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9.—ON A NEW FORM OF FILTER OR DIAPHRAGM TO BE USED IN THE CULTURE OF OYSTERS IN PONDS.

By JOHN A. RYDER.

The unexpected success which crowned, in a measure, the attempt made by the writer, in association with Mr. H. H. Pierce and Mr. G. V. Shepard, at Stockton, Worcester County, Maryland, during the past summer, to rear the spat of the American oyster from artificially fertilized eggs in an inclosed pond connected with the open water by a trench only, into which a permeable diaphragm was fitted to give ingress and egress to the ebbing and flowing tides from without, in order to change the water in the pond, has given us experiences which will enable us to greatly improve the diaphragms to be used in the connecting trenches, and also render it possible to clean or renew the filter of sand whenever desirable or necessary; also to *increase or diminish at will the thickness of the stratum of sand used as the filter and as a barrier to prevent the escape of the embryo oysters swimming about in the pond.* Such a diaphragm the writer proposes to describe and figure in this communication, believing that for simplicity and effectiveness the apparatus in its present form cannot fail to be in a large measure the means of obtaining spat at will and also the means of preventing the escape of the swimming embryos of oysters cultivated in ponds or coves with narrow outlets.

The fertility of the oyster, as shown by the investigations of scientific men, is truly astounding; some conception of this fact may be gained when it is stated that a single female oyster, according to its size, may produce all the way from one to one hundred millions of eggs in a single season. How to save, in a measure, this vast yield of germs from wholesale destruction, has engaged the practical attention, for several years past, of such men as Professors Brooks, Rice, Lieutenant Winslow, U. S. N., and Col. M. McDonald. In Europe, with the Portuguese oyster, the greatest success in artificial culture has been attained by Bouchon-Brandely, of Paris. The viviparous *Ostrea edulis* of Europe has also been thoroughly studied by Messrs. Hoek, Hubrecht, and Horst, of Holland, with prospects of ultimate success in its artificial propagation. Science has therefore been more thoroughly awakened to the importance of studying the life-history of these three, probably the most valuable of all edible mollusks, during the last half decade than ever before, and it is not too much to say, that more real knowledge of economical value has been gained, respecting especially the American oyster, during this brief renascence than had been acquired during the previous half century. All investigators are agreed that only a small fraction of one per cent. of the total number of eggs produced by oysters under natural conditions, ever, even when those are favorable, attain a size large enough so make it an object to carry them to market. While Professor Huxley may be right in the opinion expressed in his recent address before the Royal Institution, 11th May last, that it would be difficult to prove that overdredging is accountable for the wholesale destruction of oyster beds, I cannot but believe that it has been, to some if not to a great extent, responsible for the diminished productiveness of the beds of our native species in its natural home, the Chesapeake Bay and its tributaries. If the oyster embryos survived in a uniform proportion to the number of adults existing during any and every season, then dredging and overfishing would necessarily have their effects, but we have the best of reasons for believing that the proportion of young to old oysters during different seasons is variable, so that in some years there is a much greater yield of spat than in others. Professor Huxley, while he is bound to admit that the oyster beds of Europe are less productive than formerly, however believes, after all, that there is hope for oyster consumers, and that artificial propagation may yet be successfully carried on. Here is what he said: "I for my part believe that the only hope for the oyster consumer lies first in oyster culture, and secondly in discovering a means of breeding oysters under such conditions that the spat shall be safely deposited. And I have no doubt that when those who undertake the business are provided with a proper knowledge of the conditions under which they have to work both these objects will be attained." These remarks were apparently intended to apply to the European oyster, but they apply in reality with equal force to our own species.

My own studies and experiments during four years past have borne upon the question of the artificial propagation of the oyster, and while I am aware that shell-planting is practiced on the shores of Connecticut and Long Island with gratifying and even with very profitable results, another phase of the industry remains undeveloped in the United States, namely, pond, park, or *claire* culture as practiced in Europe. It is upon the development of this branch of oyster culture in this country that I largely build my hopes regarding the future utilization of the many thousand of acres of swamp-lands or flats adjacent to waters where the oyster is already native, while I also believe that the seed or spat can be reared in these ponds in quantity sufficient to supply the needs of culture, provided diaphragms such as, or similar to, what I am about to describe are used to prevent the escape of the naturally produced embryos from the culture ponds. I look forward to the possibility of depending entirely upon the embryos produced by the natural spawning of the adults confined in the ponds and not altogether to the process of artificial fertilization, in the practice of which both the male and female parents are sacrificed. *The* question is, how can we retain the embryos in the ponds which are produced there, and what can we do to afford the embryos, developed and swimming about in such confined waters, surfaces to which they may attach themselves and become converted into fixed spat which can afterwards be transferred to other ponds or to open waters?

