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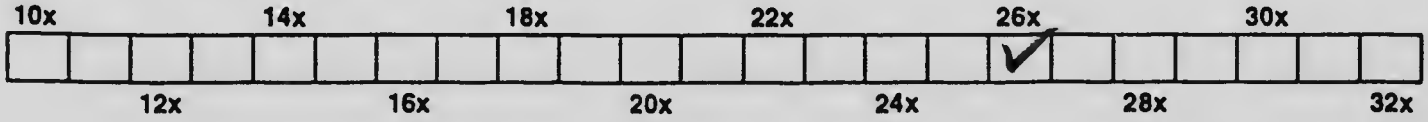

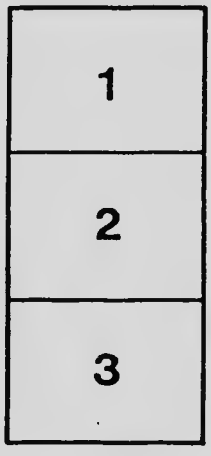

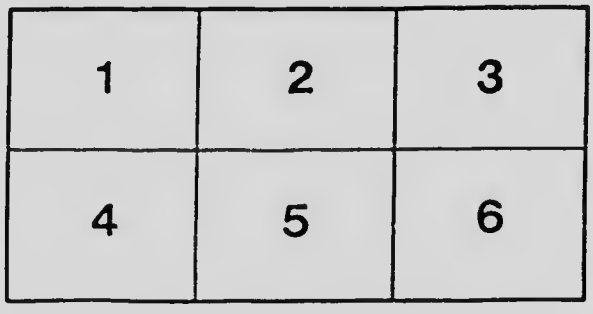

[REPRINTED WITHOUT CHANGE OF PAGING FROM THE REPORT OF THE BRITISH COLUMBIA COMMISSIONER OF FISHERIES, 1917.]

THE NATIVE OYSTER OF BRITISH COLUMBIA.

(OSTREA LURIDA, CARPENTER.)

BY JOSEPH STAFFORD, M.A., PH.D., MONTREAL.

METHODS OF CULTURE.

The oyster is one of our natural resources, and as such has been brought into existence by natural causes and perpetuated under natural conditions. It has likewise been limited by natural forces to circumscribed areas and restricted numbers, and its struggle for existence has settled down into a reciprocal give and take between itself and the other members of its limited world. Against these it is fitted by nature to defend itself, since the mortality brought about by adverse climatic, physical, chemical, or biological elements is offset by successful defence and fertility of reproduction.

When such a natural product is discovered and appeals to the wants of civilized man there is converged upon it a strain so sudden and vast as to surpass all innocent and unprepared defence. Man, by his calculating and inventive genius, both by wholesale mechanical seizure from the natural areas and by effective transport inland far beyond the original distribution, imposes a demand upon the natural product which is not only additional to the original demand, but is overwhelmingly greater in amount. The oyster-fishery, like every other fishery that has been exploited by man, is forced soon to respond by such decided falling-off in numbers as to rouse fears of depletion and final extinction. To permit it to readjust itself naturally would require restriction of the fishery almost to the point of prohibition, in which case, as a natural resource, it would cease to be of any economic value.

The only way to turn the natural supply of oysters to almost limitless value as a national asset is by artificial cultivation. That is what has been done in agriculture, forestry, and the like, where the natural production became too meagre for human requirements. We need not only to conserve the original stock, but to increase its productivity in order to keep pace with growing demands. This offers scope for man's intellectual and constructive activities in furnishing practical and productive methods of culture.

The importance of method in oyster-culture can hardly be overestimated. Everybody has had sufficient contact with some employment or mode of livelihood to recognize the advantages of methodical over methodless procedure. From the most commonplace elementary duty of the individual to the most complexly elaborated and correlated operations of great organizations there should be that relation between proposed action and desired result which is indicated by the terms "method" and "system." The managers of every business or profession draw on their accumulated stock of personal experience and acquired knowledge in forecasting a plan of action, and even assistants and employees are selected or rejected according to their ability or inability to work towards a required end. Since this is true for long-established and well-tested occupations of the masses, it must be acknowledged as all the more urgent in a pursuit (such as oyster-culture) where the accumulation of information is in the hands of relatively few people, the operations at times exposed to unusually great difficulties, and the results not immediately or distinctly exhibited.

Methods are estimated by results, and in consequence are spoken of as good or bad. But a complete method of oyster-culture is not a simple thing; it is composed of many separate acts of which each may be regarded as a method in itself and its advantages weighed. It may happen that the end-result depends especially upon the result of a single action. Such a critical analysis is not often thought out, but more commonly people rush ahead and sum up the whole as a sort of get-rich-quick business or as a failure. Much depends upon the application of the method. A good method in poor hands may be no more productive than a poor method in good hands. Yet a rigid following to the letter of a blind rule is not advocated for all places alike, but rather the intelligent adaptation of a good general method to the special conditions of the locality.

