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American Nature Series
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SHELL-FISH INDUSTRIES

BY

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ILLUSTRATED



NEW YORK
HENRY HOLT AND COMPANY

1910

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Published February 1910

PREFACE

IT was suggested to me that I should try to prepare this account of our food mollusks for three groups of persons, namely, those who eat them, those who may be or desire to become directly interested in their culture, and those who may have an interest in the biological problems involved in their artificial control. This suggestion I adopted, and many times since have wondered at the recklessness of my courage in attempting a performance of so varied a character. I recall vividly the impression made on my youthful mind years ago on witnessing the evolutions of three beautifully matched horses and the graceful feat of James Robinson in riding them around a ring. Though in my wildest childhood imaginings I never dreamed of attempting or desired to attempt so skilful an act, I have in the last months, at a period of life that should conventionally be characterized at least by sedateness, experienced the disquieting sensation of having actually attempted much the same kind of a performance in thus endeavoring to present several topics that might hold the attention of readers possessing widely different interests. While desiring to exhibit these subjects so as to bring out their most interesting features, I, of course, have been compelled to present them for brief intervals one at a time, thus always giving two-thirds of my readers an opportunity to yawn. If, however, it should happen that the other third is interested, I shall be amply paid for my effort.

While the first three chapters, that deal with some anatomical, developmental, and physiological facts, may require closer attention than some of the others, they are designed in part to make clearer several subjects treated subsequently. That on anatomy has been made as simple as possible, and the illustrations are new. The short account of a few ciliary mechanisms in the third chapter is from my own observations, and previously I have published only those on Venus. It may be that even the small part of my cilia work here presented will be of some interest to biologists, for the subject itself is practically new.

A relatively large amount of attention has, of course, been given to the oyster. My own interest in the form began nearly twenty years ago, my attention being directed to it by the late Professor W. K. Brooks, the great naturalist and great teacher, who will always be remembered in Maryland as the father of oyster culture. My first efforts, made together with another of Dr. Brooks' pupils, were directed toward a solution of the problem of rearing the swimming embryo in small inclosures to the stage in which it became attached, and in spite of the ingenuity of my friend, we failed dismally. For that reason I write with some feeling the chapter on rearing the oyster from the egg. I may perhaps be allowed to state that from many wanderings along our coast, I have been enabled to gain a more or less extensive personal knowledge of oyster culture and familiarity with parts of the oyster field described. It has seemed to me that the person who eats oysters—and who does not?—might be interested not merely in the manner of their production and preparation for market, some descriptions of which have appeared, but also in the oyster

fields on our shores, no connected account of which has been published so far as I know. So I have given considerable space to the history and present condition of our oyster territory, and have ventured some suggestions concerning its future development.

The chapters on the life history of the soft clam, *Mya*, the conditions governing its growth, and on clam culture, constitute an account of my own work begun in 1898 at a time when practically nothing was known concerning the biology of the form except through analogy. This work was suggested by Dr. H. C. Bumpus, now Director of the American Museum of Natural History of New York, for the United States Fish Commission. In Rhode Island, successful experiments on the growth of *Mya* have also been carried on by Professor A. D. Mead. The short account of the growth of the hard clam, *Venus*, is also from observations that I published in 1903. Several facts concerning the life histories and growth of the soft clam, hard clam, and scallop have been supplied by my friend and former pupil, Mr. D. L. Belding, Biologist of the Massachusetts Fish and Game Commission, who has had these forms continually under observation since 1905, and who has experimented on a very large scale. Some of these facts Mr. Belding has not yet published. Some observations by Mr. J. R. Stevenson, another of my pupils, have been quoted.

The attempt has been made to present the great possibilities of clam culture, and to call attention to legislative changes that are necessary to inaugurate it. Biological knowledge assuring its success is at hand, while many thousands of acres in New England entirely adapted to it now lie barren and unproductive. It would be fortunate if by some means there might be extended to other parts

of the country, where these forms are now unknown in the markets, a knowledge of their great value as food mollusks, for our entire coast line is capable of producing either the soft or the hard clam.

Mr. Roosevelt uttered a great truth when he stated that the most important problem confronting the nation is the conservation of its natural resources; and the wonderful awakening of the people to that truth, for which he more than any other person is responsible, is one of the most important events that has occurred in America during a century of waste and extravagance. An attempt has here been made to show that even the resources of the "great and wide sea, wherein are things creeping innumerable," are very far from being inexhaustible, as many seem to imagine; but also that some of its useful forms may, by directing the processes of nature that are at the same time productive of so great bounty and so great waste, not only be conserved, but made to produce even on waste places greater harvests than ever before existed.

Acknowledgment for the use of figures is gratefully made to the United States Bureau of Fisheries, to various state fish commissions, to the Johns Hopkins University Press, and to the American Museum of Natural History of New York. All but one of the text figures are my own, and, with a few obvious exceptions, are drawn from my own preparations.

WILLIAMSTOWN, MASS.,

January, 1910.

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CHAPTER I

SEA FARMING



IF one were to construct a classification of the units of society, he could perhaps most conveniently group them as pessimists and optimists. It is difficult to determine which is the larger group. One is apt to say in his haste that all men are pessimists. Whether this really is true or not, chronic fault-finders certainly are not rare, and all know where to look for the glowing face of the optimist. Every one knows the cheerful friend who, while urging one to go fishing with him, would turn his back on the black cloud rising in the southwest and call attention to the little patch of blue remaining in the east to prove the impossibility of rain. On large matters of national interest, as well as in small affairs, the American public has had a long training in optimism. Popular writers, and orators on platform and stump, have always taught us that ours is the greatest of nations in achievement, and that our natural resources are limitless and inexhaustible.

It may be that general intelligence is sufficiently advanced to warrant the introduction of a third group into this classification. Whatever name may be given to the group, it includes those who, instead of constructing arguments to substantiate opinions, are interested only in what is true. They employ the simple and common sense method of modern science, stripping themselves of

prejudice and desire, and attempt to see things only as they are.

Assuming this reasonable attitude as fully as possible, it is well to consider on its merits the question of the future sources of the world's daily bread. Since Malthus, more than a century ago, showed that population tended to outgrow subsistence, pessimists have declared universal famine to be near, while optimists have refused to consider the matter seriously, or believed that if the worst should occur, some chemist would succeed in synthesizing proteids from inorganic matter, or that something else would turn up to relieve the situation. While there is certainly no immediate occasion for alarm over the matter, the recent inauguration of an attempt to make a national inventory of all of our resources is a triumph of common sense.

Heretofore the young continent has produced a vast amount of human food that it has been necessary only to gather, while other natural resources—metals, gas, oil, coal, lumber, and fertile soils—have seemed to be limitless in quantity. Viewing the present conditions as they are, without unwarranted encouragement or discouragement, it is very clear that preceding generations, giving no thought to those who were to follow them, destroyed and wasted, without substantial benefit even to themselves, sources of natural wealth that, carefully conserved, might have provided comfort for many generations. If there is any excuse in the fact that our ancestors believed it to be impossible to destroy our natural resources, there is none for those of the present generation whose greed is deliberately and mercilessly cleaning up what remains, and leaving a far-reaching inheritance of ruin. Our criminal waste and our indifference to the fate of future genera-

tions, have been said, and probably with truth, to be without precedent in the history of peoples.

The best of our forests is gone, and their actual extent reduced by at least three hundred millions of acres. In lumbering and manufacturing, we waste from one-half to two-thirds of each tree. The method of lumbering is responsible for incalculably destructive fires that often destroy even the soils on which they occur. Nearly all of the waters of the deforested areas go to the seas in devastating floods, while summer brings its droughts. In the South alone, millions of acres of rich agricultural lands have been gullied beyond repair. The wonderful valleys west of the Cascades in Washington and Oregon, now attracting wide attention because of the peculiar fertility of their soils, and possessing probably more than a fourth of the available water-power of the nation, are endangered by the ruthless destruction of forests. It is estimated that a billion feet of natural gas—an ideal fuel—is every day allowed to escape from the earth unused, and that from one to two tons of coal are wasted in mining each ton that is marketed. Worse than all else, soils are being robbed. Agriculture is now practically impossible in New England, and farm values in the agricultural state of Ohio have suffered a decrease of sixty millions of dollars in a decade. All recall the wanton nature of the extermination of the buffalo and the passenger pigeon. Water-fowl are now rarely seen where, thirty years ago, migrating flocks stretched from horizon to horizon. The wonderful run of the salmon in the rivers of the Pacific slope has until recently been believed to afford an inexhaustible supply of valuable food. Beside being put to this use, millions of pounds of salmon and herring have each year for a quarter of a cen-

ture been utilized on the Pacific coast in the manufacture of fertilizer. Cod, mackerel, shad, and other valuable food fishes of the Atlantic, within the memory of men now living, were many times as abundant as now. At the present rate of decrease, the lobster must soon disappear from our eastern coast. Nearly every natural oyster field on the Atlantic has been destroyed. Most of the clam flats of New England, once immensely productive, are now almost barren.

But in spite of these depressing facts, there are many hopeful conditions to which attention should be given. Our natural resources may be separated into two groups, namely those consisting of materials accumulated through eons of time, which are replaced only by the infinitely slow processes of nature, and resources that may be made rapidly to perpetuate themselves under human direction and control. To the first belong ore deposits, petroleum, gas, and coal. These, once consumed, are gone forever. The second group includes organisms useful to man. Obviously the resources included in the first group should be used judiciously and without waste, in the knowledge that substitutes for them will one day be required. Those of the second group may never disappear.

While wanton destruction and waste are always deplorable, it must be admitted that even with the greatest care, animals and plants useful to man would, if allowed to remain under natural conditions, soon become too few in numbers to meet his requirements. The butchery of our buffalos by hide-hunters and European "sportsmen" naturally excited strong disapproval, but it hurried by very few years their extinction, that was inevitable from the occupation of their ranges by stockmen and agriculturists. The great multitudes of pigeons inhabiting the

northern states east of the Mississippi half a century ago, met their fate largely through the destruction of their nesting and feeding places. Fishes, oysters, clams, and other animals propagating in a natural state, have rapidly decreased when used for food. Even the most prolific have proved to be anything but inexhaustible. But even if these forms had been used without waste, their final failure as sources of food would have been merely postponed. This inevitable destruction only becomes deplorable when it fails to be accompanied by an effort to domesticate, or in adequate measure to control the perpetuation of the vanishing form; for such effort in the past has in nearly all cases been marvelously successful. Man's achievements in domestication have been possible largely from the fact that he has nearly always been able to overcome in great measure the vast wastefulness of nature. In a natural state, seed is produced in profusion, but its growth is left largely to chance, and its destruction is enormous. Usually with little effort on man's part, intervention results in a rapid increase in the number of individuals.

Whenever terrestrial animals and plants have been domesticated, the achievement has consisted not merely in accelerating the rate of reproduction, but in controlling nearly every condition on which their lives depended, with an effect so far-reaching that most of them bear so little resemblance in structure and habit to their wild ancestors that the relationship would hardly be suspected. Indeed, the original forms from which many of them were derived, have been lost to human tradition and are entirely unknown. How great some of these changes are is illustrated in the many known descendants of a wild mustard plant. Among them are the numerous vari-

eties of cabbages, cauliflowers, brussels sprouts, kales, and kohlrabis, that are so different from each other and from their common parent, in the character of stem, root, leaf, and flower, in size, and in color, that it is difficult to believe what is known to be true concerning their relationships. Great changes equally useful to man, have also been made in animals on which he has come to depend, numerous examples of which will occur to any one.

But these great results have been worked out on the land. Is it possible to hope that the waters also may be made productive in any similar manner? The available land area will soon be occupied, but here is an immense expanse of shallow water along our shores that has always yielded a large amount of food. Is it possible that this also may be converted into fertile and productive gardens and pastures?

Though man domesticated food organisms long before recorded events began, as some prehistoric remains prove, he has not yet seriously given his attention to the possibilities of sea farming. It is true that along certain lines immensely important results have been obtained, but that it would be possible greatly to extend them is not to be doubted. The whole subject is one that has been insufficiently considered. It might be urged with some show of reason that as yet there is no necessity for the development of sea farming, because our land area is still sufficient to meet all requirements of food production. But within the next decade or two all of the wheat land and probably all of the arable soil of the North American continent, not covered by forests, will be occupied, and while this is capable of supporting a population very much larger than the present one, it would be the part of wisdom now to turn to the sea, in order to determine to what

extent it also is capable of producing organisms under a system of artificial culture.

It may also be argued that man is unable successfully to give intimate attention to aquatic or even to semi-aquatic forms. It might be asked, for example, why frogs, that are sold in great numbers in some markets, have not been improved by domestication; or why fishes reared from artificially fertilized eggs have not been so bred that it would be possible for them to abandon their natural habits of feeding and migration, to mature and reproduce themselves in captivity. In the first case, the answer is that selective breeding, which perhaps would not be difficult, has not been attempted. It is perhaps not impossible that our markets may some day display gigantic frogs that will require water only to drink. As to the fishes, the only cases in which the attempt has been made to modify structure and habit, have not shown results different from those obtained in terrestrial forms, as is proved by the very curious modifications exhibited in the numerous varieties of Japanese gold-fishes. It must be admitted that the domestication of aquatic forms will be attended by many difficulties not encountered on the land, but there is no good foundation for what appears to be the common belief that an attempt to domesticate them may not be worth the undertaking.

It is possible that some marine animals, on account of their habits, can never be really domesticated. Such are fishes that make long seasonal migrations, or that, as the salmon, make one migration into fresh water to spawn and perish, at a definite period in life. But even in these cases the human agency may become vastly helpful in the matter of their propagation. At various points along the Atlantic coast, the eggs of shad are hatched in the sta-

tions of the United States Bureau of Fisheries, and cared for through the early period of life, during which destruction is greatest in a state of nature. The losses under this care are few, and the young fishes, now much better able to care for themselves, are liberated to pass the remainder of their lives in a natural state. There are good reasons for the belief that the shad would have become practically extinct years ago, if this method of artificial propagation had not been practised. The numbers of several species of fishes are maintained in the same manner.

In the case of one marine form not included in the group of fishes, very remarkable success has attended the employment of culture methods. The culture of the native oyster of the Atlantic coast, the simple beginnings of which date back only half a century, affords the one great demonstration that we at present possess of the possibilities of sea farming; and the extent and value of the industry depending on it are very significant. It is the purpose of the following chapters to set forth the achievement of the oyster culturist, and to show that other food mollusks, now rapidly disappearing, may also be made very much more abundant than they ever have been under natural conditions.

And why should this work not be extended? To begin, we should know that the sea contains immense quantities of nutritious and palatable food, of which no use is made. The Agricultural Department is searching all the corners of the earth for useful plants with a view to habituating them to our own soils and climates. Why should the effort not be made to introduce on our own shores marine food organisms from other seas? Probably quite by accident, our eastern long neck clam was in-

troduced on the Pacific coast, where it has now spread over large areas. Why may not some of the more valuable of the bivalves of the western coast be reared artificially in the colder waters of the Atlantic? The Japanese possess a larger and better oyster than the native form of the Pacific, found in Washington and California. It is perhaps not superior to our eastern oyster, but the latter is not able to reproduce in the cold Pacific waters, in which possibly the Japanese form would thrive. The state of Louisiana is about to make the attempt to establish the hard clam or "little neck," found near the Chandeleur Islands, on its coast west of the delta of the Mississippi, where shore bottoms are now entirely barren, but on which conditions seem to be favorable for the existence of this valuable food mollusk. There are nearly everywhere similar opportunities to utilize waste and barren places on our shores. And without becoming unduly optimistic over the matter, we are probably warranted in expecting that, when the experiments are made, many forms beside the cod, the shad and other fishes, the oyster, and the clam, will prove to be more or less perfectly responsive to the new conditions that the human agency shall determine.

A most auspicious beginning has been made of what may in time become the artificial control of very many useful marine organisms. Why should the sea and its inhabitants be regarded as essentially untameable? There is something about the vastness of its resources that appeals strongly to the imagination. Who is able to stand unmoved before the awful demonstration of power that the waves make on a shore? We possess no means of measuring the force of the tides. Even those who profess to be shocked at the thought of utilitarianism in con-

nection with nature's grand displays of force, may find poetry in the thought that, by methods, some of which are already known, much of this vast and purposeless waste of energy may be made to undergo a magical transformation into comforts that would lighten the heavy load of human toil, and make human experiences happier and more ennobling. The potential fertility of the sea, also, is sufficient, when use shall be made of it, largely to supply man's greatest need.

CHAPTER II

NOTES ON THE ANATOMY OF THE FOOD MOLLUSKS



SOME time before the publication of Darwin's "Origin of Species" in 1859, a few naturalists had come to believe that similarity in structure in different species of animals or plants could be explained only on the assumption that these species were more closely related to each other than to other species. To them it seemed unlikely that the many points of resemblance in structure and habit to be found in comparing scores of varieties or species of violets, for example, could mean anything but a relationship between them. From the analogy afforded by different breeds of domesticated animals, known to be derived from a common parent form, it seemed reasonable to assume that several kinds of thrushes, or of crows, of squirrels, hares, or similar groups of species differing only slightly from each other in nature, had descended one from another or from common ancestors.

But this view was then founded merely on analogy and met with little favor. The world continued to hold tenaciously to the still less reasonable hypothesis that each species of animal and plant had originated independently in an act of special creation. According to this traditional belief, no relationship existed between different species. The Creator of the animate world had decided

upon several types of organisms, and each new creation was made to conform more or less closely to one of them. Having become a religious dogma, this idea was so firmly fixed that it required a revolution in popular thought to destroy it. The publication of Darwin's first great book accomplished this end.

The "Origin of Species" showed how natural forces now in operation might produce new species from parent forms. It presumed that the same forces had been operating on organisms in the same way since the dawn of life. According to this view, all living organisms have a real relationship to each other, recent or remote. As a rule, great differences in structure indicate distant, as great similarities indicate close relationships.

On account of fundamental similarities in development, structure, and habit, which exist among oysters, clams, scallops, mussels, and other members of the lamellibranch family, no naturalist now doubts that they descended from some common ancestor, which, however, must have lived in the very remote past, as man measures time. What this ancestral form was, is not positively known; but naturalists have agreed on what must have been the general characters of many of its organs. Why they should have a positive belief in regard to a creature that no one ever saw, even in fossil form, is a long story; but the reasons for it, if they were explained, would probably be satisfactory to most minds.

Among the very few bivalves here considered, it is not easy to determine which, in its structure, conforms most closely to the hypothetical ancestor. It is not the black mussel, with its aborted foot and anterior adductor muscle, and its sexual glands in the mantle folds. It is not the scallop, in which much of the body is modified to

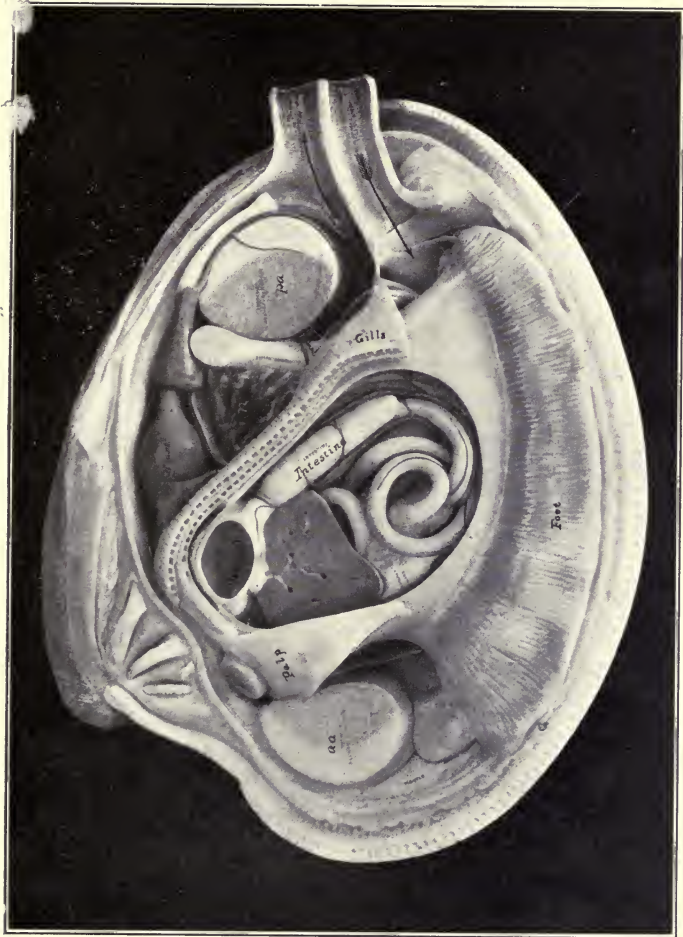


FIG. 1. Anatomy of the round clam or "little neck." From a model in the Amer. Museum of Nat. Hist. / line of ligament attachment.



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conform to the swimming habit. Certainly it is not the degenerate oyster that has completely lost the organ of locomotion, and the anterior adductor muscle. Probably it is not the soft clam, for in it, also, the ancient foot is greatly reduced. Of the short list, the hard clam, *Venus mercenaria*, probably has a greater number of organs that are most like those of the ancestral bivalve, though some, like the gills, depart much farther from the primitive condition of those organs than do those of the mussel and scallop. But because *Venus*, not by any means one of the more primitive of living bivalves, is somewhat the more simple of the species here described, it may illustrate best some of the anatomical characters common to them all.

The Shell. The hard protective covering of *Venus* consists of right and left parts known as valves. It is composed of carbonate of lime, which is deposited in a viscous secretion poured out by the fleshy mantle fold lining its inner surfaces. On the shore, one sometimes finds valves of clams or other bivalves, recently dead, that are united on the upper or dorsal side by a piece of stiff, elastic substance, resembling rubber. This is known as the shell ligament. The position of its attachment to the shell is represented in Figure 1 (*l*).

Just within the ligament, each valve bears prominent ridges or teeth that fit into corresponding depressions in the opposite valve. This mechanism, serving to hold the two parts of the shell in their proper relative positions, is called the hinge. It may be noticed that the shells of dead bivalves are always open at the under or ventral margin. In the living animal, lying quite undisturbed in the water, a slight gaping of the valves may also be observed; but when the animal is disturbed, the valves

close. An attempt to pry them open will show that they are held together with great force. The closing mechanism consists of two cylindrical bundles of muscle fibers, known as the anterior and posterior adductors, running directly across from one valve to the other. The ends of these muscles, severed from the left valve, are shown in the figure (*a a* and *p a*).

The functional relations of ligament, hinge, and muscle, may be understood by referring to the text figure

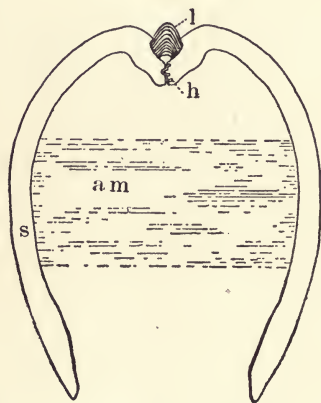


FIG. 2.—Transverse section of the shell of *Venus* to show relations of ligament (*l*), hinge (*h*), and adductor muscles (*a m*).

(Figure 2), which represents a transverse section of the shell in the region of hinge and ligament. The rubbery ligament (*l*) occupies such a position and is of such a width, that when the adductors (*a m*) contract, the hinge (*h*) acts as a fulcrum, and the ligament is stretched. On the relaxation of the muscles, the mechanical contraction of the ligament, acting on the hinge, causes the lower edges of the shell to separate.

Examining the outer surface of a valve, there is to be noticed, far dorsalward and forward, in *Venus*, a rounded prominence, the umbo, so called on account of its fancied resemblance to the boss of a shield. Its position on the shell varies in different bivalves, and in some it is very inconspicuous or absent altogether.

From the umbo as a center, concentric lines of growth

spread over the entire outer surface (Figure 64). Each represents what was, at one time, the edge of the shell. A cross section of a tree trunk reveals similar concentric growth lines. Each line in the section marks the cessation of growth in the fall and its resumption in the spring, so that the years of a tree's life are recorded in them. From such an analogy it might be assumed that the growth lines on a bivalve shell indicate its age, also; but the analogy is misleading. Most shells, like that of Venus, possess fine and closely crowded, as well as conspicuous lines, all irregularly arranged. While they represent successive deposits of lime, many are formed in a summer, and no idea of age may be had from them. Differences in their distinctness and size are probably due to the irregular action of weather, tide, temperature, and the abundance or scarcity of food.

The mantle edge secretes a thin, dark colored, rubbery coat that is applied to the outer surface of the shell. This probably is produced to prevent the dissolution of lime, especially in the young. In some bivalves, this cuticle, as it is called, is so thick and tough that it performs its function perfectly throughout life; but in most cases it wears away, especially on the older part of the shell, and the lime is slowly dissolved. The addition of new shell to the inner surface may keep pace with this, but in the case of clams living in foul mud, in which humus acids are abundant, the shell is sometimes perforated and the animal dies. Very little of the cuticle is to be found on the shells of adult oysters, clams, or scallops.

Closely connected with the addition of new layers to the inner surface of the shell, is the formation of pearls. These precious structures are merely shell formations unattached to the valve. Their shape has much to do with

their value. Their hue and iridescence also are important. Most of the pearls of commerce come from the so-called pearl-oyster of the Indian Ocean. This mollusk, however, is only distantly related to edible oysters. Pearls have been found in the bodies of most bivalves, and those from several species are valuable. Fresh water clams, especially in the streams and lakes of the central states, produce pearls of great beauty. Every one has found them in our oysters. These are usually small, though sometimes very symmetrical in outline, but are not valuable, as they are not iridescent.

Pearls, really abnormal shell growths, are formed by the introduction of some foreign object between the mantle and the shell. This body becomes a nucleus about which the sticky secretion of the mantle accumulates. Just as in the case of the shell layers, lime is deposited in this sticky coating. Successive layers are added and the pearl gradually increases in size. The foreign bodies acting as centers about which the pearly layers are accumulated, have been shown, in some cases, to be small parasitic worms. It is easy to determine experimentally, however, that an inert body like a grain of sand, will also become coated with pearly layers. Professor Brooks, in his book on the oyster, writes of the miraculous origin of the sacred clam shells of the Chinese Buddhists. He says:—"The inside of the shell has a beautiful pearl luster, and along it is a row of little fat images of Buddha, squatting with his legs crossed under him, and his elbows on his knees: they are formed of pearl precisely like that which lines the rest of the shell, a little raised above its surface, and outlined in faint relief, but they are part of the shell, with no break or joint. In the process of manufacturing them, the shell of the living

animal is wedged open, and thin images, punched out of a sheet of bell-metal, are inserted. The animal is then returned to the water, and is left there until enough new shell has been formed to cover them with a varnish of pearl thick enough to cover them, and to hide the metal, while permitting the raised outline to be seen."

Pearl growth is really very common. Fresh water clams, of which there are scores of varieties, exhibit it with great frequency. But usually it will be found that the pearl has become fastened to the shell. Even when these growths are large, they cannot be removed and ground into a symmetrical form, because abrasion of the surface destroys their luster. It is only the large, symmetrical growths, which have not been glued to the shell during their formation, that have great commercial value, and these are relatively very rare.

There is often considerable variation in the shapes of shells, especially in oysters and long-neck clams. This is often due, in the case of the former, to the close crowding of individuals, and in the latter, to pressure against objects in the walls of the burrow. When young oysters crowd each other closely, after their attachment, the direct effect is that the shells grow narrow and become greatly elongated. If a clam in its burrow presses against an unyielding obstruction, the growing shell will be distorted by conforming to the outline of the object.

Right and left valves are normally symmetrical in most bivalves, but in the oyster there is a great inequality. The animal is attached by the left valve, which is very much larger than the right. It forms the stony box in which the soft parts of the body lie, and the right valve is little more than a lid to the box. In the embryo, the valves are of the same size, and are perfectly symmetrical. This

was undoubtedly the condition of the distant ancestors of the oysters, which were unattached. The habit of attachment is of great value, for oysters are permanently held in favorable localities above the soft mud of the bottoms, which might otherwise smother them.

The primary function of the shell, of course, is protection. But in spite of its hardness and toughness, it sometimes fails. There is a mighty and unceasing struggle in nature in which every organism strives to obtain necessary nourishment, and at the same time to protect itself against its enemies. The shells of bivalves have become strong, but at the same time their enemies, which must in some way obtain food or perish, have developed special organs for crushing or penetrating them. The jaws of the drumfish of Atlantic and Gulf waters, for example, have become so powerful that they are able to crush even the strong shell of an oyster. But it is interesting to observe that there is difficulty in doing this; for if the task were an easy one, these fishes might be able to cause the extinction of the race of oysters. Drumfish are able to dispose of small oysters which the oyster culturist has separated and scattered over the bottom to grow, but they experience so great difficulty with oyster clusters on the natural beds, that their mouths are often badly lacerated in their desperate attempts to obtain food from them. The sheepsheads, fish with jaws armed with large, hard teeth, crush the relatively thin shells of young oysters. Among the deadliest enemies of bivalves are some of their own distant cousins, snail-like mollusks which possess, in the end of a proboscis, a rasping or boring organ which slowly cuts through the hardest shell, and allows the creature to feed on the pulpy tissues within.

There is at least one phase of what is called the struggle

for existence among organisms that popularly is very little appreciated. It is that the battle, which never ceases, is, in almost all cases, nicely drawn—so delicately balanced through long periods of time, that any slight advantage on one side or the other may result in the more or less complete extinction of one, or even of several interdependent species. At one time newspaper reports informed us that ordnance and projectiles had become so perfected that the armor of war vessels afforded little real protection. Later it was stated that armor-plates had been made so hard and tough that they could be penetrated or broken only with great difficulty. Yet improvements in both go on, and the layman understands that there is a nicely balanced contest for supremacy between them. Everywhere in nature, also, weapons of defense and offense are slowly being perfected, but in the test of actual warfare. A harder armor in the oyster and other mollusks might possibly deprive drumfish and certain marine snails of so much food that their ranks would at least be reduced; and stronger and harder jaws in the drumfish might result in the annihilation of oysters living in the warmer waters of our coast. This balance in the struggle among organisms sometimes is upset, and fossil remains show that, as a consequence, many great races, both of animals and plants, have suddenly declined, and then completely disappeared from the earth.

The Mantle. This structure has been referred to as a flap or fold of tissue that grows out from each side of the body, expanding so as to line the inner surface of the shell. Figure 1 shows the edge of the mantle lying parallel to the margin of the shell; but a much better idea of it is given by Figure 3, which represents the body of

the oyster lying in its left valve. Here, as in many bivalves, the margin is provided with projections or tentacles, capable of some extension, and acting as sensitive touch organs. Certain parts of this edge are sensitive to changes in the intensity of light, and in the scallop there are developed eyes so perfect in function that moving objects are seen at a distance of several yards. It is evident that this is the only part of the body where visual organs would be of any use.

In the two forms here illustrated, the mantle folds below are separate from each other. In some bivalves, the soft clam for example, there is an extensive fusion of the edges, so that the mantle chamber becomes an enclosed space.

Venus is a form that spends most of its time burrowed in the bottom just deep enough to cover the shell. As in all other burrowing lamellibranchs, two tubes, the siphons (Figure 1), grow out from the mantle posteriorly, their purpose being to reach up to the water. Through the lower one a stream, bringing food and oxygen, enters the branchial or mantle chamber. After passing through the gills, the water is discharged through the upper tube. These siphon tubes are very long in the soft clam, which burrows many inches into the bottom.

In addition to these functions, the mantle of forms that possess a large, distensible foot, serves as a blood reservoir, and thus probably functions as the chief organ of respiration; for the blood here is separated from the water only by the very thin mantle walls. ↗

The Digestive Tract. Referring again to the figure illustrating the hard or round clam, it will be observed that the mantle fold, the two gill folds that hang down on

the sides of the body, and the body wall itself, have been removed so as to expose the digestive tract and other internal organs. In most animals that possess a tubular digestive tract, the mouth is to be found at the forward or anterior end of the body, and the rule holds in this case. Usually, also, this opening into the digestive tract is situated in a modified part of the body that may be called a head. This was probably true of the very early ancestors of the bivalves, but as the result of the development of a shell completely covering the body, the head of all living bivalves has disappeared as a distinctly modified region. For this reason they are sometimes called Acephala.

The mouth is not shown in either of the illustrations, but its position in the oyster is indicated. The opening is hidden by a pair of huge folds or lips, one placed in front of, and the other behind it. These labial palps extend, right and left, far out from the mouth, and are shown in both figures. In Figure 3, the front or anterior palp on the right side has been partially removed, and the inner surface (that nearest the mouth) of the inner palp is exposed. The organs are so situated that they may come in contact with the anterior margins of the gills. The latter are collectors of the microscopic food, which they pass forward, by ciliary action—cilia being minute hairs that cover various surfaces and have a rapid lashing movement—to the inner surfaces of the palps. Over these, in turn, it may continue forward to the mouth. As will be shown later, when material is too abundant on the palps, it is not directed to the mouth, but to tracts that carry it out of the body.

The mouth, having the form of a funnel, leads directly into the œsophagus. This tube may be traced backward

to its opening into the stomach. As represented in the figure, the latter appears as a simple dilation of the digestive tube. Surrounding it on all sides, are the digestive glands, which pour their secretion into it through short but wide ducts. The digestive glands constitute what is commonly called the liver in anatomical descriptions of many invertebrate animals; but it is not similar to the liver of vertebrates, either in structure or function. Its secretion has the power of rendering fluid and changing chemically the digestible parts of the food. The gland is always of a dark color, that varies somewhat in different bivalves, and every one has noticed it in the ruptured bodies of oysters and clams.

The intestine arises from the posterior end of the stomach. Its course is downward and backward, and in the lower part of the body it bends in a way characteristically different in different bivalves, before finally ascending to the region in front of the heart. Coursing straight backward on the dorsal side of the body, it passes directly through the heart in most bivalves, and then over the posterior adductor muscle where it ends, the anal opening of the tube being so situated that the strong current of water leaving the body immediately carries away the fecal matter. The parts of the digestive tract in other bivalves have much the same arrangement.

The Vascular System. It rarely happens that the blood of invertebrate animals is colored, though there are one or two exceptions to it even in the bivalve group. In our edible mollusks, it is a nearly colorless fluid, circulating through the body along very definite paths. As in all other cases, it carries liquid food obtained from the walls of the digestive tract, and oxygen received in the gills and mantle, to all the living tissues of the body. At

the same time it gathers up waste material resulting from muscular activities, and as it flows through the walls of the excretory organs, or kidneys, certain cells of the latter have the power of removing these substances.

The heart is situated on the dorsal side of the body under the hinge of the shell, in Venus. By opening the delicate wall of the chamber in which it lies, it is seen to be made up of three parts. On the mid-line of the back, is a large sac, with filmy muscular walls, which is called the ventricle. It is by the contraction of these walls that blood is forced to various parts of the body through two arteries, one running forward, and the other backward. Joining the ventricle on either side are two auricles, sacs even more filmy and delicate. Their office is to pump into the ventricle blood which they receive from the gills.

It has been stated that the intestine courses through the ventricle from before backward. This is true of the clams and of most other bivalves. But in the oyster and scallop, the heart has been moved to a position below the intestine. The oyster's heart may very easily be found by picking away the thin wall just in front of the large adductor muscle so as to expose it as it lies in its chamber (Figure 3). It is the common belief among oystermen that the adductor (*pa*) itself is the heart, and that when it is cut, the animal is at once killed. The fact is that if one valve of the shell is very carefully removed, and the animal is placed in a favorable current of water, it will continue to live for days.

The Excretory System. The organs for removing waste matters formed as a result of muscular and other activities are usually difficult to observe. In the simplest cases among our edible mollusks, they are dark colored tubes, one on each side of the mid-line of the body, open-

ing by one end into the chamber in which the heart lies, and by the other to the exterior of the body near the base of the gills. Their position is shown in Figure 1, *n*. Waste matter is extracted from the blood as it flows through the walls of these kidneys, and is discharged to the exterior through the outer opening of the tube.

These nephridia, as they are technically called, may be seen directly exposed as conspicuous swellings on the under side of the large adductor muscle of the scallop, but in the other forms their examination is difficult.

The Sexual Organs. As a rule, our edible mollusks are of separate sexes, though there are no secondary sexual characters that will enable one to distinguish male from female. The small warm water scallop (*Pecten irradians*), found from Cape Cod to Texas, is hermaphroditic, that is, possesses both male and female sexual glands. Hermaphroditism is a very common condition among lower animals and among plants, but where it occurs, it usually happens that the two kinds of sexual cells come to maturity at different times, in order to prevent self-fertilization. The breeding together even of nearly related animals, usually tends to produce weak offspring. The sexes are separate in the northern or giant scallop, and in *Venus* and *Mya*. This is also true of the oyster, while its near relative, the European flat oyster, is hermaphroditic.

Because the losses among young bivalves are so enormous, immense numbers of eggs are produced. Fifty or sixty millions would be a conservative estimate of the actual number discharged by a large female oyster during a single breeding season. Though the eggs are minute, they are large enough to be distinguished by the unaided eye. The sexual glands constitute the greater

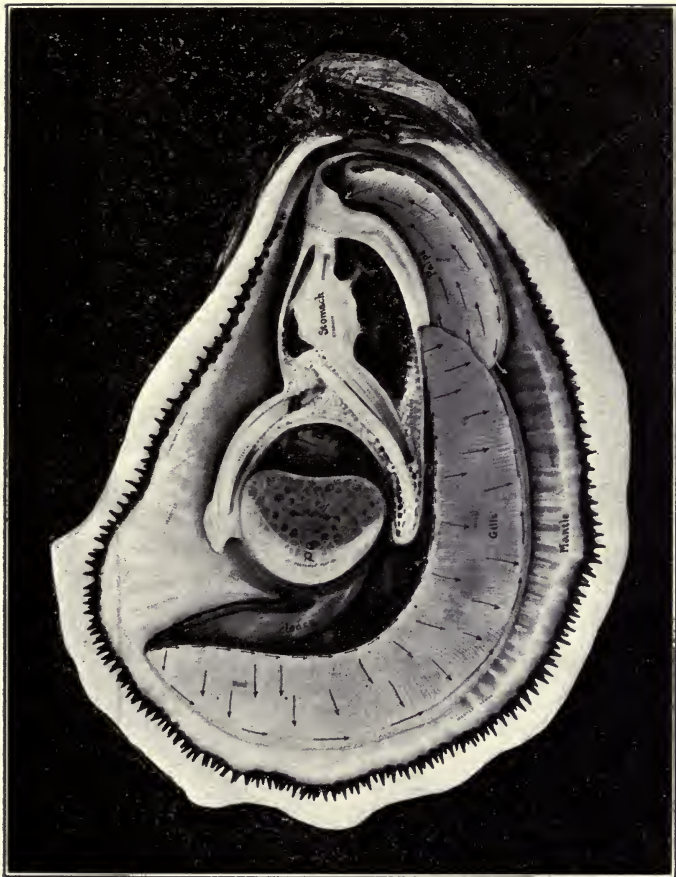


FIG. 3. Anatomy of the oyster. From a model in the Amer. Museum of Nat. Hist. The arrows, which have here been added, indicate cilia currents on gills and palps. (See Chapter IV).



part of the pulpy body, being packed around the digestive tract, extending down into the base of the foot, in the quahaug, and backward in the oyster and scallop so as nearly to surround the adductor muscle. The ducts through which the sexual cells are discharged, open, one on each side of the body, near the bases of the gills, though in the scallop and some other lamellibranchs, the opening is into the tube of the nephridium.

The breeding season comes in the late spring and early summer. All through the winter the body is swelling with the accumulating sexual cells, and it is then, of course, more valuable as a food. For several weeks the sexual products are gradually discharged. By the middle of the summer the body has become comparatively thin and watery, especially in the soft clams, and remains so until fall or early winter. Oysters, and probably clams also, living in the warm waters of the Gulf of Mexico, continue to spawn through the summer, and the former, in these localities, produce a few eggs during every month of the year.

It is often asked why oysters are not generally marketed and eaten during the summer months, but the reason is not that oysters are then somewhat less full and nutritious, although that happens to be the case. Reason plays no part in determining many human habits and customs. The answer is simply that it is the custom to eat oysters in winter and not in summer. It is the custom south of Long Island Sound to eat "little necks"—small, hard, or round clams—during the summer, and to refrain from eating long neck clams. Just as it is the custom, across the sound in Rhode Island, and in other New England states, to use the long neck clams during the summer in the famous clam-bake. The truth is that

none of the bivalves are quite so good for food from July to September; but the critical insight of the person who declares an oyster stew or a clam-bake in August to be failures from a gastronomical point of view, is very much to be questioned. There is no very good reason, except the difficulty of transporting and keeping long neck clams, why all of our food mollusks should not be marketed during the summer.

The Nervous System. In a great many invertebrates, the central nervous system possesses one chief ganglion, or pair of ganglia, situated in the anterior part of the body. But in the bivalves there are three pairs of large ganglia: one, the pair of cerebrals, in the region of the mouth; a second, the pedals, in the base of the foot; and a third, the viscerals, close against the under side of the posterior adductor muscle.

The ganglia of the cerebral pair are often separated, being placed on the right and left sides of the mouth. These are connected by a strand or commissure of nerve fibers crossing in front of the mouth. The two pedal ganglia, connected with the cerebrals by a pair of commissures, are partially fused together. They supply the muscles of the foot with nerves. The viscerals are the largest, and are fused together into a single ganglion from which nerves are given off to the gills and mantle. A pair of commissures also unites visceral and cerebral ganglia.

Structurally this nervous system seems to be simple, when compared with that of higher animals, and one is apt to lose sight of the very complex functions that it really performs. The responses of the attached and greatly degenerated oyster seem to be few and simple. Superficially regarded, its functions, except those per-

formed automatically by cilia, over which the nervous system has no control, are almost limited to opening and closing the shell. It will be shown, however, that even in this degenerated form, many wonderful responses of the nervous system to various stimuli occur, by means of which this automatic ciliary mechanism is rendered effective in inducing activities that result in the acceptance of microscopic food particles from the water, and the rejection of useless material.

The Foot. This organ, which is characteristic of the Mollusca, is simply a muscular thickening of the under or ventral wall of the body. It varies greatly in size, shape, and position in various bivalves, but the chief features of its primitive form are probably represented in *Venus*. Here the entire ventral wall is thickened, forming an organ having some resemblance to a plow-share, the point projecting forward. Though the adult hard clam, and many others having a similar foot, seem more or less completely to have abandoned the habit of creeping, a few adult bivalves possessing a locomotor organ of the same general character use it for that purpose, sometimes covering considerable distances. The very young of the long neck clam, mussel, and scallop possess a foot much like that of the adult *Venus*, and all are active creepers. Later in life the organ becomes relatively much reduced in size and modified in form, and in each the creeping habit is gradually abandoned. Because of the early form and function of the foot in these species—and the same will probably be found to be true of many other bivalves—it may be assumed that the ancestral organ was large, covering the entire ventral side of the body and projecting far forward, and that its primary function was that of creeping.

The descendants of these ancient forms, adapting themselves to various new modes of living, found new uses for the foot which gradually became modified to perform these functions more perfectly. Burrowing was one of these habits. It is well demonstrated by the young of the long neck and little neck clams, that thrust and worm the sharpened anterior end of the foot into the bottom, then expand it so that it acts as an anchor. Special muscles (shown in the figure of Venus) extending from the base of the organ to an attachment on the shell, then contract and draw the body down into the bottom. This is repeated until the desired depth is reached.

In the black mussel and the young of the shallow water scallop of the Atlantic, the foot performs a very special function, that of shaping and attaching the anchor threads of the byssus. The byssus gland is an organ developed in the ventral tissues of the foot, near its posterior margin. It produces a viscous secretion that hardens in coming in contact with water, forming threads of great strength. It is also present and functional in young little neck and long neck clams.

In the smaller scallop and black mussel, there is a groove on the under side of the foot, extending from the opening of the byssus gland to the end of the foot, where it expands into a diamond-shaped cavity. This cavity remains open below, while the groove is temporarily converted into a closed tube by the folding together of its edges. The foot is stretched out from the body, the end placed against some foreign object, and the fluid is poured out through the tube. When this is opened, water comes in contact with the secretion, which instantly hardens into a thread, and the foot is withdrawn to be

extended in another direction. The process is repeated until several threads are formed. Though the mussel remains attached during its life, it is possible for it to cast off the byssus at its base and form a new one. The scallop has the same habit, but attaches less frequently after attaining the adult condition. In the clams the byssus disappears early in life.

Still another use is made of the foot in a few cases. The large sea-clam (*Macra*) of the north Atlantic coast, is able to leap a distance of several inches, when out of the water, by a quick movement of the organ, and it is not difficult to see how such a habit may, at times, be useful to it. There are some cases in which bivalves are able even to swim short distances by a rapid paddle-like movement of the foot.

Finally it is to be noticed that in the oyster, the foot, although present in the very young, early begins to disappear, and soon completely vanishes. This is presumably the result of the mode of life inaugurated by the attachment of the shell to some object on the bottom, for the foot is then of no use.

The Gills or Branchiae. The gills are the most complicated organs of the lamellibranch body. They, like the foot, have been greatly changed from the primitive condition to conform to various modes of life which characterize different species. So many of the activities of bivalves depend on them, and so much also concerning their functions is of importance to those who use oysters and clams for food, that they should be thoroughly understood. No one, for example, who knows how these organs continually strain from the water the minutest solid particles, and hold them tenaciously, can have any doubt about their power to collect the organ-

isms of typhoid fever and other germ diseases, especially intestinal diseases, from infected waters.

The organs are exposed when the mantle flaps are lifted, and there are seen to be two of them on each side of the body, one lying nearly over the other. In the figure of Venus, they are represented as being cut off near their bases. In the oyster the gills have been moved from this position on the sides of the body so as to lie in four parallel folds on its ventral margin (Figure 3). Behind the body the four gills unite so as to separate a space above, the cloacal chamber, from the large mantle chamber below. With the unaided eye, it may be seen that each gill is vertically striated. Although at first sight a gill appears to be a solid fold of tissue, closer examination shows it to be made of two plates or lamellæ (from which the name Lamellibranchiata, sometimes given to the bivalve group, is derived), which enclose a space between them. Each lamella, also, is composed of a great number of parallel, hollow rods, the gill filaments, placed regularly, side by side, so that the plate, as represented in a diagram (Figure 4), has a resemblance to a picket fence. Each filament corresponds to a picket, the lamella to the fence, and the entire gill to two parallel fences. The spaces between the filaments allow water to enter the interior of the gill.

In one important respect, the illustration of the parallel fences fails. If we trace a single gill filament from the base of a lamella down to the free lower margin of the gill, we will find that it does not end there, but bends and continues upward as one of the filaments of the other lamella.

As these rods or filaments are very delicate and much elongated, their regular position might easily become dis-

turbed if there were no means of binding them together. Such a means is always provided, but it is different in different bivalves. The two halves or lamellæ of the gill must also be bound together by cross partitions to prevent their spreading apart, and they, too, are always present.

The simplest gills among our edible mollusks are found in the black mussel (*Mytilus edulis*). A single

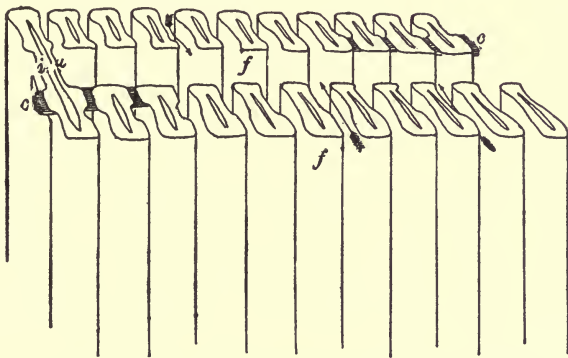


FIG. 4.—Diagram of the gill of the mussel (*Mytilus edulis*). The filaments (*f*) are bound together by round patches of cilia shown at *c*. Transverse bands of tissue or interlamellar unions (*iu*), hold the two walls or lamellæ of the gill together.

filament, isolated from the gill, is shown in Figure 5. The reference-letter *b* is placed at its point of origin from the body, *b* is the descending, and *a* the ascending limb. At the bend, which marks the lower edge of the gill, the filament is notched, and many of these notches placed side by side form a groove on the gill margin, along which food is carried forward to the palp. One of the interlamellar unions is shown at *iu*.

The relative position of the filaments is shown in

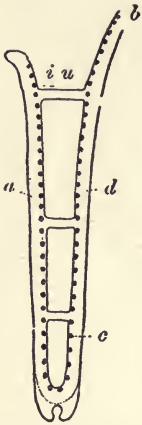


FIG. 5.—Single filament of the gill of the black mussel. The reference-letter *b* marks the point of origin from the side of the body, *d* is the descending and *a* the ascending limb of the filament, *iu* an interlamellar union, and *c* one of the patches of cilia uniting contiguous filaments.

Figure 4. The two rows of tubes represent the outer and inner lamellæ. Along regular horizontal lines are found the interfilamentar unions (*c*). They are small, rounded patches, slightly elevated from the sides of the filaments, the cells of which bear long cilia or hairs. These tufts of cilia are placed opposite each other on contiguous filaments, and are intermingled much as one might interlock the bristles of two paint brushes by pushing them together. This intermingling of straight hairs is sometimes disrupted, but they have a slight oscillatory movement, and on being brought in contact, soon work together as before. The interlamellar unions (*iu*) are bands of tissue reaching across the cavity of the gill, and uniting the two limbs of the same filament.

The gills of *Pecten* (Figure 6) are essentially like these, but are more specialized in that, at fairly regular intervals, a filament has become greatly enlarged, in order to support firmly the interlamellar partition which it develops. Another difference is that the filaments between these, instead of lying in a straight line, bend outward in a fold. Such an arrangement allows of a greater number of filaments in a gill. The interfilamentar unions in the scallop are ciliary, but the cilia, instead of appearing on patches as in the mussel, are borne on spurs that project from the filament into the interior cavity of the gill, as shown at *c s*.

In the giant or northern scallop, cilia unite some of the filaments near the free margin of the gill, but near its

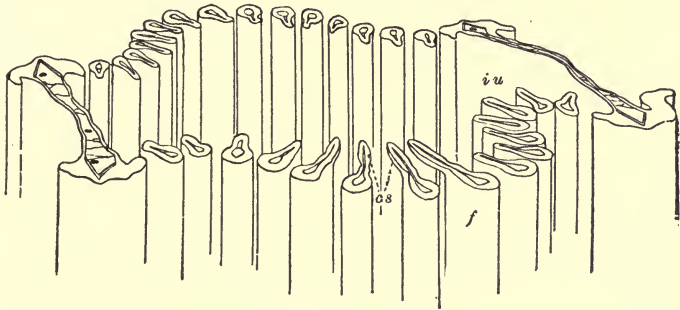


FIG. 6.—A portion of the gill of the scallop (*Pecten irradians*) showing the folding of lamellæ. The reference-letter *f* designates one of the filaments. The letters *cs* indicate ciliated spurs that are sectioned, and *iu* an interlamellar union.

base they are joined by bands of fine tissue, thus forming a much more stable union. This growing together of adjacent filaments becomes very much more extensive in the clams and the oysters.

Comparing the gill of the little neck clam, *Venus*, with that of the scallop, we find the same folding of the lamellæ, and largely developed interlamellar partitions. But the filaments are small and all of the same size. The greatest difference in the two cases is that in *Venus* the filaments have grown together very extensively on their inner margins, leaving mere slits here and there where water may enter the gill. A very curious structure is found in this gill. Thin walled sacs grow from the interlamellar partitions and the filaments into the

interior chamber of the gill. They contain blood and are probably developed to facilitate its oxygenation.

While the oyster has become, through degeneration, one of the simplest of lamellibranchs in general structure, its gills are among the most highly modified and perfected to be found in the group. In a general way, this may be explained by saying that the extensive degeneration of certain organs has resulted from the habit

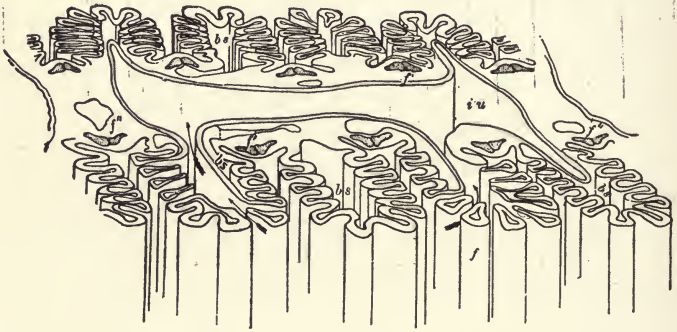


FIG. 7.—The gill of the oyster (*Ostrea virginica*). Reference-letters *bs* indicate blood spaces; *f'* and *f''* enlarged filaments at reentering angles of lamellar folds; other letters as before.

of fixation, and that this mode of life has made special demands on the gills, which have been rendered more complex in consequence.

Comparing the diagram of the oyster gill (Figure 7) with the others, the folding of the lamellæ seen in the scallop gill, is developed to the greatest degree. Between folds as in *Pecten*, a single filament is greatly enlarged (*f'*), and at regular intervals a large interlamellar partition appears, uniting the inner edges across the gill chamber (*f''*). As in the little neck gill also,

the filaments have grown together by their inner edges, leaving slits here and there for the ingress of water.

Figure 8 represents a cross section of several filaments in the fold of a lamella of the oyster gill. Four of these filaments have grown together along their inner margins. If the section had passed a little higher or lower on the gill, one or more of these would have been shown to be free from the others. Several free filaments are shown in the figure, and between them water enters the interior of the gill. But above and below the plane of the section, these also would be united with contiguous filaments for shorter or longer distances.

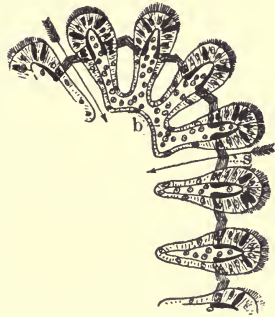


FIG. 8.—Transverse sections of several filaments of the oyster's gill. A union of the inner edges of four of these is shown, and their common blood space is indicated at *b*.

Gill filaments, when greatly magnified (Figure 9), show essentially the same structure in nearly all lamelli-branches. They are tubes for the circulation of blood, and their walls are single layers of cells as shown in the sectional views of the oyster and scallop gills. Each filament contains a pair of rods of secreted, rubbery substance that give stiffness to the slender tube, and probably tend to keep its blood space (*b*) open. The cells of the wall are modified on the outer edge of the filament. Some of them bear an immense number of cilia (*f c*), which are protoplasmic hairs having an excessively rapid lashing movement that produces currents in the water, and also removes foreign particles from the surface of the gill. At the margins of this tract are rows of cells

bearing greatly elongated cilia. In the majority of lamellibranchs, are found two such rows, but in some cases there are four, two on each side. Among the cells that bear the small frontal cilia, are certain ones that have become gland cells (*gc*) producing a large quantity of sticky mucus which they pour out on the surface of the filament.

The functions performed by these complicated gills are many. They are breathing organs, and were probably developed originally for that purpose alone.

Blood, that is continually streaming through the many filaments, is brought so close to the water surrounding the gills that oxygen borne by it enters the fluid by diffusion and is then carried to all parts of the body. But it is necessary that water surrounding the gills should frequently be changed because its oxygen is quickly exhausted. In many aquatic animals the gills move back and forth to agitate the water, or special organs are developed to direct a current upon them. Here a very powerful current of the most effective sort is produced by the gills themselves. The cilia lash in such a way as to drive water

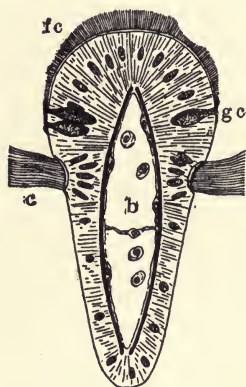


FIG. 9.—Transverse section of a single filament of the gill of *Pecten irradians*. Structures designated are:—*fc*, frontal cilia; *gc*, gland cells; *sc*, straining cilia; and *b*, blood space.

between filaments on both sides of the gill into its interior. The passageway is indicated by the arrows in the figures of the oyster and scallop gills. The current does not pause here, but continues swiftly upward toward the

base of the gill, where it enters a tube which is without obstructing interlamellar partitions, and leads backward to the cloacal chamber. This has been described as a space above the four gills and behind the main portion of the body.

Into this cloaca all four gills continually pour their streams, which unite to form a powerful current that leaves the body either directly between the unmodified mantle folds, or through the dorsal chamber of the siphon tube. As a large amount of water is in this way being constantly forced out of the body, a corresponding volume is being drawn in. It enters directly between the mantle folds into the gill chamber, or, in the clams, is drawn into it through the ventral tube of the siphon. So rapid is the stream in all forms, that without doubt many gallons of water flow through the gills daily.

It is interesting to notice that this greatly perfected pumping mechanism never ceases its activity during the life of the individual. The cilia are not under the control of the nervous system, and the direction of their beating is never changed or apparently slackened. There is but one way to prevent the streaming of water through the body, and that is to close the shell or contract the siphon so as completely to close the gill chamber.