Our experiments at Stockton, this year, have gone far towards giving us a solution of some of these questions. They have shown that, first, it is possible to excavate ponds in salt marshes where oysters will also grow; secondly, artificially fertilized spawn may be placed in such places and live; thirdly, such spawn may fall as spat in such inclosures if surfaces for its attachment are provided; fourthly, it will grow just as rapidly as the spat which has grown under natural conditions in the open water; fifthly, the natural microscopical food is continually generated within the inclosure and consists mainly of very minute animal and vegetable organisms; sixthly, the water may be partially changed within the inclosure twice a day by the rise and fall of the tide provided a permeable diaphragm or filter composed mainly of fine sand is placed in the sluice way joining the pond to the open water of the bay or sea.

It is imperatively necessary that the water used be of the right density. If it is too saline or contains too little saline matter the oysters die. A specific gravity varying from 1.007 to 1.020 or 1.022 seem to represent about the range of density of the waters in which the American oyster will thrive. In the Chesapeake Bay the water over the great oyster beds ranges mostly from 1.012 to 1.016. In the Chincoteague the density may be as great as 1.022. At Wood's Holl, Massachusetts, I have found oysters growing in water having a density of 1.0146, 1.0172, and 1.018. The last mentioned was about the density of the water in the pond at Stockton in which we obtained spat under conditions of confinement.

DESCRIPTION OF AN IMPROVED FORM OF DIAPHRAGM FOR OYSTER PONDS.

My improved permeable diaphragm is placed horizontally within an oblong trunk or box, A, Fig. 1, of the accompanying plate. The box is made of inch planks, to which strong horizontal side pieces, *a*, Figs. 2 and 3, are secured, and to which are fastened the transverse cross-bars *b b*, of Figs. 1, 2, 3, and 4, upon which the permeable diaphragm rests. Fig. 1 represents the trunk A secured within a pair of quadrangular frames, F F, and partially in sectional elevation in place in the trench or canal leading from the pond to the open water. Fig. 2 represents the construction of the end of the trunk next the open water, and Fig. 3 that of the end next the pond, while Fig. 4 shows the trunk as viewed from above.

On the cross-bars *b b*, a single screen of galvanized wire cloth, W, Fig. 1 (galvanized after it is woven), is superimposed, having meshes say one-half inch in diameter; upon the wire screen a layer of gunny cloth, C, Fig.

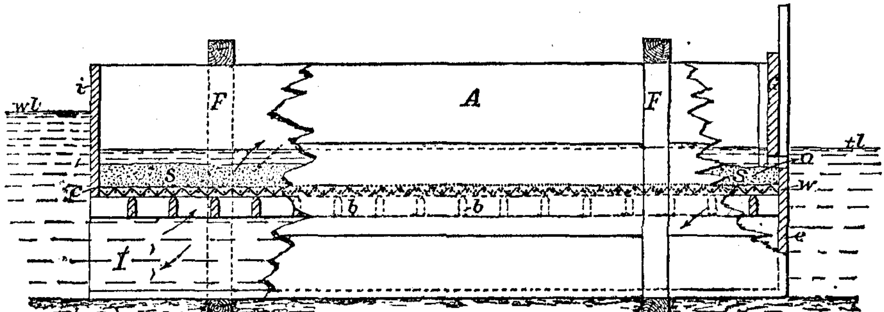

Fig. 1.

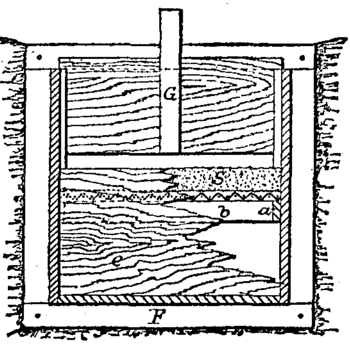

Fig. 2.

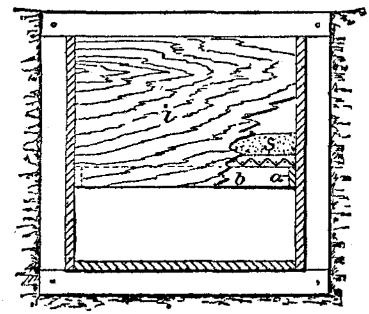

Fig. 3.