Methods of oyster-culture have originated in different countries and at different times. There is nothing remarkable about an independent origin in countries far distant and having no communication with each other. The accidental observation of oysters on anchors, ropes,

or hulls of ships, on buoys, piles, or lower timbers of wharves, or on other structures, is sufficient to suggest the putting-out of solid bodies for the purpose of catching spat and originating experiments that develop into a system. In olden times such a method was passed on from father to son from generation to generation, and in later times by historical transmission.

Italy has had a method of oyster-culture since about 100 B.C. According to Pliny, the artificial propagation of oysters was first carried out in the salt water of Lake Averrus by Sergius Orata, a Roman knight, who soon made a fortune thereby. On one occasion, becoming involved in a lawsuit for trespass, his counsel, Lucius Crassus, declared that if expelled from the lake his client would grow oysters on the roof of his house—no doubt a gross exaggeration for the time, but a remark that would cause little surprise at the present day.

England as a home for native oysters in great quantity and superior quality was frequently referred to by early Roman authors; it has been even hinted that it was the oyster that attracted Caesar to the coasts of Britain.

France, Holland, and Belgium have, since the middle of last century, developed the most painstaking methods of modern times, and some other countries of western Europe have likewise carried on culture of the common European species (*Ostrea edulis*).

Japan for some two hundred years has attained to considerable success with a different species (*O. cucullata*).

The United States began the cultivation of the common oyster of the Atlantic Coast of America (*O. virginiana*) independently of European countries and a few years before the modern methods were instituted in France. The oyster-fishery is now the most important fishery of the United States and greater than that of all other countries combined. Seed-oysters are shipped to the Pacific Coast and planted in suitable bays of California, Oregon, and Washington. The common oyster of the Pacific Coast of America (*O. lurida*) has also been cultivated in more recent time.

Canada possesses natural beds of the same two species as the United States, and of late years has made some progress in their cultivation. Intensive culture is all the more necessary here because of the more northerly position, the restricted areas, and the sparse seeding of the natural beds. The high attainment of the industry in the United States should spur Canada to great efforts in developing this fortunate natural possession. The coasts of Eastern New Brunswick, of Prince Edward Island, and of Eastern Nova Scotia have many warm shallow-water bays adapted to the requirements of the eastern species, so well known to the fresh-oyster trade, and seed from these regions as well as from Eastern States grows rapidly to marketable size in British Columbia waters. The eastern oyster is already cultivated at Crescent in Boundary Bay, at Ladysmith in Oyster Harbour, at Horseshoe Bay near by, and at Esquimalt. The western oyster is cultivated at Crescent and at Ladysmith.

In the early days people were content to gain a ready and comfortable livelihood, and culture was pursued on a small scale and generally in a half-hearted spirit. Progress was slow. A feeling of satisfaction with existing conditions, the self-assurance that accompanies little experience, and the assumption of special knowledge, set views, and unimproved machinery were some of the retarding causes.

With the progress of time, the growth of population, increased demand, the development of a commercial spirit, desire for wealth, competition, investment, formation of companies, etc., oyster-culture, like other means of production, came to be applied more earnestly. Calculation, adaptation, improvements, additions, inventions, were made and information sought from other districts and other countries. Along with a general advance in education, the improvement of implements, machinery, and transport did much to overcome prejudices. A deeper insight and a broader comprehension were gained, and men began to awaken to the possibilities of future developments and to cultivate a spirit of enterprise in great undertakings.

The fisherman, culturist, and capitalist have done much in the carrying-out of methods when once instituted, but the direction of the most important advances has always been indicated by the trained investigator. The routine work of mechanical operations can be applied by the masses, but the grasping of complex problems and the methods for their analysis can be handled only by men accustomed to research and that have the leisure to think. It requires the marshalling of all related sources of knowledge as well as the power of their application. Methods must conform to the mode of development, the structure and manner of life of the oyster, must take account of the physical conditions of the environment, must be applicable from local resources,

and must be kept abreast with the advance in knowledge and the improvement of machinery. New methods or new adaptations may be tested by inexpensive experiments on a small scale; experiments giving the best results can be applied on a large scale.

SELECTION OF LOCALITY.

Before going to expense in preparation for oyster-culture it is well to make sure of a few primary essentials with regard to locality, site, accessibility, market, transport, and the like. It must be understood, of course, that it is rarely possible to obtain everything that is desirable in a single location. But some things can be done without, even though inconvenient, while others cannot be dispensed with at all. A good deal depends upon the kind of culture it is proposed to carry on and whether such work is or has been conducted in the district before.

If there are or ever have been natural oyster-beds or scattered oysters in the region, one may feel sure that the physical requirements are at least somewhere near the mark. If there are no oysters but other bivalves that usually accompany oysters, the conditions may still be sufficiently suitable for some phases of culture. In any case it is best to examine with regard to the four primary essentials referred to in the section on environment (1015)—viz., sea-water (salinity), heat (temperature), bottom (substratum), and food (nourishment)—in order to decide whether or not oysters are likely to be able to live at the place under consideration. In this connection it must also be remembered that planted oysters can often live where reproduction would be impossible, and if the complete process or all the processes of culture are to be pursued it is necessary to be still more careful about the selection of a locality. The extent of the variation in salinity and in temperature, the amount of fluctuation in rise and fall of tides, the depth of water, currents, fresh water, flats, beaches, and exposure are some of the main things.