Now it happens that this inflowing stream bears many minute marine plants that these shell-fish use for food. They are not so numerous but that a large amount of water must be strained to enable the animal to obtain enough of them for its nourishment and growth. These organisms are small enough to pass through between the gill filaments and so out of the body again; but on coming in contact with the gill, they are instantly en-

tangled in the mass of mucus produced by the gland cells of the filaments.

Cilia now carry the mucus, with its captured organisms, down to the margin of the gill, or in some cases to its base, where it is passed forward along ciliated tracts toward the palps. The palps, on touching the margin of the gill with their inner ciliated surfaces, remove the mass, which travels toward, and finally into the mouth. In addition to aerating the blood, then, the gills have become modified into food collecting and food transporting organs also.

The gills of the European oyster and several other bivalves also, serve as baskets, in the female, into which the eggs are discharged. Here they are held until they have passed through the early stages of development. This, however, does not occur in any of our Atlantic food mollusks.

CHAPTER III

DEVELOPMENT



IN view of the present vast extent of knowledge concerning the minute structure of animals and plants, it seems almost incredible that the beginnings of such studies had hardly been made within the lifetime of persons now living. It was not until nearly four decades of the nineteenth century had passed, that the epoch-making fact was established that the bodies of all organisms were composed of living units which were, and still are, called cells.

The term cell is really a misnomer, for it implies an investment or wall enclosing an empty space. The older observers discovered that the stems of woody plants were composed of bodies having thick walls that in each case surrounded an empty cavity. These bodies they properly called cells, but the units of structure which they had discovered were really only walls, the essential or living parts within having disappeared. Such empty spaces are not found in animal bodies or in the living and growing parts of plants.

Cells that compose the body of an animal or plant are not all of the same sort, as are the bricks of which a building is constructed. Some are nearly spherical, others are flattened or are elongated into fibers. Most of them are minute, but there is a great variation in their

relative size. They are thus differentiated in structure because they have become adapted to various uses.

So far as we are able to judge, all cells, whether animal or plant, are essentially similar in their nature. Each is a body of living protoplasm, usually with a jelly-like consistency, but with a minute structure that is difficult to determine. Each cell mass contains a small spherical or ovoid body called the nucleus. This is a part of the living substance, and is complicated in structure. It is a constant and essential part of the cell.

Among the cells of the bodies of animals and plants are those set apart to perform the function of reproduction. The essential feature of sexual reproduction is the union of two cells, usually one from each of two parent individuals, to produce a new cell which, by multiplication, builds the body of the offspring.

These two sexual cells that thus unite, differ from each other in size and in structure. The female cell, or ovum, as it is called, is usually spherical and often relatively large from the presence of secreted yolk or food substance. With this the body of the early embryo is to be fed until it possesses a digestive tract, and has some means of capturing its own food; or, in animals in which the young develops within the body of the parent, until it forms organs by means of which it can, in a parasitic fashion, take its food from the body of the mother. Because they carry the food substance, ova are inert, and must be sought by the male cells.

The spermatozoa, or male cells, are exceedingly minute. In structure they are much the same in nearly all animals. Each is a single cell containing a nucleus. This latter body forms what is known as the "head," and the remainder of the cell is extended from it in the form of

a fine thread and is called the "tail." The object of such an extreme modification of the cell becomes clear when it is observed that its tail or flagellum is capable of a violent lashing movement that propels it rapidly through the fluid in which it finds itself after being discharged from the body of the male. This cell is modified for swimming in order that it may meet the ovum, and its great motility also enables it to penetrate the latter when contact with it has been effected.

For a time the male cells possess great vitality, though their life is short if they fail to meet the ovum, for they carry no food. Even in higher animals, where, in performing their function, they are neither exposed to the air nor to a change of temperature, they will live for a time outside the body, and apparently are not injured by many salts in solution, recover from the effects of narcotics, and may even regain their motion after being frozen.

The necessity of such great vitality is especially clear in the case of marine animals like oysters, clams, starfish, and many others, where there is no union of the sexes, but a mere discharge of sexual cells into the water where, often under adverse conditions, they must find each other.

The ovum and spermatozoon of the oyster, and also the male cells of the quahaug and scallop, are represented in Figure 10. With slight changes this figure would represent equally well the sexual cells of other bivalves—and, in fact, those of almost any sexual animal. The ovum is seen to be relatively large, with a conspicuous nucleus (n), and bears minute granules of yolk. The long flagellum or tail of the spermatozoon drives the cell with the nucleus forward. The latter structure has a

slightly different shape in different bivalves, as indicated in the figure.

After becoming mature in the sexual glands of bivalves, usually in the early summer, both male and female cells are discharged into the water. Both may be

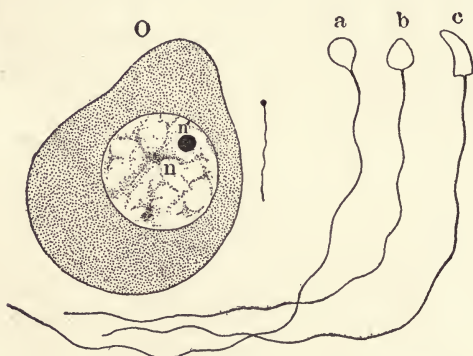


FIG. 10.—Ovarian ovum of the oyster (*o*) showing nucleus (*n*) and nucleolus (*n'*). The relative size of the male cell is represented by the small figure lying near it. There are also shown, greatly magnified, the spermatozoa of *Ostrea* (*a*), *Pecten* (*b*), and *Venus* (*c*).

carried by currents. The ova are passive and gradually sink, but the spermatozoa very soon begin to swim. They are vastly more numerous than the eggs which they are intended to find. Though a single spermatozoon only, unites with an ovum in normal cases, it might appear that conditions are such that comparatively few unions would take place, and the opinion is sometimes expressed that such probably is the case. There is, however, no good reason for such a belief. Males and females with full glands, may be stimulated experimentally by employing certain changes in the surroundings

in such a way as to cause the discharge of both sexual products simultaneously. In nature, as they lie close together, such a stimulus as a rise in temperature probably brings about the same result, and it is quite possible that few ova fail to be found by spermatozoa.

An ovum unites with a single spermatozoon only. When the two cells finally meet, the activity of the flagellum soon forces the nucleus or head into the body of the ovum. The flagellum itself does not enter. Its function being completed, it is cast off.

In the American oyster a curious phenomenon appears just at this time. The nucleus of the ovum divides and a small cell containing half of it, separates from the ovum. The process is soon repeated, and a second small cell appears beside the first. These polar cells, as they are called, are shown in Figure 11, II to VI, and are designated by the reference-letter *p*. They have no part in forming the body of the embryo, and though they remain attached to it for some time, they finally are lost. Theoretically their nature can be very satisfactorily accounted for. The formation of polar cells has been witnessed in most animal eggs. It precedes fertilization, and is referred to as the maturation of the ovum.

The male and female nuclei now lying within the ovum, move toward each other, touch, and finally fuse to form a single new nucleus. Once more we have an ovum with its nucleus, but it is now a complex of male as well as of female elements. This wonderful process is still called fertilization, a term given to it when it was supposed that the male cell simply stimulated or excited the ovum to produce a new individual. We now know that it has an equal part with the ovum in forming the body of the young.

The new cell, called the fertilized ovum, or, better, the oosperm, now begins a process of division that results in a large aggregate of cells, which gradually group and arrange themselves into the form of organs, in which form, position, size and function, conform to the conditions characteristic of the species.

There is nothing in nature so marvelous as this minute fragment of living substance. It was formerly believed that the oosperm was a fully formed individual in miniature, possessing all the organs of the adult body, and that, like a plant bud, it merely expanded and unfolded during development. In reality it is a simple cell, undifferentiated in structure, and yet possessing the most wonderful potentialities. If we place side by side the fertilized ova of the simplest and the most highly specialized of many-celled animals, we are able to discover only minor differences in structure, such as are easily accounted for by secondary causes—a greater or less accumulation of yolk and the like. Even the fertilized ova of plants are essentially similar to these. And yet we know that each holds in its minute body, when living, the hidden power to set in motion and to continue a long series of marvelous transformations, ending in one case in the production of a sponge, or in another of a human being. The marvel of it was recognized before Paley, a century ago, wrote:—"A particle, in many cases minuter than all assignable, all conceivable dimensions; an aura, an effluvium, an infinitesimal; determines the organization of a future body; does no less than fix whether that which is about to be produced, shall be a vegetable, a mere sentient, or a rational being: an oak, a frog, or a philosopher."

The oosperm possesses the power of self-division, a

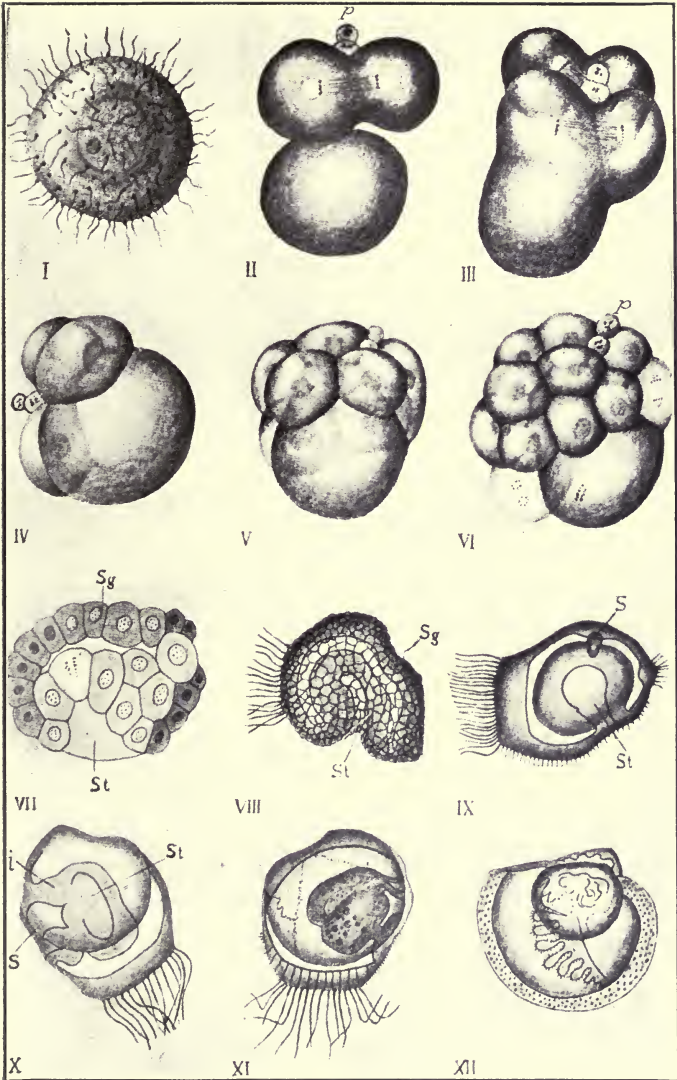


FIG. II. The development of the American oyster, after Professor W. K. Brooks.



power that its cell descendants retain. The manner of its division or segmentation in the American oyster will illustrate the process in the group of the bivalves, and, briefly following the description of Professor Brooks, is as follows:—

About an hour after the male cell has entered the ovum, the latter becomes somewhat enlarged at one end—that to which the pole cells are attached. The nucleus of the ovum divides, the two nuclei separate, and a constriction of the body of the cell separates it into two cells. The cell to which the pole cells are attached soon divides, and a stage represented by II in Figure 11 appears. Here are shown one large and two slightly smaller cells. Preceding every division, there is a division of the nucleus, so that every cell always contains a nuclear body.

Even thus early in development, it is possible to determine a difference in the fate of these cells. From the single larger one, will arise the digestive tract, and from the two smaller, will be formed the outer wall of the body.

In the course of a few minutes, if the temperature is not below 70° Fahrenheit, the two smaller cells divide, forming four, each of which is about half the size of the cell from which it is derived. Again after a pause, there is another division of the small cells. One more division gives us the segmenting egg represented by VI, in which one large cell is partially covered by a cap of several smaller ones.

The multiplication of the smaller cells continues, and they spread still farther over the surface of the larger one. The latter finally divides, forming an inner layer. The relative positions of these parts is illustrated by VII,

which represents a section cut through the center of the mass. The outer cells, darkly shaded in the drawing, will form the wall of the body, the inner ones the digestive tract. The reference-letters *s t* indicate a pit or cavity, now wide open to the surface, but later nearly closed, which becomes the stomach. The reduced opening is the primitive mouth.

Up to this time, the shape of the embryo has approached that of a sphere, but it now changes, assuming a form like that represented by VIII. The outlines of surface cells are shown here, but in subsequent figures they are omitted. At one end of the body the surface cells throw out some protoplasmic hairs, or cilia, which begin a lashing or rowing movement so violent that the embryo is raised from the bottom, where it has been lying, and swims upward to the surface of the water.

From two to four hours have now elapsed since spermatozoon and ovum united. As in the case of many other animals, the rate of segmentation depends on temperature. When this is lower than the optimum, development is retarded, and may be stopped altogether. The swimming embryos of the oyster are greatly affected by cold, and a heavy shower or cold wind coming when they are gathered at the surface, may kill them all. This apparently often happens on the north Atlantic coast, and probably accounts for the failure of the "set of spat" which sometimes occurs in restricted localities, or even generally, in certain years. Such a failure is almost unknown in the Gulf of Mexico. On the other hand, the reproduction of the eastern oyster is almost entirely prevented in the cold waters of the Pacific, where it is planted and is able to grow.

Soon after the embryo begins to swim, the valves of the shell appear as minute secreted plates one on each side of the body. In other bivalves, the shell rudiment is at first unpaired. These shells grow rapidly at their edges, and soon cover the body. Sheets of cells grow out to line the shell valves on their inner surfaces, and become the mantle folds. The part of the body bearing the cilia projects as a rounded disk which is called the velum. Muscle fibers form by the elongation of cells in mantle and velum, and by their contraction, these parts may be entirely withdrawn within the shell.

In the meantime, internal changes have occurred. According to Professor Brooks, the primitive mouth closes. In about the same locality, the surface of the body then pushes in to form a pit. The bottom of this unites with the anterior end of the stomach. These walls are broken through, and the stomach and the new mouth become connected. Posterior to the mouth a second pit from the surface of the body touches the stomach. Its cavity in the same way becomes connected with it, and there are formed the anal opening and the rudiment of the intestine (X and XI, oysters about three and six days old respectively).

Up to this time, the embryo has subsisted only on the food yolk deposited in the ovum during its growth in the parent's body. Consequently it has not increased in volume. With the formation of mouth and anus, it begins to capture organisms in the water and to digest them, and rapidly increases in size.

An interesting feature of the development is the formation of a foot which is never used, because the embryo becomes attached before it is large enough to make use of a creeping organ. An anterior as well as a posterior ad-

ductor muscle also appears. Subsequently the foot and anterior adductor degenerate and completely disappear.

During the formation of the shell the small oysters leave the surface of the water and continue for some time to swim at lower levels. About the sixth or seventh day after development begins, they settle to the bottom, and, if fortunate enough to come in contact with a hard, clean surface, attach themselves by a sticky secretion of the mantle. In the figure, XII represents such a recently attached oyster, and shows the finger-like rudiments of the inner gill, which is the first of these organs to form. The velum with its cilia, having now become useless, soon disappears.

The early development of two or three others of our edible bivalves has now been studied, and it appears that the succession of changes in each is very much like that of the oyster, as would be expected. But because of differences in the manner of living in adults of different species, we find diversities of structure appearing soon after the swimming stage. The details of the early life of some of these forms are not yet known, but many observations have been made on the growth and habits of the attached oyster, the small soft clam, and the young scallop, and these will subsequently be mentioned.

CHAPTER IV

CILIARY MECHANISMS



LITTLE more than a century ago, a remarkable book on Natural Theology was published by William Paley, an English ecclesiastic. It presented an argument for the existence and benevolence of a personal deity, and was founded on some of the phenomena of nature. In essence, Paley's argument was that the existence of any contrivance in nature necessarily involved the existence of a designing mind which created it, and he described many mechanisms which are, without doubt, constructed for very definite and particular uses. This argument was not new in Paley's time. It had previously been presented in published form by a Dutch writer, and undoubtedly had existed in some form in man's mind since an early period. But Paley developed it elaborately and with great success, and it has ever since had a powerful influence on the common conceptions of the Creator and the universe.

Nevertheless the world has generally come to agree with Huxley's statement that Paley's argument from design, as he evidently intended to apply it, received its death-blow from Darwin's "Origin of Species," which accounts in quite a different manner for the appearance of mechanisms in nature. What Paley really accomplished for the theology of his time, was the damming up of the flood of knowledge that later destroyed the greater part

of it. It was the irony of fate that the lasting benefit of his labor was to natural science, the deadly foe of theology, by fixing in the mind of the thinking world, as nothing else had done, knowledge concerning the utilities of mechanisms, the usefulness of parts, and the adaptation of the whole organism to its environment—foundation facts in Darwin's explanation of the origin of species by natural selection.

So it has happened that the structure and operation of mechanisms in animal and plant bodies have received much attention from biologists, and have often excited great admiration for the complexities and beauties of their adjustments. Illustrations of mechanisms may be had from any group of organisms, though the more intricate ones are to be found, as might be expected, in the bodies of higher animals or plants.

They are often very complicated, however, in more lowly forms. Judging from the jocular references to the placidity of the oyster and the happiness of the clam that no popular writer has ever been able to avoid when mentioning them, the common notion seems to be that these are inert, structureless, functionless masses of pulp, living the simple life reduced to its lowest possible terms. But in the chapter on anatomy, it was shown that a semi-automatic ciliary mechanism exists in the members of the bivalve group for straining food particles out of the water and passing them to the mouth. That such a function was performed, has been known for a long time, but it was first observed by the writer that there exists in connection with it another and even more complicated mechanism, depending largely on the nervous system for its operation, by means of which mud and other useless matter collected by the gills may be carried away from

the mouth and out of the body. It is because this mechanism is so intricate and so beautifully adapted to the environment in which bivalves live, and because few facts concerning it have yet been published, that a short description of it, as it appears in the common food mollusks, will be given here.

But first, brief mention must be made of the minute food organisms which the animal allows to pass into its mouth. Then it may be noted how it deals with the undesirable mud particles, also brought by the incoming stream, and how it rids itself of them without checking the flow of water into the body.

There are reasons for believing that, from the beginning, lamellibranchs lived on floating organisms that they were able to take from the water. However that may be, all living forms whether creeping, attached, or burrowed in the bottom, now derive their nourishment entirely from microscopically small organisms brought to the body by the action of the gills.

The food forms thus captured and consumed, belong, with few exceptions, to a universally distributed group of plants known as diatoms. They are single-celled organisms, but possess some structural modifications of great complexity. The bit of protoplasm constituting the living part of the body is enclosed in a case of pure glass, made of two pieces nearly equal in size, one fitting into the other like a pill-box into its cover. This case is often sculptured with extremely minute and exquisitely regular markings, definite patterns characterizing many species. In outline they vary from circular disks to slender rods (Figure 12). On account of their beauty and variety, they are the stock subjects for exhibition by amateur microscopists.

As might be expected, all localities are not equally favorable for the growth of these plants. Temperature has much to do with the rate of their multiplication.

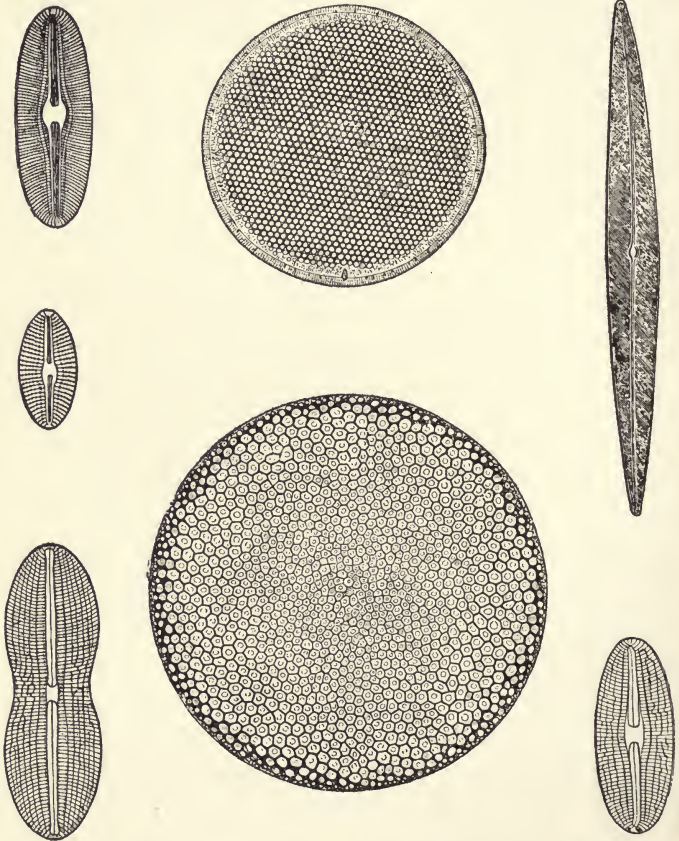


FIG. 12.—Diatoms found in the stomachs of oysters. (From the U. S. Bureau of Fisheries.)

They are numerous enough in the cold waters of the Atlantic coast above Cape Cod to support large areas of long neck clams, but their numbers are much greater in

warm waters like those of the Gulf of Mexico. They are more numerous in the shallow waters of coast lines than in the open sea, probably because the salts in solution, forming a necessary part of the material required for their nourishment, exist in sufficient quantities only near the mouths of rivers or small streams which, in turn, have derived them from the soil. The temperature of the water on extensive flats and in shallow estuaries, also, is higher than in the open ocean. As a result of this distribution of diatoms, bivalves are most numerous in comparatively shallow waters near the land.

The normal process of feeding, when the water is free from mud, is much the same in all bivalves. Imagine an oyster, for example, lying with valves open in water containing only diatoms. The cilia on both surfaces of each gill continually drive water from the branchial chamber through the spaces between filaments and into the gill interior. Here it passes upward to the base of the gill, falls into the epibranchial space, and is forced backward and discharged from the body above the gills.

Now and then the stream bears a diatom to the gill surface. On touching a filament, it instantly adheres to the sticky mucus produced by the gland cells. This mucus, with its entangled diatoms, is then moved by the gill cilia down to the free edge of the gill, as indicated by the arrows on the gill surface in Figure 3. It now proceeds forward on the gill margin until the palps are reached. The material is transferred from the gill to the ciliated inner surfaces of the palps, and proceeds directly across their ridges toward, and finally into the funnel-like mouth. So much of the function of the gill and palp cilia has been known to biologists for many years, but practically nothing more has been ob-

served, though there are several variations in the method of directing food to the mouth. The fact that palps in all forms also possess ciliated tracts leading away from the mouth, and that the sides of the visceral mass and the walls of the mantle possess complicated ciliated surfaces, has been very generally overlooked.

In some bivalves certain gill faces or lamellæ carry the captured organisms to the base, instead of to the margin of the gill, where they also are borne along ciliated paths leading to the palp surfaces; and in one case among our food mollusks, that of the scallops, the transportation on the gill faces may at one time be to the bases, at another to the edges of the gill, and without any reversal of the ciliary action. The figure of the oyster also shows a tract at the gill base that leads to the palps.

One who carefully observes oyster beds or clam flats at different seasons, notices that there are often great changes in external conditions. Even where tide currents are strong, thus mixing waters, there is considerable variation in temperature during the summer, and the average difference between summer and winter temperatures on the north Atlantic coast of course is great. Continued cold checks the growth of diatoms, and so lessens the amount of bivalve food. Though it has not been carefully studied in most forms, it has recently been shown that scallops and little neck clams do not grow at all during the winter in northern waters. Whether this is true of warm southern waters is not known, but probably it is not. It is a safe prediction that the growth of all bivalves living on the shore of the Gulf of Mexico will be found to be uninterrupted. There are also great changes in the salinity of water, especially near the mouths of rivers entering the sea, and oysters par-

ticularly are sensitive to such changes. Along the shore of the Gulf of Mexico, near the mouths of the Mississippi and other rivers, the water for days at a time may be nearly fresh enough to drink.

It is sometimes difficult to determine the precise effect of such changes on the inhabitants of the bottom, but there is one condition, frequently observed, the response to which in the case of bivalves, we are now able to describe in detail. This condition is the periodical loading of the water with mud, that occurs on all coasts. It may be observed even on the Maine coast in regions where there are practically no beaches or flats, and where the bottoms are very generally rocky; and almost everywhere along the coast of the Gulf of Mexico, but especially near the mouth of the Mississippi, the water is clear one day and fairly thick with mud the next. The phenomenon is undoubtedly due to the irregular discharge of rivers and to tide currents.

It may readily be understood that water bearing suspended mud or fine sand presents a serious problem to the bivalve feeding on microscopic plants strained from it, and if the gill apparatus that collects them were the only one to deal with them, mud as well as food would necessarily be carried into the digestive tract as long as the shell was allowed to remain open. This ingestion of mud or sand normally occurs in some animals that are able to digest the organic matter included in the mass, but, with the exception of one known genus, the digestive organs of shell-fish are evidently not suited to perform such a function. There are two ways in which the problem may be solved. While the water is muddy, the shell may be closed so as entirely to prevent it from entering the body, or the flow may be allowed to con-

tinue and the mud strained out and discharged from the mantle chamber instead of being taken to the mouth. But an objection to closing the shell for long periods is that aeration of the blood ceases when the water stops flowing. It is true that some lamellibranchs may live for days or weeks out of the water, when the temperature is low, but they seem to be injured by such treatment, at least in the adult state. Probably for this reason, the second plan is the one that has been adopted.

Bivalves persist in keeping the shell open, thus allowing water to enter the branchial chamber, even when bearing mud in considerable quantity. On entering, many of the suspended particles are brought in contact with the inner faces of the mantle and the wall of the visceral mass. Now all of the free surfaces of the mantle chamber—mantle, visceral mass, and gills alike—produce a sticky mucous secretion, so that particles adhere to any of these surfaces that they happen to touch. Let us first inquire into the disposition of those that are lodged against the inner mantle wall.

Figure 13 represents the inner surface of the mantle (*m*) lining the left valve of the shell of the hard clam, *Venus*. All other parts of the body have been removed. If a few grains of powdered carmine or fine sand are allowed to settle through the water upon a living specimen prepared in this way, they may be seen to adhere to the mantle wherever they touch it, and then, together with the mass of mucus in which they are held, they begin to move in the direction indicated by the arrows of the figure.

This movement is due to the action of cilia, lashing continually in definite directions, and uncontrolled by the nervous system. Everything is moved downward,

finally reaching a sharply defined tract parallel with the mantle edge. Here the stream is directed backward to a point just below the opening of the incurrent siphon (*is*). It will be remembered that the siphon is a pair of tubes formed as a growth from the mantle, and that in the living clam, a strong stream of water enters the

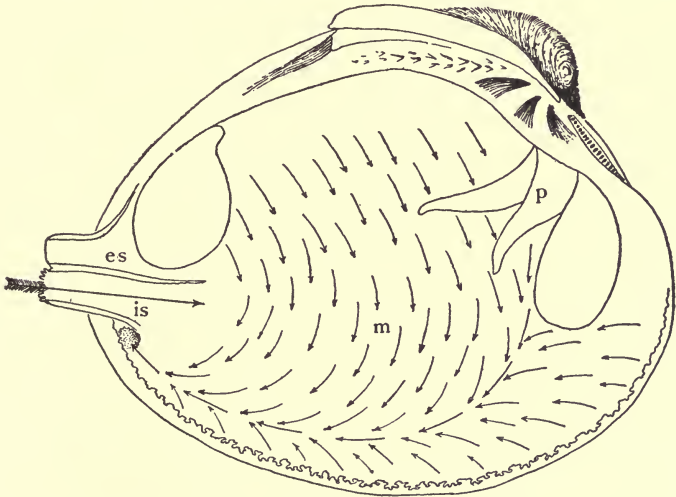


FIG. 13.—Ciliation of the mantle of the round clam or "little neck" (*Venus mercenaria*). The arrows indicate the directions taken by foreign particles in the mantle chamber that come in contact with the mantle wall. The palps are represented at *p*.

lower one. If a mass of material being moved by the mantle cilia were brought in contact with this stream, it would be swept far back again into the mantle chamber, so it comes to rest in this small bay below the siphon, where a considerable quantity of it may collect. What is to become of it? It could not easily be carried directly outward between the edges of the mantle, because the entire shell is covered in the bottom. The only

path to the exterior is through the lower tube of the siphon, and cilia could not possibly move the mass against its powerful incoming current.

When a sufficient quantity has collected, the clam suddenly contracts the adductor muscles, the result being that some of the water filling the spacious mantle chamber is thrown out in a strong jet through the lower siphon tube, and the waste material being in so favorable a position for it, is discharged. All bivalves seem to have this habit of periodically discharging water from the mantle chamber, and for the reason given. Long neck clams, if steamed or baked immediately after being taken from their burrows, usually contain in the mantle chamber a very annoying amount of sand. But if they are allowed to stand over night in a bucket of clean water, the sand is removed. In effecting its removal, a large part of the water of the bucket will be found on the ground where it has been thrown, sometimes to a distance of several feet, by the powerful jets directed out of the siphons.

Though there are always differences in details, the mantle ciliation of all lamellibranchs so far examined is practically like that of *Venus*. Apparently its sole function is the removal of objectionable matter from the body.

The ciliary tracts of the side of the body are represented in Figure 14. Mud particles or fine sand grains adhering to its surface are carried backward to the point x , where they fall on the mantle, which disposes of them as described. The figure also illustrates the position of the labial palps and shows the striations or ridges on the inner face of the posterior one, across which food is carried to the mouth.

But the mantle and sides of the body collect comparatively little of the mud from the water, for the stream that rushes into the gills brings to their surfaces the greater part of it. Probably none of it is allowed to enter, but all is caught by the mucus on the gill surfaces. It now is carried downward on all the gill

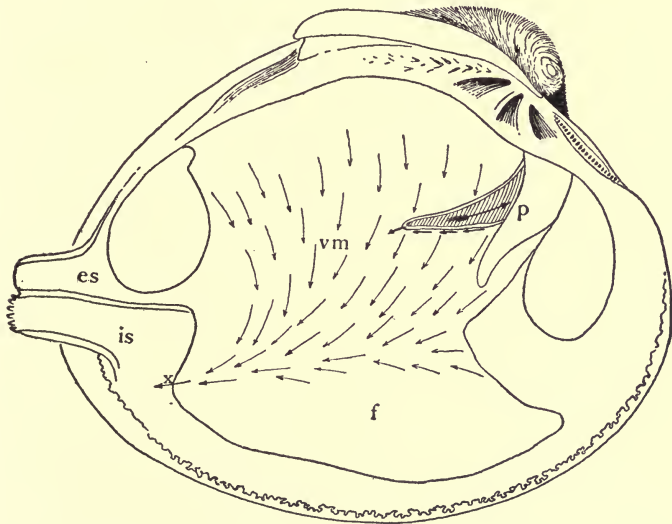


FIG. 14.—Cilia currents on the side of the visceral mass of the round clam, *Venus*. The currents on the inner surface of the palp are also shown.

lamellæ to the edges of the gill, in *Venus*, and, falling into the grooves on their margins, is conducted swiftly forward toward the palps. The position of these organs is seen to be such that the edge of the inner gill lies between them.

In one case at least, among bivalves (*Yoldia*), the gills possess a special mechanism by means of which col-

lected material may, if it is desirable, be transported directly to the epibranchial chamber and out of the body; but in all of our food mollusks, the gills can only collect and transport to the palps any material, whether food organisms or mud particles, that comes to them in moderate quantities. If the mass of material is very great, it may sometimes fall from the gill margins to the mantle walls, instead of going to the palps.

But in all cases in which the labial palps receive material collected by the gills, they determine whether it shall go into the digestive tract or be sent out of the body. Their inner surfaces are seen to bear fine parallel lines, the direction of which is indicated in Figures 3 and 14. These ridges are ciliated and the hairs lash in such a direction that food crosses over them on its way to the mouth. The palps being muscular and capable of extensive movements, receive material from the gill edge simply by placing their inner surfaces against the gill, and the mass of mucus with its particles is easily lifted off and carried onward.

But on the lower edge of each palp, as shown in the figures, is an unstriated margin very strongly ciliated, that sweeps directly away from the mouth. Now when large quantities of material are delivered by the gills, the palps at once respond by moving these margins into such a position that they, instead of the ridges, remove the gill collection. Then, swinging down, with their loads of accumulated waste, the palps cast the material off from their free tips into the mantle chamber. Here the undesirable collection is picked up by the mantle cilia, and disposed of in the manner already described. This ciliated margin of the palp, then, is the special organ for switching the mud accumulation on to the outgoing track.

It is practically the same in other lamellibranchs, though in some cases the entire mechanism is much more complex than in the little neck or oyster.

Though diatoms and useless particles are sometimes brought to the gills at the same time, an examination of the stomach contents of any bivalve will show that there has been a selection of the food organisms and an exclusion of mud or fine sand. The latter are sometimes found in the stomach, but in small amounts. When this mixed mass of food and mud is brought, it is not possible to separate them, and the whole is rejected and sent out of the body. It thus happens that the bivalve ceases to feed when the water is muddy to a certain degree, though it still allows water to enter the mantle chamber, presumably for the sake of the oxygen it bears.

It appears that the animal is not able to distinguish food from mud particles either by the gills or palps, but the selection of food results directly from the differences in the response of the palps to varying *quantities* of matter transported to them by the gills. Under favorable conditions, diatoms are collected a few at a time, and are sent across the palp ridges to the mouth. In muddy water the particles increase in number until the palps respond by diverting everything received to the outgoing tracts.

This may be proved experimentally, though the operator must exercise care and skill. Very fine grains of carmine, dropped on gills or palps of any bivalve, in very small quantities, may be observed, with the aid of a glass, to pass into the mouth. This simulates conditions favorable for feeding, when diatoms are steadily strained, a few at a time, from clear water. When

larger quantities of carmine grains are used, their number finally causes the palps to reject them, the ciliated margins often being folded over so as to sweep clean even the striated surfaces of the palps, if carmine has fallen directly on them, and they are able to clean themselves in still another way that cannot be described here.

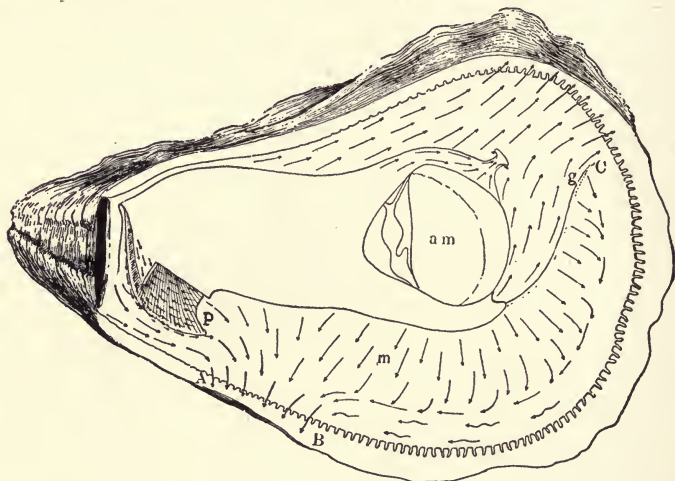


FIG. 15.—Cilia currents on mantle (*m*) and palp (*p*) of the oyster (*Ostrea virginica*).

The general direction of currents and the possible routes for food or mud in the mantle chamber of the oyster will be understood without description by a study of Figures 3 and 15. The gills are represented as having been removed in the latter figure, their former line of attachment to the mantle being shown by the line *C*. It will be seen that undesirable matter is cast out of the body over the edges of the mantle between the points *A* and *B*, and that this is the most favorable region for such a discharge. If farther back, as below *C*, this would

have to be accomplished directly against the incurrent stream of water. The palps function, as in *Venus*, in disposing of material that they receive from the gills.

There is a widespread belief that oysters and clams may be fattened with such substances as corn-meal. Even those well acquainted with the subject often have supposed that bivalves had the power of taking such material into the mouth. The following is a statement on the subject published in an authoritative and valuable guide to oyster culture:—

“Experiments have been made with a view to feeding the adult oysters upon corn-meal or some similar substance, but such attempts have been of no practical value. There is no doubt that they would eat corn-meal or any other substance in a sufficiently fine state of division to be acted upon by the cilia. The oyster is incapable of making a selection of its food, and probably any substance, nutritious, inert, or injurious, would be swept into the mouth with complete indifference except as to the result. Corn-meal and similar substances would doubtless be nutritious, but their use must be so wasteful that the value of the meal would be greater than that of the oyster produced.”

In view of the account of the feeding habits of bivalves here given, these statements require some interpretation. Corn-meal ground to microscopically small particles might be taken into the mouth of oyster or clam if brought to the gill surfaces a very little at a time, but even in a laboratory experiment, it would not be easy to arrange these conditions properly. In such experiments as those to which the writer of the quoted paragraph refers, in which corn-meal, as ordinarily ground, is merely thrown into the water over the bivalves, or even

in cases in which it is placed directly in the mantle chamber, a very small amount of it, if any, would ever reach the mouth opening. Moreover, it has been found that clams refuse to allow such substances as very finely ground fish or shrimps even to enter the mantle chamber through the siphons. Mere contact of such materials with the sensory end of the incurrent siphon causes violent contractions of the adductor muscles, and of the siphon also.

Though the same general plan is followed in all, there are many curious modifications of these ciliary mechanisms that are characteristic of different bivalves, and they occur on palps, mantle, or gills. One of the most astonishingly ingenious (if the word may be permitted) of these, is an arrangement on all the gill surfaces of the scallops, by means of which foreign particles, strained from the water, are automatically directed toward the palps and the mouth, when few, and upon outgoing tracts whenever they increase to a certain number.

To understand the operation of this mechanism, it should be noticed that the gill surfaces are thrown into marked folds, as described in the chapter on anatomy. These folds extend from the bases to the margins of the gills, and between them are deep grooves (Figure 6). The surface cilia of the filaments near the middle of the folds lash toward the free margins of the gills, while those in the grooves between the folds lash in the opposite direction, toward the gill bases (Figure 16). When the stream that rushes between the filaments into the interior of the gill brings particles to its surface a few at a time, the majority of them fall into the grooves (*g*), and are then carried to the base of the gill. Here they go to a ciliated tract leading to the palps and

mouth (*m*). This is the normal food collecting process.

But when much material arrives on the gill, it not only falls into the grooves, but adheres to the surfaces of the folds (*f*) as well. Everywhere it seems to stimulate a copious secretion of mucus, and the whole mass, both in the grooves and on the folds, becomes continuous. Now begins a struggle between opposing tracts. The material in the grooves is pushed toward the base and that on the folds toward the free edge of the gill, as at *b*. The tension on the string of mucus becomes so great that finally—and invariably—it is lifted up out of the grooves and all is borne to the edge of the gill (*c*). Now, too, the whole gill is responding to the stimulus of a large quantity of foreign matter on its surface, by writhing and swaying from side to side.

If it is the inner gill that has made this collection,

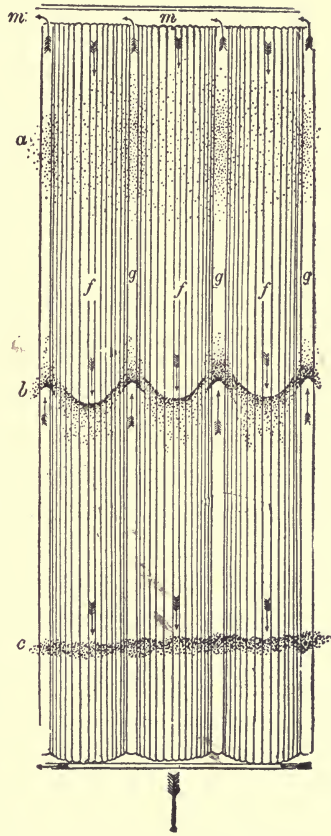


FIG. 16.—Three folds of the surface of the gill of the scallop (*Pecten irradians*) to illustrate automatic action of cilia in bearing small quantities of material to the mouth on the tract marked *m*, and large quantities away from the mouth and to the mantle wall from the edge of the gill.

it transfers its mass to the outer, or casts it off into the mantle chamber. The outer gill often touches the mantle, the cilia of which relieve it of its burden and carry it away.

Thus the gills as well as the palps of *Pecten* reject material when it is too abundant, but the process in this case is purely automatic. The course taken by foreign matter is determined by its volume, and so certainly that the experimenter is soon able, when allowing carmine particles to settle on the gill, to predict which path they will follow on reaching its surface.

There are few known mechanical contrivances of animal bodies more wonderful than this self-operating mechanism of the *Pecten* gill. Cilia, in all animals above the Protozoa, or single celled forms, lash only in one direction. Yet here is a ciliated surface that automatically selects from the water what usually is suitable for food, and rejects that which is not suitable, carrying the first toward the mouth, and the other in the opposite direction, the matter being determined wholly by the quantity of the material.

It is possible here to make only the brief statement that some bivalves develop special organs the ciliated surfaces of which are constructed to cope with peculiar conditions of the environment. Such, for example, is a filmy membrane that grows out from the posterior surface of the body wall in a species of *Pholas* in the Gulf of Mexico. This organ rolls itself into the form of an inverted trough, and, collecting mud from the sides of the body, carries it under cover, directly against the incurrent stream, out into—and perhaps entirely through—the lower siphon tube to the exterior. This special apparatus is apparently necessary in this creature

that lives in water often very heavily laden with mud. One might search far among organisms to find a contrivance more strikingly ingenious, and its utility is so perfectly evident that it would no doubt have enraptured Paley, had he possessed knowledge of it.

CHAPTER V

OYSTER CULTURE IN EUROPE AND JAPAN

EUROPEAN OYSTER CULTURE



HERE is abundant evidence that marine mollusks were extensively used for food by man before historic times. In many parts of the world ancient shell heaps, some of them of immense proportions, are found near waters that are still capable of producing the same forms. These are so disposed and so constructed that it is certain that they are not natural accumulations on what was formerly ocean bottom, but the work of human hands. This conclusion is substantiated by the fact that among the shells of clams or oysters or marine snails, the bones of aquatic and land animals are often found, together with primitive weapons or domestic implements. Such shell heaps are common on our Atlantic coast, and on some of the islands off the coast of California, there are mounds of shells of great extent that contain mortars and pestles, the bones of fishes, seals, whales, and implements and ornaments of various kinds. Indeed, on the island of San Nicholas there is said to have existed as late as the nineteenth century a primitive tribe of people living after the simple fashion of hundreds of generations of ancestors, and making the last contribution to vast shell accumulations. Nothing in history is more ghastly than

the destruction of that race, nor more strange and pathetic than the rescue, after eighteen years of solitude, of its single survivor.

There are two species of oysters native to European waters. The flat oyster, *Ostrea edulis*, is found on the northern shores. It is rounded and flat, and its shell has a diameter of but two or three inches (Figure 17). It is hermaphroditic—that is, both male and female organs are developed in each individual.



FIG. 17.—European flat oyster (*Ostrea edulis*). (This and the following figure are modifications of figures by Professor Bashford Dean.)

Its cousin, the Portuguese oyster, *O. angulata*, found on the southern shores, is not so highly esteemed as the flat oyster. It is said naturally to be elongated, even when not crowded in clusters. It is very small (Figure 18). The sexes are separate.

These oysters have been cultivated since ancient times. Pliny, who may be called the father of a class of discredited nature observers that still flourishes, states that at the beginning of the seventh century oysters were artificially reared with great success in Lake Lucrin; but there is evidence to show that he had in this case been correctly informed. M. Coste, a French naturalist, and the originator of modern oyster culture in Europe, describes two funeral vases, one found at Pouille and the other near Rome, which prove that oyster embryos were col-

lected and reared in ponds in the time of Augustus, for on these vases are designs in perspective, representing oyster ponds and objects used in the capture of oysters.

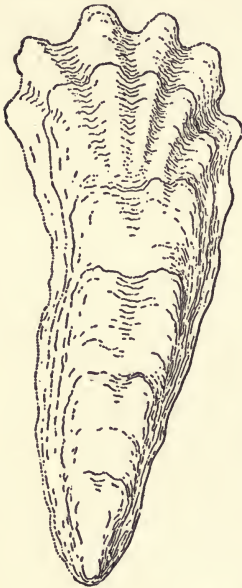


FIG. 18.—Portugese oyster (*Ostrea augulata*).

There are also inscriptions that make the meaning of the artist certain. The simple methods of oyster culture in use to-day at Lake Fusaro and the Gulf of Tarente are apparently identical with those of the Romans of two thousand years ago. Stakes are driven into the bottom enclosing small rectangular spaces. These are connected by means of ropes from which are suspended bundles of twigs. On this brush the swimming young of the oyster attach. They are left in this position to grow to marketable size, or are removed and spread out in wicker baskets, which also are suspended from ropes. As tides are not great, they are seldom exposed.

Oyster culture, as it is carried on in various parts of the world to-day, is everywhere essentially the same process, but what may be called modern methods are of independent origin in Europe, in Japan, and in our own country. During the first half of the nineteenth century, natural beds in Europe and America were still large enough to satisfy the demands of the markets, but in the last fifty years very rapid social changes have occurred, one result being that many of the luxuries of previous times became common necessities, especially in our own

country. Among other things, the demand for oysters increased enormously. This soon resulted in the destruction of natural oyster beds, and the development of artificial means of supplying the market.

In the early part of the nineteenth century, natural oyster beds were numerous on certain parts of the French and English coasts. The history of their destruction is valuable, because it shows how entirely misleading statistics may become in matters of this kind. In Cancale Bay, on the northern coast of France, comparatively few oysters were taken during the last of the Napoleonic wars, and the beds, having been undisturbed, had become very extensive. In 1817 dredging began again without interruption from English war vessels, and during that year, great numbers of oysters were marketed from these beds. Year after year they increased. Every one connected with the industry came to regard the natural beds as inexhaustible. A decade passed, then a second and a third, and each year the supply was greater than the last, until, in 1843, seventy million oysters were marketed. If, during that time, any warning voice had been raised, it certainly would not have been heard. If any one had been able to attract attention by his statement that the beds were becoming exhausted, he would have been effectually silenced by the statistics. It would have been useless to show that each year the number of fishermen was greater, and that the time and labor required in obtaining a boat-load was rapidly lengthening. The significant thing to consumers would have been that oysters in the market were increasing in numbers.

This has been the experience in our own country, where the people may control such conditions more directly,

and perhaps more easily, than would have been possible in the monarchical France of that day. The marvelous natural wealth of Chesapeake Bay, as well as that of other great natural oyster fields, has been nearly destroyed, and the naturalist who was able to predict the present condition with perfect certainty, had studied the natural beds and the habits and life history of the oyster while the public studied the display in the fish markets, and, perhaps, statistical statements concerning the number of oysters brought to them. Fortunately artificial beds have proved to be much more prolific than the natural bottoms, but in nearly all cases, oyster culture has been resorted to only after the natural supply has been practically destroyed.

The inevitable change came to the Cancale Bay fisheries in the middle of the century. From that time the supply failed with great rapidity, as it usually does in such cases, until, in the year 1868, only about a million oysters were obtained, where, for so many years, more than fifty times that number were dredged each season. The natural beds had been practically destroyed through excessive dredging.

A similar destruction occurred at about the same time in the districts of Marennes, Rochefort, the island of Oleron and elsewhere on the French coast, and also in the oyster bays of England. Everywhere the cause was the same.

For such a condition of affairs two remedies are always possible. The supply may again be increased by enforcing a long close season, or a new and artificial industry may be developed. Obviously the latter is the only practicable course to pursue. All of the more valuable sources of the world's food are founded on arti-

ficial propagation. Wheat, corn, and many other domesticated food plants, do not even exist in a wild state. Under domestication there is almost no limit but land area to the possibilities of their increase. The world's supply of beef, pork, and mutton, being under man's control, is limited only by the amount of grain and hay that he is able to raise for feed. Why should he not also be able to control many of the animals of the sea, that bears a vast supply of nourishment on which they may thrive?

France adopted a wise policy. Dredging was greatly restricted, but investigations were begun in the hope that the beds might be reclaimed by artificial means. As a first step, M. de Bon, Commissioner of Marine, was directed, in 1853, to attempt to restock the old beds of the Rance and Saint Malo. This he did by transplanting oysters from the Bay of Cancale. He was an acute and accurate observer, and able to detect the significance of what he saw. The transplanted oysters not only flourished, but some of them, placed on beaches where they were exposed at low tide, were able to reproduce themselves as when continually immersed. It then occurred to De Bon that if the young oysters, or "spat," could be collected here and placed on favorable and convenient bottoms, the laborious process of dredging could be done away with altogether, and that oysters could be reared without the use of boats, and marketed at pleasure.

It was a great idea, and De Bon at once began to devise some feasible means of capturing the swimming oyster embryos. Constructing platforms of planks, some inches above the parent oysters on the bottom, he covered them with bundles of twigs, in the hope that the

swimming young might find in this brush a suitable substance on which to attach. This hope was fulfilled, the experiment became widely known, and the beginnings of modern oyster culture had been made in Europe.

At the time of these observations, M. Coste, Professor of Embryology in the College of France, became greatly interested in the ancient and primitive culture methods which he had examined at Lake Fusaro, in Italy. He seems to have been imaginative, energetic, optimistic, and persuasive. He conceived the idea of transporting this obscure Italian industry to the depleted shores of his own country, and attracted a great deal of attention by the publication of his views in 1855. He suggested means similar to those employed in Italy for collecting the "spat," and proposed that a trial of them be made in the salt lakes in the south of France.

He succeeded in interesting Emperor Napoleon III, who two years later commissioned him to make experiments along the lines which he had suggested. On making a tour of the French coast, he received a great surprise on viewing the work of De Bon. There, before his eyes, were flourishing oysters, not only transplanted, but reproducing themselves in an exposed position between tide lines, and this he had formerly declared could not occur. With a mind fired by the possibilities revealed, he published a report to the Emperor, in which he drew a vivid and optimistic picture of the entire coast of France converted into a great oyster garden and bearing an inexhaustible supply of food.

M. Coste now constructed beds at various points in the Bay of Saint Brieuç, deposited mature oysters over shells previously spread on the bottom to serve as collectors, and suspended bundles of brush for the same purpose.

At the end of the spawning season, these collectors were well covered with young oysters. He now began in earnest the task of reclaiming the coast, and large areas at Toulon, Brest, and Arcachon, were covered with oysters, many of them imported from England for the purpose. Now, too, stimulated by the success of Coste, private interests began rapidly to develop the new industry, especially on the coasts of Normandy and Brittany. Beds were constructed in many localities, and the work proceeded with great enthusiasm.

In many places the initial successes were gratifying. It became certain that oysters transplanted from natural beds to other bottoms would grow well, in the majority of cases, though often they did not spawn. So much had been gained, however, that for three or four years a spirit of great expectation prevailed.

Then, in the following years, came reverses, disappointments, failures, and disasters. Fishermen despoiled the natural beds. Storms scattered the oysters that had been planted in the shallow waters. The beds of Saint Briec, especially, suffered from wave action, the brush collectors being torn from the bottoms, broken, and swept away. The natural beds had become so greatly reduced in supplying breeding oysters that regions formerly producing every year a good set of young became barren. Apparently the brilliant plan of Coste had failed. Discredited, disappointed, and finally completely discouraged, he died, perhaps not dreaming that in time—not quickly, as he had hoped, but in the course of normal growth—the conditions which he had predicted were, in large part, to be realized.

One fact of importance, underlying these events, has received little or no attention. It is not simply that the

life and experience of Coste afford a beautiful example of the dangers of optimism, though that is an important subject on which much might be said. It is that the most important element in this disaster to an industry which, with rare good fortune, had begun so auspiciously, was the failure to study the oyster from a biological point of view at the very beginning. Had Coste known that the European oyster is able to reproduce only in water of a certain definite degree of salinity, or density, and that such waters are to be found in comparatively few localities on the French coast; had he discovered that the oysters' food is abundant only in certain localities, where peculiar conditions are necessary for its production; had he investigated the bearing of tide currents on the distribution of food and of oyster embryos; in short, had he known the oyster in relation to its surroundings, the greatest of his disappointments would never have occurred, and the industry itself, instead of being discredited and retarded by arousing public suspicion against claims made in the name of science, would have grown without loss of time and wealth.

The present application of these reflections is to those well-meaning critics of our institutions founded for the purpose of promoting a scientific study of animals and plants useful to man. Our state agricultural schools, and our state and national fish commissions, often publish at public expense, technical papers that seemingly have no bearing on any economic problem. This is sometimes the subject of adverse comment, but not so frequently as in the past. It is cause for congratulation that the public is learning that a detailed knowledge of the nature of organisms and their relations to their sur-

roundings is the first logical and necessary step toward their control by man. We are beginning to give these institutions credit for the great benefits that have been derived from their researches.

After its disheartening experience, the French industry began to revive. One extremely important feature of its subsequent growth was the lease of oyster grounds by the state to individuals. What had formerly been public property, now came under the control of private interests, ambitious to make it as productive as possible. These also were afforded protection, and as a consequence, capital was invested in large amounts. That this was the only wise course to pursue, has since been proved in every country in which an oyster industry has been developed, and it is because such a policy has not yet been adopted by any of our Atlantic states toward the clam industry, that it has declined into its present state. Common sense indicates and the historical record proves that this is one of the fundamental requirements for the artificial rearing of any form.

Slowly the important facts concerning the conditions necessary for the increase of the oyster were learned and applied. It was found that a method, successful in one locality, might not succeed in another. Each region had its own peculiar problems, and these were solved one after another by patient experiment. It is recorded that in 1871, at Arcachon, 1,450 acres of public ground were leased in private holdings. In 1875, there were 2,434 concessions, covering 6,625 acres. Their number increased at various points, and to-day the industry is a very extensive one.

French culture methods of the present are more complicated than those employed in our own country. This

is especially true of the means used for the capture of the swimming embryos. There are but two places on the French coast where oysters spawn regularly in abundance. Here, at Arcachon and Auray, attention is given chiefly to the collection of the young, which are sent to various parts of the coast to be reared in what are called parks—walled areas between tide lines.

The collection of young oysters is a very much more serious problem in European waters than in our own. There the great salinity of the water restrains the reproductive process, while in almost all localities where our oysters are found, they are extremely prolific, and it is interesting to observe that when they are transported to European waters, they also become sterile. The water is very muddy on European shores. On settling, this mud forms so soft a bottom that young oysters sinking on it perish at once. A hard object to be used as a collector is also very quickly coated with mud and slime, so that an oyster embryo that has succeeded in attaching, is in danger of being lost even here. After this coat has formed on the collector, attachment is impossible. For this reason, the American method of covering the bottom with clean shells to capture the spat would be relatively ineffective.

Where waters are least muddy, bundles of twigs are employed, after the ancient practice of the Romans. In shallow water, where these can readily be handled, some of the sediment may be washed off, giving sufficient time for attachment. If oysters are well spaced on the branches, the bundle may be allowed to remain suspended during the period of growth. If they are closely set, the twigs may be broken into small pieces and spread on some hard bottom, or in racks that have been pre-

pared for them. Board platforms, placed one above another with slight spaces between, are also used in the collection of spat. After the young adhering to these have attained a sufficient size, they are removed by means of a knife.

Brush and boards, however, will not serve in most localities, because both so rapidly become coated with slime. In the development of the industry it became necessary to devise some other form of collector that would overcome this difficulty. The object that proved most successful was a roofing tile. The form of tile now commonly in use is a little more than a foot in length, about six inches wide, and has a slight arc of about one-fifth of a circle. When these are placed in the water with the hollow or concave side down, very little slime attaches to that surface, which is thus favorable for attachment (Figure 19).

The young oyster is very firmly cemented to the object to which it is attached. To remove it from a tile would usually necessitate the breaking of the shell, and this would result in its death. To allow it to remain on the tile to grow to marketable size, would be impracticable for several reasons, chief among which is that so many young usually attach to a single tile that they would crowd each other, and the growth of all would be interfered with. When tile collectors were first used, therefore, they were broken into pieces after the attachment of the young, and in such a way that an oyster was borne on each piece. This required much skill and labor, and the destruction of the tiles made the process expensive.

After a time an extremely ingenious plan was devised which made the tile collector almost perfect for

European oyster beds. The idea was to cover the tiles with a crust of some substance that could easily be removed after the oysters had become fixed to it. After some experimenting, a cement was invented that answered all requirements, and it is in use all along the coast to-day. It is a mixture of quick-lime and sea water to which is added enough fine sand or mud to give it the consistency of thick cream. Into this, dry tiles are dipped, and coated with a layer of the mixture having a thickness of about a millimeter. The coat is thoroughly dried before the collector is placed in the water. After several weeks of immersion, it softens somewhat by the action of the sea water, and, though still firm enough to adhere while the tile is being handled, it flakes off readily in the process of removing the young oysters. This is effected by means of a flat knife-blade. When the crust bearing the spat has thus been removed, the tiles are stored to be coated and used again during the next spawning season. In this way the same collectors are used for several years. At Arcachon and Auray it is estimated that each tile annually affords attachment to about two hundred oysters.