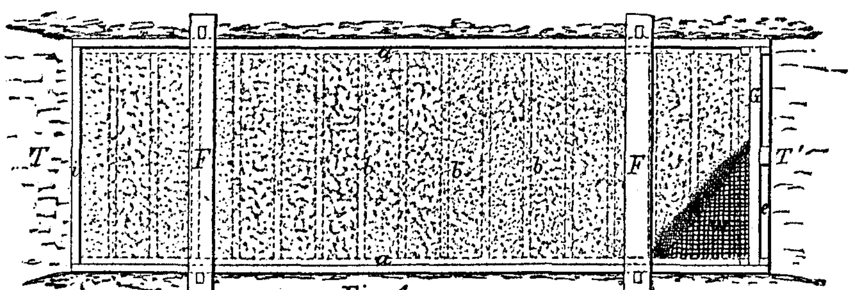

Fig. 4.

Fig 5.

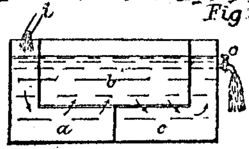

Fig. 6.

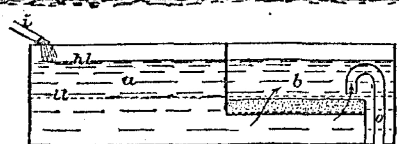

Fig. 7.

IMPROVED PERMEABLE DIAPHRAGM FOR OYSTER PONDS.

1 and 4, is laid, upon which a layer of fine, clean sand, S, is spread evenly from one end of the trunk to the other. The end board *e*, extending half way up at the outer end of the box, runs up past the level of the wire and cloth to confine the sand at that extremity, as shown in Fig. 2, while the sand is confined by the board *i* at the other end of the trunk next the pond, as shown in Fig. 3. The wire cloth and bars *b b* constitute the support for the sand as it lies upon the gunny cloth, which is supported in turn by the wire cloth or screen W. This is essentially the construction of the filtering apparatus in which the layer of sand, S, is at all times accessible, so that it can be removed if it becomes clogged with ooze carried in by successive tides under the gate G, Figs. 1, 2, and 4. This layer of sand can also be increased or diminished in thickness so as to strain the inflowing and outflowing water more or less effectually, as may be desired, or in order to more or less effectually prevent the escape of any eggs or embryos of oysters which may be developing within the pond and wafted to and fro by the ebbing and flowing currents which are carried in and out of the pond through the diaphragm by tidal action. The gunny cloth C, Fig. 4, may possibly be replaced by, first, a layer of coarse gravel, then a layer of finer gravel superimposed upon that, which would prevent the fine sand from sifting through the supporting wire screen W. Gravel would be more durable than gunny cloth or sacking, which, like all other textile fabrics, will rot if immersed in salt water for a few weeks. In practice, however, a mode of getting over all such difficulties would soon be devised; a coarse sacking to be used for the purpose might be saturated with a drying oil or with tar diluted with oil of turpentine, which when dry would act as a preservative of the material, but not cause it to become impervious.

In the old style of diaphragm used in the experiment at Stockton, it was difficult to renew or clean the sand, inasmuch as the apparatus consisted essentially of a box open at the top, and as wide and as high as the trench connecting the pond with the open water. Its depth was three feet, its width two feet, and its total thickness about four inches. The sides forming its greatest depth and width were perforated with numerous auger holes. On the inside, this narrow, deep box, of the above dimensions, was lined with gunny sacking and the intervening space filled with fine sand. This diaphragm was placed vertically in the trench, and it will be readily understood that the filtering surface was limited by the depth of the water in the ditch, while its free action was also to some extent impeded by the small amount of ingress and egress offered to the ebbing and flowing tide, in passing in and out of the pond through the auger holes, in the sides of the box, on either side of the vertical stratum of sand. It will also be readily understood that it would be impossible to remove the sand from the box to repair or renew the filter without destroying its effectiveness for the time being.

The diaphragm, of which I am about to describe the working, obviates all of these objections, while it is possible to augment the extent of the filtering surface to any desired extent, by simply widening and lengthening the horizontal stratum of sand which does duty as the filter of the sea water and acts as a barrier to prevent the escape of the embryos. A description of the working of the apparatus will make it much better understood.

When the trunk A is put in place (which should be done before the water is let into a freshly excavated pond, and also before the water is let into the trench from the sea-end), it should be securely placed in position and the earth tightly rammed in along the sides so as to prevent any sea water from finding its way into the pond, except such as passes through the filtering diaphragm. It is also unnecessary to insist that the trunk be constructed in such a way that it will be practically water tight, and not liable to leak between the planks or at the corners. The wire-cloth, sacking or gravel, and sand having been got into place, and when complete forming a stratum having a total thickness of five or six inches, the operator is ready to cut away the barrier at the sea-end of the trench to let in the water.