One of the first questions to arise is whether the business can be made remunerative. To judge this requires a consideration both of the probable productiveness and expense of working. The first must take into account the possibility of securing sufficient area to be worked and the chance of extension in order to keep pace with a growing trade. The second deals with such things as manner of working the beds, whether at low tide on exposed flats or at other times by means of tongs or dredge; accessibility of the beds; proximity of a continuous market; means of transport by train, railway, or boat; possibility of hiring help; sites for house, wharf, and other necessities convenient to both beds and shipping-station; means of living and of provisioning and of procuring utensils and construction materials. The best localities are those possessing more than one kind of regular communication with large cities, so that competition will keep down rates and orders may be filled often and promptly and without delay in transit. On the other hand, on account of the manner in which the oyster procures its food, oyster-beds should be kept out of the way of drainage and sewage from large centres of population and from wastes from manufactories, mills, and the like.

GOVERNMENT PERMISSION.

It needs scarcely to be mentioned that the sanction of Government is required to right of usage of a bay or portion of a bay or other body of navigable water for special purposes. Such right refers only to the purpose for which granted and should not interfere with the rights of others in legitimate navigation, fishing, etc.; neither should others interfere with the rights of the culturist or damage or remove any of his property. It must be understood that property on or under sea-water or exposed at low tides can be personal and private in the same sense as property on land, and as such is subject to protection according to law.

APPARATUS AND CONSTRUCTION-WORK.

Even the simplest kind of culture on a small scale requires some apparatus and construction-work. It is surprising how little suffices at some places. It may be well to not procure or construct much at the start until it is found by practical carrying-out of the processes what will be most convenient and efficient for the locality. A strong, somewhat shallow motor-boat with some deck-space, a float, a wharf or landing, a house, are most likely to be needed. Instead of several large scows some companies make use of a larger number of much smaller "batteaux" that can be left anchored on different beds ready for loading, and because of their narrowness and pointed fore end are not so likely to drag anchor in a storm or be swamped and may be

towed with greater speed. Depending on the manner of working the beds, additional boats, scows, floats, buildings, and dredges, tongs, rakes, forks, hand-harrows, wire shovels and pails, sorting-knives, etc., will be required, and sacks or boxes for shipping.

OPERATIONS OF CULTURE.

The operations bearing most directly upon the cultivation of oysters may be primarily separated into two groups—the first dealing with the simple process of planting and growing-up of seed oysters obtained from dealers who make a business of supplying seed, the second dealing with the more difficult special processes of raising one's own seed. The culturist who wants to reap the greatest benefit from his knowledge and labour should do both.

RAISING OYSTERS FROM PURCHASED SEED.

In order to keep this set of operations more distinctly separate from others, we may select the planting and growing in British Columbia of seed-oysters obtained from Prince Edward Island or Connecticut or other Province or State in the East. This is what culturists generally set out to do, because the work is more easily and surely performed and results are sooner visible in the production of grown oysters ready for market.

Buying Seed-oysters.—Seed, as referred to in oyster-culture, does not have the same meaning as in grain-culture. Seed-oysters are not a definite stage in the life of oysters as grains of wheat are in the life of wheat-plants. Such oysters may be any stage between the youngest spat and the grown oyster. They correspond, therefore, more closely with young fruit-trees obtained from a nursery and are not all of the same age, size, or appearance. They are already oysters (not eggs or seeds) and only deserve the name of seed in the sense that they are the starting-point of cultivation by many culturists.

The value of seed depends primarily upon the number of living oysters it contains as compared with useless matter like dead shells, stones, sponges, etc. It may even carry over enemies, parasites, or other undesirable animals. If it is in the rough state as scraped from the beds where it was produced it will contain a greater proportion of rubbish than if it has been more or less culled. The larger the oysters the more valuable they are counted, because the more capable of withstanding change of conditions and attacks of enemies and the sooner they grow into marketable sizes. On the other hand, the smaller they are the greater the number in a bushel and the greater the gain if they succeed in growing to maturity. Another consideration is the locality from which obtained and the climate to which accustomed.

The price may vary from about 10 cents to more than $1 a bushel. What is called "spat" by the oystermen, young seed set in the summer of one year and offered for sale (as seed) in the spring of the following year, requires 8,000 to 10,000 to fill a sack of three bushels. "Two-year-olds," belonging to the same set but sold a year later, go about 5,000 to a sack.

Transport.—This may be by boat or by train or part of the way by each, and transfer may be required by wagons. Handling should be reduced to the minimum and performed with care. The seed should not be kept out of the water longer than necessary. It should be shipped while the weather is cool. It should not be left exposed on a wharf or side-tracked in a car. It should be kept cool and moist with ice, but not frozen, and there should be no sudden or extreme change. If possible, the car should be ventilated, the inflowing air passing over ice, and the sacks, made of loose, open material, packed so as to allow the air to pass among them.

