either not have left it, or they would have immigrated again from the Northern Kattegat, where there are natural oyster-beds. That the oyster will go anywhere where all the conditions for its healthy life are found is proved by their spontaneous immigration into the Limfjord, in the north of Jutland. Till the year 1825 this fiord consisted of a series of brackish lakes, having an outlet into the Kattegat. During the eighteenth century several futile attempts were made to plant oysters in the Limfjord; but after the dike separating the western portion of the Limfjord from the North Sea had been broken by the great flood of February 3, 1825, the water of the fiord grew more salty every year, the animals peculiar to the brackish water disappeared gradually, their place was taken by animals living in the North Sea, and among these oysters were discovered in 1851. Their number increased from year to year; in 1860, 150,000 were caught, and in 1871-'72 more than 7,000,000 were exported to foreign parts. At present one knows ninety-eight places in the Limfjord where oysters live.

We must therefore give up our fine hopes to see all our coasts fringed with oyster-beds and to see oysters as an article of food on every table. Both the nature of our seas and the nature of the oyster drive us to this conclusion. It will be particularly hard to understand this for those who share the wide-spread opinion that every egg laid by a full-grown oyster is destined to become an oyster. Those animals have the smallest number of eggs or young ones which shelter and nurse their offspring till they can find their own food. In many lower grades of ani-

mals, to which the oyster belongs, the propagation of the species is secured not by a long period of nursing, but by producing so large a number of young ones that, in spite of all the destructive influences to which they are exposed, a certain number invariably live to grow to maturity. But this remnant of the full-grown offspring of the mother-oyster is, even in the best and most carefully managed beds, so small that I feel convinced no one would credit my statements if I could not prove their correctness by authenticated figures.

The Schleswig-Holstein oyster-beds were, in the year 1587, seized by King Frederick I of Denmark, as property of the crown. Since the beginning of the eighteenth century they were rented, generally for a long number of years. In order to prevent their being exhausted, the government had these beds officially examined from time to time. In the presence of the government officials, the oyster fishers had generally to throw out their nets in three different places in every bed. All the oysters which they caught were separated into three classes: "*Zahlbar gut*," marketable goods; "*jung gut*," young oysters; and "*junger anwachs*," the youngest and scarcely developed oysters. The first class comprised the full-grown oysters. They are at least 9 centimeters long and broad. Most of them are seven to ten years old, some even older, the oldest being, according to my estimate, twenty to thirty years. The second class comprises the half-grown oysters, measuring less than 9 centimeters, and being three to six years old. The third class comprises the smallest oysters, one to two years old. In the official reports it is mentioned how many of the first two classes were taken at every haul. Those of the third class were not counted, but it is merely mentioned whether the quantity taken was large or small.

Between the years 1730 and 1852 all the oyster-beds were examined ten times. In comparing the number of grown and half-grown oysters taken at each of these inspections, we find figures which differ very much from each other, and do not seem to indicate any leading rule or principle. But if from these figures we calculate the proportion of half-grown to full-grown oysters at every inspection, we find the astonishing result that this proportion scarcely varies at all, and if we take the average of these ten inspections, we find to every 1,000 full-grown oysters not more than 421 half-grown ones. The half-grown oysters make the total of grown young ones produced by the full-grown oysters of a bed. How small does this number, 421, seem if compared with the immense number of young produced by a full-grown oyster! I said before that in our beds at least 44 per cent. of all full-grown oysters lay eggs. Of 1,000 oysters, 440 would, therefore, lay eggs, and as every full-grown oyster lays at least 1,000,000 eggs, we would, of 1,000 full-grown oysters in one bed, get at least 440,000,000 young oysters; but as, on an average, only 421 grow to maturity, we lose, for every Holstein oyster which comes on the table, 1,045,000 young oysters. By sacrificing this immense number of young oysters, nature secures a mature oyster to a few.

In 1870 a small oyster-bed was discovered in the mouth of the Thames, northeast of Whitstable, measuring 60 feet in length and 20 feet in breadth. Forty-eight hours after it had been discovered 75 vessels were on the spot fishing oysters. Most of those which they caught were not fully grown, but there were not more than 9 to 10 young oysters of different ages to every full-grown oyster. This fact goes to show that I was correct in proving that, compared with the immense number of young oysters produced, but few reach maturity.

To 1,000 human beings we count 6.26 births, and of 1,000 human beings born 554 reach the age of twenty or more years. The productiveness of the oyster is, therefore, 7,000,000 times larger than that of man, but the capacity to mature is 579,000 times greater in man than in the oyster.

From the steady proportion between the full-grown and half-grown oyster of one bed, we find that a certain space requires two to three years to replace 1,000 oysters that have been caught. It follows from this that even the most productive beds, if fished every year, must gradually grow less productive and finally be totally exhausted. Unmistakable proofs of this fact are found in the official reports on the oyster fisheries of France and England. Near Falmouth 700 men, with 300 boats, used to carry on very profitable oyster fisheries, as long as the old prohibition laws were in force. Since 1866, when these laws became a dead letter, the beds have decreased in productiveness, so that at present only 40 men, with less than 40 boats, are engaged in the oyster-fishery, each boat catching, on an average, no more than 60 to 100 oysters per day.