If then the trunk A has been let down into the trench deep enough, the sea level at low tide ought to be somewhat above the upper edge of the board *e*. The water will then, as the tide rises, flow back over the sand as far as the board *i*, and will percolate through the diaphragm into the space I, under the latter, and so find its way into the pond. After a day or so the pond will be filled with sea water, which has practically been filtered, and filtered more or less effectually in proportion to the thickness of the stratum of sand constituting the diaphragm. After the pond has once been filled, with the rise and fall of the tide in the open water, the level of the latter and that in the pond will be constantly changing; in other words, when the tide is ebbing the water level in the pond will be higher than that of the water outside, as in fact represented at *wl* and *tl* in Fig. 1. Under these circumstances there will be a supply of water flowing out, through the under division I of the trunk A, up through the sand and out over its surface, through the outlet O under the gate G. After the ebb tide is over and flood tide begins these levels will be reversed and *wl* in the pond will be lower than *tl* in the open water, and under those circumstances there will be an inflow of sea water into the pond through the diaphragm instead of an outflow, as in the condition of the water levels during ebb tide. Under such conditions there will be four alternating periods during every twenty-four hours of inflow and outflow, lasting we will say four hours each, not reckoning the nearly stationary intervals between tides or during slack water. This almost constant partial renewal of the water will unquestionably maintain the water inclosed in the pond or ponds, by means of diaphragms, in a condition fitted to support oysters colonized therein, provided its density is not too great or too slight, and if there is also some microscopic vegetation present.

It will be readily understood from the preceding description how it is intended that the apparatus is to be operated. The figures also give a very good idea of how the diaphragm and trunk are to be constructed; the first four figures being drawn to a common scale of one inch to three feet.

THE POND.

In Fig. 5 I have represented a pond in vertical section to which a diaphragm D, of the form above described, has been adapted and fitted into the connecting trench T leading to the open water B. This pond P, it is supposed, has been dug out of a salt-marsh of the type so common adjacent to waters well adapted to the cultivation of oysters along the shores of the shallow bays and sounds of the Eastern United States. The French are in the habit in some places of walling up or facing the sides of the rearing ponds with cement or tough clay, or even building the sides of stone. That breeding ponds should in some way have their sides made firmer when dug out of a mere salt-marsh, would hardly be doubted by any one, because such an arrangement is an important safeguard against the bad effects of rains and frost in causing the sides of the pond to crumble and wash down into the bottom as mud and sediment, thus tending to cover and smother the oysters at the bottom. It cannot be questioned either that in case the pond is excavated on salt-marsh lands, which are often merely large accumulations of sedimentary deposits consisting of ooze or mud which has been piled up along the shore by the waves during ages, the bottom should be covered with at least a coating of loam or clay, to, in a measure, intercept the poisonous marsh gases coming up from below. To render such an artificial bottom firmer, old oyster shells scattered thickly over the bottom would render the loam or clayey sand firmer and less liable to give way under the soft and yielding bottom, which is really in a viscous, yielding condition at a depth of a few feet, so much so that when a horse or other heavy animal walks over the surface the thick turf usually vibrates up and down perceptibly on the soft stratum below. In such situations it is therefore plain that a preparation of the bottom of the pond excavated would be necessary. In other situations, such as, for example, in the vicinity of Point Lookout at the mouth of the Potomac River, where there is a firm clay bottom near the surface, oyster ponds might be excavated and a bottom found which would need no preparation, and at a level which would require no more digging to get below tide-level than in the salt-marshes adjacent to Chincoteague Bay.

The deposition of sediment which is held in suspension by the ebbing and flowing tides on the bottom of ponds has been very troublesome to the French in the conduct of pond-culture, and it will be one of the difficulties to be overcome in this country, as a very cursory glance at a few facts will readily show. Here, as well as there, ooze is very rapidly deposited on the bottom of oyster coves or confined natural areas, which in this country represent rudely, in some cases, the "claires" in which oysters are grown in Europe. I now call to mind the extensive deposits of ooze on the bottom of a cove at Saint Jerome's Creek, where deposition over a limited area has been going on for many years until in some places the ooze is 9 feet deep and utterly unfit as a bottom upon which to plant oysters, because they would inevitably sink into the mud and be smothered. In the moat around Fortress Monroe, which is in communication with the Chesapeake Bay, there is also a very considerable sedimentary deposit, few oysters being able to exist on the bottom, but large numbers are attached as "natural growths" to the clean surfaces of the walls on either side of the moat, to which the spat has at one time and another affixed itself in such numbers, and there grown so rapidly as to nearly cover the vertical and inclined surfaces of the massive boundary walls. Ooze or sedimentary deposits of more than a very few inches in thickness are therefore hurtful to growing adult oysters, while a very thin film of a similar kind is fatal to the young oyster in its extreme infancy or embryonic state immediately after fixation. Getting rid of or preventing such deposits is therefore of the very greatest importance in the work of practical oyster culture.