From Bridgeport, Conn., to Crescent, B.C., a car-load, all the way by rail, consisted of:—

175 sacks at $3.50 a sack	$ 612 50
Freight, 31,800 lb.	571 50
Ice	12 00
Total	$1,196 00

It will be seen that for such a distance the transport costs about as much as the seed itself—another reason why it is of advantage to buy clean seed. The time required was seventeen days and the oysters were received in very good condition—only a few having dried badly by having the thin edge of the shell broken through contact, weight, or rough handling, so that they were unable to retain their juices.

Having been informed beforehand of the time of arrival, everything was ready to get the seed into the sea-water without delay.

Planting.—The sacks were slid down a trough-like incline of planks reaching from the car to a scow, on to which the seed was emptied and the loose sacks were dipped into the sea-water and spread over the oysters to protect them from the sun. The scow was then towed by motor-boat at high water to the planting-ground, already staked out at low tide, and the seed scattered by men with shovels (Fig. 1) as the scow was slowly moved back and forth over the bed.

The ground selected is on what has been called the "eastern bed" in the last report, situated south and east of the channel of the Serpentine River where it makes a semicircular curve to pass between eastern and western beds on its way to join with the channel of the Nicomekl River. The area that can be used is upwards of half a mile broad and covered with 8 or 10 feet of water at high spring tide, but exposed for about five hours at the corresponding low tide. The space required for a car-load of seed is a surprisingly small patch, so that there is room for a good deal of selection even within the limits of the eastern bed. There are parts higher and first exposed, somewhat sandy and without eel-grass, and parts that are lower or on which the water lies longer, inclined to be muddy and to some extent covered with eel-grass. The car-load referred to was put down on such a place as the last, where one sinks a little in walking, but it is firm underneath and can hardly be said to ever dry off.

The specific gravity of the water above this bed rarely falls below 1.016 and is generally between this and 1.020. The fresh water of the Serpentine spreads out over the bed at high and falling tide, but when the flats begin to be exposed it comes to be confined to the channel. At rising tide, when the water of the channel begins to overflow, mixed fresh and sea water is brought back over the bed. The fresh water of the Nicomekl is carried off without affecting the bed at falling tide, but some of it may be brought back at rising tide. Ordinarily the water from both rivers is not sufficient to lower the salinity to a greater degree than that mentioned. At times fresh water from the Fraser River is turned by tide and wind into the bay and lowers the S.G. to 1.012, 1.010, and even 1.008. This happened in July of 1913 and 1916, but not in 1914 and 1915.

The temperature of the high-tide water above the bed seldom reaches 15° C. before the first, second, or third week of May. Shallow layers left in hollows on the flats for several hours during low water, river-water coming down a warm valley or channel-water draining off flats, and the shallow edges of tidal water on beaches may attain to this temperature a week or two earlier. A degree of 20° C. in the high-tide water over the bed is touched very rarely—about once in a summer, although 19° C. is attained several times. The great mass of the tidal water is held at 16 to 18° C., but thin layers left stranded and exposed to the sun for hours during falling and rising tide may reach 25°, even 29° C. for an interval.

Separating.—After the seed has grown for a year it will be found to be largely composed of bunches of about half a dozen oysters with the hinge ends grown together and stuck in the mud, while the opening ends of the shells point upwards and diverge from one another. It is quite plain that the oysters in a bunch were originally held together by the same piece of cultch, although they may have grown to each other more securely since, and that the upward divergent extension was due especially to an effort on the part of the growing oysters to separate as much as possible and get to free water and food. If left in this state they will continue to grow long and narrow or some of them will die. It is part of the work of the culturist to break these bunches apart into their separate oysters and to distribute the oysters over the beds thinly (Fig. 2), so that each has room to grow in breadth and thickness as well as in length without interfering in feeding, respiration, and excretion. Where the oysters are too thickly planted some of them should be carried to spots where there are few or none. This can be done during the long low-water periods of spring tides.

Growing.—The seed grows to good-sized oysters in two or three years from the time of planting, depending upon the size started with and the rate of growth—the latter again being largely due to locality (temperature, salinity, food, etc.), but also to individuality and attention. They do not all grow at the same rate—even oysters lying side by side in equal conditions differ in size and shape. They have their differences of constitution and appetite as well as in other respects. Some weaken or die from hereditary causes, some happen accidents, while others are partly starved or smothered. The death-rate is usually low for the first year, but increases rapidly with the second and third years. There is an advantage in using them as fast as they grow to sufficient size.

Harvesting.—In gathering the oysters for market, if there is much variation in size the larger may be picked by hand, leaving the rest for further growth. They are carried in wire pails and loaded on to a near-by scow. If the greater number are marketable a speedier way is to rake all the oysters (Fig. 3) into little heaps, then rake the heaps on to hand-barrows, each of which is carried by two men and emptied on to the scow. As oysters are not cultivated in deep water in this country, there is no need of using tongs or dredges, except perhaps rarely as a means of procuring oysters at high tide when the collected stock has run out.