The spawning season is not sharply limited. As in the case of the American oyster, some young appear in the water at almost all times of the year. But the great majority are produced in the early summer, and it is a matter of great importance to the French culturist to determine the time of their appearance. If tiles were immersed for any length of time before spawning began, even their concave surfaces would become so contaminated with slime, that attachment would be interfered with. Salinity of the water, temperature, and other conditions that vary from year to year, determine

the spawning time, so that there can be no set date for the laying of the collectors. By close observation, the most favorable time is determined each year for the capture of the maximum number. This is usually near the end of July, and the spat continue to appear in numbers until the middle of August.

Two hundred small oysters might perhaps be left with safety on the surface of a single tile during the winter months when growth is not rapid. Indeed, this is often done in the warmer southern waters; but on the north coast there is always great danger from frost. As the collectors are so placed that they are exposed at low tide, many of the young would be killed by the cold; so in October, when the shells have attained a diameter of half or three-quarters of an inch, they are removed from the tiles and shipped to the *éleveurs*, or culturists, who place them in water deep enough to preserve them during the winter.

The young are hardy enough to endure a journey lasting three or four days, especially at this time of the year. From the collecting places, they are sent to all parts of the French coast, as well as to neighboring countries. Great numbers are sold in England, where, however, the fact is concealed as carefully as possible, because, like any other people, the English consider their own products superior to others. The collection and sale of spat is so extensive as to be an important industry in itself, and this is a feature of oyster culture that should be much more extensively developed in our own country.

An American oyster culturist would probably be appalled by the adverse conditions that confront the industry in European waters. He himself has much to contend against, but his task is not difficult in compari-

son with that of the European culturist. There is one fundamental difference between the two industries. In America, except on the Pacific coast, oyster grounds are all below the tide lines, and some are in very deep water. In Europe they lie between the tide lines. Deep water farming is not possible on the coast of Europe, but there is no natural condition that would prevent the employment of European methods here.

But the time can not yet be seen when it may be profitable to utilize the beaches for oyster culture in America, though the imagination is excited when one views the immense wastes of salt marsh bounding much of our Atlantic coast, that might, if expense were no object, probably successfully be converted into innumerable oyster ponds. Whether or not the utilization of our marsh lands will ever be attempted, the difficulties that have been overcome by the European culturist are very interesting. He leases a plot of ground on a flat that is exposed for a considerable period each day at low water, and in most cases much labor is necessary to prepare it before it can be used for rearing young oysters. Enemies are numerous. Among them are the starfish that infest the bottom—slow-moving, harmless appearing creatures, but the most voracious and deadly of the foes of the oyster; crabs, the powerful claws of which are able to crush the fragile shells of the young; and drilling mollusks that pierce the shell even of adult oysters and consume the soft part enclosed within. These also must be avoided or destroyed. To all this may be added the fact that bottoms are often so soft that they will not bear more than a man's weight. Such a condition alone might seem sufficient to make oyster culture impossible.



FIG. 19. Tile collectors in place on a tidal flat at Auray, France.



FIG. 20. Arcachon, France. Oyster parks with low clay walls. Water is retained in those at the right at the low tide, that at the left being emptied for repairs.



FIG. 21. Arcachon. Parks with somewhat higher walls containing cases for the growing young. Figures from Professor Bashford Dean, U. S. F. C. Bulletin.



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The difficulties that have been enumerated are met by converting the ground into a series of basins by means of walls or dikes. These ponds are variable in form and in area, but are usually rectangles of two or three hundred square yards. The walls are often simple and inexpensive. Very shallow basins, like those shown in Figure 20, are easily constructed. To form the wall, parallel lines of planks are held in position on edge by means of wooden pegs. Parallel lines of stakes are also sometimes employed, the space between being filled with soil. If tide currents are strong, stones are used with the other filling material, in order to give sufficient strength to the wall. In some localities it has been profitable to build walls of solid masonry, but this construction is usually resorted to only when a large area, to be flooded to a considerable depth, is to be shut off from the sea. The height of the wall varies from a few inches to several feet. At some favorable point in the wall, a gate is constructed that, when closed, may retain the water that enters at high tide.

The bottom of the basin must now be prepared. In the better parks, the center is made a little higher than the margins, where trenches are often dug, in order that sediment, settling on the bottom, may be carried into them. When the gate of the full basin is opened, the current leaving the inclosure by these is sufficient to carry away much of the soft silt. After the bottom has been roughly shaped, it is sometimes hardened by pounding, and is covered by a layer of clay or sand and gravel. If the soil in the walls is pervious, these also are lined with clay in order that water may be retained.

It is interesting to observe that bottoms, originally of the softest mud, are easily reclaimed and made hard and

firm by a covering of shells or of sand and gravel, and that this covering need be only a few inches in thickness. Shifting sand on which oyster parks are built is also held in place by a layer of clay.

In the simple basins illustrated in Figure 20, oysters of sufficient size are spread over the bottom and left to grow. At low tide they remain covered, and may thus continue to feed until a new supply of water comes with the flood tide. They are also protected from the sun of summer and the frost of winter seasons. Not all sediment will drain away, even though the gates are opened frequently, and though the bottoms have been arched from center to margins. When a quantity of mud has collected, oysters are removed from one basin to another until the bottom has been cleaned.

But the entire process of removing young oysters cannot be carried on in basins as simple as those shown in the illustration. So much mud is deposited that small oysters would be smothered. These seed oysters are from half an inch to an inch in diameter, and must be protected from sediment until they are much larger.

This necessity for the protection of the very young has led to the construction of racks or boxes designed to suspend them above the bottom. It is very important also to insure a free flow of water within the boxes, so these are made with narrow wooden sides, the tops and bottoms being constructed of galvanized wire netting. The top netting is fastened to a wooden frame provided with hinges, or so fitted that it may be lifted off. The box is then suspended a few inches above the bottom on stakes.

Such boxes are represented in Figure 21. Evidently they are roughly and cheaply made, but a large number

would be required to provide a means of livelihood for the most unambitious *éleveur*, and his initial expense would be considerable. But, properly cared for, these boxes serve for many seasons. If carefully tarred each year, they may be kept in use for ten, or sometimes twenty years. Occasionally more elaborate boxes are constructed that hold a number of trays, but all are built on essentially the same plan.

Not only are these cases necessary as a protection against mud, but there is great advantage in their position on the flats between tide lines; for, being exposed at low water, oysters may readily be placed in them, sorted from time to time, and finally removed. The cases, also, may be repaired with ease. When cases are used in enclosed parks, it of course is necessary that the surrounding walls should be high enough to hold sufficient water to cover them.

The young oysters that have been removed from tile collectors are at first spread evenly, but closely, in the bottom of the cases, and as they increase in size, are removed a few at a time and placed in other cases in order that all may have food and a sufficient amount of water for aeration. The number of food organisms brought to the growing young varies in different localities along the shore, and for this reason there is a difference in the length of time during which they must be kept. In some localities, two years are sufficient, while in many others they must be cared for during a third, a fourth, or even a fifth year, before attaining marketable size.

It sometimes happens that lamellibranchs of various species, living in certain localities, collect in the gills and in parts of the mantle, a quantity of chlorophyl, the green coloring matter characteristic of most plants.

Green oysters appear in certain basins along the European coast, and the color has happened to strike the popular fancy. Such oysters are practically unmarketable in America, where they also appear, though they are as wholesome as any others; but in Europe, and in France in particular, they are very highly prized by connoisseurs on account of their "peculiarly delicate and delicious flavor"—which, if it exists at all, does not arise from the green coloring matter.

Most of the green oysters found in the European markets come from Marennes in France. Here in the tide basins are great numbers of green diatoms, organisms used by oysters for food, that collect in such numbers that they form what is termed a "moss." To this is ascribed the green color assumed by oysters growing near it. Here it was discovered by the culturists that the "moss" developed most rapidly in very muddy inclosures in which water was seldom changed. These basins, or *claires*, are usually situated so high as to be filled only once or twice during the month. The temperature of water held in such a manner rises several degrees, and this condition is found to be very favorable to the multiplication of diatoms. But while it produces oyster food in great abundance, the water loses so much of its oxygen during its stagnation, that it affects oysters adversely. Those individuals that are able to endure the conditions, are said to fatten rapidly, but the mortality is usually great, being in most cases at least fifty in a hundred. There is an extreme variation in the rate at which the green coloration is acquired by the living oysters, the necessary time in some *claires* being two or three weeks, in others as many months.

Great attention is paid to the appearance of these oysters before they are marketed. After a period of rapid feeding, there is apt to be some outward sign of the dark colored matter contained in the digestive tract. In order that this may be removed, the oysters are placed in inclosures containing clear water, and allowed to remain for a week or more, during which time very little food is consumed. They are then removed, and not only are the shells thoroughly scrubbed with a brush to remove any trace of mud, but any marked roughness is reduced by a process of scraping. It is not necessary to contrast their appearance with that of oysters marketed in the shell in America.

OYSTER CULTURE IN JAPAN

Oysters have been cultivated in Japan for several centuries. We are told that in ancient times a certain clam, *Tapes*, was gathered in the Sea of Aki and kept, awaiting shipment to market, in inclosures made of bamboo. It was discovered that in certain places young oysters attached to the brush of the bamboo, and that their position was so favorable for growth that it became profitable to capture them in this way, and rear them in inclosures. Thus, gradually, oyster culture displaced the *Tapes* industry.

Two species of oysters grow on Japanese shores. The one that occurs most commonly and is reared by the culturists, is known as *Ostrea cucullata*. It has the general appearance of our Atlantic oyster, but is somewhat smaller. Its cultivation is practised most extensively in the Inland Sea.

On the southern and eastern coasts, a very small oyster, possibly a variety of *O. cucullata*, grows in great numbers in the shallow waters of bays and inlets. The shell rarely attains a length of more than two inches. This oyster encrusts the rocks between tide lines, and cannot be removed without breaking the shell. The fishermen therefore go among the rocks at low tide, and open the oysters without attempting to detach them.

Another distinct species, *Ostrea gigas*, an extremely large and heavy form, is found in a few localities on the Japanese coast. It seldom occurs in very shallow waters, where other oysters are commonly found, but at a depth of ten or twelve fathoms. Though this oyster is used for food, it is so rarely taken that it does not often appear in the market. Its habit of life in deep water perhaps has made its culture impossible.

Because the habits of all oysters are very similar, the methods employed in rearing the Japanese oyster, though entirely independent in origin, are essentially like those of Europe and America. In the Inland Sea, as elsewhere, oysters require for the process of reproduction the comparatively fresh waters of bays receiving streams from the land. On the Japanese coast, as in Europe, localities having waters of the optimum density are limited in area and more or less narrowly defined. At certain points, however, it is possible for the culturist to obtain his own set of young, and rear them for market on a single small plot of bottom which he has rented. In Europe it is almost everywhere necessary for him to purchase his young oysters from another who possesses ground on the very few bottoms favorable for oyster reproduction.

Japanese culturists have not adopted the tile collector

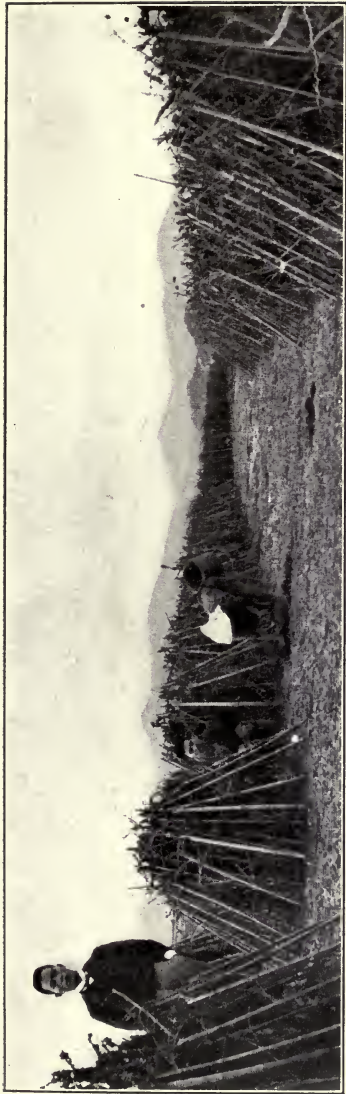


FIG. 22. Newly arranged collectors of bamboo on a tidal flat in Japan.

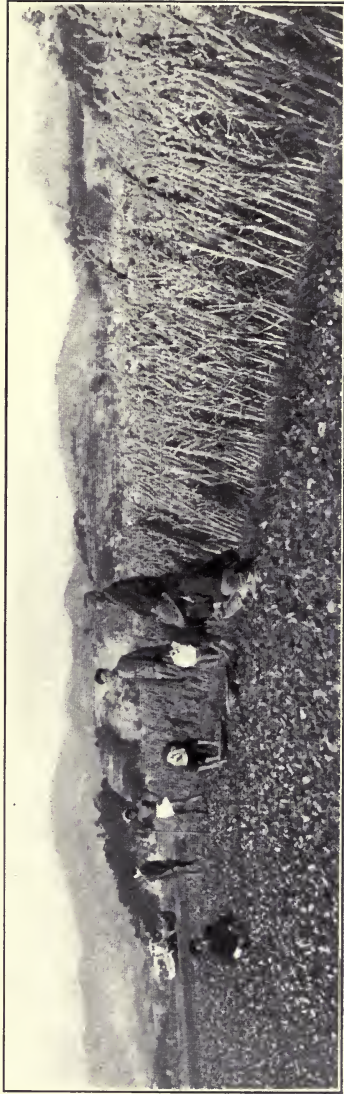


FIG. 23. Oyster park or growing ground in Japan. Figures from Professor Bashford Dean in the U. S. F. C. Bulletin.



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of the European industry, but retain the ancient and effective brush collector. For this, the light, strong bamboo is employed. It serves its purpose admirably, and is easily obtained. Short pieces, usually bearing their branches, are thrust into the bottom between tide lines. In this position they are easily examined and kept in order. There is little trouble from mud, or the formation of slime. The collectors, arranged in lines or clusters so as best to be exposed to the currents, are set out in the early spring, and young oysters begin to appear near the middle of April and continue to attach for some weeks. The character of such a collecting ground is well shown in Figures 22 and 23. Here the bamboo rods are arranged in long rows, three or four feet in height.

If left to themselves, young oysters, greatly crowded on the stakes, would not be able to attain a rounded form, and very many would perish. So those oysters that have attained a certain size are detached from the collectors and removed to a deeper bottom, that has been prepared for them. On this they are immersed for a longer period each day and grow more rapidly in consequence. Oysters are from one to two years old when thus spread on the bottom, and remain for another year or two before attaining marketable size. Very few enemies trouble them. One or two species of boring mollusks appear at certain points on the coast, but these may easily be removed at low tide. The starfish gives little trouble.

Usually the larger oysters from such a bed are removed from time to time, and placed in still lower beds where they are uncovered but once or twice each month, and here they attain the greatest possible rate of growth.

In this way are produced fine, large oysters much like our own in size.

Many natural conditions make oyster culture easier in Japan than in Europe. The coastal waters are less muddy; there is no necessity for artificial ponds; oysters reproduce over a large area; the cheap bamboo is a good collector, and is easily handled; and there are few natural enemies to contend against.

It is fortunate, also, that oyster grounds in Japan are not exploited as a government monopoly, but are rented to private interests, for it is only in this way that the greatest success in such an industry is possible.

CHAPTER VI

CONDITIONS GOVERNING OYSTER GROWTH—OYSTER PLANT- ING IN AMERICA



OYSTER culture in America is very simple as compared with that in Europe. There it is difficult to obtain the young, or the "seed," and laborious and costly methods are resorted to in effecting its capture, and in protecting it during the period of its growth. Here seed is abundant, growth is vigorous, and bottoms are naturally better adapted to the industry.

The complicated methods, necessary for success in Europe, will not be employed in this country until the price of oysters is relatively very much higher than it is there. These foreign methods if introduced on our shores, would reclaim much marshy shore-land now entirely unproductive, and the American oyster would undoubtedly respond to the treatment as the foreign form does. Nevertheless, it will be many decades before the simpler American method will be superseded by any other on our coasts, if indeed the event ever occurs.

There are two reasons for such a belief. One is that the area along the American coast available for oyster culture after the less expensive American method, is enormous. No one can now accurately estimate its extent. It includes not only the territory formerly occupied by "wild" oysters, but also great tracts where

oysters have never existed, and which may be discovered by intelligently directed experiment. Already many of these have been determined in Long Island Sound, where oysters are successfully cultivated miles from shore, and under water as deep as one hundred feet. Elsewhere on the coast, these unoccupied areas have hardly been considered; but in certain localities, as in Pamlico Sound, and about the delta of the Mississippi, they will undoubtedly prove to be very extensive.

For yet another reason, European methods can hardly obtain in this country. Extensive oyster culture abroad would, on account of the labor involved, be impossible without a social caste system. This is everywhere present in Europe, and, to a genuine American, presents an appalling state of affairs. Even in republican France, society retains a real reverence for its princes and its counts, and every other nation but Switzerland staggers under the heavy burden of an idle and expensive aristocracy. Below its members in the scale are the middle classes, the trades people, subservient to their superiors, and often brutally contemptuous of the under stratum, the common people. The latter, born into humility, seldom have independence bred into them, but calmly submit to their heaven-sent estate. And they obediently labor for a pittance that an Americanized Oriental would scorn. It is this one condition that makes oyster culture possible in Europe.

Labor of that character would be necessary if the same method of oyster culture were to become profitable in the United States. That it ever will exist here is improbable. It is, however, interesting to observe that European social customs continue to have a great influence on our own. Some of us believe that they do things bet-

ter there. Waves of fashion in dress, and manners, and social customs, sometimes degrading enough, continually roll toward our shores from abroad. Though these break and spend their force largely on the northern coast, some of them continue westward across the continent as very noticeable ripples. Not all of them are alarming, and some sinister ones may hardly succeed in crossing the ocean, but they are all worthy of attention.

Much more interesting is the growing aristocracy of wealth that is desperately striving to establish itself among us, and it is inevitable that there should be many who regard it complacently. A little too frequently in speech, and even in the editorial writings of leading journals, appear such phrases as "our middle class" or "our common people." Even this attempted social segregation of the few persons of great wealth, however, is not disturbing in view of the fact that, with every year, democracy more clearly appears to be the fundamental element of the nation's life.

The chief differences between the oyster culture of the continent, in Europe, and that of our own shores, are that here oysters are cultivated below tide lines; we neither employ tile spat collectors, construct reservoirs for the growing young, or for the growth of diatoms on which they feed, nor build racks on which to support them above the bottom. Small oysters from natural beds are spread on suitable bottoms to mature, or the swimming young are captured on simple collectors, and planted in the same way. There has been little change of procedure since the days of the City Island men who began oyster culture in America, because natural conditions have remained so favorable that a change has not been necessary.

Success in oyster farming, however, is not so easy of attainment as it may appear to be. There are a great many necessary details to be learned, especially in regard to the natural requirements of the oyster. One should be able to recognize suitable bottoms. Water currents must be considered. One must know the varying effects of muddy water on mature oysters and swimming larvæ. A low temperature of the water in the spring or early summer, while not apparently harmful to adult oysters, may be sufficient to prevent reproduction. In the north, water less than a certain depth may be dangerous in winter. It is important to know the extremes of salinity within which oysters can live. The successful oyster farmer should also know the optimum density for adult and young alike. The amount of food in the water, of course, vitally affects rapidity of growth and the condition of oysters. Thus it is not always easy to select areas that conform to all the conditions necessary for success.

For many reasons the character of the bottom must be carefully considered. A rocky or very uneven surface is out of the question, but bottoms rough from the presence of small obstructions are sometimes made suitable for oyster planting, even in deep water, by a thorough scraping with dredges.

Over the greater part of the oyster territory bottoms are more or less muddy, and the nature of this mud must be determined. On many of the best northern oyster grounds there is but a thin surface layer of it covering a firmer foundation. This, without any preparation, is found to afford a secure resting place for planted oysters. In many parts of the Gulf of Mexico, however, the bottom is composed of mud so soft and oozy that a pole may

be driven into it, by force of hand alone, to a depth of several feet. It is very generally believed that such conditions cannot be overcome, the assumption being that any kind of pavement placed on it would sink below the surface. That such is not true, will be shown in the discussion of the Louisiana field. In parts of Long Island Sound, where mud is deep but not so soft as in the Gulf, bottoms have been successfully prepared by paving with shells or with sand and gravel. Bottoms naturally sandy are also often selected by the oyster farmer, but under shallow water, where they may be shifted by wave action, they are unsafe. It is specially desirable that the bottom should be firm, to withstand wave or tide action where spat is to be gathered on collectors, for the young are quickly smothered in a quantity of mud that would not seriously affect mature oysters.

The oyster finds almost its entire food supply in diatoms of various species. These are floating plants, microscopically small, which derive their nourishment from substances brought down in solution from the land. Their distribution along the coast is universal. They are not confined to the surface, but may be found at all depths. Every one has noticed the brown coat left on the surface of a clam flat when it is exposed at low water. When examined, this is found to contain vast numbers of diatoms, though it is not by any means entirely or even chiefly composed of them, as sometimes stated.

The amount of available oyster food over a given area depends largely on water currents. Where there is no current, oysters quickly exhaust the water about them of the food that it carries. A current continually re-

plenishes the supply. Up to a certain point, the more rapid the current, the greater will be the amount of available food. But one current bears more food than another. Salt water, for example, that flows out from shallow marshes during the ebb tide, usually bears great numbers of diatoms because the marshes are warmer than the sea water outside, and the higher temperature stimulates a rapid multiplication of these organisms. Food is sometimes so abundant that a rapid current is not necessary. For this reason it is not possible to give a rate that shall be most favorable for oyster growth in all localities.

The presence of suspended silt in the water is a condition to be observed with care. It is an especially important problem in the Gulf of Mexico. There it is found that oysters often thrive and reproduce in localities where, much of the time, the water is very muddy. But it is also true that currents in such places are too rapid to deposit much of their silt. In more quiet waters, where mud slowly collects on the bottom, mature oysters may be able to exist, but even a slight deposition is fatal to newly attached spat. Finally, there are many places where mud collects so rapidly that life on the bottom is impossible. Much experience is needed to enable one to recognize these conditions, when searching for available bottoms not already occupied by oysters.

Oysters will grow in water having a summer temperature so low as to prevent reproduction. At several points on the coasts of Washington and California, small Atlantic seed oysters grow to marketable size. The summer temperature is much lower than on the Atlantic below Cape Cod, and the sexual products mature only in certain warmer coves. Experiments made many years

ago in North Carolina and in the Chesapeake, indicated that reproduction practically ceased when the temperature during the breeding season fell below 60° Fahrenheit, and that the swimming stage was rarely reached when the water was warmer than 80°. But it is probable that the minimum temperature at which reproduction is possible is nearer 70° than 60°, and it takes place in water above 80° in certain parts of the Gulf of Mexico. If the facts were known, it might possibly be found that there were variations in minimum, optimum, and maximum temperatures, oysters having accommodated themselves to the varying conditions in different localities.

Because of danger from frost or ice, oysters are not left in very shallow water where the winter temperature is low. Young oysters, especially, are susceptible to extreme cold.

Though a determination of the salinity of the water, and a systematic observation of its variations, would be of value to oyster culturists, few have interested themselves in the subject. It is nearly as easy to observe salinity as temperature. All that is necessary is a simple case containing two glass floats (Figure 24), with hollow bulbs so weighed that in distilled water, each sinks until the surface of the water reaches the zero point on a scale borne in the stem. The density of distilled water is read 1.000.

The salt in solution in sea water prevents the float from sinking to so great a depth as this. If the water, in a test case, reaches the numeral 9 of the scale, the density is read 1.009. This scale measures densities from 1.000 to 1.011. The second float bears a scale registering densities ranging from 1.010 to 1.021, the range for both covering variations likely to be found



FIG. 24.—Salinometer. A glass bulb weighted with shot and carrying a scale for measuring the amount of salt in seawater.

over oyster beds. The floats are about eight inches long, and nothing else is required but a vessel that will hold a column of water of that height, in which the apparatus may be immersed. Temperature corrections are not necessary in ordinary observations.

Surface and bottom densities often vary greatly, and obviously that at the bottom is the one of greatest interest to the oysterman. It may be obtained by sinking a corked vessel and then removing the cork by means of a cord.

Oysters are brackish water forms. Their natural distribution has always been close to the shore where waters are fresher than in the open sea. If other conditions are favorable, they will exist in very salt water, but grow little, and do not reproduce. On the other hand, mature oysters have been known to live for some time in water nearly fresh. Such an experience, however, is always harmful. It sometimes happens, as in the Carolina field and in the Gulf of Mexico, that long continued freshets cause widespread destruction. On a considerable part of the latter shore, especially, the freshening of the water is a contingency on which the oyster culturist must take his chances.

The extremes of salinity between which the growth of

mature oysters is possible, are greater than those limiting reproduction. The optimum has not been precisely determined in either case. When food and temperature conditions are favorable, growth apparently is most rapid in water with a salinity varying from about 1.012 to 1.016. There may be no very narrowly limited optimum salinity, but whatever its limits, it is possible that they are not the same on all parts of the coast.

In the matter of reproduction, also, very few experiments have been made to determine the optimum salinity. Some observations made several years ago indicated an optimum much lower than that of growth, and these are usually quoted. It would naturally be expected that the most favorable density for growth would also be best for reproduction, and recent observations confirm this. Where it has been noticed by a trained observer, the best set of spat occurs in water the density of which varied between 1.010 and 1.017. Whether or not there is an optimum of narrower limits, is not known.

Sudden changes of density, so common everywhere in shallow water near the shore, are always harmful and sometimes fatal. Swimming embryos, for example, are often destroyed by a fall of rain. Though the resulting change of temperature may play a large part in it, it is possible that the sudden change of density is also very harmful. Recent experiment has proved that the transplanting of oysters to water of a different density, whether greater or less, has a bad effect even when the difference is slight. If the difference is considerable, oysters may cease to grow or may die. These effects are specially marked on mature individuals. The very young attached oysters are better able to adapt themselves to such changes.

It thus appears that the conditions necessary for oyster growth are numerous and more or less sharply defined. Some writers extolling the peculiar advantages for oyster culture afforded by certain untried waters, have had the belief that oysters would grow and multiply anywhere in them. But the required conditions are as exact as those governing the production of wheat, or cotton, or rice. It is a fortunate circumstance that the requirements are met by so great a part of our Atlantic and Gulf shores. Nevertheless there are many localities on these coasts where one or more of these conditions are lacking, and where an attempt at oyster culture might result in failure.

It need not be said that where oysters flourish in a state of nature, the conditions are fully met. If one were to use only such a locality for his oyster garden, a careful study of the conditions governing growth would be unnecessary; but the application of such a study has shown that vast tracts that have never borne oysters, only lack some requirement that may be supplied by the culturist. In this way, the productive territory has been greatly extended, and is yet capable of vast expansion.

OYSTER PLANTING

For the sake of convenience in description, the methods of rearing oysters employed in America may arbitrarily be separated into two groups, those that have to do with oyster planting, and those employed in oyster culture.

Oyster planting, as here defined, consists in gathering oysters from one locality and spreading them out in another to grow. It is the only culture method employed over a considerable part of both of our coasts. In oyster

planting, the number of oysters is not increased, but only those are used that have been produced under natural and unmodified conditions.

The term oyster culture, on the other hand, may conveniently be applied to that process that increases the number of oysters by artificial means, as when artificial collectors are employed to capture the young that would perish if nature were not thus aided.

In some cases oyster culture has become diversified, a division of labor being effected, in which certain individuals devote their entire time and energy to increasing the number of oysters by means of artificial collectors, while others complete the process by caring for them during their growth.

Usually a barren bottom is selected for planting, as the laws of most states reserve the natural beds for seed. When this has been cleared, and if necessary, made firm by the deposition of shells or sand and gravel, small seed oysters are spread evenly over its surface. These are allowed to remain until they have attained a marketable size, when they are gathered and sold. This method is carried on extensively, and often gives large returns for the money and labor invested.

Seed oysters vary greatly in size. Sometimes the almost microscopic young, newly attached to the shells of adults or to pebbles, are employed. In other cases, oysters two or three inches in length are planted. The usual size of seed oysters is perhaps about that of a silver half-dollar.

There are some evident advantages in planting large seed oysters. The first is that they need to grow for a relatively short time. More important still, they seldom need to be disturbed until they are ready for market.

When large, they usually have been culled, or separated, after they have been taken from the natural bed, and consequently grow more rapidly and assume a better shape than if closely crowded. On the other hand, increase in the size of large oysters is relatively slow, and the amount of increase is not great. A bushel of very small seed may eventually produce ten bushels or more of marketable oysters, while seed may sometimes be so large as to yield but two or three bushels from the one planted.

The most important feature of the planting of small seed is the possibility of its great increase in volume. In Europe, seed oysters as small as one's finger nail are carefully separated from each other when removed from the collectors on which they have become attached. But the price of labor in this country, when compared with the market price of oysters, precludes the possibility of employing such methods here. So very small oysters are planted still attached to the collectors—shells or gravel—and allowed to grow for some time closely crowded as they are.

Usually a time comes when they should be removed from the bottom and separated in order to prevent crowding. This is accomplished much more easily and with smaller loss with oysters that have been growing for a year or two than with very small seed. Planters naturally differ greatly in their methods. Some will allow small seed to do the best that it can without attention, and finally dredge and sell the oysters that have been able to attain marketable size. Others really cultivate the beds, culling the oysters and removing useless shells, seaweed, and other obstructing material, and they receive larger returns, because their oysters are of better shape and size.

There has always been much discussion among those who are interested in oyster culture over the relative advantages of different sections of the coast, especially as they concern rapidity of growth. But it is evident from the statements that have here been made, that the length of time during which planted oysters must be left in the water to mature, depends on several factors that must vary even in neighboring localities.

One might ask how long planted oysters must be allowed to grow in Long Island Sound as compared with the Gulf of Mexico, before attaining marketable size. But to answer accurately would require a volume of comparisons and averages. The rate of growth may be twice as fast on one bed as on another a mile or two distant, for it depends on the nature of local currents, temperature, salinity, the character of the bottom, and the number of oysters placed on it. The size of the seed when planted would make it necessary to leave one lot six or eight times as long as another. As a matter of fact, this time in northern waters varies from six months to three or four years.

The question of relative rapidity of growth in certain specified localities is one worth determining when possible, and some known cases of increase, from the time of the attachment of the embryo, will be mentioned in another place.

After the culturist has prepared the surface of his bed, he must determine the number of oysters to be planted on it. If there are no other beds in the immediate vicinity on which the matter has been tested, he may need to experiment in order to determine how great a number the waters will support. The greatest danger is from overcrowding, for when numbers reach a certain limit, the

food supply will not be sufficient for maximum growth. In Long Island Sound the limit is from three hundred to six hundred bushels for an acre of bottom. It is quite possible that some waters in the South may yet be found capable of supporting a greater number.

On the shore of the continent in Europe, oysters are planted between tide lines. There they are spread out evenly on the ground at ebb tide, or arranged by hand in racks. On our shore, all planting is done below the tide lines, so seed oysters must be thrown overboard from boats. The planter tries to spread his seed as evenly as possible. If he has a large area to cover, he temporarily divides it into small plots, by stakes in shallow water, and by buoys in deep, and then plants one plot at a time.

Let us suppose that he has but a few acres that are to be planted from skiffs, and that he desires to spread about three hundred bushels of seed oysters on an acre. If he does his work carefully, he temporarily divides an acre into sixteen squares that are somewhat more than fifty feet on a side. Loading a skiff with eighteen or nineteen bushels of seed, he takes it to one of the small squares, and, with a shovel, flirts the cargo as evenly as possible over the area. A like amount, spread in the same way on each of the other squares, gives him an evenly seeded acre bearing about three hundred bushels. The advantages of even planting are obvious, but the work is not always done carefully.

Those who practise planting on a large scale, especially in the deeper waters of Long Island Sound, employ steam vessels for towing scows, loaded with seed, slowly back and forth over an area marked by buoys, while a gang of men on each scow unloads it by means of shovels.

In northern waters especially, planted areas are very

extensive, and one naturally asks where the planter obtains his seed. When the states with oyster shores passed laws allowing individuals or companies to buy or lease bottoms for oyster culture, they very generally reserved the natural beds for common seed grounds. Serious trouble has arisen everywhere because of the difficulty in formulating a satisfactory definition of a natural bed. But the plan of reserving wild oysters was essentially a good one, because they usually assured a set of spat. Planted oysters, of course, also spawn, but it might happen in any locality that there would be few or none of them left during the breeding season. Planters are usually allowed to gather small oysters from natural beds for planting. These are culled and placed on new bottoms. In the North, where this has been practised for many years, the natural beds in some localities have become depleted; but in Connecticut, the greatest of seed producing states, there are still six thousand acres of natural beds that usually yield a large number of seed oysters.

Many years ago the planters of New England and New York conceived the plan of purchasing seed from the South. There were many localities, especially in the Chesapeake, where the set of spat was abundant and rarely failed. There was then no planting done in Maryland or Virginia, and the business of transporting seed to the North became, and for many years remained, a very great one. To-day, however, it has quite passed.

There were two reasons for this. The people of Virginia finally woke to the fact that if it paid to transport seed to the North for planting in the relatively unfavorable waters there, it certainly should pay to plant the seed already at hand on barren bottoms in their own fertile

waters. Laws were passed giving citizens rights to private holdings, and the planting industry was established. The second reason for the decline of seed transportation from the South was that northern oystermen learned to supply their own needs, and even, finally, to produce more seed at home than they required, thus allowing them to export to Europe and to transport to the Pacific coast. This was accomplished when certain companies and individuals gave up oyster planting for collecting alone. As on all oyster coasts, there are several specially favored localities in Long Island Sound where young oysters may be collected in great numbers. In such places available bottoms are utilized for obtaining the young on collectors, and the material so gathered is sold to planters. Much seed is also taken from natural beds.

This business of collecting and selling seed in northern waters is sometimes remunerative, but it is precarious, because the set is irregular and beyond control. The total number of oysters in Long Island Sound has been increasing rapidly for many years, but there has not been a proportionate increase in the set of young. During the summer and fall of 1899 there occurred a very profuse and long continued set of spat. This year is still spoken of as "the year of the great set." Attachment was not confined to the vicinity of natural beds, but occurred in deep water as well. The phenomenon was so general that the price of seed oysters became very low. The industry as a whole was greatly benefited by the condition, but dealers in seed made less from it than did the planters.

No marked changes in natural conditions were observed during the next year, but they must have existed, for the spawning season was a failure. Hopes for the following season, also, were not realized. Up to this

time, oysters from the set of 1899, now two years old, continued to be taken from the natural beds and planted. It was thought that the season of 1902 would surely bring relief, but no relief came, and the whole industry began to suffer.

It may be imagined that shells from the natural and artificial beds were anxiously examined for newly attached oysters in the early summer of 1903, and that alarm was felt when none appeared. The summer and then the fall wore away, and the fourth lean year proved to be the leanest of all. There was no set on the natural beds. Five years previously the great Stratford and Bridgeport natural bed alone had yielded more than 400,000 bushels of seed oysters, and on this year it did not produce a bushel. The matter had become serious for all northern planters, for seed from the Connecticut beds had for years supported not only the planted areas of the state, but also very largely those of Massachusetts, Rhode Island, New York, and New Jersey. In the waters of these states, three years, on an average, are required for the maturing of seed oysters. Those planted during "the year of the great set" were now marketed, and a long delay in the future was inevitable.

Again no changes in natural conditions were noticed, but the season of 1904 brought a harvest of young oysters that was nearly equal in volume to that of 1899. This time dealers in seed received large returns for their labor. Planters everywhere, not yet discouraged, bought every bushel that could be produced, and the price of seed rose to an unprecedentedly high level. More than a dollar a bushel was often paid, and the average price for the entire season was nearly seventy-three cents. Planters were compelled to wait long for returns, but the industry

was safe once more. The set of 1905 was small and much scattered, as was that also of the year following. The oysters of the natural beds produced very few young. In a few localities the set was good, while neighboring beds were barren.

Such a sequence of events excites the interest of a biologist as well as that of an oyster culturist. Though oystermen have observed no marked changes in the natural surroundings of the oysters that at one time prevent and at another stimulate reproduction, such changes undoubtedly occur. It is possible that a close observer who should, for a long period, keep a daily record of salinity and temperature, and all other conditions known to effect reproduction, would be able to offer a simple and satisfactory explanation of irregularities in the appearance of young oysters; or he might be able to discover some other factor, now unknown, that causes the phenomenon. Whether, after having found the explanation, he would be able to suggest a remedy for the present state of affairs, is another matter; but at least it is certain that the remedy will not be discovered until the cause of the trouble is known.

CHAPTER VII

REARING OYSTERS FROM THE EGG



IT has been suggested that the set of spat might be made certain by an artificial fertilization of the eggs. It is perhaps not to be wondered at that this possibility has for many years proved very alluring, not only to oystermen, but also to some biologists who have been interested in the life-histories of bivalves, because of its novelty, and because it would give so great control over natural processes. Nearly every one who has written about oysters within the last quarter of a century, has referred to this proposed method, and many have become enthusiastic over its possibilities.

If a score of millions of young oysters may be brought into being in a tumbler of water—as they may with the greatest ease—and if these, or any considerable number of them, may be caused to attach and be reared to maturity, one of the greatest obstacles to oyster culture will be overcome. Truly, it is a fascinating suggestion, but to the present time it has become nothing more. Because it has attracted so much attention, because it still is practically an unsolved problem for the American oysterman, and because it really is not so necessary to the industry as it has been assumed to be, a few rather unusual comments on it may not be out of place.

Previous to the year 1879, the anatomy of the American oyster had been studied very little, and nothing was known of its breeding habits or development. A few European biologists had found that the oyster of their northern coast was hermaphroditic, that the eggs were fertilized and developed within the body of the parent, and that they were retained there for some time. It was supposed that the American oyster was structurally and functionally very much like its European relative.

In the year mentioned, the late Professor Brooks of the Johns Hopkins University, made some observations on our form that have become classic, and in their publication showed, among many other things, that the American oyster is unisexual, and that the eggs are fertilized and develop outside the body of the female. He also discovered that it was possible, at will, to bring about the union of the sexual cells in a dish of water, and to observe the process of segmentation and the formation of organs. He was not able, however, to devise means of keeping the swimming embryos alive until they had become attached.

In performing the experiment, Professor Brooks simply opened the ovaries of a mature female with a scalpel and pressed the almost microscopic eggs into a dish of water. From a mature male he obtained a few drops of the spermatic fluid in the same way, and mixed them with the ova, the great majority of which became united with male cells.

Attention was at once attracted by this experiment. In the light of what had been accomplished in fish culture by means of artificial impregnation, possibilities seemed great in this case. Others took it up with enthusiasm. Before very long what purported to be an improvement

on the original process was published. This designated the original method as "barbarous," because crude, and singularly enough, it attracted much attention from those interested in oyster culture, though in reality it meant nothing.

It was merely a detailed description of a method of procedure by which one might be able to press mature eggs from the ovaries or the spermatic fluid from the testes of oysters without actually rupturing the sides of their bodies, after the manner of stripping the sexual cells from the bodies of fishes. But even if artificial fertilization had possessed some practical value, this added nothing whatever to the method employed by Professor Brooks, for unlike the fish that may not be injured in the stripping process, the oyster to be treated must first be opened by severing the adductor muscle and tearing off one valve of the shell, and not so many eggs can be obtained. This publication mentioned some anatomical facts and referred to implements that might be employed. It dealt simply with artificial fertilization, and proposed no method for the care of the embryo. Its author almost certainly did not regard it as a real contribution to oyster culture—indeed, he stated his opinion that the artificial fertilization of oyster eggs would probably never be practically important. Without doubt, if he had had any idea of the immense amount of attention that it was destined subsequently to attract, of the mistaken interpretation it was to receive, and of the false hopes that it was to waken, he would not have published it. But matters of that sort never can be foreseen, and it was launched on a very remarkable career.

Shortly afterward there appeared in a publication also designed to encourage the oyster industry a further de-

velopment of the operation, by another writer. It was as impracticable as the one just mentioned, and perhaps even more complicated. After long-continued and patient experiment, this investigator had met only with discouragement in his attempts to carry the swimming embryos to the period of attachment, and apparently not being optimistic concerning the possibilities of artificial fertilization, he also stated that he formulated this method only for those who would persist in the attempt to make something of it. He reached one conclusion that was sound when he stated that "it will at any rate do no harm to liberate a few millions of embryos [obtained] in this manner over a bed."

It is strange that some person living on the shore has not appeared, during the last quarter of a century, with curiosity enough to crush a few oysters with a stone, and shake them in a bucket of water in imitation of the above mentioned experiments. If he had done so, the chances are that he would have succeeded as well in obtaining swimming embryos, and gotten nearly as far toward a solution of the practical problem of rearing them as any one has to the present.

The unfortunate thing concerning these publications is that they have been read and copied and read again by the really intelligent element among oystermen and others who were interested, until the popular mind from New England to Texas seems perfectly possessed with the idea that the culture of oysters—and clams, also—from artificially fertilized eggs may, with a little more experiment, become a great achievement of science that will give wonderful practical results. After twenty-five years, shell-fish commission reports still refer to it hopefully. The commissioner of one great oyster state, for example,

writes in his report for 1906, of these early and abandoned efforts to obtain practical results from artificial fertilization as if they were recent, and concludes with the statement that "Meanwhile those engaged in the industry are watching these experiments with the greatest interest and hopefulness." If those engaged in biological work are sometimes regarded as impractical, it was not so in this case.

It is true that some advance has been made beyond the mere production of the swimming young. In 1881, Lieutenant Winslow, U. S. N., published the statement that he had found it possible to bring about the fertilization of the eggs of the Portuguese oyster, in which as in our own, the sexes are separate. A year later M. Bouchon-Brandelely, a Frenchman, who seems not to have known of Winslow's statement, showed that he had been able not only to cause the fertilization of the eggs of the Portuguese oyster, but also to catch the young on collectors.

This was a great achievement, but it depended on a condition that would make it impracticable in American oyster culture. M. Bouchon-Brandelely had at his disposal a very large fish pond excavated in a marsh. The water in this had a depth that varied from three to six feet. Several times a week, for a period of two months, artificially fertilized oyster eggs were placed in it, and a set was obtained on the collectors. He proved, too, that the attached young were really those that had been liberated, and not those borne into the reservoir from outside waters. Since that time a few repetitions of the experiment in large French claires, seem also to have been successful.

This French experiment excited much interest in this

country, and many attempts were made to repeat it here. The first of these was made in 1883 by Professor John A. Ryder, in a small pond on the shore of the Chesapeake. The excavation was a little more than twenty feet square, and about three and a half feet deep. Water from the bay was led into it by a ditch. In order to exclude young swimming oysters from the entering water, it was caused to flow through a sand diaphragm constructed in the ditch. After stakes, suspending shell collectors, had been placed in the bottom, artificially fertilized oyster eggs were poured into the pond from time to time. About seven weeks after the beginning of the experiment, the collectors were found to bear young oysters varying from a fourth to three-fourths of an inch in diameter; but the set appears to have been so meager as to have offered no encouragement to oyster culture. In summarizing his results, Professor Ryder concluded, "The writer does not think that the rearing of oysters from artificially impregnated eggs will ever be a profitable business."

Similar results were obtained from ponds constructed on the shores of Long Island Sound and elsewhere, but none were really successful, and some were entire failures. The accounts of most of the experiments are too vague and imperfect to be valuable. For example, a "good set" was obtained in a Long Island pond two hundred and eighty feet long and one hundred feet wide, and containing from two to six feet of water. But we do not know the observer's idea of a good set. From the account one must assume that water was led directly into the pond from the harbor near at hand, and that no attempt was made to exclude swimming oysters from it. Some years later that harbor was literally paved with

growing oysters from which such young might have been derived, and perhaps was at that time also.

All attempts to keep young oysters alive in tanks or aquaria until the time of attachment, have proved to be failures, though it is claimed in one case, that a few spat became attached in a tank containing somewhat more than two hundred cubic feet of water.

Laboratory experiments have been made, in which water was caused to flow steadily and rapidly through a series of aquaria. Filters of sand and other substances were provided to prevent the escape of the young oysters; but although the water was rapidly renewed, and the temperature kept constant, they perished, many of them becoming entangled in the filter.

Thus it seems probable, from observations already made, that the chances are much against the future discovery of facts that may make it practicable in America to rear oysters from artificially fertilized eggs. It has been shown that the young of our oyster will become attached in large and deep ponds so constructed as to prevent the deposition of mud on the collectors, but most of those who have conducted the experiments admit that they do not solve the commercial problem involved.

The matter might appear in a different light if it had been shown that the set in the reservoirs was much greater than in open water. It would be interesting to know, also, if a set could be obtained in a pond from artificially fertilized eggs in one of those occasional seasons in which it more or less completely fails on outside oyster beds. But even if these were demonstrated facts, they probably would be of little commercial value.

Usually the natural set is sufficient. If it fails in one

locality, a neighboring shore most often produces enough seed to meet the demand. When widespread failure continues for three or four years, an abundant supply of seed certainly could be obtained from other parts of the coast. Failure is most common in the North, but the New England planters might obtain seed in an emergency from the Chesapeake, the Carolina sounds, or even from the Gulf, where the set is practically always good. The present difficulty in this is simply that seed is not yet gathered for sale in large amount on these sections of the coast. All coasts do not fail at the same time. During the lean years in Long Island Sound following the large set of 1899, seed oysters were very numerous along the shores of Pamlico Sound and elsewhere, and were left untouched.

When the oyster industry shall have become as greatly developed in other sections as it now is in the North, and when everywhere the gathering of seed shall have become an extensive business, there will be no possibility, with present means of transportation, of suffering in any section from the lack of it. The seed problem, whenever it arises, will, in the future, be solved in this manner. Natural oyster seed is, and probably always will be, sufficiently abundant to supply all demands. It is only necessary to gather it from natural beds or on collectors and distribute it cheaply, and without doubt this can and will be done.

There have been many ardent expressions of the hope that the time might soon arrive when long neck and little neck clams shall be reared for market from artificially fertilized eggs. It would be well if that hope might now be completely destroyed. With these forms such a practice is an impossibility. The culture of clams by any

method has not yet been seriously attempted, though simple and successful methods have been tried and proved experimentally. When these are put into practice on a large scale, there will be seed clams for planting, and without lack, but they will not have been reared from artificially fertilized eggs.

CHAPTER VIII

OYSTER CULTURE IN AMERICA



MORE or less arbitrary distinction has been made between oyster planting and oyster culture, the latter being defined as a method by means of which the number of oysters are increased by artificial means above that produced under natural conditions alone. Except in Long Island Sound and in the region about the mouth of the Hudson, true oyster culture is still rarely practised in this country. In Maryland, Virginia, North Carolina, and the Gulf states, the universal opinion appears to be that while natural beds continue to exist, seed should be obtained from them. All these states possess extensive natural beds. In most cases oysters are still taken from them directly to market, and where planting is practised, they furnish the seed. The idea seems to prevail, also, that the New England and New York oystermen are driven to the use of collectors because their natural beds are so nearly destroyed.

It should not escape attention in the southern states that there are some important advantages in the method of gathering spat upon artificial collectors. The first of these is that the number of oysters is increased. Such an increase may not seem necessary at present in most places, and the fear, sometimes expressed, that it would glut the

market, is certainly without foundation; for it would come gradually, and the market might easily be made much more extensive than it now is. Nothing but good could come to the industry from its gradual extension and improvement. Again, seed gathered on collectors, while somewhat more expensive, is in every way superior to seed from natural beds. It is of uniform size. When planted, it all comes to maturity at nearly the same time. Young oysters so gathered are best able to withstand changes in environment encountered when the transfer is made to planting grounds in different localities. The increase in volume, also, is much more rapid and relatively much greater when the small seed from collectors is used.

On the other hand, oysters taken from natural beds for planting, are of all sizes and ages. To put the seed into good condition for planting, it should be separated from oysters of larger growth. To grade oysters taken from a natural bed according to size, requires much labor. Usually all are planted together. The young must grow with the old, which are often weakened by the changed conditions, and grow slowly. Many of these old oysters are ill-shaped, and can be very little improved.

More important still, the development of a branch of oyster culture for the collection of seed, would give stability to the whole industry. If the natural set should fail at one point, seed might be obtained at another, and probably not distant locality, where it had been collected for sale. Under such conditions there would be no lean seasons in the oyster territory.

Before the beginnings of oyster culture were made in Europe, the method of culture employed to-day had been established in our own country. From the fact that the young become attached to any clean, hard, foreign body

accidentally present in the water (Figures 25 to 28), the practice arose of purposely throwing objects on the bottom to capture them. Naturally, old oyster shells accumulated on the shore suggested themselves as collectors, and from that day to this, they have been the most generally used of collectors in America.

Shells are cheap, and are to be had near oyster grounds. Firm bottoms are usually selected for spat collecting, but the young are sometimes secured on soft ground. This is possible because the shells settle with their concave or inner surfaces uppermost. The edges of the shells are thus held above the mud, and even when the deadly silt is sufficient to kill those attached to the upper faces, others continue to exist on the under side of their margins.

The great disadvantage in using the oyster shell for a collector is that it is so large that a great many young may attach to it, and so tough that it cannot be broken to separate them. A large cluster may thus arise on a single shell, the individuals of which, from crowding, die or become elongated; and it is only after they have attained a considerable size that the cluster can be broken apart without great loss. But, on the whole, the oyster shell has proved to be the best of available collectors on the Atlantic coast.

There are some shells that are superior to it in many respects. Such are the thin, brittle shells of the scallop, the mussel, and the small "jingle shells" found on some beaches. If these are used where currents are not strong enough to bear them away, oysters that grow on them will break them into bits as soon as pressure is developed from crowding. In quiet waters these shells are ideal collectors because of this fact that the clusters formed on them will separate automatically without handling; but



FIG. 25.



FIG. 26.



FIG. 27.



FIG. 28.

FIGS. 25-27. Objects to which small oysters have attached.
From N. Y. Forest, Fish and Game Commission.

FIG. 28. An iron mast hoop from Chesapeake Bay covered by
thousands of oysters of various sizes. From Va. State Board
of Fisheries.



very unfortunately they are not to be had in large quantities.

Large parts of the Gulf oyster field possess an advantage over the Atlantic coast that some day may prove to be very important, in its immense deposits of small shells. These could hardly be improved on for the purpose of collecting oyster spat. They are hard, but so small that clustering on them would be impossible. At the same time, they are heavy enough to remain unmoved in a strong current. These will be described in another place.

In certain parts of Long Island Sound, water-worn pebbles or fragments of crushed rock are employed as collectors, or "cultch." Though this material is somewhat more expensive than shells, its pieces are so small that oysters cannot cluster on them. It cannot, however, be used on soft bottoms, unless enough of it is employed to act both as pavement and cultch. On hard bottoms, from five to six hundred bushels are spread over an acre—somewhat more than when shells are used.

Rarely spat is collected over very soft bottoms where the water is shallow. This is accomplished by driving the bases of saplings into the mud, leaving their branches immersed. Now and then a heavy set is gathered on them. If oysters are allowed to grow where they have attached, they are likely to fall into the mud because of the decay and softening of the bark. For this reason, the brush is usually removed soon after attachment is accomplished.

It is possible to use many other kinds of material for cultch. Scraps of tin and tin cans, for example, serve the purpose well when they are available, and very suc-

cessful results have been obtained from them. Though a great many young may attach to a can, the corrosive action of the salt water soon reduces it to fragments, thus freeing the oysters before they have begun to crowd each other and eventually the cultch is entirely destroyed.

It would be possible to manufacture saucer-shaped collectors of thin sheet-steel, gypsum, cement, tar, or asphaltum, that would be successful where currents were not rapid—the targets or “clay pigeons” used by trapshooters would be ideal for the purpose—but the cost, in any case would be prohibitive, and it is not likely that any form of cultch will be discovered or invented that will take the place of the shell collector in our waters.

One of the things learned early in the practice of oyster culture was that collectors may be placed on the bottoms only after the breeding season has arrived. Usually it will not do to plant the shells at any convenient season during the year to await the appearance of swimming embryos. The reason for this is that they soon become covered by a slime upon which the young oysters are unable to attach. The material which thus coats all exposed parts of the shells is composed of marine algæ, diatoms, hydroids, or sponges. These organisms are apparently able at all seasons to establish themselves, and their growth is rapid. It is therefore necessary to have the collectors ready on shore, and to spread them on the collecting grounds after the oysters have begun to spawn. Spat then attaches before the slime coat has formed.

If, during July, August, or September, the spat has failed to attach on the collectors, it may be necessary to

dredge all the cultch and expose it to the air so that the slime organisms may decay, dry, and flake off the shells before they are again planted.

Most of the slime organisms, however, inhabit relatively salt water only, and collections placed in brackish water may for a long time remain free from this organic coating. It thus happens that young oysters become attached to the shells of others that may have been growing in brackish water for some time. This explains why the clustering of oysters is more rapid where the water is relatively fresh, in or near the mouths of streams, than in deeper and saltier water.

When a farmer has plowed his field and planted his corn, he must still expend much labor on the growing plants if he expects to harvest a good crop. Thistles, ragweed, cockles, and other weeds spring up with the corn, and if they are not plowed under and kept down until the corn is high enough to shade them, much of the crop becomes stunted or perishes. If planted too thickly, the struggle among the corn plants would bring the same results.

So it is in rearing oysters. Only labor insures a good crop. This should seem reasonable, for one's experiences teach him that he seldom receives benefits without working for them. By analogy, he should hardly expect an exception in this case, but the fact is that a great many who have undertaken the cultivation of oysters seem to have had this very expectation. Analogy is usually a poor form of argument, but it is safe in this case.

In ignorance of the methods of the thrifty Connecticut oyster grower, many a prospective culturist on other coasts has taken a few boat-loads of "coon" oyster clusters from a natural reef, dumped them on a barren

bottom, and left them to work a miracle for him. He has then been ready to declare that oyster culture is a delusion. Talk of that sort is not uncommon to-day in some quarters, but at many points on our long shore line, that type of oysterman is learning his lesson from his more intelligent and more thrifty neighbors. Success in oyster culture requires work.

There is one extreme variation in this work that depends partly on the condition of the industry. The nature of the labor required when one collects and sells seed and another plants, is different from that required of one who must depend entirely on his own efforts. Stability arises from cooperation, but the isolated oyster farmer is apt to suffer many hardships. But the greatest variation in the work necessary for success in oyster culture arises from differences in local natural conditions. It has been proved by several failures that it is impossible to follow successfully in Pamlico Sound precisely the same methods that have succeeded in Connecticut. Oyster culture in Jamaica Bay is not exactly like that at New Haven. In Long Island Sound the work on deep beds is not like that near the shore. Culture is, of course, everywhere the same in its main features, but the necessary details, that are essential, vary with the locality, and must be discovered by experiment. This fact should be kept in mind, especially on the Gulf coast, when the time comes for introducing all phases of oyster culture there. The chief thing necessary everywhere to assure success is painstaking labor.

An examination of the labors of the Long Island Sound oystermen, who have carried oyster culture to the highest point of perfection in this country, shows them to be extensive. After the preliminary work of

preparing the bottom for planting, which has already been mentioned, the seed demands attention. If a planter has obtained his seed from a natural oyster bed, it will be more or less clustered, and these masses are made up largely of decaying shells, of hydroids, sponges, and other organisms. The clusters are culled, the living oysters, of many sizes, being gathered together, and the débris is thrown away.

When shells, or some other form of cultch, have been used for collecting the young, they are sometimes left without being disturbed until some of the oysters have grown to marketable size. In such a case the oysters, when dredged, are culled, the smaller ones being returned to the water to complete their growth.

Usually, however, the young are all removed soon after attachment and placed on other bottoms where experience has shown growth to be more rapid. The culturist sometimes plants them closely, for small oysters require a relatively small amount of food: but they must soon be removed and spread over a greater territory. The process of dredging and replanting is often repeated two or three times.

Those who carry on the most extensive business, own tracts in various localities. If they have obtained a set of the young near shore, these may be removed to deep-water beds several miles out in the sound. If a culturist owns no bottom on which a natural set is likely to occur, he sometimes spreads his cultch, and on it places "breeders"—mature oysters about to discharge the sexual cells. This is—or should be—done with due regard to the salinity and temperature of the water, and some time before the breeding season normally begins, in order that the oysters may become accustomed to their new sur-

roundings. From twenty-five to fifty bushels of these are usually placed on an acre.

