XXVIII.—A PRACTICAL GUIDE TO OYSTER CULTURE, AND THE METHODS OF REARING AND MULTIPLYING EDIBLE MARINE ANIMALS.

By FÉLIX FRAICHE,*
Professor of the Natural Sciences and Mathematics.

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INTRODUCTION.—PRESENT CONDITION OF THE OYSTER INDUSTRY UPON THE COAST OF FRANCE.

The oyster industry, which was formerly carried to a high degree of perfection by the Romans, as shown by the results obtained at Lake Lucrin by Sergius Orata, who, according to the testimony of his contemporaries, would not have found any difficulty in causing oysters to thrive upon the roofs of buildings, and by the industry yet in full activity at Lake Fusaro, has always been left in France entirely to the forces of nature. As a result of this our numerous oyster banks, furnishing sufficient supplies for all demands when the imperfect means of communication hindered the shipment of this mollusk from point to point, have not been able to resist the abusive fishing to which they have been subjected since our railroads have afforded facilities whereby the oyster can be carried to all parts of the country, and thus to millions of new con-

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sumers. In 1858 M. Coste addressed to the Emperor a report upon the condition of the oyster fisheries of the coast, and exposed in these terms the deplorable impoverishment of "the oyster industry, which has fallen into such decline that unless prompt measures are taken, the source of all production will very soon be entirely exhausted. At Rochelle, Marennes, Rochefort, and the islands of Ré and Oléron, of twenty-three banks, which formerly constituted one of the sources of wealth of this part of the coast, eighteen are completely depopulated; while those which yet furnish oysters are seriously affected by the increasing invasion of mussels. Moreover, the oyster breeders of these regions are no longer able to find there, not to mention those necessary for consumption, a sufficient harvest to supply their 'parks' and 'claires' with oysters, which are there fattened and brought to perfection, and are obliged to bring them, at great expense, from the coast of Brittany. The bay of St. Brieux, which is so admirably and naturally adapted to the production of the oyster, and where there formerly existed, upon a hard and permanent bottom, thirteen beds in full activity, has to-day not more than three beds, from which twenty boats might in a few days carry away the last oyster. At the time when the gulf was in its prosperous condition, more than two hundred vessels, manned by fourteen hundred men, were engaged in fishing each year from the 1st of October to the 1st of April, and took from these waters a harvest valued at three to four hundred thousand francs ($60,000 to $80,000). In the harbor of Brest, and at the mouths of the rivers in Brittany, the decrease has been less rapid, because these fertile sea-territories have not as yet been subjected to so active a fishing; but as the decimation of other parts of our coast forces us to resort to these beds for what can no longer be found elsewhere, they will soon share in the general ruin. At Cancale and Granville, two classical quarters for the growth of the oyster, it is only by dint of care and good administration that they succeed, not in increasing the crop, but in moderating its decline." Such, then, was the deplorable condition of the oyster industry upon the coast of France in 1858, when M. Coste wrote his report,—a condition much more threatening for the future, in that it coincided exactly with the completion of our net-work of railroads, which permitted the products of the ocean to be carried in a few hours throughout the entire territory of France, even to the departments most remote from the sea, thus tending unquestionably to increase the consumption by placing a large number of our people in a position to profit by the delicacies which were formerly forbidden them, on account of their distance from the centers of production. A continued rise in the price of oysters, coincident with a decrease in their delicacy and fatness, were the immediate results of this state of things. But still another very grave and menacing result was the continued diminution of our maritime population, the sole source whence, in our days, are recruited the sailors for our fleets; for, where fifty boats, each with from five to eight men, formerly found profitable labor in gather-

ing oysters, it is now barely possible for ten boats to provide support for fifteen to twenty families, who have, moreover, no other means of support than gathering this mollusk. Hence we find a very general abandonment of maritime careers, the impoverishment and degradation of our coast population, and, finally, the imminent weakening of our marine. At this time M. Coste discovered a remedy for the evil he had announced, and through the munificence of the Emperor obtained the means of experimenting, upon a grand scale, with the object of restocking the oyster banks of the coast, and of applying to this great and useful end the principles which had been revealed to him in his long and arduous scientific labors.

The harbor of St. Brieux was chosen as the site of the first experiment; and during the months of March and April, 1858, the general planting took place with oysters brought from the sea at Cancale and Tréguier. Two imperial guard-boats, the Ariel and the Antilope, were employed to assist in this work. The oysters were placed in six long beds, situated in various portions of the bay, and these beds were then carefully buoyed out so that they could be easily found and examined when necessary or desirable. Besides the oysters, the bottom was paved with oyster shells and the shells of Cardium and various other mollusks, with the object of offering support and shelter to the young oysters; then bundles of twigs, from two to three meters (6 to 10 feet) in length, were anchored with stone and maintained at a short distance from the bottom; thus completing a series of collecting apparatus sufficient to secure and hold all the young which might appear. Six months later, the experiment had already promised complete success; for the shells

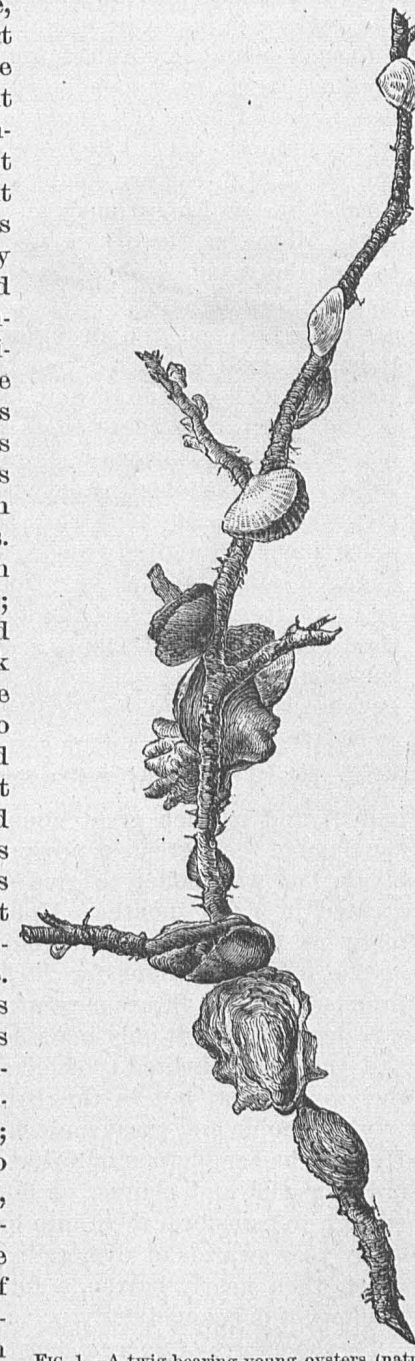

FIG. 1.—A twig bearing young oysters (natural size).

and fascines planted for the reception of the young were found, upon examination, to be literally covered with young oysters (Figs. 1

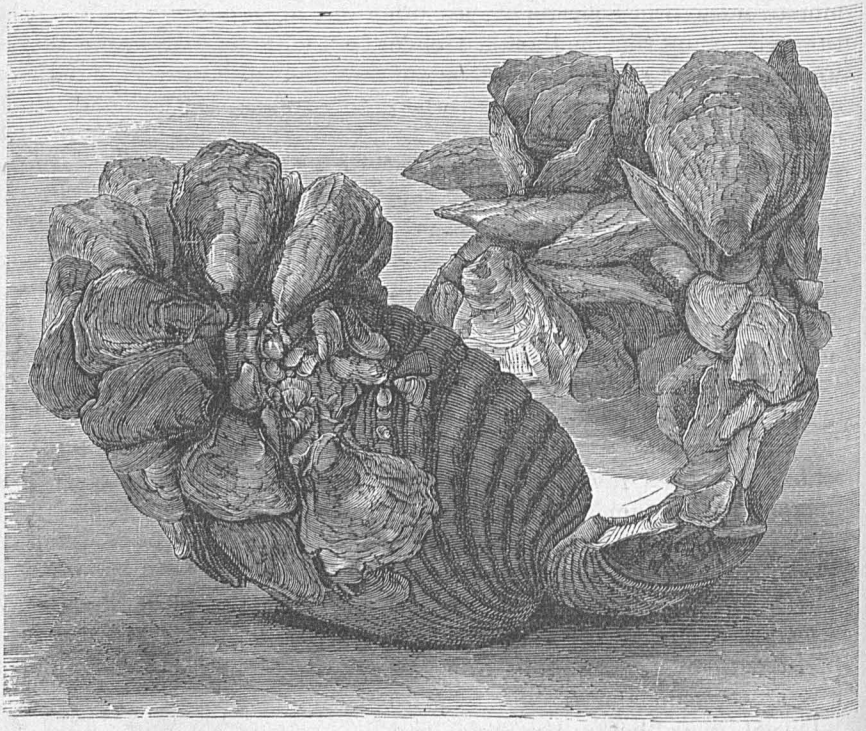

FIG. 2.—Shell of cardium covered with young oysters (natural size).

and 2), and in such great abundance that Cancale and Granville, in the days of their greatest prosperity, never saw such a spectacle. One single fact will suffice to give some idea of the immense wealth thus created in a few months. Upon one single bundle of the twigs as many as twenty thousand young were counted; and as oysters sell at the fishing stations for 20 francs ($4) per thousand, this bundle promised for the future a return of 400 francs ($80). The experiment was decisive, and it only remained to have these teachings propagated and the people incited to similar efforts, not only at other points along the ocean coast, but in the British Channel and the Mediterranean. It was a noble and great undertaking, in which M. Coste had *not* failed. He soon had numerous imitators. In the Bay of Arcachon the possessors of parks and claires, or fattening and feeding places, were wise enough to transform them into breeding places, veritable hives, whence every year swarms of oysters issued forth into the sea, assuring to this coast, then nearly barren, a future revenue of from twelve to fifteen millions of delicious bivalves.

By the efforts of government two model establishments were founded upon this bay, and one hundred and twelve persons, associated with the

marine, came to carry on the new industry, which occupied an extent of 400 hectares (about 960 acres) of emergent lands, made over by the administration. In 1863, during six tides and upon only one-half of the restocked lands, the oystermen took sixteen millions of oysters—that is to say, more than the public fisheries of Cancale and Granville have ever produced. Not long ago I had occasion to visit an artificial park, which had been instituted only three years before, at a total cost of $2,400, and which sold at the time of my visit for $8,000.

On the island of Ré three thousand people migrated from the interior to occupy the emergent sea-territory, ceded to them in individual lots by the government. The condition of these lands necessitated arduous and long-continued labors on the part of the men, since these portions of the island were simply vast wastes, where to-day more than two hundred parks can be seen in full activity, occupying the entire coast from the point of Rivedoux to that of Loix, a distance of twelve miles, and covering an area of nearly 205 hectares (about 492 acres). In these parks, or prepared oyster-beds, there are to-day, on an average, six hundred oysters to the square meter, or a total of two billion oysters, representing a value, when of marketable size, of about 40,000,000 francs ($8,000,000). Before this new industry had transformed the arid and desolate character of these portions of the coast, the 18,000 inhabitants of the island of Ré had no other source of revenue except from the growth of barley and the culture of the vine, whence there were few returns, the production being slight and of poor quality, and by fishing, which produced about 50 francs ($10) per month for each boat employed.

This state of affairs, instead of growing better, grew worse until the year 1858, when Hyacinthe Bœuf, of Rivedoux, upon the island, undertook for the first time the artificial breeding or cultivation of oysters upon eighteen hundred meters of emergent lands granted him by the state. Bœuf was a mason, and commenced his labor by inclosing his property with a wall of rocks. He then covered the soil with straw and branches to consolidate the mud and render the place suitable for the reception of the oysters which he proposed bringing from Brittany, since the coast of the island was entirely destitute of them. What, then, was his astonishment when he saw the stones of his wall become covered spontaneously with a young growth of oysters, which appeared in the water surrounding the island and probably came from the parks along the coast of Nieulle; they were so numerous that they averaged about two thousand young oysters per square meter. He at once demolished his wall, stone by stone, and placing the oysters upon the bed of the park, he succeeded, by favoring their development by intelligent care, in creating on the island an industry destined to bring wealth and prosperity. His example was soon followed by others, and numerous parks were laid out, so that in 1860 oysters were sold to the value of 3,150 francs ($630), and in 1863, 53,000 francs ($10,600), without counting the thousands of oysters deposited in the fattening-ponds, the

value of which could not have been less than from 25,000 to 30,000 francs ($5,000 to $6,000). I cannot omit to mention in this connection, without injustice, the name of Dr. Kemmerer, of St. Martin, whose labor and example have been of great value in the progress of oyster culture on the island of Ré. The work of transformation thus begun in the Bay of Arcachon and upon the coast of the island of Ré gradually extended to the entire ocean coast and even into the Mediterranean, multiplying to an almost unlimited extent the edible treasures, of which the ocean contains inexhaustible germs, creating upon these desolate and barren territories wealth and abundance, and attracting there a hardy and numerous maritime population, from which to draw recruits for our marine. Such, then, are the grand results already due to the learning and devotion of M. Coste, and to the powerful and efficient aid which he has received from the Emperor, who has not hesitated to place at the disposal of this great worker the lands and material resources required for the undertaking.

The domain of the sea is public property, and it becomes the duty and the right of the state alone to extend prompt aid to the increasing impoverishment and sterility of one of the branches of public industry and wealth, and it is evident from what has already been done, that the state has not failed in this duty. But although this is the chief cause of the renewed activity in the oyster industry, is it to be considered or does it follow that this industry can prosper only over great tracts of waste territory, like the bays of St. Brieux and Arcachon, with the help of powerful auxiliaries, such as the government vessels with their many intelligent men and officers? Does it follow, in a word, that there is nothing to be done, so far as personal endeavor is concerned, by the dwellers in coast territories? We think just the contrary; we believe there is much to be done, and that the cultivation of marine species is an inexhaustible mine, in the fruitful working of which each one can find his place according to his strength and means, and with that belief in view we have written this book, designing it especially for the proprietors of marine lands and salt marshes, and for the possessors of parks and claires, the products of which can be easily increased a hundred-fold. While the labors of restocking, executed under the authority of the state, the reconstruction of old breeding or fattening ponds and the creation of new banks where none previously existed, are undeniably great results; as is also the re-establishment of the national maritime wealth by the reconstruction of the fishing grounds; yet it is important in another respect that it forms a grand example which each individual possessor of emergent or tide lands, of salt lakes, or simply of lands bordering the coast, can follow with profit, in creating artificial oyster stations, or fattening ponds, where oysters, mussels, crustaceans, or even marine fish can be confined, and where, as a result, there will gather an uninterrupted, fruitful, and

abundant harvest, even upon ground primitively condemned to eternal sterility on account of mud or stones. It is with the object of instructing proprietors of fishing privileges, or dwellers upon the sea-shore, concerning a source of immense wealth, the labor of which concerns them alone, and in order to facilitate the methods of attaining the best results, that I have endeavored to present in this book a summary of those principles, now sanctioned by experience, which ought to guide them in this new culture. The question of oyster culture will then be treated here from a restricted point of view, as a private industry, such as a small farmer, who is desirous of increasing his revenue from his marsh or fattening pond, can readily undertake. In accordance with the plan which I followed in a former work, upon the culture of fresh-water fishes, I have preceded the account of the special processes of oyster culture with some remarks upon the functions, habits, and structure of various species of mollusks and crustaceans, the cultivation of which can be undertaken with profit, and with a study of the causes of the depletion of our coast waters. For it is only when acting with a full knowledge of the cause, that is to say, in reasoning in regard to his labors, and choosing his processes according to the nature of that which he grows, and the circumstances and conditions of growth, that one can hope to prosper in a work of this kind. Many of the earlier attempts in this direction miscarried simply from not having followed rational methods. But their authors had one excuse, the nearly universal ignorance in regard to the habits and needs of the species upon which they experimented, and they had to guide them only the numerous and accredited errors which tainted this branch of natural history.

To M. Coste belongs the honor of having destroyed these illusions, and his learned researches enable us to work with better results. Thanks to him, the route is now defined, the guide has been found, and success is insured to all except those who are willfully ignorant or careless. This latter cannot be said of the experiments recently made by M. Thibaut upon the rocks of Bouchots near Oléron; by the government upon the bank of Richelieu at Rochelle; by M. Boissière at Arcachon; and, finally, among others, by M. Cressoles in the marsh of Kermoor, where, in practicing the principles of a sound agriculture in regard to oyster culture, he has been able to transform an uncultivated and pestilential morass into vast reservoirs for fish and oysters, thus changing into a source of great wealth what was before a barren and disease-breeding tract. Their example is both a proof and encouragement; my most earnest desire is that this book may stimulate numerous others to imitate their labors.

THE NATURAL HISTORY OF MOLLUSKS AND CRUSTACEANS.

MOLLUSKS.

The third division of the animal kingdom, that of Mollusks, contains animals having a generally symmetrical body, that is a body with similar parts upon either side of a median line, and which never presents an internal skeleton, as in vertebrates, or external one, as in the crustaceans, and never becomes divided into segments, as with the annelids. The body is soft, and is generally inclosed in a calcareous test or shell, which may be univalve or bivalve.

The nervous system of mollusks, especially the ganglionic, does not present a median longitudinal disposition as in the vertebrates and articulates, but consists simply of symmetrically disposed little nodules or ganglions of nerve matter, united together by nerve cords, and located throughout the body in the neighborhood of the principal organs. Mollusks breathe in the same manner as fish, by means of gills, which are either superposed laminæ or branched filaments, and which act by separating from the water and absorbing those gaseous elements held in solution. Some few species present an internal respiratory cavity, to which is given by analogy the name of lung. These exceptional species are always terrestrial. Those mollusks having the most perfect organization are ranked in the class of Cephalopods (*κεφαλή*, head, *πούς*, foot; head-footed animals), so named because of the tactile or prehensile appendages, which are located upon the head end of the body in a complete circle about the mouth, and called arms, feet, or tentacles. The only useful species is the cuttle-fish (*Sepia officinalis*), which produces the color called sepia or India ink, and the bone sold in commerce under the name of sea-biscuit or cuttle-fish bone. The poulpe or squid also belongs to this class, and is likewise called cuttle-fish; it serves as food for some of the poorer classes along the coast of Italy.

The second class of mollusks is that of the Gasteropods (*γαστήρ*, belly, *πόύς*, foot; belly-footed), which owe their name to a fleshy, contractile base serving as an organ of locomotion. Their shell, when it exists, is always univalve. As examples may be mentioned the slug, the snail, and those animals which furnish the helmet and porcelain shells.

The last class and the least specialized group of mollusks, which, however, contains species of great importance in a commercial point of view, is that of the acephalous mollusks (*ἀ*, without, *κεφαλή*, head; headless). This class contains all of those mollusks having a bivalve shell, such as the oyster and the mussel, which we propose to study. All are without a distinct head, hence the name. The body has the form of a flattened, oval disk, and is pierced at one extremity with a mouth orifice

surrounded by tactile appendages, the palps, which seem intended to take the place of the organs of sight and touch. From each side of the body hang two folds of integument, formed of a double membrane, which clothe the inner surfaces of the shell, protecting the body of the animal from immediate contact with the hard external covering, and guarding it from any rubbing that might take place if in contact with such a surface. These protecting folds form the mantle, which also secretes the shell.

Some species, the mussels among others, possess a sort of fleshy foot, which can be protruded at will from between the valves of the shell and the folds of the mantle, and can also aid in locomotion. But the greater portion of the acephalous mollusks live firmly attached to solid objects under the water, either by a union of the calcareous matter of their shells with the object upon which they are stationed, or by means of a small bunch of hair-like threads, which arise from near the ligament uniting the valves, and which are called collectively the byssus. Other species live buried in the mud, or move about in the water, sometimes swimming great distances. They are met with in the fresh water of our rivers and lakes, and in all salt water.

THE OYSTER.