Sorting.—This can be performed as the oysters are picked, or may be done on the scow during the period of high water, when the undersized and small oysters may be thrown back on to the bed at once. But it is generally more satisfactory to tow the loaded scow (Fig. 4) to the wharf, where sorting and trimming can be carried on irrespective of tide and weather. The large oysters have the undersized and small ones pried off by a strong oyster-knife, the barnacles chopped off by a heavy butcher or carving knife, or they may be otherwise cleaned and washed. They are then shovelled into a large float beside the wharf or scow, where the tide-water can flow over them and keep them fresh for market. The undersized and small oysters are taken back and replanted either together or, better, in assorted sizes on some portion of the bed for further growth.

Shipping.—The oysters may be shipped to markets in sacks or in boxes. The latter are preferable; they are more easily handled, the oysters do not jam so badly and get their edges broken, and they look tastier. The boxes are made of thin, dry lumber (not too closely nailed together) of a size to hold 25 dozen packed oysters. The name of the company or the trade-name of the oyster may be printed on the ends of the boxes and the address to which consigned may be conveniently written by coarse blue pencil on the top or side. The best shipping arrangements should be made to protect from the sun and to hasten delivery—whether by wagon, auto-truck, railway-car, motor-boat, or steamboat.

Marketing.—Orders come from fish and meat markets, fish and meat retail stores, restaurants, and hotels. When once introduced the business is likely to hold from year to year and even advertise itself and grow. At first some advertising, canvassing, correspondence, or sending of samples may be necessary.

RAISING OYSTERS FROM COLLECTED SEED.

Another way of starting with seed-oysters is to collect seed from natural oyster-beds and transfer it to one's own beds. To the culturist in British Columbia the great natural oyster-beds or reefs of the Atlantic Coast are too far distant to be practicable, and the only thing for him to do is to buy from a seed-collector there, as has been already considered.

With regard to the native oyster in British Columbia, there are no great natural beds and any small and thinly seeded beds that do exist would soon be exhausted if there were any drain made on them. Moreover, it would take a great deal of work for the small amount of seed that could be collected. Their value lies in being there, little as they are, as an indication of suitable environment and a starter for cultural operations.

To transplant the native oyster to other parts of a bay or to other bays for further growth it is necessary to pick or rake them and transfer by boat or otherwise in a similar way to what has been described for the eastern oyster, except that for small quantities and short distances some of the precautions are not necessary. There is no business in the supply of seed-oysters on the Pacific Coast and it is not possible to buy them in car-loads. The culturist has to gather them himself or hire it done, a few sacks at a time.

RAISING ONE'S OWN SEED.

In procuring his own seed there are open to the culturist the same methods as are made use of by the seed-producer who provides seed for sale—viz., the collecting of natural seed from favourable natural beds and the raising of seed by cultural methods. Since, as has just been stated, the natural beds of the Atlantic oyster are too far away to be practicable and the natural stock of the native oyster is too limited to furnish a continual supply, the only alternative is to buy seed of the former and to raise seed of the latter. In order to keep the operations separate we may now select the method of raising seed of the native British Columbian oyster in home waters.

1. In an Oyster-bay.—If the culturist is operating in a bay more or less naturally seeded with native oysters the beginning is already made for him. The oysters there have been perpetuated in successive generations for unknown time, and an examination will show that the existing individuals can be classified into several generations. From the largest and oldest adults it is an easy matter to select sizes descending to those smaller and younger ones which the oystermen might call "seed," and continue to the still smaller and younger stages which they would call "spat." If close inspection is made there may be found specimens so small as to be almost invisible to the unaided eye—the spat of the zoologist.

Spat on Natural Marine Objects.—It is not only possible to find spat on adult and seed oysters, but to find them on other shells, such as clams, cockles, mussels, whelks, even on gravel, stones, rocks, and other natural bodies.

Natural Cultch.—Since all such hard bodies offer anchoring-points that are seized upon by larvæ to save themselves from sinking into the mud or from drifting away by currents, they long ago came to be known to fishermen as "cultch" (clutch). Empty shells of dead animals are just as good or even better for the purpose than the shells of living molluscs; in fact, the greater part of naturally occurring cultch is composed of the empty shells of oysters that have lived on the surface and of clams that have burrowed into the bottom but whose shells have come to be washed bare after death.

Artificially Supplied Cultch.—Of the spat that becomes fixed to natural cultch comparatively few grow up to maturity, so that the natural accumulation of cultch is slow. The deficiency may be made good by the culturist who can gather oyster, clam, or other shells wherever they are to be procured and scatter them on his bed among the living oysters. The spat collected by either the naturally occurring or the artificially supplied cultch can be used as seed for transplantation.