Seed oysters having been spread on beds where they may complete their growth, sometimes require little attention; but usually their safety depends on constant vigilance and care. Much also depends upon the locality. In the year 1882 several of the Connecticut oystermen prepared beds in deep, salt water far from the shore. When oysters planted on these began to be removed, it was found that great numbers of starfish were present, and in succeeding years they became more and more numerous. This was the beginning of an affliction that has continued to the present time. Starfish are terribly destructive to oysters, the soft parts of which they consume, and no really effective means of destroying them has been devised. Other enemies, to be referred to later, also demand the oysterman's attention, especially in salt waters.

There is also work to be done on the brackish water beds. Much of this arises from the spawning of the oysters themselves, which are more prolific in such waters. An oysterman plants young that must grow three or four years before being marketed. During the following July a great many embryos may appear. The shells of the planted oysters may be quite free from slime, as often happens in brackish water. The spat collects on them and begins to grow. In another year or two the beds are covered with clustered oysters which, if allowed to remain longer, tend to destroy each other. Survivors will be stunted, ill-shaped, and poor. The entire contents of clustered beds must be dredged and culled, and a part of it removed to other bottoms.

In the care of planted oysters there are still other con-

ditions that often call for labor. Two or three varieties of sea-weeds frequently appear on the bottoms, often attached to the oysters themselves. In a current, these are matted down so as to interfere with the feeding process, and if allowed to grow, may become a serious menace. Strong currents frequently drag rubbish of various kinds on to the beds, and waves from heavy winds may cause the bottoms to shift. Oysters in this way are frequently "sanded," but even if completely covered, they would continue to live for some days, so they may be saved if cared for in time. All of these conditions the successful culturist must heed. There is nothing to be done but to dredge the entire crop, scraping the bottom clean. Then sea-weed and rubbish are removed, and the oysters are returned.

For still another reason it is often of advantage to disturb the oysters. There are bottoms on which they increase in size, but fail to fatten. Indeed, on most of the deep water beds, oysters do not attain so favorable a condition as in fresher water. In order to improve them as much as possible before marketing them, many culturists remove their oysters in the spring from the less favorable deep water to warmer and fresher shore beds, where fattening rapidly takes place during the summer. Such oysters are called "harbor plants," and though now often in a more favorable position for straining the bacillus of typhoid out of the water, they are plump, and are sold for a higher price than that obtained for the "sound stock."

Perhaps it has appeared from these statements that the oyster-culturist's year is not made up of days of idle waiting for his crop to mature. He has his "slack season," to be sure. In some years starfish may give him

little trouble. The set of spat may be so abundant as to make planting operations easy and certain of success. But there are always strenuous weeks of harvesting; rubbish and sea-weed may collect on the crop, or a hurricane may descend upon it at any time; and he, like the farmer, must be observant and always prepared to battle against enemies and the weather if he expects to be successful. Rewards are often large, but are only to be had as the result of much labor.

It will be interesting to compare the labors of the oyster and clam culturists—when the latter come into being. The returns to the clam culturist undoubtedly will be large, and the labor that he will be compelled to put on his fields will be trifling as compared with that of the oysterman.

CHAPTER IX

IMPLEMENTS AND THEIR USES—BOATS— THE PREPARATION OF OYSTERS FOR MARKET



THE expense to the oyster culturist of providing himself with appliances for carrying on his trade is slight as compared with that in many other fields of labor. He must have boats, large or small as the magnitude of his undertaking demands. But besides these, there is little else that he must purchase if he does not himself attempt to market his crop. Oysters are removed from the bottom by means of tongs and dredges, the former being used in shallow and the latter in deep water.

Tongs are of the same general pattern everywhere on the coast. As shown in Figure 48, two long wooden shafts or handles are crossed like scissors blades and held together with a "pin," or "pivot." The lower end of each shaft bears an iron head fashioned like a garden rake. Just above this is a basket-like arrangement of small iron rods that prevents oysters from falling when the two rakes are brought together.

Tonging is done from boats the length of which seldom exceeds twenty-five feet. These are usually fitted with a plank on either side level with the gunwale and extending from stem to stern. On this the tonger stands and lowers the head of the tongs to the bottom (Figures

29 and 30). With his hands on the shafts three or four feet above the water, he opens them, then pressing downward on the bottom, brings them together again. This operation is repeated several times until the weight indicates that the rakes have gathered a full load of shells. The tongs are lifted and the load is allowed to fall on the culling board placed across the boat back of its middle.

The sizes of tongs vary with the depth of water in which they are used. The shortest have a length of about twelve feet. It is obvious that a heavier load may be lifted from shallow than from deep bottoms; so in order to make the area of the "grab" sufficiently large the heads of the short tongs are usually about thirty inches wide.

To the inexperienced, ten or fifteen feet might seem to be the greatest depth at which oysters could be taken by this means, but as a matter of fact, they can be tonged in thirty feet of water. As a rule, however, tongs are seldom used in water more than twenty-five feet in depth, and the greater number are taken at a depth of less than fifteen feet.

Tongs are obviously the implements of the poorer oystermen, who have not the means to purchase large boats from which dredges may be used. But they are also frequently used in oyster culture by those whose operations are extensive; for oysters are often planted in water too shallow to float dredging boats. On the shallow natural beds of Chesapeake Bay, Pamlico Sound, and the Gulf of Mexico, a great many men make a living by the use of oyster tongs. The figures will give an idea of their occupation.

When oysters are greatly scattered in shallow water,



FIG. 29. A fleet of gasoline tonging boats in Hampton Roads, Va. From State Board of Fisheries, Va.



FIG. 30. Tongers and cullers at work on Pamlico Sound, N. C. From the U. S. F. C. Report.



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they are sometimes secured one at a time by light tongs having very narrow heads. These are called "nippers," and can only be used where the water is clear and very quiet.

A modification of the principle of the tongs is employed for use in deep water. There are many deep beds in the Chesapeake and its larger tributaries that are inaccessible even to dredges. Such beds may easily be reached by the so-called patent tongs, invented by a Maryland oysterman in 1887. Every one is familiar with the mechanical principle involved in a pair of ice-tongs. The iceman lifts on the handles to secure a grip on the load to be lifted, and the heavier the piece of ice, the tighter this grip becomes. Imagine that rake-heads, with teeth pointed inward, are fastened to the ends of such a pair of tongs where the calks or spurs are placed, and one has all but a few details of the patent oyster tongs. A rope is tied to each handle, and these are fastened to a single rope a few feet above. Before being lowered into the water, the tongs are locked open by a simple device. This lock is disengaged when the weight of the tongs rests on the bottom, and a pull on the rope causes the rakes to come together. The heavier the load, the tighter it is grasped. In order to scrape the bottom with force, weights are attached, or the tongs themselves are made of heavy material. This necessitates the employment of a windlass. The area of the bottom scraped, or the extent of the "grab" of the tongs now manufactured is one square yard, and the implement has proved to be very useful where oysters are numerous.

The dredge is much the most important implement used in American oyster culture. It does its work so

thoroughly and so rapidly that it sustains a never-ending chorus of protest against its employment all along the Atlantic and Gulf coasts. Naturally, this is largely from the tongs engaged in the laborious task of competing with it on what seem to be very unequal terms. But the dredge is also sometimes condemned by much more influential and generally well-meaning persons, who see in it a menace to the industry, at least where it depends on natural beds. State legislatures have listened with attention, and the influence on them of this cry against the dredge is still recorded in the oyster laws of almost every coast state.

Many now living may remember the profound disturbance in the minds of some, caused by the introduction of such labor-saving devices as the combined reaper and binder for harvesting grain. They seemed inevitably to involve the end for the farm laborer. To persons who formerly held this view of the matter, the frantic appeals for help that each year come out of Kansas when the grain harvest approaches, must have a strange sound.

The oyster dredge bears much the same relation to tongs that the reaper does to the old-fashioned cradle. The reaper gathers the crop, but the cradle is still useful on small areas, and on the edges of large fields. Oyster culture can never be what it should be without the unrestricted use of the dredge. If the industry is to depend on natural beds, it may be well to restrict its use, but there is no part of the coast where these conditions should be allowed to exist. On the northern coast, where states have been so educated in the matter as to have perceived the wisdom of leasing—or better still, of selling—oyster bottoms to culturists, there has been granted with the property right, the equally sensible right to

work upon the property without greater restrictions than are placed on the farmer who is allowed to cut his grain with a reaper. This seems like common sense and common justice, but there are still those who are strongly prejudiced against the use of the dredge.

But the old conditions are fast passing. There was too often just cause for complaint against the use of the dredge when state laws set apart some natural beds for the use of tongs only, and others for dredgers. But now that any citizen, in most states, may lease or buy bottoms in deep or shallow water, to which he confines his operations, and in which he is supposed to have the protection of the state, he should be allowed to handle his own crop as he chooses, so long as he injures the property of no one else by so doing.

The implement is very simple in construction. In the foreground of Figure 31, a dredge is shown lying on the deck of a North Carolina dredging boat. It consists of a rectangular iron frame from the corners of which rods lead forward and join at a distance of about three feet from the frame. The towing rope is attached at this point. Fastened all around the frame is a sack constructed of iron rings which is dragged behind it. The lower side of the frame that rests on the bottom, is sometimes provided with teeth that turn the oysters upward into the sack.

The size of the dredge varies greatly. The one just referred to is about three feet wide, and probably weighs about thirty pounds. This is near the minimum size. In Chesapeake Bay such dredges are employed on boats having a capacity of from three to four hundred bushels. On larger boats dredges more than five feet wide are used. These weigh about one hundred pounds and will

hold five bushels or more. The average capacity of dredges used on steam vessels by Connecticut oystermen on private grounds, is ten or twelve bushels, but some are of immense size, and capable of gathering thirty bushels at a haul.

Almost everywhere at present, except in Long Island Sound, sailboats are used for towing the dredge. There, the more powerful and more reliable steam power has come into general use, and it probably will not be long before the example of the northern planter will be followed elsewhere, though the cheaper, if more primitive, sail power may never be entirely abandoned.

Two masted, schooner-rigged vessels, such as is shown in the illustration, have long been employed in Chesapeake Bay, in Pamlico Sound, and elsewhere. These carry two dredges that are hauled by hand winches or windlasses bolted to the deck back of the foremast. Opposite each windlass, three or four feet of the rail are removed, and level with the deck there is placed a bar or, more commonly, a roller, over which the dredge rope plays. When the oyster beds are reached, dredges are thrown over and dragged until it is supposed that they have been filled.

Each windlass has two long handles and is operated by four men. The dredge, with its load, is hauled upon the deck and emptied. From natural beds a great amount of waste material is brought up with the oysters. When dredging is done in the daytime, the dredge load is at once culled, the oysters being stowed below the deck, and the waste thrown overboard. At night, culling is dispensed with until daylight.

When the bed has been crossed, the boat tacks, hauling the dredges across once more. In this way the work



FIG. 31. A North Carolina dredging schooner, showing dredge and hand-windlass. From Dr. Caswell Grave in U. S. F. C. Report.



FIG. 32. Drawing a more modern dredge by steam power on the New York oyster grounds. From a Report of the N. Y. Forest, Fish and Game Commission.



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in the Chesapeake is continued day after day until a load has been secured. This usually means two or three weeks of dredging. The boat then puts in to market.

While the dredges used by the oystermen of Long Island Sound are of usual pattern, their operation has been greatly perfected. On many of the modern steam vessels as many as four of them are handled simultaneously, and the winches, instead of being operated laboriously by hand, are controlled by steam power. By this means dredges are drawn in very rapidly. They are usually much larger than those drawn by hand, and the number of the boat's crew is greatly decreased.

Reference has been made to the tonging boat, which is of much the same pattern everywhere. Every one is familiar with the common schooner and sloop rigs. These are found on the oyster grounds from New England to Texas. The hulls of these boats of course vary in size, in depth of keel, and the use of center-board, conforming to the nature of the oyster region. A brief reference to an unusual and specialized form may not be out of place.

At the present time in Louisiana, many schooners and sloops are employed by oystermen, and under the intelligent and progressive management now in force, the more modern power boat is being added to the oyster fleet. But not long ago the oyster boats were all of a class seldom seen on our coasts, which, from its Mediterranean rig, was known as the "lugger." A few of these boats may still be seen on the oyster grounds.

The lugger, varying from sixteen to forty feet in length, is decked over fore and aft, the center being left open. There is one long mast carrying a large, nearly square sail that is suspended from a long yard. The

lower corners of the sail are secured at the bow and stern on travelers, so as to work across the deck. There is no jib. In sailing close to the wind, yard and sail are drawn so as to lie nearly parallel to the keel. It is said that these boats are superior even to schooners and sloops in beating to windward. Before the wind, yard and sail are swung across the boat. They are fast sailers, and may be handled quickly; but the long yard is apt to give trouble in squalls, and it is said that the danger of capsizing is great.

The most highly specialized craft employed in the oyster industry, are to be found in Long Island Sound, and vessels of a similar sort will doubtless eventually be employed over much of the oyster territory. As early as 1874, an oyster planter of Norwalk, Conn., put steam power into one of his sloops for the purpose of towing oyster dredges. The advantages of steam power in this work would seem to be obvious. It may be used as an auxiliary to sail power, the latter being employed alone in weather favorable for it. It may be used on calm days, and is at command at all seasons, and in every sort of weather. Its power may be made as great as desired, and is easily controlled. Steam may be used not only for propelling the boat, but also for drawing in the dredges. But the expense of installing boilers and engines is relatively great, and this, with operating expenses, may have convinced oystermen at this time that steam would not be profitable. At any rate, when Captain Decker began to convert his sloop into an oyster steamer, he was ridiculed by all the oystermen in the region, and the failure of his experiment was predicted with the utmost confidence.

But, contrary to all expectations, its success was im-



FIG. 33. Steam dredging vessel on Long Island Sound. From a Report of the R. I. Shell-fish Commission.

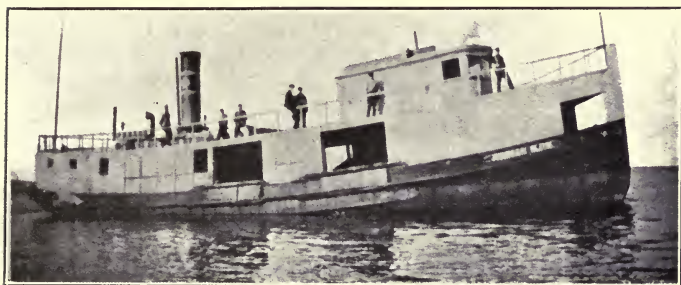


FIG. 34. Steam dredging vessel owned at New Haven. From a Report of the R. I. Shell-fish Commission.



FIG. 35. New York steam dredging vessel towing the dredges. From a Report of the Forest, Fish and Game Commission.



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mediate and complete. Captain Decker owned about sixty acres of bottom in deep water that he had been unable to use, largely because he could not keep it free from starfish. With his new boat, that proved to be able to operate large dredges rapidly, he thoroughly cleaned his ground, and after oysters were placed on it, was able to handle them easily and to keep down the numbers of their foes. The result of this first attempt to use steam power on an oyster boat in America was a tenfold increase of the boat's capacity for dredging oysters without great increase in operating expenses.

When this fact was realized, as it was immediately, a great cry was raised by all the oystermen along the shore against the employment of steam in the oyster industry. The state legislature became convinced that something should be done to reassure these conservative petitioners, so it prohibited the use of steam power on the natural beds, and that prohibition remains to-day in Connecticut.

But a revolution in American oyster culture had been inaugurated, and has resulted in an enormous increase in the number of oysters produced, and in the reclamation of much of the deeper area of Long Island Sound. Steamers to be used in oyster culture at once began to appear in Connecticut and New York, and have steadily increased in number, size, and efficiency ever since.

The little converted sloop "Early Bird" measured but seven tons. In 1880 there were six steam oyster vessels in Connecticut, one of them measuring thirty tons, net. Five years later the number had increased to forty-eight vessels, averaging twenty-seven tons—but three tons less than the greatest in 1880. By 1887 there were fifty-seven oyster steamers in the Connecticut field,

but for some years following, the increase was very slow.

By this time there were probably as many steam vessels as the condition of the industry in Connecticut demanded, and they increased in number slowly as it grew. Growth has been steady, and each season sees a few steamers added to the fleet. In 1903 there were about one hundred of them; in 1906 one hundred and fourteen, and that rate of increase may be maintained for some time.

The average displacement of the steamers employed by the oyster culturists to-day is nearly thirty tons, net. Several of them recently built have a displacement of more than a hundred and forty tons, or nearly ten times the average size. The tendency seems to be toward the construction of larger and more powerful vessels.

It should be stated that there is still much work on the oyster field that can be done by schooners, sloops, and small boats, and that there has also been a steady increase in their number.

This demonstration of the utility of steam in northern waters should be of great value to culturists in those fields where steam vessels are not yet in use. So much of the success of northern oyster culture has depended on the development of these boats that it is of prime importance that their construction and the nature of their work should be studied by, and generally known to, the culturists in the Chesapeake, the Carolina sounds, and in the Gulf of Mexico. Unfortunately, publications on the subject are few and meager.

The great superiority of steam-driven vessels may be indicated by a brief statement of what one of them is actually able to accomplish. This vessel is of seventy-three tons displacement. It has a length of eighty-three feet,

a beam of twenty feet, and a depth of six feet. It carries a crew of eight men. Its original cost was sixteen thousand dollars, and a hundred dollars a month purchases fuel, water, and oil.

The carrying capacity of the vessel is twenty-five hundred bushels of oysters, and it is able to dredge eighteen hundred bushels a day from beds under thirty-five feet of water. In order to equal a single day's catch by this vessel, it is stated that it would be necessary for the sailing vessel of average size employed by the oystermen in Long Island Sound, carrying a crew of three men, to dredge the same bottoms for *nearly two and a half months*.

The fearful tortures to which the crews of many dredging vessels in the Chesapeake have in the past been subjected by their masters, form an interesting subject that will be referred to later. To these cruelties have been added the sufferings caused by exposure to winter weather. Under the most humane treatment, the lot of the crew of a dredger with exposed decks is a hard one. In the North especially, where winters are so severe, the limit of human endurance is required of the crew of an open boat. In contrast, life on a modern steam dredger is pleasant. It is housed over so as to afford almost complete protection to the crew, no matter what the weather may be. The four dredges are hauled by steam winches, and powerful propelling engines make frequent visits to port a certainty.

One extremely important advantage possessed by the steam dredger that should not be overlooked, is that its owner is able at all times during the winter to deliver his oysters when he has promised to do so. If he is to dredge them from deep water and in the middle of the

sound, neither ice nor storm can prevent him. The work is done so rapidly that dates may be set for the delivery of large quantities. Market demands may be met at once. On the other hand, the market is not glutted, as is the case when several sailing vessels, that have been weeks in obtaining a cargo, happen to reach port together.

The recent increase in the number of gasoline boats everywhere on the coast is one of the most remarkable phenomena that the shore has witnessed in many decades. Naturally, these boats have become very useful in the oyster industry. But fuel for the new motors, whether gasoline or alcohol, will be too expensive for large boats, and steam will have no rival here.

In many instances, the preliminary work of preparing oysters for market, begins when they are dredged. In the Chesapeake, for example, where dredging for market until the present time has been done only on natural beds, state law requires the culling of oysters on the beds in order that empty shells and young oysters may be returned to the bottoms. This culling makes handling more easy and rapid for the dealers who receive the cargo. In other localities, culling of the material taken from private beds may, for various reasons, be done on shore.

Oysters are usually very muddy when taken from the bottom, and must be cleaned. On the steam dredgers the greater part of the mud is removed before the dredge load has reached the deck. The older winches or windlasses were provided with what is called a positive clutch—the same device that is employed on well windlasses to prevent them from turning back and lowering the bucket. Now what is called a friction clutch is em-

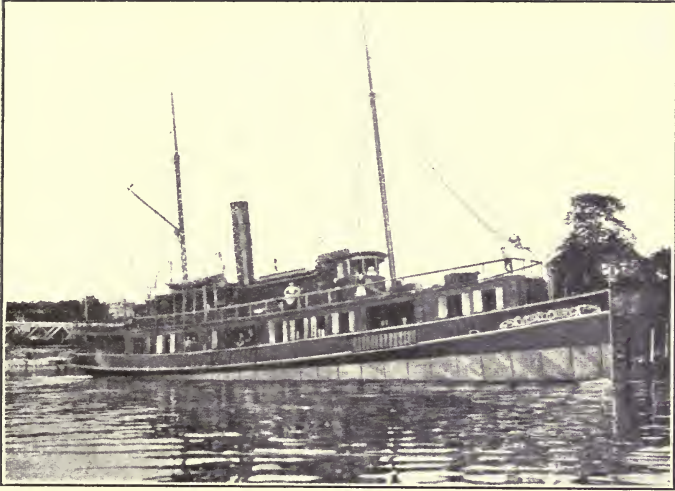


FIG. 36. A powerful ice-breaking steamer owned at New Haven, Conn. This vessel is capable of dredging 1,200 bushels of oysters an hour in water forty feet deep. From a Report of the Conn. Shell-fish Commission.



FIG. 37. The largest of the northern oyster fleet. This vessel, drawing six huge dredges, has a capacity of 8,500 bushels of oysters a day in forty feet of water.



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ployed. It may be only partially released and acts as a brake to stop the descent of the dredge. A load of oysters is drawn up close to the surface of the water, then suddenly dropped, checked, and raised again, this being repeated until the mud is washed out.

On reaching the shore, the culled oysters are sorted into the various grades that are required by the wholesale trade.

Before being marketed, oysters are almost invariably placed for a time in fresh water. The danger to the consumer resulting from this process, as it is usually carried on, is great because the fresh water is so often contaminated with sewage. Even if it were clean, the procedure is not defensible, for its chief object is to bloat the oysters so that they will fill a larger measure. For freshening, they are placed in flat scows or floats and towed into a stream, or are unloaded from the dredging boat into tank-like inclosures, where they may be covered for a short time with fresh water.

On the Atlantic coast, the shell trade, as it is called, has for many years centered in New York City, most of the oysters sent out from Baltimore and Norfolk being "shucked." The marketing of oysters in the shell has assumed great proportions. Formerly inland cities and towns were satisfied with oysters shipped in tin cans. Later the container more often employed was a wooden pail. But finally, in city restaurants and hotels it became customary to eat oysters from the half-shell, and to-day there is a large demand for them in that form.

For the most part, however, oysters are still marketed removed from the shell. It is not often possible to obtain anything but shucked oysters in smaller towns and villages. It should not be imagined that such oysters are

necessarily inferior to the "shell stock," even when they are to be eaten raw. It is probable that the tissues of an oyster live longer within the shell, though shell stock, also, usually is subjected to the fresh water treatment before being marketed, and it would be a difficult matter to distinguish a difference in the flavor of oysters on the half-shell and those that have been shucked.

Popular requirements in articles of food are usually arbitrary and without reason. Appearance often seems to be more important than quality or taste. There is a demand for pure rich butter, but few would care to eat it, for pure, rich butter is not bright yellow. Oranges and plums are desired only when they are bright colored and large, which too often means that they are sour and tasteless. Rice must be polished by removing its most nutritious outer parts. Oysters must be bloated and must have their natural salt removed in order readily to be salable. The same is true of a long list of food-stuffs.

If one were to write a dissertation on the sense of taste, he would have ample room for reflection on the causes and significance of diseased tastes, such as those that are trained to an enjoyment of some fancy foreign cheeses, of partridges and grouse in a state that might be naturally pleasing to a buzzard, or of oysters so copery that one possessing a taste in its naturally innocent state would fear poisoning by them. One curious characteristic of persons who possess such tastes is that they sometimes believe themselves to be able to appreciate the most subtle and delicate flavors. Possibly that may be true, but carefully conducted experiments on such subjects might prove interesting. Even consumers of oysters on the half-shell, possessing normal and unperverted tastes, would probably, with few exceptions, declare

them to be of much better flavor than shucked oysters. It is always interesting to hear comments on the fine flavor of the oysters, when canned "New York Counts" or oysters of a similar brand are served on shells saved for the purpose. It is just as interesting to blindfold an expert in matters of taste, who then possesses the advantage of knowing that he is being tested, and to serve him with oysters fresh from the shell, and shucked oysters, in either case the best that the market affords, but both of the same size, in order that his discriminating taste may try to distinguish one from the other.

It cannot be successfully maintained that all oysters are alike in flavor when all come fresh and unspoiled from the water, or even when all are more or less spoiled by the fresh-water treatment. There certainly are very positive differences in the flavor of oysters from different localities. But probably an unprejudiced observer whose sense of taste is normally acute would be slow to admit after a trial, that a peculiar and particularly delectable flavor characterizes the oysters of every bay, cove and river-mouth, as is locally claimed for each of them all along the shore.

Observations of this sort may be of little value to one who is fond of oysters and believes that those that he is able to purchase are a little superior in flavor to any others; indeed it would be a loss to him to be convinced that he had been mistaken. But on the other hand, there are persons who believe that they are being given a little the worst of everything, and if such may possibly be cheered by following the line of experiment suggested, it will not have been proposed in vain.

Returning to the marketing of oysters; it may be said that the greater number are opened where they are

landed, and hurried to all parts of the country in a fresh condition. In former years there was little organization in the preparation and distribution of raw oysters, and because they soon became spoiled, they were not shipped far from the shore.

Any one who has attempted to open a living oyster, appreciates the task of the professional shucker. The thin edge of the shell often cuts like a knife. Even leather gloves afford slight protection, being cut to shreds in a short time. The most successful covering for the hand that holds the oyster in shucking, is a thick woolen mitten. In spite of every protection, the shucker's hands are always covered with cuts.

When a living oyster is handled, its adductor muscle draws the valves of the shell together with such force that prying them apart is impossible. More than that, the valves fit together so nicely that there is no space into which a knife blade may be inserted. The only thing to be done is to break off the edges of the shell enough to allow a blade to enter, and it is so extremely tough that a blow from a hammer is required to accomplish it. The oyster is then held with the flat valve uppermost. A quick side cut severs the muscle from the upper valve, which is thrown off. Another cut frees the "meat" from the deep lower valve, from which it is thrown into a receptacle of some kind. The knife used possesses a blade that is rounded at the tip, and cuts on both edges, but is not kept sharp. The handle is of wood or iron. The swiftness and dexterity developed by an expert shucker are little less than marvelous, but the work is always hard and disagreeable.

The "meats" are washed, measured, and quickly packed for shipping. At Baltimore and some other

centers, they are often placed in tin cans and hermetically sealed. These are packed in a wooden box in two rows, leaving a space between for ice. Though the tin can has gradually fallen into disuse during the last few years, it is in some ways the best container yet devised for fresh, shucked oysters. But the more usual method in the North, as well as at Baltimore and Norfolk, now is to use barrels, half-barrels, or pails of wood. Pieces of ice are put in with the oysters, a practice that fortunately is being abandoned—and before the pure food laws went into effect, it is possible a pinch of boric or salicylic acid, also—and a cover fitted tightly and securely over them. Other containers, such as pint and quart bottles with pasteboard stoppers, and double receptacles with a space between for ice, are beginning to be used.

Even without additional refrigeration, these raw oysters will remain fresh for ten days or two weeks in the winter. They are transported by special oyster trains or by express, and all the central states, even west of the Mississippi, receive them in good condition. Baltimore controls a large part of the inland territory, New Haven and other Long Island Sound cities naturally supply the denser population of New England. Many raw oysters from Chesapeake Bay are also sent North. Several fancy brands of northern oysters in the shell, on the other hand, find a large market in Baltimore, Washington, and other southern cities.

The packing industry has long been established at Mobile, and is growing steadily and rapidly at New Orleans. There is a great territory in the South to be supplied from these centers, but they are also shipping oysters as far north as Chicago, and as far west as the Rocky Mountains. Without doubt New Orleans will in a few years

become one of the great oyster shipping centers of the country, for the oyster territory about the delta of the Mississippi is extensive and possesses great natural advantages, and oyster culture has begun there in earnest, and under most intelligent control.

Before means of rapid transit existed, oysters were steamed at a temperature far above the boiling point, in order to kill the micro-organisms of putrefaction, and then canned. Many packing houses, especially in the South, still prepare oysters in this way. The virtue—if the word may be allowed in this case—of this method is simply that oysters so canned may stand on the shelves of the country grocery store for several years without becoming worse than when they were received. They do not, however, commend themselves to any one who has eaten raw or freshly cooked oysters.

Attempts have been made to market oysters pickled in spiced vinegar, but with little success. Oysters carefully fried in crumbs have also been marketed in sealed tins, but for some reason, little demand was created for them.

CHAPTER X

NATURAL ENEMIES OF THE AMERICAN OYSTER



WHAT may be called the balance of nature—the interdependence of organisms on each other—as it appears in a multitude of forms, is one of the most striking and interesting of the phenomena that the naturalist observes. These vital relations among living things are frequently complex, involving many different species of both animals and plants. They are not fixed, but even without man's influence, are subject to many changes.

One of the conclusions derived from the study of the interrelations of organisms is that every animal and every plant has enemies that may injure or destroy it. These enemies are not of a single species, but many. Wild rabbits, for example, in order to exist must escape from foxes, wild members of the cat family, minks, weasles, hawks, snakes, and many other vertebrates; and in addition to these they must contend against a host of insect and worm parasites. The list does not end here, but includes many deadly bacterial and perhaps protozoan parasites. While this may seem to be an extreme case, one may be perfectly certain that even the eagle and the lion, that we are accustomed to think of as fearing no foe, are subject to attack by many deadly enemies.

Animals and plants in nature have, through the action

of natural selection, developed many means of protection, some of them very extraordinary, so that a balance is established that allows a species to survive. But when man makes his appearance, and domesticates wild plants or animals, these equilibriums are disturbed, and complicated results follow.

While these conditions might be illustrated by scores of interesting examples, that might be selected from the observations of naturalists, it is sufficient to call attention to the fact that the agriculturist is constantly waging a war on numerous enemies that attack every animal or plant that he attempts to rear, and that would destroy them without his intervention. Not only is this true, but often when one foe is conquered, an entirely new one appears. It is an ever changing and never ending warfare.

Naturally, the oyster culturist does not escape the necessity of fighting oyster enemies, and there are many of them. Fortunately, natural surroundings are not greatly changed by the methods of the culturist, but even the slight changes that are necessary, have facilitated the attacks of some enemies, and led to their rapid increase. Natural oysters in dense clusters are more or less protected from the attacks of starfish, drumfish, boring mollusks, and other foes, but when spread out singly on smooth bottoms, are easily destroyed. Fortunately the distribution of no oyster enemy is as extensive as that of the oyster itself. Some of these foes exist only in salt water, while others seem to be limited in their distribution by temperature.

In the most northern of the Atlantic grounds, the common starfish is by far the most destructive of the oyster's foes. Fortunately it is a truly marine animal,

and is killed quickly when immersed in fresh water. It is not abundant in sea-water that is only slightly freshened. On the other hand, the oyster is naturally a brackish water form. The natural ranges of the two forms, then, are not the same, but overlap. It thus happens that almost the whole of Chesapeake Bay and the shore of the Gulf of Mexico, while salt enough for oysters, are too fresh for starfish, and in these regions this curse of the northern industry is practically unknown.

It was not until about 1882 that it was recognized as a serious menace to the northern industry. The reason for this was not the sudden appearance of the form at that time, but simply that the industry had previously been confined to comparatively fresh waters near the mouths of rivers, or streams, where the creature found difficulty in perpetuating itself. It is usually on the outer beds only that oystermen have great trouble with the pest.

The starfish or "five-finger" certainly does not reveal its real character by its appearance, for among the shore animals, few are seemingly more harmless. Its body is made up of a central circular disk, a little more than an inch in diameter in the species inhabiting Long Island Sound and neighboring waters. From this there radiate symmetrically five arms or rays, each five or six inches long in a large specimen. The wall of the entire body is composed chiefly of short rod-like plates of lime joined together at their ends by muscles, and in such a way as to form a network. Borne on these plates of the skeleton, and projecting outward over the entire surface, are a great many short, blunt, spines.

The mouth is situated on the under surface in the

center of the disk. Radiating from this on the under side of each arm, and extending to its tip, are grooves from which project a great number of fleshy tubes, each provided with a disk-like sucker at its end. These are the tube feet, and are used in locomotion.

One would hardly imagine, after examining a dried specimen, with its hard, unyielding body, that it might

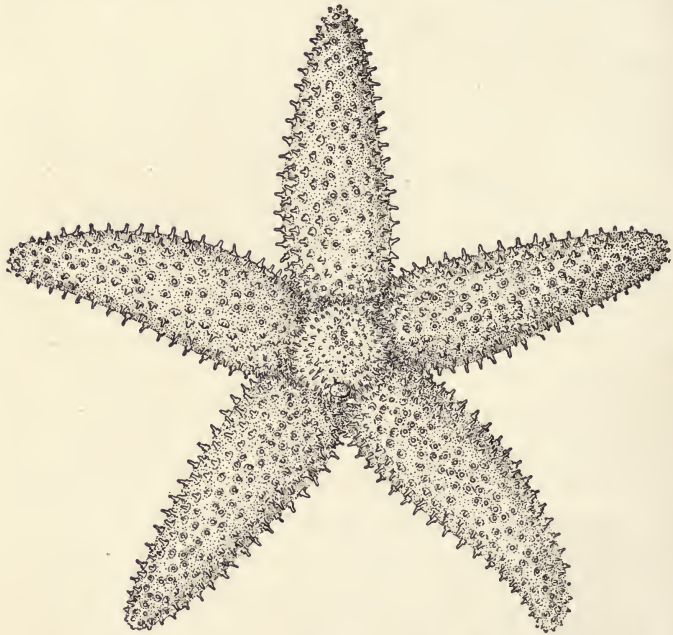


FIG. 38.—Common Starfish of the North Atlantic Coast.

be capable of much bending in any part. But the living animal is able to bend these arms upward, downward and sideways, to an extreme degree, by the contraction of muscles connecting the plates of the skeleton.

The animal creeps on the bottom with great deliberation. Six inches in a minute is fair speed for a large

individual. Its locomotion is accomplished by thrusting out a number of the sucker feet in a definite direction and attaching them by their ends. The feet may be extended an inch or more. After attachment these contract, other feet that have been tenaciously holding to the bottom at the same time detaching, and the body is slowly pulled along. Thus, many feet, acting independently, reach out in the direction of locomotion, attach, and then exert a pull by contracting, while all the time other feet that have already contracted loose their hold and then reach out again. Slow as these movements are, they result in migrations of considerable extent, that often surprise and trouble the oyster culturist.

One other anatomical feature is of interest in this connection. Nearly the entire interior of the central disk of the body is occupied by the stomach, while the arms, or rays, are nearly filled by great glands that secrete a large quantity of digestive fluid. The starfish feeds principally on barnacles and bivalve mollusks. The mouth, merely an opening unprovided with teeth, and capable of expanding to a diameter of little more than half an inch, even in large specimens, is not intended to receive the bodies of animals preyed on. Sometimes however, very small mollusks are taken into the stomach, shell and all, but probably not often. Without teeth or other organs for breaking the shell, and with a small mouth—merely an opening through a muscular membrane—how is it possible for a starfish to devour an oyster as large as itself?

Various opinions have been expressed on the matter. It has been supposed that the starfish reaches the soft parts of the oyster by inserting some part of its hard body between the valves so as to keep them wedged open.

It has also been stated that they break off the edges of the oyster's shell so as to make an opening to the interior. A mere examination of the body of the starfish would show this to be impossible. They have been thought to kill their prey by some poison, and even to dissolve the shell by some acid.

The whole performance of disposing of the oyster may be witnessed in an aquarium, and appears to be as follows. Slowly creeping on to its victim, the starfish wraps its rays about it, at the same time taking up such a position that its mouth is nearly opposite the shell edges. The oyster responds even to this cautious and gentle caress by contracting its adductor muscle and closing its shell. The contraction of the muscle may be made so powerful that if one should attempt to pry the valves apart, the tough shell might break without causing the muscle to yield.

The starfish cannot match such a sudden demonstration of muscular strength. It simply camps on the trail in oriental fashion. If it cannot win now, it may later, and it invariably wins. Scores of its feet are attached to each valve of the shell. Apparently they contract so as to exert a gentle pull in opposite directions, and against the oyster's powerful muscle, which in time becomes fatigued. Eventually it yields altogether, incapable of further effort, and the valves of the shell gape open. It is possible that the sucker feet have each in turn enjoyed periods of rest during this siege. At any rate, their gentle insistence conquers in the end.

The shell valve will not open far, and the digestible part of the mollusk's body is still some distance away—but not out of reach. It is a physical impossibility for the captor to get the great mass of food into its

stomach, so to overcome the difficulty, nature has made it possible for the stomach to go to the food. The greater part of this sack-like organ is made of a very distensible wall. This now begins to roll out of the mouth and between the valves of the oyster's shell in the form of a great thin sheet. It is spread over the soft tissues of the victim's body, the great digestive glands connected with the stomach cavity, pour out their secretion through the tubular passage remaining in the center of the sheet, and the food is rendered fluid and absorbed without being disturbed from its position within the shell. When the meal is finished, the muscular part of the stomach is slowly contracted and rolled back through the mouth into the body.

The starfish would not be so great a menace to the oyster industry if its appetite were not so nearly insatiable. It may live for months practically without food, but having the opportunity, it will creep from one bivalve to another—whether oyster, clam or mussel—without observing a between-meal period, and thus becomes extremely destructive. A small star has been observed to devour more than fifty clams somewhat smaller than itself in six days, and increased in size at a very rapid rate.

It may be interesting to notice that this gluttonous habit, certainly one of the most remarkable observed among animals, begins in infancy, even at a time when the arms are as yet mere rudimentary lobes on the sides of the minute central disk. Figure 57 represents such a precocious infant engaged in the destruction of a baby clam. That this is beginning a life of ravin early, may be indicated by the fact that the bodies of the two animals together measured less than two millimeters across.

At this age the shell of the clam was quite transparent, and the protruded stomach of its infant destroyer was observed spread out within it. Newly attached oysters, also, as well as those of larger growth, are destroyed in the same manner by starfish of various sizes. They are never too small to escape.

Professor A. D. Mead has demonstrated the fact, interesting both from a biological and economic standpoint, that the growth of small starfish is proportionate to the amount of food that they consume. Beginning an experiment with two starfish of the same age, and with bodies about the size of a pinhead, if one is starved, it may still be living at the end of a month, but of course will not have grown. The other, if well fed, will, in the same length of time, have become large enough to cover a silver dollar. It was formerly supposed that starfish became sexually mature only after a period of six or seven years. It is now known that they reproduce on attaining a certain size, and size, as indicated above, depends directly on the amount of food. The result is that a female starfish may, if large enough, begin to extrude eggs during its second summer, and many by that time attain the required size.

Oyster culture would be quite impossible over a large part of the northern field if starfish were left to themselves, yet to keep down their numbers is a very difficult task. When not excessively numerous in shallow water, the culturist sometimes takes up the larger individuals one at a time on a spear.

The real damage is done when starfish move together in great numbers, as they often do. Traveling but a short distance each day, a great army of them may creep over a bed, utterly destroying it. In deep water their

presence may not be discovered until the damage is done. It is thus necessary for the culturist to exercise eternal vigilance. The number of these enemies that must be dealt with in certain localities may be imagined when it is stated that one oyster planter in six years removed from his deep water beds ten thousand bushels of them.

There is considerable variation in their number, due to changes in environment. It sometimes happens that a

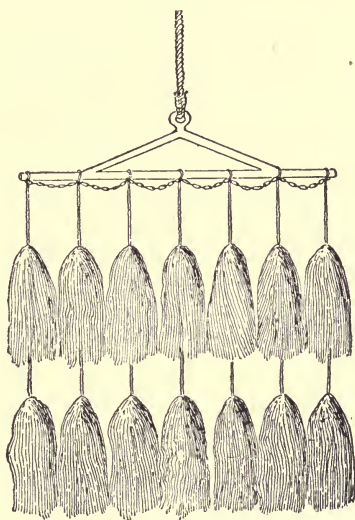


FIG. 39.—Tangle of frayed rope or pieces of cotton waste used in collecting starfish on oyster beds. Drawn from a figure published by the U. S. Fish Commission.

year or even more may pass without the appearance of great numbers. At another time they become very abundant.

The removal of these pests has always been a very

difficult matter, and no entirely satisfactory method has been devised for accomplishing it. Several devices have been tried and abandoned. Two chief means of dealing with them have been employed. In one case everything lying on the bottom is removed by dredges. Ordinarily this is too expensive, unless oysters thus dredged are in need of culling. The second method is one recommended by the United States Fish Commission, and is universally employed; indeed, the oyster industry could hardly exist in New England without it.

Naturalists had for many years used a large mop made of frayed rope ends for entangling and raising spiny animals from the sea bottom. It was a modification of this that the Fish Commission naturalists recommended to the Connecticut oystermen. The starfish tangle, as shown in the accompanying illustration (Figure 39), consists of an iron or wooden bar from which depend several chains or wires. On the latter, mops of frayed rope or cotton waste are hung. The tangle is dragged over the bottom, the spines of the starfish catch on the mops, and the load is hoisted to the deck of the vessel and plunged into a tank of hot water.

The tangle does not sweep the bottom clean of starfish, but by its use their number is kept within bounds. There is no danger that the pest may ever get beyond control. There is great occasion for the southern planter to be thankful that he knows nothing of such an oyster foe.

There are several species of snails that are destructive to bivalves. Among these the large winkles or conchs of northern shores do very little damage; but some of the smaller forms, particularly the oyster drill, cause large losses here and there along the Atlantic coast.

The shell of the oyster drill, represented in Figure 40, has a length of an inch or somewhat more. When the fleshy parts of the body are extended one may observe the flat muscular "foot," and projecting forward above it, a proboscis-like extension of the head, on the end of which is the mouth. Just within the mouth opening, in a position corresponding to that of the tongue of higher animals, is developed a band of minute, hard, sharp teeth, which together constitute what is known as the lingual ribbon.

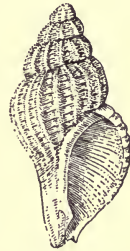


FIG. 40.—The oyster drill (*Urosalpinx cinirea*). Drawn from shell.

When at work on the shell of an oyster or clam, the foot may be seen to adhere firmly to it, while the mouth is everted sufficiently to expose the ribbon. This is pressed against the shell, and a slow, rotary movement is begun that finally results in the drilling of a clean, smooth hole directly through it. Some of the results of this work are shown in Figure 64. It is now only necessary for the drill to remove the soft parts of the victim's body by means of the proboscis or manubrium, which is thrust through the aperture.

The drill, or *Urosalpinx*, is most destructive to young oysters. It seems to be unable to bore through the shell of large individuals. While not nearly so destructive as the starfish, it does much damage, because it is continually at work, and is so small that it falls through the mesh of ordinary oyster dredges. In order to prevent this, dredges are sometimes covered with fine-meshed nets.

Like starfish, oyster drills were formerly not numerous on the New England oyster beds, but in recent years

have increased greatly. In New York Bay and in the Chesapeake, they are abundant. Many also are found in Pamlico Sound. In the Gulf of Mexico they are absent, but it is claimed by oystermen in Louisiana that a larger drill, *Purpura floridana*, is sometimes very destructive. There seems to be much doubt concerning the accuracy of this statement.

Another enemy of the oyster having a wide range, and often being destructive, is a member of a group of fishes

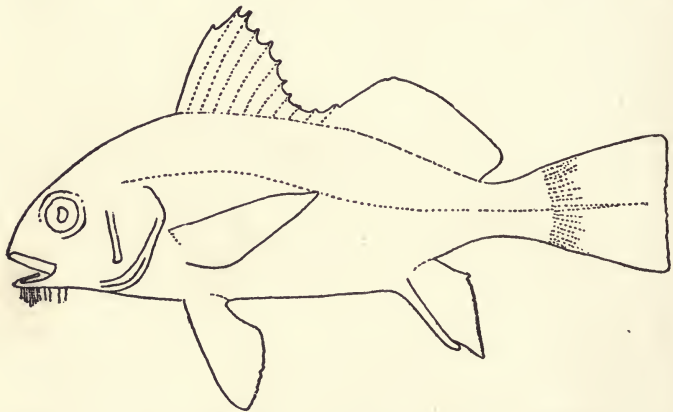


FIG. 41.—The Drumfish (*Pogonias chromis*). Outline of a figure in Dr. Jordan's "Fishes."

popularly known as croakers. This species, *Pogonias chromis* (Figure 41), is called the drumfish, from a deep, croaking noise that it makes while in the water, a noise probably connected with the large air bladder.

The drum is a food fish, though its flesh is coarse, and sometimes it attains a weight of nearly one hundred and fifty pounds. It is found all along the Atlantic coast, and is abundant in the Gulf of Mexico. It gives comparatively little trouble in New England waters, but farther south, especially in the Gulf, it is often very an-

noying. It is a bottom feeder, and by means of its powerful jaws is able to crush oysters of considerable size. The interesting statement is made by oystermen that the drum is unable seriously to injure clustered oysters on natural reefs because, in attacking a cluster, its mouth is soon lacerated by the sharp edges of the shells. It is only when oysters are culled and scattered singly on prepared bottoms that they become easy victims of this enemy.

Drumfishes are perhaps not more numerous in Louisiana waters than elsewhere in the Gulf, but because oyster culture has only been seriously attempted here, their depredations have been specially felt in this state. Their attacks are not constant, and it has been observed that there is greatest danger to the beds immediately after planting, and that if no attack is made during the first few days, there is little subsequent danger of it. It has been suggested in explanation of this fact that after oysters have sunk slightly into the mud and have been sprinkled over with sediment, they become inconspicuous enough to escape observation by the fish.

There seems to be but one means of protection against these fishes, and that is to build a stockade or fence about the beds that they cannot pass through. This is done in some parts of the Louisiana field.

Other fishes sometimes make trouble for the oyster farmer. In warmer waters, from the Chesapeake southward, a valuable food fish, the sheepshead, often feeds on young oysters, crushing them by means of its large, blunt, incisor-like teeth.

Rays and skates abound all along the coast. They are bottom feeders and their bodies are greatly flattened and spread out laterally. Several of these destroy oysters,

crushing them with strong jaws that are covered with short, hard teeth. The list of oyster enemies in this group of fishes includes the common skate; the sting ray, or "stingaree," as it is usually called on the shore, a form that bears a long, dagger-like spine on the base of the tail; and it is supposed, also, the "devil ray," an

enormous creature having a width of eighteen or twenty feet, and weighing, in some cases, as much as twelve hundred pounds. The latter, however, has been reported as an oyster enemy only from Port Eades, Louisiana, where it is known as the "stone cracker"—though there is probably not a stone large enough to crack within a hundred miles of Port Eades.

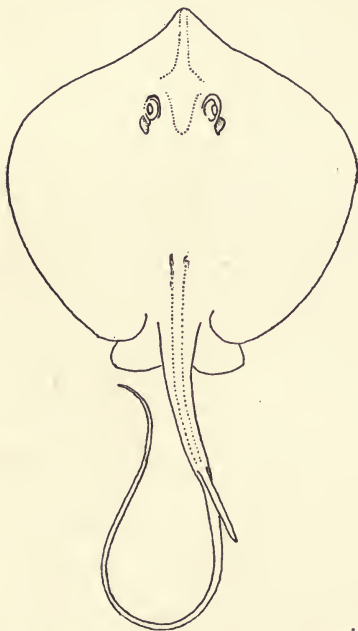


FIG. 42.—The sting-ray (*Dasyatis sabina*). Outline of a figure in Dr. Jordan's "Fishes."

Oystermen believe that crabs destroy young oysters, and this is probably true in some cases. The pinch of the claws of many crabs is powerful enough to break the shell

of small oysters. It is observed that they gather in crowds where oysters are being planted, apparently attracted by broken individuals. It is possible that they also attack the uninjured young, though accurate observations on this point seem to be wanting.

Mr. Ingersoll calls our attention to the fact that "Al-drovandus and others of the naturalists of the Middle Ages entertained a singular notion relative to the crab and the oyster. They state that the crab, in order to obtain the animal of the oyster, without danger to their own claws, watch their opportunity when the shell is open, to advance without noise, and cast a pebble between their shells, to prevent their closing, and then extract the animal in safety. 'What craft,' exclaims the credulous author, 'in animals that are destitute of reason and voice.'"

Every one who eats oysters has observed the small oyster crab that lives in the mantle chamber. Only the female is found within the oyster's shell, and the male has rarely been seen. This small creature is not an enemy, but simply a guest. It has been suggested that she consumes organic particles brought in by the water currents; but it may be that the masses of mucous secretion that collect in the mantle chamber constitute "the chief of her diet." This, however, is proposed without actual observation to support it.

Members of the mussel family—near allies of the oyster—while they do not prey on their cousins, often smother or starve them. They frequently become fearful pests to the oyster culturist, especially in southern waters. Their young, finding a suitable lodging-place on oyster shells, congregate on them in numbers, attaching by the many tough fibers spun by the byssus gland. They may become so numerous as completely to cover the oysters and prevent the opening of their shells, which, of course, means death. Even if this does not occur, they strain out of the water the same organisms that the oysters must have for food, and the latter fail

to grow. Figure 43 well illustrates this condition of affairs. At the right, appear the gaping shell edges of an unfortunate that has succumbed to the extreme neighborliness of mussels and barnacles. It may easily be imagined after one has by experience measured the force necessary to tear the muscles away from their attachment, what a great task of culling is before the oyster culturist whose beds have become infested with these bivalves.

The boring sponge is another animal that finds lodgment on the oyster shell, and injures its host indirectly. *Cliona sulphurea* is a sponge mass sometimes six inches in diameter at its base, attaching by strands of root-like tissue that excavate channels within the substance of the shell. While this is not done with the purpose of using any part of the oyster's body for food, the honey-combed shell may accidentally be perforated, making it necessary for the oyster to consume all of its energies in secreting new shell substance, or the shell may break, exposing the inner body, which leads to death. *Cliona* occurs frequently enough in northern waters, in the Chesapeake, in the Carolinas, and in the Gulf, to be recognized as a foe to the oysters.

In a similar manner the shell of the oyster is perforated and weakened by the boring clam (*Martesia cuneiformis*) in the Gulf of Mexico. This creature in infancy bores into the shell and excavates a chamber which is used as a dwelling place. A few of these animals infesting a shell make it as fragile as when bored by the sponge *Cliona*.

In brackish and salt water alike, there are almost everywhere certain sea-weeds that attach to objects in the water, such as stones or shells, and produce great



FIG. 43. Oyster cluster covered with mussels.



FIG. 44. The nature of the crowding in oyster clusters. Figures from Dr. H. F. Moore, Document, U. S. Bureau of Fisheries.



masses of vegetation. Sometimes oyster shells become covered by such weeds as the sea lettuce (*Ulva*), spreading out great sheets of tissue that are held flat on the bottom in tide currents.

These plants are not parasitic, but may interfere with oyster growth by preventing the access of food-bearing currents. When oysters so covered are dredged, it is necessary to strip the weed off, and in the Gulf, certain weeds with cylindrical fibers are brittle enough to break into small pieces, and these, getting into the "meats" during the shucking process, though harmless, make them quite unsalable. From this cause beds are sometimes temporarily abandoned.

In the brackish waters in which oysters thrive best, the shells rarely become covered with a growth of hydroids. These animals with their root-like bases, their branching bodies, and beautifully colored spreading zooids, greatly resemble gardens of miniature flowering plants; but they have no beauties for the oysterman. Feeding on minute swimming animals, and merely resting on the shells, they do not harm the oysters, but it is difficult to clean the shells of them, and both on "shell stock" and oysters for shucking they are a nuisance.

Like other animals, oysters seem to be subject to certain diseases, one of which, at any rate, is known. In the Chesapeake, and probably all waters to the south, there sometimes appears in the pulpy visceral mass, a swarm of small worm parasites. These seem not to be known to oystermen, who may, however, have noticed the very poor condition of certain individuals that are really diseased. It was left to a biologist to show that disease existed.

The presence of the parasite *Bucephalus* prevents the

formation of the oyster's sexual products, so that in the breeding season, its body appears thin and watery, and observations have shown that under adverse conditions, such as long-continued freshness of water, that is a severe test of vitality, the mortality on infected beds is much greater than elsewhere. This organism seems not to exist in northern waters, where ineffectual search has been made for it.

It is possible that future study may reveal other organisms causing disease in oysters, but extensive epidemics apparently do not occur among them. Any such parasitic forms, causing diseases in the oyster, would probably always be quite harmless if taken into the human digestive tract. The germs of typhoid, that may be carried by the oyster, of course do not harm it. Distantly related organisms do not have the same diseases.

The list here given is a fairly complete catalog of the oyster's enemies, and when it is considered that very few of them exist in the same region, it would seem that the oyster crop was nowhere menaced by destructive agencies more than is the farmer's wheat or corn. On the whole, it may be doubted if the menace is anywhere so great.

Yet any one who has a wide acquaintance with the human inhabitants of the shore, has known some who illustrate the fact that those who live on the bounty of nature without other effort than that needed to gather what she has prepared, are apt to be improvident and unsuccessful. A great many oystermen complain that their business is a poor one—and it is. But those who have gone to the sea with the energy requisite to success anywhere, and with the intelligence necessary to assist and direct nature, have found her, like wisdom itself, "easy to be intreated, full of mercy and good fruits."

In spite of enemies and bad seasons, many an energetic oysterman, beginning with small capital, has built up a comfortable fortune. There is a constantly growing demand for this form of food, and there are hundreds of miles of fertile bottoms, now barren, where, with comparatively little labor, it may be produced, and other fortunes will be made on them.

CHAPTER XI

BIVALVES IN RELATION TO DISEASE



RECENTLY great popular interest has been awakened in regard to shell-fish, and particularly oysters, as carriers of the micro-organisms that cause certain human diseases. The daily press, and especially popular magazines, have published numerous articles that might well have proved to be disquieting, on the dangerous conditions existing on oyster beds or in waters in which oysters are stored or freshened. On the other hand, some claiming to be competent authorities, have publicly stated with much positiveness that oysters cannot transmit diseases, and it may well puzzle the average reader to know where the truth lies. Because oysters are so highly prized, and are so generally consumed uncooked, the matter of the possible danger that may lie in them has excited a growing desire to know the facts.

Newspaper and magazine science should be received with caution and discrimination, but it now happens very much more frequently than formerly that popular scientific articles are prepared with due regard to matters of fact, and are sometimes presented by eminent authorities. Though much that has been written on the possibility of the contamination of oysters and clams may have had the appearance of exaggeration, the truth has usually been stated. One human disease at least, greatly

feared on account of its insidious and dangerous nature, is without doubt sometimes communicated to man by oysters, and certainly may frequently be so transmitted both by this form and by other shell-fish that are eaten uncooked.

Typhoid fever, known and dreaded nearly everywhere, is caused by a rod-like bacterium or bacillus that enters the body through the digestive tract. Several sources of infection are very well understood. The most common is drinking water, and many epidemics of the disease have been traced to it in ways that do not admit of doubt. Milk, also, is often the medium by which it is introduced, but here the real sources have been proved to be the person handling the receptacles for it or, more often, the water in which cans or bottles have been washed. The recent epidemics of army camps also have shown that the organisms may be introduced into the digestive tract on solid food. In such cases flies that have gathered infected material on their appendages alight on food ready to be eaten, and leave some of it there. It is probable that the bacillus of typhoid passes through the digestive tract of the fly without being injured, and if allowed to do so, the fly deposits its digestive tract discharges on food. Within a considerable distance of a typhoid fever patient—or convalescent for that matter—these creatures, formerly regarded merely as pests, become deadly enemies. It may also be stated as a fact that epidemics are sometimes caused by eating uncooked oysters. Several times they have been traced directly to that source. The evidence collected on that point in this country and abroad is conclusive, and a biological study of the habits of this and other bivalves clearly indicates the way in which the transmission is accomplished.

It is just as certain that clams and mussels taken from polluted waters may as readily bear the organisms of typhoid, but except the "little neck," these are not so often eaten uncooked, and for this reason the fever is not so frequently contracted through their agency.

One of the important facts concerning the disease is that vast numbers of typhoid bacilli leave the body of the patient in the digestive tract discharges and in the urine, and more important still, that a convalescent from the disease is as dangerous to others as a patient, if not more so, for the organisms continue to appear in the discharges from his body for many months after recovery. With this knowledge of the nature of the disease, and the organism causing it, its extermination seemed possible, and the statement was made and often repeated that for every new case of typhoid there should be a hanging. But recently discovered facts indicate that certain persons at least, after having suffered from the disease, may continue for many years, and perhaps for life, to pass typhoid bacilli from the body, and that this may be true even when the disease occurred in so light or obscure a form that its true nature was not recognized.

While there is much criminal carelessness in the matter, especially where there is a convenient sewage system, the discharges from the bodies of patients are sometimes disinfected before being disposed of, as of course they always should be, but this is probably never true of convalescents, and typhoid carriers are a constant menace wherever they may go. The result is that the sewage from almost any city constantly contains some of these organisms which remain alive in it for a long time. Even when sewage is treated in disposal plants, organ-

isms from the human body may sometimes be found in the water that runs away from them to our rivers and harbors and bays, in very many of which, along the coast, are oyster and clam beds. It is altogether probable that other intestinal diseases may also be disseminated by shell-fish taken from polluted waters, but not so much is known of this as of typhoid fever.