Naturalists have united under the common name of oyster a large number of mollusks having very different aspects; they are the genera *Gryphœa*, *Plicatula*, *Vulsella*, *Malleus*, *Lima*, *Meleagrina* or pearl-oyster, &c. These mollusks are widely distributed, and have been very abundant in both fresh and salt water, in all ages of the world, so much so that they have left some very extensive fossil remains, as in the cretaceous beds of Versailles, of Meudon, and in all of those deposits to which, from their marine origin, the name of Neptunian beds has been given. Without entering, however, into useless details in regard to the various species of this family—since as articles of food they are of little or no interest—we will confine our attention to the edible oyster (*Ostrea edulis*), which is easily recognized by its compressed, roundish body and bivalve shell, the two valves of which are quite unlike, one being nearly flat, the other convex, and both without teeth at the hinge joint. The two valves are formed of a series of imbricating, circular layers of carbonate of lime secreted from the mantle, and are held together and closed by a single large and powerful adductor muscle, attached near the center of each valve. The layers of shell material have very much the appearance of shingles upon the roof of a house. The best-known forms of this animal are the common oyster, used upon our tables; the horse-foot oyster (*Ostrea hippopus*), very large and broad, but little esteemed, found at many places along the shores of the Mediterranean, and also at Bologne-sur-Mer; the oyster of Beauvais (*Ostrea bellovacina*), taken at Bracheux, near Beauvais, &c. But the oyster is so well known to every one that, without attempting a minute descrip-

tion of its structure we will pass at once to the study of the phenomena of reproduction, which have for us a very important significance. The oyster is hermaphrodite*; that is to say, each individual contains in itself the organs of both sexes—the ovary, or egg-producing organ, and the testicle, or organ for the formation of the male element or spermatozoa. This question, which for a long time was the subject of debate, is now entirely settled (MM. Quatrefages and Blanchard sustained the contrary opinion, and several memoirs read before the Academy of Sciences treat of the artificial fecundation of the eggs and the artificial formation of oyster beds). It is recognized that in every individual are to be found at the same time both eggs and spermatozoa, and that, moreover, the eggs present all the phases of fecundation before they have left the ovaries of the animal and have reached a place where an external impregnation could be possible. One should not think, therefore, of artificially impregnating the eggs of the oyster, for this would require the removal of the eggs from the ovary of the mother while in course of development, which would be incompatible with an independent existence.†

The spawning season of oysters lasts about three months, from June to September. The eggs are produced in the ovary,‡ which is situated deep in the body of the animal, and whence, after they have arrived at a certain stage of maturity and have been impregnated, they descend along spacious canals into a fold of the mantle, where they remain inclosed in a mass of mucus, until they have completed their development. The eggs form at this time two whitish, creamy masses, which increase the size of the oyster very much, and cause it to be much sought

*This is without doubt not true so far as regards the American oyster (*Ostrea Virginiana*). I have examined, under the microscope, hundreds of oysters during the last two years, and throughout nearly the entire spawning season as late as the middle of October, and never in a single instance have I found any evidence of hermaphroditism, the sexes always being well marked and perfectly distinct. Neither have I seen any evidence of the development of the egg until after it had passed from the ovary and come in contact externally with the floating spermatozoa; from my own observations, and from those of accurate observers with whom I am acquainted, I am of the opinion—which coincides with that of Quatrefages and others as to the European form—that the American oyster is as truly unisexual or dicœcian as any mammal.—(Tr.)

†Notwithstanding this statement in regard to the oyster in general, Prof. W. K. Brooks, of the Johns Hopkins University, Baltimore, Md., has succeeded, during the past summer of 1879, at Crisfield, Md., in successfully impregnating great numbers of eggs of the American oyster. The impregnation was effected by taking the ripe eggs from the ovary of the female and mixing them artificially with the spermatozoa taken from the male animal. Many others of the party, of the Chesapeake Zoological Laboratory, including myself, also succeeded with the artificial impregnation, and there is no question but that such a process can be successfully performed, although to what extent it is practicable is a question yet to be settled.—(Tr.)

‡The statement of the author in regard to hermaphroditism and its results, and the changes undergone by the eggs within the ovary, must, in all probability, be considered as entirely erroneous.—(Tr.)

after by certain amateurs; but this should not be done, for when in this condition the animal should be especially protected. Although we may now consider the eggs as laid, yet they will not be ready for some time to leave the protecting mantle of the mother; they must undergo a sort of incubation, during which the mass loses some of its fluidity, and assumes a dark, violet color, a certain indication of maturity. From this time the embryos can lead an independent existence, and if they are now taken from the mantle they can be preserved alive for several days in sea-water; and, moreover, by frequently renewing this water and arranging solid bodies for their attachment, such as bits of wood or fragments of shells, one can reproduce artificially what takes place at every spawning season in the depths of the ocean. When the embryonic mass has assumed a bluish black or muddy color, the young leave the mantle of the mother and become dispersed in the surrounding waters. Each individual is furnished, at this time, with a special swimming organ, which disappears as soon as the animal has found a suitable place of attachment where it can continue its growth. This fleshy pad, or velum, is covered with cilia, and by the aid of these and of powerful muscles, which seem to retract or extend the velum, the embryo can move in any direction.

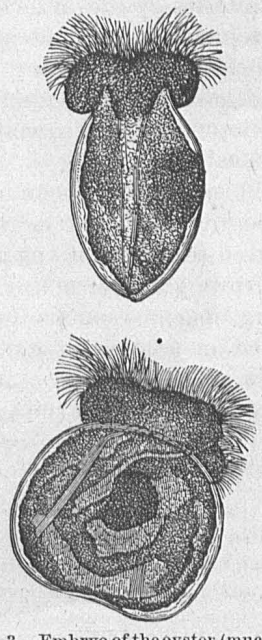

FIG. 3.—Embryo of the oyster (much enlarged).

The accompanying figures represent much enlarged a young oyster which has just left the mantle-cavity of the mother oyster; the first shows it in front view; the second, as seen in profile; at the upper part can be seen the ciliated velum. The number of embryos spawned in a single year from a single mature oyster cannot be estimated at less than from one to two millions, and the imagination is simply astounded at the idea of the immense numbers which would result from each annual spawning of a single bed of oysters, if this living cloud, which at a given moment almost darkens the waters, found for each one of the minute beings composing it a support and a protection which would enable it to escape the innumerable causes of destruction to which the laws of nature and human negligence expose them, and develop into mature and edible oysters. In order that an embryo oyster may live to acquire a shell which shall serve to protect it, it is necessary that it should find near at hand a solid body, stone, bit of wood, or shell, for its attachment, so that it may be protected from too strong currents, which would carry it off; from deposits of mud, which would smother it; and from the voracity of the inhabitants of the sea, among which there are countless

varieties of crustaceans, worms, and polyps, which prey upon these animated organic corpuscles, so easy to capture and so attractive as food. And, finally, it is especially necessary that no blundering or greedy hand shall come with rake or dredge to seek for a few oysters of edible size and by so doing tear to pieces and overturn the objects upon which the young are attached, and thus kill or bury in the mud all the young generations to which the few old ones have given birth. If the young oyster can escape its many enemies and causes of destruction it will in about six months acquire a diameter of 8 to 10 millimeters, a very rapid increase when one takes into account its size at the time of swarming, about one-fifth of a millimeter. At one year of age the oyster is from 4 to 5 centimeters in diameter, and in about three years it attains marketable size—from 8 to 10 centimeters—when it can be gathered and sold for consumption.

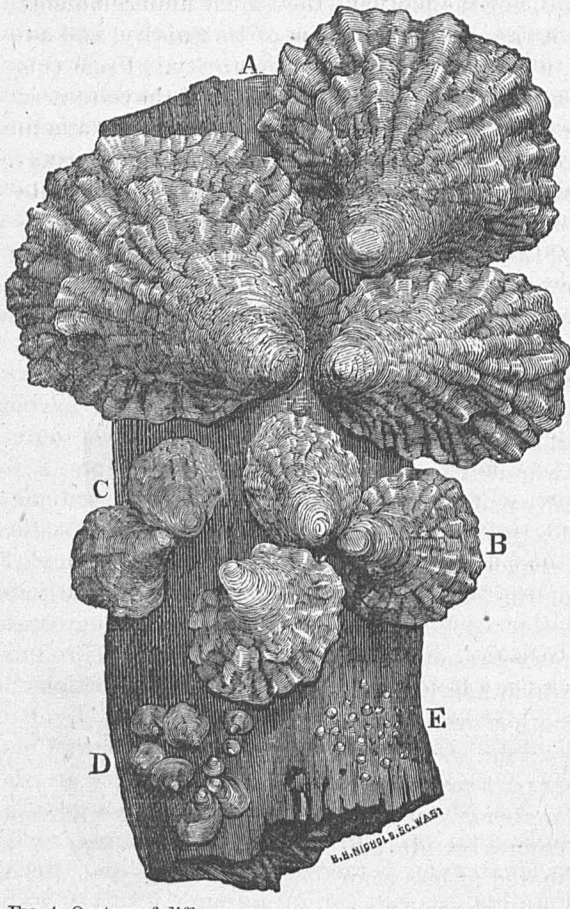

FIG. 4. Oysters of different ages (natural size).—A, oysters from 12 to 14 months old. B, oysters from 5 to 6 months old. C, oysters from 3 to 4 months old. D, oysters from 1 to 2 months old. E, oysters from 15 to 20 days old.

Figure 4 represents a number of oysters of various ages attached to the same object.

But like nearly all animals destined for man's use, the oyster is susceptible of great improvement by special cultivation, which gives it a flavor and appearance very different from those of oysters freshly taken from the great common reservoir—the ocean.

Upon our entire coast, especially where oysters are taken, it is well known that a prolonged sojourn in a fattening pond, or park, is necessary in order that they may acquire those qualities which place them in favor with consumers.

Under the generic name of *parks* are designated reservoirs containing

sea-water, which communicate with the ocean by means of sluices and flood-gates, that can be opened at each flood-tide or at pleasure; here it is that the oysters are deposited, after being taken from the beds, in order to protect them, and make them convenient for the demands of trade. In this stagnant water, charged with organic material and protected from all agitation, the oysters increase in size very rapidly, become fat, and lose the bitter flavor and slightly tough consistency common to the natural oyster. It is greatly to be regretted that the steady diminution of this mollusk will not allow the oystermen to retain the oysters in their parks but a very short time; the full benefit of the park is then not attained, while at the same time the continually increasing price makes the oysters articles of luxury reserved for the tables of the rich. Often, one can see placed on sale in our markets oysters which have been sent in immediately after being taken, and without having been placed in a park at all.

This mode of cultivating oysters by means of parks forms an important industry for the inhabitants along the coasts between the harbor of Brouage and the mouth of the Seudre, and constitutes the chief source of wealth of the territory of Marennes. There, in ponds or parks, to which they give the name of *claires*, and which differ from ordinary parks in that they do not receive any water from the sea except during spring-tides, while the parks receive it at every flood; there, I repeat, the oystermen, known under the name of *amareilleurs*, cultivate their oysters, procured either from the banks of the neighboring coast, or from the coasts of Brittany, Normandy, or Vendée, and produce those delicious bivalves known in the southern and central portions of France as green oysters. Oysters which leave the ocean very light in color, after being placed in the claires at Marennes for a short time, acquire a deep green color, most pronounced in the gills; these are the veritable oysters of Marennes, which are preferred to any other growth. The reason of this is simple, and the color has little, or nothing, to do with it. The oyster, deposited when young in the claires—and this is an indispensable condition—undergoes a careful nursing, a sort of stabling, and acquires, at the same time that it receives its characteristic color, a fineness and delicacy of flavor and a fatness which it could not acquire upon the muddy and disturbed natural banks; from this cause arises its real superiority, a superiority which it would acquire equally well in any other park where it could be treated with similar care and where it would even retain its natural color. This is so true that adult oysters placed in the claires at Marennes rapidly acquire the green color, but always remain just what they were when they were taken from the sea, although they present all the external characteristics of the most highly prized oysters. As to the peculiar color of the oysters which have been kept in the claires, it has been attributed to certain marine algæ growing in that neighborhood, to the presence of a

small animal (*Vibrio ostrearius*), and also to a disease of the oyster, a sort of jaundice or affection of the liver; but to-day it appears certain that this coloration is due solely to the peculiar nature of the soil forming the bottom of the claires, and that every park having as a base a soil composed of a blue or a rich ferruginous clay will give to oysters placed in it this esteemed color; but this character will no longer be of any importance when colorless oysters raised in parks with the same care as those in the claires at Marennes shall present the same qualities. Upon those coasts where favorable circumstances permit their multiplication, oysters form beds or banks often several hectares (a hectare is 2.41 acres) in extent. These banks are formed by the aggregation of oysters of different ages and sizes, whose shells become firmly attached or soldered to the stones or rocks covering the bottom or to the shells of neighboring oysters. If it were not for the destructiveness of oyster-fishing, these banks would go on increasing in size and depth, without limitation, and also, as a natural result, in value, by the annual accumulation of new germs; an accumulation singularly favored by great numbers of vacant places over the bottom of the ocean.* The oysters which are most esteemed in Europe come from England, while the best of the French oysters are found upon the coasts of Brittany and Normandy. Those most commonly eaten at Paris come from the north, from Cancale, Dieppe, Étretat, Dunkerque, &c. The southern and central portions of France are supplied from Bordeaux and Rochelle, and from the few rare banks of the west coast which are not yet exhausted.

The principal parks are those of Marennes, Saint-Waast, Courceul, Étretat, Fécamp, Dieppe, Tréport, and Dunkerque. The fishing is done by means of a dredge, which is dragged over the bottom of the sea. This dredge scrapes over the soil and gathers up into a bag of leather or twine, which is attached behind it, everything that lies in its course. When the dredge net is felt to be full the dredge is drawn on board of the boat and its contents emptied and sorted, those oysters only being retained which are of the size established by law, the rest being cast back into the water. We will now end this study by some observations upon a foreign species of oyster which it may be possible to acclimate in our southern waters, and which, although without value as an article of food, is of very great commercial importance; I refer to the pearl-oyster.

The shell of this species is semicircular, greenish externally, and of a beautiful nacreous color upon the inside. The animal is white, soft, and similar in form to the common oyster. The pearls found in the shell of this mollusk appear to be calcareous secretions from the mantle lobes

* A judicious fishing or working of an oyster-bed tends to increase both its size and value, while a natural unfinished oyster-bank, instead of being of unlimited growth, is always limited in size by the condition of the soil upon which it is formed as affected by the currents of the surrounding waters.—(Tr.)

and of the same nature as the secretions which form the nacreous lining of the valves, but which in consequence of peculiar conditions, either a sickness of the animal or the presence of some strange body, assume a spherical or pyriform shape. It is certain that the presence of a foreign body, by irritating the mantle, produces an abnormal secretion of the nacreous material which soon entirely covers that body with a material identical in character with that forming the pearls.

For a long time the Chinese have made use of this peculiarity of the pearl-oyster and of certain other mollusks. Among the class of pearl-producing or nacre-producing animals must be placed our fresh-water mussel. In order to have any ornament covered with nacre it should be placed within the shell of a pearl-oyster and left there for several months, after which time it will appear as though entirely composed of pearly material. The most valuable pearls come from Ceylon and the Persian Gulf. The pearl-oysters are found in banks, like the common oyster, at a depth of from 5 to 20 meters. The pearl-oyster bears a general resemblance to the edible oyster, except that it is much larger, attaining sometimes a diameter of 30 centimeters (between 9 and 10 inches). They are taken in Asia at four principal places: around the island of Bahren in the Persian Gulf, on the coast of Arabia near Carisa, in the Gulf of Manaar in Ceylon, and upon the coast of Japan. The fishing commences in February and ends in April; it is performed by native divers furnished simply with a knife to detach the shells and a basket to gather them in. The fishing of the banks is subject to a sort of police supervision on the part of those who lease the right to fish for pearls. Only a certain number are taken, and the banks are carefully inspected at every fishing; the divers are always careful to spare the young ones, and take only those which look as if they ought to contain pearls, since all do not contain them. The valves of the pearl-oyster are also objects of commerce, as they furnish nacre. But they are not the only ones which furnish this product; upon our coasts a great number of mollusks are found, among others the *Haliotus*, which furnish a very valuable nacre, more beautiful even than that of the pearl-oyster. In seeking conditions of soil, depth, and temperature as nearly as possible like those surrounding the pearl-oyster in Asia, it would seem possible to acclimate this mollusk in the waters of our coast and of the African shores of the Mediterranean; waters which even now contain much unexplored wealth, particularly vast beds of coral, and which would seem to cover naturally fertile places for the abode of the pearl-oyster.

MUSSELS.

Under the generic name of mussel (*Mytilus*) are united bivalve mollusks having a symmetrical shell and equal valves, and with the mantle, is divided into two similar lobes, entirely separated along the ventral edges, both of which are smooth, much thickened and attached to the

edges of the valves. These mollusks have two very powerful adductor muscles and are furnished with a foot or thick and fleshy prolongation of the central portion of the body, which can be protruded from the shell at the will of the animal. From the foot posteriorly arises the *byssus*, a small bunch of hair-like stiff threads, secreted by a gland, and by means of which the animal is permanently attached to some solid body, such as a rock, shell, bit of wood, &c. The gills, differing from those of the oyster, are made up of two laminæ fixed to one end of the ventral mass along either side and free at the other, which is prolonged from either side of the posterior adductor muscle.

The mussels are hermaphrodite like the oyster, and reproduce in the same manner (?), giving birth, after an incubation in the folds of the mantle, to a gelatinous mass, composed of a great number of young mussels, each furnished with its byssus and ready to float away in the water, to become fixed to the first solid body which it encounters, or to perish in the mud, or serve as food for its innumerable enemies. Mussels cannot move about, or at the most move very slightly, yet, nevertheless, if a mussel becomes detached from its support by the rupture of its byssus it can move some by thrusting its foot out from between the valves of the shell and pushing against the ground as against a fixed point. Mussels live nearly everywhere; there is not a point upon the coast of France where they cannot be met with, clustered in groups upon the rocks, in crevices, upon piles, and upon bits of submerged wood. They are to be found especially at the mouths of rivers and in muddy bays, the contact of fresh water not being objectionable to them, and, according to Beudant, they can even be acclimated out of sea-water. Of the many species of mussels, we shall speak here only of the edible one (*Mytilus edulis*), which has an oblong shell, of a very deep violet color externally, and white within except along the border and at the two muscular impressions, where the violet color also appears.

In Normandy the light-colored mussel is much esteemed; it is smaller than the above and the valves are of a brown-fawn color. It is found principally at Villerville (Calvados).

In France the mussel is taken throughout the entire year, except during the hottest months and the spawning season. The women and children, armed with a strong knife, gather them from the rocks which are uncovered at low tide, or dig them from the mud of the sea-shore. These mussels, however, are small, tough, and bitter, while those which grow in quiet and protected places, where the bottom is muddy but not sufficiently so to bury them, attain a large size and a delicate flavor. The mussel banks are practically inexhaustible, but as this mollusk is not of great value until it has attained a certain size, and lost the bitterness and toughness belonging to the sea-mussel, the means of bringing it to perfection have long been sought for. Upon certain parts of our coast they are placed in parks like oysters, and in the Bay of Aiguillon they are made the object of a very important enterprise, which

we will describe in the chapter in which we treat of the rearing of this mollusk. At other places they are taken from the sea and placed in salt marshes, since it has been noticed that a sojourn in water less salt than that of the sea improves their flavor. Finally, there are no places along our coast where this mollusk cannot be cultivated with advantage and profit, and our many railroad facilities will cause it to be still more widely known and esteemed throughout France.

CRUSTACEANS.

The important class of crustaceans constitutes one of the divisions of the sub-kingdom *Articulata*. The animals of this class are characterized by a symmetrical body divided into a number of more or less similar segments, and provided with a nervous system, consisting of a row of ganglia, or small, nervous masses, connected by nerve cords and arranged in a longitudinal chain following the median line of the body, with a ganglion located in each segment. The appendages constitute a variable number of pairs, each pair being carried by a segment. Respiration is aquatic, or by means of gills; the skin is sometimes soft, and sometimes hard or coriaceous, forming an external skeleton moved by internal muscles. This last characteristic is peculiar to crustaceans, as is also the pyramid-like gills, furnished with hairs or little tufts, and placed on each side of the thorax at the base of the feet, or under the abdominal portion of the body. The segments of the body are generally twenty-one in number, but the first are nearly always united into a firm, inflexible portion, containing the head and thorax and named, accordingly, the cephalothorax. The remaining segments remain distinct and together form the abdominal portion of the animal. This division is very easily recognized in the crab and lobster, in which animals that portion which is popularly known as the tail represents the abdomen. The limbs of crustaceans number from five to seven pairs; those which are borne by the abdominal segment being generally only rudimentary and designated false feet. These false feet subserve respiration, in some forms, and in others carry the eggs during incubation, as in the species to be mentioned farther on. The crustaceans are subdivided into several families, among which we shall call attention to those containing useful species, all of which belong to the same order, that of decapods (δεκά, ten; πούς, feet). The name clearly indicates the distinctive character, that of having five pairs of feet. Of these five pairs, the anterior is often terminated, as in the cray-fish, crab, and lobster, by large and powerful pincers or claws, which are of use in prehension and in defense. A large abdomen, lengthened into a caudal appendage and terminating in a broad swimmeret, characterizes the macrurous decapods (μακρός, large; οὐρα, tail). When, on the contrary, it is short, flat, and recurved under the cephalothorax, it classes the animal among the brachyurous decapods (βραχίς, short; οὐρα, tail), as the crab, &c. With these general definitions we can now pass to the consideration of those species which are

useful to man as food, and which, thanks to the patient studies of M. Coste, can now be reared in great numbers.

CRAY-FISH, LOBSTER, ROCK LOBSTER, AND CRAB.