2. In an Oysterless Bay.—If there are no native oysters in the bay and the culturist has good reason to believe that they could live and propagate there, he has to begin by procuring native oysters from some other bay (preferably of the same region) and planting them out on his own beds. Any stage of spat or seed or grown oyster will do, but the younger they are the longer it will take them to grow to maturity and become breeding oysters. The present object is not to grow planted seed to oysters for the market, but to grow it to breeding oysters with a view to developing a stock. For this purpose the full-grown oysters are best, since they will be ready to spawn in the first season and will produce the greatest amount of spawn. Such oysters are what practical oystermen call "spawners." They are also seed-oysters in the sense that they are the starting elements of production in a fresh area. If there are young oysters and spat mixed with them it will not be objectionable, since these will grow up to increase the spawn as well as to increase the cultch. This last is a very important point. Next after having oysters in a bay the culturist must see to it that there is cultch.

Where there is no cultch there can be no naturally occurring or artificially propagated oysters because there can be no naturally deposited spat from which oysters can grow up. In every bay or in some part of every bay there is almost sure to be something in the form of cultch even if it is only an isolated stone or clam-shell. But it takes a long time for nature to build up an oyster-bed from such a start. This is one reason why our oyster-bays are so thinly seeded with oysters. Another reason is that so few eggs are successful in developing to the spatting stage. Before spat can be deposited there must be these two conditions present at the same time and place—viz., the presence of the young of the oyster at the spatting stage and the presence of cultch on which to set. The greater the number of the young the greater is the chance for each piece of cultch to receive one or more spat; the greater the number of pieces of cultch the greater is the chance for each of the young to find one of them. These two conditions operate together—each a correlative and a necessity for the other. A stone or a clam-shell may catch a spat which may grow and sooner or later become adult and give origin to numerous young. Several of these may be deposited on the original piece of cultch or on the parent shell, and by their number as well as by their growth increase the surface of the cultch, or by breaking apart increase the number of pieces of cultch. In such a way a bed may be originated and extended. Under the best conditions it is a slow process, for each generation requires time to develop to maturity before it can take part in the process of reproduction. Moreover, the increase is not so fast nor so sure as the mathematical calculation might lead to suppose, for the spat and oysters are subject to many and powerful agents of destruction which keep reducing their numbers.

It is in the power of the culturist to do much to increase both the number of the young and the amount of the cultch and in so doing to assist and hasten natural processes. Of the two, he can do by far the most in the supply of cultch. In a natural oyster-bay the scarcity of oysters is evidently not so much due to want of young as to lack of cultch. The very presence of oysters shows that there has been a succession of generations each of which must have produced great numbers of young. The natural capacity for increase of young is greater than for increase of cultch. The natural increase of young is annual, that of cultch requires several years to become effective and may be destroyed in the meantime. New cultch overlies old, often without increasing its surface, and old cultch in the form of shells is continually wasting away.

Whether a bay contains a few thinly dispersed, naturally occurring oysters, or whether it has had a few oysters native to the coast artificially deposited in it, the operations of the culturist are the same. Increase in the number of oysters can only be brought about by increase in the number of spat, and spat must have cultch. The cultch formed by the shells of the living oysters is not enough. The cultch added by the natural accumulation of shells of clams, cockles, mussels, etc., is too slow. The culturist is losing time by waiting. This is one reason why it is advisable to begin growing transplanted eastern oysters. Their shells are an important contribution to the stock of cultch. Besides, they soon grow to marketable size and help to pay expenses as well as make a start in procuring a market.

An oyster-bay and an oysterless bay may be considered as extremes between which there may fall bays that according to size and structure would need to be managed in one way or the other. Extensions from the sides of oyster-beds, provided they are furnished with cultch, will become automatically seeded with oysters. Similarly, an artificially prepared new bed within reasonable distance from a prosperous old bed will also become seeded, provided tidal currents flow from the seeded to the unseeded bed. A bay may be so large and the tidal movements so modified by islands or reefs that one part of it is as effectively separated from another as if it were in reality in a separate bay. In such a case a new bed will have to be planted not only with cultch, but also with living oysters (spawners).

EGGS, EMBRYOS, AND LARVÆ NOT PRACTICABLE AS SEED.

In the foregoing pages has been considered the method of raising spat for seed. This is the method, it might be said the historic method, of the culturists. Long before the complete life-history of the oyster came to be known, long before even isolated stages of the developing oyster were known, it was already known that young oysters could at times be obtained by putting out solid objects for their reception. The youngest stages of these young oysters were not seen and the culturists knew nothing about them. It was only after the cultch had been in the water some time that the spat could be seen and their further growth followed into recognizable oysters. Since all the stages in the life-history of the oyster have come to be known, the question arises, "Why not begin with a younger stage than the spat—why not, in fact, begin with the egg as is done in breeding poultry, fishes, and lobsters?"

This is not practicable. As has been seen from the experiments of last year's report, it is not a difficult matter to procure eggs of the eastern oyster and sperm for their fertilization and to develop the young from the egg through the embryo to the larva. But it becomes very difficult or impossible to develop it to late larval stages such as immediately precede the youngest spat. In fact, I do not believe it has ever been accomplished. There are statements in the literature, it is true, that would indicate it had been done, but it is not hard to show that they were mistakes dating from a time when the full development was not known.