It is explained in the chapter on the feeding habits of shell-fish that large quantities of water are constantly being drawn within the shell and into the interior of the basket-like gills. Even the minutest of solid particles borne by this stream are stopped on the outer surfaces of these organs and caused to adhere in masses by the presence of a sticky mucus. The organisms of diseases, though very minute, are not small enough to escape. Several gallons of water every day pass through the gills of every full grown oyster or clam, and every solid-particle is removed from it and remains in the body.

This collected material is then passed on to the mouth, and once in the digestive tract of the bivalve, the organisms dangerous to man probably are eventually killed by the digestive fluids. But because the collecting process never ceases, at least when the creatures are continually submerged as are oysters and little necks, they may be present on the gill surfaces at all times. The shell surfaces also afford lodging places for them, and to handle them is not safe. The organisms probably are not at all injured by the gill secretions, and, carried into the human digestive tract when a raw oyster or little neck is eaten, will multiply and cause the disease. It is thus plain that even if relatively few in the water, the chances are that a dangerous number of disease organisms will be strained out of it by these shell-fish.

It may not be pleasant to contemplate these facts, but that there is here a real menace to health is not any longer to be questioned, and the more generally it is understood the better. Between twenty-five and thirty millions of bushels of oysters alone are annually sent to market from our shore beds, and it may seem strange that, under the conditions, any considerable number of the inhabitants of this country escape some terrible disease contracted from eating shell-fish. While typhoid fever, often very difficult to diagnose, is more prevalent than is generally realized, there is no necessity for alarm but only for caution in this case. The reason that there is not more danger from bivalves is that, while they are wonderfully efficient mechanisms for straining dangerous organisms out of the water, such organisms probably do not accumulate in living masses by multiplication in their bodies, but are perhaps soon destroyed by the digestive fluids. Only those that happen to be on the gills or other surfaces of the body at the time of marketing are dangerous. Again, long neck clams, quahaugs, scallops, and even oysters, are usually cooked before being eaten, and any dangerous organisms that they may bear are thus killed. A healthy human body, also, is able to withstand many an invasion of them without danger if they are not too numerous.

But caution certainly is necessary, and it is well to know something of the source of this food when possible. There is slight danger from little necks or other clams not taken in the mouths of harbors or rivers bearing sewage. The same is undoubtedly true of oysters taken from the majority of beds along our coast. But the trouble lies in the fact that before food mollusks are marketed they are almost invariably placed for a few

hours in fresh water to undergo what the oystermen term the drinking process. Oysters sold in the shell as well as those that have been shucked are usually subjected to the fresh water treatment. To make delays and the cost of transportation as slight as possible, the localities selected for this are almost without exception in harbors or river mouths near large markets. In very many cases such waters bear the sewage of cities of hundreds of thousands of inhabitants.

It should be recognized that this source of danger to the public health could easily be removed. A strong popular sentiment against the process of freshening oysters might lead to its voluntary discontinuance by dealers, or to legislative prohibition, and the enforcement of laws against the practice would largely do away with the danger. The end might perhaps be attained if intelligent health officers were empowered to forbid the sale of such as are taken from, or stored in, contaminated waters. The State Board of Health of Massachusetts is the first to prevent the sale of shell-fish from certain dangerous bottoms.

It is a curious fact that many persons who may be willing to accept the truth of statements on the nature of infectious diseases and their transmission, yet regard the dissemination of such knowledge almost with resentment, apparently because it is disturbing to peace of mind, and may have a tendency to interfere with careless habits. Who has not heard remarks of this nature:—"Our fathers lived in comparative safety, but science has surrounded us with deadly germs. We are afraid of the crystal water from the old oaken bucket, and drink what comes through the mains with protesting fears. We are worried because we do not know the source of

our lettuce and celery. Flies and mosquitoes that we cannot escape have become more deadly than serpents. We cannot keep the dust from our houses, and are assured that germs lurk in it. The church, the theater, the cars are germ-laden, and we are not able to draw a comfortable breath. Away with such nonsense! We must live, and the germ theorists are trying to make existence impossible."

But there is little advantage in trying to hide from the fact that recognized dangers to health and life are more numerous than they were in former times. The cheerful thing about it is that such knowledge has revealed so many avenues of escape from them that were before unknown. Some dangers of course remain to be faced, but fear of them is ordinarily unwarrantable, and familiarity with them should not breed fear any more than contempt, but only caution which, when it is habitually practised, ceases even to make one uncomfortable. It might be supposed that even a dissection of the body of an oyster would result in a loss of appetite for it as an article of food, but expert testimony may easily be had to the effect that this is not true; and knowledge of the fact that some oysters carry typhoid bacilli does not alter the flavor of unfreshened salt water individuals that one is reasonably certain have come to his table directly from deep waters far from shore.

While every one must take some risks in eating and drinking, there is little excuse for foolhardiness, and precaution usually costs little. So far as oysters are concerned, the reasonable person will even be willing to do what he can to assure himself of the source from which they come, and will require a statement from the packer who supplies his retail dealer concerning the position of

his oyster beds and the directness with which oysters are transferred from them to the shipping containers. If this is not possible, he will not eat his oysters uncooked. He will also examine the containers employed by his retail dealer, and ask to see those in which the oysters were shipped, especially when they are shucked. One fact concerning oysters that are to be eaten uncooked cannot be too strongly expressed. It is that, as the preparation of oysters for market is now usually carried on, it is never safe to eat those that have been freshened or bloated. Those coming directly from salt water beds far removed from shore are likely to be safe if ordinary care has been taken in washing and icing them. Some dealers are already beginning to take great precautions against the possible infection of the oysters that they handle, and a little discrimination on the part of the consumer would soon add to their number. The matter of safety rests largely with him.

CHAPTER XII

THE NORTHERN OYSTER FIELD— HISTORICAL



FOR the sake of convenience, the oyster coast may arbitrarily be divided into several fields. What may be called the northern field includes the shores of New England, New York, and New Jersey. The second includes the Chesapeake, the third the Carolina and south Atlantic shores, the fourth the Gulf of Mexico, and the fifth the Pacific coast. A brief account of the history of the industry and natural conditions peculiar to each of these fields will be given.

Cape Cod is an interesting part of our Atlantic coast to the biologist, because it tends to separate two faunas and floras. The warm gulf stream, turning northward through Florida Strait, follows the shore closely until it reaches this cape, and is then deflected away from the shore. From the north, the cold arctic current descends along the coasts of Labrador and Newfoundland, a portion of it continuing southward closely hugging the Nova Scotia and Maine coasts, and finally ending in Massachusetts Bay on the north side of Cape Cod. Because of the resulting differences in temperature, many marine animals and plants are found on one side of the cape, that are not able to exist on the other. There are, how-

ever, many forms that inhabit the cold and warm waters alike, and among them are the oyster and the soft clam.

At the present time the "wild" oyster is practically extinct north of the cape, a circumstance that might lead one to believe that these icy northern waters are not congenial to it, and there is much foundation for such a belief. Its growth and reproduction are much more rapid in warmer waters, but are not impossible in some of the sheltered bays even of Maine. A quarter of a century ago a few scattered oysters, the descendants of native ancestors, were known to exist a few miles up from the mouth of the Piscataqua River in New Hampshire, and it is possible that some of them still remain. It is also true that the oyster has existed and may be found even to-day farther north than the extent of our coast. In the Gulf of St. Lawrence lies Prince Edward Island, and between it and the shore to the south is the shallow Northumberland Strait. At the mouths of many of the small rivers entering this, both on the mainland and on the island, are oyster beds of considerable size.

This fact alone would suggest that at one time natural oyster beds connected this isolated northern region with those south of Massachusetts Bay, and many interesting facts, especially those collected by Mr. Ernest Ingersoll, substantiate that theory. It is perfectly certain that for a long time before the first Europeans visited this continent, oysters flourished at a few points on the north New England coast, and that they were still abundant at the time of the arrival of the early colonists.

Our knowledge of the matter comes largely from numerous mounds of oyster shells that dot the shore. Such ancient collections, found in many parts of the

world, and especially on sea shores, have always excited great interest, and have told many tales of ancient peoples, as well as of the inhabitants of the sea.

The Danish Kjökkenmöddings, or "heaps of kitchen refuse," among the first to be studied, were formerly supposed to have been accumulated by wave action, and some have suggested that our own "kitchen middens" were also merely beach deposits thrown up in great storms or by the action of ice. But the critical eye would at once see that in the majority of cases their form and position alone preclude the possibility of such an origin, and examination has revealed among the shells and rubbish not only the bones of many beasts and birds, but also stone implements, pottery, and even the charred remains of ancient fires.

Such shell heaps are found all along the Pacific coast, from the Gulf of St. Lawrence to the Florida keys on the Atlantic, and nearly everywhere on the Gulf of Mexico. Many of them are of immense size. In Florida, there are vast repositories, the accumulations of ages. On the Chesapeake, single heaps often cover many acres, in some places to a depth of twenty feet. In the northern oyster field, there is a great kitchen midden at the mouth of the Damariscotta River in Maine, the contents of which are estimated at eight million cubic feet. It, like other shell heaps, contains many relics of the native peoples who formed it, and without doubt marks the gathering-place of Indian tribes, many of which probably came from a distance to attend great feasts.

So numerous are these shell collections along the Maine coast that even the summer visitor, cruising in his

small boat among its rocky islands, that rise straight up from the water, or in its innumerable bays, with their steep, wooded shores, may easily discover them for himself, if he will explore the backs of the little beaches that he comes upon here and there. The same is true of the coast of Nova Scotia. The shells that he finds, often covered by a growth of large trees above them on the bank, are usually those of the soft clam; but there are also many heaps all along the coast made almost entirely of oyster shells. The immense pile on the Damariscotta, for example, is composed largely of them. This proves that the oyster is indigenous to these cold northern waters. The shells are not those of a northern or of an extinct species, but of our modern American oyster.

In addition to the evidence afforded by shell heaps, the records of the early colonists contain many references to extensive oyster beds on this northern shore that they found on their arrival, and from which, for many years, they obtained food. Ingersoll says that there is abundant evidence that, at the time of the coming of Europeans, oysters were flourishing in the Bay of Fundy, at Mt. Desert Island, at the mouths of Georges, Damariscotta, and Sheepscott rivers, in Maine; in Portsmouth Harbor and the Great Bay of Durham River, in New Hampshire; in the Parker, Rowley, Ipswich, Charles, and Mystic rivers, and at Weymouth, Barnstable, and Wellfleet, in Massachusetts.

That oysters in a natural state do not now exist north of Cape Cod as formerly, is due to two chief causes. Their numbers were greatly reduced by excessive tonging, and silt, washed from cultivated fields, was deposited at the river mouths, thus making it impossible

for the oyster young to exist as in the earlier time, when the waters were clear.

The early settlers also found oysters in great abundance all along the shore southward from Cape Cod. Natural beds were present in many parts of Buzzards and Narragansett bays, and almost everywhere on the Connecticut coast. Just across the sound on the western half of the Long Island shore, they were equally numerous. The bays on the sea side of Long Island also contained many oysters. All about Manhattan Island they were very abundant, occurring on both sides of East River and the Hudson, extending up the latter as far as Ossining. The waters about Staten Island bore a rich harvest. In New Jersey, Barnegat Bay, the long, river-like body of water that parallels the shore line, afforded suitable conditions for oyster growth, as did the much larger Delaware Bay, south of it.

The early colonists on the northern shore established themselves near the coast. It was natural that they should for some time depend largely on the sea for their food. Agriculture on a scale proportionate to their needs had to be developed in the face of great difficulties. On the other hand, the waters contained fishes in incredible numbers, beaches and flats were crowded with clams, and almost every shallow bay and river mouth supported extensive oyster colonies. These could be obtained at all times of the year. Even in New England, with its terrible winters, clams were dug from the beaches, and oysters were sometimes taken through the ice.

But finally oysters became so scarce in Massachusetts Bay that before the end of the seventeenth century laws were passed taxing those exported, and prohibiting

oyster tonging by outsiders. These measures, however, were insufficient, and natural oyster beds soon disappeared entirely. They persisted longest at Wellfleet, near the end of the cape, but their destruction came, even here, from excessive fishing about the year 1775.

The natural oyster growth on the shores of Connecticut, Long Island, and Manhattan Island, was so extensive that it was long before there was any anxiety about its depletion. From the time the country was first settled, however, there was a steady decline, and early in the nineteenth century it began to attract attention.

Meanwhile it had been observed that any hard, smooth body thrown into the water near oyster beds in the early summer became covered with young oysters. The possibilities of human control over natural processes wrapped up in such a simple phenomenon, would escape the attention of the great majority of men. To see the possibilities there presented, required imagination—and imagination under intellectual control, such as has advanced science at all times. And a few East River oystermen proved themselves to be real scientists, when, on this simple natural phenomenon, they built up a method of artificial oyster culture that brought material well-being not only to themselves, but to a great number of their countrymen as well. It should not be forgotten, as has been pointed out by Professor Brooks, that before the people of France, England, Belgium, or Germany discovered a method of controlling and vastly improving the natural production by the sea of a great source of human food, these men had found it, and had put it into practice.

In the year 1855 a few East River oystermen began to spread clean shells on some of the unproductive bottoms near City Island. This was done under the protection of a very wise law, passed in the same year, that gave them the right to occupy and control certain definite tracts on the river bottom. Multitudes of young oysters settled on these shells, and were transplanted and cared for until they had become large enough to be marketed. In this way there arose a method of controlling the natural production of the water that is similar to that practised on the land.

We cannot depend on a natural, undomesticated growth of land plants or animals for food. In nature one generation usually gives rise only to an equal number of descendants that reach maturity. But grains and fruits placed on waste places, in soil that has been prepared for them, are made to reproduce many fold, and swine, sheep, and cattle that, under natural conditions, could not long maintain numbers great enough to be of use to man, with protection from him, appear on a thousand hills. And American oyster culture, though simple, affords the essential element of protection from destructive natural agencies that has covered desert places with plenty. Compared with the achievements of agriculture those of the early sea farmers seem simple; but it should not escape attention that it had always been the common belief that the organisms of the sea were untameable. It required bold thinking, unfettered by the prejudice of generations, to conceive of the possibility of adding such a realm to man's dominion.

Connecticut and other northern states with waters suitable for oyster growth, followed New York in enacting laws fostering the new industry. By their protection

there was built up an artificial source of supply while that of nature was being destroyed. It must not be supposed, however, that this was accomplished without a struggle. Everywhere there was strenuous opposition to the sale or lease of bottoms, particularly from those whose living depended on the gathering of oysters from natural beds, and the lawmakers very wisely decided that the industry was possible only under private ownership, as in the case of agriculture.

But some of the colonial charters had reserved all beaches below high tide line for the State. There were no private beach rights or rights to shore bottoms under water. Probably no one desired rights to such bottoms until oyster culture was developed. By that time the idea had been fixed by tradition that the sea was and should be the common possession of all. So objection was made not only to the sale or lease of bottoms bearing oyster beds, but also barren bottoms on which oysters had never been known to grow. Oyster culture has had to contend against this principle at all points along the entire coast. This state of mind is typically set forth by Mr. Ingersoll, who describes the efforts of a New Brunswick fisheries inspector to convert the natives to the idea of oyster culture, which of course involved the lease of bottoms. They had destroyed the natural beds by excessive raking, but would not hear to a lease. The only argument that he elicited was "My grandfadder rake oysters, my fadder he rake oysters when he want 'em, and by Gar! I rake him too."

One of the great objections to sale or lease was that monopolies would thereby be fostered. This objection to the lease has been used in every state possessing oyster bottoms. As a result, the earlier laws allowed the lease

only of a small plot to a single person. Connecticut, for example, allowed but two acres. Ordinarily these were quite insufficient for the support of a family, but it was not difficult to evade this provision when a man was allowed also to develop the adjacent acres leased by "his sisters, his cousins, and his aunts." In this way a single person often came to control a large area.

It was soon found that such monopolistic holdings not only worked no injury, but were of great benefit to every one in the neighborhood including those who worked only on the public beds, who found the rapidly extending markets and high prices obtained by the large holder much to their liking. More liberal laws in this state finally allowed the unlimited lease or sale of barren bottoms. This has proved to be the wisest possible provision.

One interesting provision of the earlier oyster laws that has, in some states, been preserved in those now in operation, is the close season. Where this is in force, oysters may not be dredged or marketed during the summer months. Southern states particularly should note that experience in the northern field has proved the futility of the close season as a protection to the natural beds, and should recognize the injustice of allowing a culturist to market a commodity, produced on his own property, only during a limited season. It is an unjust and purposeless restriction.

The entire futility of a close season as a provision to preserve natural beds, is well illustrated by the destruction in early days of natural beds near New Haven, Conn. This has been graphically described by Mr. Ingersoll as follows:—

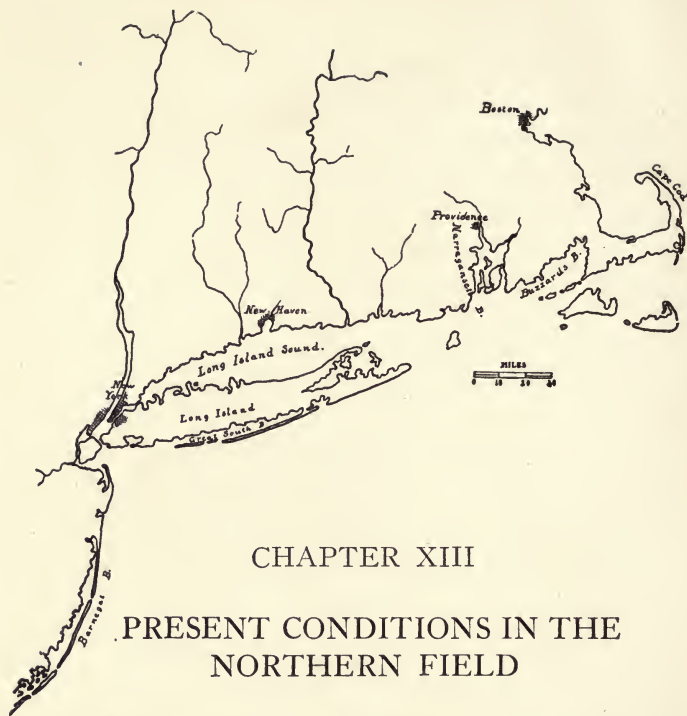
"The fishing was done mainly for each man's winter

supply, and nobody paid much attention to any regulation of it beyond the close-time in summer. Gradually, however, these public river oysters became more rare and coveted. The law was 'off' on the first day of November, and all the natural beds of the state became open to any person who wished to work them. In anticipation of the date, great preparations were made in the towns along the shore, and even for twenty miles back from the sea side. Boats and rakes and baskets and bags were put in order. The day before, large numbers of wagons came toward the shore from the back country, bringing hundreds of men with their utensils. Among these were not unfrequently seen boats, borne in the rigging of a hay cart, ready to be launched on the expected morning. It was a time of great excitement, and nowhere greater than along the Quinepiac. On the day preceding, farmers flocked into Fair Haven from all the surrounding country and brought with them boats and canoes, of antique pattern and ruinous aspect. These rustics always met with a riotous welcome from the town boys, who hated rural competition. They were very likely to find their boats, if not carefully watched, stolen and hidden before they had a chance to launch them, or even temporarily disabled. These things diversified the day and enlivened a community usually very peaceful if not dull. As midnight approached, men dressed in oilskin and carrying oars, paddles, rakes, and tongs collected all along the shore, where a crowd of women and children assembled to see the fun. Every sort of craft was prepared for action, and they lined the whole margin of the river and harbor on each side in thick array. As the 'witching hour' drew near, the men took their seats with much hilarity and nerved their arms for a few moments' vigorous

work. No eye could see the face of the great church clock on the hill, but lanterns glimmered on a hundred watch-dials and then were set down, as only a coveted minute remained. There was a hush in the merriment along the shore, an instant's calm, and then the great bell struck a deep-toned peal. It was like an electric shock. Backs bent to oars and paddles churned the water. From opposite banks, waves of boats leaped out and advanced toward one another in the darkness, as though bent on mutual annihilation. 'The race was to the swift and every stroke was the mightiest.' Before the twelve blows upon the loud bell had ceased their reverberations, the oyster beds had been reached, tongs were scraping the long-rested bottom, and the season's campaign upon the Quinepiac had begun. In a few hours, the crowd upon some beds would be such that the boats were pressing close together. They were all compelled to move along as one, for none could resist the pressure of the multitude. The more thickly covered beds were quickly cleaned of their bivalves. The boats were full, the wagons were full, and many had secured what they called their 'winter's stock' before the day was done, and thousands of bushels of oysters were packed away under blankets of sea-weed, in scores of cellars. The first day was the great day. By the next day the rustic crowd had departed, but the oysters continued to be sought. A week of this sort of attack, however, usually sufficed to clean the bottom so thoroughly that subsequent raking was of small account."

To-day natural sources of supply in the northern field amount to little except for seed that they produce. The same has long been true in Europe. There are still enormous natural oyster reefs in the south Atlantic and Gulf

fields, but they cannot last. Where there is such great abundance, it seems to be difficult to believe that it is not inexhaustible. Though it must disappear, its place will undoubtedly be taken before that event by a better and much larger supply such as now exists in the North.



CHAPTER XIII

PRESENT CONDITIONS IN THE NORTHERN FIELD



If one were to sit before a large map of the United States and, compass in hand, compare the extent of other parts of the Atlantic and Gulf shore line with that extending from Delaware Bay to Narragansett Bay, which comprises what may be called the northern oyster field, he would discover, if he were not already acquainted with the fact, that in extent the latter is relatively a very short stretch of coast. To be sure, this is merely a matter of miles, but it must be admitted, after measuring the irregular shore lines of inland waters connected with the sea, that there are many of them between the Delaware and the Mexican boundary.

But a very large part of this is actually or potentially a part of our oyster territory. Here is a wonderful succession of bays, estuaries, sounds and lagoons, vast nurseries in which multitudes of marine animals and plants flourish; where conditions for shell-fish growth in particular are unrivaled, and of these the oyster is most widely distributed and naturally most abundant.

Our attention is often called in a deprecating manner to the enthusiastic admiration of many Americans for the big things possessed by their own country. Even if this state of mind might be regarded as a national characteristic, it would be possible to suggest more grievous and less patriotic sentiments held by some of those who number themselves among the judicious. Perhaps something may be said for pride in the great achievements and great resources of one's own land even when its expression involves comparisons.

Possibly it would do no harm to make the statement for the benefit of such enthusiastic Americans, that nowhere do oysters grow so rapidly, nowhere are they so abundant, nowhere may they be so easily cultivated, and nowhere is the oyster area of such vast extent, as on our Atlantic and Gulf shores. In truth here is very much the largest thing of its kind in the world.

They may also know, if they choose to pursue the matter, that there are to-day immense oyster covered areas in the South that lie undisturbed, that natural beds in the Chesapeake have been tonged and dredged for nearly three centuries without becoming entirely exhausted; that in northern waters cultivated areas have taken the place of natural beds, and are producing more and finer oysters than before; and that much larger tracts, on which oysters formerly never grew, are yielding a har-

vest equally abundant and valuable. As a home for mollusks useful as human food, no other shore is comparable to this.

Even in size, the eastern American oyster has a great advantage over its European cousin. Some, having become familiar with the diminutive oyster obtained abroad, may question the superiority of mere size in our native product. There is much, it may be said, in daintiness and delicacy. Hence the popularity of Blue Points and other baby oysters that formerly found no favor in American markets. On account of their very small, thin, rounded shells, these are in great demand. But it is a safe statement that the average American who has experienced the Blue Point flavor in New York, could not sit down in Norfolk to half a dozen large, fat, adult Lynnhavens, which afford not only the finest flavor, but also something to eat, without declaring the superiority of the latter. However the matter of superiority as an article of food may be decided, the fact remains that the American oyster, north or south, will become as large as the Lynnhaven if allowed to grow under favorable conditions, while a large native oyster in European waters is an impossibility.

The flat and the Portuguese oysters of Europe have a shell but two or three inches long and are very thin. The eastern American oyster, on the other hand, sometimes attains a length of a foot or more. "There be great ones," wrote William Wood of Massachusetts in 1634, "in form of a shoe-horne; some be a foot long." A shell fifteen inches long was taken from the Damariscotta shell heap in Maine. Oysters six or seven inches long and more than four inches wide are sometimes found in our markets.

Oysters from some localities are thin shelled, as in the eastern end of the Great South Bay, the home of the Blue Point. Usually the shell is thick and heavy. Its thickness depends on the amount of lime in solution in the water. In the Carolina sounds and southward, as also in the Gulf of Mexico, natural oysters are characterized by relatively small and much elongated shells. But without question, all of these variations in appearance are due simply to local differences in environment, and there is a single species, *Ostrea virginica*, on the Atlantic and Gulf coasts. In this form the sexes are separate. It is sometimes stated that an individual may change its sex, being male one year and female another, but there is no foundation for such a statement.

One important element in the development of the modern industry in the North was the aid received from the Chesapeake. The planting of small oysters never began anywhere until the natural beds had been practically destroyed. The demand for small seed oysters then outgrew the supply.

As early as 1825, a few small seed oysters from Chesapeake Bay were transferred to waters near Staten Island. At about the same time the town of Wellfleet on Cape Cod had sent to Buzzards Bay and then to Connecticut for seed oysters. Finally it began to receive them from Virginia, and during the decade following 1850, from one hundred to one hundred and fifty thousand bushels were transported each year from the Chesapeake to beds near this town. The Civil War made it impossible to obtain much seed, and Wellfleet did not subsequently recover its position as an oyster center.

During these same years just preceding the war, Narragansett Bay, Long Island Sound, New York Bay, and

Delaware Bay each had come to depend on the Chesapeake for its seed. Each year half a million bushels were used in Narragansett Bay, and an equal number at New Haven, while nearly a million bushels were transferred to the west or Delaware side of Delaware Bay. Even after the war this great business continued.

But in the course of time, the Connecticut oystermen perfected the methods of capturing young oysters in their own waters. By the year 1880 the transportation of southern seed to the northern field had fallen off greatly. Ever since, there has been a steady decline, and to-day very little Chesapeake seed is planted north of Delaware Bay. On the other hand, the Connecticut culturists now are able not only to supply the entire northern field, but are sending an increasingly large quantity of seed to the Pacific coast as well as to Europe.

Instead of suffering from the loss of this business, the Virginia shore of the Chesapeake, from which the greater part of the supply had come, really gained by it. Soon after the war, planting began in that state, and at present the supply of seed from the natural beds of the lower Chesapeake is barely sufficient for the needs of those there engaged in the industry.

It is seldom possible for a legislative body deliberately to plan the organization and future development of an industry, and to formulate laws establishing the plan, before the industry exists. Such a feat was accomplished with every prospect of success, by the legislature of Louisiana, when it formulated its present oyster laws. The result will be to avoid years of wasteful experiment and controversy and to add rapidly and permanently to the wealth of the state.

But this was only possible because other states had

slowly and painfully solved the problems involved in modern oyster culture. It was necessary for New York and Connecticut to legislate and repeal and legislate again until their present wise and effective laws governing the oyster industry had been developed. This, of necessity, was a matter of slow growth. Unforeseen obstacles continually arose. Interests clashed, and many difficulties had to be adjusted by the courts. New questions arose with the development of the industry, and a wise general policy of legislation came only after a long course of demonstration and education. Not all that is desirable has yet been gained, but a great and valuable source of wealth has been established.

The interest of the outsider still centers about the state of Connecticut. From the beginning it has been the leader in accomplishment on the oyster field and in legislation. Neighboring states, and then those more distant, have followed its example. It has been necessary for them to do so in order to keep in the field. It may be observed that in Connecticut it has really been the individual culturist and not the state that has led in the wonderful development of the oyster industry. The culturist has demonstrated his needs and the state has wisely supplied them by legislation. On the other hand in Louisiana and more recently in Maryland, the state itself has become the leader; and this also is undoubtedly wise, for neither state contemplates ownership of the industry. The plan is simply to insure the success of private interests that may engage in it, and this, under the laws that have been formulated, seems to be assured.

It may be interesting to contrast the old with the newer plan of state control over the oyster industry in Connecticut. There is still much to be learned, by states that

have not had the experience, from a history of the progress that has been made in oyster legislation.

Previous to the year 1880, a system of local control over Connecticut waters was in operation. The state relegated to the towns the disposal, under certain limitations, of shore privileges on their boundaries. The selectmen, or an oyster committee in each town, were given the power to "designate" suitable places in the waters of the town for the planting or cultivation of oysters, clams, or mussels. But the holding of each person was not to exceed two acres.

The plan was an utter failure from many causes. In the first place, no protection was afforded the culturist. Without it oyster culture is impossible. Planted oysters were stolen with perfect impunity because there were no laws punishing the act, which was everywhere regarded as a joke. The towns appointed no officers to protect leased bottoms.

In the majority of cases the holdings were not even mapped, and titles to the land were very insecure. There were no hydrographic surveys. When boundary stakes were lost in storms or removed by ice, contentions among adjacent owners were inevitable, and no legal decisions of such quarrels were to be had. Non-residents were not permitted to lease bottoms. Quarrels over town boundaries arose, and the rulings of one town committee were different from those of another. If, in spite of all these difficulties, one were willing to risk capital in an attempt at oyster culture, he was able to do nothing on two acres of bottom. The result was open and wholesale fraud in gaining control of other holdings than his own. Concerted action by culturists, necessary to establish and maintain a large market, or to protect the oyster terri-

tory from starfish and thieves, was impossible under the conditions imposed. Inadequate and absurd as this plan of local control now appears to have been, it was adopted by the majority of the states possessing oyster shores; and even to-day the same ancient and farcical laws prevent the establishment of a soft clam industry in New England.

Since 1880 there has been a gradual change of plan in Connecticut, New York, and in other states, but the old method has not yet been entirely abandoned. Waters in the immediate vicinity of towns, on the shores of some states, are left in their care, though the powers of selectmen and oyster committees are limited in such a way that local regulations must conform closely to the general plan governing all waters of the state. On application from the town, the Superior Court may appoint a committee that shall locate natural beds, and the town may then grant perpetual franchises in barren bottoms to be used as oyster beds. A town is not allowed to grant oyster bottoms to its own residents alone. This feature of the system of control is cumbersome and unnecessary, and should be abandoned. But the state now maintains control of the greater part of the oyster territory within its boundaries. While it has reserved six thousand acres of natural beds, the remainder of the bottom is held for sale.

The real beginning of the present prosperity of the industry was inaugurated by an elaborate survey of the waters of the sound, based on the triangulations of the United States Coast Survey. Large maps, clearly defining all holdings, are published from time to time by a state Oyster Commission, and are available to any one desiring them.

That such a survey is a necessity does not yet seem to be realized by some of the southern states. Without it an incontestible title is impossible, and in Connecticut it has put an end to a most fertile source of discontent and strife that arises everywhere when the sale or lease of bottoms is in question. There has been in every state a strong demand that the natural beds be reserved as public property. But what is a natural bed? The answer is clear when natural oysters lie thickly massed, but there are few such tracts. Such areas, once existing, have been tonged and dredged until oysters are few and scattered. Are they still natural beds?

The definition of a Maryland judge has been accepted everywhere on the coast. According to this, a natural bed is a bottom on which oysters propagating by nature are numerous enough to afford a living wage to the oysterman. This is arbitrary and indefinite, but it cannot be bettered. Its acceptance does not settle specific cases, for it does not and cannot determine what constitutes a living wage. The public is determined to retain its "rights" to natural beds, and culturists desire to buy or lease the bottoms. Who shall decide between them?

In this matter the legislature of Connecticut did a very wise thing. It provided its Oyster Commission with a survey of the bottoms, and gave it power to decide, after a careful examination, what bottoms contained natural oysters sufficient for a daily wage, and what did not. This they did fairly, but of necessity, quite arbitrarily, defining and charting the outlines of all the natural beds in the state. They then proceeded to sell and lease the remainder. When their boundaries were contested, the State Supreme Court upheld them. That was the end of the matter.

Other states have followed the example of Connecticut in this. Even Maryland has recently had the courage to do so, and if the decisions of its Oyster Commissioners in establishing boundary lines are upheld by the state courts, much future trouble will be avoided.

The amount of land that may be owned or leased by an individual or corporation in the state is now not limited by law. The ancient fear of an oyster monopoly seems to have disappeared. Titles to oyster grounds may be transferred. If grounds are found by experiment to be unsuitable for oyster culture, they may be released to the state. Speculating with oyster grounds is made illegal, and such a practice is difficult, for grounds not occupied in good faith for the planting or cultivation of oysters, may revert to the state at the end of five years.

A perpetual franchise for the cultivation of oysters on barren ground may be had from the state at one dollar an acre. It has not been the plan in Connecticut to receive a large revenue from the sale of land, but rather to vest the great wealth of the industry with the citizens. In this way taxable property on shore is greatly increased, and a small tax also is levied on the oyster beds. In order to determine the amount of this tax, owners must make an annual statement of the value of their property, and the Oyster Commissioners declare a tax of one and a half per cent. on the valuation given. Some revenue also is derived from licenses granted to boats which, with thirty-pound dredges and tongs, are allowed to take oysters from the natural beds. This direct revenue, however, amounts to comparatively little. The accepted view of the situation seems to be that a five million dollar business in the state is a better investment

than a smaller one that would pay a larger direct tax for its existence. Rhode Island and some other states have adopted the latter plan.

The market value of Connecticut oyster beds varies as real estate values do everywhere. The valuation probably ranges from one to forty dollars an acre, and in a few cases is much greater.

One of the most important features of the Connecticut law is the provision it makes for the protection of owners of private beds. A number of state police are employed to protect private grounds, and are given the power of sheriffs in making arrests and seizures.

The law also provides that sheriffs and constables, as well as oyster police, shall, and that any other person may, seize any boat or vessel illegally used in dredging, wherever found after the offense has been committed, within one year. If now such property is proved to have been used contrary to law, it is sold, and half the proceeds is paid to the person making the seizure.

If every other state owning oyster grounds possessed such a law as that of Connecticut directed against oyster thieves, and would enforce it, that form of larceny, so exasperating in some localities, would be controlled. It provides a maximum fine of five hundred dollars, or imprisonment for one year. American criminal proceedings are notoriously lax everywhere, and it is not surprising that arrested men are often discharged, and that others have their cases appealed; but on the whole, property in Long Island Sound is as well protected as on the land. Fines and imprisonment are also provided as penalties for injuring oyster inclosures or buoys used in bounding them.

The other states of the northern field possess oyster

laws that are, in many of their essential features, similar to these; and though much revision may become necessary, it may be stated in a general way that the northern field has solved the legal problems involved in the industry.

It is interesting to observe that one very desirable provision is omitted from the oyster laws of all states in the Union having mollusk industries. It is one for the protection of the public against shell-fish contaminated by the germs of human diseases, and certainly one that should everywhere be demanded. While the laws of several states prohibit the discharge of sewage into fresh-water streams, none refer to the contamination of salt waters on their boundaries by this means. Neither is it illegal to offer for sale shell-fish taken from such waters. The danger, especially from typhoid fever, is great in such cases, and there is little excuse for this neglect.

As one leaves the Connecticut shore at New Haven or Bridgeport, he may have the feeling that he is putting out to sea, for the sound is a large body of water. But soon he begins to notice that he is passing many odd-looking buoys. Before long it becomes evident that these are not stationed for the purpose of marking navigation channels, for they are too numerous, and as he looks about, he observes that the water is covered with them in every direction as far as the eye can reach.

Almost all the way to New York the vessel plows along among cultivated fields, the presence of which would be unknown except for these boundary marks. When their significance is understood, one soon obtains a definite impression of the great extent of the oyster farms that have been constructed in these waste places. It is difficult, however, to realize that here also, as on

the land, there has been a preparation of the ground, a sowing of seed, and a cultivation in preparation for a harvest. The impression is strong that there can be little depth of water over these farms, and that navigation here by large steamers would be perilous, but the largest of vessels might pass safely over much of the field.

Naturally, oyster farmers first chose their fields near the shore, where the majority of the natural beds had existed. When these were all occupied, they ventured farther into the sound. To-day one sees from the steamer's deck that some of the oyster grounds have been extended to the middle of the sound, or to the boundary line between Connecticut and New York. Some of these are more than six miles from shore.

Perhaps the thing that most astonishes one is the information he obtains concerning the depth of water over many of these cultivated acres. Only a few years ago, no one would have supposed it possible that oysters ever could be taken economically from a depth of more than seven or eight fathoms, yet to-day, in some places, they are planted in and readily removed from bottoms covered by a hundred feet of water. Such a depth, it is true, is exceptionally great, but it is hardly less wonderful that a very large part of the planted area in the sound is seventy or eighty feet in depth. The great majority of the beds are under water from twenty to eighty feet. It may even be surprising to learn that the shore-loving, brackish water oyster can exist at all at so great a depth as a hundred feet. The fact, however, is that it has been taken from a natural "rock" in Delaware Bay at a depth of more than five hundred feet.

The achievements of the deep-water culturist, that

seem not to be generally appreciated, are made possible by the recent development of mammoth steam dredging vessels. The finest of the fleet of the eighties, housed over, operating four steam dredges, and having a daily capacity of five hundred bushels, could almost be carried on the deck of some of the vessels now owned by the same company. Figure 37 gives a view of one of these powerful ice-breaking boats. It steams out regularly to distant farms, perhaps in Narragansett Bay or eastern Long Island, where its owner has leased bottoms, and neither weather nor ice fields seriously interfere. In one day it is able to dredge eight thousand five hundred bushels of oysters in forty feet of water, and during the next it can, from the most distant point, deliver the cargo at its owner's packing establishment at New Haven.

One may imagine the nature of the protest that would come from the Chesapeake oysterman if a few vessels of this sort were suddenly to appear on his own oyster territory. He would expect his Maryland rocks to melt like snow in April, and his expectation would be realized. Yet he boasts that the immense reaches of Chesapeake Bay comprise the greatest oyster field in the world; and undoubtedly he is right. How, then, is it possible for vessels of this sort to operate in so small a body as Long Island Sound, where natural conditions for oyster growth are so much less favorable, without destroying the industry? Here they are busily occupied from fall until summer in taking immense cargoes from the bottom, and yet the industry actually increases from year to year. This forest of buoys explains the matter, for among them during the remainder of the year these vessels and many smaller ones are engaged in sowing a distant harvest. The future, perhaps see a similar

fleet in the Chesapeake that will bear to market cargoes of which the oystermen of the present do not dream.

One notices, on passing up and down the sound, that oyster beds are more numerous at its western end. Eastward there are not so many planted areas, though in time, trial may prove much of this barren region to be suitable for oyster culture. One to whom figures have some significance would be interested to know that besides the shore, which is still under the jurisdiction of the towns, there are seventy thousand acres of bottom under cultivation in Connecticut, and that in order to carry on the work, there is employed a fleet of more than one hundred steam vessels, aided by nearly four hundred sailing craft.

In New York, including Long Island, the cultivated area is nearly half that of Connecticut, and there are still large barren tracts that may prove to be of value to oyster culture. Here, as in Connecticut, most of the bottoms are owned by individuals or companies.

Parts of Narragansett Bay in Rhode Island, have long proved to be valuable planting grounds, and there all bottoms are rented by the state. Bottoms less than twelve feet in depth are reserved for residents only at an annual rental of ten dollars. Deeper bottoms are rented for five dollars to non-residents, as well as to residents, of the state. By this plan, thirteen thousand acres now bring an annual revenue of ninety thousand dollars to the state treasury.

While in each of these states the cultivated area will be enlarged, no one can estimate its possible future extent within narrow limits; but at the present rate of expansion, these limits, whatever they may be, will soon be reached.

An important question arises in the mind as one views the field of this industry that has become so extensive. Are these cultivated acres owned by many as on the land? or have the smaller holdings been merged into large ones? Is the business of such a nature that the modern industrial method of combination may be profitable to it? A citizen of Maryland or Louisiana, where the fear of an oyster monopoly has been a consuming one, might be interested in the answer.

There has been a merging of holdings, and on a large scale, over the entire northern field. In Connecticut, for example, 338 persons owned 68,000 acres of oyster land outside the town districts in 1893. Eleven years later, in 1904, the area had decreased somewhat, being 66,000 acres. It was owned by 180 individuals and companies. The number of owners had thus decreased nearly one-half. It is now somewhat smaller than in 1904, and the number of acres is larger. Some of these companies hold very large tracts, owning and leasing bottoms in more than one state. One, for example, controls 13,000 acres in Connecticut, 5,000 in New York, and more than 4,000 in Rhode Island—a total of more than 22,000 acres. This being true, it may appear that the northern oyster field is perhaps already in the hands of a few great corporations, and that the poor man can have little part in the industry except as an employee.

But this is not the whole truth. There is another fact that completely reverses such a conclusion. Not only are there a great number of small holdings within the limits of towns, but even in the sound, more than one-sixth of the holdings are of less than fifteen acres—some of them but two or three acres—and they are owned and planted by “the poor man,” who conducts his business

in perfect independence and security by the side of his powerful neighbor. If he is thrifty and understands his business, he makes it a success. He does not owe his existence as a small culturist to the benevolence of the large corporation, but to wise laws, and to the nature of the industry itself, which is so extensive on the Atlantic and Gulf coasts that a crushing oyster monopoly is an impossibility, and probably always will be.

When, from personal observation, one has gained some conception of the great extent of the cultivated areas in the northern field, he is lost in wonder that seed could be found sufficient for its sowing. But it must be remembered that three, four, and sometimes five years are necessary for the maturing of the crop, so that it is not necessary to seed the entire area each year. The method of capturing the spat has already been described. A large corporation may secure its young oysters both on its deep water farms and on its property near shore, but most of it is taken on the comparatively shallow areas.

While Connecticut culturists have heretofore supplied almost the entire field, Rhode Island planters are now beginning to discover that, even with the high rental they must pay, the planting of shells for a set of young is profitable. Since 1903 seed collecting has become an important factor of the industry in Narragansett Bay.

Thus the sound and the bays in the northern field have become centers of great activity. During the summer large fleets are engaged in the planting of breeding oysters and shells or crushed rock for the collection of spat, in cleaning bottoms or hardening them with sand and gravel, in dredging, culling, and transplanting oysters to growing or conditioning grounds, and in dragging mops for the capture of starfish. In the winter all are

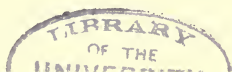
busy in dredging and carrying oysters to the shucking houses and shipping centers.

There are several large markets and distributing centers in the northern field. Chief among these are New Haven and New York. In the former city are the establishments of fifty dealers, who together own thirty thousand acres of planted ground in the state of Connecticut, and control an area equally great in Rhode Island and New York.

Many oysters fresh from the water are shipped unopened to nearly all parts of the United States. The greater number are opened at the packing houses. Some of the larger companies are able to ship nearly a thousand gallons of "meats" in a day. These are washed, cooled, and sent out in barrels or tubs in a perfectly fresh condition.

Packers have learned that their business depends largely on extreme cleanliness. Dirty receptacles used in preparing or shipping oysters make certain their early loss. Consequently barrels, tubs, or pails returned to the dealers are most thoroughly cleaned and coated inside with a water-proof preparation that of itself does much to insure cleanliness.

New York City, also, is a large distributing point, and the West Washington market, on the Hudson River, has become its center. It is thus described by one of the state Oyster Commissioners:—"On the river side of the market there is an enclosed basin where boats may be secure while unloading their cargoes of shell-fish. The unique and commodious house-boats which are moored to the docks are picturesque objects, quite familiar to residents of the city. These barges are really two-story houses, built upon scows or floats with ex-



tensive expanses of floors or decks upon which large quantities of stock may be stored, assorted, opened, and shipped. The ends of these houses fronting the street may properly, perhaps, be called bows, and are constructed with more or less attention to architectural effect, so that the façades are not unattractive. Upon the top, or cornice, of each boat, usually extending across the entire front of the structure, is the sign of the firm doing business within. These boats are fixed with more or less permanency in their berths, and have every appearance of busy establishments of trade. They rise and fall with the tides, which keep them on a level corresponding with that of the decks of the boats of the oyster-carrying fleet, thus facilitating the loading and unloading of stock. These houses may be moved from place to place, when necessary, by tow boats."

Philadelphia, being situated on the Delaware River, is the chief market for the product of Delaware Bay. Many of the oysters from the New Jersey bays are sent to New York.

In New Jersey there are three separate oyster regions. The most northern, Raritan Bay, is really a part of New York Bay, and the industry there is much like that of other parts of that body of water. On the ocean side of the state, Barnegat Bay lies parallel with the shore like a river separated from the open water only by a low ridge of sand. Its waters are brackish, and support a large number of oyster beds. The third oyster district is the eastern shore of Delaware Bay. This body of water, some thirty miles wide at its lower end, has always produced many oysters, and planted beds may be found covering large areas both on the New Jersey and Delaware shores.

Seed for these beds was formerly brought from the Chesapeake, but in recent years, oystermen have followed the example of Connecticut culturists, and now produce much of their own stock for planting. Some planters, however, still depend largely on the natural beds for their supply.

Thus during the past few years a great industry has been developed on the barren bottoms of these northern bays. Each year it contributes many millions of dollars to the wealth of the states that have fostered it. But its benefits are not confined to one region. Its methods, and the vexed experiences of its development may be avoided in other regions where an industry has yet to be established. The more serious problems have been solved by the northern culturist.

CHAPTER XIV

THE CHESAPEAKE



VERY one is familiar with the frequently repeated statement that Chesapeake Bay is the most extensive and prolific oyster territory in the world. The statement is undoubtedly true. When one compares it with the northern field, the marvel of its natural fertility is astonishing. The colonists of New Amsterdam left many enthusiastic accounts of vast stores of "brave oysters" that Providence had provided for them in their new home. "The oyster banks," it was written by a New England colonist, "do barre out the bigger ships." And yet even in early colonial times, these natural beds became so impoverished that laws were formulated to prevent their entire annihilation. In the beginning, oysters became an important article of food of the inhabitants of Maryland and Virginia also. As population increased, greater and still greater numbers were removed from the waters of the Chesapeake. Inland towns began to be supplied. Oysters were transported by wagon, as roads extended into the interior. Finally, when railroads began to lead northward, and westward across the Alleghany Mountains, the ever increasing supply of oysters found a market in the rapidly growing territory far from the coast. Decade after decade passed, millions of bushels finally being marketed every year, and now,



after almost three centuries of tonging and scraping and dredging, the wonderful natural beds of the Chesapeake, though sadly depleted, still exist, and still supply the greater number of the oysters marketed from the bay.

Lying within the boundaries of Maryland and Virginia, the Chesapeake has a length of nearly two hundred miles. In Maryland it is, roughly, from five to

ten miles wide, and, in Virginia, its shores are from fifteen to thirty miles apart. The shore line is everywhere very irregular, with extensive bays, and entering from the west are wide rivers like the Patuxent, Potomac, Rappahannock, and James, the mouths of which are brackish water estuaries, most favorable for oyster growth.

In no body of water would necessary conditions for oyster growth be present everywhere on the bottom. It has already been shown that the requirements are many and exact. Even the most skilful culturist cannot make it possible for oysters to grow everywhere in the Chesapeake; but the relative amount of favorable bottom as compared with that of other oyster fields, where oyster culture has been practised, is very large. If intensive and scientific oyster culture were employed here, as it is in Long Island Sound, the result would astonish the world.

Only a very fragmentary record of the early industry in this bay has been kept. The importance of so great a natural source of wealth has been recognized, and the legislative bodies of Maryland and Virginia have formulated and revised numerous oyster laws; but until comparatively recent times, it has apparently been deemed unnecessary to record information on any phase of the business. Indeed, no one seems to have been particularly interested in the biological conditions in the bay, or in more than his own part in the industry.

Following the method of the archeologist, which is almost the only one available for gaining information on the industry before the middle of the nineteenth century, we are able to obtain a vague idea of the proportions of the oyster trade in the indefinite past from the fact that accumulated shells were used at an early period not only

in supplying lime for building and for the construction of beautiful shell roads, but, in some cases, to build the very foundations of towns from the bottom of the bay.

It is true that Maryland, in 1882, appointed a commission to inquire into the condition of the industry in her waters—providing it with no means for making a survey, and paying no attention whatever to the valuable report returned by it. Since that period the main facts concerning the industry have been recorded.

During the first quarter of the last century there seems to have been a brisk local trade in the opening and sale of oysters in cities and towns near the bay. But in this early time began the shipping of oysters to the northern field for planting and for opening. It has already been stated that this trade increased in magnitude until checked by the Civil War. Out of it grew the present packing business of the Chesapeake, and in the following manner:—A few far-seeing and energetic oyster culturists of Connecticut, recognizing the great natural resources of the bay, and the possibilities of a market with Baltimore as a center, established branch packing houses in that city in 1834. These pioneers of the modern business, with characteristic energy, began to establish wagon lines for the distribution of their product, extending them as far west as Pittsburgh. With the construction of the Baltimore and Ohio, and other railroads, this distribution was enormously facilitated, oysters were plentiful, and these firms conducted a great business.

Writing of the establishment of the first packing houses, Mr. Ingersoll, who had collected all available data for his census report of 1880, continues:—"A few years later, Mr. A. Field, also a native of Connecticut,

began to sell oysters, which he first steamed and then hermetically sealed in tin cans. This preparation was received with favor, and the new trade grew very rapidly. Records furnished by C. S. Maltby inform us that in 1865 1,875,000 bushels of oysters were packed raw in Baltimore, and 1,360,000 bushels were preserved. In 1869 he numbers in Maryland 55 packers, who, at 500 to 2,500 cans per day, put up 12,000,000 to 15,000,000 cans in a season of seven months, using 5,000,000 bushels. Sixty 'raw' houses that year employed 3,000 hands, while the packers gave employment to 7,000 persons. Large quantities of canned oysters were annually sent, at that time, by steamship to Havana."

Mr. Richard Edmonds, describing the industry of the same period, wrote in regard to it:—"The raw-oyster business has always been more profitable and less subject to the vicissitudes of trade, although there are many losses from spoilt oysters when the weather happens to turn suddenly warm. Raw oysters, after being opened, are packed in small, air-tight cans holding about a quart, and these are arranged in rows in a long wooden box, with a block of ice between each row, or they are emptied into a keg, half-barrel, or barrel made for this purpose. When the latter plan is pursued, the keg or barrel is filled to about five-sixths of its capacity, and then a large piece of ice is thrown in, after which the top is fastened on as closely as possible, and it is at once shipped to the West, usually by special oyster trains or by express. Packed in this way, with moderately cold weather, the oysters will keep very well for a week or ten days. During the most active part of the 'raw' season, there are daily oyster trains of from thirty to forty cars from Baltimore to the West, where nearly all the Baltimore oysters are

consumed. From the shores of the Chesapeake Bay as far as Detroit there is scarcely a city or town (connected with any of the great trunk lines) which is not supplied with Maryland raw oysters. Farther west, and to a considerable extent in European countries, the demand is supplied by steamed oysters. The oysters used in the raw trade are of a finer quality, and consequently command better prices than steamed."

When this was written, there were forty-five packing houses in the city of Baltimore. During the winter of 1879-80, these firms marketed more than seven million bushels of oysters, the production of other firms in the state raising the total to ten million bushels.

The packing business of Virginia began very much later than that of Maryland. It was not until 1859 that an establishment was founded in the city of Norfolk. The time and place, however, were unfortunate for the new venture, for shortly the war began that paralyzed every industry, transformed a garden state into a wilderness, and covered its waters with hostile fleets.

No one but a Virginian knows how the state suffered in that conflict, though it is mournful enough to an outsider even to-day to see so much of its formerly fertile interior grown over with jack pine and broom straw, worn out because of the poverty of its owners, or gullied beyond repair. But one very important source of revenue remained after the conflict. The natural oyster beds that had for many years suffered from excessive tonging, had been resting for four years, and were now densely packed. Prices were high, and a great many persons now engaged in the tonging of oysters.

Immediately on the cessation of hostilities, packing houses began operations in Norfolk, and the industry in-

creased for several years. Very few oysters have ever been canned in Virginia. The early trade, like that of to-day, was largely in opened oysters that were sent north in a fresh condition, where they were usually sold as northern stock. In 1880 the state produced nearly seven million bushels, and more than sixteen thousand persons were engaged in the industry.

There seem to be no definite data bearing on the production of the entire bay before the year 1880. The notes of one Baltimore packer estimate the total production of the bay at 6,944,500 bushels in 1865, of which Maryland produced 4,879,500, and Virginia 2,065,000 bushels. It is stated by Professor Brooks that in 1875 the bay produced 17,000,000 bushels. The census estimate for 1880 was slightly more than that. Professor Brooks believed that the average for fifty-six years following the establishment of the packing industry in Baltimore, was at least 7,000,000 bushels a year, or, during the period of little more than half a century, a total of 392,000,000 bushels. This is an enormous production, and all the more wonderful because the greater part of it was from natural beds.

But high tide in the Chesapeake industry was reached soon after the formulation of the tenth census estimate in 1880. On account of the continued fertility of the waters decade after decade, the inhabitants of Maryland and Virginia seemed to have become convinced that they were inexhaustible. Some, however, were able to see that a continuation of dredging, as it had always been carried on, would eventually bring destruction to the natural beds. Influenced by those who had this belief, the Governor of Maryland in 1882 requested the late Professor W. K. Brooks of Johns Hopkins University

in Baltimore, a naturalist of world-wide reputation, to accept the position of chairman of a commission to examine and report on the condition of the natural beds in the Chesapeake, and to suggest measures needed for their protection or improvement. Professor Brooks had already, in 1878, completed an important biological study of the American oyster. By a long-continued observation of the animal in its natural state, he had become thoroughly acquainted with its needs and with the nature of its surroundings. No other person was so well fitted for the task, which he accepted, and for which the university gave him leave of absence.

In 1884 he published an exhaustive report, in which he showed that, with the methods then employed in gathering oysters, the Chesapeake industry must decline, and eventually cease to exist. He used the historical and biological arguments with such skill and force that it seems impossible that an intelligent person could have followed them without conviction. The report attracted the most respectful attention of many citizens, but had no effect on those directly engaged in the industry, and they held the balance of political power in Maryland.

In 1891 Professor Brooks published an interesting and less technical account of the natural resources of Chesapeake Bay in a book that deserved wide popular interest. Even at that time nothing had been done in Maryland to promote oyster culture, and the natural resources were very rapidly declining. Fifteen years more passed before the state saw that the vast wealth of its waters had dwindled dangerously near to the vanishing point. Then, nearly a quarter of a century after this condition had been shown to be inevitable, it was compelled to listen to reason, and, in 1906, made an attempt

—not a thorough-going one, by any means—at reform. “A prophet is not without honor, but in his own country, and among his own kin, and in his own house.”

The record of the decline in the Chesapeake since 1885 is very incomplete, but that kept by the transportation companies and the packing houses of Baltimore indicates its nature. During the season of 1885-6 more than three and a half million bushels of oysters were shucked in the city of Baltimore. In 1889-90 the number had fallen below two and a half millions. In 1893-4 it had declined to a little more than one and a half millions. For the next four years it remained nearly the same, and hopes began to be entertained that the low mark had been reached, and that the natural beds of the Chesapeake would continue to yield a harvest of at least that amount. But in 1899-1900 the supply hardly exceeded a million bushels, and the following season fell below the million mark. Since then the same steady decrease has been maintained, if more slowly, yet none the less certainly.

This falling off in the business of the packers was not due to any increase in what is called the shell trade, or to the establishment of new packing houses elsewhere, but simply to the fact that the natural supply of the bay was nearly exhausted. It was stated by the railroad companies that during the decade between 1890 and 1900, the shipments of oysters in the shell had decreased three-fourths in volume.

But the decline was even more rapid than indicated by these figures, for in 1889 the Baltimore packers began to send dredging vessels down the coast to Pamlico Sound in North Carolina, where they taught the unsophisticated native oystermen something about the dredging of oysters, and incidentally nearly ruined the

natural resources of the sound in short order. Oysters dredged there were all taken to the packing houses in Baltimore, where they were shucked, sold, and counted in the fragmentary records of the business as Chesapeake oysters. Thus the prophecy of the commission of 1882 was fulfilled. Its report was not merely a warning. It showed the decline in the great industry to be unnecessary. It explained the simple course to be pursued that would increase the production of oysters to a vast extent; and there is even more reason to-day than there was in 1884 for the belief that every prediction of vast success and fortune contained in it might by this time have been realized by the state of Maryland had it chosen to develop a thorough-going system of oyster culture.

The history of the industry in Virginia's part of the bay is not so depressing. Much of the bottom is shallow, and is worked by tongs. In 1879 dredging on natural oyster rocks was prohibited, though allowed on private grounds. But in spite of the fact that only tongs were employed, the natural beds rapidly became depleted. At this time planting was allowed by the state, but few availed themselves of the privilege. Naturally, planting could not well flourish when there was great doubt as to the limits of natural rocks as distinguished from barren bottoms. Planting had also been allowed in Maryland for many years, but very few had dared to invest labor and money in it.