Many oystermen are ready to affirm that some mud is a necessity in the work of oyster culture; they in fact make bold to say that the animal needs a certain proportion of mud to feed upon. The origin of this mistaken doctrine is probably to be sought in the fact that a few of the more intelligent culturists have possibly noticed that the nearly black fæcal matters of the animal consist almost wholly of a material which, without critical examination, would be taken for mud molded into the form of the internal cavity of the intestine. A little investigation will serve to convince the most skeptical, however, of the utter absurdity and irrationality of the hypothesis that oysters feed upon mud. In the first place mud is not in any sense food, either vegetable or animal, and whatever of ooze or sediment is found in the alimentary tract of the oyster, or any other mollusk, was carried there accidentally together with what was truly food in the form of minute animal or vegetable organisms, upon which it is also known that the oyster exclusively feeds. It is well known to naturalists, moreover, that when one wishes to find such minute living organisms for study with the microscope, they are not to be found buried in the mud, where they would as inevitably be smothered and killed as the oyster itself, and from the same causes, namely, interruption of respiration on account of the absence of oxygen, and the exhalation from the ooze of poisonous, asphyxiating gases. Here is what a very eminent authority has said about the habits of certain minute organisms living in water: "The favorite habitation of many kinds of Rhizopods is the light superficial ooze at the bottom of still waters, where they live in association with Diatoms, Desmids, and other minute Algæ, which form the chief food of most of these little creatures. They never penetrate into the deeper and usually black mud, which, indeed, is almost universally devoid of life of any kind."* This remark, which was meant to apply to small organisms found in fresh water, applies with equal force to those found in brackish or sea water, because the fresh-water and marine faunæ and floræ of microscopic forms really blend together or overlap. It is therefore evident that ooze or mud on the bottoms of oyster-beds or ponds in excess is invariably to be regarded as injurious both to the oysters themselves and to the minute organisms upon which they feed.

To prevent in a measure the accumulation of sediment on the bottom of oyster ponds and coves the introduction of sand filters will be found effective in proportion to the practical skill and knowledge brought to bear in their construction and management. I do not mean to affirm that the form of diaphragm here described will be found to be the most suitable means of attaining our object after prolonged experience has been had in the work. It may be found in using a single diaphragm, through which the water may flow in either direction alternately, that when the flow is reversed a certain amount of sediment will be washed out of the sand filter, and that when this occurs during the inflow into the pond a certain quantity of sediment would be carried in and deposited. If this should be found to be the case it would be an easy matter to arrange two separate diaphragms in a trunk divided by a longitudinal vertical partition alongside of each other. One of these might be arranged, as shown in Fig. 1, to filter only the inflowing water and the one alongside of it to filter the outflow. They could be made to operate automatically if wooden valves were provided at the inlet and outlet of either, so arranged as to close and open when the pressure of the tide was least or greatest as the latter rose and fell, but such complications in the construction of filters or diaphragms would only make them more difficult to operate and less suited to be left to the management of the ordinary laborer. If it is possible, therefore, to keep out the sediment with the simple form here described, it would be much better to stick to that without additional complications. The confinement of the brood or fry either thrown off from old oysters living in the pond or of such as has been artificially introduced into the inclosure, as was done at Stockton, would be well enough accomplished, in all probability, by a simple diaphragm such as that here described.

The freedom of the flow through the diaphragm will depend mainly upon the area of the latter and the fineness of the sand composing the filtering stratum. And it would therefore be possible to construct a filter of a capacity great enough to filter enormous volumes of water, or enough for the very largest operations, by simply increasing the area of the filtering surface. The obstruction or clogging of the filter by deposits of fine and coarse materials on the top of the stratum of sand might be obviated to a large extent by the use of wire screens placed

* Fresh-water Rhizopods of North America. By Joseph Leidy, M. D. Rep. U. S. Geol. Surv. Terr., vol. xii, 1879, pp. 8 and 9.

in the trench beyond the diaphragm to intercept such coarser materials, along with which a good deal of pretty fine sediment would be caught and prevented from clogging the diaphragm. If one diaphragm failed to accomplish the desired result, two placed in the same trench in succession could not fail to answer, and it would then doubtless be possible to completely arrest all sedimentary materials as well as effectually prevent the escape of any brood in the outflow which it was desirable to confine in the inclosure.