For the western oyster it is not difficult to get eggs, embryos, or young larvæ from the mother-oyster and they may be kept for several days, but the same difficulty arises as with the eastern oyster. The later stages of the larvæ of either oyster, right up to the spatting stage, can be readily captured in the sea-water about its natural beds by means of a plankton-net, and may be kept in beakers of sea-water for several days, but they will die rather than become fixed and metamorphosed into spat. Artificial methods have not yet been able to imitate in a small way, not to say improve on, natural methods at this period. The reason is not hard to find; it is due to the difficulty of keeping larvæ confined in small vessels of water so as not to be lost and at the same time supplying them with suitable food, keep the water aerated, and effect the removal of their excreta without introducing undesirable animals and plants that may multiply in overwhelming numbers to the disadvantage or destruction of the oyster larvæ. It is not hard

to believe that it will yet be possible to overcome these difficulties and to cultivate food in suitable kind, quantity, and purity, either in the same vessels with the oyster larvæ or in separate vessels from which the larvæ may be fed. A clear perception of the requirements is an important step towards the achievement. It would seem, however, that there is little to be gained in extracting larvæ from the water to be kept and attended for a brief period and then returned to the sea. All the eggs, embryos, or larvæ that culturists could collect from oysters or from the sea, even if they could be kept alive for a time and again turned out into the water, would be an almost negligible number compared with what are naturally poured into the sea without the help of man.

SEED OF EASTERN OYSTER NOT ORIGINATED IN THE WEST.

While the eastern oyster in all sizes from the youngest "seed" ("spat") up is capable of living, growing, and spawning in western waters, and while fertilization, segmentation, and development may proceed for an interval, there is no seed produced and the stock of the eastern oyster cannot be replenished by breeding on the planted beds, but has to be kept up by repeated shipments of seed from the East.

WORK ON OYSTERS.

The work of the culturist has to deal first with the oyster and second with the environment. The work on the oyster is not confined to the adult, but includes the developing stages as well. This is where all former work in culture has failed to produce the best results. Men worked with only the marketable oyster in their minds and did not consider how the marketable oyster comes to be such. They did not stop to think whether more can be accomplished by providing for the eggs and young stages than for the adults. The best method must take account of all stages of development and begin to provide for the egg and the larva as well as for the spat and the adult. To do this we need to know these stages of the developing oyster and to know where and when they are likely to occur and what conditions of environment they require. It was for this purpose that I made the special investigations and wrote the four preceding reports on Embryology, Anatomy and Physiology, Environment, and Cultural Experiments.

Egg.—The egg, as the first stage, is especially to be guarded. It is bad policy to permit wholesale loss of eggs and afterwards become oversolicitous for the few survivors that have passed into succeeding stages. Medium- or average-sized western oysters spawn about 1,000,000 eggs at one time. Where there are many spawning oysters on a bed there must be countless numbers of eggs spawned. Yet in a state of nature there is little, if any, increase in the number of oysters to be seen from year to year. The number of eggs that develop successfully into adults agrees pretty well with the number of deaths of adults. There is a tremendous loss from what may be called the accidents of life. Nature seeks compensation through numbers. Artificial propagation should profit from the lesson and seek to increase the number of eggs spawned. To this end it will not do to keep selling off all the adult and well-grown oysters. A good proportion should be held for breeding purposes. The number of eggs produced increases rapidly with the increasing size of the oyster. The largest and oldest oysters are by far the best egg-producers.

At this point it may be mentioned that there is a notable difference in the number of eggs spawned by our two species of oysters and in the manner of treating their eggs. Whereas the eggs of the western species are to be counted by hundreds of thousands, those of the eastern oyster are to be enumerated in millions. But the western oyster makes up for what it lacks in numbers by a greater parental care. While the 16,000,000 or more minute eggs of our large Atlantic oyster ooze out or are squirted out of the parent into the sea-water and sink to the bottom about or in the neighbourhood of the spawners, the 1,000,000 or so of the comparatively large eggs of our small Pacific oyster are retained for upwards of two weeks in the mantle of the parent, where they escape many of the exigencies of life to which the corresponding stages of the eastern oyster are subjected. The reproductive elements of the Atlantic oyster, when discharged from the parent, are minute helpless eggs, entirely at the mercy of their environment; but from the Pacific mother-oyster issue larvæ provided with locomotory swimming organs, protective shells, sense-organs, etc. In the former there is all the more need for the spawners to be left or placed in suitable locations as regards substratum. If the eggs settle on to soft mud or shifting sand, at least a large proportion of them is likely to be lost. Hard bottom of rock, gravel, or clay is best for this purpose. Another requirement is the absence of strong currents

that would wash the eggs away from the good bottom. Both of these conditions are also conducive to successful fertilization where, as in the Atlantic species, the eggs may be extruded from the parent before being fertilized. In the Pacific oyster the eggs are fertilized after leaving the oviduct but while lying in the suprabranchial, intralamellar, and infrabranchial cavities by means of sperms from other oysters brought by the respiratory currents. In the Atlantic species, while some eggs no doubt meet with sperm in the same way, it is likely that, on account of the rapid passage to the outside, most of them first come in contact with sperm after complete extrusion. To facilitate this chance not only is the character of the substratum of consequence, but the presence of somewhat quiet water and the number and proximity of male spawners. If the breeding oysters are thinly scattered there may be an advantage in collecting them more in clusters to assist in fertilization. Muddy water should be avoided, for eggs may be crushed or smothered by even a thin layer of deposit.