In 1892 a survey of the natural oyster beds was made in Virginia. These were staked out, and though their boundary marks have long since disappeared, the good effects of that designation have been felt ever since. If a triangulation survey of the barren bottoms had been

made at the same time, a much greater stride in advance would have been taken.

Maryland was still the proud leader of all the oyster producing states in 1891. Ten years later she had relinquished this position to Virginia, from which were marketed nearly eight million bushels in 1901. Of these more than three million bushels came from private beds. The Virginia oyster planter still has his serious troubles, but the practice of planting has become so extensive that the market does not depend entirely on the natural rocks, and hence possesses much stability.

Of late years it has everywhere become the habit to refer to the upper Chesapeake as the dead goose that laid the golden eggs. When modern oyster laws are being demanded in other states, Maryland is exhibited as the horrible example of the effects of faulty legislation on the oyster industry. Her natural resources have largely been wasted, and almost perfect lawlessness has been tolerated on the bay.

No one has ever supposed that the people of Maryland were peculiarly indifferent to the destruction of the natural treasures buried in her bay. They have known what they were losing, and why, but, like the American public everywhere, they were long-suffering in patience. An American from any other part of the country knows without being told that such a state of affairs is probably to be explained by what was the fact in this case—that the Maryland oyster had been deeply involved in politics.

When a sufficient number of persons become interested in the lumbering of pine, spruce, or fir, these become factors in state or even national politics. The same is true of such sources of natural wealth as metals, coal, petroleum, and many others. This happens because those

who are most directly interested desire all that may be obtained, and in getting what they can as rapidly as possible, usually waste much more than they get. They resent public interference, and, when necessary, purchase immunity in one way or another of political machines—an old story the world over.

The oyster industry has been of the greatest importance to Maryland and Virginia. It supports thousands of shuckers, tongers, and dredgers. The business of the oyster dredger is to get oysters where they grow, and he has always attended to it—as one writer has put it, “regarding neither the laws of God or man.” All that he has ever desired from the public is to be let alone. The tonger, for whom certain shallow waters have been reserved, has asked nothing more. Each of these has often maintained his “natural rights” against the other by means of rifles, and both have taugth the oyster planter, whose unnatural business, it has seemed to them, might glut their markets, and whose unholy purpose has apparently been to take the bread out of the mouths of the honest poor, that Maryland, at least, was no place for him.

The “rights” of these men have been looked after in state legislatures by those whom they have sent by their votes, and restrictive laws have seldom been passed. Some years ago the statement was made in a government document that one candidate for the Virginia legislature promised the oystermen that, if elected, he would defend any of them in the courts free of charge should they transgress any of the state oyster laws; and every one has always believed the situation to have been worse in Maryland than in Virginia.

Until 1906 the oyster laws of Maryland aimed at little

but the prevention of quarrels between tongers and dredgers, and the collection of revenue by means of licenses. To enforce the laws, it has been necessary to support an "oyster navy." The plan of collecting a revenue has always been a favorite one. Just previous to the passage of the new oyster laws, the state was able to collect about forty thousand dollars—at an expense of more than sixty thousand. The revenue plan has usually operated in this way in Maryland. A law to compel culling on the beds where oysters were dredged has been on the statute books for years, but it has been observed only when convenient. In short, such oyster laws as Maryland has possessed, have rarely been enforced. It must be said, however, that on so extensive an area as the Chesapeake, where public sentiment was overwhelmingly against existing laws, their enforcement was practically impossible. It is an interesting problem whether the provisions of the new statutes can be enforced more successfully than were the old.

Many hard things, to be found in newspaper files, magazines, and government reports, have been written by citizens of Maryland and Virginia concerning the oyster pirates of the Chesapeake, especially of their almost incredible lawlessness and cruelty, and hard as these statements are, those who have been at all familiar with the conditions in the bay in former times, will probably agree with the statement of Mr. Ingersoll, who investigated the oyster industry previous to 1880, that he believed them to be just.

Other states, in past decades, have tolerated politics as bad as those of Maryland. There are still localities where even dynamite and the sawed-off shotgun may be used against life with comparative impunity; but the

social conditions that obtained on the Chesapeake for many years were so unique that one is quite at a loss to understand how they could have escaped the attention of the modern magazine story writer. During the quarter of a century or more since the grim and grizzled pioneer and the polite but dreadful cowboy, with his "six-shooter," have become extinct, they have been celebrated as typical western characters in a deluge of magazine literature by eastern writers, and the flood continues unabated to this day. The equally picturesque bad man in their midst has entirely escaped attention, perhaps because he has so recently been with them. It remains for some Pacific coast writer, who has never crossed the Coast Range, to exploit the wild oyster pirate of the Chesapeake. There will be color for his tale in the facts when he obtains them, and fiction will not be necessary.

It has been stated that shallow waters along the shore lines have long been set apart by law for tonging, while it is intended that dredging shall be carried on elsewhere in deeper water. While tonging is slow work that can only be carried on in good weather, thousands of men have been engaged in it.

One of the functions of the state police is to prevent dredging on the tonging grounds, but the bay is so extensive that a very large force would be required to accomplish it. With the pirates banded together for mutual protection, and especially under the cloak of night, tonging grounds may be dredged with safety and profit when they yield more than those in deeper water.

Night dredging on forbidden grounds has not always been necessary. We are told, for example, that during the winter of 1879-80 a large fleet of dredgers entered the Rappahannock River in Virginia, and began opera-

tions on the tonging grounds. Incensed at this act, the tengers made an attempt to drive them off, but the dredgers were well armed and able rapidly to concentrate forces when necessary. The scattered small boats of the tengers were driven to cover, and for weeks obliged to keep at a respectful distance. The Virginia legislature being in session, voted to supply the shore men with a cannon and small arms, but before these arrived, dredging operations had been completed, and the pirate fleet had sailed away.

Tengers have always been practically helpless against these raiders, but the greatest sufferers have been the few bold men who have attempted to plant oysters on leased bottoms in Maryland, or in Virginia, near the Maryland line. Professor Brooks records the experience of a Virginia culturist who had incautiously leased about seventy acres a short distance from Maryland waters. At the expense of more than four thousand dollars, he had shelled the bottom, obtained a large set of young oysters, and had employed watchmen during their growth. Two years after the bottom was shelled, the crop was estimated at three hundred and fifty thousand bushels, and valued at more than one hundred and twenty thousand dollars. The dredgers were perfectly willing to witness this wonderful demonstration of the fertility of the bay under oyster culture. It proved to be a fine harvest for them. There were no inter-state complications, like the threatened warfare between Louisiana and Mississippi some years ago over a trespass on oyster ground, and there was no redress. The culturist lost a fortune, and that was the end of the matter.

It is interesting to notice who these buccaneers and their crews were, and what were their relations to civ-

ilized society. In the denunciatory accounts of them by their fellow citizens, that one may find, not all vessel owners were attacked. They seemed to have had knowledge only of the number of trips made by their captains. Some of the captains also are said to have been honest and law-abiding, "but it is an unfortunate fact," we read, "that such form a very small minority."

It may be gathered from the reports, that captains of dredging vessels were forced by the demands of vessel owners to disregard the oyster laws. They were required to deliver oysters within a limited time. That meant that they must take them from the most convenient localities, and that they must dredge day or night in all kinds of weather. It meant that crews were to be driven without mercy, and that no one should be allowed to have any rights in the bay. Such a system resulted in the selection of as merciless a band of pirates to captain most of the vessels of the oyster fleet, as ever ruled a deck on the high seas.

The cruel treatment of crews on these vessels has always been a frequent subject of comment, and yet there were ways of getting them together. In the majority of cases, when a ship-owner or a captain desired a crew of seven or eight men, he simply placed an order for them with a shipping agent. This person, on making a round of the saloons and dives near the "basin" in Baltimore, was usually able to round up a sufficient number of men, often irresponsible from drink, and these he delivered on deck at about two dollars a head. The only qualification in the acceptance of a hand was evident muscular ability—when muscles should be under control—to turn the crank of a windlass. Crews of this sort—vagrants, thieves, and murderers—declared in an account by a na-

tive of the Chesapeake shore to be "one of the most depraved bodies of workmen to be found in the country," made good men for the work in hand.

But the worst feature of the fearful business was the virtual kidnapping of newly arrived and ignorant foreigners for this killing work. Shipping agents were allowed to meet the immigrants in New York and Philadelphia, and, with promises of pleasant and remunerative employment, lured them to Baltimore in large numbers, and delivered them to dredging captains. There they entered into an abject slavery, from which it was not possible to escape, at least until the end of the voyage. The work was cruelly hard, being chiefly at the windlasses used in drawing the heavy dredges, and in culling the loads that were dumped on deck. Winter on the Chesapeake is cold and stormy, and the men were compelled to work on an icy deck that was entirely exposed to wind and spray. In 1880 the average pay for this was said to be about eleven dollars a month.

Along the shore one hears many gruesome tales of mysterious disappearances, and even of open murders of members of these crews. Stories are told of unspeakable cruelties on board the vessels, and of the maroonings of entire crews on isolated shores, perhaps to save the amount due in wages. That such barbarities were practised on the bay probably few good citizens of Maryland doubt, and yet complaints have been rare and redresses still less numerous. Without doubt there were some humane captains among the Baltimore dredgers, and many such in the lower part of the state; but the opinion of those best acquainted with the conditions seems to be that, as a class, they have established a record of crime and cruelty that has rarely been equaled in this country.

Conditions governing the oyster industry in Virginia and Maryland are in a state of transition from dependence on the wild crop to oyster culture. A great and radical change is contemplated in the latter state, while the former is slowly continuing progress inaugurated years ago.

There are several reasons for the slow progress of oyster culture in Virginia. The industry has reached that stage where its natural beds are as much a curse as a blessing. According to the Baylor survey of 1892, these beds covered an area of two hundred and twenty-six thousand acres. These have dwindled to small proportions; their size cannot be accurately estimated. Over large areas oysters are scattered, and many of the original rocks are now quite barren. Yet nearly every one clings desperately to the idea that the future industry depends on their preservation as natural beds.

The result is that all the energies of the state are expended on policing this territory—in an attempt to enforce the close-season, and to prevent the sale of small oysters by tongers to planters—instead of affording some protection to the oyster culturist, who is making a serious effort to succeed. As it is, the oyster “navy” is too small to enforce the laws on a quarter of the public territory alone.

Another reason for slow development is the absence of a triangulation survey of barren bottoms available for oyster culture, and the consequent insecurity of title. The oyster laws are so confused and so conflicting, contain so many exceptions and special and local provisions, that no one has a definite idea of his rights.

The state is committed to the plan of raising the greatest possible direct revenue from the industry, and gives

practically no return of any sort. This will prove to be a short-sighted policy.

The fear of an oyster monopoly is very general and very acute. Not enough bottom is leased to one individual to invite extensive oyster culture, and non-resident capital is not allowed to develop any of the extensive and barren areas in the bay. All of the oyster producing states have at some time placed this prohibition on the oyster industry—but never on one conducted on dry land. It would be interesting to know what is the economic principle involved in the discrimination.

While there is a considerable area covered by planted oysters in Virginia, the chief source of supply is still the natural rocks or beds. Planting is not at present increasing, and partly for the reason that the business of rearing seed for sale has not yet been established. Planting in the deeper parts of the bay has not yet been given a fair trial. True oyster culture—the capture of the young on collectors and its rearing for market—has been tried, and with success, but is not yet extensively practised.

Criticisms of the Virginia industry should lead no one to be pessimistic concerning it. In actual production the state is one of the great leaders. Large and flourishing packing houses are numerous, and some of the brands marketed by them are of the greatest excellence.

Methods of state control, that change only with the gradual modification of public opinion, are slowly working through that series of experiments to the conclusions that other states have already reached. Communities, like individuals, seldom are benefited by the experiences of other communities. But the time probably will soon come in Virginia when dependence will be placed on a

cultivated rather than on a natural crop, and to the great benefit and satisfaction of every one concerned.

Public attention is now attracted to Maryland. For so long a period the first among the oyster producing states, it was the last to recognize the importance of oyster culture. The reason for its long delay is that its natural supply has been astonishingly great, and public opinion did not force a change in method until these natural oyster nurseries were very greatly depleted, and on the way to early extinction.

In April, 1906, the Governor of Maryland signed an act "to establish and promote the industry of oyster culture in Maryland; to define, survey and mark natural oyster beds, bars and rocks, to prescribe penalties for the infringement of its provisions, and to establish a permanent shell-fish commission."

Previously, an act known as the "five-acre law" allowed citizens of the state to select a small plot on barren bottoms for planting oysters, "twelve months peaceable possession" to constitute a sufficient title thereto. Although many such small tracts were taken at one time or another, the bedding or culture of oysters practically did not exist in the waters of the state.

Among the features of the act of 1906 may be noticed the following:—

No non-resident, or any corporation or joint stock company will be permitted to lease or acquire by assignment any lands for oyster planting or cultivation.

All natural beds or rocks are excluded from the operation of the act.

A Shell-fish Commission is created.

A triangulation survey of natural beds (*but not of bottoms for lease*) was provided for.

All bottoms not included in natural beds were set aside for lease.

Boundaries of natural beds, as determined by the Commission, may be decided by Judges of Circuit Courts.

Within the territorial limits of any of the counties, no person shall lease or acquire more than ten acres. One hundred acres may be acquired in the bay outside county lines.

The terms of lease are twenty years, rental being one dollar an acre for the first and second years, two dollars for the third, three dollars for the fourth, four dollars for the fifth, and five dollars a year for the remainder of the term.

No right is given to redeem or purchase land so leased.

Severe penalties are provided for injury to state buoys, and for the theft of oysters from leased bottoms.

The state fisheries force shall prevent violations of the act.

The Commission appointed by the Governor was of great efficiency. One of its members, a professional biologist who had had extensive experience in oyster work and a complete knowledge of the entire subject of oyster culture, took charge of the field work.

By an act of Congress, it was directed that members of the Bureau of the Coast and Geodetic Survey, and the Bureau of Fishes, should aid the Maryland Shell-fish Commission in making the survey of the natural oyster beds in Maryland. This aid was promptly given, the expenses being met by a special appropriation from the national treasury. It is a fact not generally noticed, perhaps, that federal aid in oyster investigation and surveys, has frequently been extended to states, which, in some instances, have profited largely by it.

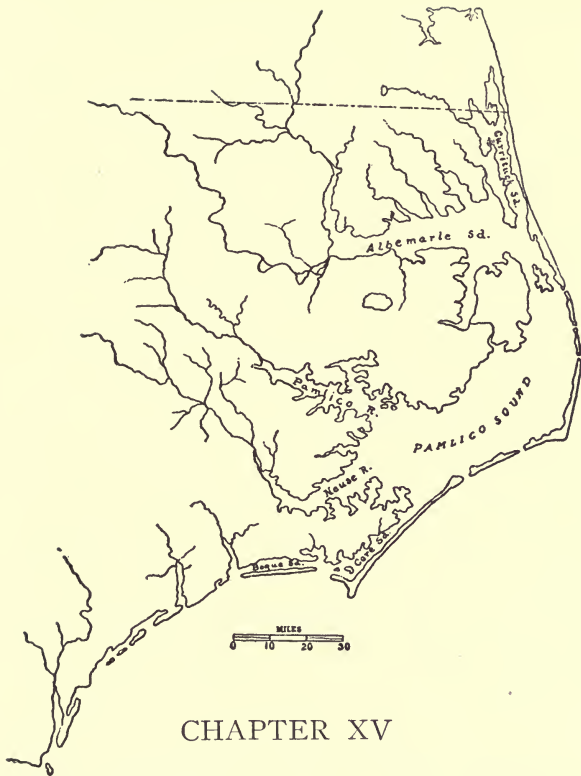
It is safe to say that no natural beds have ever been so carefully examined and charted as have those of Maryland. Their limits have been drawn liberally in favor of tongs and dredgers, and are marked by permanent buoys. The Shell-fish Commission has published expert advice in regard to specific areas open for lease, on which conditions for planting or for seed collection seem to be favorable. They have designated other areas as of doubtful value. They have given reasons for some previous failures under the "five-acre law"—due to ignorance of biological conditions necessary for the attachment of spat. By experiment, they have shown to doubters among the oystermen that abundant seed may be captured on collectors in the Chesapeake as well as in Long Island Sound. They have done everything that any similar body of men could do, under the conditions, to inaugurate a new and prosperous era for Maryland.

But some of the legislative conditions probably are anything but favorable, and it is safe to predict that oyster culture will have a very slow growth in the state until changes are made. Experience has shown that oyster culture which shall produce the best stock, and be able to market it with certainty when it is demanded, can only be carried on by large interests. With several thousand acres, on which natural conditions vary, an individual or a company may obtain a set, transplant it to growing beds, move it again, if necessary, to fattening grounds, always have oysters ready for market, operate vessels that can obtain them quickly and at any time, and thus keep the market steady and certain. Those on whom perfect reliance can be placed in the delivery of the best goods, will always have the best markets.

Under the present system, Maryland can have only small planters, who may succeed one year and fail another. Holdings are not large enough to warrant the employment of suitable boats. Most of the planted oysters will be tonged or "scraped" after the old fashion, and only in good weather is such work possible. If leases should become numerous, much litigation will arise because boundaries are insufficiently surveyed and charted. Prices will rise and fall as many or few bring in their harvest, and these small and poor planters will have the greatest difficulty in protecting themselves against dredging vessels.

The foremost desire is still for direct revenue to the state. The direct revenue system of Rhode Island is very attractive about the Chesapeake, but Narragansett Bay is small enough to be policed efficiently, and capital is invested only because the state offers unlimited territory and has allowed much of it to be taken by non-residents. Many of the essential conditions are different in Rhode Island, and it is doubtful if, even there, the state profits by its industry as does Connecticut, in which bottoms are sold, but where taxable property has developed indirectly under the great increase of the oyster business.

But in the course of time—after the natural oyster beds have been destroyed—the tonger and the dredger of the natural crop will have disappeared. All opposition to oyster culture having vanished, the Chesapeake, rich with food for an unlimited oyster growth, free from the most destructive of oyster enemies, with its safe and unvarying natural conditions, will prove to be of greater value to the people on its shores than mountains full of silver and gold.



CHAPTER XV

THE NORTH CAROLINA FIELD

EXAMINING a map of North Carolina, one finds a long, narrow strip of land that, extending southward from the Virginia shore, bounds more than half the coast line of the state. This sandy barrier, more than two hundred miles long, and formed by the action of waves, is wide and permanent enough effectually to shut off from the sea a series of large, shallow sounds. On the north is the narrow Currituck Sound. This communicates at its southern end with Albemarle Sound, that reaches inward from

the ocean for a distance of sixty miles. Still farther to the south, and connected with Albemarle, lie the more extensive waters of Pamlico Sound. Continuing down the coast, one finds the much narrower Core and Bogue sounds.

The map shows that the ocean barrier effectually shuts off the two northern sounds from the sea. Opening into Pamlico Sound, however, are two large, and several smaller inlets, and through them so much salt water enters, that characteristic marine shore animals and plants are found growing in abundance on its bottom. Between Core and Bogue sounds, also, is a large inlet, and the waters of these are salt.

One other physical feature of the region, shown on the map, is of great importance in a study of its biological conditions. It is that several large and many small rivers enter the sounds on their western shores. As one might surmise from an examination of the map alone, Currituck and Albemarle sounds are nearly fresh, and oysters and clams are not able to live in them.

But oysters do not breed readily—indeed, are not able naturally to maintain themselves—in water having the salinity of the open sea. Successful growth demands within somewhat narrow limits, a mixture of sea and fresh waters, and it is because these natural requirements are very nearly met in Pamlico Sound and near the Bogue Sound inlet, that they become profitable fields of study to one interested in the future development of the oyster industry.

The coast of South Carolina is quite different from that which has just been noticed, in that most of it is unbroken. At the city of Charleston and just above the Georgia line, however, there are bays with many rami-

fications, and in these there are natural oyster beds. Though the oysters are generally of poor quality, several canneries have been established in the state to supply a local market. The possible production of these bays under culture methods merits attention, but reference to it will be omitted from this account, only the larger and more promising field in North Carolina being considered.

This latter in some respects is strikingly different from the fields farther north on the Atlantic coast. It also differs from the oyster areas of the Gulf of Mexico, and in most ways, perhaps, to its disadvantage. It is without doubt the poorest of the large Atlantic oyster grounds, and yet it is valuable, and under culture methods fostered by wise legislation, may in the future become much more so.

The map will show much irregularity in the western shore-line of North Carolina's oyster area. Many bays, or, as they are called locally, rivers or creeks, lead into broader waters from surrounding marshes. In these rivers are usually many oysters, and their peculiar position or distribution would excite the interest of a northern oysterman; for they are found only along the river banks, and are very generally absent from the bottoms. Not only is this true, but the majority of them lie within the limits of the high and low tide lines, and as a consequence are exposed to the air for long periods each day. The average vertical distance between tide levels over this field is about three feet.

When the bank of a river or creek rises abruptly from the low tide mark, a narrow line of oysters, all exposed at low tide, will be found along its surface. But often the banks are so low that the rising water flows over them and covers an extensive area on each side, thus

forming tidal flats that may be partially or completely covered with oysters (Figure 49).

Islands are formed in many of the channels, often so numerous that there remain only narrow streams between them. Though these rise only a few inches above the high water line, they are frequently covered with grass in the center. Around their margins are oyster fringes, here, as elsewhere, extending from the low to the high tide level.

It has recently been shown by some very interesting observations conducted by Dr. Caswell Grave, that these islands are formed by the oysters themselves. In the beginning of the process there may have been an open channel, the river banks alone being fringed with oysters. A river bank, of course, does not lie in a perfectly straight line. Here and there parts of it project into the current. Now oysters growing on such points are very much favored, because the currents are a little more rapid there. This means that aeration is better, and especially that a greater amount of food is brought. Consequently these favored oysters grow more rapidly than others. Their number, also, increases more rapidly here, for the reason that the more active current keeps their shells comparatively clean, thus affording objects for the attachment of the young. A greater number of swimming embryos, also, will be brought to the projecting point by the swifter current than to other parts of the river bank. From time to time, winds, waves or ice, break clusters of oysters from the point. They roll down toward the channel, many of the oysters continuing to live and grow. Year after year these clusters accumulate on the bottom beyond the point. Sediment gradually settles among the lower shells, while new gen-



FIG. 48. Laboratory employees tonging and culling clustered oysters in Louisiana. Note the character of tongs and culling board.



FIG. 49. Natural growth of "coon oyster" clusters between tide lines in South Carolina. Professor Bashford Dean, U. S. F. C. Bulletin.



erations of oysters attach to the upper ones, so that finally the living oysters are raised first to the low and then nearly to the high tide line. In this manner, the point, advancing on the foundation that it itself prepares, thrusts itself in the form of a narrow reef out into the current, and its advance will continue until the direction of the current is changed, or its force is checked.

In the meantime, the current has become so slow at the point on the shore from which the reef began to grow, that most of the oysters in that locality have died. There is here, then, no longer a living crust of oysters on the reef to protect it from erosion, and gradually the rising and falling tides wear through it, and cut it down until the remainder of the reef has lost all connection with the shore from which it arose, and has become an island. This widens somewhat, waves now and then throw detached oysters on to its center, floating matter catches there, grass begins to grow, and it gradually rises above the ordinary high tide line. Around its margins oysters still continue to grow between the tide lines.

Such a process requires many years for its completion, and even after an island is formed, it probably is still subjected to slow but unceasing changes that are in some cases constructive, in others destructive. In many of the bays or rivers, all stages of growth, from the small and inconspicuous point to the fully developed island, may be observed.

To one familiar with other fields where oysters never are found fixed between the tide lines, but exist only on bottoms that are continually immersed, these peculiarly elevated reefs, and bottoms so generally barren, are very curious. Two questions at once arise in his mind. First, why do not oysters naturally establish themselves

on beaches and flats in the Chesapeake or Long Island waters, as they do here? All Atlantic oysters are of one species, and in all regions their habits are probably identical; yet in one place they grow and reproduce on periodically exposed flats, and in the other, only on the bottom below tide lines. The answer is that they do attach between the tide lines in the northern fields, but that very early in the terrible northern winter, every such unfortunate perishes from cold.

But a second question is not so easily answered. Why, in these marginal waters of the Carolina sounds, do oysters not more often appear on the bottoms below the tide lines? Farther north it is only in such a position that they establish themselves. Several suggestions have been made concerning conditions that might explain the phenomenon. The most plausible is that the water is so heavily burdened with silt, frequently deposited, that very young oysters are smothered, even when not actually covered by it, possibly, it has been suggested, because their gills become encumbered with mud particles. This probably is not true. The gill of the adult can free itself of any quantity of mud, as may be shown by experiment. Adult oysters sometimes survive when deposits have been so heavy as to cover them to a depth of several inches, the gill currents keeping an opening through the mud like the burrow of a clam. The gills of the young probably are not less capable of keeping their surfaces clean.

The fall of silt in some waters may, of course, be so heavy as to cover, and thus to smother, recently attached oysters; but even when less heavy, it may, when long continued, lead to their death, not by smothering, or preventing the oxygenation of the blood, but by starv-

ing the young bodies that have not yet stored reserve food in their tissues (see Chapter IV). The mere periodical sprinkling of young oysters with silt is probably not so destructive as it is generally supposed to be.

It may be noted that other waters than these, that successfully support oyster life, are also muddy. Silt is constantly deposited over a great part of the European oyster territory. The waters of the Chesapeake are muddy. The finest of sediment is at frequent intervals settling to the bottom about the Mississippi delta, where flourishing oyster beds below low water are everywhere present. In the light of these facts it may seem strange that only here oysters should be generally absent from the bottom.

It will be shown presently that in these rivers oysters do establish themselves below the low water level, along the sides of reefs. They are confined to those localities, and the bottoms elsewhere are barren. Such segregations are formed on shells that drop from the reefs above and pave the bottom, no matter how soft it may be. Not only is this true, but the young attach to these shells and grow. This proves that, while the water is often excessively muddy, not enough silt is deposited to prevent oyster growth when the bottom is once paved.

The bottoms below tide lines are very generally barren, then, only because, away from the immediate vicinity of oyster reefs, there is no natural deposit of any foreign objects to harden it. Experiments show that if a sufficient number of oyster shells or other hard bodies are spread on the softest of these bottoms during the breeding season, so as to afford surfaces for attachment, beds of oysters form on them, and spread at the margins, one generation growing on the shells of another. On these

river bottoms there have never been, under natural conditions, any such bodies that might afford attachment, and thus serve as a nucleus for oyster growth. Along the north coast are stones, and gravel, and the shells of mollusks; and about the Mississippi delta, vast numbers of shells of two or three species of small bivalves that inhabit the mud, came naturally, in certain localities, to lie on the surfaces of the softest bottoms. On these, natural beds became established.

There are very extensive oyster beds on the banks of these small bays or rivers. Because they are exposed at low water, these oysters could easily be gathered. As a matter of fact, they are seldom disturbed, for they are not marketable. They have been used as a fertilizer, and burned for the lime in their shells. A few of the oyster establishments occasionally succeed in disposing of them in cans, but from the commercial point of view they are almost valueless on account of their small size, elongated form, and poor condition.

To one who has seen oysters only from artificial beds, where they lie spread out in an even layer, these present a strange appearance. What first attracts attention is that they are in clusters of various sizes. If one were to attempt to lift a cluster from the bank, he would find that its base extended down into the mud so deep as to afford a secure anchorage. A vigorous pull may dislodge the whole mass, though the lower part of it may be buried under many inches of soft mud. It will then be discovered that the cluster of living oysters that was exposed above the bottom, is firmly attached to a number of empty oyster shells below them, the whole being fused into a compact mass. The shells of living and dead oysters thus bound together may number scores.

The explanation for such a relation between so many individuals is simple. A single large oyster shell may lie on the surface of the mud near living oysters. If it is free from slime when oyster embryos are swimming in the water, it affords a surface for the attachment of one or more of them. Usually several establish themselves on it. Not all of these live, and many perish early. A few continue to live and extend their bodies upward into the current. Only those that grow upward can survive, for the currents steadily deposit silt obtained from the land. Slowly the original shell is buried, and finally disappears, and the mud creeps up to the younger individuals that it bears. If their bodies are growing outward from its sides, they, too, are covered. Again in the breeding season, a second generation attaches itself to the exposed portions of the shells of the first. If sediment has collected rapidly, they become fixed only to the exposed edges of the shells; if slowly, to any part of them, in this case forming a larger and broader cluster.

Year after year the process continues. The earlier generations are buried and die, but still their empty shells lift up their descendants into the life-giving streams above. The time finally comes when the earlier shells are completely dissolved, if the mud contains acids formed by the decay of organic matter, but it is often possible to distinguish in the cluster uprooted from the mud, six or seven generations of oysters.

The oysters of these river banks are of little value commercially, because of their form and condition. Most of them are narrow and greatly elongated, and this is due entirely to crowding. Like clams in small and irregular spaces between stones, their growing bodies conform to

the outlines of the available space. The shell is sometimes greatly distorted. Crowded oysters growing parallel with each other on the top of a cluster can only elongate, if they grow at all. Oysters, when not crowded or confined, assume a rounded form, though when allowed to become very old and large, they normally begin to elongate. The soft parts of densely clustered oysters are usually thin and watery, probably because food is not sufficient for all members of a cluster. This is especially true of oysters exposed at low tide, for they are able to obtain food only when immersed.

Such elongated forms are called "raccoon" or "coon oysters," either from their fancied resemblance to a raccoon's paw or from the fact that these animals frequent the beaches where they are found, presumably in search of them.

Clusters of coon oysters are not peculiar to the Carolina sounds. Where beds are not frequently tonged, they are found in Louisiana, and would form readily in northern oyster waters if left undisturbed. A cluster on a hard, clean bottom would assume a roughly hemispherical, instead of an elongated form, because young oysters attaching to the sides, as well as to the top of the growing cluster, would be able to live and grow. These, also, not being so often forced to grow parallel with each other as in the case of those being covered with mud, would not so often be elongated.

A question of economic importance presents itself here. As the elongated form assumed by clustered oysters is due only to close crowding, would such oysters become large and well rounded if separated from the clusters and spread on a suitable bottom? Might not

these useless coon oysters be converted into marketable forms?

As a result of observations recently made in North Carolina waters by members of the staff of investigators of the U. S. Bureau of Fisheries, it may be answered that the larger coon oysters are not able to make much improvement in form. But it has been shown that in-



FIG. 50.—Upper row, young oysters beginning to elongate from pressure in thick clusters. Lower row shows rapid improvement in form after liberation from cluster. Outlines from photographs by O. C. Glaser, U. S. F. C. Report.

dividuals less than two inches in length, even though they may have begun to elongate, do respond, on being freed from clusters, by assuming the desired normal outline and size. This is a fact of some importance, for it proves that seed oysters, in case of a poor set upon collectors, may safely be taken from these abundant clusters.

The results of such an experiment are represented in Figure 50. The individuals of the upper row were taken from clusters, and had begun to elongate. The actual length of the larger ones was about one and three-fourths inches. The lower group represents the same

oysters after a growth of but two months on a favorable bottom. They have not greatly increased in size, the larger ones being about two and a half inches in length; but the significant fact shown in their outlines, is that immediately after being freed from their crowded condition, they began to widen and assume the normal form.

It may appear from some of the statements made that the marginal waters of the sounds would be of little value if oyster culture were to be practised in North Carolina, but though clustered oysters exposed at low tide are not marketable, they would become invaluable in case artificial beds were constructed in the sounds, because of the vast numbers of oyster embryos that they produce. These embryos, suspending themselves in the water for many hours, may be carried to some distance by currents before they finally settle to the bottom and make the attempt to attach themselves. How far, in extreme cases, they may thus be transported before becoming attached, no one is able to say. Cases are known in which they have been carried several miles. But spat collectors spread on bottoms near the reefs, judiciously selected with reference to tide currents that might bear the embryos from them, would, in most seasons, be able to gather a supply of young that, under normal conditions, settle on the soft mud and perish.

But in still another way these natural reefs are already valuable, for it is from them that the existing tonging grounds have arisen. Two agencies, one natural, the other artificial, have been at work on the natural reefs to form beds of another sort, on which a considerable number of marketable oysters are found.

If one were carefully to observe the reef oysters through the various seasons of the year, he would dis-

cover that now and then certain of them break from the reef and roll down the steep sides into the channel. This occurs when storm waves at high tide dash against the clusters, breaking or uprooting them. In winter, the grinding action of ice adds to the number of oysters lying on the deeper bottom below the tide lines. The accumulation is made slowly, but continues from year to year, and finally a firm shell bottom, sometimes many yards in width, is formed parallel to the sides of the reef. On this are found not only clusters that have rolled down, but single oysters scattered here and there, which, having grown without crowding, have become large and rounded. In the breeding season, swimming young attach to these deeper shells as well as to those between tide lines, and in this way the deeper bed grows rapidly. As one would expect, these, if left to grow undisturbed, become as completely clustered and worthless as the reef oysters above them. But wind, waves, and frost, thus operating to form a new bed, have scattered over it so many single oysters that they begin to be sought by tongers, and in this way is introduced the more important agency that makes the tonging ground more extensive and valuable.

Consciously or unconsciously the tongers begin to practise a very successful method of oyster culture. They lift from the bottom numbers of empty shells, small clusters, and a few single oysters of large size. Because the clusters are comparatively small, they contain some individuals of good shape and size. These are separated from the others on a culling board carried by the boat, and the empty shells and small oysters from the broken clusters are returned to the bottom. Two important results follow this practice. The area of the shelled bot-

tom is increased, and clusters are broken apart, the number of single small oysters on the bottom being rapidly multiplied. Oysters probably are not culled on the ground with the purpose of extending or improving the beds, but because the waste material from culling is too great in volume to be carried to the shore. But here is only another demonstration of the fact that the shelling of the bottom and the breaking and scattering of clusters soon produces a valuable oyster bed.

The total area of the existing river tonging grounds is so limited that they have never been of great commercial importance, and in recent years have become much less prolific than formerly, because of excessive tonging. Before the opening of canning establishments like those at Beaufort, it was sometimes possible for a tonger to gather in one day thirty or even forty bushels of oysters from these river beds; but the canneries so stimulated the fishing that at the present time the maximum catch is not more than fifteen bushels. The price received for these oysters, also, is small. When sold at the canneries, a bushel seldom brings the tonger more than twelve cents. In certain seasons, however, he is able to sell his oysters for immediate consumption, and then may receive as much as twenty-five cents a bushel for them. At best, the tonger's business is a poor one.

Experiment also has shown that on many of the tonging grounds natural conditions are so variable that all the care that may be given to growing oysters would be unavailing. Variations in the density of the water, especially, are such that sometimes, even for several successive seasons, oysters become so poor as to be quite unsalable.

While river or shore grounds, with their reefs and tong-

ing bottoms, possibly may never produce many marketable oysters, conditions are different in the broader water. In Pamlico Sound, a body of water approximately sixty miles long by twenty-five miles wide, the possibilities of future oyster culture seem to be great. Opening through the spit that separates it from the ocean, are five or six inlets of sufficient size to give the sound waters a tidal rise and fall of three or four feet. There are, however, no tidal currents except near the inlets, but variable wind currents, often having a velocity of half a mile an hour, are frequently developed, and serve the purpose of carrying food to extensive oyster beds in various parts of the sound. The greater part of the bottom is of hard sand, covered by a thin layer of mud and organic material. The water is shallow, seldom attaining a depth of more than twenty feet. Here and there are extensive tracts at a distance from shore over which there are less than ten feet of water. Waves drag the bottom during severe storms, and sand thus shifted where oysters are growing destroys them in great numbers.

The history of the oyster industry in Pamlico Sound is a record of the usual series of events. Natural beds were discovered, dredging became excessive, the beds were soon impoverished, many of them being completely destroyed, and the ruin of a large natural source of wealth was begun. All this occurred much more rapidly than in Chesapeake Bay—a fortunate circumstance in one way, because it is the usually necessary preliminary to oyster culture.

In the winter of 1887-8 a survey of the oyster grounds of the sound was made by Lieutenant Winslow, U. S. N., and many extensive oyster beds, before unknown, were

charted at this time. There had come a great decline in the yield of the Chesapeake. In the year 1889 the demand greatly increased, and the attention of Baltimore packers was drawn to this newly discovered source of supply made known through Winslow's survey. Many of them sent their vessels south to "develop" the new territory. Large quantities of oysters were dredged and sent to Baltimore, where they were marketed by canners and dealers in raw oysters as the product of Chesapeake Bay.

Pamlico Sound oysters were inferior to those taken from the Chesapeake, chiefly because they were from beds that had never been dredged or extensively tonged. Having grown undisturbed, they were clustered, but because the bottom was hard, they were not so extremely elongated as on the river reefs, and many were large and of good shape.

The appearance of the Chesapeake dredgers made a great and sudden change in the modest industry of North Carolina. Previous to the year 1889 oysters had been gathered only from very shallow water by means of primitive, short-handled, wooden-toothed rakes. From all the waters of the state the number taken had seldom exceeded a hundred thousand bushels. Competition in the markets with other states had been impossible, and only local needs had been met.

But now there had come a great general demand with high prices. There had suddenly appeared a number of experienced oystermen with implements entirely new to the region. The native tongers for the first time learned of the long-handled, basket-like, iron-headed tongs used in the Chesapeake, and they soon profited by the knowledge. Formerly they had been content to fish within a

mile or two of the shore in very shallow water, but the native fishermen soon followed their more venturesome visitors farther into the sound, where many new and extensive beds were discovered. In a short time the tonging industry became an extensive and important one. While much of it was carried on by the non-residents, local interest in the business was also greatly stimulated.

The really important matter, however, was the introduction of the dredge to these waters, where previously it had been unknown. Having found an oyster bed on such a hard, smooth bottom, the captain of a Maryland pungy knew how to load it rapidly. The serious question at first was in regard to the number and extent of oyster beds; but as the work of the dredgers progressed, new beds were continually discovered for several years, until many times the number indicated in Winslow's report was known. Without doubt the early hopes of the Baltimore dredgers were more than realized for some time. But if any entertained the idea that Pamlico Sound would continue to produce oysters as the Chesapeake had done, while subjected to the rapacious method of dredging employed, they were disappointed. There is but one possible result from such methods. It was long delayed in the Chesapeake, because of its unequalled fertility, but it was not long delayed here.

A few statistical statements will tell the story of the rise and decline of the oyster fisheries of North Carolina after the advent of the Maryland oystermen.

For some years before the survey of Winslow, there had been kept a more or less accurate record of the number of bushels of oysters taken by residents from the waters of the state. From this it appears that it rarely exceeded a hundred thousand bushels, and was often

much less. In 1890 the resident oystermen alone sold 914,130 bushels—probably quite ten times the average number formerly gathered. But during this one season, the non-resident dredgers, who had excited all this industry among the local oystermen, gathered and carried away a much larger number, of which no record was made. The outsiders had now come not only from the Chesapeake, but also from Delaware and New Jersey, and their dredging vessels numbered at least two hundred and fifty. It has been estimated that in this year they obtained at least 1,800,000 bushels from Pamlico Sound.

When these facts were understood by the people of the state, they naturally felt very strongly that they were being despoiled by outsiders of great wealth belonging to them alone, and before another oyster season had come, drastic laws were passed that prohibited all dredging by non-residents, and shortened the season for the taking of oysters by resident oystermen. The result of the enforcement of these laws exceeded all expectations, as is shown by the fact that the number of bushels marketed during the season ending in 1894 was only sixty thousand—less than the average of the earlier years, when only wooden tongs were employed. But still the laws were retained, and in the season ending in 1897, but forty thousand bushels were reported as having been taken.

Of course, such a degree of stagnation made it evident that a mistake had been made, and in that year the open season was lengthened. The wisdom of the change was proved during the following season, when 858,818 bushels were marketed. Very much encouraged by this showing, with the demand for oysters increasing, the

oystermen made great preparations for the season of 1898-9. A large number of dredging vessels and tonging boats began work with its opening and continued to its close. The total number of oysters marketed was greater than ever before, 1,559,000 bushels being credited to the dredgers, and 900,000 to the tongers.

Naturally, hopes for the season of 1899-1900 were high, but it brought disappointment, for dredgers and tongers together succeeded in gathering about 1,900,000 bushels, a number far below that expected. In many cases dredgers were not able to pay expenses by their catch. The season's work clearly developed the fact that the source of supply was limited. The optimism of the previous years, that could see nothing but an inexhaustible supply, gave way to the fear, in many minds, that the beds were being destroyed by excessive dredging.

Another explanation for the decrease was offered, however. In the months of August and October of the year 1899, terrific southeast gales had torn the bottom, and had cast upon the west and northwest shores of the sound large numbers of oysters from shallower beds. It also covered many shore beds with mud and sand. It was asserted that waves in the open sound had been large enough to drag bottom, and that shifting sand had thus covered and destroyed oysters enough to account for the great decrease in their number on the beds.

In January and February of the year 1899, the United States and North Carolina Fish Commissions united in an effort to determine the causes of the partial failures of the fishing reported earlier in the season. The investigation showed that the storms had indeed made many changes. In some localities, where destruction had been greatest, as many as twenty per cent. of the

oysters had been covered with sand in quantities sufficient to kill them.

But it was shown with equal certainty that the beds had been reduced, and in some cases almost completely destroyed, by excessive dredging, and that this had been much more harmful than the storms. It was stated in one of the reports on this investigation that for two or three years everything that came up in the dredges of the oystermen had been taken on board and carried to the canneries, where the culling had been done. Culled shells, often bearing young oysters, had been heaped on the shore in great piles, and yet the law provided that culling should be done where oysters were dredged, empty shells and small oysters to be returned to the bottom. The responsibility for this lawlessness rested largely on the state authorities, for no attempt had been made to enforce the law. A fairly good harvest is still marketed each year, but the cull law is not strictly enforced, and the natural beds are still failing.

True oyster culture is not practised in the state. Artificial beds had been constructed in a river near Beaufort as early as 1840, and subsequently many attempts were made to rear oysters on bottoms selected for the purpose. This was not done with the idea of producing oysters for market, but only for private consumption. The small plots were spoken of as "oyster gardens," and the term has been retained locally and applied to all artificial beds. Since 1872 private beds have been authorized by law.

The earlier attempts at oyster culture were naturally confined to the rivers and small bays along the shores. They were conducted on a very small scale, and apparently were never systematically, or consistently carried

out. Usually clusters were removed from a reef and thrown unculled on a convenient bottom. Naturally, these transplanted oysters did not improve, and more often perished. Usually, however, young oysters became attached to their shells in great numbers. In this way it was shown that in some localities a good set could be depended on, and that with suitable collectors a seed-gathering industry might easily be established. But sooner or later the river beds have invariably failed as growing and conditioning grounds, and probably never can be improved. Until the present, also, there has been no protection against trespassers, a condition that alone makes oyster culture an impossibility.

Natural conditions in Pamlico Sound are much better than in the rivers. At about the time of the publication of Winslow's report, on the natural beds of the sound in 1888, and again a decade later, much enthusiasm over oyster culture was developed, and many beds were constructed in the sound; but here, also, the failure of all attempts was complete. The reason given for this by the Fish Commission experts who studied the matter, is that those making the experiments were unfamiliar with the biological requirements. Of the planters it was said, "They were not aware how very much depends upon the selection of ground, the accessibility of an abundant food supply, the specific gravity of the water, and its freedom from extreme fluctuations, the time and methods of planting cultch and oysters, etc." State laws also, very defective and seldom observed, rendered success impossible.

There are, nevertheless, reasons for believing that the biological conditions in many parts of Pamlico Sound are favorable for the maintenance of an artificial oyster

industry of large proportions. The cotton states of the South must soon increase greatly in population. With a greater market for oysters near at hand, extensive oyster culture may be expected to develop in the sound, if reasonable laws are enacted and enforced.

long way to go from the present state of affairs to successful oyster culture.

Florida is the most backward of all states having an oyster territory. In prehistoric times great quantities of oysters were taken from its bays and lagoons, as is shown by extensive shell heaps along both of its coasts. On the Atlantic side natural oyster reefs still are found near Fernandina, and in certain parts of the Indian River, which is a long, narrow bay of salt water cut off from the ocean by a low ridge. The coast-line on the Gulf side is broken by several extensive bays and wide river mouths, in which oysters grow luxuriantly.

Oysters from parts of the southernmost coast are said to be very "coppery" in taste. This peculiar flavor is to be found in oysters from many localities north and south in this country, as well as in Europe. It is not caused by the presence of copper in solution in the water, as it has been supposed, but its nature is not known.

Many of the oysters of the lower part of the peninsula are of the "coon" type, and lie above the low water mark, as in the Carolinas. Much has been written of oysters attached to the roots of the mangroves in Florida, that are exposed at low tide, as if they were as anomalous as the fruit of Eugene Field's "Sugar-plum Tree." These "oysters that grow on trees" are, of course, exactly the same in habit and in position, with reference to the tide, as many of the oysters that grow on mud. In the middle and upper parts of the Gulf shore are many beds bearing oysters of good shape. This is because they are tonged frequently enough to insure the breaking apart of clusters.

Here, also, most of the beds are below tide lines. As in the Carolinas, they have the form of long, narrow

reefs, and lie in very shallow water. Beneath them is a deposit of soft, deep mud that characterizes the Gulf everywhere. The most important growth is in Apalachicola Bay, but it is almost everywhere covered by mussels.

The state of Florida created a Fish Commission in 1889. It formerly paid the president of this commission a salary of one hundred and fifty dollars a year. He has now been made "Honorary President," without remuneration. The secretary of the commission has never received a salary. Out of pure loyalty to the commonwealth, entirely without appropriations, with almost no authority, advancing the interests of the fisheries to the best of their ability from their private means, receiving no indirect benefit, subject to criticism, and doing a large amount of valuable work, this commission has served for many years.

There are oyster laws in Florida, but none are observed, except that the cull law, requiring shells and small oysters to be replaced on the beds from which they are taken, has been enforced in Apalachicola Bay—at the expense of local dealers, and not by the state. A very few oysters are steamed and canned.

Undoubtedly there are extensive tracts on the Gulf coast of Florida that might supply a large market with cultivated oysters. An estimate based on a U. S. Fish Commission oyster survey places the number of acres suitable for oyster culture in Apalachicola Bay alone at 6,800. A great fear that assails Florida as well as other states, is that these oyster bottoms may sometime fall into the hands of some monstrous corporation. For several reasons, this will not be realized. Among them are the facts that capital will not be invested while political conditions remain as they are on the Florida shores, and

that the shallow bottoms permit the gathering of oysters only by the slow, laborious, and uncertain method of tonging.

A glance at a map reveals the limited shore lines of Alabama and Mississippi. From east to west the former has about fifty-five and the latter about seventy miles of coast, though Mobile Bay and Mississippi Sound make the shore line actually very much longer. But oyster waters within these states are not extensive enough to promise important developments in the oyster industry of the future.

To the present time, however, Mobile in Alabama, and Biloxi in Mississippi, have been important canning centers. Most of the oysters canned in the latter city were formerly taken from waters claimed by the state of Louisiana, which claim was upheld by the U. S. Supreme Court in 1906.

Louisiana is the most progressive of oyster producing states excepting those of the northern field. Its production is not large when compared with that of Maryland or Virginia, but it has made great and substantial progress in oyster culture, and the industry, responding at once to sensible and liberal laws, is growing rapidly and securely.

In one respect Louisiana is unique among states possessing oyster fields. While the greater part of its product has been derived from natural beds, it has not waited until these were destroyed before searching for some other source of supply, but has energetically and intelligently encouraged oyster culture. At the same time its natural beds, though now more or less depleted, are being systematically cared for, and bid fair to remain as prolific public tonging grounds for some time to come.

Better oysters than those from the natural beds are being produced in increasing numbers on cultivated tracts.

Every one is familiar with the manner in which the great Mississippi is bearing down and depositing in the Gulf, as it has done for ages, vast quantities of surface soil eroded from the interior. It perhaps is not so well known that the land all about its delta is slowly subsiding. Back from the shore, the preserved stumps of trees once standing near the water, have been found hundreds of feet beneath the surface of the ground. It is stated that oyster shells have been encountered at a depth of two thousand feet, in some of the recent oil well borings near the Texas line, though the statement needs verification. In spite of this subsidence, that still continues, the river is building its channel each year farther into the Gulf on its own deposit.

The whole of the present delta and the shore east and west of it is irregular and much broken. Some have estimated the actual extent of the shore line in the state at two thousand miles, but on account of its unstable nature in some places, no accurate estimate of it can be made. The extent of the enclosed bays and lagoons is, however, very great, and in them oysters thrive. Comparatively few oysters are found, or can be reared, on the west half of the coast of the state.

Some very optimistic estimates have been made of the area available for oyster culture. One writer, for example, citing the fact that oysters are planted in seventy-five feet of water in Long Island Sound, reasons from it in the following interesting manner:—If it is possible to rear oysters at that depth in Connecticut, it will be possible also in Louisiana. If, then, we draw a line on the map following the seventy-five foot level, in the Gulf,

the bottom between it and the shore will constitute the oyster field. This area embraces six million acres.

Though it is believed by some that oysters exist in the waters of the open Gulf, this has not been demonstrated, and is very doubtful. Whether conditions will allow of their growth if planted there, must be determined by experiment. What evidence we possess, as will be explained later, makes the possibilities of oyster culture in open waters other than those of Chandeleur and Isle au Breton sounds seem to be very few.

The broken coast of St. Bernard Parish, or County, as it would be called in another state, is quite typical. Sailing southeast from the opening of Lake Pontchartrain across Lake Borgne, one sights what seems to be a low, straight shore line in the far distance. Soon the stranger to this region discerns, at wide intervals, isolated groves of dense forest growth, but nothing in the background to break the monotony of the straight line of shore. Then, with bewildering suddenness, the vessel draws near; the distant coast, with its hidden details, resolves itself into a line of grass near at hand. While one gazes at them, the trees shrink into low shrubs, and one experiences the weird sensation of having arrived at the kingdom of Lilliput.

But the vessel skirts this dense jungle of stiff, high grass from morning until night, and a second or a third day may still find it passing the unchanging, but by no means uninteresting, borders of this strange kingdom. Now and then an excursion may be made into its interior through one of the numerous inviting channels that lead to a network of narrow bayous, broad passages, or salt lakes, many of them of great size. One might sail for weeks through these meadows and among islands always

new, and yet always the same, but it requires only a short time to make a strong impression of the immense expanse of this land. There are more than five hundred square miles of it in this and in the neighboring parish of Plaquemines, and some of the inland bays or lakes are many miles in extent.

The soil is everywhere a stiff mud rising less than twenty inches above ordinary high tide, though here and there the waves of storms have piled up long banks of shells to a height of three or four feet. Nothing else except low mangrove bushes relieves the monotonous expanse that stretches to the horizon. But this is not everywhere true, for once or twice on the way down to the east bank of the Mississippi, an oysterman's hut or a small canning factory, unnaturally and monstrously imposing in its surroundings, appears high up on the ends of piles. In spite of all precautions, these buildings are in a precarious position, for in hurricanes like those of 1893 or of 1900, the whole region may be covered by angry water to a depth of ten or twelve feet.

Those passes that serve as channels for the tidal flows are sometimes deep, but in the bays and quiet lagoons, from three to six feet of water only, cover a bottom of mud. The normal rise of the tide is but a few inches, and very little bottom is exposed at low water.

In spite of the general atmosphere of barrenness and utter desolation, the waters of this country are found almost everywhere to bear natural oyster beds, many of which have practically never been disturbed. Some of the bottom is hard and otherwise offers an inviting opportunity for oyster planting. Much tonging is done on some of the natural deposits, and culling on the tonging grounds is more generally practised in Louisiana than in

any other state. The supply is thus in a measure continued. Oysters are not found exposed, as in the Carolinas and Florida, because the normal fall of the tide is so slight. Growth being rapid, clusters form in a very short time, but when these are culled after tonging, the beds produce large and well-formed oysters. The extensive waters of Lake Borgne to the north, into which Lake Pontchartrain empties, are too fresh for oyster growth.

If one will consult his map, he will find, about twenty miles to the east of St. Bernard Parish, and a slightly greater distance south of the Mississippi shore, a long, crescent-shaped group of islands known as the Chandeleurs. These, with the Errol group to the south of them, constitute a sand-spit nearly thirty-five miles long that encloses Chandeleur and Isle au Breton sounds.

Strange sensations also await the explorer of these uninhabited and utterly lonely islands. Climbing to the top of one of the greater elevations—some twenty feet above the water—he sees about him a succession of mountains and valleys of silicious sand, many of them bearing mammoth vines and scattered grasses. For some reason that is difficult to define, one seems to stand among formations having all the appearances of great hills, valleys and plains, but all in miniature; and the vivid imagination of childhood, lost and mourned by those who have had too much to do with realities, comes back unbidden in a flood. Here, at least, in all the world, it is possible for a day to step back through the years, and, care-free, to explore the wonders of fairy-land.

On the east, surf from the open Gulf breaks on a wide, firm beach, the monotony of which is broken by stranded

tree-trunks floated out from shore, or by the wreckage of vessels—for it is a dangerous region for the sailor.

On the protected western side, the bottom is extremely shallow for a mile or more, and bears quantities of "eel-grass," while on the shore is a growth of thatch. One experiences a feeling of insecurity on discovering the shells of sand-dollars and other aquatic animals halfway up the sides of the sand hills, where they have recently been left by the waves of a storm, and there is at once recalled that terrible night, never to be forgotten in Louisiana, when the gay summer colonists of Dernier Isle were surprised by a tropical hurricane, and swept inland for a distance of many miles on furious waves from the Gulf.

So seldom are the Chandeleur Islands visited that stilts and other birds, pattering over their western mud-flats, are almost without fear, and may be closely approached.

The hundreds of square miles of bottom in Chandeleur Sound lie in less than eighteen feet of water. Whether any considerable part of it will ever be available for oyster culture cannot now be told, but according to fishermen, it formerly supported beds of considerable size. It is possible that here, where some of the natural conditions seem to be different from those in the Gulf, oyster culture might be established. The territory is so great, and is so conveniently situated with reference to markets, that experiments should be made to determine its possibilities.

West of the mouth of the Mississippi, the character of the coast is much like that of the eastern side, for the entire lower part of the state many miles back from the water, is a swamp that rises very little above sea level. Here are extensive bays—Barataria, Timbalier, and Terrebonne—once the home waters of the pirate La Fitte,

a century ago the terror of the Gulf. These bays are now the busy scene of a rapidly growing oyster industry.

The most important oyster grounds of the state are found west of the river in Terrebonne Parish, but nearly everywhere in this region they are becoming depleted, and are giving way to the more productive cultivated beds.

The first move toward true oyster culture has always been the transplanting of culled oysters from natural beds to prepared bottoms where they may grow. This was practised many years ago in Louisiana by the luggermen, and has been continued by others, often on leased ground. But true oyster culture—the capture of spat that would otherwise perish—is very easily accomplished in these waters, and since about 1885 a large number who have rented grounds from the state, have learned to spread oyster shells for this purpose. With the decrease of the natural beds, this practice is growing, and promises much for the near future.

To the present time, little effort has been made to cultivate oysters on very soft bottoms, of which there are great numbers situated where other conditions are favorable for oyster growth. Such bottoms have been reclaimed in Long Island Sound by the use of sand and gravel. But the bottoms here are often so soft and oozy that it is the common belief among oystermen that even shells would sink out of sight in them.

Experiments conducted on these bottoms in 1904 by the writer, proved that this is not true, and that a firm pavement may be constructed on the softest silt. In the open waters of the Gulf, where the mud was so soft and deep that a sounding pole was thrust into it to a depth of many feet with no effort, and from a boat under way, an extensive foundation of shells was prepared for an oyster

bed. A coating from four to six inches deep was found to make a firm and permanent foundation. Experimental beds on ooze exposed by the tides, constructed of small shells, in layers two or three inches deep, remained in a firm layer on top of the mud, and without change, for at least a year.

One of the most curious sights to be witnessed along the Louisiana coast is the immense accumulation of shells found rising above the water at many points. These are of several species of marine or brackish water bivalves, and on account of their small size, afford ideal material for seed collecting. Very few oysters can attach to a single shell, and, consequently, clusters cannot form on them. In most cases but a single oyster will develop on each shell (Figures 52 and 53).

To appreciate fully the great advantage that the Louisiana culturist might possess in these shells if he would use them, it must be stated that oyster growth in these warm waters is so rapid that a large cluster may form on an oyster shell in one year. To assume a size and shape that will fit them for market, these must be culled before further growth takes place. The labor of culling during the first year at least might be avoided by the use of these small shells. Their accumulations are of great extent, and often are so situated that planks may be extended from them directly to the deck of a schooner lying alongside.

Yet this ideal cultch is used very little in Louisiana, oyster shells being preferred, perhaps because shell heaps at the canneries are convenient and must be disposed of. It is a pity that they should be used only to pave streets in New Orleans and Lake Charles.