There is a single edible species of crustacean called the cray-fish, which is found in our fresh-water streams. This animal, which it is scarcely necessary to describe since it cannot be confounded with, or mistaken for, any other aquatic animal in the waters which it inhabits, is provided on the anterior pair of limbs with two strong but unequal-sized pincers; the abdomen is generally very much developed, the six segments composing it being very convex above, furnished with powerful muscles, and supplied below with false feet, movable at the base, which serve as swimmerets. The false feet of the male differ somewhat from those of the female, and present moreover two pieces which are formed beneath the first segment, are movable at the base upon a cartilaginous articulation, and generally lie directed forward upon the sternum. There are two rolled laminæ forming a sort of tube which repesents the male copulating organ, and connects with a triple testicle and seminal vessels. The female has two ovaries placed one upon either side of the body and opening beneath at the base of the first joint of the third pair of walking appendages. At the period of spawning these ovaries become elongated and much distended with eggs. Copulation is effected as with many species of flies, belly to belly. When the male attacks the female he turns her over upon her back and the two then closely clasp each other by means of their claws and walking legs. It does not appear that the male organs enter into the oviducts of the female, but the semen is simply shed upon the plastron and around the orifices of the oviducts, where it solidifies, allowing, without doubt, the spermatozoa to escape and penetrate into the ovaries.* When a female is found full of eggs and with certain whitish flakes adhering to the under side of the carapace, it is pretty certain that the eggs have been impregnated. Spawning takes place about two months after fecundation, and the eggs when laid become attached to the false feet upon the abdomen. They are secured to the feet by means of a membraneous pedicle formed by a prolongation or hardening of the envelope or glutinous mass in which the eggs are laid, and are held in this position until the young are hatched, and even after this period the young cray-fish, soft and delicate, find protection under the abdomen of the female, whom they do not entirely abandon until their

* According to the careful observations of Mr. P. R. Uhler, president of the Maryland Academy of Science, the fecundation of the eggs of the cray-fish is external, or after they have left the oviducts; that is, the seminal fluid of the male is emitted, while in the position described above, upon the plastron and swimmerets or false appendages of the female; the eggs are then discharged from the body, pass back to the swimmerets, where they are retained during the incubatory period, and where they at once come in contact with the fecundatory spermatozoa and are impregnated.—(Tr.)
[See "The Cray-fish," by T. H. Huxley.]

calcareous test or covering is sufficiently hard to completely protect them. The cray-fish change or shed their skin or test once a year, and this shedding takes place from May to September. During the shedding period the animal retires into some hole or sheltered place so as to protect itself from the thousand dangers to which its soft and defenseless body would subject it. It remains concealed for two or three days, in which time its new covering acquires nearly the solidity of the old envelope. Among the cray-fish and other crustaceans of the same family the feet and antennæ possess the remarkable property of being renewed in case they are accidentally lost either in part or wholly. A few days after a leg is lost a reddish membrane forms over the place, covering and obliterating the wound; soon a conical bunch appears, which elongates and finally bursts through the membrane and shows a small, soft foot, which increases in size, regains its calcareous test, and in a short time duplicates completely the lost member. The river cray-fish, which is also much sought after for food, is found in fresh-water streams throughout Europe, but it is quite particular in its choice of habitation. It loves clear, flowing water, where the bottom is composed of small stones and pebbles without mud, and where it can find protection and plenty of holes and crevices into which to retire, and which it leaves only to seek food, consisting of mollusks, little fish, and the larvæ of insects; it also feeds upon, and even prefers a more wholesome diet, decaying animal substances, or dead bodies floating upon the water, and in default of any of the above-mentioned articles it will make a bountiful meal of vegetables or young shoots. It lives for about twenty years, and as it increases in size at each moult, it may become relatively of considerable magnitude. It can be very easily acclimated in foreign waters, providing the water is sufficiently pure and the surrounding conditions suitable to its existence; it also conforms readily to a state of confinement, and will readily develop and reproduce in small basins, analagous to those in general use for artificial fish culture.

The lobster (*Homarus vulgaris*) may be known by its smooth carapace and greenish-brown, sometimes bluish, color, which, when cooked, changes to a pale red, thus diminishing a little, when upon our tables, the repulsive aspect characteristic of all crustaceans. The head of this animal is terminated anteriorly by a sort of three-pronged rostrum, and is armed with long reddish antennæ and two pedunculated eyes. The anterior pair of feet are armed with powerful pincers, which are often out of proportion to the size of the rest of the body. The lobster is widely distributed in the ocean, the British Channel, and the Mediterranean, and inhabits rocky bottoms, often at great depth.

The rock-lobster (*Palinurus vulgaris*), which is nearly as much sought for as an article of food as the lobster, is distinguished by the large fan-shaped termination of its abdomen, by the five pairs of similar legs without pincers, by possessing long and strong antennæ and a moderately long carapace covered, especially in front, with small points or pro-

tuberances. The female is distinguished from the male, at the spawning season, by a character, which was recognized even in the time of Aristotle: the last pair of walking legs, that is, the pair nearest the abdomen, presents near their distal extremities a spur, which is absent in the male, and the use of which will be revealed later. This animal is very common in the Mediterranean, but rare along the ocean coast except in the harbor of Brest. Like the lobster it is carnivorous and very voracious, consuming mollusks, worms, and fish, which are abundant upon the bottom in the waters where it lives. It rarely swims, or leaves the bottom, except to escape some threatened danger.

The crab (*Cancer*) is distinguished by having a large, broad carapace, and its posterior pairs of legs all modified for walking; the anterior pair is furnished with powerful pincers. The carapace is broader than long, and is denticulated, much like a saw, along the anterior border. The eyes are close together in front and furnished with short peduncles. The crab is partly terrestrial, partly marine; it inhabits holes among the rocks and in the sand, which are covered by the sea during every tide. It is carnivorous, its principal food being dead mollusks or any pieces of animal matter that may be within its reach. The most important edible species is the *Cancer pagurus*, which has the carapace smooth above and with the edges marked with prominent serrations. The rostrum is three-pointed and the large anterior feet are black and furnished with large, smooth tubercles upon the inside. This crab is very abundant in the ocean but rare in the Mediterranean. It grows quite large, and its flesh is, with reason, much esteemed, and must not be confounded with that of the common crab, about the only form found in our interior markets, and which the fishermen of our coast consider of very little value.

After this summary of three marine species which are useful as food to man, it is especially important that we should carefully study their mode of reproduction as well as the method of exercising this function, and the precise length of its duration, since by this means we shall be able to obtain a foundation for our efforts in artificial breeding. The period of reproduction with the lobster commences in October, with the rock-lobster in September, and it lasts about six months; but the union of the sexes takes place most commonly in November for the rock-lobster, and in December for the common lobster. It does not end, however, until towards the close of January. As with the cray-fish, the sexual act is accomplished belly to belly, and so closely and firmly do they clasp each other, that, if taken from the water at this period, it is with difficulty that they can be separated. With the rock-lobster the penis or copulating organ of the male does not penetrate into the body of the female, the seminal fluid being shed upon the plastron in the neighborhood of the external orifices of the oviducts, where it hardens, forming plates of a gelatinous consistency, from which the spermatozoa escape and work their way into the oviducts and thus to the ovaries,

which are filled with eggs, the latter in this manner becoming impregnated. With the lobster and crab the seminal fluid appears to be introduced directly into the oviducts. As already indicated, the autumnal months are, as a rule, the time for the union of the sexes; but, especially with the lobster, this time is extended somewhat into the winter. The spawning takes place about one month after fecundation. When the eggs are ready to issue the female folds the abdominal portion of the body against the plastron, thus forming a close cavity into which the oviducts open, the orifices being located at the base of the third pair of walking appendages. This cavity receives the eggs as they pass from the body, and in the course of one day the common lobster will deposit in this chamber about 20,000 eggs and the rock-lobster about 100,000. During the period of spawning the sides of the abdomen secrete a kind of viscous substance, which incloses the eggs, and hardening around them, attaches them in irregular groups to the abdominal appendages. In this manner the cavity formed by the incurved abdomen soon becomes a nearly solid mass of ova. Incubation now commences, and while in this condition the female is said to be ripe. This new stage of reproduction lasts about six months, or until about March to June. During this time the female attends closely to the welfare of its eggs.

By reversing their abdomen as much as the calcareous nature of the segments will allow, the eggs are exposed to the light, or by gentle movement of the false appendages they are subjected to a hygienic bathing; now, by refolding the abdomen, the eggs are carefully protected from the many dangers which threaten them; and so well is all this managed, that among the thousands of eggs of a ripe lobster one can rarely find any that are sterile or bad. When the young crustaceans are about to escape from the eggs the mother animal assists in releasing them by the aid of the spur upon the last joint of the last pair of walking legs. With this she detaches the groups of eggs, and at the same time, by an oscillatory movement of the false or abdominal appendages, she scatters the myriads of newly-born animals on every side. The young animal at this time has no resemblance whatever to its parent, and up to the date of the recent investigation of M. Coste, to whom we are indebted for the preceding account, these young crustaceans had been placed in a special genus under the name of *Phyllosomes*. These embryos, with a soft, nearly gelatinous body, are furnished, upon each limb and at each joint, with a sort of tuft of vibratile cilia, by the incessant motions of which they float in the water and are carried about in different directions. Upon leaving the maternal protection the young animals mount to the surface, and there often form quite extensive swarms, which, from the constant movement of the animals and the constant changes in position of the swarms, sensibly alter the transparency of the water. They continue to live in this manner for quite a time—thirty or forty days—during which they undergo three moults; finally they lose the cilia from their feet, fall to the bottom, and gradually

work their way, by means of their walking appendages, back to the shore where they were born. From this time onward their form is like that of the adult, or nearly so, but they are very small and grow very slowly. They increase in size only at intervals, that is, at each period of moulting, for the animal, enveloped upon all sides by a solid and inelastic covering, preserves almost exactly the same size up to the moment when its envelope is removed, and while awaiting a new covering the body can enlarge to but a limited extent. The number of moults is quite considerable, and is not the same during the same period of time for all individuals, for it is known that when placed under apparently similar conditions individuals of the same brood will vary much in size. Every moult is a very critical period for the animal, and a cause of great mortality, not only because at this time there is a considerable interval when the animal is without defense against its numerous enemies, which at other times might have been kept away by its hard and formidable pincers, or resisted by its firm carapace, but especially because this period forms a sort of crisis, occasioned by its increase in size with every moult.

Mr. Coste has shown that the common and rock lobsters change their carapace or moult—

The first year from 8 to 10 times; size then, $0^{m}.04$.

The second year from 5 to 7 times; size then, $0^{m}.09$.

The third year from 3 to 4 times; size then, $0^{m}.14$.

The fourth year from 2 to 3 times; size then, $0^{m}.18$.

In five years the two forms above mentioned attain a size of 20 centimeters (about 6 inches), this being the size established by law as the smallest that can be caught for the market, and at this time they begin to reproduce their kind. After the fifth year, moulting takes place only once a year, for, if it were more frequent it would, in the case of the female, seriously interfere with the reproductive functions.

CAUSES OF THE CONTINUED DEPLETION OF THE OYSTER BEDS AND THE IMPOVERISHMENT OF THE FISHERIES.

What are the causes that have so greatly impoverished the oyster beds of our coast, as announced by M. Coste in the report from which we have already cited certain extracts? This is the question which we propose to discuss in this chapter—a question of prime importance, for if it explains the past it also indicates the entire future of the oyster industry. The productive forces of nature are so powerful, and the laws of general harmony, which preside over the increase and the existence of animated beings, are so evenly balanced, that sometimes an apparently futile modification in the conditions of development of these beings is necessary, in order to give an unlimited range to their reproduction, just

as an inequality of these conditions may suffice to lead to the decline or disappearance of an entire species.

Like all of those organized beings, animal or vegetable, which are obliged from their nature to live securely fastened or attached at the place of their birth, forming there aggregations of similar individuals, aggregations which are always increasing, and which, when reaching beyond certain limits, become fatal, first to other species inhabiting the same places, and finally to themselves, oysters have numerous enemies, which restrict their increase and retain them within the just limits of fruitfulness, not permitting the general encroachment or usurpation of outside localities and the destruction of other marine species.

Innumerable hordes of fishes, mollusks, crustaceans, and polyps gain their nourishment almost exclusively from the spawn of the oyster and from the oyster itself; for, even in an adult state, the oyster is the prey of crabs, aquatic birds, and certain worms which pierce the valves of the shell and destroy the animal sheltered within them. But the fecundity of the oyster is so great, and the number of living germs which float in the water during the spawning season is so large, that all of these enemies together are not able to diminish the number and extent of the oyster banks, nor even arrest for an instant their continued growth and enlargement. It is not then against these enemies that we shall have especially to seek a means of defense, since such defense would be valueless, as it would not operate against the real cause of the evil, and powerless, as it is impossible to subvert natural laws.

Along all portions of our coast where oysters exist this mollusk has very sensibly diminished in numbers. This fact is unfortunately acknowledged by all; diversity of opinion exists only with regard to the causes which have led to this decadence, the principal ones, dependent upon locality, being accumulations of mud or sand upon the bottom, invasions of mussels, or the invasion of the *maërle*. To these pretended causes we will add a fourth, the only true one, according to our opinion, which can account for the continued decadence of the oyster industry, and in fact the only one which demands prompt remedy. It is, unintelligent and avaricious fishing of the oyster banks by oystermen, a fishing which has heretofore been directed by routine and the selfish carelessness of the fishermen, and not by a profound knowledge of the nature and wants of this mollusk.

In fact the encroachment of mud and sand, and the invasion of mussels, and *maërle*, are not, as are generally believed, the causes of the destruction of the oyster banks, but are consequences of their destruction, or at least coexisting occurrences. People are, in general, very easily led to establish between two facts, by reason of their simple coincidence, a relation of cause to effect, while really they are both only consequences of some common and unknown cause; thus in the country, and even in the most enlightened centers, the frosts of early April are attributed to the influence of the moon, because its appearance coincides with a clear

sky, which is really the true cause of the phenomenon. In like manner with the oyster banks; just in proportion as they diminished in size, as became manifested by vacant places appearing where oysters formerly grew, people said of the work of destruction, here it is mud or sand; there mussels; and at other places the *maërle*, without reflecting that the dredge which, in tearing up the soil and plowing over the beds, brutally and ruthlessly destroying countless oysters, young and old, was the prime cause of these vacancies and of the filling in by mud and sand which shortly followed. This can be easily understood. When a bed of oysters is intact, that is, before the dredge has commenced its work of destruction, the oysters, congregated upon the rocks and pebbles, firmly united to one another and superimposed without order, form at the bottom of the sea a complicated network of prominences and hollows, of tortuous channels and rocky crests. When, during high tide, these beds are covered with several meters of water, which always holds quantities of mud in suspension, the tendency is always for this mud to be deposited upon the beds, and it is actually deposited during tidal changes. But when at low tide the water passes down the beds, the eminences and crevices of the bottom formed by the irregular disposition of the oysters constitute so many obstacles to its onward flow, that it is divided into a thousand little streamlets, which, however calm the sea may be, form a sufficiently rapid current to carry away any mud which may have been deposited, and in this manner subject the oysters to a sort of hygienic cleansing. So true is this, that the fishermen to whom the government conceded the tidal or emergent lands of the island of Ré, which formed an immense sand-flat or sand-morass, working from these data, undertook and succeeded in obtaining, in a relatively very short time, the entire removal of the deep mud which rendered their lands sterile. They paved the muddy bottom of their territory with irregular fragments of rock taken from the island, and by ingeniously varying the hollows and eminences, so as to break up the water into thousands of currents and streamlets, they had the satisfaction of seeing the mud sensibly diminished in depth with every tide, and the young growth of oysters coming in from the open sea soon took possession of this territory, which had been so long deserted by these animals. By the accumulation of the oysters upon the rocks which follows this reclamation, the beds are preserved from mud and sand, and consequently from the invasion of mussels; but as soon as the dredge is used indiscriminately upon this surface, and a vacant place or hollow produced, where the water can remain stagnant at each flood tide, a deposit of mud soon forms, which augments every day, gaining perceptibly in length and breadth, invading the oysters, leveling the bottom, and tending by its presence even to destroy the beds and at the same time to favor the birth and development of mussels. It is the same with the *maërle*, which is the common name for a submarine plant, an alga, having a kidney-shaped form, and closely resembling both in shape and appear-

ance a fresh brain, of a whitish color, tinted with rose externally, and inclosing a glutinous, greenish tissue, or growing into ramified branches. This plant has the singular property of absorbing or secreting lime, which, by hardening at the surface, forms an external coating or semi-solid test. It is gathered in considerable quantities along the coasts of Brittany and Normandy as a fertilizer for very silicious soils, which in this manner receive their lime. And this is the plant which is wrongfully accused of destroying the oyster banks and usurping the territory. I say wrongfully, for, as in the case of the mud, the *maërle* never attacks the oyster banks until after the dredge has commenced the work of destruction. In fact a surface completely restocked with oysters, which are absorbing animals, furnished with calcareous shells, cannot supply all the calcareous elements demanded by the oysters for the formation of their shells, and at the same time supply the *maërle*, which also requires a large quantity of the same materials to enable it to multiply. Wherever the *maërle* exists it is certain that the oyster cannot flourish, for it could not find subsistence there; and, reciprocally, wherever the oyster occupies the entire territory and absorbs all the shell-producing elements, the *maërle* can neither flourish nor live. But when human industry, yielding without reflection to selfish and grasping desires, carries away incessantly and by thousands the oysters and their progeny, leaving the surface absolutely bare in patches, it is not surprising that the germs of the *maërle*, which lives near by in the same waters, should come and plant themselves upon the ground, whence the enemy has disappeared, and there developing, become predominant, and finally entirely supersede the former occupant. From all this it is evidently necessary to seek the true and only cause of the depletion of our oyster deposits in the mode of fishing practiced at the present time.

Some details will here be necessary in order to explain our ideas. In all sections of the country oysters are taken by means of the dredge. This is a heavy iron frame, which is loaded with stones to render it more effective, and cause it to "bite" the ground deeper. A rope is attached to the dredge, which is dropped overboard from a vessel of some kind, and the vessel set in motion causes the dredge to drag over the bottom upon one of its sides, which, having a sharp edge, cuts or tears up everything in its course and gathers them into a net or bag attached to the lower side or bottom of the dredge. When the dredge appears to be full it is drawn on board of the vessel and its contents emptied upon the deck. The heap is then culled, and those oysters which are not of the size established by law are thrown back into the sea, and the rest placed to one side either for market or, as in Cancale, for the parks or fattening ponds.

In the month of August the commissioners of fisheries inspect the beds so as to ascertain their condition before permitting any fishing upon them, which, before M. Coste had made known the time when they could be worked with the least damage, commenced in September and lasted until May.

In certain localities where the fishing of oysters is a national industry, as at Cancale and Granville, in order to obviate the evil as much as possible and prevent the entire depletion of the banks, the oyster territory has been divided into zones or sections, and each section is fished in turn, while the others are left for perhaps a year or two to repair their losses and fill up the vacancies caused by the dredge. Thanks to this system, which, unfortunately, has not been general, these two quarters have been able to preserve their beds from complete ruin, but have not been able to increase their fruitfulness or restore them to their ancient splendor. In fact the use of the dredge—bad at any time, for it not only tears up oysters of all sizes, but also buries the spawn and the young beneath the mud which it stirs up, and destroys thousands of oysters which should be left to mature, for every thousand procured for the market—becomes more injurious every day, since, in order to increase the returns of fishing upon a devastated soil, and supply the demands of an ever increasing consumption, the oystermen are obliged to employ stronger and larger dredges and drag them more frequently over the same territory, so that the bottom becomes torn up, denuded of shells and rocks which are indispensable to the young growth, and offers a surface ready to receive a deposit of mud suitable for the development of mussels.

Further, in designating September as the time of opening of the fishing season, the administration acted with a desire to protect the oysters during the spawning period, but it did not perceive that the measure was useless, because incomplete. Of the immense number of germs produced at this time from a bed of oysters, only a very small proportion escape the innumerable enemies always near at hand, or, failing to be carried away by the ocean currents, become attached to the valves of the mother oysters or to the prominences of their native bed and serve to restock it. In September, when the fishing commences, these oysters, now only about a month old, are scarcely visible, requiring very close scrutiny to detect them, and when an old oyster is taken from the water at this season all the young upon its shell are inevitably destroyed. If, on the contrary, the fishing was begun in February, these oysters could be easily seen and removed from the objects of attachment, either to be returned to the sea or placed in parks or claires. This method would be of triple advantage to these latter places, since the fishing would not last longer than three months, and the parks would receive the harvest, which could be held there and retailed in accordance with the demands of commerce. Upon such considerations as these, which are in a high degree protective, the new fishing regulations have been founded, and these prudent measures, added to the practice of restocking, will be sure to re-establish and increase the oyster industry of our coasts. The state, as proprietor and guardian of the domain of the sea, has thus done its share; the fisheries

are regulated by wise and efficacious laws, and the restoration of the devastated banks is in a fair way of being accomplished, so that in the near future not only will the evil be repaired, but a return to the former state of affairs will become impossible. But is this all that can be done? We have already said that among the myriads of germs sent forth from a bed of oysters at every spawning period, a small proportion only, that which becomes attached to objects on its native bed, is apt to furnish any recruits for the bed, or any subjects for the fishermen, while by far the greater share are devoured by their many foes, carried away by the tides, or buried up in the shifting sand and mud. Now, if it were possible to gather up at the time of spawning all of these swarms and place them where the conditions are favorable to their development, what incalculable wealth would result, and the truth of the matter is that this gathering up and guarding of the young is entirely feasible. It has been tested by so many experiments that it rests beyond a doubt, and one can even now with ease and certainty labor in this direction, since we know the conditions favorable to the growth of the young, such as are met with in the depths of the ocean, and which it would be necessary to provide artificially in order to favor their development. This is the work reserved for private enterprise, and it has been with the desire of furnishing a guide in this labor that this book has been written, and that the practical development of the oyster industry has been made the subject of the following chapters.