On the rich oyster-beds of Cancale, on the coast of Normandy, 62,000,000 oysters were, on an average, caught every year from 1842 to 1849. After the year 1849 the number decreased from year to year. In 1859 it was 16,000,000; in 1861, 9,000,000; in 1863, 2,090,000, and in 1865, only 1,100,000.

The official reports on the inspection of our oyster-beds have furnished the key for the solution of this problem.

If the oysters on the coast of Normandy have the same capacity to mature as the Schleswig-Holstein oysters, from 1841 only 40 per cent. of the 62,000,000 full-grown oysters near Cancale ought to have been annually taken away in order to preserve for the beds the capacity to mature which was necessary to secure maturity to 24,000,000 to 25,000,000 young oysters. This excessive oyster-fishing in France and England is contemporaneous with the age of railroads, and grows almost in the same proportion as the railroads extend.

Before the age of railroads the inhabitants of the sea-coast were the principal oyster-eaters. September 21, 1740, the first 100 fresh oysters were in Hamburg sold for 1.42 marks (present German money) apiece (about 37 cents); on the same day 900 were sold for 1.20 marks the hundred; then 3,400 for 60 pfennige a hundred, and finally 10,800 for 30 pfennige a hundred.

As scarcely any oysters were shipped farther inland, it was necessary that the price should fall rapidly if the oysters were not to spoil. And this rapid fall in the price of oysters preserved the beds from being exhausted.

But as soon as the railroads brought fresh oysters to the inland cities the number of oyster-eaters increased, and thus the demand for oysters likewise increased from year to year in spite of the rapid rise in the price. I think that this has caused a more reckless fishing of oysters since 1852; and this conviction is strengthened by the fact that at the inspection of 1869 there were only 282 half-grown oysters to 1,000 full-grown ones, instead of 421, as in former years, and during the five inspections held, 1872 to 1876, this number had decreased to an average of 107.

Many Englishmen who are theoretically and practically well versed in everything which concerns the oyster think that the rapid decrease of the number of oysters is not caused by too reckless fishing, but try to explain the fact by a series of years unfavorable to the breeding of the oyster. According to their statements no considerable number of oysters has been bred since 1857-'59. This may be true with regard to some oyster-beds, but it has no influence on the general oyster-trade on the western coasts of Europe, as this is not dependent on particularly favorable summers, but on the average climate. And, according to observations made by the Paris Observatory, since 1806 this average climate has remained the same during this century, which has witnessed the total depletion of some West European oyster-beds.

If the average profit from a bed of oysters is to remain permanently the same, a sufficient number of mother-oysters must be left on it, so as not to diminish the capacity of maturing. For if all the destructive causes continue in the same degree, the capacity of maturing must decrease in the same proportion as the number of oysters capable of propagating is diminished.

If an oyster-bed is to retain its usual capacity of maturing, even when its productiveness is diminished, the causes which destroy young oysters must be diminished. This can be done:

1. By increasing the number of places to which young oysters can cling.

2. By diminishing the number of enemies of the oyster.

This can only be done under such favorable natural conditions as in Arcachon and some other places on the French coast, at least on such a scale as to make the profitable cultivation of the oyster possible. As we cannot cultivate it on our coasts, it is our duty to regulate the fishing in our natural oyster-beds in such a manner as to make them produce permanently the highest possible average quantity of oysters. As the annual increase of half-grown oysters is 421 to every 1,000 full-grown oysters, not more than 42 per cent. of these latter ought to be taken from a bed during a year.

It is best only to take the older of the full-grown oysters, in order that the fully matured ones may get as large and as fat as possible, and produce the greatest possible number of young ones before they are brought into the market.

Every oyster-bed where fishing is going on ought to be examined at least every two to three years to ascertain the following points: 1, the numerical proportion between full-grown and half-grown oysters; 2, the density of the oysters; 3, the nature of the bottom, the fauna and flora of the bed; 4, whether the area covered by oysters has been diminished or enlarged, or remained the same.

If movable bottom in the neighborhood of a bed becomes firm, it should be covered with oyster-shells or other objects to which the young oysters may cling.

If a bed has become filled with sand or clayey mud, it ought to be cleaned with oyster-nets or harrows.

Wherever circumstances permit, the enemies of the oyster ought to be kept away from the beds as much as possible.

As not all beds produce oysters of the same fine quality, experiments ought to be made to show whether young, half-grown oysters of an inferior quality will improve in flavor if transplanted to other beds having better oysters. This ought, however, not to be done systematically if the productiveness of the beds seems to suffer by it. The sea-water which daily flows over the bed contains only a certain limited amount of nutritious matter, and there is a possibility of this being exhausted. If the number of oysters produced by a bed is doubled by introducing oysters from other beds, only half the quantity of food comes to each oyster, and its growth is retarded.

It is fortunate that the Schleswig-Holstein oyster-beds are the property of the state. If everybody could fish there, they would soon be exhausted. If they are to remain a permanent source of profit to the whole population of the state and of special profit to the inhabitants of the coast, the quantity of oysters to be taken annually ought not to be determined by the price of the oysters, but solely by the annual increase. Oyster-beds ought to be worked on exactly the same principles as the state forests, with a view to the welfare of the present and future population of the whole state.