It is not possible with data that we now possess to

make a definite statement of the average rate of growth of oysters in any of the great oyster fields. One bay or river mouth may afford advantages such as food, that a neighboring locality lacks, and growth here may be much more rapid than elsewhere. But the general practice of oystermen in Long Island Sound is to allow oysters to grow four, or very rarely three years, after the spat has been collected.

Without doubt, in Louisiana waters, the average time required to produce a marketable oyster having a length of five or six inches, is at least a year shorter than in the northern field. Usually this size will be attained in three years from the time of attachment, and sometimes in two years. In Quarantine Bay, whole beds have been known to develop in eight months, oysters averaging nearly three inches in length. In Bayou Coquette, collectors have borne oysters more than two inches long in seven months. A piece of rock in the possession of the U. S. Bureau of Fisheries bears forty or fifty shells, all more than four inches long, that had grown in the waters of Bayou Schofield in twenty-three months. In many parts of Terrebonne Parish, oysters are said to attain marketable size in three years. It is said that in Bayou Cook, from which come most of the best oysters, the period of growth is but two years. So reliable and well informed an observer as Mr. H. F. Moore, of the Bureau of Fisheries, states that he has seen in Plaquemines Parish "oysters six inches long which, from known data, could not have been over twenty-three months old." No comment is necessary on the immense advantage possessed by the Louisiana culturist in this short growing season.

While starfish never molest oysters in this field, the



FIG. 52. Shells of *Arca* with young oysters attached. These shells are very numerous on parts of the Louisiana shore.



FIG. 53. Single oysters attached to shells of a small clam. These shells make ideal collectors. They and the shells of an allied bivalve form great collections all along the Louisiana coast.



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drumfish is often destructive in some localities. The only certain protection against it is a stockade of pickets built about the beds, and such fences are often constructed. It is not, however, a general practice on the oyster fields, and in most places there is little danger from this oyster destroyer.

If it should ever be possible to cultivate oysters in Chandeleur Sound, steam vessels with large dredges might be employed, as in Long Island Sound. There is immense advantage in being able to gather large cargoes rapidly, and in all kinds of weather. One of the disadvantages of the shallow waters in which oysters are now cultivated is that dredges can seldom be used, and the fishing must be done only with tongs.

Now and then—though at intervals of several years—the Gulf coast is visited by appalling hurricanes, that shift the shallow bottoms and destroy great numbers of oyster beds.

The most serious menace to the industry in Louisiana is the flooding of the fields with fresh water from crevasses in the Mississippi River. By consulting a map, it will be seen by the courses of the waterways, that any great break in the Mississippi levees below the mouth of the Red River, may threaten the oyster territory either on the east or west. The great Nita crevasse of 1890, still often referred to by the oystermen, poured its flood southward through Blind River, Lake Maurepas, Lake Pontchartrain, and Lake Borgne, and freshened the waters of St. Bernard Parish for so long a period that oysters were nearly exterminated over an immense area. The waters remained fresh for weeks, and the flood deposited a large quantity of sediment. Other great crevasses have occurred, and some of them it has never

been possible to close. The map shows how flood waters from the Mississippi and the Red rivers may also be poured into the bays west of the delta. It should be said that, in the majority of instances of widespread destruction by fresh water, the usual profuse set of young has occurred during the breeding season following, from adults that have escaped destruction in deep depressions in which the water remains salt. If the much discussed plan of improvement of the waterways of the entire Mississippi basin by the federal government should be realized, this greatest danger to oyster culture in Louisiana would disappear—a fact that seems to have attracted little or no attention.

The chief advantages possessed by the Louisiana culturist may thus be summarized:—Growth is much more rapid in the Gulf than elsewhere. This is due to the unusually large supply of diatoms found in the warm waters. They are plentiful enough to support an enormous oyster population. The growing season, also, is of long duration.

There is nowhere anxiety lest the set of spat should fail. The collection of young is much more certain than in a colder climate. The chief reason for this probably is that sudden and extreme declines of temperature, and cold rains, that destroy so many swimming oysters in the north, do not occur here in the summer. Usually the salinity of the water is very favorable for reproduction over the entire field. Small shells, that may be used as collectors, are almost everywhere piled up on the shores. Gulf oysters have very few natural enemies, and none cause extensive or frequent losses. Winters are mild and short, so that the gathering of oysters is never difficult on account of cold.

There is already a much greater demand than can be met by the local supply. Louisiana oysters are favorably known as far north as Chicago, and a great market is waiting in the Mississippi valley, north and south. Even with present transportation facilities, New Orleans might readily obtain a large part of the Pacific trade in eastern oysters, if the Gulf were made to produce them.

Little definite information exists concerning the oyster territory or the oyster industry before the year 1898. In that year the state legislature requested the U. S. Bureau of Fisheries to examine the oyster field. This was done, and in 1902 a state Oyster Commission was created. This has since been given powers that have made it the most effective body of its kind in the country.

Its members receive adequate salaries, and give their entire attention to the work of building up the oyster industry. It has been made a department of the state government. It has authority to sue, and may be sued. It may buy, sell, or lease property, enact contracts, and do anything necessary to enforce the oyster laws. It adopts by-laws for its own government and that of its employees. It enlarges and cares for natural beds, and protects lessees of private oyster grounds. It determines the limits of natural beds, and may use its own discretion in allowing the use of dredges on them. Its acts are subject to review by the courts. It has police power, and has organized an extremely efficient force. It has been granted large appropriations. Practically all of its recommendations have been acted on promptly by the legislature. In short, that body has had the great wisdom to place the entire management of the industry in the hands of a few competent men, and to hold them responsible for its success.

As might be expected, their success has been very great. In two years after the appointment of the Commission, the number of leased acres increased from 2,820 to 23,303, and since then has steadily grown. Production, also, is now increasing rapidly, and new packing houses are being established. The oyster laws are being enforced, lessees are being protected, and the commission reports that there is "a notable absence of any disposition to violate the oyster law or the regulations of this Commission." This is all so unusual and so refreshing that it might well be commended to the attention of students of popular government. There is much to be learned from the practical wisdom of Louisiana.

It should be interesting to those who make the laws of some other states to witness in Louisiana the subsidence of the fear of an oyster monopoly. This at one time was acute, but since even corporations—Louisiana corporations, it is true—have been allowed to lease a thousand acres, and leases have been made heritable and transferable, no indication of a monopoly has appeared. The "poor man" with ten acres, benefits by the improved markets as he does in Connecticut. The fear of an "oyster trust" is so nearly dead that the time will probably come when outside capital will be invited, and the limit on leases extended or removed altogether.

Leases are made at a dollar an acre each year for fifteen years. For the ten years following, the rental is two dollars an acre annually. After that, the value of the property shall be assessed, and such rental shall be paid "as conditions shall warrant." There is a tax of three cents a bushel on oysters produced on leased ground.

There is no close season on the leased grounds, and no

restriction is placed on implements that may be used by lessees.

One admirable section of the law is that instructing the Oyster Commission to publish and distribute copies of the act, and to publish its rules and regulations, as they are adopted, in its official journal, chosen from among the daily papers of New Orleans.

Among other interesting provisions is that reserving bottoms for scientific experiment near the biologic station at Cameron. The state seems to have placed much confidence in the work of biologists, whom it has invited to study the natural conditions existing on its oyster fields.

In Texas, the most western of the Gulf states, practically the entire coast is bounded by a narrow water zone that, in turn, is separated from the Gulf by a low bank. In many parts of this confined area, conditions are favorable for oyster growth. One hundred and forty square miles of Matagorda Bay, probably comprising the best of the natural oyster area of the state, has been surveyed by the U. S. Bureau of Fisheries, and its scattered and limited beds have been charted. It was shown by the expert in charge of the survey that the natural beds would supply only a limited number of oysters. There is every reason, however, to believe that oyster culture might be successfully practised over a much greater area than that occupied by the natural growth, and, on the whole, the oyster laws are favorable for its development.

One advanced feature of the state oyster law is that permitting any citizen of the United States, or any Texas corporation, to lease bottoms. This approaches the legal provisions of Connecticut. The lease, however, is lim-

ited to six hundred and forty acres. As yet there have been few applications for oyster grounds, though there is little opposition to the system.

It may be expected, in view of the growing demand for oysters, that the shore of Texas will soon possess cultivated beds, and though the supply may not seek distant markets, it may be great enough for a time to satisfy the requirements of that rapidly growing state, which, however, is truly an empire in itself.

CHAPTER XVII

THE PACIFIC FIELD



INSIDE waters are so numerous all along the Atlantic coast that a few short canals would provide an enclosed navigable waterway from Massachusetts Bay nearly to the South Carolina line. Some of the Gulf shore is similarly protected by outlying spits and islands. But the Pacific coast, from the entrance to Puget Sound southward to Mexico, is entirely different, being straight, unbroken, and unprotected. There are few enclosed bays or even harbors on this great stretch of coast, the only extensive ones being Puget Sound, in Washington, and San Francisco Bay, in California.

The same species of plants and animals are not found in Atlantic and Pacific, but more or less distantly related forms. The class Asteroidea, of zoological classification, for example, is represented by several species of starfish in one ocean, and by somewhat different kinds in the other. The eastern oyster, *Ostrea virginica*, is replaced on the Pacific coast by another species of the same genus known as *Ostrea lurida*. On the Mexican coast are still other species.

Ostrea lurida is much smaller than the eastern oyster, and differs from it also in having a light, thin shell, and in being hermaphroditic, a condition in which each individual produces both male and female cells. In the im-

portant commercial matter of taste, all oysters are much alike.

Several Atlantic animals have been introduced into the Pacific, and have established themselves. Among them are the shad, striped bass, and the soft or long neck clam. For many years, also, small eastern oysters have been planted in the bays of Washington and California, where they grow to marketable size in three or four years. They, however, have not become established.

Entering the Golden Gate in California, the water spreads north and south to form San Francisco Bay. Into it flow many streams, some of them large like the Sacramento from the north. The water is consequently brackish and favorable for the growth of the native oyster, which is found here in great numbers. Perhaps because this oyster is very prolific and because there is much crowding on the natural beds, it attains scarcely half the size to which it develops in Willapa Bay, and consequently is not often marketed.

In Puget Sound and Willapa Bay in Washington, the transplanting or bedding of the native oyster has become an extensive industry. Some years ago, the state of Washington set aside immense tracts in these bays, designating them as "Oyster Reserves." On parts of these were natural oyster beds. It was intended that from them oysters should be taken only for the purpose of planting on barren bottoms, and not for immediate sale.

But the state has not been able to police these grounds and enforce the provisions of the laws, and has received very little revenue from licenses issued to tongers. The public beds in Puget Sound are infested with starfish,

which the state authorities have not attempted to destroy, and, as in all similar cases, the bottoms are rapidly becoming depleted.

As yet, true oyster culture—the capture of young on collectors, and their subsequent planting—has hardly been attempted in these waters. Instead, seed has been obtained entirely from natural beds, three or four years being required for its growth. Much of the planting is done on bottoms that are exposed at low water. The capture of the swimming native oyster may easily be accomplished, however, in favorable localities near breeding individuals, and with the decline of the natural beds the method will undoubtedly be resorted to.

About twenty thousand acres of barren bottoms have been sold to individuals or to corporations, but few have been planted. From them, seventy thousand sacks of native oysters, each containing about two bushels, are marketed annually. The destruction of San Francisco, which had consumed a large part of the Washington harvest, temporarily affected the market, but as in every other oyster field in the country, there is now an increasing demand for this universally appreciated food.

Live eastern oysters were first sent to the Pacific coast at San Francisco about 1870, on the completion of the first transcontinental railroad. These were sometimes bedded in San Francisco Bay, to be removed for sale, and were found to thrive. Afterward it became an established practice to ship small seed from New York for planting in this bay, and the industry has continued and assumed large proportions.

Eastern oysters are usually planted on mud flats that are exposed at low tide. So placed, they may easily be fenced in and protected from the attacks of a sting-ray

that abounds in the bay during the summer. Seed oysters reach a marketable size in three or four years.

It was not until 1894 that eastern oyster seed was planted in Willapa Bay. This shoal body of water is twenty-five miles long, and has an average width of about five miles. It has always been a famous bedding place for native oysters. Eastern seed from Maryland, New Jersey and Long Island, planted here by the U. S. Fish Commission, grew as well as in San Francisco Bay. A hundred car-loads of seed oysters, varying in size from a quarter of an inch to an inch and a half in diameter, are sometimes planted in a year. During the last few years eastern oysters have been planted in Puget Sound, but not yet in large numbers.

In spite of the fact that freight charges on eastern seed amount to five hundred, or at times to more than seven hundred dollars a car, the trade is growing on the Pacific coast. Retail prices are necessarily high.

It is a fact of economic as well as of biologic interest that these transported oysters do not often reproduce in Pacific waters. To the present time, not a case of attachment by a swimming eastern oyster has been observed in the state of Washington. In 1889, however, it was discovered by an investigator of the U. S. Fish Commission that they were breeding in a few places at the south end of San Francisco Bay, and hopes were entertained that they might become well established there. These hopes have not been fulfilled.

The adverse condition in this case is probably the low temperature of the water. The fact may not be well known on the eastern coast that the waters of northern California, of Oregon, and of Washington are, during the summer, as icy as those of Maine. There is little

variation in temperature during the year. In the Atlantic, a set of spat is rarely obtained if the water temperature often falls much below 70°F . during the breeding season. Failure of the set is common in the northern field, probably because of rapid declines in temperature from cold summer rains.

On the Pacific coast, even in the bays, the maximum summer temperature of the water rarely exceeds 70° , and at most places the average is nearer 60° . It is not to be expected, then, that eastern oysters may reproduce in these waters. But in some of the creek mouths of San Francisco Bay, the shallow water is kept warm by the sun, and it is in them that reproduction has been observed.

Perhaps it is possible that the species might be acclimatized to a lower temperature, but this could be effected only in several generations. There is no reason to expect that any constitutional change that might accustom any individual oyster to its new surroundings, would restore its lost fertility. But it may be that the species could again be made fertile by following the selection method of breeders of domesticated animals and plants. After careful observation of summer temperature, bottoms might be selected over which the minimum was somewhat below 70° . If large numbers of eastern oysters were planted here, some individuals might possibly be found to possess the constitutional power of breeding at a slightly lower temperature than that required by the majority. Whether this is true or not in this case has never been observed, but similar individual differences have been found and taken advantage of in the cases of many other organisms.

If now some individuals of the first generation should

have produced offspring, and these were captured on collectors, this second generation might be planted in an isolated locality. If few in number, the water should be of the same temperature as before. If numerous, they might be placed in slightly colder water. It might be assumed, from analogous cases observed in other organisms, that some of the individuals of this second generation would exhibit a still greater power to breed in a low temperature than that possessed by their parents. In water of the same temperature as that in the first experiment, also, the average fertility would have become greater.

In the same manner, the third generation, if numerous in individuals, could be planted in still colder water. Perhaps only a few of these could breed, but if any were able to do so, the offspring again would exhibit the power to withstand the increasing cold, and this might be carried on until all surviving individuals would be able to propagate anywhere in the cold Pacific coast waters.

Whether such an experiment would succeed, cannot be predicted. Much would depend on the judgment of the experimenter and on the facilities at his command. But on account of the superiority of the eastern oyster as a food mollusk, it may be an experiment worth a trial.

The production of native and Atlantic oysters in Wilapa Bay and Puget Sound is increasing rapidly. The red-blooded generation of men that has made this wonderful region its home, is losing no opportunity to develop its natural resources. It is said that the annual profits on some oyster farms have reached a thousand dollars an acre. Such achievements have naturally attracted the attention of investors. Numerous stock companies have been formed, and have purchased barren

bottoms. In many cases, after the manner of modern business, stock in these companies has been greatly over-capitalized. Some companies have sold stock and have failed even to begin to operate. Most failures have resulted from the fact that no attention has been given to the habits of the oysters, or to biological conditions existing over the bottoms purchased.

But where intelligence has united with an honest desire to succeed, large dividends have been paid to stockholders by many companies, and the time probably is not far distant when the available bottoms will be made to produce a large harvest.

Several years ago the important suggestion was made that the large oyster cultivated in Japan might be introduced on our Pacific coast. It is a larger and better oyster than the native form. Neither state nor federal authorities have performed the experiment, but individuals have made several attempts in the state of Washington. What successes they have attained, however, have not been made public.

CHAPTER XVIII

THE SOFT CLAM—DISTRIBUTION AND CONDITIONS CONTROLLING IT



SINCE the earliest times the soft, or long neck clam has held a place in public esteem on the north Atlantic coast above all food mollusks but the oyster, and in recent years it has become even more highly prized than formerly. One curious reason for this growing appreciation is the fact that it is becoming scarce. It has always been observed that a leading characteristic of human nature is to desire most strongly anything that is denied. On the other hand, the abundant things are not often esteemed. The flounder, very abundant on the north Atlantic coast, is one of the finest of salt water fishes, yet the native of the Maine shore will seldom use it on his table if a morning of hard labor will bring him a tough and tasteless cod or haddock. He may catch the flounder without effort at his dock on any rising tide, but must go outside and fish patiently for his cod.

All along the New England shore, the soft clam was once extremely abundant, as we learn from the quaint records of the early colonists. Well into the nineteenth century, beaches and flats continued to be crowded with them. With the growth of the fisheries, they were dug in increasing numbers for bait, and some were used for food. They have continued to be valuable chiefly as fish bait, but during the last decade, especially, the deli-

cious clam chowder has become popular, and now, a hundred miles inland from the New England shore, no outing of a Mystic Order or Barber's Picnic is complete without its clam bake, in which both soft and hard clams are used. When one has the time for it, nothing on the bill of fare of a restaurant is more tempting than the dish of steamed soft clams with the cup of melted butter.

From the time when Captain John Smith wrote, "You shall scarce find any Baye, Shallow Shore or Cove of Sand, wyere you may not take many Clampes," to a quarter of a century ago, many New England farmers living near the shore made it a practice to fatten their hogs on clams.

Though the soft clam is sometimes found below the low water line, it usually lies buried several inches beneath the surface of bottoms that are exposed at low tide. It is found on narrow beaches, where only a few yards of bottom are uncovered, but the larger beds are situated on great flats. There are many places on the New England coast where the low tide exposes hundreds of acres of continuous flats, and most of these at one time bore enormous beds of clams. It seems incredible that digging alone could have destroyed them, and yet without question, this is almost the sole cause of the nearly complete destruction that has occurred on almost all of these immense beds. There is no such thing as an inexhaustible supply of organisms useful to man.

In Massachusetts, extensive flats are perhaps more numerous than in other New England states. From the mouth of the Merrimac River an almost continuous flat extends southward to Gloucester, a distance of fifteen miles. In Boston Harbor and the other bays connected

with it on the south, miles of flats are exposed at low tide, and one may stand at Plymouth and look northward toward Duxbury on to a flat that stretches away for nearly seven miles, and is approximately four and a half miles wide.

Only a few decades ago, a very large part of these immense areas bore clams. Many are still taken near Newburyport on the Merrimac, and near Boston, but the famous Duxbury and Plymouth flat is practically unproductive. Less extensive areas, that formerly produced clams, are now barren almost without exception.

For several years the same has been true of Connecticut and Rhode Island, and the market has depended on the state of Maine for its supply. Here the shore is high and rocky, and beaches and flats where clams may grow are comparatively few and small. As the Maine clam beds had been little dug until recently, they produced a large supply for a few seasons, but now are far on the way to destruction. Neither ice and the extreme cold of the long winter, nor the close season during the three summer months, that has been in force for a number of years, has prevented the rapid decline of the industry in Maine.

Outside of New England, on the Atlantic coast, the soft clam has never been very abundant, though many were found about Long Island and in the New Jersey bays. It is essentially a cold water form, and the southern limit of its range is the coast of South Carolina. It is found in parts of Chesapeake Bay, but is there used as food only by the poorer residents of the shore. From Maine it extends northward to the Arctic Ocean, where the seal, walrus, and polar bear sometimes feed on it. It is also found on the northern coasts of Europe and Asia.

It is in New England that the soft clam is most prized, and during the cold months it is marketed alive in the interior towns as well as on the coast. It does not live long out of water in warm weather, but in a temperature near the freezing point, will keep alive for weeks. Near the shore it is eaten during the summer, steamed and baked and in chowders. Immense numbers are cooked and canned, suffering much less change of flavor in the process than oysters do, and the solid "meats" and chowders thus prepared are shipped to all the northern states. Recently, also, "clam juice," the mucus drained, from the bodies of shucked clams, has been canned or bottled, and is widely used as a broth, especially by invalids, for with most persons it is readily digested, and its flavor is pleasant.

Exactly as in the case of the oyster, this, one of the most valuable of marine foods, has so nearly approached destruction that it is time to plan for its future production by artificial means. By aiding nature, the shores have been made to produce more and better oysters than they ever bore when uncared for by man. As yet, clam culture has not been practised on a commercial scale, but for a number of years the preliminary study of the creature's life history and habits has been carried on under the auspices of the U. S. Bureau of Fisheries, and by the state commissions of Massachusetts and Rhode Island, and the result, as was expected, is that a method of culture has been devised and tested, and has proved to be entirely successful. Not only is this true, but it has proved to be very much easier and cheaper to rear the soft clam than the oyster, as will be shown. When the conservative New England states become sufficiently aroused to repeal their antiquated and absurd colonial

laws governing beach rights, and are ready to formulate new ones giving irrevocable titles to clam bottoms, the clam industry will quickly become established on a safe basis, and its growth will be rapid. This battle for property rights on the shore, and for protection, has been fought and won by the oystermen, and to the satisfaction of all; and it must be fought in the same way by the prospective clam culturists. The result will be the same, and immense wealth will be produced from lands now entirely barren and useless.

Common names given to plants and animals are local, while the technical or "scientific names" that often cause so much popular amusement by their length or unfamiliar sound, are universal names. A form is often given one common name in one locality, and others elsewhere. The large mouthed black bass, for example, is also called the Oswego bass in the North, while the same fish is known as the trout in some of the southern states. At least thirty other common names are given to this fish in different localities. Along the shore, the name dogfish refers to a species of shark, while inland it designates a very distantly related form. The lay reader may readily appreciate the necessity of a technical and universally employed system for the naming of a species, if he will consider the case of the clam. The name clam north of Cape Cod usually refers simply to *Mya arenaria*, though it may, in some localities, designate *Mactra solidissima*, the sea clam. From Rhode Island to the Carolinas the term might refer not only to *Mya* and *Venus* (the little neck, hard clam, or quahaug), but to half a dozen allied forms. From Florida to Texas, *Venus*, *Pecten* (the scallop), *Pholas*, *Gnathodon*, and several others are "clams." Not only does one term

refer to many forms, but a single form may have several names. *Mya*, in different localities, is known as the clam, the soft clam, the long neck, long clam, squirt clam, and in England as the sand gasper, and old maid. In France, Norway, Korea, and Japan, it of course has many other names. To use only vernacular names in zoological writings evidently would lead to the utmost confusion, so biologists the world over employ a common nomenclature, and when an English book or paper refers to *Mya arenaria*, the Japanese student who reads it has no doubt as to the species that is meant.

Each species is given two names, the first or generic, being a family name, and the second a species name. In New England waters we have two scallops, closely related, but differing in some characters. The generic or family name of these is *Pecten* (begun with a capital), and the two species are distinguished as *Pecten tenuicostatus* (the species name begun with a small letter) and *Pecten irradians*.

With this lengthy explanation, we may consider securely some of the habits of *Mya arenaria*—or *Mya* for short, for there are no other species on our shores with which it is apt to be confused; or if, from force of habit, we return to “clam,” the name at present is to mean *Mya*.

Mya spends the greater part of its life buried in the mud or sand. Large individuals sometimes burrow to a depth of more than a foot. Food and oxygen must continually be gotten from the water, so the creature reaches up to it by means of its siphon tubes, the ends of which may be seen when the bottom is nearly exposed. When the water is quite gone, these siphon ends are slightly retracted from the surface, and leave a depression

or hole. By the size and number of these pits, the digger may judge whether his labor is likely to be worth while.

Such a bottom is well illustrated by Figure 54, where individuals happen to be very numerous. Though most of the pits are relatively large, one cannot always be certain that all clams forming them are also large, for often a pit is used by several individuals in common. These lie at different depths according to size, the larger occupying the lower levels. This distribution allows an immense number of clams to crowd together where there is food enough to support them all. The clams shown in Figure 55, for example, were all dug from beneath a single square foot of a prolific bed.

The bottom in which clams burrow is not always muddy. Most often it is made up largely of sand mixed with mud or clay, and at times they are found in almost clear sand. In the latter case the shells, instead of being discolored as in muddy bottoms, are pure white. In some localities, usually on sandy beaches, lime is not abundant, and shells are thin. Such clams are known as "paper shells."

When a clam bed is dug frequently, many are killed by the fork or hoe, and subsequently become covered. Their decaying bodies stain the surrounding sand a pitchy black, and give it an offensive odor, so that clam digging is not always a pleasant occupation. If clams are very closely crowded, especially where tide currents are sluggish, the decay of several bodies leads to the death of others, indirectly by the formation of compounds that eat through the lime of the shells, and apparently also directly by poisoning or infection.

Mya sometimes lodges and burrows in places quite in-



FIG. 54. Holes of long-neck clams very thickly set in a beach. From a Report of the Mass. Fish and Game Commission by D. L. Belding.



FIG. 55. Long-neck clams dug from beneath one square foot of a flat. Such a yield is very unusual. The ruler has a length of six inches. From a Report of the Mass. Fish and Game Commission, by J. R. Stevenson.



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accessible to the clammer. Beaches so covered with large stones that the ground can be dug only with great labor, often hide clams in large numbers. They also settle and burrow among the thatch plants near the high water mark, and are safe in the dense feltwork of roots.

It is interesting to watch an expert clammer at his back-breaking work, and to observe its effect on the clams that remain where the bottom has been disturbed. The implement used in digging is a short fork with four or five tines bent at right angles to the handle. This is forced down with one hand placed near the head, and the dirt is thrown back between the digger's feet. In this way, clams too small to be placed in the basket are covered with loose dirt or left exposed.

When the tide comes in, the dirt piles are leveled somewhat. As soon as the buried clams feel the water, they right themselves so as to bring the posterior ends of the shells upward, and push the fleshy siphon tube toward the water, which few of them fail to reach, unless severely injured. It appears from this that no harm is done the survivors when a clam bed is dug, except the unfortunate individuals that have accidentally been crushed by the fork. Indeed, they are benefited by the removal of competitors for food, and by the partial washing and purification of the bottom in which they lie.

But what becomes of the unfortunates that are rejected by the clammer and left on the surface? Some of them may be nearly three inches long. Smaller ones will usually be numerous, and if it is summer, a careful examination may reveal individuals a quarter, an eighth, a twentieth of an inch long, and even so small as hardly to be distinguished from sand grains. These lie without movement until touched by the water, and if the oppor-

tunity presents itself the larger ones may be seized by herring gulls, carried into the air, and dropped on rocks, in order to break the shells.

As soon as the water comes, all the uninjured ones become active and attempt to burrow into the bottom. This is accomplished by the fleshy foot, which is thrust out from between the shell valves near their anterior ends. Because the foot is relatively very large and extensible in smaller individuals, those between one-eighth and half an inch long cover themselves in a very few minutes. With a foot relatively smaller, clams from one to two inches long require from half to three-quarters of an hour to effect a lodgment, but they reach the usual depth of several inches only after long-continued effort. Very large clams are able to project the foot so short a distance that they are often not able even to touch the ground with it, and after a brief effort to do so, close the shell and lie helpless until destroyed by crabs and fishes, or by birds and mammals, that pick up a living on the shore at low tide.

When the human factor is left out of the account, the life of the adult clam appears to be as monotonous and uneventful—"happy," most commenters have it—as possible. After reaching maturity, the creature, if undisturbed, never leaves its burrow, being quite unable to do so. Its early life, however, like that of the oyster, is so full of adventure that not one in millions attains the safety of the bottom.

Like all other organisms, *Mya* requires for its existence many conditions of a precise and definite sort. By long experience and observation the oyster culturist has learned that the oyster will grow and reproduce itself only in water of a certain density and temperature, and

on bottoms bearing clean objects for the attachment of the young. Some of these same conditions are also required by *Mya*, but many are different. The more important ones that have been observed, may be mentioned briefly.

Even on a flat that has not been greatly modified by man, it will be seen that clams do not grow everywhere. A little observation may reveal the reason, or reasons, for the existence of these barren patches. Perhaps ripple marks have been left here by the retreating tide. That means that the surface sand is loose, and shifts easily under the action of waves or currents. Now if clams were planted on such a bottom, it would be found that when sand grains, carried by the water, touched the sensory tentacles at the end of the incurrent siphon opening, the whole organ would be withdrawn for a greater or less distance into the burrow. Into the pit thus left, the sand gradually settles, and is densely packed. Apparently clams are not able to push this sand out. It is not so easy a task as that of pushing the siphons through loose sand or mud piled up by the clam digger on the surface of the ground, and the creatures are smothered.

Therefore, if one is to become a clam culturist, one of the first things he must do is to select a bottom for his clam bed that has a tenacious soil. Even when he has found a bottom that does not shift under ordinary conditions, he should remember that great gales, that may be expected from definite directions, may tear it up if it is in a position to be exposed to them. The November gale of 1898, from which time is sometimes reckoned on the New England coast, made many remarkable changes in clam flats all along the shore. Many beds were overwhelmed with sand or smothered with eel-grass

and mud, and most of these were permanently destroyed. Storms of such magnitude occur only once in a lifetime, but more common ones, if less terrible, are often destructive.

Soil is rendered tenacious in several ways. First, when sand is found to be mixed with fine sediments, its grains are often held together by this cementing substance. Clay, the finest of sediments, is very resistant to the erosive action of water, and is often found on flats and beaches. Another important agency in rendering the surface tenacious, and thus preventing the shifting of particles, is the growth of algæ, which forms a close, thin mat over some surfaces. The presence of this dark, green crust gives a flakey or cake-like appearance to the bottom. The plants do not extend deep into the sand, but bind the surface grains closely enough to prevent their movement even in strong currents. The growth of algæ seems to be best where tides move with some force, and such a combination of firm bottom and fairly strong currents, bearing abundant food, affords the best conditions for clam growth. When such a bed is dug, the coating of algæ again forms over the surface within a very short time.

Again, under natural conditions, one observes that sometimes a growth of thatch plants will convert a waste of sand into a clam bed. Thatch is found on many flats between tide lines. The plants grow close together, their blades rising to a height of two or three feet, and their roots forming a feltwork beneath the surface. In this mass of vegetation, clams are often abundant, even when the soil is almost pure sand and the currents rapid. They are able to establish themselves because the plants prevent a shifting of sand. On account of the wire-like

roots, it is difficult to dig these tracts, but in such beds there is preserved a great number of breeding individuals that may restock neighboring beds rendered barren by excessive digging.

Mya, like the oyster and all other lamellibranchs or bivalves, feeds almost entirely on diatoms that are carried in countless numbers by the brackish tide currents. Other conditions being favorable, the number of clams that may exist on any area, depends on the amount of food that they are able to obtain. It is evident, also, that the quantity of nourishment will depend on the amount of water that passes over the bed, as Möbius, the Dutch biologist, pointed out many years ago. Hence a tide current passing over a bottom that is firm enough to be undisturbed by it, is more conducive to rapid growth than quiet water. This theoretical assumption has been abundantly proved by experiments with *Mya*, as with the oyster. Rapidity of current, within certain limits, determines, in large measure, the number of clams that may exist on a given area, and also the rate of their growth. So, in selecting a bed for artificial culture, a bottom should be chosen over which there is a free movement of water.

An interesting and suggestive condition existing on most clam flats, is found in the close crowding of individuals over certain areas. If such a tract is kept under observation, it will sometimes be found that, for years, the numbers remain nearly constant, while growth seems to have ceased, and there seem never to be any but small clams. Food is sufficient for the existence of a certain number, each apparently being able to get its share, but none obtaining enough for growth. Such a balance has often been observed.

Experiments on such dense segregations of clams have also revealed the fact that if numbers are reduced by digging, the remaining individuals begin to grow. The conclusion is that the judicious and intelligent digging of a clam bed is beneficial to it. All clammers will agree with this statement. It is the same condition that all are familiar with in a garden of vegetables. Lettuce plants or radishes will fail to develop if too closely crowded. A densely planted bed must be thinned in order to do well. The real difficulty on our natural clam beds has been that no one has cared to thin the garden and transplant the superfluous individuals on barren ground for fear he would receive no return for his labor; and this fear, of course, has its justification. Such an improvement over the process of nature would be effected if the clammer were given the same lawful right to a bit of beach that he has to his vegetable garden, or that the oysterman has finally succeeded in obtaining in the deeper water of many of the coast states for his oyster beds. It is a short-sighted policy that denies such rights to citizens who desire to make productive, tracts that are now waste places.

It will be remembered that one of the most important conditions governing the existence of the oyster is the salinity of the water. The process of reproduction especially, depends on a proper degree of saltness, and its range apparently is confined within rather narrow limits. With *Mya*, these limits are very much wider. Clams will grow and reproduce normally in water almost as salt as that of the open sea, as well as in that which is nearly fresh. The limits of salinity where this has been observed are 1.024 and 1.005, these being the averages of several observations made during the summer while re-

production was occurring. Not only is this true, but it has been shown by experiment that clams may be transplanted from waters of one of these extremes to the other apparently without being in the least affected by the change. In this respect, as in others, the artificial culture of clams will prove to be much simpler than the culture of oysters.

Enemies of the adult clam are few. It is more difficult to gather a bushel of seed clams than of seed oysters, but when the former have attained a lodgment in the bottom they are safe from all foes, while the latter are never entirely safe. On a few occasions, snail-like mollusks have been observed to dig two or three inches beneath the surface of a clam flat, and to devour imbedded clams, but not one shell in thousands dug from clam beds will show the hole drilled by these animals. There is no reason to believe that any other animal ever attacks them in their burrows. The very young, however, before they are able to cover themselves, are preyed on by several forms.

It will therefore be necessary for the clam culturist to give close attention to the character of the bottom and to tide currents, when selecting grounds for his operations. In many cases the existence of proper conditions will be proved by the presence of natural beds; but on many tracts now barren all natural requirements are met, and all that is needed is the planting of seed clams. To be able to recognize such areas will, obviously, be of great advantage. Unfavorable conditions on other bottoms also may be overcome. Even shifting sand might perhaps be reclaimed by a covering of firmer soil. The oyster culturist has several such achievements to his credit.

CHAPTER XIX

THE LIFE HISTORY OF THE SOFT CLAM



IN Mya, as in the oyster of our Atlantic coast, the sexes are separate. South of Cape Cod the breeding season begins about the middle of June, reaches its height during the last two weeks of July, and continues until September. North of Cape Cod the season begins somewhat later, probably on account of the difference in temperature.

As in most other bivalves, male and female cells are extruded into the water, where they unite. As might be expected, the early stages of development are similar to those of the oyster, resulting in the formation of a swimming embryo that rotates spirally as it passes through the water. When the embryonic shell appears, the animal has a diameter of about one three-hundredth of an inch. The entire swimming period covers from three to six days, varying considerably with changes in the temperature of the water. A fall of temperature checks, and a rise to a certain optimum accelerates development. The numbers over some flats during the height of the reproductive season are very great. A small surface net a foot in diameter, on being towed a hundred yards through the water, has been observed to capture from twenty-five to thirty thousand of the swimming young.

At this time the young are undoubtedly destroyed in

great numbers by many swimming enemies, and Mr. D. L. Belding, Biologist of the Massachusetts Fish and Game Commission, has recently made observations which show that cold rains are very fatal to them. "During a long, cold rain," he writes, "counts were made of the number of larvæ in a certain amount of water which passed through the plankton net: before the rain, 30,000; after nine hours, 15,000; after fifteen hours, 3,000. After the rain had ceased, the number of larvæ gradually increased until it was the same as at the first count." This is interesting, because the variation in the "set" in different years seems, as in the case of the oyster, to be best explained by these and other sudden lowerings of temperature during the swimming period.

From this time on, the habits of the young clam become very different from those of the young oyster of the same age. While the latter settles and at once becomes fixed to some foreign object for the rest of its life, the young *Mya* must still expose itself to many dangers before reaching a safe resting-place in the bottom.

During the later part of the swimming stage, a well developed, muscular foot appears, extending along the whole lower or ventral side of the body. It is now relatively very large, as it is in the adult hard clam or little neck, but later it will become proportionately much reduced in size. Siphon and gills, also, have made their appearance. The velum, a projecting pad covered with the swimming cilia, gradually disappears, and the small clam settles to the bottom.

During the few days of the swimming period, the young clam may have been carried some distance from its starting-point, not only by its power of locomotion, but

passively by tide currents; but because the young always settle in considerable numbers on old natural beds, some of those carried away by the retreating tide must be brought back by the flood. But in selecting bottoms for artificial beds, localities possibly might be found that are favorable for planted clams, but on which there would be little or no natural set of the young because of peculiarities of currents.

It is certain that the young clam makes no selection whatever of bottoms on which to settle, though curious segregations of minute clams that are often met with might suggest some such power. Here and there it will be found that sea-weeds bear newly settled clams in great numbers. Certain strips of beach also have been observed on which multitudes of small soft clams have settled, the margins of the tracts being sharply limited. On adjacent bottoms very few are to be found. Probably these great inequalities in distribution are due entirely to peculiarities of water currents. When a certain stage of development is reached, the swimming form settles, wherever it happens to be. More will fall where large volumes of water pass in the form of sharply defined currents than where there is little movement of water. As so often happens in nature, the seed is sown broadcast. While in this case it can usually live only on certain restricted tracts between tide lines, it falls in deep water and shallow alike, probably thousands of times more often where death is inevitable than where farther development is possible.

During the swimming period there has been formed far back on the under side of the foot a gland for secreting a transparent fluid which, on being ejected into the water, hardens into a minute, tough thread known as the

byssus. Immediately on settling, the young clam attaches itself by means of this thread to shells, sea-weeds, pebbles, or even to sand. It is now not much larger than many of the sand grains, and its body is so light that if it were not anchored in some way, it would be rolled along by the action of the water. When water movements cease, as at slack tide, it often casts off the byssus

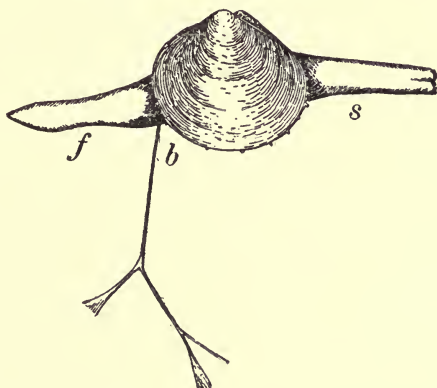


FIG. 56.—Very small long neck clam (.4 millimeter). *b*, byssus; *f*, foot; *s*, siphon. Drawn from living specimen.

and begins to creep by means of its foot. What the object of this habit may be it is difficult to imagine, for the little creature, even if in search of a more favorable locality, is able to move only very short distances. After a little exercise of this sort, it rapidly secretes and fastens another thread, but sometimes continues to creep about to the length of its tether.

The general appearance of this newly settled clam is illustrated in Figure 56. Foot (*f*) and siphon (*s*) are shown extended, and the byssus thread (*b*) with its

terminal branches, is represented. The outline of the shell is very different from that of the adult, being nearly round. The umbones also are very prominent.

Probably not even the swimming stage is more critical for *Mya* than this period of creeping, which is of longer duration. If on a beach, where it has a chance of continuing its existence, it may be washed away by stormy waters; and everywhere on the bottom it is exposed to numerous enemies and has little defense against them, for its transparent shell is still very thin and brittle. Perhaps to this stage at least the line from Saxe's "Ode to a Clam" might apply, "Thy valves are sure no safety-valves to thee."

Crabs and small fishes probably take many of them for food, but the most destructive of the clam's enemies are young starfish. These are produced in the early summer when the young clams are making their appearance, and after a short swimming period, also settle to the bottom in company with them. Even before their rays are formed, these pests develop an almost incredible voracity. They embrace their infant companions with all the gentleness displayed by their parents in their relations with adult bivalves, and to equal purpose.

This tragedy in miniature is illustrated in Figure 57, which represents a starfish about two days old devouring a young clam that it has found on the surface of the bottom. The drawing is not fanciful, but was made from the living subjects—or, more properly, perhaps, the living and dead. The actual length of the clam's shell was one and seven-tenths millimeters—about one-sixteenth of an inch. Some of the sucker feet are seen to be attached to the shell of the clam, while others are extended laterally. The faint outline of the stomach of the starfish

may be discerned through the transparent shell of its victim.

Escaping its enemies and becoming larger, the diminutive clam begins to exhibit the digging habit, for now and then it attempts to thrust the sharp point of its foot down among the sand grains. At first, even when

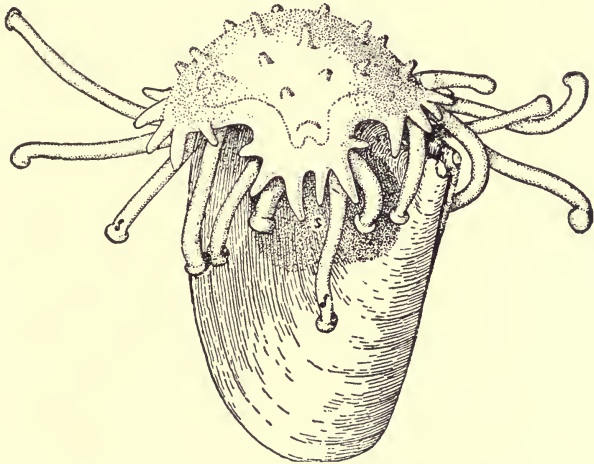


FIG. 57.—Very small starfish devouring a young long neck clam. *f*, sucker feet; *s*, everted stomach of starfish seen through the transparent shell of the clam. Drawn from the specimen.

the sand is fine, it is unable to accomplish anything because of the lightness of its body. Soon, however, when the shell has become about two millimeters long, it is able to push and worm the foot into the bottom, and the shell is then gradually worked in after it. Clams six or seven millimeters long are able to burrow into very stiff bottoms.

Having thus completely covered itself, the young *Mya*

once more spins a byssus, attaching it to several sand grains or pebbles in the wall of its burrow. The burrow at this time is very shallow, and there is safety in thus anchoring, for a storm that might disturb the bottom even slightly, would expose the creature. Newly

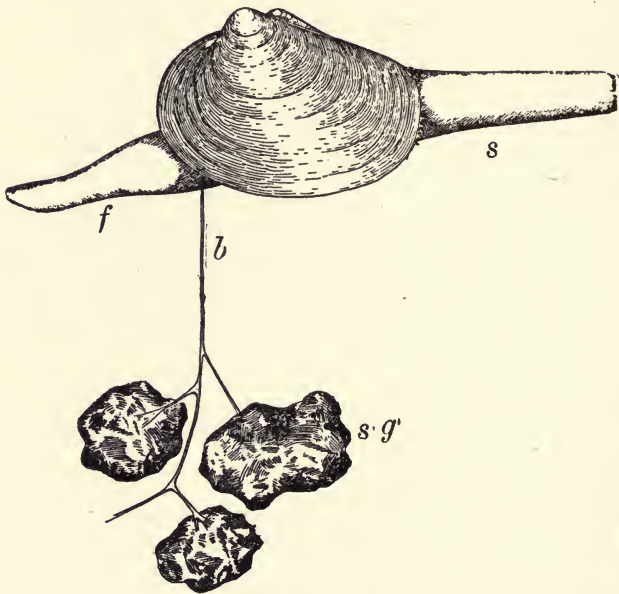


FIG. 58.—Long neck clam, *Mya*, with a byssus (*b*) attached to sand grains (*s.g.*). Drawn from living specimen, on a smaller scale than Fig. 56.

buried clams have the habit of casting the byssus off at the point of its attachment to the body, of coming out of the burrow and creeping for short distances, and then of burrowing once more.

Figure 58, drawn on a much smaller scale than Figure 56, represents a soft clam two and three-tenths milli-

meters in length removed from one of its earliest burrows. The outline of the shell is now quite as different from that of an earlier period as from that of the adult condition. An idea of the actual size of the clam may be had by comparing it with the bodies *s g*, which represent sand grains of average size. Byssus threads continue to be secreted until the clam is at least half an inch long. It is probably at about this time that a final descent is made. The byssus gland then atrophies and entirely disappears, and the animal never comes to the surface again through its own effort.

CHAPTER XX

THE GROWTH OF THE SOFT CLAM AND SOME NOTES ON CLAM CULTURE



It has not been many years since it was the habit of some to complain at the expenditure of public money in the maintenance of scientific departments by the federal government. There was also much prejudice against state agricultural schools. Scientific farming was scorned by those who regarded themselves as practical farmers, and no one else was much interested in experiments looking toward the preservation of soils, the production of new varieties of corn or wheat, and the warfare against insect pests. A thousand problems, the solution of which has now added untold wealth and comfort to the nation, were once regarded as foolish speculations. Prejudice has now been completely overcome, and every one is familiar with the great practical achievements of scientific workers in the U. S. Bureau of Agriculture, and in the state experiment stations and schools.

It has come to be understood also that fish commissions, instead of existing merely to stock streams for wealthy sportsmen, have worked wonders in the artificial propagation of fishes, and in saving many of them from extermination. They have given their attention also to other aquatic food animals. The aid which has been given by the federal Bureau of Fisheries to various

states interested in the oyster industry alone, in surveys and in experiment, has been great, and is now sincerely appreciated. Now that the nation has been awakened in a wonderful manner to the necessity of saving what remains of its natural resources, and of increasing them when possible, it is an encouraging and stimulating thing to possess so many demonstrations of the ease with which vast material results may be obtained by working intelligently with nature instead of against her.

What may be a relatively unimportant example of the nature of such work, is afforded by the clam problem that effects the north Atlantic shore. When it became evident that the soft clam industry was rapidly becoming ruined, a study of the subject was begun by the writer in 1898 at the suggestion of Dr. H. C. Bumpus, with a view of determining the conditions governing the life of *Mya*, the rapidity of its growth, and other facts that might lead to the development of a practical method of clam culture. This result was arrived at, and has been thoroughly tried and proved by state commissions, especially in Massachusetts. All that is now necessary for the rapid regeneration and improvement of the soft clam industry is the formulation of state laws giving titles to bottoms where it may be carried on.

Most of the early experiments were made on beaches where conditions were recognized as being unfavorable, because facilities for the work were not to be had elsewhere. Tide currents especially were sluggish on some of the ground, and on many of the beds that were constructed there was little more than a quiet rise and fall of water. These facts make the results all the more remarkable.

The plan followed was to select bottoms for the ex-

perimental beds where differences in soil, time of exposure, salinity, and especially variations in the exchange of water over them, should be as great as possible. When the areas chosen had been staked out, the ground was carefully dug over and all clams found were removed. Seed clams were gathered sometimes from the same locality, and sometimes at distant points, where the temperature and salinity of the water were very different. Clams to be planted were of different sizes, and some were planted quickly in beds prepared for them, while others were exposed to the air for varying periods before planting. Records of these facts were kept, and results noted when the beds were subsequently dug. In order to determine accurately the amount of growth, the length of each individual clam—and altogether there were many thousands of them—was measured, and those of a size were planted together. Beds were subdivided by measurement, and diagrams in a note-book showed exactly what clams were placed in each square foot, and gave their number. Planting was done during the months of July and August, and the beds were dug a year later.

Some of the results of these first clam experiments, made on the south side of Cape Cod, may be given briefly.

The most important fact brought to light was that growth, as compared with that of the oyster, was very rapid. As already stated, the length of each clam was determined just before planting, and again after a year of growth, to determine the amount of increase. But a statement of the increase in length gives no adequate idea of the amount of growth. That is best accomplished by obtaining the actual increase in volume, and

may be expressed in weight or in cubic contents. The latter plan was chosen, and the determination made by displacement in water. A clam one inch long displaces approximately 1.6 cubic centimeters of water; one two inches long displaces about 11 cc., or nearly seven times as much; while an individual measuring three inches displaces 43 cc., and is about twenty-seven times as large as the first. With a table of such facts, inches were transformed to cubic centimeters, and the increase in volume expressed in percentages.

Again, clams all of the same length when planted will vary somewhat in size after a year's growth. When these were dug and measured, they were segregated into sets according to size. The number in each set was counted, the sets arranged in a series, and the arithmetical mean of the series calculated. Then the volume of the mean of the series was compared with the volume of the clams when planted, and the percentage of increase in volume determined.

Perhaps a specific example of the employment of this method will be less opaque than the foregoing statement. In a bed planted on July 13, 1899, the planted clams were one and one-half inches long. They were removed on July 4, 1900, the length of each obtained, and all were arranged in sets, and the sets in a series. The mean length of the series, expressed in eighths of an inch, was 20.952, or nearly two and five-eighths inches. The volume of a clam one and a half inches long is 4.5 cc. That of an individual two and five-eighths inches in length is 32 cc. Therefore the increase in volume in this case is about 688 per cent.

Many thousand clams were placed in beds in a locality in which there was practically no current, the only ex-

change of water being in the rising and falling tide. In July, pebbles and stones on the surface became coated with a dense growth of sea-weed. Masses of dead eel-grass, which were barely floated at high tide, also remained on the beds for days at a time during the summer. All of this must have interfered greatly with the feeding of the clams, but in spite of the unfavorable condition, the increase in volume was great, as is shown in the following table:—

Size when planted.	Approximate percentage of increase in 1 year.	Size when planted.	Approximate percentage of increase in 1 year.
	Per cent.		Per cent.
1 inches.....	556	2½ inches.....	139
1 inches.....	422	2 inches.....	109
1 inches.....	347	2 inches.....	78
1 inches.....	284	2 inches.....	38
1 inches.....	210	2 inches.....	28
2 inches.....	190		

In order to present some tangible idea of this growth, Figure 60 was prepared. The jar to the left contains seventy-five individuals, each one and five-eighths inches long. The other holds an equal number of the size of the mean after a year of growth—two and a half inches. The increase in volume is 347 per cent. If clams much smaller when planted had been chosen, the illustration would have been much more striking.

The following table shows the growth of several thousand clams on a bed where the exchange of water was much better than on the first, though not so good as on some flats. Unfortunately most of the clams planted here were smaller than those on the first beds, so that the percentage of increase cannot be compared. Small

clams increase more rapidly than large ones under identical conditions. One series of the same size—that in which clams were one and three-eighths inches long—was planted in each locality. On the first beds, where there was little current, the increase was 556 per cent., on the second 711 per cent.

Size when planted.	Approximate percentage of increase in 1 year.	Size when planted.	Approximate percentage of increase in 1 year.
	Per cent.		Per cent.
1 inch.....	1150	1 $\frac{2}{8}$ inches.....	768
1 $\frac{1}{8}$ inches.....	802	1 $\frac{3}{8}$ inches.....	711

It will be noticed that the increase of one inch clams was 1,150 per cent. The mean length of these clams when dug was nearly three inches, that is, they had grown from a length of one inch to marketable size in one year. Most of this growth took place during the summer and fall.

It is usually possible to obtain large numbers of clams of this size for planting. When spread on a beach, they are able to burrow into it readily, and when established, will remain. In order to be certain of the growth of individuals of this size, another bed, with which great care was taken, was selected for them, this time where the current was a little more marked, and where they were immersed each day for a somewhat longer time. The increase in this bed was 1,337 per cent. The relative sizes of the clams at the beginning and end of the year are shown in Figure 59.

These experiments with *Mya* were subsequently repeated on a much larger scale, both above and below Cape Cod, by the Massachusetts Fish and Game Com-

mission. The work was done with extreme care, and by expert observers, beds being constructed at many points on the coast and in all sorts of localities. The results of the earlier experiments were completely verified, and as most of the work was done on flats instead of on beaches, were even more favorable.

The following quotation from the commission's report for 1907 gives a general summary of results in the case of a one inch clam:—

“ A 1-inch clam will grow in one year to a size between 2 and 3 inches. Under fairly favorable conditions, with a moderate current, a 1-inch clam will increase to 2½ inches, or a gain of 900 per cent. in volume. For every quart planted, the yield in one year will be 9 quarts. For beds without current, 1-inch clams average about 2 inches, or a gain of 500 per cent.; *i.e.*, five quarts for every quart planted. Beds under exceptionally fine conditions have shown the amazing return of 15 quarts for every quart of 1-inch clams planted. Clams increased in these beds from 1 to 3 inches in length. Therefore, by planting clams 1 inch or over, under favorable conditions a marketable clam can be produced in one year.”

The growth of *Mya* has been studied in much more detail than that of the oyster. It is, of course, the point of greatest importance to the culturist, and the possibilities of increase under good conditions, as here illustrated, certainly are not overstated.

Though some practical clammers have seen the value, and more recently the coming necessity, of clam culture, there have been few attempts to practise it, and almost none that have been thoroughgoing. The chief reason for this is that it has been impossible to obtain rights to clam bottoms that would be respected.

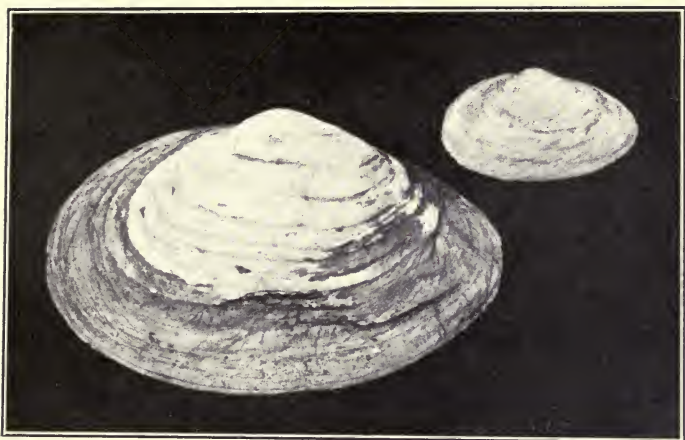


FIG. 59. Increase in size in one year of clam one inch long when planted.



FIG. 60. Increase in volume in one year of clams in an experimental bed with slight current. J. L. Kellogg, Special Shell-fish Commission, U. S. F. C.



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In a U. S. Fish Commission report published in 1887, reference is made to an attempt at clam farming at Bridgeport, Conn. It is stated that a beach right was secured under a general state law, but that there was "immense opposition from the shore people of the suburbs, who, as usual, bitterly and blindly opposed any cultivation of marine products."

Small clams were planted by being placed in holes made in sand, but this was found to be slow, and an attempt was made, by the use of all sorts of plows and cultivators, to plow the seed in. Finally a light plow was invented that was said to do the work satisfactorily. The bed, which was about half an acre in extent, was inspected three years after the first planting, and showed an immense number of clams. As they were apparently too thickly set, the owner was engaged in thinning and transplanting them, and believed that he "must wait four or five years for his first crop." Even at that, the writer of the report declared, "I know of no branch of mollusk culture likely to prove more remunerative than this, so long as it is not overdone." Nevertheless, for some reason the attempt at Bridgeport was discontinued.

Laws of New England shore states allow towns to rent their flats to citizens for the purpose of planting clams. At one time or another several towns have done this, but all attempts at clam culture have proved to be dismal failures, not because of adverse natural conditions, but from rivalries and ill feeling among those who were most interested, and from the difficulty in punishing trespassers.

Perhaps the nearest approach to success was made by the town of Essex in Massachusetts. In 1888 its selectmen were authorized to rent lots of one acre or less, to

any citizen of the town, on the flats along the Essex River; but it was not until 1891 that any applications were made for them. In that and in the following year, nearly forty acres are said to have been rented. At that time the flats were practically barren from excessive digging, though formerly they had been extremely productive. In most cases planting was desultory, each renter waiting to see what his neighbor might be able to accomplish in his experiment, before he gave his own time to it. A few diligent ones succeeded in demonstrating the feasibility of the method, but as no person lived within sight of the majority of the beds, the property was not guarded, and no planter received any benefit from his work. There were no reapplications for leases when the first had expired.

Again and again it has been proved that the way to meet an increased demand for living natural products is not to limit the supply, but to increase it, and almost invariably this can be done. Undoubtedly state laws will ultimately be modified so as to make clam culture possible, and many will engage in it. A few general suggestions may be of value to those who shall be able to acquire protection in rights to shore property, and who desire to engage in clam culture.

The prospective culturist will look about for favorable bottoms. As already stated, he should avoid a shifting surface or one in which there is much decaying organic matter. It will be safe to select one on which clams are growing if it is available, but many that are quite barren, having been made so by excessive digging, are quite as good. It may sometimes be good policy to construct small experimental beds.

Free exchange of water, though not enough to disturb

the bottom, is best. As the oyster culturist chooses certain bottoms on which oysters grow rapidly, so the clam culturist may sometimes advantageously plant seed from one and a half to two inches long in a current even strong enough to disturb the bottom. Growth is often very rapid in such localities, but small clams planted in them would be washed out or smothered. The rate of growth depends directly on the amount of food that the clam obtains, but the amount of food does not always depend on swiftness of current. There must be some movement of water, but in some localities there are so many food organisms in it that growth is rapid when currents are sluggish. Such points must be proved by trial in each locality.