Among crustaceans the common and the rock lobsters occupy an important rank as food animals and as objects of trade; the fisheries of our coast supply not only all of France, but also a great part of Europe. The high price of these animals during the last few years, which has banished this kind of food from the tables of the poor, at least in the interior, and at the same time their relative scarcity in our markets, are consequences of the increased fishing to which they have been subjected, and of their gradual disappearance from our waters, where they were formerly so abundant. As in the case of the oyster fisheries, it is necessary to seek for the cause of this disappearance in the avariciousness of the fishermen and in the uselessness of the old protective regulations. In fact, if one has carefully followed the details which we have already given on a previous page, in regard to the manner of reproduction of crustaceans, it will be seen that the period of time intervening between the fecundation of the female and the hatching of the eggs, is about nine months, the fecundation beginning in September and the incubation ending in May. During these nine months these animals ought then to be entirely protected, for the death of a female at any moment whatsoever of this time is equivalent to the destruction of many thousands of individuals, even where great allowance is made for the many chances of destruction which surround the young before they are fully developed. It is thus during only three months, June, July, and August, that regulations really protective to

these animals would allow of their capture, especially as concerns the common and the rock lobsters. But far from conforming to these natural requirements, the old regulations authorized the taking of these crustaceans at all times throughout the year, with only two restrictions: first, to return to the sea all ripe females, that is, females with eggs attached to the abdomen; and, second, to return all individuals less than 20 centimeters in length. The first of these requirements of the law was excellent in principle, but it was impossible to secure its rigorous execution.

The fishermen would not consent to throw back into the sea often as much as half of their catch, and so eluded the law by tearing off the bunches of eggs from the females, thus destroying at a blow myriads of young ones. It is evident that such action as this has had not a little to do with the increasing scarcity of these animals and their nearly complete extinction in certain sections. On the other hand, if the fishing season were limited to three months it would ruin the fishermen in thus restraining the use of a commodity now generally in demand at all seasons of the year. So under the new regulations now actually in force, and which are due to the exertions of M. Coste, the taking of these crustaceans is forbidden only during the last three spawning months, March, April, and May, during which time most of the young are hatched from the egg. To this eminently protective measure is added the obligation to return to the water every animal less than 22 centimeters in length from the eye to the beginning of the abdominal portion; for all animals smaller than this not only sell for a minimum price, and, being too young for reproduction, their destruction before having fulfilled this function at least once would be a loss without any compensation. What has thus far been done is all that can be done judiciously in the present state of affairs, when both the common and the rock lobsters, as soon as they are taken from the water, are delivered immediately to the consumers, or at least are preserved in small live ponds or boxes only as long as is necessary to find a purchaser. But it is known to-day that both of these animals do well in confinement, and when kept in spacious basins where the conditions suited to their normal existence are artificially realized, they will live, increase in size, fatten and reproduce their kind just the same as in a state of nature. And it is even to be supposed that, like oysters in parks, this mode of breeding should improve them in flavor and delicacy.

Here, then, is a new industry open to the inhabitants of our coast; an industry which, in multiplying products, is suppressing non-values, since every individual which is under the marketable size can be preserved until such a size is attained. By being able to satisfy instantly all the demands of commerce, even at times when bad weather or other circumstances prevent fishing, the consumption in the interior and the exportation to foreign countries will be considerably augmented, and a wise and effective protection will become possible, since the fishing

grounds will be invaded only to supply vacancies in the breeding-basins, made in answer to the demands of the market. The industry, moreover, far from being independent and distinct from the breeding of oysters, or of forming the basis of a special labor, is simply supplementary, and additional in that it increases the supply and the revenue without increasing the expense at the beginning. The breeding of mussels will also be considered in detail; for if their disappearance is not to be feared, there is such a vast difference between the sea-mussel and the mussel of the parks that the latter alone should be used for food, and this method of breeding enables a useful article of food to be grown upon bottoms whose nature is entirely incompatible with the production of oysters. In the following pages I shall only mention methods which have been sanctioned by long experience, dating back certainly for several centuries. I shall not entertain any theories or enter the domain of hypothesis, but remain faithful to the practical idea in which this book was conceived.

METHODS OF BREEDING AND REARING OYSTERS, MUSSELS, LOBSTERS, &c.

CHAPTER I.

INDUSTRY AND PRESENT METHODS.

In the preceding pages we have said that the only methods described in this book would be such as had been sanctioned by centuries of experience, and we now propose to prove that our assertion was not falsely made by describing in a few words the artificial breeding of oysters, taking as guides, if not as models, two examples: one, that of Lake Fusaro, which dates far back in the Christian era, and the other, that of Marennes, which began in the earlier times of our history. About the beginning of the seventh century a Roman knight, Sergius Orata, undertook the artificial breeding of oysters in the waters of Lake Lucrin, the Avern of poets. Historical documents prove incontestably the existence of this establishment of oyster culture, and Pliny informs us that the enterprise was very successful, and its author in a short time became very rich. The methods followed, and probably invented, by Orata have been perpetuated to our day upon the banks of Lake Fusaro, a small salt-water lake, about a league in circumference, situated in the neighborhood of Cape Misène, near the ruins of Cumes, which has been poetized by Virgil under the name of Achèron. Upon the blackish mud, which covers the volcanic soil of this basin to a depth of from one to two meters, the fishermen have constructed here and there artificial rockeries formed of rough stones gathered together and thrown into heaps sufficiently elevated to be protected from deposits of mud or slime. Upon these rocks oysters taken from the sea were deposited, to form an

artificial planting ground for all time, except, as is well understood, in the case of accidental mortality, such as has been occasioned by volcanic eruptions, which have sometimes necessitated their renewal. Each rockery (Fig. 5) is surrounded by a circle of stakes, which are fastened

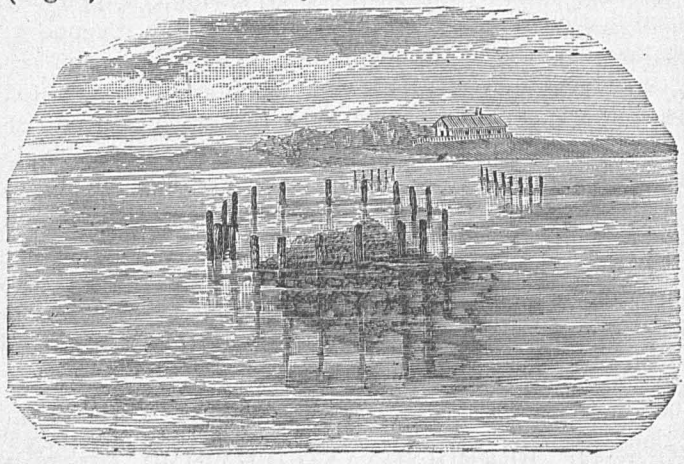

FIG. 5.—Artificial oyster rockery of Lake Fusaro.

in the bottom of the lake by one end, while the other extends up out of the water so that they can be seen and removed when necessary. Often these stakes are united by a cord passing from one to another (Fig. 6), and to which is suspended, between each two stakes, a small bundle of twigs, floating in the water a short distance from the bottom. These, together with boats, tools, and a storehouse, constitute the entire apparatus used for oyster culture at Fusaro, and such is the apparatus which common experience has found to be invariably efficacious. At the spawning season the oysters deposited upon the artificially formed rockeries, and living there as if in the open sea, allow the myriads of germs to which each gives birth to escape, as an animated cloud of dust-like particles, which, finding close at hand suitable materials for their attachment, become located there almost as a mass, beside the mother oysters. An insignificant portion only of these young oysters are lost, either by being carried away by the current of the water, or by being buried in the mud of the bottom. The colony is thus continually increasing in size by the

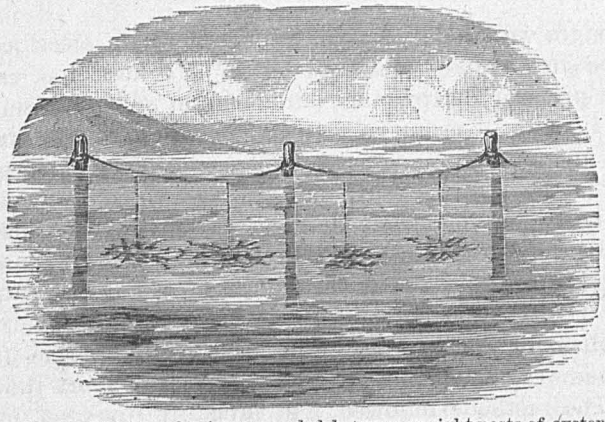

FIG. 6.—Bundles of twigs suspended between upright posts of oyster rockery.

annual deposit of new germs, which develop under favorable conditions of shelter, light, and temperature. When the fishing season arrives the owners or leasers of these artificial banks take up the stakes and bundles of fagots, select without any trouble from among the oysters which cover them those of a suitable size for the market, and then replace the stakes, &c.; the remaining oysters continue their growth, and the vacant places become filled another season with a new lot. The industry at Lake Fusaro, which has prospered for centuries, employs, as can be readily seen, only methods of great simplicity—probably the same as were used by Sergius Orata—and it teaches for our benefit, that by careful and skillful management, aided by suitable means of collecting the spawn of the oyster, all of which is neither difficult nor expensive, one can indefinitely multiply this bivalve, while the processes employed by us at present lead only to the ruin of our naturally excellent beds. At Marennes, upon both sides of the mouth of the Seudre, a similar industry is perpetuated, and is being developed more and more under the patronage of the state, but unfortunately it is merely directed to the work of bringing to perfection these animals taken from the sea and transplanted in the new regions without any effort to reproduce and multiply them. In spacious live-ponds, called claires, constructed upon a definite plan, to be described in one of the following chapters, are placed the oysters taken from the sea, preference being given to those about 12 to 18 months old; that is, much below marketable size. These claires are so arranged as to allow of a careful inspection on the part of the breeders, to facilitate the distribution of the sea-water at will, the clearing of the bottom, and the gathering of the products. In these claires the oysters are arranged by hand upon the bottom, which has been made hard and free from mud; they are so deposited that they do not crowd one another or lie in piles, and are left there to increase in size, grow fat, and acquire that greenish color which is so much desired by amateurs. During the period of their growth the water is renewed only during the spring-tides. The additional labor consists simply in regulating the depth of water over them according to age and temperament, in changing them from one claire to another if any danger arises of their becoming covered with mud and thus smothered, and in culling them according to size. In about two years they attain marketable size, and compensate largely by their extra value for the necessary outlay in their rearing. This method is far from perfect, since in the first place the great mistake is made of drawing from the claires only one-half of what they might be made to produce. As breeding places they ought also to be places of reproduction and multiplication, and they might be such, as has been often shown accidentally. But, such as it is, it offers us a good model as a method of management, and also an argument in favor of the new industry, the reality and success of which is, I trust, no longer doubted by the reader; thus we can enter without fear upon the details of the practical workings of oyster culture, which we shall proceed to develop in the following chapters.

CHAPTER II.

MEANS AND METHODS OF GATHERING AND TRANSPORTING OYSTER-SPAWN.

If the reader has attentively followed and understood what has been recorded on the preceding pages concerning the causes of the ruin of our oyster-beds, the evil resulting from the present mode of gathering oysters, and, finally, the methods of reproduction, especially that employed at Lake Fusaro, he has probably been able to recognize that the first, and by all odds the most important, thing to be done in the new industry, is to gather up, with the least possible loss, the young growth sent forth by the mother oysters during each spawning season, then to cause them to attach themselves to some object which will give them sufficient support for their future growth, and also allow of their removal, either to preserve them from mud or other causes of mortality, or to transport them to a distance in order to restock barren territories, or acclimate foreign species.

Accordingly we propose to proceed at once to the description of various styles of apparatus used in such collecting, and indicate, for each one, the conditions under which it is especially to be recommended.

Movable collecting apparatus.—In those sections where oysters already exist, and where the fishermen have not completely stripped the beds, the fixed collecting apparatus is alone necessary for the multiplication of this mollusk; but when it is demanded of the beds that they not only furnish supplies to the ordinary fishermen, but also the young necessary for restocking barren lands, and medium-sized oysters for the artificial parks and basins, then movable collecting apparatus should be used. This is the most economical method, and the most certain, when it is desired to plant oyster-beds upon virgin soil. Many efforts have already been made to stock new waters and restock old by throwing into the sea oysters which have been taken at a distance and transported at great expense to the place of the experiment; but nearly all the attempts have proved futile, either from the impossibility of keeping oysters alive on board of vessels during a long voyage, or from their soft condition at the time of their arrival and their sudden change into a strange water, or possibly from not encountering in their new locality conditions suitable to their existence. Moreover, this process is very expensive, and very slow, for the oysters destined to be the source of the future supply are necessarily always very limited in number, and must be above all carefully preserved and no fishing allowed until the young from the first spawning, which may have been much retarded by reason of the change of locality of the old ones, have attained a marketable size. Thus a period of five or six years at least must elapse before sufficient returns can be ex-

pected to compensate for the advances made; during this period, from the impossibility of knowing precisely what is taking place beneath the surface of the water, everything must be left almost entirely to chance. On the contrary, when the movable collecting apparatus is used the territory can be planted not with thousands alone, but with millions of young, of various ages, whose management is easy, since they are all bound together, thanks to their common support, which permits them to be placed at will in the most favorable conditions of bottom, depth, temperature, and light. Inspection is also easy, and can be undertaken at any moment. At the end of three or four years, when the oysters should have attained marketable size, they can be culled, on account of their large number, and the largest sold, leaving still a sufficient number to assure the continuous and definite repeopling of the bed.

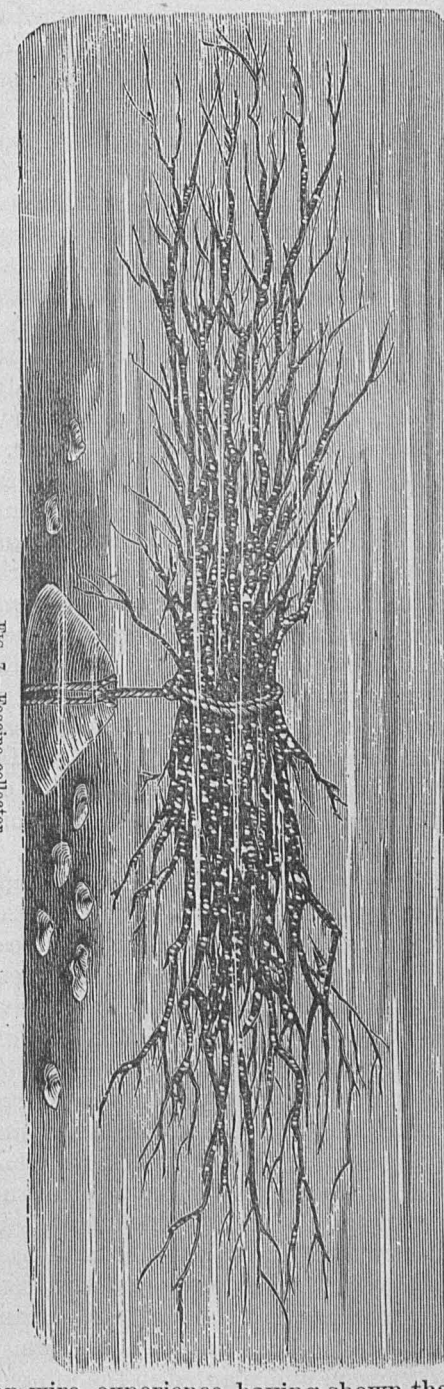

FIG. 7.—Fascine collector.

Fascine collector (*Fig.* 7).—The most simple movable collecting apparatus, and the least expensive, at least in the beginning, consists of bundles of small branches of chestnut, oak, or elm, fragments of grapevine, or, in fact, of any wood containing no poisonous or aromatic principle which by dissolving in the water can injure the spawn or prevent its adherence. The fascines or bundles of fagots, from one and one-half to two meters in length, are bound around the middle with strong galvanized and tarred iron wire, experience having shown that

hemp cords cannot endure, without decay, a prolonged sojourn under the water. The fascines are also furnished with stones, which, being attached by other wires to the first-mentioned central wires, serve to anchor the fascines and maintain them at a depth of from 20 to 30 centimeters above the bottom.

About three weeks before the spawning season the fascines are placed over the beds from which the spawn is to be gathered, and are so disposed, according to the configuration of the bed, that obstacles as collectors shall be met with in every direction where the tidal currents may be transporting the embryos. Experience has shown that fascines thus disposed receive the young in such abundance that each often holds several thousand. They are left in place from five to six months; by this time the young oysters have attained a size of from 2 to 3 centimeters in diameter, and can very easily be removed from the branches to which they are attached, and placed in such grounds as it is desired to restock, whether these be far or near, for nothing is easier than to carry these young animals, either upon the fagots or off, providing fresh sea-water is supplied them. The disadvantage of this apparatus is that the same fagots cannot be used more than once, or for a single gathering. The action of the sea-water soon destroys them, and they do not generally last long enough to permit the oysters which cover them to acquire a marketable size. This process may be advantageously employed to increase the supply of oysters in a park, but always upon the condition that it is to replace those taken away and for the multiplication of the quantity in the park, for the entire renewal of the fascines each year would be too expensive. This is not the method, however, to which we would give the preference in the case of a long journey by land or sea, in transporting the young growth from the place of production to the breeding ponds.

Platform collector.—This collecting apparatus is susceptible of all manner of modifications as to form and size to adapt it to the character of the ground upon which the bed is located. Not only is it easily made, arranged, and handled, since one person can perform all the labor necessary, but it also does no injury whatever to the oysters which it covers. It is generally placed in position one or two weeks before the spawning period, and during its stay over the bed it preserves the oysters from all deposits of mud; when it is charged with a young growth it can be taken down in a short time and transported to any required distance, leaving the bank which it had covered not only in its primitive condition, so far as the original stock is concerned, but moreover enriched by a large number of germs which, had it not been for the presence of the collector over the bed, would have been carried away, at least in great part, by the tidal currents, and thus lost. The platform collector consists (Fig. 8) of several rows of posts arranged in pairs, A, each pair being fastened together, with an intervening space of 12 to 15 centimeters (4 to 5 inches), and planted in the ground over the entire area of the bed

at a distance apart of about 2 meters, with each pair occupying one of the angles of a square, so that the surface covered is divided up into

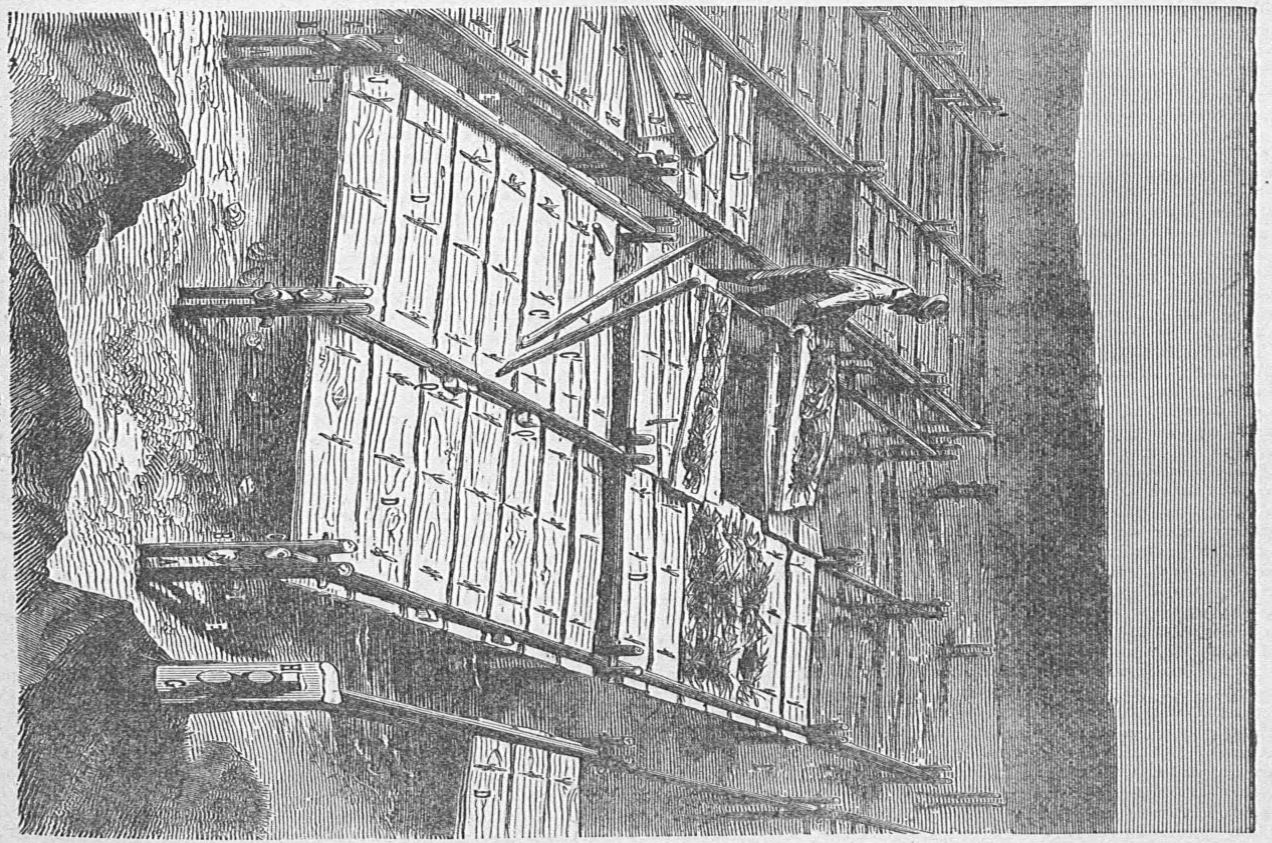

FIG. 8.—Platform collector.

blocks, much like the surface of a chess-board. Each set of posts is pierced through by two sets of holes, the first at one-half meter and the

second at .75 to .80 of a meter from the bottom; bars of wood or iron are passed through these holes, thus making each pair a sort of ladder with two rounds. Upon the lower rounds, from post to post, are laid bed-pieces, or stringers, B, which should be quite strong, and which together constitute a frame-work of contiguous squares, upon which a platform of rough planks, D, is built and maintained in position by a second series of stringers, C, held down by the upper round, J, of the posts; the pressure upon the planks is regulated when necessary by means of beveled wooden blocks, Q, Q'.