Such in the main are the conditions to be fulfilled in the construction of artificial oyster ponds. In Fig. 5 the conditions are essentially those obtaining at Stockton. The shell collectors consisted of perforated oyster shells strung upon wire and hung upon the stakes *s s s s s*, as shown in the figure. Shells were also strewn upon the bottom, but in practice these ponds ought also to be available for the culture of adult oysters both for market and breeding purposes, and if the pond is prepared with the proper bottom, supplied with water of the right density and temperature and with the proper amount of oxygen in solution, there is no reason why success should not reward the experimenters. In Europe the claires are often constructed so as to have their bottoms at about low-tide level, so that they may be drained and cleaned. This would hardly be practicable along the eastern seaboard of the United States because the rise and fall of the tide is, as a rule, not great enough. But this need not be any obstacle in the way of success, for in the Report of the United States Fish Commissioner for 1880 there is a translation of a Norwegian notice, by Prof. H. H. Rasch, of a natural basin near Stavanger, Norway, in which oysters are indigenous. This lake, strange to say, "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:" it has a percentage of saline matter ranging from 0.02 to 3.90 per cent.—the former at a depth of 2 feet, the latter at 27 feet. The oysters thrive best in it at a depth ranging from 3 to 15 feet; in this so-called oyster belt swarms of young oysters appear to congregate during at least nine months of the year. In 1879, 65,000 young oysters of the European species were taken from the lake, scarcely five acres in area, a quantity which would be equivalent to about 430 bushels of the American species. These young ones were transplanted to fattening grounds.

This lake is protected by cliffs around three sides 300 to 400 feet high, which defend it from the cold winds of this inhospitable northern region. Algæ grow in the lake, and, with its relatively uniform high temperature in its protected situation, affords probably amongst the very best conditions for the growth of oysters.

We know very well that it is quite out of the question to attempt to control the character of very large bodies of water so as to adapt them to the purposes of the oyster culturist, but if nature has in a few instances, as in the example just cited, brought together the very best conditions on a small scale, there is no reason why man should not imitate them successfully, and in such a way as to make it exceedingly profitable. While it is not possible in one year to settle upon all the conditions necessary for success in the work of artificial oyster culture, I believe that the business will in time be successfully pursued and will engage the attention of an industrial and producing seaboard population in the eastern United States which for numbers will surpass anything of the kind the world has yet seen. In order to imitate nature where she has been unusually successful in producing results profitable or advantageous to man, we must go to work to study her methods by scientific means, and when we have discovered her combinations of conditions favorable to her ends we shall have discovered those which may be approximately imitated by man and applied by him to his own purposes of gain.

The successes of Brooks, McDonald, M. Brandely, and myself during the past four years with the unisexual species of oysters has proved that we are nearing a solution of the question of their artificial culture—in fact that we are translating the language of Nature into terms intelligible to man, and rendering her methods to some extent available industrially. The first steps in this work are necessarily to some extent empirical, but the results so far achieved have shown how utterly impossible it would have been for the merely practical and avowedly unscientific man to have gained possession of all the information now in our hands.