The idea of obtaining seed clams from artificially fertilized eggs should be dismissed at the beginning. Artificial fertilization of oysters eggs is easily accomplished, but no one has yet been able to make any practical use of it. With the eggs of *Mya* it is very difficult, and no one is likely ever to make a success of rearing the young from the egg. Furthermore, it would seldom be of value in either case to be able to do so, for the natural supply is sufficient.

The set will always vary as the oyster set does. In any locality it will be heavy one year and light another. On one flat it may be a failure, usually from a local adverse condition like a cold rain when the water is full of swimming embryos. Several days of low temperature may cause it to be more widespread. There seems, however, seldom to be a failure over much of the shore at one time. If necessary, it should be possible to purchase seed at no great distance from any point where a failure occurs.

Sometimes the set is quite evenly spread over a flat. Most often it is very irregular, being generally thin, but very dense in a few spots. These dense segregations, that every clammer knows, are caused by sharply defined currents that have passed near spawning clams. Every day during the breeding season some swimming individuals reach the stage of development in which they sink to the bottom, and a more or less steady shower of them continues to fall for several weeks. More swimming forms will pass over the bottom that underlies a current than elsewhere, and this will receive an unusually large number of the settling individuals. Some modification of a current, as an eddy on its margin, may sweep together astonishingly great accumulations. Such segregations are common, and the fate of the young clams comprising them has been studied and described.

Two such areas, for example, lying under parallel and sharply defined currents that were separated by a dense mat of eel-grass, were nearly two hundred yards long (Figure 61). Each was but two or three yards wide. In the middle of the breeding season they were as densely packed as it was possible for them to be. Before the end of the summer all had died from overcrowding.

A similar segregation, occurring on the flats near Ipswich, in Massachusetts, the fate of which, however, was not witnessed, has been well described by Mr. J. R. Stevenson. "Often," he writes, "they are so numerous that only a small portion can burrow, the rest being but half in the sand, or merely resting upon its surface, the sport of every storm. Such an area I found during November, 1906, in Plum Island Sound, upon the east side of Rowley Reef. The narrow channel here washes the eastern thatch bank. Upon the west side of this channel

a long reef has grown up, on which lay the prodigiously abundant set. Several clammers have told me that frequently such sets occur here. Upon an area of 600 to 700 feet long, tapering at the ends, and about 150 feet wide in the center, I found a set of young clams from 1,000 to 5,000 per square foot. From an average square

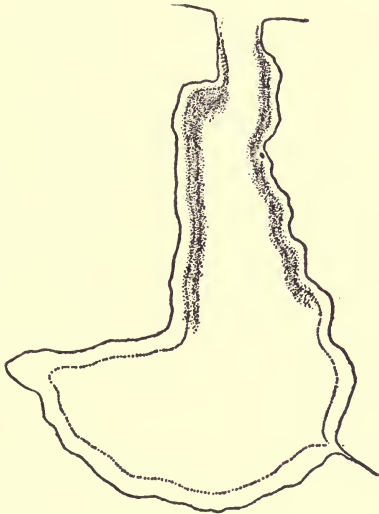


FIG. 61.—Position of dense set of young of *Mya* in a small bay. Dotted line marks the low-tide level. J. L. Kellogg. Report of Special Shell Fish Commission, U. S. F. C.

foot of sand in which every clam was burrowed out of sight, and in which I counted roughly 1,000 holes, I dug 1,937 clams, averaging about half an inch in length. From a square foot of sand into which the clams had not completely burrowed I sifted 2,486 clams. Roughly

estimating this area at 50,000 square feet set with clams at least 1,000 per square foot, we have the enormous total of 50,000,000 young clams. Averaging, as I found, about 3,000 per quart, there are about 17,000 quarts, which is over 500 bushels of young clams. The producing power after two years' time, of these 500 bushels we may scarcely estimate. From certain productive flats less than 500 two-year-old clams filled a bushel basket. This young set on Rowley Reef goes 100,000 per bushel. If all were thriving after two years, we would find a gain in volume of 160; *i.e.*, if to-day we were to plant 1 bushel of this set, within two years we would be able to dig over 160 bushels of fair-sized, marketable clams. Many of these clams, even if carefully transplanted, would die; yet, if but a half survive, the gain in volume of even 80 bushels is enormous.

“Near the center of the most thickly set area I found a tidal pool, roughly 12 feet long by 6 feet wide, and about 15 inches deep. At first sight it seemed but an inch or two deep, but upon wading into it I sank to my knees. Imagine my surprise when I found it was not mud into which I sank, but a mass of living clams. Here were more than 60 cubic feet of solid clams.

“The first day I visited the reef I dug a short trench, about 15 feet long, across a portion of this thickly set flat. The day following I found several pailfuls of young clams gathered by the force of the water into clean heaps. When such natural tide pools fail in their supply, it is possible to dig others, and, by turning over the thickly seeded flat, to let the tides and waves fill the new pools with the dislodged clams.”

Very little attention has been paid to these collections by clammers, but they are well worth careful observa-

tion. They afford a good illustration of the wastefulness and destructiveness of nature, and at the same time present an excellent opportunity to retrieve what usually would be a total loss, for when left to themselves, these vast communities of infants commonly perish. In the case of most organisms seed is scattered beyond recovery, but here it is collected by the tides in such a manner that it may easily be gathered. While there is great variation in the size and position of these segregations in successive years, they occur on large flats with sufficient regularity to insure a source of seed for planting.

A careful examination of an extensive clam bottom will also reveal areas here and there on which are clams of all sizes up to two inches in length. These are crowded, but not often densely packed. Here there seems to be a balance, the greatest number possible, with the supply of food brought by the currents, continuing to exist, but growing very little, if at all. Year after year the numbers and sizes of clams in such places have been observed to remain about the same. Such collections also afford seed, and the rate of growth under more favorable circumstances that may be expected of individuals between one and two inches in length has been indicated.

The planting of very small clams is as simple a matter as can be imagined. If the bottom is not too hard, and if the water does not come upon it or leave it too rapidly, they may be sown broadcast like grain. Those less than half an inch long will, when covered by water, burrow in the course of five or ten minutes. Most clams an inch long will also cover themselves, though the process requires a somewhat longer time. It has been shown that this might be made easier if the bottom were previ-

ously plowed or raked in order to loosen its surface. Ordinarily this would not be necessary.

Larger seed might perhaps be successfully plowed under, but no experiment besides that at Bridgeport has been made to test it. In the U. S. Fish Commission experiments, clams were dropped into holes made with stakes. On a pebbly beach where the making of the hole was very difficult, four men at one time thus planted three thousand clams in two hours. Subsequently on a sandy bottom the work was accomplished three or four times as rapidly. It would not be difficult to construct wheels with pegs on the rims that would make rows of depressions as rapidly as desired. Such a method of planting clams would ensure their lodgment and their proper distribution, and the labor required ordinarily would not be great.

After attaining a length of more than two inches, the soft clam is soon injured by exposure in summer. Temperature, however, and not merely exposure, is the important factor. For several days the animal is able to withstand temperatures near the freezing point apparently without injury, but it lives only a short time out of the water in warm weather. Experiments show that an exposure of forty-eight hours during the hottest part of the summer will lead to the death of the majority, even if they are then planted, but few perished on being exposed twenty-four hours under the same conditions.

Clams to be planted, however, should ordinarily be much smaller than this, and the power to resist heat increases as size diminishes. When kept in aquaria supplied with running water, large clams live only a few days when the weather is warm; but those less than half an inch long have been kept alive in a hot room, barely



FIG. 62. Box suspended from a raft near a clam flat from May 15 until October 15 of the same year. The long-neck clams shown below had all settled from the swimming condition into the sand that it contained during this period.



FIG. 63. Growth of *Mya* in two years on 1-100 of an acre of a barren flat. The small pile at the right represents the size and volume of the seed clams planted. The larger pile is eight times the volume of the smaller. Experiments by D. L. Belding, Mass. Fish and Game Com.



covered with stagnant water, until, after many days, a scum of bacteria had formed over them. Seed for planting could be kept in good condition out of water for several days in a comparatively low temperature.

Great numbers of soft clams have been dug from localities where the water contained very little salt, and planted where the salinity was very high, apparently being not at all affected by the transfer. Great changes in salinity have a markedly bad effect on oysters, interfering especially with reproduction; but soft clams breed well in either extreme. This condition, that requires so much attention from the oysterman, may probably be entirely disregarded by the clam culturist.

No rule can be formulated to govern the volume of seed to be sown on a specified area, for one part of the bottom will support several times as many clams as another, and a bushel of very small seed clams should be spread over a larger space than if they were of greater size. In a report on the Essex experiment it was stated that about five hundred bushels of seed were required properly to plant an acre. This is an excessive number for the most favorable parts of any flat, even if the clams to be planted were relatively large. Very few—perhaps four or five—bushels of half-inch clams would be required to fill the best acre that could be selected, and the best acre would support many times the number that could exist on some of the poorer ones. Only experience will indicate the quantity of seed of a certain size that will produce the best results on a specified area.

The recent extensive experiments of the Massachusetts Fish and Game Commission show that, on a flat of ordinary fertility, ten or fifteen clams to the square foot are as many as can maintain a maximum rate of growth.

But the difficulty of defining the conditions on a flat of ordinary fertility is naturally great. All that may be said is that, usually, it would not be safe to plant a greater number than this. With experience one may estimate with some confidence the possibilities of an untried bottom after examining it, and becoming familiar with the flow of water over it; but certainty in all cases is to be had only by trial.

Extensive experiments are numerous enough to make it certain that on many of our flats now almost entirely barren, it would be possible to produce each year at least four hundred bushels of marketable clams to the acre. These should be made to return a net profit of at least seventy-five cents a bushel, and probably more, for the labor involved is not great. It has been estimated, after a careful examination of the coast of Massachusetts by trained biologists, that there are now in that state six thousand acres of barren bottoms capable of producing clams. The available territory in the other northern states is not so great, but in some it is very extensive, and all of it together might be made to produce a vast amount of food. It now lies as it has lain for many years, almost entirely barren and useless.

In the newer parts of our country it has not been difficult for a few individuals to obtain control of natural resources. Such a state of affairs is unjust and detrimental to the best interests of the nation, and has resulted in a wanton and appalling waste of wealth, all of which properly belongs to the many and not to the very few. But on our eastern shore the fisheries, which the courts have decided include the mollusk fisheries, theoretically belong to all the people, and it is interesting to observe that by exercising these rights that they hold in

common, they have succeeded in wasting and destroying and exterminating quite as successfully as have the monopolistic owners of natural oil, anthracite coal, or timber resources.

There is a middle course between these extremes. It has been explained that the oystermen, after a long struggle, have forced the public to take that course, and it has been generally recognized in the Atlantic states as a just one, bringing hardship to no one, and developing for the benefit of all a great industry that otherwise could not have existed. Apparently no citizen who has desired to taken an active part in oyster culture has been prevented from doing so, either from lack of shore room or from pressure brought to bear on him by strong competitors; and there are now many times as many oysters growing in some waters than ever existed in them under a state of nature.

There is every reason for taking the same middle course in the disposition of the extensive area that might yield an abundance of clams—soft and hard clams alike. There seems to be no reason to doubt that the result would be as beneficial to the public in general as it has been in the disposal of the oyster territory. The case as it exists in New England is very clearly put by Dr. G. W. Field, Chairman of the Massachusetts Fish and Game Commission, who says:—

“The parallelism between the shellfisheries and agricultural conditions, both historical and biological, is very close. In each, the original inhabitants depended entirely upon the natural products, and public ownership of land and all natural utilities was universal. Later there developed the advantage, and even the necessity, of private ownership of land and its products, if prosperity

in its widest sense, or even the actual subsistence of the increasing population, was to be maintained. The acquisition of titles to land areas was the first logical step. The fixing of permanent bounds was simple. The land then furnished a more readily accessible and certain source of food, which not only could be produced with relatively little labor and capital, but which from its very nature would be readily and compactly stored in barns, cellars and granaries, where its quality did not deteriorate and where it was quickly available in stress and storm. The chance which brought the first settlers to Plymouth rather than to another section of our coast was responsible for the present law, that the owners of land bordering tide water own the tidal flats for a distance of 100 rods (approximately the conditions at Plymouth), or to mean low-water mark if less than 100 rods from the high-water mark. In accordance with the early English law, the 'fisheries,' which the courts have since decided included the mollusk fisheries, were declared to be forever the property of the whole people, *i.e.*, the State; and these fisheries were for a long period open to any inhabitant of the State who might need to dig the shellfish for food for his family or for bait. From time to time, however, special grants have been made to certain towns, carrying control of the shellfisheries; special acts of the General Court of Massachusetts delegating to certain towns practically all the rights of the State in the shellfisheries within the limits of that town.

“The present laws have essentially in a marked degree converted the shellfisheries, the undivided property of all the inhabitants of the State, into holdings of the shore towns and cities. In many instances there has resulted up to the present time merely legalized plundering

of the flats, local jealousies prohibiting the digging of clams by 'outsiders,' and little or no care given to maintaining the normal yield of the flats. The regulations made by the selectmen or the mayor and aldermen are usually but distinct attempts at checking the demand, by prohibiting digging for certain periods, by limiting the number legally to be dug by any one person, etc. It would be quite as logical for a town or city to prohibit by by-laws the use or digging of potatoes or any other food crop, when the supply was short, rather than to attempt to *increase* the supply. As a result, the unsystematic methods of marketing have led to the premature destruction of far more clams than ever go to market; a similar condition would exist if the farmer should dig over his growing potato field before the crop matured, either in the hope of finding a few marketable tubers, or to prevent the possibility of his neighbor digging up the potatoes at that time or later.

“. . . The owners of the land adjacent to the flats, are under the present laws often subjected to annoyance or loss by inability to safeguard their proper rights to a certain degree of freedom from intruders and from damage to bathing or boating facilities, which constitute a definite portion of the value of shore property.

“. . . That any one class should claim exclusive 'natural valid rights,' over any other class, to the shell-fish products of the shores, which the law states expressly are the property of 'the people,' is as absurd as to claim that any class had exclusive natural rights to wild strawberries, raspberries, cranberries or other wild fruits, and that therefore the land upon which these grew could not be used for the purpose of increasing the yield of these fruits. This becomes the more absurd from the

fact that the wild fruits pass to the owner of the title of the land, while the shellfish are specifically exempted, and remain the property of the public."

In time these antiquated laws will be changed. Clam bottoms will be leased to individuals by the state, and not by the towns, if, indeed, they are not eventually sold as they should be, and the harvests they bear will belong to the owners. But the demand for the change should come from the public and not alone from the few who would engage directly in the clam industry.

With the formulation of new laws to establish the industry, there should not be omitted those safeguarding the public health, by requiring cities and towns near clam flats to make a proper and safe disposal of sewage. Oystermen are able to establish growing grounds far from shore, where oysters will be safe from contamination by disease-producing micro-organisms, and many of them are doing so; but soft clams can be dug only on the shore between tide lines.

The facts should be recognized that the present soft clam industry, that depends entirely on natural conditions, is far on the way to destruction; that nature at best is extremely wasteful in her methods; and that the hand of man can easily compel her to produce great wealth on desert places. The establishment of the new industry should be accomplished with much less effort than was the existing oyster industry. Very much less labor need be expended in the collection of seed. There need be no spreading of collectors. Some thinning and equalizing of the distribution may be necessary on areas seeded naturally, but without boats or expensive implements, barren ground may easily be planted. Once in the ground, the clams are safe from all natural enemies.

They will be ready for market in half the time required for oyster growth. For several years the demand has been steadily growing. There is room for an indefinite extension of the market, and when production becomes certain, a fair and steady price may be depended on. The man with small capital may profitably engage in the new enterprise. The culture of the soft clam in some of the northern states should be as successful as that of any other marine food organism, and the culture of the hard clam, or little neck, on southern shores as well as in parts of New England, should also become of great importance.

The time may come when the matter of the artificial culture of *Mya* will be of interest to the states of California and Washington, for the creature has established itself on the Pacific coast and is slowly finding favor in the markets. *Mya* was introduced into California waters by accident or design about 1870, and being a cold water form, found conditions suited to its needs, and at once multiplied rapidly and spread over a large territory in San Francisco Bay and elsewhere, occupying beaches between tide lines, as at home in the Atlantic.

The "eastern clam," as it is known on our western coast, appeared in Willapa Bay, Washington, about 1880, and is supposed to have come directly from California. From this point a few years later a small number was transported to Puget Sound, near Tacoma. Since that time they have spread, appearing at many points on the shores of the sound, and in some places are very abundant. To have attained so wide a distribution in so short a time, proves that the conditions in the new waters are very favorable for the propagation of the soft clam.

The Pacific states possess half a dozen fine edible

clams of their own. Among them are the "giant clam" or "geoduck" (*Glycimeris generosa*), that sometimes attains a weight of more than six pounds; the great "Washington clam" or "gaper clam" (*Schizotherus nuttalli*), formerly abundant, but now so much reduced in numbers that it is seldom found in the market; the "little neck," "hard shell," or "rock clam" (*Tapes staminea*—not the little neck of the Atlantic coast), which is found in the markets of Bellingham, Seattle, Tacoma, and elsewhere; and the "butter clam" (*Saxidomus nuttalli*), now extensively canned.

But the virtues of *Mya* are such that it will probably commend itself to the western public, especially as most of the native species are becoming much less abundant. Even if *Mya* could be had in numbers great enough eventually to take their places in the markets, it would be a great pity to see these wonderful western forms materially decrease. Unfortunately, practically nothing is now known of their development, their life histories, or their rates of growth, and it is idle to speculate on their possible fate, or on what their cultivation in the bays of Washington and California might mean commercially to those states.

CHAPTER XXI

THE HARD CLAM



NEXT in commercial importance to *Ostrea* and *Mya arenaria* in New England, is the hard clam. It is a warm water form, and its distribution extends from the southern side of Cape Cod to Texas. Small isolated beds exist in warmer bays above Cape Cod, but they are very few. The ranges of hard and soft clams overlap from Cape Cod to the Chesapeake, but from New York southward the hard clam becomes "the clam."

Venus mercenaria is so called because a portion of the inner surface of its shell is often stained a beautiful bluish purple, and this was used by the Indians of the eastern shore in the manufacture of wampum beads. Wampum was used not only for dress ornamentation, and symbolic belts exchanged to seal intertribal transactions, but also as a currency medium even in trading with the early white settlers.

A common name for *Venus* in New England is "quahaug" or "quahog," and is probably derived from an Indian name which signified "tightly closed"—a better name for the genus than that given to it by the naturalists—thus distinguishing the shell from that of *Mya*. The term "little neck clam" is also used, for the siphon or "neck" is much shorter than in *Mya*, and the origin of

the name "hard clam" is readily understood when one examines the thick, heavy shell.

Though often found between tide lines, the hard clam occurs in greater numbers in deeper water, where it is continually submerged. In many localities in which conditions are favorable, it grows at a depth of at least fifty feet, and the outer limit of its distribution is probably considerably farther. It burrows into the bottom, but only deep enough to cover the shell. It is found in sand, but more often where there is considerable mud.

A primitive method of finding these clams was "treading" or feeling in the mud for them with bare feet. It is very slow work, unless clams are numerous and the water shallow. The fishing is usually done from boats. Infrequently oyster tongs or dredges with long teeth are used, but the implement commonly employed is a large rake with long steel tines. The handles of these rakes are sometimes sixty feet long for use in forty or fifty feet of water. To operate such a rake requires immense muscular strength, but on many parts of the New England coast, where the fishing is done, irregularities of the bottom prevent the use of dredges.

For many years quahaugs have been cooked and marketed in cans, and there is a large demand for them in the form of canned chowder. At one time an effort was made to market their dried and granulated flesh. It was said that this material, convenient in form for soups and chowders, had much merit, but it failed to find favor. During the last few years there has been a rapidly increasing demand for small individuals to be eaten, without cooking, from the half-shell. In restaurants and hotels these are called "little necks."

Venus will live out of water very much longer than

Mya. The edges of its shell form a joint that is almost air-tight. It is safely shipped far inland, even in the hottest part of the summer, and consequently is the form most commonly used in fresh water clam-bakes—a rather poor imitation all through, of the genuine New England institution, but an enjoyable affair for all that.

The hard clam, like Mya, has suffered a marked decrease in numbers during the last few years. In 1898 a single company that had been marketing ten thousand cans of hard clams daily for years, was compelled to abandon the Great South Bay of Long Island for the Carolina sounds, because of an almost complete failure in the supply. Most other bottoms where hard clams were formerly abundant have failed because of excessive digging.

There are still great beds of these clams in the South that have never been disturbed. South of the Chesapeake they are very little used as food. In 1904 great numbers of them were discovered by the writer on the muddy west shore of the Chandeleur Islands, near the delta of the Mississippi. Oystermen and fishermen along that coast stated that they were never dug even for bait. New Orleans possesses a great supply of fine oysters, but should also become acquainted with New England clam chowder, that she might so conveniently make her own.

The chief features of the development of Venus have recently been determined by Mr. D. L. Belding, who finds that, after being fertilized in the water (from early June to the middle of August in New England), the eggs segment or divide in much the same manner as in the oyster, and produce a swimming form. Before the

swimming organ, or velum, disappears, a large foot is developed. Soon afterward the creature settles to the bottom. It was found that for some time the habits of the young Venus were almost precisely similar to those of Mya of the same age. A byssus gland is present at the beginning of the creeping period, and the young quahaug attaches itself to objects on the bottom by a byssus thread. This is cast off at will, the creature creeps about for short distances, and then reattaches itself. Finally it is large enough to burrow, and immediately, on covering itself, spins a byssus which it attaches to sand grains or pebbles in the burrow walls. As in Mya, the object of this is to prevent the animal from being washed away from the point where it is lodged. The byssus gland remains as a functional organ until the quahaug attains a length of at least nine millimeters. In larger individuals it seems to have disappeared.

The first experiments made on the growth of Venus were conducted in 1901 on the north shore of Long Island. In order to obtain as much security as possible against trespassers, permission was obtained from an oysterman to use a portion of an oyster bed that could be watched. Though growing oysters were thickly planted on the surrounding bottoms, there appeared to be an abundance of food, and the rate of growth obtained probably represents fairly the powers of increase possessed by the quahaug on ordinary bottoms near a beach line.

As many and as diverse conditions as circumstances allowed were selected in placing the beds. Some were made on the beach between tide lines, and others where they would be continually submerged. Several observations have made it seem probable that, as might be expected,

bivalves obtaining food continually will grow more rapidly than those that are exposed at low tide. It proved to be true in this case. The currents were strong, but much the same on all beds.

The belief prevails among clammers that the fully grown quahaug sometimes leaves its shallow burrow and creeps for some distance before burrowing again, and that in this way it may effect a considerable migration. At least one account of this supposed habit has been published. "On these bottoms of sand and mud," it runs, "the clam spends most of its time in crawling about with the shell upright and partly exposed. It can travel pretty fast, and leaves behind it a well-plowed furrow." This might be assumed to be true from the fact that it possesses so large and powerful a foot. Some fresh water clams have this habit well developed, but hundreds of quahaugs used in this experiment remained for six months where they were planted. The fact that they move about very little if at all was later verified by extensive experiments in which the creatures were under observation at all times of the year. It seems certain from the many observations that have now been made on this point that the future culturist need have no fear that his planted quahaugs will leave him of their own accord.

But at the time of the first experiment such a result was feared, and in order to forestall it beds below low tide were covered and walled in with wire netting. The small quahaugs were planted during the first week in July, and when the beds were dug in the last week in December, the netting showed no signs of having been disturbed. Beds between tide lines were not thus screened and none of the clams had moved beyond their limits,

which had been marked by tagged staples driven into the ground.

The results of six months of growth during the warmer part of the year may briefly be stated as follows:—Continually submerged, quahaugs one and a quarter inches long when planted, increased in volume in one bed two hundred and twenty-two per cent. in six months. It is possible that the increase might have been somewhat greater here if the bed had not been almost entirely surrounded by great numbers of oysters that consume the same food.

The increase was less in other beds in the same locality. For example, clams one and three-eighths inches long increased only seventy-eight per cent. in volume. Here, however, the wire netting exposed above the bottom had become the lodging-place of an abundant growth of sea-lettuce (*Ulva*), which flattens down in a current so as to prevent free access of the food-bearing stream. The effect of this mat of sea-weed in preventing the growth of hard and soft clams alike has been noted carefully in many cases. It should, however, cause little trouble to the culturist, for it may easily be removed by a little raking.

Where everything seemed to have been favorable on the beds between tide lines, quahaugs varying from one and a half to one and a quarter inches in length showed an increase in volume ranging from one hundred and fifty-five to two hundred and fifty-five per cent.

In 1904 extensive experiments on the growth of *Venus* were begun by Mr. Belding for the Massachusetts Fish and Game Commission, and these were carefully and continuously pursued for several years following.

Mr. Belding has found that growth nearly ceases

about the first of November, and does not begin again until about the first of May, reaching its maximum in August. The precise time when growth ceases in the cold waters of the northern coast varies with the weather. When November is unusually mild and warm, there is some growth, but it is not extensive. There appears to be no growth after the first of December in any year. There is every reason to believe, however, that farther south the growing season is longer than in New England, and that where it never becomes cold, as in the Gulf of Mexico, it is continuous.

Few figures showing the percentage of increase in volume in these experiments are yet available, but it has been found that under very favorable conditions the size of the "little neck"—which is about two inches in length—is attained in a little more than two years after the egg is fertilized, but on some of the less favorable beds where eel-grass had prevented the flow of water, it was estimated that as many as eight years would be required to produce a two inch little neck. It is believed, also, that quahaugs more than three inches long are at least four years old, and in cases where conditions have not been favorable, more than that. Thus it is not possible to make a statement concerning the growth of Venus that will apply in all cases, because so much depends on local conditions. In a general way it may be stated that the average rate of growth is not so rapid as that of Mya, but more so than that of the oyster in cold northern waters.

As in all previous clam experiments, the most important condition governing growth was shown to be the advantage of a current of considerable strength. Doubtless this is true with all bivalves. In certain fa-

vored places, shallow boxes or racks, containing three or four inches of sand, were suspended one above another, and clams planted in them grew very rapidly, many gaining an inch in length in five months. It was found possible to obtain good results in a strong current even when young clams were placed close together in these boxes. This "intensive farming" possesses many obvious advantages. By selecting a locality in which a strong current carries much food, a maximum growth could be attained with large numbers of clams, for much water above the bottom could be utilized. Such clams could easily be examined, and a market demand for a definite size could be met with little labor. On the other hand, there might be practical difficulties in handling continually submerged racks, and the expense of the method might be prohibitive. But interesting results might come of rack culture if it were practised on a commercial scale, and it is worth an extensive trial in more than one locality.

The hard clam is apparently as little affected by differences in the salinity of water as is *Mya*. It was found to reproduce normally and to grow in waters in which salinity varied from 1.009 to 1.025. The oyster is much more sensitive to these variations. Outside much narrower limits than these, its general condition, and especially its power of reproduction, are seriously affected.

Natural enemies of the adult are few, and do little damage. Starfish destroy some, and a few are killed by one or two boring mollusks (Figure 64). Probably there are heavy losses among the young before they are able to burrow, but once in the bottom, they are secure.

Sufficient preliminary biological work has been done to make it certain that the quahaug industry, the newest

of the shell-fish industries, but already fast declining, might be firmly established and greatly developed by artificial culture. The demand for the adult clams is growing rapidly, and there seems to be no danger that the "little neck" will lose its popularity and again become only a young quahaug. Present prices for this baby clam are high, the clammer sometimes receiving four dol-

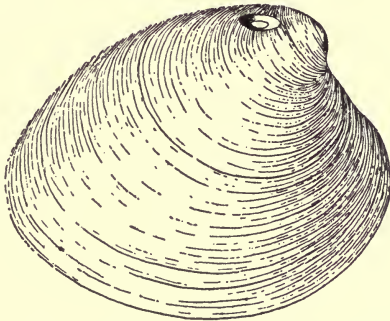


FIG. 64.—Shell of a "little neck" clam, *Venus*, showing a hole bored over the visceral mass region by an oyster drill, *Urosalpinx*.

lars a bushel for his catch, while one who orders them on the half-shell at a Boston or New York restaurant, pays for them at the rate of fifty dollars a bushel. If their production were to increase, the price received by the clammer might be lowered, but because of the merits of this form of food, the demand for it must continue to be greater.

The control of the present quahaug industry in New England is very generally placed in the hands of the selectmen of shore towns. Too often the responsibility of supervising and intelligently regulating the raking of natural beds is entirely neglected. In no case, appar-

ently, has artificial production been encouraged, and the only effort to conserve the supply has been to declare a close season now and then. There are no provisions for forcing negligent towns to care for their shell-fisheries, and losses from such negligence fall on the public. The rights of citizens of the states, so far as the clam industries are concerned, have been given to the few living on the shore. Not only have they in most cases failed to take advantage of these great and special privileges, but they have, with almost perfect unanimity, declared that "outsiders" shall be allowed no privileges whatever on their shores.

It thus appears that laws are urgently needed in the north Atlantic states that will permit of the artificial culture of the quahaug by any citizen of the commonwealth formulating such laws. It would be better for each state possessing bottoms suitable for quahaug culture to make them accessible by lease or sale to non-residents. This has proved to be good policy in the management of the oyster industry. Unfortunately the time seems not to be near when such a condition may be attained in New England.

When quahaug culture is attempted on a large scale, there will be some disadvantages as compared with soft clam or oyster culture. Chief among these will be the difficulty of obtaining large quantities of seed. The set seems usually to be scattered. One often finds on an exposed beach or flat great accumulations of very small bivalves having a superficial resemblance to young quahaugs, and which the natives of the shore usually confuse with them. Dense segregations of the young of *Venus* seem not to be so common as those of *Mya*, though why this should be so is difficult to explain, for the habit

of settling from the swimming condition seems to be identical in the two cases. There are certain isolated coves and bays on the New England shore, however, where young quahaugs are sometimes raked up in vast numbers—usually to be sold for planting in Long Island, a practice that has recently been begun there. Thus the price of seed may be high, though the clam is abundant enough in its scattered distribution.

It will probably be found, however, that the few disadvantages are more than counterbalanced by peculiar advantages. Venus, for example, is one of the hardiest of bivalves. It is not only peculiarly insensible to changes in temperature and salinity, but it withstands long exposure to the air, even in hot weather, without apparent injury. Shipments to distant markets or planting grounds may thus be effected without loss. Again, there is a market during the entire year, and on the greater part of the Atlantic coast, and in the Gulf of Mexico, weather conditions would not interfere seriously with raking.

The territory available for quahaug culture also is greater than for that of the soft clam. The only labor involved will be that of taking the seed and marketable individuals from their shallow burrows in the bottom. Planting in all cases may be accomplished as easily as in oyster culture, for quahaugs of all sizes are able to burrow when thrown on the bottom.

It may be of interest to speculate on the actual returns that should be expected by an energetic and reasonably cautious planter, who might now be able to lay out his quahaug or little neck beds in New England waters. When ordinarily favorable conditions obtain, he would plant on an acre at least one hundred and twenty bushels

of seed clams averaging one and three-quarters inches in length. For this seed he might have to pay five dollars a bushel, though often he would be able to obtain it for less. These young clams, for which he has paid six hundred dollars, he plants in early May. By the first of November following they should average two and a half inches in length, and would have increased in volume to six hundred bushels. These he should be able to sell for at least three dollars a bushel, or eighteen hundred dollars. After deducting the amount spent in raking, which would vary according to the depth of water and the character of the bottom, he would in any case receive a relatively large profit from his investment. The production on some bottoms would not be so great as this, but on many others it would be considerably greater.

The hard clam is widely and favorably known in the northern states, while in the South, in the warm waters of which it is much more at home, it is rarely seen in the markets, and in many regions is entirely unknown. Where it is now consumed, the demand for it is rapidly increasing, and when it has made its way into southern and far interior markets, a new and extensive industry will without doubt appear on the Atlantic and Gulf coasts over an area that is now practically unproductive.

CHAPTER XXII

THE SCALLOPS



AMONG the most beautiful objects to be found on the sea shore are the shells of scallops that are often thrown above the reach of the water by the waves of storms. Many species are found in temperate and warm parts of the world, and the rounded outline, the radiating grooves, or the exquisitely varied coloration of the shell, have attracted attention since the earliest times. It was often worn to indicate that the bearer had visited the shores of distant countries. The holy Palmer, brought before Lord Mar-mion, had come

“From Salem first and last from Rome;
One that hath kissed the blessed tomb,
And visited each holy shrine,
In Araby and Palestine”

• • • • •
“He shows St. James’ cockle shell”

• • • • •
“The scallop shell his cap did deck.”

And after an adventurous and tempestuous life, when the time had arrived for his celestial pilgrimage, Raleigh sang

“Give me my scallop shell of quiet,
My staff of faith to walk upon.”

Lovers of the beautiful are not confined to civilized peoples, and we find that even ancient savages in various parts of the world employed the shells of scallops in many of their rites and ceremonies.

Every one is familiar with these shells, which are used in many kinds of decorations, and are figured in decorative drawings and paintings; but comparatively few, perhaps, are aware that the animals that form them are eagerly sought in many countries for a more utilitarian, and—in the minds of those who may be inclined to agree with a modern French neurasthenic who has declared eating to be one of the most disgusting of human functions—less noble purpose, that of being used for food. However one may regard the function of eating, he has found it to be necessary, and has developed a taste that esteems one thing above another; and some of those who have come to regard this particular power of discrimination in themselves as an art, have assured us that the scallop is the daintiest of all the foods that the waters produce.

The reason that so many are unfamiliar with the scallop as a food animal is that until recently it has been kept fresh with so great difficulty that it has been shipped only short distances from the shore. The secret of its seemingly perishable nature lies in the fact that four and a half quarts of small, yellowish scallop "meats," if soaked in fresh water for a few hours, will emerge plump and white—so greatly bloated, in fact, that they now fill a seven quart measure. Most consumers apparently desire to pay for plumpness and whiteness; but freshened scallops are very perishable, while in a more natural state their keeping properties at the low temperatures of modern refrigeration are nearly if not quite as good as those

of unfreshened shucked oysters. If they feel that the bloating of scallops is necessary to the trade, it would seem that dealers might ship them in a normal state, allowing agents to bring about the required pathological condition after they had reached their destination. But the fact is that the market near the shore is sufficient for the present scanty supply, prices are already high, at times reaching five dollars a gallon at wholesale, and if scallops were to be sold unfreshened, a still greater sum would have to be asked for them. The scallop dredger has a good reason for continuing to freshen his product, and the consumer may continue to live in ignorance of the nature of the unspoiled article.

Those who are familiar with the scallop as it is exposed for sale in cities near the coast, have seen only small, white cylinders of flesh, for the part that is eaten is the single adductor muscle, the remainder of the body, tender and of fine flavor, being thrown away, or at best used as a fertilizer. That this is a great sacrifice appears from the fact that a bushel of scallops yields but two and a half or three quarts of "meats."

Among the common names applied to the form in America are "scallop," "scollop," and "escallop," while on the Gulf of Mexico, where, however, it is not known as a food mollusk, it is called a clam. In England such names as "queens," "frills," and "fan-shells" are heard.

Two species, *Pecten irradians* and *Pecten tenuicostatus*, the one found from Cape Cod to Texas, the other north of the cape, are captured on our eastern and southern coasts. The warm water scallop is the smaller, its shell attaining a maximum diameter of about three and a half inches. It is marked by radiating grooves,

and in young individuals is often variously and beautifully colored. This form is much the most common in the market. The northern scallop when full grown possesses a shell about seven inches in diameter, that is without radiating grooves or pigment. It is now so difficult to find that it is seen in few markets outside the state of Maine.

Pecten irradians inhabits shallow waters near the shore line, and is usually found where eel-grass is abundant. The reason for this will presently appear. Like the other members of the genus, it is in many respects a very highly specialized form among bivalves. Along its mantle edge, for example, are many complex eyes that are visual organs of surprising acuteness. The creature has the habit of lying, at times, on the surface of matted eel-grass, and on being approached, becomes alarmed, flaps itself off of its support, and sinks to the bottom. Like a few other bivalves, the adults are able to swim, but in a very peculiar manner.

Lying on the bottom, they sometimes may be observed to snap the valves of the shell together, and water being thus ejected from the mantle chamber, the body is forced in the opposite direction. It might be assumed from the examination of an individual held in the hand that the animal must move in swimming with the hinge edge of the shell forward, but quite the reverse usually is true. It may be puzzling to understand why the expelled water should not all escape from the edges of the shell opposite the hinge where the gape is widest; but when the mantle folds are examined, a very wide and thick flap is found on the edge of each, which, when the water in the chamber is put under pressure by the closing of the shell, is thrown inward in such a manner as to prevent its escape

(Figure 65, *f* and Figure 67, *m f*). But these folds are muscular, and on the closure of the shell they bend outward near one of the lobes or "ears" of the shell on the hinge side, so as to form a short tube-like aperture. Through this tube the jet is driven, and the body, rotating somewhat, is propelled in the opposite direction. Immediately the shell again opens and closes, and another jet is driven out, but this time near the opposite ear of the shell. Again the body is slightly rotated and driven onward at an angle to the first course. Alternately the jets are discharged from near one ear and then the other in rapid succession, and the creature rises from the bottom in a zigzag course until it reaches the surface. This is represented in Figure 66. Contractions then ceasing, it settles to the bottom, usually several feet from the starting point. If this performance were repeated many times, a considerable distance might be covered, and it has been assumed that scallops make periodical and concerted migrations from shallow to deep water and back again.

This, however, almost certainly is not true, though it is commonly believed. No reliable observer has ever asserted that he has seen these migrations. On the other hand, Mr. Belding, who for several years has watched them closely at all seasons where they grow naturally, and who has had the matter of their supposed migrations in mind, writes that they have remained in the same places the year around. The more intelligent of the scal-

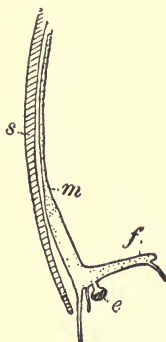


FIG. 65.—Cross section, edge of shell (*s*) and mantle (*m*) of *Pecten*. *e*, eye; *f*, flap or fold extending inward from the edge of the mantle.

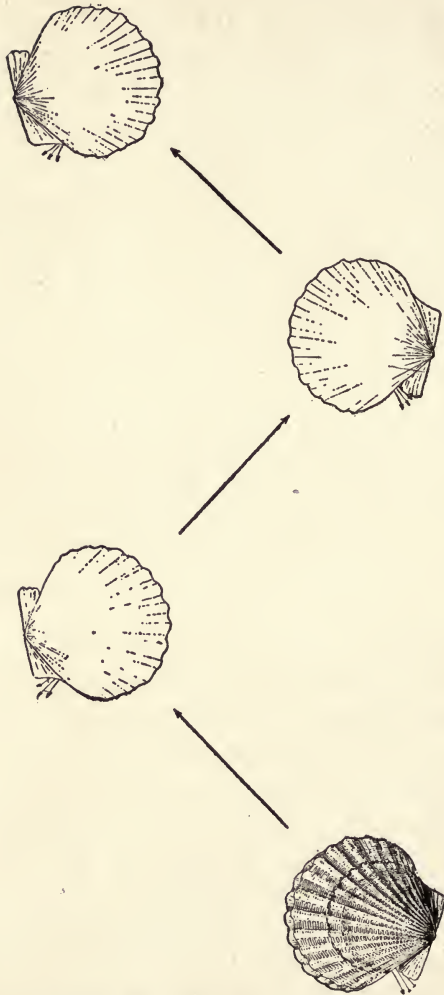


FIG. 66.—Course taken by *Pecten* in rising from the bottom by successive closures of the shell.

lop dredgers hold the same view of the matter. It does sometimes happen that scallops in shallow water are

segregated near the shore line, or even thrown on a beach, being rolled by dragging waves in a gale, but such a movement is not what is meant by migration.

The small *Pecten irradians* is marketed in the fall and early winter, and in very shallow water is taken by means of an implement known as a "pusher," a rectangular iron frame about three feet wide with a bag at the back, which is pushed over the bottom by a handle. In water too deep for wading it is secured by means of light dredges towed in ten or fifteen feet of water by cat-boats, or more frequently, perhaps, by small gasoline launches.

South of Cape Cod this small scallop is found at Nantucket, all along the south side of the cape, in Buzzards and Narragansett bays, and in some of the bays on the shores of Long Island. It was formerly abundant on both shores of Long Island Sound, but now is rarely found. Everywhere in northern waters it has been greatly reduced in numbers, like the clams. In the Carolina sounds it is taken for a few of the local markets, but is seldom disturbed in the Gulf of Mexico. In 1904 great numbers were discovered by the writer on the eel-grass covered bottoms west of the Chandeleur Islands—enough of them, probably, to support an industry of considerable magnitude. They are not at all known, however, in the neighboring markets.

The northern scallop inhabits deep waters, most of the best known beds lying at a depth of from forty to sixty fathoms, and is dredged with difficulty, owing to the rocky nature of the bottom.

Until recently little was known of the life histories of either of our Atlantic *Pecten*s, though in the case of the shallow water form the fishermen had made some ac-

curate guesses as to the time of breeding and the length of life. We now possess a thorough study of the anatomy and development of the giant scallop by Professor G. A. Drew, and an interesting investigation of the development and habits of the shallow water form has been made by Mr. D. L. Belding.

In the giant scallop the sexes are separate, but the shallow water form is hermaphroditic. In both cases the ovaries are easily recognized without dissection during the breeding season by their bright salmon-pink color.

The spawning season of *Pectan irradians* begins about the first of June in New England, and ends in early August, weather causing some variation. Probably it begins earlier in warm southern waters. The ripe eggs of this form, one four-hundredth of an inch in diameter, are extruded into the water, and there meet the male cells. Usually in hermaphroditic animals one set of sexual cells is matured and discharged before the other, apparently in order that self-fertilization may be prevented. But in an aquarium a scallop sometimes discharges ova and spermatozoa together, and these unite with each other. More frequently one set is discharged, and then, after an interval, the other, and under natural conditions cross-fertilization would most often occur.

The segmentation of the fertilized egg is of the same general character as that of oyster and clam eggs. It also, from fifteen to twenty hours after fertilization, becomes a swimming embryo or veliger and, suspended by the activities of its cilia, is carried about by water currents. The velum or prominence bearing swimming cilia has made its appearance, and a shell is secreted that is soon large enough to cover the entire body. The velum is extended out beyond the shell margin when in func-

tional activity. Whenever the creature is disturbed, it, like the veligers of other bivalves, immediately withdraws the velum within the shell, which closes, and sinks. Sometimes it resumes its course before settling far, but even if it reaches the bottom it may soon rise.

During the last three days of the short swimming or veliger period, a foot begins to develop on the under side of the body. It becomes relatively very large, and its first function is a curious one. Being extended from between the valves of the shell to a distance equal to that of two-thirds of the body, its end is seen to be covered with cilia, the movements of which begin to aid in swimming, and thus supplement the work performed by the velum. The latter organ soon atrophies and disappears, and the creature ceases to spend the greater part of the time afloat. But it is still able to swim, and frequently rises from the bottom—not yet, however, by the flapping movement of the shell valves that characterizes the swimming of the adult, nor by the action of the foot cilia alone, for the body soon becomes too heavy to be moved by them unaided—but by a paddling motion of the foot. Swimming by a paddle-like foot action is sometimes practised by adults of other species of bivalves (*Mactra*, *Ensis*, *Solenomia*, *Yoldia*), and the habit is retained by the young *Pecten* for some time. Gradually it begins to swim by the shell, being aided for a time by the foot, but as the animal grows, the latter organ becomes relatively small and ceases to have a part in the performance of this function.

Thus in early life the foot aids in swimming in two ways—by the action of its cilia and by paddling: but in addition to this, it performs two functions—that of spinning the byssus for attachment, and of creeping. Prob-

ably even in the late embryonic swimming stage a byssus gland is developed at its base and becomes functional, for very small individuals hardly more developed than the late swimming forms, have been found attached to floating objects, and Mr. Belding has witnessed somewhat older individuals, about one millimeter in diameter, swimming at the surface of the water with foot extended, and has seen them attach by the sucker-like end of the foot on coming in contact with the sides of the aquarium. A moment later they were seen to be attached by byssus threads.

By a groove on its under surface, the foot forms this thread from the byssus secretion, and attaches its end. While at first the thread is single, the number of strands in the organ increases as the animal grows, and it becomes a firm tether. Figure 67 shows its appearance and relative size in an individual about half an inch in diameter. The deep notch shown in the shell where its lobe-like wing joins the main body, is for the accommodation of the attached byssus. This bundle of threads is cast off at will from its proximal end, and new threads are formed when needed. From time to time attachment occurs during the greater part of the scallop's life, though infrequently in full-grown individuals.

It should be observed that the habit of very early byssus attachment seems to have a direct bearing on the distribution of scallops, for it accounts for the fact that they are so frequently found in grass-covered bottoms. Usually in the early summer great numbers appear attached to the blades of eel-grass with which they may have come in contact while swimming, and to which they have fastened, as to the glass of the aquarium. The long blades of this plant, rooted in the bottom, seem to be both

detrimental and useful to the scallops, detrimental because their mass checks the food-bearing currents, and useful because they undoubtedly offer great protection by preventing the washing away of these light bodies in

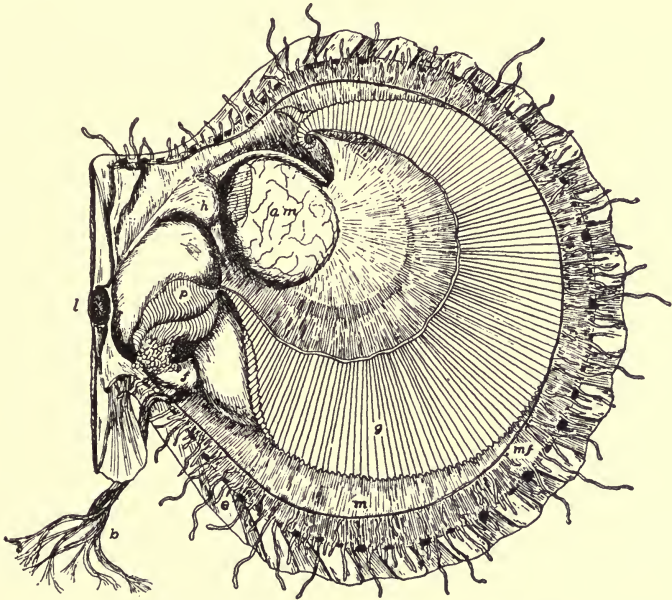


FIG. 67.—Pecten one-half inch in diameter. *am*, adductor muscle; *b*, byssus; *c*, eye on mantle edge; *f*, foot; *g*, gill; *h*, heart; *l*, shell ligament; *m*, mantle; *mf*, mantle fold; *p*, striated inner surfaces of the palps.

storms. Pectens that have had only scanty protection of this kind are often thrown up by waves to die on beaches. This probably is the explanation of the fact that the best scalloping grounds are on eel-grass covered bottoms. They also attach in deeper water, though in smaller numbers, to stones, shells, and other bodies.

Long after they have passed the embryonic stage, they

may reach the grass blades above the bottom, for they still continue to swim from time to time by the paddling motion of the foot, and then by the shell, and during these short journeys they may attach on striking any solid body. They may perhaps also attain a lodgment above the bottom by creeping up the grass blades, and this is a function of the foot not yet described.

When the small scallop settles, on the disappearance of the velum, the foot is relatively of great size, covering the entire ventral surface of the body. Frequently the animal extends it, attaching the end by a sucker-like action; then by a contraction of the foot, the body is drawn toward this point, and by a repetition of the process the young *Pecten* creeps and often climbs up vertical surfaces. This habit is continued for some time, and during the creeping period, of course, swimming and byssus attachment are also practised.

It is interesting to observe that *Pecten* as well as *Mya* and *Venus*, and probably other bivalves, possess what may be called the creeping stage, a definite period during which they employ a part of the time in creeping on the ventral surface of the foot, and for the remainder lie attached to various objects by means of a byssus, which they may cast off and reform at will, and also, in the case of *Pecten*, in swimming. In 1891 incidental mention in papers published by two German biologists was made of the fact that the young of the bivalve *Dreissensia* exhibited the habit, after the swimming stage and before attachment, of creeping on the bottom. Details of this curious habit, however, were first published by the writer from observations made on the soft clam *Mya*, and recently it has been studied more thoroughly in *Pecten* and *Venus* by Mr. Belding. As the habit of creeping

seems to be of little or no value to any of these forms, except possibly to *Pecten*, and as the foot in all of them is at this stage proportionately a very large organ, though later becoming greatly reduced in *Mya* and *Pecten*, it may be assumed that the adult ancestral form of each possessed a large foot capable of effecting relatively long journeys, and that the creeping habit here exhibited by the young of their modern descendants is merely a memory of that ancient practice. *Venus* still retains the large foot in the adult condition, but in the light of the experiments mentioned in the previous chapter, seems, after it has begun to burrow, to make little or perhaps no use of it in locomotion.

On account of the depth of water in which it lives, the early period in the life of the giant scallop is unknown. The adult seems not to be able to attach itself, though there is a byssus gland in the foot; but there are no reasons for doubting that the young has the same habits of creeping and attachment that are found in its smaller relative.

Some of the facts concerning the growth of *Pecten irradians* are of great interest and economic importance. Increase in size, after the scallop has settled from its embryonic swimming state, is fast or slow according as food-bearing currents are favorable or not; but growth is most rapid in August and September, and decreases steadily as the water becomes colder. When, about the first of December, in New England south of Cape Cod, it has reached 50° F., growth ceases altogether. It is only resumed when, about the first of May, the temperature again rises above that point. It thus appears that in New England there are five months in the year when the scallop does not grow. The same is true of the hard clam,

and it would be interesting to know if these forms grow continuously in the warm waters of the Gulf of Mexico. During May growth is rapid, but in June or July, when the scallop is one year old, it begins to mature and discharge its sexual products. So great is the tax on the creature's energy during the period in which it is performing this function, that its growth is about half what it had been in May. When the reproductive period is passed, rapid growth is resumed.

Actual increases in volume during known periods have not been calculated, but some idea of the rate of growth may be had from measurements of the longer axis of the shell in successive periods. Many growth experiments, carried on under varying conditions, have been made in Massachusetts. They show the average length of the axis of scallops spawned on July 1 to be about one and a half inches on December 1, and that on December 1 a year later these scallops will possess a shell about two and a quarter inches across.

There have been various speculations on the normal length of life of bivalves, but only in the warm water scallop have we any positive knowledge of it. While both of the edible Atlantic clams are known to live four or five years, and probably may live longer under favorable circumstances, fishermen have generally held the belief that the scallop's life was limited to two years, and very careful observations have proved this to be true. The fact was ascertained in part by observing great numbers of individuals kept under normal conditions in large inclosures. Many observations were also made on those living among entirely natural surroundings, and altogether the data conclusively indicate a natural life period of from eighteen to twenty-six months.

Life begins in June, July, or early August. One year from its beginning the scallop normally spawns. It lives on until about the first of the following March, beyond which time there are very few chances of its survival. Some members of its generation perish earlier, the great majority die with it, when there begin to be some promises of spring, while a very few companions, undiscouraged even by a New England winter, are able to reach a second spawning season, soon after which they also perish.

All this has an important economic bearing, briefly put by Mr. Belding as follows:—"All scallops less than one year old must be protected [by law], for these furnish practically all the spawn for the following year. Only scallops under this age need protection. . . . It does no harm to capture scallops more than one year old; in fact, it would be an economic loss if they were not taken, as nearly all die before a second [dredging] season."

It is an interesting biological fact that in *Pecten irradians* we have an instance of an invertebrate animal the existence of which beyond its breeding time is of no value to its offspring, yet continuing to live nearly half its life after that period. If, from the fact that a few live to breed a second time, it may be supposed that all formerly performed the reproductive function more than once, there still remains to be explained the abbreviation of the life period, and the fact that it now ends just before instead of just after the reproductive act, a condition that might possibly be detrimental because of so large a food consumption, and at any rate certainly is not useful to the species.

Paley undoubtedly would have seen in this an evidence of the benevolence of nature in allowing this highly organized creature to live on into a placid old age to enjoy

the pleasures of life after its responsibilities had passed. The convenience of an older method of interpreting natural phenomena is sometimes wistfully recalled.

If laws protecting "seed" scallops, or those less than a year old, and allowing the capture of those above that age, should be passed and enforced in the scallop territory, how would it be possible for the dredger to determine the age of individuals in his catch? For it frequently happens that seed scallops that have had abundant food are larger than the older ones.

There is a very interesting way in which this may be done in the majority of cases. When the growth of the shell is resumed in May, a line is made around its margin where the new shell is added (Figure 66). This is usually distinct and remains unaltered, so that when dredging begins in the fall, the fisherman may know that all scallops so marked have passed through a spawning season. In the few that live through a second May, another line is added. In some individuals, it is true, the line is indistinct, and in a few others additional lines are formed from some temporary check in the growth at various seasons, but usually the line clearly records the resumption of growth in May. Probably the declining scallop fishery would be much improved if laws protecting the young, which have not spawned, were strictly enforced.

The enemies of *Pecten irradians* are not numerous or very destructive. Scallops are occasionally eaten by ducks and geese, and some are destroyed by bottom-feeding fishes. They are attacked by the oyster drill, a spiral-shelled mollusk that files a hole through the shell and consumes the pulpy mass of the body. These drills, however, appear readily to be shaken off by the vigorous movements of the scallop, for partially drilled shells are

frequently found. The most dangerous enemy is perhaps the starfish, which is quite numerous at times on some scallop beds.

What might reasonably be hoped for in scallop culture is still difficult to state. Great numbers have been kept, the year through, confined in pens, and have grown rapidly; but when free, their wanderings apparently are not extensive, so that it might not be necessary to plant them in inclosures. Like oysters and clams, they require a good circulation of water. It is an encouraging fact that young scallops for planting are extremely abundant in certain spots, where circumstances favor their collection. If these were removed and deposited on other bottoms, where they might be less exposed to ice or waves, it might sometimes prove to be profitable to the planter; but usually there would be little advantage in this, and at the present time it does not appear that any method of artificial culture other than the replanting of exhausted areas would be worth the labor involved in it.

It has been said that one of the characteristics of the American poor is that they must have the best and most expensive of everything, and that more good food is wasted in the United States than in any other country on the globe. Certainly there are many edible marine mollusks, some of them occurring in great abundance on our shores, that are not found in our markets. In Europe, small gasteropods are cooked and marketed on the streets in paper bags as popcorn or roasted peanuts are here. The common black mussel (*Mytilus edulis*) is reared artificially all along the European coast. It grows rapidly, and immense quantities are consumed. It occurs

on our shallow bottoms and tidal areas in enormous numbers, and is a great pest on oyster and clam beds. Yet it is marketed in but one or two of our Atlantic cities, and is eaten for the most part by foreigners. A near relative of the black mussel, *Modiola*, is quite as good for food. The large sea clam (*Mactra*), and the razor clam (*Ensis*) of the Atlantic, *Gnathodon* and *Pholas* of the Gulf, sometimes used locally for food, are rarely found in any market. Of the last mentioned, only *Gnathodon* is very abundant, however. It is true that most of these forms have a sweetish taste that is not agreeable to many persons, and intestinal troubles in rare instances result from eating the black mussel.

Among fishes there are many of fine flavor that are not esteemed, and others perhaps equally good that are never eaten because it is not the custom. One of the best examples of wastefulness in the matter of food is afforded by the dogfish, a small shark some four feet in length so destructive to other fishes, and so numerous that it has come to be regarded as the most serious menace confronting our marine fisheries. It has been estimated that thirty-seven million dogfish, equal in weight to half the total catch of Massachusetts fishermen, were taken by them in 1905. These pests are liberated after being caught, because at present they are of no value. They are almost equally numerous everywhere on the Atlantic coast, and are exceedingly abundant on the Pacific as well. And yet the flesh of the dogfish is firm, snow-white, and of very good flavor—not by any means to be regarded as inferior when one is unacquainted with its source—and the fact that such enormous numbers of them are each year actually taken from the water and cast back again, is a sad one to contemplate in view of

the struggle that many are compelled to make for food.

It would be fortunate if the nation might wake to the fact that there are in the seas immense quantities of palatable and wholesome food not yet utilized. Custom interferes with the introduction of such food in many cases, but custom in this matter has been changed many times in the past, and it is easier now than it has been to consider all matters on their merits.

The natural supply of many of the best of marine foods has been misused and dissipated. So it has been with useful terrestrial animals and plants. To have directed nature so that these were improved for human use and increased almost without limit, is one of man's greatest achievements. Many of the inhabitants of the ocean also are within his control, as he has already demonstrated in oyster culture and in the artificial propagation of many fishes. There is no reason to doubt that the harvest of many other marine forms will eventually become many times more abundant than the most bountiful that nature ever produced unaided.

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