It will be readily seen that, by the aid of these stringers and rounds, nothing can be easier than the mounting and dismounting of the planks, either to change or turn them, or transport them elsewhere. Whenever desired the stringers and posts can be so arranged as to leave free spaces, E, as passages, to facilitate the working of the platform. The planks should be of pine or fir, and from 2.10 to 2.15 meters (6 to 7 feet) in length, by .20 to .25 of a meter in breadth (8 to 10 inches), and .04 of a meter (about 1½ inches) in thickness.

In order to facilitate the adherence of the spawn, planks with a rough surface are used, and the rougher the surface, as by gouging it out so as to increase its irregularities, the more easily can the young oyster adhere to it. The sides of the planks can also be covered with a layer of pitch and tar, in which, while it is yet soft, valves of oysters, mussels, or any other shells, which occur abundantly along the shore, or bits of coral, or small stones of about the size of a nut, can be placed, so as to form a sort of artificial, rock formation, favoring very much, by the roughened surface and the multiplication of points of attachment, the deposition and development of the young animals. This is much preferable to the other method, since it preserves the planks from the action of the water and the destructive borings of certain worms and mollusks. In order to afford a still greater number of points of attachment for the young germs, the lower face of the planks is covered with fascines of chestnut, oak, or other wood, which are held close to the planks by means of cords, passing through holes in the planks and fastened upon the upper side (see Fig. 8). Upon sandy or muddy bottoms the posts which support the stringers can be set without difficulty; but when the bottom is rocky or too hard they cannot be employed. They should then be replaced by blocks of stone, G (Fig. 8), about .70 of a meter in height by .25 of a meter in breadth and thickness, pierced through by a hole of sufficient size to receive the ends of the stringers, which are fastened there by means of a small block, H, driven in upon the upper side. These blocks can then be simply placed upon the bottom or fastened there with iron clamps; or the wooden stakes can be employed by fixing their lower ends into blocks of stone which when in place should be large enough to give steadiness to the collector and maintain it in its right position. This form of collector, it is true, is costly to establish, and more so from the fact that on account of the long time it must stay

in the water it is necessary to select firm, solid wood, of good quality, but in its adjustment there is no need of any particular nicety of workmanship or finish, and there is moreover this advantage that it lasts a long time and can be used for several harvests. However, in those waters where boring worms and mollusks occur, a single season will render the platforms unfit for further service. In this case galvanized iron supports can be used in place of the wooden frame-work and the planks may be replaced by sheets of metal having the two faces covered, as already described, with a mixture of pitch and tar, in which valves of shells, bits of coral, or small stones have been imbedded. The metallic sheet, which forms the body of these pitch planks, will give sufficient solidity to the structure, and the supports can be in the form of a frame-work, capable of holding at least three sheets, which can be fastened in position by means of bolts; the entire structure may be arranged like a table upon four or eight legs, which can be driven into the ground, or fastened into blocks of stone, which will give the desired stability to the whole. These tables can be placed in rows according to the configuration of the bed, leaving passages between each two rows to facilitate working them. After the spat or germs have been collected upon the planks of the platform they can be easily transported either by sea or land. If by sea the planks are taken from the stringers and suspended lengthwise and vertically in a frame-work provided with floats, or arranged in the direction of the current, like a series of shelves, about one-fourth of a meter apart, and thus kept constantly in the water; in this shape they can then be towed without trouble to any distance. When they are transported by land the planks are either carried in tanks full of sea-water, or placed between layers of wet sea-grass, and when so managed the young oyster can sustain, without serious damage, a journey of one or two days. When their destination is reached the young oysters are detached from the planks without trouble, as this operation demands only a slight amount of skill and attention, and deposited in the places to be stocked; or the planks may be placed upon supports similar to those whence they were taken, and the young oysters allowed to continue their development protected from the mud, and in such a position that by turning the planks the conditions of light and aëration can be varied to suit the wants or requirements of the growing brood.

Box collector.—This apparatus unites the double advantage of presenting in a relatively small compass the greatest possible extent of surface for the attachment of germs, and, at the same time, the most favorable conditions for the transportation and ultimate development of the young, in the movable and independent parts which compose it. It consists, essentially (Fig. 9), of a rectangular box, two meters in length by one meter in breadth and height, and is without any bottom. It is formed of planks, O, placed from 2 to 3 centimeters apart, or pierced with holes, for the entrance and circulation of water in the interior. These planks are permanently maintained in place upon the

front and back sides by two cleats, R R, extending below the edge of the box and are nailed to transverse pieces, which pass across the bottom from side to side. The ends are pierced by three sets of holes to accommodate the transverse bars, S, upon which in the interior are placed movable frames, dividing the box into superimposed compartments. The cover is formed of thinner planks, D, placed side by side, and maintained in position by the bar T, which slides into the two sockets, A, at the ends of the two stakes supporting the ends of the box. It is hardly necessary to add that the apparatus should be constructed of solid planks of a durable wood, such as oak, and that the fastenings of the parts should be, so far as possible, of the same kind of wood, employing neither iron nor nails; but if their use is absolutely necessary, then the preference should be given to iron or galvanized nails. The frames for the inside are of wood, about 4 centimeters in thickness, and furnished with two handles to facilitate removing. The bottom is covered with brass wire netting (Fig. 10), the meshes of which are about 2 centimeters upon a side, and in order to increase the strength of the frame and sustain the netting, diagonal wires can be run across from corner to corner, or a central bar of wood from side to side.

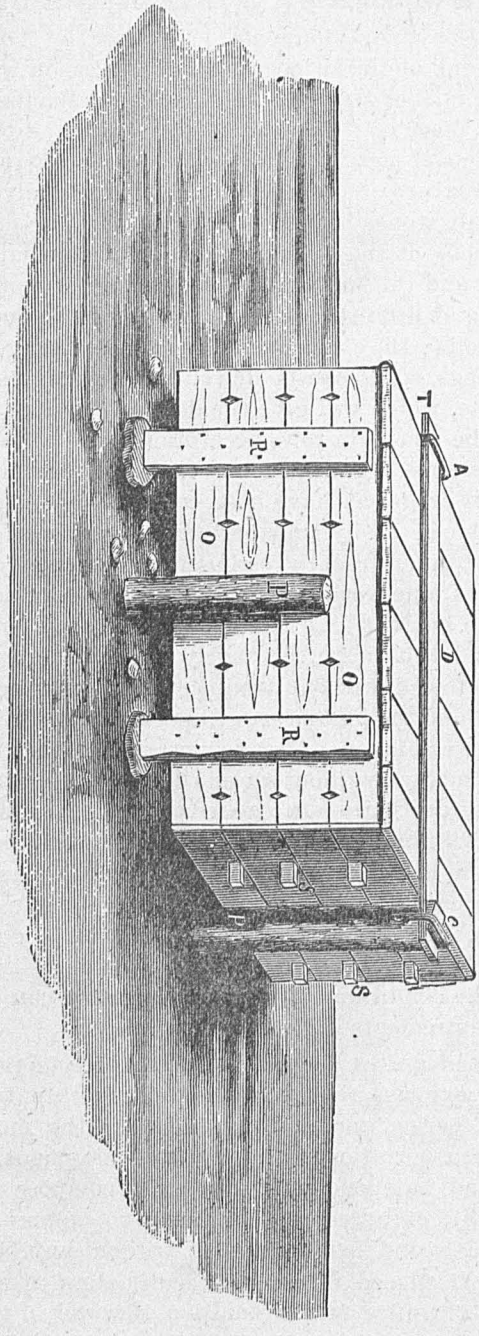

FIG. 9.—Box collector. Exterior view.

These frames are made of such a size that when placed side by side, two

of them will form a continuous flooring or division across the box, as shown in Fig. 11, where the front portion of the box has been removed so as to show the arrangement of the interior. It is necessary, however, to give sufficient play to the frames, so that they can be moved at any instant without trouble and without shaking. We herewith give the conditions in which this apparatus is used, and the method of operation.

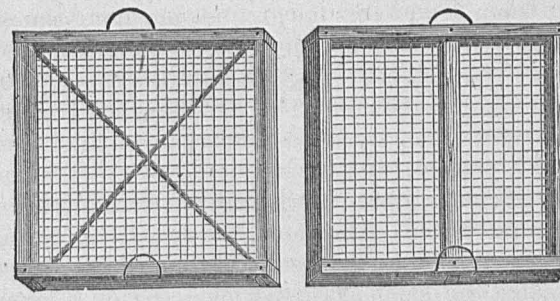

FIG. 10.—Inner frames of box collector.

The box collector is especially valuable when the oyster culturist has no natural bed near at hand whence to gather germs, and yet wishes to procure a large number of young to rapidly stock a park or live-pond. For he can always, just before the spawning season, have several hundred oysters brought from the bed nearest his basin, since oysters when they have attained a certain size will sustain transportation for several days without damage, providing the precaution is taken to furnish them with water now and then. Once in possession of these oysters, in a good location, where the water is calm without being stagnant, the bottom pebbly and properly protected from mud, and the light and depth suitable—or even in an artificial basin of from 1 to 1½ meters in depth, which communicates with the sea at each tide—the box is placed upon the bottom in such a manner that the lower transverse pieces rest upon stones and the entire lower side is off

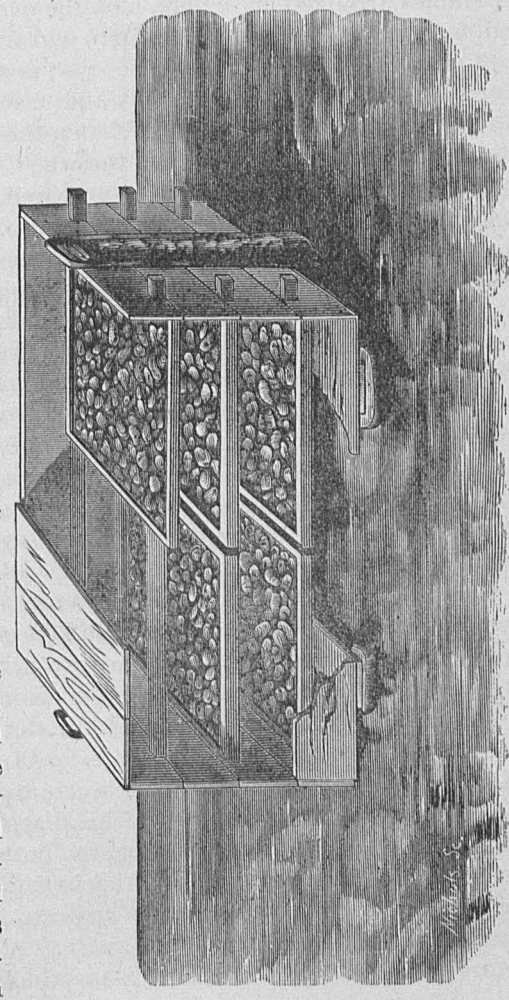

FIG. 11.—Box collector. Interior view

the ground, enabling a free circulation of water. Four stakes, P P, Fig. 9, are then driven into the ground, one along the middle of each face of the box, so as to prevent any swaying or change of position, by the action of the waves and currents, and maintain the apparatus in the same position. The cover is then removed, and sixty mother oysters are deposited upon that portion of the soil circumscribed by the box, care being taken, if the soil is soft or muddy, to cover it previously with empty shells, so that the oyster, when placed there, may not become covered up but always remain in pure water. This done, the two lower stringers, S S, are placed in position, and upon them two frames (Fig. 10), are arranged, which are treated the same as the bottom; that is, a layer of shells is first placed upon them, and then a certain number of mother oysters above and over the shells. The second set of stringers is then placed in position, the frames arranged as before, and the oysters distributed over them, and, finally, the third set of stringers and frames are arranged and covered with shells (Fig. 11), but no oysters are placed upon them. The cover is then placed upon the box and fastened down by means of the top bar and the wedges, C, which fasten the ends of the bar in the sockets of the end posts, and render the whole apparatus solid and immovable. The apparatus being thus prepared, it is easy to conjecture the result. The oysters, under such excellent conditions of existence and in such pure and quiet water, soon spawn; the young growth, finding itself imprisoned, or nearly so, in the various compartments of the box, and coming upon suitable places of attachment near at hand, remain in the box and dispose themselves nearly everywhere, but from preference upon the shells covering the frames, and proceed in their development under the best possible conditions and protected from all danger. In from five to six months the young oysters have attained such a size that they can be removed without danger. The apparatus is then taken apart piece by piece, commencing with the cover, and as each tray is removed its contents are deposited upon the bottom of a park, live-pond, claire, or such place as one wishes to restock or supply. If it is desired to carry them to a distance the trays can be placed in a floating box pierced with holes, and if arranged in layers, like shelves, and with sea-weed packed between them, so as to prevent the disturbance and shaking incident to movement in the water, they can be towed for long distances without danger of injuring the shells of the young oysters or detaching them from their supports. And if the trays are packed in boxes with wet sea-weed between them they can be transported by land very nicely. For one who has limited means at his disposal, and when labor and expense is an important consideration, the box collector ought by all means to be given the preference; by the ingenious method of multiplying surfaces, which is its distinctive feature, innumerable germs can be hatched out in a very restricted space. A small case of a few square meters in area, a small artificial basin which can be filled at each tide, and a narrow passage-way between two rocks, is amply sufficient for

the production of the thousands of germs necessary for the stocking of a live-pond, or even a larger inclosure; for the possibility of placing two or more of these boxes close together without injury to the oysters or the germs which they contain, permits a response to all the demands of the breeder, however restricted or extended they may be. Moreover, the apparatus itself, besides being easy to manage, arrange, and transport, will last for several years if suitable wood is used in its construction, and if the outside at least is protected in some such manner as are the bottoms of vessels, by a sort of sheathing. As to the inside, as well as the cross-pieces and the wooden parts of the trays, they can be covered with the mixture of tar and pitch already mentioned, and incrusted with shells and stones, which will not only preserve them from rapid decay, but also render them suitable places of attachment for the young oysters.

Fixed collecting apparatus.—When the bottom is already covered with oysters, either from the existence there of a natural bank or by artificial means, movable collectors are useless, and for the multiplication of these oysters, the proper method is by means of fixed apparatus, which, while much less expensive and complicated than the preceding, performs the same office. The various kinds of fixed apparatus are as follows:

First. *Pavement collectors.*—This method, employed at the island of Ré, at Rochelle, &c., consists in covering the bottom with blocks of stone irregularly broken and formed into a sort of uneven pavement, and by so arranging the pieces that as many crevices and prominences may exist as possible. The best way of arranging these pieces is to group them in threes, two being placed flat, at a short distance apart, and the third above and resting at its extremities on the other two, in such a manner as to form a sort of bridge with the arch, or third stone, sufficiently elevated above the bottom to be out of reach of mud.

The young growth, moving freely in the water, becomes attached to these rocks, in the hollows and under the arch stone of each set of three, where they are protected, and where pure water and a mild light are offered them, conditions which are very necessary during the early stages of their existence. During the first year they should be left entirely in peace, and at the spawning period all that is necessary is to simply turn over the upper stones without touching in any manner the lower ones. The oysters which have become attached to the lower sides of these stones are thus exposed to a full light, a condition favorable to their future development, and the upper faces of the stones, now turned downward, are ready for the attachment of the next growth. During the third year the oysters upon the upper surfaces of the stones can be taken off, having acquired a sufficient size to permit of their being placed with others upon the beds or in the fattening ponds, and the stones can again be turned so as to expose the oysters upon the under side to the full light, and leave a fresh under surface for a third growth. This process is not expensive, at least in those sections where, as in the island of Ré, the rocks of the coast furnish ample supplies for all the pavements neces-

sary in the working of the beds. Moreover, it demands neither much skill nor long and wearisome labor; but there is one bad feature: the oysters which develop upon the stones become attached to them so firmly that they cannot be removed without destroying a great number, and they often grow in such a bad shape that they are not of much value in the market. I think, nevertheless, that the nature of the pavement has

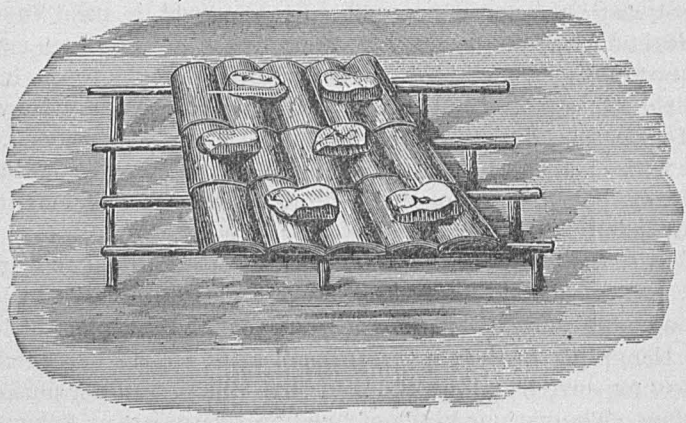

FIG. 12.—Tile collector, simple form.

much to do with the first of these two defects, and that, where one can make use of soft stones, such as limestone and pudding-stone or fragments of coral, the adhesion of the shells might be easily overcome, and in this case the pavement collector, as being economical and easy to use, would give most satisfaction. Those misshapen oysters, on the other

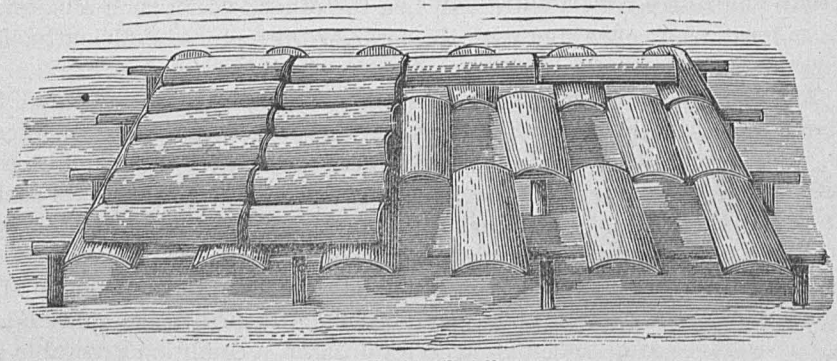

FIG. 13.—Double tile collector.

hand, which are little sought after for the table in their natural condition, can be used without disadvantage in making pickled oysters, or preserved in any other manner, and thus supply a constant and remunerative demand.

Second. *Tile collector.*—In regions where rocks are scarce, and also to avoid the disagreeable features mentioned above as pertaining to the pavement collector, one can make use of curved tiles, similar to those

employed in certain countries upon the roofs of houses, to gather the young oysters. For this collector lines of stakes are driven into the ground, over a space of 15 to 20 centimeters of the surface of the bed whence it is desired to take the spawn. Upon these stakes transverse stringers are fastened, along which tiles are placed side by side, with the concave side down (Fig. 12). Here and there heavy stones are placed upon the tiles so that neither the current nor the waves can raise or displace them. But this disposition of the tiles is not the only one; many others can be adopted which multiply the surfaces of attachment for the young. Thus the tiles can be disposed in two superimposed and crossed layers (Fig. 13), forming a double tile collector, or again, as in Fig. 14, they can be set up obliquely between the trestles, which in this case may be placed nearer together; the tiles form an angle of about 25° to 30° with the surface. Still another method, in which the wooden trestles are dispensed with, is to arrange the tiles in the form of a tent, or pointed roof, kept in place by stones placed between the rows

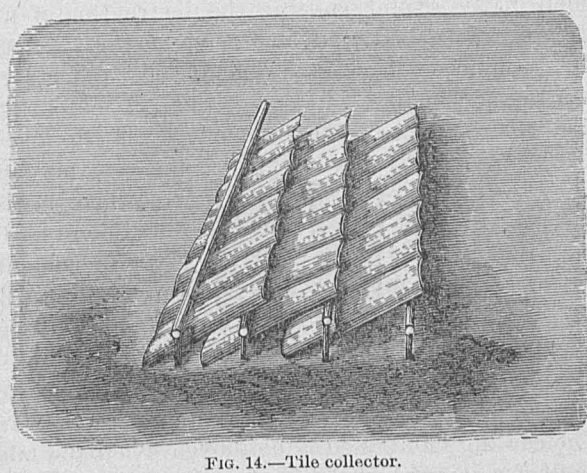

FIG. 14.—Tile collector.