The writer took up the subject in 1880, and then supposed that a box constructed as shown in Fig. 6, in section, would answer to confine and rear oyster spawn. The permeable bottom of the compartment *b* rested upon a partition along its middle, which divided the space at the ends and below *b* into the spaces *a* and *c*. The water was let into *a*, from which it would filter up through the half of the bottom of *b* and down and out again through the other half into *c* and off by the faucet *o*. While this arrangement it was found would retain the fertilized eggs in the compartment *b*, the filter on the bottom, made of filtering paper, backed on either side by strong canvas, was found would soon clog and stop the passage of the water. Then it was attempted to force water through an apparatus of the same kind; this too was a failure. A large flannel pen was then tried; this too failed. In 1881 a tidal box was constructed similar in principle to what is shown in longitudinal plan and section in Fig. 7. In this the spawn was confined in the chamber *a*, into which the water was allowed to run slowly through the pipe *i*. The filter was horizontal and formed the bottom of most of the compartment *b*, into which the water would rise until it reached the level *h l* in both boxes, when it would be run off rapidly through the wide siphon *o* till it reached the level *l l*, when it would again fill to the level *h l*, to be again partially emptied. This was also a failure as well as the Wolff's-bottles apparatus devised in 1882 by Colonel McDonald. We got the young oysters so far along as to have them adhere to the sides of the vessels and to old oyster shells, but beyond that point our results were not satisfactory. Somewhat similar results were obtained during the same year by Messrs. Brooks and Winslow. That same season M. Brandely conceived the idea of using sand as a barrier for the embryos of *Ostrea angulata*, the Portuguese oyster, and succeeded in confining them in a pond fed partly by salt water by the tide and partially by water from another pond used as a reservoir, and from which the water passed through a sponge filter to the breeding pond. The Stockton experiment was even simpler than that of M. Brandely, which has already been described in the translation of his paper, addressed to the minister of marine of the French Government, having been published in Volume II of this Bulletin. It will also be seen that his method does not differ essentially from the method used in 1881 by the writer, on a small scale, at Cherrystone, and shown in sectional plan in Fig. 7.

In 1882 the writer also tested the method of blowing air upon the surface of the water contained in the hatching receptacles, which, like the cotton-wool diaphragms used during the same season for the purpose of retaining the fertilized eggs of the American oyster, was also a failure as far as valuable practical results were concerned. Various devices were also used for the same purpose by Dr. Brooks, Lieut. Francis Winslow, and Henry J. Rice, and I believe all of these three last named experimenters, like ourselves, had reared the young oysters to the condition of fixation, so that it is not absolutely true that M. Brandely was the first to successfully rear oysters to the condition of fixation; but he seems to have been the first to obtain spat from artificially fertilized eggs.

These historical details are introduced to show that the results so far obtained are not the fruits of the efforts of any one person, but that a number have been actively engaged in the work, and that probably had it not been for the success of the American investigators, who attacked the problem of the development of our native oyster in 1879, the Europeans, who now again took up the subject after twenty years of inactivity, would not have been stimulated to undertake the investigations which led to such successful results, at the hands of the secretary of the College of France.

The essentials for the artificial culture of oysters, we very well know, have not yet all been determined, though some of the conditions required have been successfully supplied. What seems now to be required seems to be further experiment to determine finally and quite satisfactorily the following points:

1. Can sediment be effectually prevented from finding access to oyster ponds, and how can the embryos naturally or artificially bred there be confined in such inclosures?

2. What are the best means of preparing the sides and bottoms of

the ponds and the communicating trenches, so as to make them durable and easily cared for where there is a muddy or clayey bottom?

3. What simple and effective devices will best serve the purpose of diaphragms or filters to be placed in the sluiceways of oyster ponds as filters?

4. To what extent will it be profitable to prepare an extensive system of connected breeding-ponds or claires in which to rear the American oyster for market?

5. What is the most economical and successful mode of using collectors for the purpose of rearing spat for seed or for stocking barren or uncultivated waters?

6. How thickly can oysters be planted upon a given area, say per square yard, rod, or acre; and is it best to spread the planted oysters evenly or irregularly over the bottom?

7. Do embryo oysters stick to the under surfaces of collectors because they are freer from mud or sediment? (This is the experience of observers both in Europe and America.)

8. What is the length of the spawning period of the American oyster, and in what month does spat first appear, and when does it cease to fall or set in the autumn?

9. What is the minimum of time in which an oyster is matured, counting from the time it was spawned until it is of marketable size?

10. Do oysters vary very greatly in the rapidity of their growth in different localities?

11. What is the cause of the variation in the quality or flavor of oysters from different localities?

12. What forms of microscopical organisms are the most frequently met with in the stomachs of oysters, and therefore the most valuable food of the animal?

13. What is the average density of the water in which oysters will always thrive best?

14. What temperatures are most favorable to their growth?

15. What temperatures are most hurtful, and under what circumstances?

16. What means of oxygenating the water in oyster ponds are the most satisfactory?

17. What parasites and enemies of the oyster are most hurtful, and in what way?

Some of these queries we have, in different publications issued during the past two years, sought to answer approximately, but it will be seen that many of them would require an elaborate series of investigations to be carried out before it would be possible to give entirely satisfactory replies. It is much easier to ask questions than to answer them, but there is no easier way to find out how little we really know than to ask a series of questions such as the above. It will doubtless require many years of observation before most of them will have received completely satisfactory replies; but it none the less behooves the practical men who are interested in the oyster industry to experiment and observe till they are in a measure answered, because until then we shall have made no very solid progress in the pond-culture of the oyster.

Whether policing and districting the Chesapeake will be of as much use as intelligent efforts at culture even in a very primitive way, I gravely doubt. The average oysterman is very conservative; the great majority could not even be induced to sow shells, often being quite ignorant that such a means was ever resorted to for the purpose of giving the beds a chance to spread and cover more territory; the thought of the possibility of the fixation of some of the millions of embryos which are emitted from the oysters on the old beds, and wafted hither and thither by the tides, never seems to enter their minds. They plant oysters, it is true, but this means simply, among the Southern oystermen at least, that poor or undersized oysters are brought from some other place and laid down for a season or two to grow, when they are again taken up, sorted, and marketed; those which have not grown large enough, together with such spat as in some cases may have been produced on the beds, are thrown back and replanted, and not usually in a very thorough or systematic way. There is to-day very little effort being put forth by the planters, so-called, of Maryland and Virginia to really cultivate the oyster. The old system of simply shipping the poorly grown or two-yearlings from some other old bed to a new one, is what is called planting and cultivation. The time has come when these "planters" will have to awaken from their indifference to this subject, and take hold of the industry in an intelligent and scientific manner.

It may be urged that pond culture will be expensive, and involve large outlays for digging and preparing the ponds, but it should also be borne in mind that ponds once prepared can, with slight annual repairs, be kept in condition for the business for many years, besides which the work is condensed and becomes more accessible and easily managed. The oysters are planted thickly, about 100 per square yard, in the claires or ponds of Europe. At this rate one acre of cultivated oyster bottom, worked on the pond or basin system, ought to accommodate 480,000 single oysters, or 3,200 bushels, reckoning 150 oysters to the bushel. This is a yield which ought to satisfy the most extravagant expectations. Though this is not actually the produce per acre, which is found over the limited areas known as natural beds or "oyster rocks," where an average of 270 single oysters will sometimes be found to the single square yard, giving a total of 1,296,000 single oysters to the acre, aggregating the almost fabulous yield of 8,740 bushels, a result which must of course be regarded as the growth of at least three years, as I have known "oyster rocks" to be formed within that time, through the agency of man, where piles of old oyster shells had been thrown overboard, and left heaped up on the bottom, to which a large set of spat had caught and grown so as to produce the above result.

The average depth of the pond should, of course, be at least 3 feet, and and probably a depth of 4 feet would be better in practice, as this would pretty effectually prevent frost from reaching the oysters on the bottom in winter, while the water would not be heated in summer as much as in shallower ponds. The culturists abroad are said to occasionally suffer losses from the water becoming too warm in their "claires" or ponds, many of which get no water except once in every fourteen days or during spring tides. From this cause also it is evident that considerable loss must be experienced from evaporation, while of course the warmth and quiescence of the water would tend to cause the microscopical vegetable organisms in the water to multiply rapidly and give off oxygen to the water, and in turn consume the carbonic acid gas given off by the oysters during respiration. In this connection I must not forget to mention the fact that I have known the water along some parts of the shores of the Chesapeake to rise to a temperature of 101° F. to 105° F., after exposure to the sun during the middle of the day, where the bottom was composed of dark or black mud, which would of course absorb the heat from the burning rays of the sun and again radiate it into the overlying stratum of water at night.

WASHINGTON, D. C., *November* 24, 1883.

10.—NOTES ON THE ACCLIMATIZATION OF FISH IN VICTORIA, AUSTRALIA.

By W. P. WHITCOMBE.

[From a letter to Prof. S. F. Baird.]

We have had a small fish acclimatization society here for some years. We have stocked our waters with English trout (*S. Fario*), with English perch, tench, and carp. Kindred societies on the seaboard have tried (with what success remains to be proved) to introduce some of the migratory *Salmonidæ*. We have not attempted this as our streams are not suitable. Indeed, I may say we are very badly off for permanent streams in this district, most of them becoming a mere chain of water-holes during the summer without any flow through them, and should the fall happen to be dry it is not uncommon for the streams not to run until the winter is well passed. Such dry seasons are not unfrequent. We have in this neighborhood some small lakes which we should like to stock with as good fish as we can. In some of them there are already English perch and trout, and in one a fish known here as the "Murray Cod" (*Oligorus Macquarientis* Gunther). This fish is a native of the Murray or Macquarrykion, is non-migratory, and is a good table fish, but not good as a sporting fish. The lake into which it has been introduced is fed by small streams which run only during wet weather, and as it lowers through evaporation in summer becomes