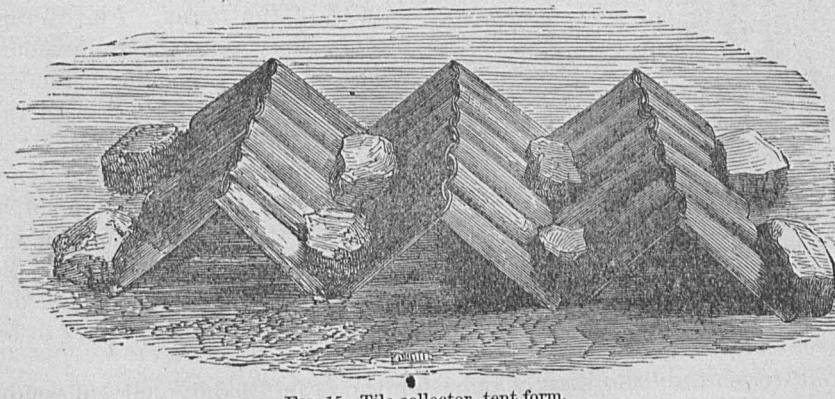

FIG. 15—Tile collector, tent form.

(Fig. 15). This last disposition is the most simple, the least expensive, and moreover not a bad one, for it offers a very large amount of surface for the attachment of the young. Whichever style of tile collector may be employed the concave surfaces of the tiles become covered at the spawning season with the young growth, which develops there under excellent

conditions and which can be easily detached when the size of the oysters is such as to fit them for the parks, or for the bottoms where the mother oysters live.

To Dr. Kemmerer, of the island of Ré, is due the credit of numerous ingenious contrivances in the arrangement of tiles as collecting apparatus. The tile is in fact the fixed collector par excellence, except that, like the pavement, it affords too firm and complete an attachment for the shell of the oyster, causing the destruction of numerous animals when they are detached, and also often giving a defective form to the shell. Dr. Kemmerer, in order to remedy these defects, covered the tiles with a coating of cement, composed of water-lime, four parts of water and one of defibrinated blood. This cement dries rapidly, hardens under water, but remains sufficiently brittle to enable the oysters to be detached without difficulty. Or, if desired, the entire layer of cement can be taken off in a single piece, when the young oysters are sufficiently grown, and in this manner transported to a distance to stock depleted parks or territories, while the tile can be recovered with a coating of cement and used a second time. The coating mentioned is employed when the labor of preparation can be performed at home, but when it is necessary to make repairs, or coat the tiles at the parks or preserves, then a coating is used of water-lime and Grignon or Vassy cement, very hard plaster, or water-lime and pounded brick. The presence of the lime seems, moreover to have a very favorable influence upon the deposit of the young. Fig. 16 represents the various arrangements preferred by Dr. Kemmerer for his cement tiles. No. 3 represents the tile pierced by a simple hole, 4 the tile with its coating of cement alone, and 1 and 2 the cemented tiles with fragments of grape-vine and shells embedded in the cement. Fig. 17 represents the best methods of arranging the tiles so as to give a large exposure of surface and sufficient solidity to the pile. The various forms of apparatus we have just described are not the only ones in use, nor are they the only ones to be recommended.

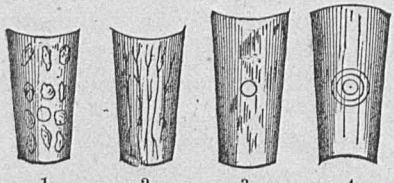

FIG. 16.—Kemmerer tiles.

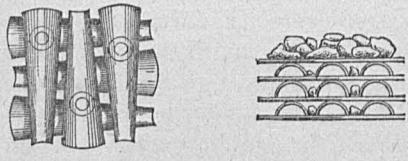
FIG. 17.—Tile collectors.

The essential condition which should be fulfilled by all collecting apparatus, that of offering proper and extended surfaces for the attachment of the young, is so simple that the mode of constructing apparatus can be varied in a thousand ways. The fundamental principle being once comprehended, the oyster culturist, by using the above described collectors as models, can vary the form, the disposition, and the material according to his means, the resources of the locality where he labors,

and the price of the component parts. We will leave this subject, then, to his ingenuity, trusting we have said enough, so that he need not run any risk or labor in the dark in this first stage of the oyster industry, in which the collecting apparatus is an instrument of prime importance.

CHAPTER III.

PREPARATION OF THE BOTTOMS.—CONSTRUCTION OF CLAIRES, PARKS, LIVE-PONDS, ETC.

All bottoms are not equally adapted to the culture of the oyster; some, even, are entirely opposed to it and can be modified only by completely changing its nature. It is, then, of primary importance for the oyster culturist to know how to rightly estimate the value of the soil which he wishes to work, as to its aptitude for the production and growth of this mollusk, and to be able to modify it according to the needs of the case. This is the subject which we propose to treat of in this chapter.

The type of marine bottom especially adapted to the growth of oysters is offered to us at several points along our coast, particularly in the Bay of St. Brieux. The bottom there is firm and suitable, covered with a rather thin layer of fine sand, formed by the *débris* of shells ground up by the action of the sea and the natural wearing of one shell against another, with large fragments or whole shells scattered here and there over the surface. There also occurs here a thin layer of marly mud, similar deposits of which exist nearly everywhere, but it never increases in this locality so as to become injurious, for at every tide the water, which comes in from the ocean with great velocity, carries the greater portion of the mud off with it as it retires. Moreover, the water of this bay is singularly well adapted to the development of all kinds of marine animals, from its vivifying properties, brought about by its ceaseless dashing and breaking upon the numerous rocks which line the coast, and by its constant renewal through which it maintains a favorable mean temperature. We will take this sort of bottom as a type and model, and indicate by what means those places which differ from it in some respects can be modified so as to produce nearly as favorable results. It can be said, in general, that all soils are or can be made suitable for the culture of oysters, although in different degrees; the only ones to be excepted are those formed of large deposits of mud, so deep and so constant in its renewal that there is no hope of its being carried away; and those constantly shifting sand-banks, which change with every spring or very high tide and every heavy sea, covering up upon one side as much as they uncover upon the other. The impossibility of any previous preparation of such soils will prevent any desire or attempt at working them. We shall not, therefore, treat of such bottoms, at least not in this chapter, but confine our attention to oyster culture on those

bottoms which are naturally solid, and only altered by superficial deposits.

Muddy bottoms.—As is well known, mud is the result of the deposition of pulverized material of any kind which is held in suspension by the water, having been gathered from the bottom of the open sea during stormy weather, or produced by the decomposition of animal and vegetable forms, or by the erosive action of the waves upon submarine rocks. So long as the water is in constant agitation these materials remain in suspension, and no mud is deposited; but whenever the water becomes quiet, these fine particles, being denser than the water, drop to the bottom, resulting in the formation of mud; however short a time the stagnation favorable to this deposit continues, so long as it lasts the layer of mud goes on increasing in thickness until the entire bottom is rendered completely sterile. The first thing to be done, then, in order to render a muddy bottom suitable for the growth of oysters, is not only to clear the bottom of the mud, but especially to prevent its future deposition. The most certain and most economical method is to make the water itself remedy the evil which it has produced, and prevent its return. One very simple observation will be a lesson in this direction. A deposit of mud is never found at the foot of a rocky cliff, or distributed over a bottom covered with reefs or ridges, since in such localities the water, even in the calmest seasons, is never in perfect rest, but always in motion, and broken into thousands of little streamlets and currents by the many obstacles which it encounters. Although pure, the water of these sections is always charged with infinitesimal particles taken from the mineral substances of the bottom, or ground up from the organic *debris* which is found here. These particles can be recognized without trouble when the rays of the sun penetrate down into the water, just as in a chamber the particles of dust in the air mark the ray of light which penetrates the room. In a word, in sections of this character the water makes mud but does not deposit it. It is this natural effect which it is desirable to have produced artificially upon bottoms covered with mud, first to clear the mud away, and secondly to prevent its return. In order to accomplish this a wall of broken and irregular fragments of rocks so disposed as to produce the greatest number of obstacles and checks to the action of the waves is built along the edge of the shore, at the extreme inner limit of the mud. The next day the success of the movement becomes apparent, the sea comes rolling in and breaking against the rocks, lashing them upon all sides; it stirs up the mud from the bottom and retires loaded with the sediment which it bears off with it, until all the mud along the base of the wall is gradually borne off to sea. A gain of ground having been thus accomplished, a second wall of breakers is formed outside of the first, and when the space in front of this is clear of mud, a third line is run around the second, and so on, breaker after breaker; by gradually driving the mud farther and farther into the sea, solid and permanent

ground is obtained, which is visited by pure and aerated water, where oysters can be planted and where they can flourish unmolested; often upon such places a self-planting takes place, that is, the young, floating in the water after having escaped from some natural bed, finding the place in excellent condition for their reception, attach themselves to the rocks and form a new colony. When the deposit of mud is once completely broken up, the rocks, by the aid of which this result has been accomplished, will serve to prevent its return, and as all the rocks will not be required for this purpose some of them can be used as fixed pavement collectors, the advantages and disadvantages of which have been noticed upon a previous page. Certain of the walls may be entirely removed and shells and valves of diverse mollusks, found in abundance nearly everywhere, can be scattered about in the intermediate zones, or other collectors, either fixed or movable, may be employed in the spaces between the lines of breakers.

Sandy bottoms.—Sandy bottoms, if the sand forms a comparatively thin layer resting upon a sure and solid subsoil, so that the action of the currents, tides, and heavy seas is never intense enough to produce great changes, capable of covering up the oysters which may be placed upon them, are the best and may be worked without any fear. All that is necessary, when the oysters are planted, is to distribute a layer of shells over the bottom, and these shells sinking slightly in the sand will give it a certain degree of fixity, and, gradually consolidating by the attachment of oysters to them, will soon transform the entire bottom and even change it into a bed of great value.

Bottoms of grass or weeds.—Certain bottoms become invaded by an abundant submarine vegetation consisting of grass, various kinds of seawrack or algæ, including the *maërle.* In their natural condition these regions cannot be utilized for the cultivation of the oyster. By their presence these plants serve to entirely stifle both old and young oysters, and they moreover give refuge to multitudes of crustaceans, mollusks, and polyps, which gain their nutriment principally by feeding upon the young of other marine animals, or in the case of some mollusks, furnished with a boring tongue, they pierce the shell of the oyster and gradually eat out the soft animal parts contained within it. It is necessary, then, if one wishes to cultivate these bottoms and raise oysters there, to commence by dragging up all the parasitic vegetation upon them, and then, to prevent their reappearance, the entire bottom must be covered with a thick layer of shells and broken fragments of rocks, which must be pounded down nearly, if not quite, to the subsoil. But even then it will be well to keep a constant lookout over these bottoms, for marine vegetation has a strong tendency to reproduce itself in the same places, and holds its ground for a long time by means either of subterranean roots or of seeds. It is only by perseverance that they can be finally eradicated. Only after this has been accomplished can oysters be planted without danger of losing both the young and future harvests. What

we have just said in regard to marine plants applies equally well to mussels when it is desired to replace them with oysters. Frequent dredgings will be necessary in order to remove the greater number of these animals, whose presence, moreover, nearly always coincides with a muddiness of the bottom, and necessitates, in this case, a cleansing of the bottom as indicated above. But the mussel is essentially rustic, if I may be allowed the expression, and accommodates itself to nearly all conditions of bottom, so that when the mud has been taken away and the mussels have all been scraped up, it will be none the less necessary to pay frequent visits to the collecting apparatus and carefully remove all the groups of mussels, large or small, which may be discovered. When the multiplication of the oyster is well assured, and it covers all the bottom without leaving any vacant places, this vigilance may be relaxed a little, for although the mussel, when it can invade a locality, is a redoubtable enemy to the oyster, the reverse is also true, and the presence of a bank of oysters in fine growing condition is sufficient to keep the mussels from such preoccupied grounds.

Emergent and non-emergent bottoms.—Finally, the marine oyster territory can be divided into *emergent* and *non-emergent* bottoms. The first are found all along the shores of the ocean and the British Channel, and consist of those lands which are left uncovered, either at every tide or at the spring-tides, thus exposing for a length of time to the air and light, which may amount to several hours per day, the marine animals which inhabit them. The second or non-emergent lands lie on the ocean coast and join the emergent lands. They are never exposed by the withdrawal of the water. Upon the coast of the Mediterranean and other inland seas, where the action of the tide is scarcely felt, all the lands are non-emergent. Both kinds are suited to the cultivation of the oyster, but to a variable extent, dependent upon circumstances. The emergent lands, since they are frequently uncovered, have the great advantage of facilitating all the labor necessary to their management, the sorting, the arranging, and the gathering of the oysters, all being done without trouble when the surface is free from water. But the oysters ought not to be arranged indiscriminately, old and young together, for a long sojourn in the air, exposed to the fierce heat of the sun in summer and the hard frosts of winter. The young oysters would surely perish by a too prolonged exposure where older oysters might exist without special damage. One should, then, if possible, arrange to have in connection with his emergent lands a certain amount of territory which is never entirely exposed, and upon which the collecting apparatus with the young growth can be placed, and the younger oysters also deposited. Then as these oysters acquire a suitable size and the power of resisting external conditions they can be moved forward, first to that portion of the territory which is uncovered only a short time each day, then to where the water leaves it for a little longer period, and so on gradually advancing, until the oysters shall be arranged in a series according to

age and size; the oldest, those destined for consumption, at the extreme inner limit attained by the sea, and the youngest at the farthest point cultivated, where the bottom is never exposed.

As the collectors furnish each year the germs necessary for the restocking of the outer zones, the young oysters in these zones, about one year old, should be passed to the next inner zone, and a rotation thus inaugurated, which would simplify and at the same time facilitate the labor. As for the lands which are never uncovered, and in this number are included all those of the littoral zone of the Mediterranean, oysters can be raised upon them, but they are more easily covered with mud, on account of the stagnation of the water at a certain depth, and it is on this account, or at least this is one of the principal causes of the absence of oyster beds along the coasts of this inland sea, except at certain places, as in the Gulf of Lyons, where the continuous agitation of the water, caused by the strong currents of this portion of the sea, prevents the deposition of mud. Of lands of this character one should choose those in preference where the water is not very deep, from one to two meters at the most, and employ the system of preparing the bottom recommended for muddy lands, in order that the obstacles placed in the way of the moving water may produce a constant agitation which will renovate the water and prevent all deposit.

There are a great many places in the Mediterranean where oysters can be raised with great success, and many of these require no previous preparation. I might mention, among others, the entire coast from Cette to Toulon, the coasts of Corsica and Africa, and the large salt lakes in the neighborhood of Montpellier and Cette, which seem to be vast natural basins especially constructed with a view to this industry.

But for all of these regions it will be necessary to add from three weeks to a month to the period already described as the spawning season, and the time for placing the collectors, &c., since the higher temperature and earlier season of this latitude cause the young to be hatched much sooner.

However, the non-emergent lands in general have a great disadvantage over the other, and the cultivation of the oyster can never attain the same perfection as upon emergent territory, since more labor and greater expense are demanded in the former than in the latter case. In fact, since they are always covered with water, all the previous labor of preparation, the management of the collectors, and the planting of the young oyster, in a word all the manipulations, must be made under water, which render the execution difficult and costly, if not impossible in many cases. Neither could the supervision be very effective, and the oyster-culturist would be obliged to leave his charges almost entirely to themselves, from his inability to cull, change, or distribute them at pleasure or when necessary. Only at the time of gathering could he obtain any exact idea of the success or failure of his undertaking, or the richness of his harvest. Concerning such lands as these, however desirable their

cultivation may be from all points of view, it is best, perhaps, that the small oyster-culturist, to whom this book is especially addressed, should look to these bottoms only for his germs, and carry on the breeding and fattening entirely in parks or live-ponds, where, master of the water which fills them, he can easily follow his products in the successive phases of their development, and give to them, from time to time, and without very much trouble, all the care they may demand. The cultivation of the constantly submerged bottoms belongs properly to the State.

ARTIFICIAL BASINS.

Claires, live-ponds, parks, &c.—For a long time past the breeders of Marennes, at the mouth of the Seudre, have employed, for fattening and perfecting oysters, artificial basins called *claires*, a description of which we now propose to give. Recommended by a long experience, they seem to us, save for the necessary improvements which we shall mention, the best model to follow in the construction of artificial breeding-ponds. The claires are basins of variable form and extent, but generally with an area of about two to three hundred square meters (about the same number of square yards). Situated at a short distance from the sea, and with the waters they contain at a higher level than the mean height of ordinary tides, it is only at the period of the spring-tides, or at each new and full moon, that the sea rises to their level and supplies them anew with water. The best claires are those which receive water periodically from the sea, during about three days before and three days after each highest tide. This period of renewal for the claires is that which experience has found to be the best, and it determines the maximum altitude above the sea for the construction of these reservoirs.

Around each claire is built a levee or dirt wall, called a *yard*, about one meter in height and thickness. This yard retains the water filling the basin, and upon it the workmen pass to and fro in inspecting and working the claire. A flood-gate closes a sluice in one side of the wall, by means of which the sea water is admitted to the basin. This gate also regulates the height of water within the basin, and if desired, the basin can be entirely emptied by opening it wide. All around the inner circumference of the yard a continuous trench is dug, to receive the mud deposited in the basin from the stagnant water, for if this mud should be left in the basin the oysters would soon be smothered. In order to facilitate the clearing away of the mud into this ditch, a slight slope is given to the bottom of the basin, circumscribed by the ditch, from the center towards the borders, so that the surface is sensibly convex. Some breeders dispense with this ditch; in which they are probably wrong, for if it does not prevent the deposit of mud, it at least retards it and lessens its effect. Its use cannot be judiciously dispensed with, unless the water has a long distance to run from the sea and is given a chance to settle before being admitted to the claire.

so as to enable it to part with the greater share of the mud which it carries.

In order to prepare the ground of the claire for the reception of oysters, it must first be cleared of stones and all vegetation which may cover it, and then the necessary slope from the center towards the sides may be given it. The ditch is next dug and the yard thrown up. Then with the sluice-way made and the gate in place the claire is ready to be filled with water during the first high tide. When the basin is full the gate is closed and the water retained after the sea has returned to its ordinary level. The sea-water soon penetrates the soil of the claire, saturating it with salt, destroying all injurious germs, and transforming it, in a word, into a marine bottom. As soon as it is supposed that this effect is produced the gate is opened and the surface paved; that is, it is first smoothed over, and then pounded until it has the even, compact appearance of a threshing-floor. In about two months the bottom of the claire will be ready for the reception of the oyster. The breeders to supply these claires have, up to the present time, had recourse to oysters taken directly from the sea, either from banks near at hand or along the coasts of Brittany, and brought in bulk in coasting vessels. In order that the products should be of a good quality and that the regimen of the claire should have a beneficial influence upon the oysters contained therein, it is necessary that they should not be older than from fifteen to eighteen months, or larger than from five to seven centimeters in diameter (about two inches). The breeder culls them, cleans them, chooses the best-shaped ones, and then scatters them with a shovel over the surface of the basin. Afterwards they are all arranged by hand so that nothing shall hinder their development or interfere with the opening of their valves. In this manner about 150,000 can be accommodated upon a hectare (about 2.41 acres) of surface. The claire is then filled with water, which is maintained at a uniform depth of 30 to 35 centimeters. This water, as has already been said, is renewed only at the spring-tides, and at this time the water in the claires is necessarily very much raised in level, and consequently the most active supervision is necessary, for the heavy pressure upon the dikes may produce breaks or fissures which it is necessary to repair immediately or widespread disaster may result. During cold or hot weather or sudden changes of temperature the breeders maintain the water in the claires at a higher level than the ordinary, in order to obviate the destructive action of the frost in winter or the rapid evaporation and heating of the water in summer. Nevertheless, the construction of the claires does not always permit of accidents from these causes being guarded against, and sometimes the result is an enormous mortality and the ruin of the breeders. Moreover, the water by remaining in the same basin necessarily deposits there a certain amount of sediment which continually accumulates, being added to at each high tide, and especially during the equinoxial tides, thus placing the oysters in no slight danger. To remedy this evil, since it is impos-

sible to prevent the deposit of mud, the breeders always have certain unoccupied claires into which they transfer the oysters from the muddy claires while these are being cleaned. After a thorough cleansing they are left empty until it becomes necessary to clean the other claires, when the oysters are transferred back to their old quarters. But certain of the breeders, not willing to allow portions of their land to lie unproductive, content themselves by cleaning the bottoms and then replacing the oysters in their old inclosure, always soiled with mud. It is useless to enumerate the defects of this practice, which can only produce inferior results both as to quality and numbers.

Such, in a few words, is the industry of the breeders of Marennes, and it is this which we shall take as a guide, if not as a model, for debarring certain imperfections, it presents the most rational and best combined principles. If the breeders were in the habit of obtaining the germs necessary to restock their claires from the claires themselves, if they had constructed their ponds so as to be able to raise the level of the water contained in them from one and one-half to two meters, and had subjected the water from each tide to a certain amount of stagnation before entering the claires, so that it would carry with it as little mud as possible, there would be nothing lacking in their methods; it would simply be necessary to copy them. Let us profit, then, by all that is valuable in their industry, such as it is; let us borrow from the claires all that can be borrowed, all that long experience has proved efficacious, and then add the improvements suggested by our recent studies, and with these elements combined we shall have an excellent guide for the future service of breeders in constructing and working their claires and live-ponds. A claire or live-pond can be established upon any ground where the altitude above the level of the sea is sufficient to enable it to be covered by the tide, not every day, which would expose it to a too frequent deposit of mud, but at least twice per month and during five or six days each time. And as a breeder should never be content with one claire, however small his establishment may be, a series of basins can be made, either in one or two rows parallel to the coast, along the surface sloping to the sea, and all having the same level. It would not be prudent, however, to have so many that it would be necessary to place them at different levels, or in the form of steps, since in this case the lower ones would receive water more frequently, and even be submerged and exposed to a more frequent deposition of mud, while the upper ones would receive very little water. But if it becomes necessary to construct claires in a series of steps at different levels, either because of a restricted amount of surface, or to utilize pre-existing basins, they ought never to be used indifferently for oysters of all ages, because the conditions offered by the upper basins would be much more favorable for young oysters, and only when they have attained a certain size and a greater degree of vitality should they be placed in the lower apartments. The soil of the bottom of the claire demands, ac-

cording to its nature, different kinds of treatment. If it is argillaceous or muddy it should be cleaned and leveled, leaving the central portion higher than the borders, then pounded to give it solidity, and finally covered with water until the bottom is thoroughly saturated, when the water can be allowed to run out, and the bottom once more pounded while it is drying. If the bottom is sandy it is necessary to render it impermeable, so that the water may not leak out, and also to consolidate it. To accomplish this the ground is worked over and covered with a layer of coarse gravel or fragments of shells, upon which is laid a layer of clay 30 to 40 centimeters (10 to 12 inches) in thickness, which is then treated as already mentioned for the marly bottoms. A bed of concrete answers the same purpose, and while it is more costly it is more durable. A pavement of blocks of sandstone or porphyry, &c., similar to those which are used in the pavements of certain of our cities, carefully pointed with clay or hydraulic cement, will also make an excellent bottom. But the clays, especially the reddish clays and the bluish marls, should be preferred in all cases where one wishes the oysters to possess the greenish tint to which the oysters of Marennes owe their celebrity. Surrounding the ground thus prepared are built the dikes which are to retain the water in the basins. These should be at least 2 meters in height above the bottom, so that a depth of water of from 1.50 to 1.80 meters can be maintained over the oysters, not all the time, as generally a depth of from .35 to .50 of a meter is best, but when it is very cold to prevent the injurious effects of frost, and when it is very warm to prevent the water becoming too salt from evaporation. These dikes should be constructed very solid, so as to resist the great pressure which is brought to bear upon them at every spring-tide, and should also be covered upon the inside, the same as the bottom, with a layer of clay or hydraulic cement, so as to prevent all leakage, which is very disastrous in these basins, since the water is renewed only at long intervals. Since these earthen dikes are liable to be injured, making it necessary to go to the expense of frequent repairs, it would be best, in my opinion, to construct them at first in masonry of rough stones and cement, and give them solid foundations. The upper portion of the larger of these dikes should be sufficiently broad and firm to permit the workmen to traverse them easily and without danger, for all the necessary manipulations of working and inspection. If the height of the ground permits, these claires can be formed by excavating in the solid earth, in which case it will only be necessary to cover the slopes of the banks with a layer of stones set in cement. This system moreover will allow of the utilization of lands slightly above the level of the tides, so that by uniting the two systems one can arrange three or even more rows of claires all upon the same level.

As to the expense of construction, I judge it will be about the same for the two methods, the excavation in the one compensating for the masonry in the other. Finally, to avoid or at least retard the deposit of

mud, resulting from the stagnation of the water, the claire should not receive a new supply of water from the sea without giving it a chance to deposit the greater part of its sediment, which can be accomplished by keeping it for a certain length of time in a special basin. These basins themselves might be made of service by providing them with gates and sluices, and using them as breeding or fattening ponds for mussels or other marine animals. Fig. 18 gives a bird's-eye view and

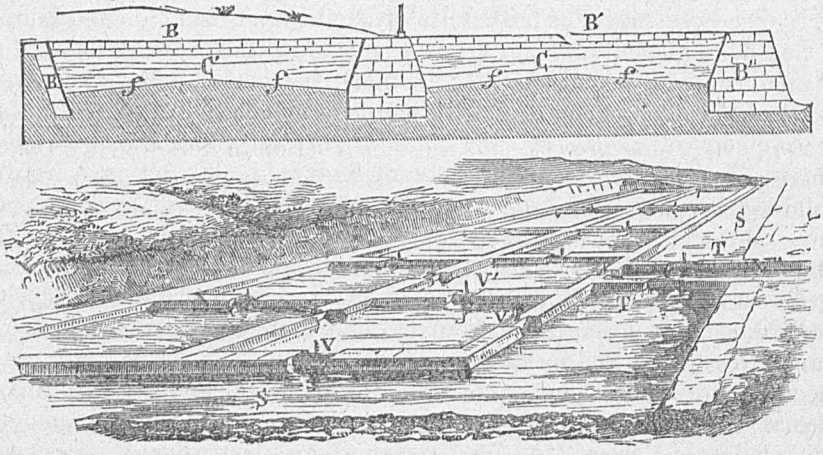

FIG. 18.—Claires. Vertical section, and bird's-eye view.

also a cross-section of two rows of claires with their feeding and purifying basins. The following explanation will sufficiently explain all the details given. C, C′ represent two claires seen in section, the one dug into the bank, the other on the same level but nearer the open water. The sides or slopes of the former, B, B, consist of a layer of rough stones cemented together; the sides B′, B′ of the second are formed of thick walls, about two meters in height above the bottom of the claire, and about 1.40 meters in thickness at the bottom and .75 to .80 of a meter at the top, with an equal slope upon either side, *f*, *f*, of the bottom of each claire, the center being higher than the sides by about .30 of a meter.

V, V, sluices and gates for the entrance of water from the sea.

V′, sluice and gate between two of the claires, to allow the entrance of water into one, only after remaining a certain time in the other, and to establish the same levels in both compartments.

S, basin for the deposit of the sediment contained in the sea-water which enters through the gate V″. It can also be used, if desired, as a supply reservoir, for the claires during the intervals between the spring-tides. In this case it should be constructed in the same manner as the claires themselves, so as to retain the water stored in it. Otherwise it will only be necessary to make the dikes of dirt. In any case it ought to be proportioned in size and capacity to the claires which it supplies.

T, T′, canal through which the water enters from the sea.

By the aid of the sluice-ways and gates in this canal the water can be admitted directly into the claires without entering the outer basin at all. This could be done in case the outer basin were utilized for the rearing of mussels and there was danger of the spawn of the mussels entering into the claires at the period of reproduction.

CHAPTER IV.

METHODS OF WORKING THE CLAIRES.

Now that enough has been said in relation to the apparatus for collecting the young growth, and the construction of the breeding-ponds, there remain only a few words to be said concerning the method to be followed in commencing and continuing a profitable artificial oyster culture. First, it is necessary to construct the breeding-ponds which, for the sake of greater precision, we call *claires*, taking as a basis for their extent the proportion of 1,000,000 oysters to the hectare or 100 per square meter, a proportion which, if it is desired simply to raise oysters, can be carried to 500 or 600 per square meter, or 5 to 6 millions per hectare; this is the proportion in the parks of the island of Ré. During their construction, and in order to stock them as soon as they are completed, the young growth is procured by means of the collecting apparatus already described, or by some of the other forms, preference being given to that which will answer best for transportation, &c., according to the distance to be traversed from the spawning locality to the breeding-pond. As six months of time at least must elapse after the young growth have become attached to the collectors before they can be transported with safety, the two operations, of constructing claires and gathering the young, ought to proceed simultaneously. It is in June that this work should be undertaken in the ocean and a little earlier in the Mediterranean. When the claires are finished, and have a layer of pure and fresh sea-water over the bottom, the oysters which have been brought upon the collectors should be distributed as evenly as possible with a shovel, and afterwards arranged by hand, so that they may not form piles in certain places, and be entirely wanting over other sections. As the oysters should not remain in the same basin during the entire period of their growth, and as the young detached from the collectors are very small, they can be easily so arranged that three or four hundred can be accommodated upon a square metre of surface, and afterwards, as they increase in size, they can be separated, so as to give more room to each. The time of this labor should be chosen so as to end, if possible, at the period of a spring-tide, in order that the young oysters, placed upon strange soil and in strange water, may be promptly refreshed by the incoming tide, and covered with a layer of water sufficiently deep to

prevent any abrupt change of temperature. During the entire first year it will be well if the water never has a less depth than about one meter, and a strict guard will be necessary to maintain the dikes in good condition, repair all breaks, look out for the deposit of mud, and if any takes place change the oysters to another claire without delay. Later, in proportion as the oysters increase in size, and are less affected by external changes, this constant oversight can be relaxed to a certain extent, but not entirely, and the level of the water may be lowered to from .50 to .30 of a meter, always taking care, however, to increase the depth to 1.50 to 2 meters during very cold or very warm weather. It will be readily understood with how much caution the level of these basins should be lowered, when it is remembered that it is only possible to fill them again at quite long intervals, eight to ten days generally, during which time, especially in spring and autumn, great changes of temperature may take place, exposing the oyster to evils against which there is no remedy. For young oysters, and especially during their first years' growth, the most formidable enemy is mud. We have already spoken of transferring the oysters from a basin where the mud has accumulated or is being rapidly deposited to another which is free from mud, but this measure, which is excellent for oysters somewhat advanced in size, is not always satisfactory for the very young individuals; and besides, at certain seasons of the year the temperature would render such a change impracticable. I would counsel the breeders then to use for the first year frames of galvanized iron, about two square meters in superficial area, covered with a netting of galvanized iron or zinc wire, having meshes of such a size that the young oysters could not fall through. These frames could be supported upon four or eight legs from .20 to .30 of a meter in length, and arranged side by side in rows over the bottom of the claires, thus forming a double bottom with a space between the frames and the soil sufficient to accommodate the mud, which would then never trouble the oysters upon the frames. They could be left in this position the entire year, without disturbing them. After this time they should have sufficient natural vitality to be handled without danger, and could be placed upon the bottom of a fresh claire. Thus in the rearing of oysters, since five years are required for an oyster to become of marketable size, it will be necessary to allot five claires to the rearing of one generation, and to establish a series which shall render the production continuous. One claire in five should, therefore, be provided with the wire tables mentioned above. The necessary expense of their construction and introduction would be compensated by the decreased cost of manipulation and attention, and the greater production from the claires. The employment of these frames would be nearly indispensable for basins along the shores of the Mediterranean, which, nearly always covered by the sea, are more liable than others to be covered by a deposit of mud, which can be cleared away only at considerable expense. During the first three or four years of such an enterprise one should, in order to procure

the young growth necessary to restock the claires left vacant by the preceding generation, have recourse, as at first, to the movable collectors and bring the young from some natural bank; but as soon as a generation of oysters becomes adult, and consequently capable of reproducing the species, the claires themselves ought to produce all the young necessary to furnish the ponds with a constant supply of animals. To accomplish this, about one month before the spawning season collectors are disposed in those claires containing the adult oysters, it having first been ascertained that these oysters are nearly ripe. The collectors are chosen at the convenience of the breeder, according to the means and resources of the country where the claires are situated, and become charged with young just the same as over the natural beds at sea, since before being taken from the ponds for market the adult oysters leave there a numerous progeny to replace themselves; as the germs produced are always vastly more numerous than the oysters which produced them, if the breeder does not desire to extend his industry and increase the number of ponds, collectors need be placed only in one or more of the ponds containing adults, so that the demands of commerce can always be satisfied during the five or six months required to charge the collectors. Experience proves the efficacy of this process. Many times, despite the defective condition of their claires, the breeders of Marennes have witnessed their basins, depleted by a wide-spread mortality, unexpectedly repeopled from a few oysters which had survived the disaster, the young developing upon the shells of the dead oysters; the shells in these cases acted as collectors to retain the germs which otherwise would have perished or been carried off by the first spring-tide.

It is perhaps to be wondered at, and even regretted, that such facts should not have caused the breeders to see the immense advantage of making their basins places of production and growth, as well as fattening establishments. To-day, thanks to the light thrown upon this question by the researches of M. Coste, the oyster industry can be raised above the condition in which it has been kept up to the present time, by routine and indifference, and spread along our coasts, which have been threatened with misery and depopulation; the consequences will be an eminently remunerative industry and a permanent source of labor, which will attract to our coasts numerous and robust men, the future hopes of our naval and commercial marine. A few figures, not chosen by chance, but selected as a possible minimum, may serve to prove to my readers that I have not exaggerated in qualifying the new industry as highly remunerative, especially when it is called to mind that the lands upon which this industry is carried on are nearly valueless and unsuited to any other sort of cultivation.

The price of a hundred oysters of the Marennes variety varies from 1½ to 6 francs. Let us then adopt the price of 3 francs, which is less than a mean, as the average price per hundred. Upon a square meter of surface in a claire we can raise from 60 to 80 oysters, and if we take

the minimum at 50 it will give us upon a hectare of surface 500,000 oysters, which, in about five years (average time of growth), would be worth, at 3 francs per hundred, the sum of at least 15,000 francs, making a yearly revenue of 3,000 francs.* Admitting what is evidently above the truth, that the expense of labor, repairs, supervision, &c., absorbs three-fifths of this revenue, then the net profits would be 1,200 francs per hectare, or for the five years 6,000 francs. But these calculations are based, as will be recognized, upon mean numbers, which are probably lower than facts would demand. It will readily be seen, then, that in five years a landed property of the value of at least 6,000 francs a hectare per year can be established upon lands which before were unproductive and of no value. I think it can be said without danger of exaggeration that there are few, if any, rural occupations which in so short a time will give equal results.

As to the decrease in price of oysters consequent upon the increased production of this mollusk there is nothing to fear at present.† Thanks to steam, the oyster can cross our entire continent without becoming dry on the way. Our coasts are called upon to answer the demands not only of all France, but of other countries. The demands for a long period have been greater than the supply, and we are too far as yet from the time when the supply shall equal the demand to include this among the risks.

CHAPTER V.

CULTIVATION OF MUSSELS.

In the preceding chapters, in treating of the rearing of oysters we have said, that the only bottoms upon which such an enterprise could not be prosecuted with chances of success were those where the mud was so deep and well established that there could be no hope of getting rid of it. These places, very numerous upon our coasts, in the coves and small bays formed at the mouths of many rivers, where the mud is deposited both from the waters of the sea and from those coming from the land, can nevertheless be made of service. Unfit for the home of oysters, they are very well adapted to mussels, which, aided by certain simple and inexpensive processes, can acquire there a size and flavor very much superior to those of the sea-mussel. For this industry, as for that of oysters, we have the experience of the fishermen of the Aiguillon, where this industry has existed since the thirteenth century, when an Irishman, named Walton, was shipwrecked upon the rocky point of

* In 1863, on the island of Ré, a sailor named Moreau sold the first gathering from his park, which contained only 500 square meters, for 1,300 francs, making the revenue 26,000 francs per hectare.

† On the island of Ré the first sales were made at 15 to 20 francs per thousand; to-day the price is 30 to 35 francs for the same quantity.

Escale, near the port of Esnandes, and founded here the first *bouchot* or fishing-crawl. Thrown by the tempest upon a barren coast, among a scattered and indigent people, without hope of again seeing his native land, Walton at once sought means of existence by hunting marine birds. The bay, or rather cove, of Aiguillon is only a great mud-flat, a vast lake of mud, where, at low tide, one cannot travel with safety. It was on this bottom, nevertheless, that Walton made his domain. In order to traverse this flat without danger and at all seasons, he constructed a sort of "pirogue" or wooden box 8 or 9 feet long, bent up in front, square behind, and flat upon the bottom. This "acon," or flat-bottomed boat (Fig. 19), is still used by the fishermen, successors and imitators of Walton.

FIG. 19.—Fisherman in his "acon."

In using this boat to travel in various directions over the flat, the fisherman places one knee in the boat near the hind end, and then with his hands upon the sides he pushes himself along with his other leg, which is covered with a long stout boot, and remains outside the boat, acting as a pole to impel it over the mud. In this manner the fishermen can proceed very rapidly in any direction where their labor may require them. In the vacant portion of the box he places his tools, or necessary materials, and whatever he may have gathered in his labors, and transports them without much fatigue. Furnished with this ingenious apparatus for locomotion, Walton planted stakes about in the mud, by means of which he spread vast nets, in whose meshes he caught those aquatic birds which in skimming over the flats flew across these lines of nets. But soon Walton noticed that the stakes which sustained his nets became covered upon those portions just above the mud which were under water at every tide, with great numbers of mussels, which very rapidly attained a size much superior to those in the mud only a short

distance away, and also a much superior flavor and delicacy of meat. This was a revelation to Walton. Thence to the establishment of the first of the five hundred crawls or mussel-frames, the revenues from which have brought ease and comfort to those countries, was but a step; and it is the crawl of Walton, for it is constructed to-day just as he constructed it, that we shall take as a guide and model in the study forming the subject of this chapter. If, as in the cove of Aiguillon, the raising of mussels is undertaken upon emergent lands belonging to the domain of the sea, the arrangement of apparatus adopted by Walton is the best for the purpose, since it gives sufficient stability to enable it to withstand the shocks of the waves and boats, and the force of the wind. The apparatus is in the form of a V, with the point turned towards the sea. Each wing is built of a row of stakes interlaced with a wicker-work of flexible branches or strong pieces of osier or chestnut. The stakes are trunks of trees in their original condition, 4 to 5 meters long and .30 of a meter in diameter, driven into the mud half of their length, and placed at a distance apart of from .50 to .60 of a meter. Together they form a palisade from 2 to 2.50 meters in height above the mud. The branches forming the wicker-work, and for which as long branches as possible are chosen, are woven upon the stakes like the osiers of a basket or gate. This wicker-work covers the stakes without leaving any vacant spaces from the top to within about 15 to 20 centimeters of the bottom, in such a manner as to allow, during ebb and flood tide, a free circulation of the water at all times, so as to avoid the deposit of mud at the base of the stakes.

The points of contact between the branches of the wicker-work and the stakes constitute the only support or fastening between these two parts, and to make this fastening as firm as possible, so that there will be no sliding of the wicker-work down the stakes, care should be used in spacing the stakes, and the branches of the wicker-work should be woven as tightly as they can be drawn. But they should not, nevertheless, be brought too close together, for they would thus present too many obstacles to the movement of the mud and thus cause deposits, which, by their rapid increase, would very soon seriously interfere with navigation and endanger the apparatus itself. The mean distance of from .50 to .60 of a meter is the best. The length of the palisades or wings of the V can be varied at will.

The length of the crawls of Aiguillon is, upon an average, from 200 to 250 meters; but this length, which is justified by the condition of the surface upon which they are built, ought to be regulated so that the sides of the V shall occupy about one-fourth of the distance between the extreme limits reached by the water at high and low tides. Upon all emergent lands those portions nearer the sea are much less often uncovered than those toward the shore, so that while the former are covered every day with a layer of water several meters in depth and are dry for only a short period, the latter are covered by a layer only a few

centimeters in depth and remain dry for many hours. Hence there are diverse conditions of life for the animals which inhabit these different zones, and there results the necessity of constructing the crawls or palisades in series along the slope of the shore so that the sea will visit them less and less in proportion as they approach the inner limits of the water. The fishermen of Aiguillon call those crawls which are farthest out in the sea, and which are uncovered only by the lowest tides, low crawls; the two next inner rows are called false crawls, and those nearest the land, and consequently uncovered most frequently, high crawls. The outer line is generally formed of single posts (Fig. 20), without any wicker-work whatever, and the posts are somewhat nearer together than in the line of palisades. They serve especially as collectors of the young growth. In fact, at the spawning period they arrest, in the zone in which they are planted, the young which are being swept out by the tide, and offer to them, owing to their nearly continuous immersion, a more secure and appropriate protection than the other collectors, where they would frequently be left out of water.

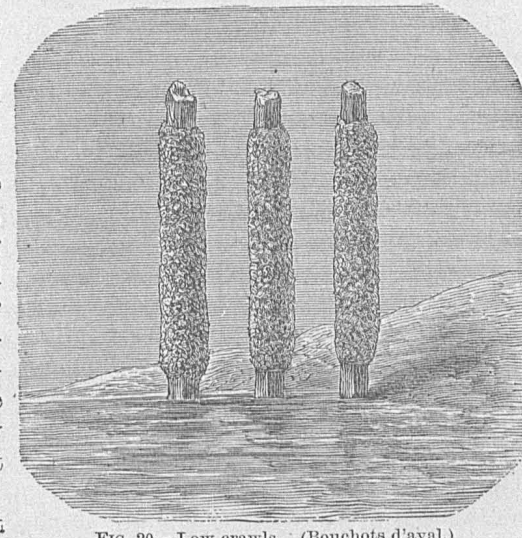

FIG. 20.—Low crawls. (Bouchots d'aval.)

The fishermen thus resort to these outer posts for the seed necessary to supply the false crawls. To obtain this the workmen go about the month of July, at the beginning of the spring tide, to detach the young, which are about the size of a bean, having been spawned in February and March. They are detached from the posts, in bunches, by means of a hook-shaped instrument, and are gathered into baskets and transported in the small foot-boats to the false palisades, to which they are then attached. In attaching them, the bunches, formed by the adherence of the byssus to the shells, are inclosed one by one in a bourse of old twine and then tied in the interstices of the wicker-work, being equally distributed, so that nothing shall interfere with their future development. Soon the net which incloses the mussels disappears, but it has become useless, the mussels being by this time firmly attached by their byssus to the branches of the wicker-work. In a short time, by a continuous and rapid growth, the mussels cover the entire palisade or trellis in a dense layer of clusters, in which one can scarcely find a vacant space (Fig. 21). When, finally, this increase in size threatens their further development, they are detached, and transferred to palisades still nearer

the shore, for by this time they have acquired sufficient vitality to endure frequent exposure to the air. They are fastened in their new positions in the same manner as at first, or, perhaps, only saddled upon the branches, where they remain until they have attained a marketable size, which takes place in about a year after this last change. At this period, when they are strong enough to endure an exposure of several hours every day, they are transferred to the high crawls, to give place to the next generation, and also to have them at hand to supply the demands of consumers. Thanks to this system, the reproduction, rearing, gathering, and sale go on simultaneously and without intermission. But it is from July to January that these transactions are carried on and the mussel is most esteemed as food. In February the spawning season begins, after which they are poor, tough, and not desirable. Those mussels are also much superior in quality which grow on the upper portion of the hurdles, while those which grow close down to the mud are more like the sea-mussels in flavor. Such, in a few words, is the history of the industry founded by Walton upon the flats of the bay of Aiguillon, an industry which has continued to the present time and extended gradually to all portions of the bay, occupying an area of 8 kilometers, with a length of hurdles of 225,000 meters, averaging 2 meters in height, and bringing ease and comfort to the surrounding communities of Esnandes, Charron, and Marsilly.

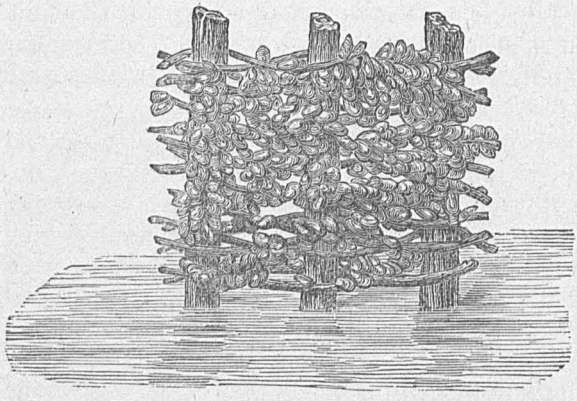

FIG. 21.—False crawls (bouchots bâtards) loaded with mussels.

According to M. D'Orbigny, the elder (*Les habitants des communes de l'anse de l'Aiguillon*, &c., La Rochelle, 1835), each crawl or double hurdle costs for construction 2,049 francs; the demands for labor, supplies, and inspection are 1,136 francs, and the production each year from the sale of mussels 1,500 francs, making a yearly gain from each crawl of 364 francs, upon a yearly capital of 3,185 francs, the legal interest of which at 5 per cent. would be only 159 francs.

It must be admitted that there are few classes of labor where the return for capital invested is at the rate of 11½ per cent. The methods invented by Walton, and imitated by his successors, are so simple, so rational, and so well adapted to the nature of the lands occupied, that it would be somewhat difficult to find anything to change or improve upon. All possessors of emergent lands can thus, by carefully imitating these methods, arrive at the same or similar results, and there remains

nothing for us to say in addition to the preceding description. But the emergent mud-flats are not the only ones upon which the rearing of mussels can be successfully undertaken. As a rule, this ought to be accomplished upon all bottoms and in all basins, whether natural or artificial, where the deposit of mud renders the cultivation of oysters impossible, and it is not only possible but advantageous to combine the two methods or kinds of culture, especially when the rearing of oysters is carried on in the claires described in a preceding chapter. This would be an excellent method of utilizing the stagnant basins, in which the water from the sea frees itself of sediment before being admitted to the claires, and which as a result of this use are necessarily muddy. In these basins, and in all of those which are dug for the purpose of rearing mussels, the hurdles would not be exposed, as in the bay of Aiguillon, to the fierce action of the sea and to the thousand other conditions which demand attention. Hence it would no longer be necessary to arrange them in the form of the traditional V, but they might be placed in parallel lines according to the shape of the basin, leaving between each two rows sufficient space to pass in working them. A gateway in the basin would permit the regulation of the height and the renewal of the water at pleasure, or allow it to run dry when necessary to aid in working the hurdles. By combining this culture, with that of the oyster, the breeders could more than cover the expense, always considerable, of digging a basin for purifying the water and a canal to lead this water to the basins, an expense which the breeders with reason often shrink from, yet which ought to be considered indispensable to complete the breeding arrangements. In case the two kinds of cultivation are united, that of oysters in the claires and that of mussels in the purifying basin and entrance canal, the only precaution to be taken, to avoid injury to the first by the second, will be at the spawning time of the mussels to avoid using the water from the outer basin to supply the claires, for in such a case the claires would become filled with great numbers of mussel-germs, which would thus tend to supplant the oysters. This result can be easily obviated by arranging upon the sides and outside the basin of purification a small body of water communicating upon one side by a gate with the entrance canal, before its entrance into the basin of the mussels, and upon the other with a claire, which, during a certain period, can play the rôle of basin of purification. (See explanation to Fig. 18, page 54.)

In Fig. 18, the purifying basin surrounds the claires and each one communicates with it by a sluice and gate. If it is desired to raise mussels in this basin, these gates can be placed between the canal and the basin and between the canal and one of the claires, so that with the gates of the basin closed the claire can be used as a basin of purification for the time being, and the spawn from the mussels prevented from entering where the oysters are. This arrangement will be necessary only during the spawning period of the mussels, that is, from the end of

February to the end of April, two months and a half at the most, and this portion of the year in France is generally cool and rainy, so that the claires, frequently refreshed by rains, need then less than at any other season a renewal of water. Moreover, if one is under the impression that the too frequent use of the canal causes deposits of mud in the claires, it need be employed only when it is absolutely necessary. The use of wood, such as osier or chestnut, for the wicker-work generally gives excellent results, and its renewal is not relatively very expensive. It may be, however, that from its scarcity, or from having to be brought too far, or from the presence of boring animals in the water, its use is not advisable; in such cases the wood can be replaced by frames of galvanized iron, covered with a trellis of iron or zinc wire, woven coarse or fine according to the age and size of the mussels which are to be placed upon it. In order to fasten the frames it is well to attach them to two posts firmly driven into the ground at a distance apart equal to the length of the frames; or better, the frames can be entirely immersed in the water and suspended vertically by means of floats, or held by chains or ropes stretched from one side of the basin to the other and worked by capstans, so that they can be raised or lowered at will according to the level of the water and in order to facilitate the labor of caring for them. This method presents this great advantage that all the manipulation, the building of the trestles or frames, the changing and gathering of the mussels, &c., can be effected without letting the water out of the basin. When desired the frames can be partially raised from the water by means of the cables, and then taken on board of a boat carrying the workmen, and after they have been either loaded with or deprived of their mussels they can be placed in the water without any derangement of the neighboring apparatus. Moreover, the mobility and independence of each frame will considerably facilitate all changes, cleaning, or repairs which it is necessary to make.

It is, perhaps, unnecessary to remark that this system is equally applicable to frames made of wood and filled in with wicker-work. When such frames are used it will only be necessary to anchor them with stones fastened to one side, so as to maintain them vertically under water. The fundamental principles of this kind of culture once fairly understood—and the preceding descriptions have, we hope, been sufficient for that—nothing can be easier than to modify the apparatus as to form and material to accommodate it to the thousand various conditions of each particular locality. But here we must leave the breeder and allow his ingenuity full sway, guided by the experience which he will acquire after a few years of labor, and which will be of much more help to him than the superabundance of details with which we might fill the rest of this chapter. We will only add a few words upon the different methods of procuring the young animals necessary at the start, and of renewing each year the young stock needed to enable the basins to meet the demands of consumers by the sale of the adults.

The sea is the place to go for the germs, and the most simple collecting apparatus is the low crawls or solitary posts employed by Walton. Stakes are planted towards the beginning of the spawning season in those sections where mussels are known to exist. Then, after several months, the stakes are pulled up and the groups of young mussels covering them used as the first supplies for the hurdles or frames. If upon the coast where the basins are built or where it is desired to establish this industry, mussels are so rare that there is no hope of gathering a sufficient number of young ones upon the stakes, a circle of stakes can nevertheless be formed, planting them from 10 to 15 centimeters apart, upon that portion of the bottom which is uncovered perhaps only twice per month, and then suspending to them, at a short distance above the ground by means of netting or twine, clusters of adult mussels which have been gathered from the sea just before the spawning season. The mussels thus imprisoned within the circle of stakes will spawn just as plentifully and in better condition than if left upon the sea-bottom, and the spawn as it encounters the stakes, which prevent its dissemination throughout the water, becomes attached to them; in this way a numerous progeny can be gathered and transported to the prepared hurdles when they have reached a suitable size for handling.

After the basin has been once planted it may be made henceforth to furnish its own supplies, and this it will do with much more certainty since all the spawn is obliged to remain in the basin; thus if one utilizes the purifying basin for mussels all communication between the claires and the basin must be cut off during the spawning season of the mussels. Stakes planted here and there will suffice to collect a sufficient quantity of the young, and the hurdles or frames to which the adults are attached will also be covered with a young growth, for in these artificial basins the water is nearly always at the same level, and the hurdles are never uncovered, as happens at sea; hence the spawn will not be liable to perish from too long an exposure to the air, but will thrive wherever it may become attached.

One can also make use of a very simple and ingenious apparatus which fills the double office of collector and hurdle or frame. It consists of a raft (Fig. 22) formed of a variable number of pieces of wood, according to its size. To this raft between the stringers and in the direction of the length of the frame are attached, like the slats of a blind, pieces of planks, or, better still, wicker-work frames, about 30 to 40 centimeters in breadth (10 to 12 inches). They can be made to turn upon their axes so as to take any desired inclination, or they can be suspended by one end, as shown in the figure. After floating a raft of this kind, with the planks or hurdles suspended vertically, in the water where the mussels are spawning, it can be carried into the breeding basins when it has become covered with germs, and the rearing go on without any other care than to replace the planks or wicker frames lengthwise of the raft, and change their inclination now and then to remove the mud

which may have settled upon them. The only disadvantage of this system is that the planks or frames, the latter especially, decay quite rapidly by a continuous stay in the water, frequently causing the breeder the loss of his harvest or obliging him to entirely renew his apparatus.

And here one cannot replace the wickets with metal, since the spawn of these mollusks will not voluntarily attach themselves to metal. So this apparatus will have to be used simply as a collector, and in numer-

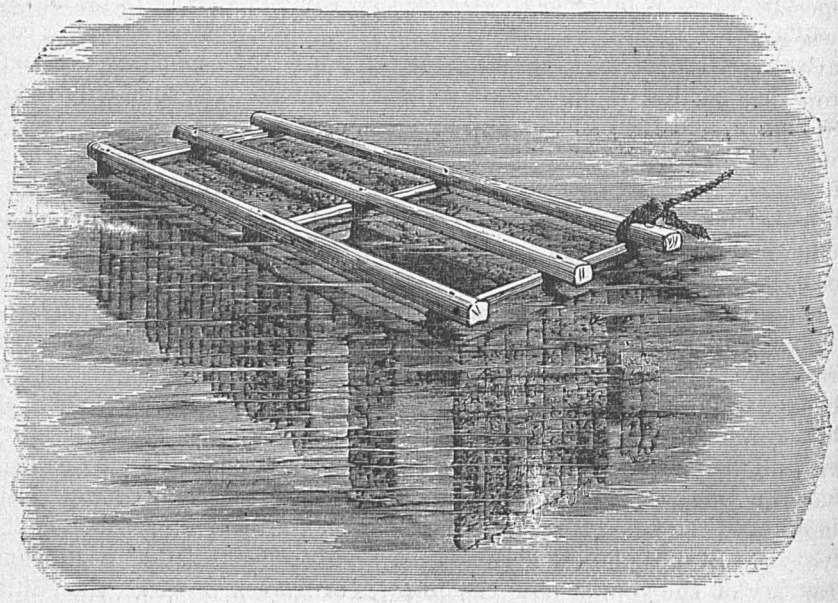

FIG. 22.—Raft collector.

ous cases it can be of great service to breeders, when, for example, the requirements of navigation do not permit the use of fixed apparatus. It can also be employed with success in the culture of oysters, when, because of the deposit of mud, they cannot be placed upon the bottom of the claires. In this case the rafts, covered with young during the spawning season, can be floated at the surface and the mobility of the frames or slats will allow of the oysters being kept free from mud while the condition of light and heat may be varied at will.

CHAPTER VI.

REARING OF LOBSTERS AND OTHER CRUSTACEANS.

In order to accomplish the task which we have undertaken, it now remains for us to speak of the processes which can be employed in the multiplication of crustaceans, such as crabs, lobsters, and the like. While the efforts at artificial reproduction and multiplication of crayfish in fish-ponds may be successful, and while the fecundated eggs of

the cray-fish deposited upon wicker frames in hatching-ponds and constantly bathed with a stream of pure running water, may give birth to hundreds of little cray-fish, which need only to eat and grow, we cannot advise the same methods for the reproduction of the larger marine species, like the rock lobster and the common lobster.

We have already said, and we repeat it now, that these species reproduce in the sea in sufficient quantities to supply all the demands of consumers, especially now that, by reason of the reports of M. Coste concerning these affairs, already cited, the laws governing the fishing of crustaceans have been modified in such a manner as to respect the females at the proper season, and prevent the destruction of young individuals until after they may have exercised, at least once, the function of reproduction. Thanks to these modifications, while the numerous natural causes of destruction will always exist, as they have existed throughout all time, without having caused the disappearance of crustaceans from a single point of our coast, it is more than probable that the preservation of these species is henceforth assured.

There is, moreover, no incentive, unless it may be from a purely scientific point of view, to undertake their artificial rearing, which would probably find a great obstacle in the vagrant and especially pelagic character of the germs of the lobster during their first transformations. But among those taken in the nets of the fishermen there are always a certain number which, although of regulation size, are so much smaller than the others that they sell in the market per dozen at the price of a single one of twice the length, and this price is far from being remunerative. Moreover, the fishing, formerly allowed throughout the entire year, is now prohibited during the three months of March, April, and May, the spawning period, and if the incessant demands of commerce would allow, it should be extended through the entire period when the sexes meet.

There are, then, two important improvements to be introduced into the regulations concerning these crustaceans: first, to preserve alive those lobsters which are too small to sell profitably and keep them in suitable places for continuing their development, so that they can be sent to market when they are large enough to command a ready sale and a good price; second, to establish depots or live-ponds, in which, during the fishing season, all those individuals, over and above what are needed for immediate use, can be stored and held to supply the market during the period when no fishing is allowed. These improvements can be readily made, and far from being incompatible with the labors described in the preceding chapters, they can be readily carried on in connection with them. Previous to the labors of M. Coste in regard to these subjects, an ordinary fisherman, the Pilot Guillou, had succeeded in acclimating crustaceans and marine fish in artificial basins of very limited extent. He very soon recognized that the restricted quarters and the care which these animals received were in nowise unfavorable to them;

that their growth continued as normally as in the open sea, and that they reproduced the same; he also noticed, what is more curious than important, that some species were capable even of being tamed and would come to recognize the hand that fed them; they could be handled and would even touch the hand in their evolutions. From these experiences of Guillou, made in restricted ponds, and since repeated by M. Coste upon a grand scale at Concarneau, it is evident that the immediate sale of lobsters and certain fish, the turbot, &c., when their size is such that they cannot command a remunerative price, is to-day an act of blamable prodigality and evil administration which is of profit to no one. It is the case of the farmer who would wastefully cut all his wheat because a few early stalks show ripe heads. The dwellers along our coast should, therefore, construct basins where the conditions of the open sea may be realized as nearly as possible, and where the water can be renewed often enough to remain fresh and pure; then after every fishing trip the catch should be culled, all the lobsters which can be sold immediately and at a good price being taken out and the remainder of an inferior size being placed in the basins to continue their development. From the basins they should not be removed until after they had attained a suitable size, and at such times as fishing could not be carried on, either from stress of weather or in observance of special rules for the marine fisheries. These basins should be constructed upon the model of claires, except that the renewal of water should be made more frequently, providing there is no danger of too rapid a deposit of mud, although in this case the mud may not produce such evil effects as in the rearing of oysters. One might also appropriate to this use the basins of purification, where the water is held for a time before being admitted to the claires, and this could be done without abandoning the cultivation of mussels in the same basins. Those places should vary in depth from one-half a meter to three meters, and have artificial rockeries, built up of irregular pieces in such a manner as to form numerous cavities and crevices where a multitude of species could find protection out of the way of mud and undisturbed by heat or cold. The summits of these rockeries should reach a certain distance above the maximum level of the water to benefit those animals which at certain periods come out of the water into the air. Sand-banks should also be constructed at the level of the water, and, in a word, we ought to have here, so far as is practicable in the limited extent of these basins, all the diverse conditions of depth, bottom, light, &c., which are met with in the sea where the different species live. In order to do this it will be necessary to observe the nature of those submarine localities which each species frequents by preference. But however frequent may be the renewal of the water it is impossible to prevent stagnation to a certain extent, which has the effect of diminishing the aeration of the water and increasing the production of noxious gases. To prevent this result, which would in a short time be fatal to the inhabitants of the ponds, it will be necessary to establish there, as far as

the necessary working of the ponds will permit, certain forms of submarine vegetation, which should be planted upon the rock-piles and bottoms of the ponds. As a rule plants of a green color should be chosen. Marine plants act in the water in the same manner that land plants do in the air. While men and animals absorb oxygen in breathing, and throw off carbonic acid, a noxious and suffocating gas, land plants, on the contrary, absorb the carbonic acid gas and decompose it, assimilating the carbon and exhaling the pure oxygen. In the same manner aquatic plants absorb the noxious gases produced by the respiration of aquatic animals and the fermentations going on in stagnant water, decompose them, and while storing up the carbon exhale the oxygen, which by dissolving in the water gives it its vital properties. It is necessary, however, to exercise some choice in selecting marine plants, since some of them grow with such rapidity and spread to such an extent that they would soon interfere with, if not destroy, the culture they are designed to promote. To prevent this extension with such plants as may be chosen, it is well to introduce into the ponds some of those univalve mollusks which feed exclusively upon marine vegetation, and they will keep in check any excessive growths.

One can also divide the basins into compartments, to separate the different species and facilitate their capture at the time of sale. In fact the claires themselves can be used simultaneously for different species of crustaceans or other animals, excepting always those like the crab, &c., which would feed upon the oysters.

One single example will suffice. The morass of Kermoor, converted by M. de Cressoles into a salt lake about 70 hectares in extent and surrounded by salt meadows or lands formed by the mud dug from the lake, contains at the present time seventy thousand adult lobsters, which flourish in this miniature ocean as well as could be desired. There are also in this same lake hundreds of turbots which prophesy by their size and rapid growth a complete success for this magnificent experiment. In a word, and to sum up the various advantages of this kind of labor, so far as regards marine species, the owner of claires is in the same position as the agriculturist with his farm, his stables, and his meadows. He can multiply, rear, and fatten a large majority of the edible marine species, and, like the agriculturist, he should, as a good administrator, allow no portion of his domain, so far as is possible, to remain vacant or unworked. He should draw a revenue from everything, and while we have spoken here only of those species which are of considerable importance as marketable commodities, yet there are thousands of other marine species, fish, crustaceans, and mollusks which form only a restricted branch of commerce in those sections where they are taken, and which the possessors of claires might cultivate. By the rapid means of transportation to all the markets of France, they would become important sources of profit. Despite the immense impulse which M. Coste and his followers have given to this science, it can hardly be considered as yet

more than in its infancy, at least from a practical point of view, thus leaving much to be done by those who wish to devote their time and skill to this labor. But at the same time it is to-day removed from the domain of speculation, for experience has demonstrated the excellence of the principles upon which it is founded and the methods it employs; hence the laborer can proceed successfully without fear, and acquire wealth in return for his trouble and expense. Imbued with this idea, I have wished to coöperate, to the extent of my feeble means, in popularizing this humanitarian science. Have I succeeded? If this book shall instruct those who are ignorant and guide those who are laborers in this field, then will my most ardent desires be satisfied.

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