A cause of more rapid destruction of eggs exists in exposure. Where they lie below low-tide mark in a continuous mass of water they are tolerably safe. But where they are supported on grounds that are left bare by the falling tide they may be exposed to a scorching sun or a shower of rain or a cold atmosphere. As the great masses of oysters occur naturally or are cultivated on grounds just above or below the low-tide line, steps should be taken to guard against overexposure. The spawners should be placed in the best positions from the standpoint of the egg. Below low-water line, in the more quiet places of channels and sloughs, in the sheets of water retained in the hollows of flats, where the water is held back by eel-grass, in coves and lagoons may be mentioned. Even parts of exposed flats may be made safe for this purpose by being inclosed in shallow dykes that retain a few inches of water during the period of low tide. Of course, such places must be selected as are not overflown with river-water, following the receding salt water.

Larvæ.—Since successful eggs develop into larvæ it may be judged that areas selected for eggs must also have reference to the needs of larvæ. In general this will be the case, but it must also be remembered that eggs are quiescent while larvæ are active swimmers. Although they do not swim great distances, they serve to keep suspended for periods in water that by tidal or other currents may be carried and distributed far from the grounds on which the spawners and eggs were deposited. From the standpoint of the culturist this is the great drawback of the larval stage. He may have succeeded in obtaining and guarding a large deposit of eggs only to have the succeeding larvæ carried off and scattered over other more unsuitable grounds or lost in deep water. Every falling tide carries suspended larvæ seaward to be deposited and settled in all kinds of places. Every rising tide carries larvæ to higher levels of flats and beaches to be exposed at the next low tide or to suffer from the effects of fresh water. The ceaseless effects of tides keeps reducing the number of larvæ in the region of the original spawners. There is no practical way of herding the original stock. They are too small to be confined by anything of the nature of wire netting. Materials such as used for plankton-nets are too perishable. Netting of even large mesh offers such resistance to flowing water as to be immediately rent. Floating timber and seaweeds clog and increase the pressure. The only thing to be done appears to be to prepare for a heavy loss of larvæ by preserving vast numbers of eggs. The more eggs there are preserved the more larvæ there will be lost, but also the more there will be saved. The whole stock of larvæ does not rise in swimming movement at one time. Some are lying on the bottom, some are swimming at different levels between the bottom and top, some are rising and some falling at every moment. This much may be observed from the experiments with larvæ in glass beakers and from the plankton collections taken at high and low water and at rising and falling tides. I have sometimes thought that the larvæ can distinguish falling from rising tide and that they govern themselves accordingly. Larvæ taken from a western oyster fresh from the flats and placed in a beaker of fresh sea-water seem to rise in greater numbers at the time of rising tide and to settle in greater numbers at the time of falling tide for several days after being removed from the sea to the beaker. Plankton during rising and falling tides often appear to verify this thought, but the collections must be taken where sediment does not interfere. There is no question but the larvæ have it in their power to drop to the bottom to avoid being drifted out by falling tide and to arise when they feel the fresh, cool water of the rising tide, but whether they have sufficient intelligence or instinct to do so it is difficult to decide. Of this much, however, we can be sure, that the larvæ are most plentiful near the centres of their origin and become fewer and more scattered in proportion to the distance from these centres.

This gives us a clue as to where to plant spawners in order to obtain a stock of larvæ—even though somewhat of a floating population. They may be put in lagoons and coves where there is a greater distance to be drifted out to sea or more obstructions to distribution by the tides, in sloughs and pools where there is sufficient water at low tide to keep them from drying out, on low parts of flats where they will be protected by water held back by matted eel-grass, or at low-tide mark where at least some of them will survive the free larval period. Where there is no natural area or where this is too small it may be possible to construct an artificial one, such as a pond or a dyked-in area. As a preparation for the close of the larval period there must be an abundance of cultch either naturally occurring or artificially supplied.

Spat.—As soon as the larvæ are grown to full size and have become fixed to cultch there is no more chance of drifting to destruction, and the care of the culturist is for the most part turned in new directions and along surer lines. The full-grown larvæ have either been saved by successful fixation or they have gone lost. It is the attached spat we have now to deal with. The expert is soon able to form a pretty safe judgment as to the value of the "catch," but the rank and file will need to wait a few weeks before the result is plainly exposed. During this time the minute spat are growing larger and becoming more visible, and the observant oysterman can form conclusions as to the number and closeness of the "set" on his cultch and whether to leave it undisturbed or to remove it to safer places.

The disadvantages to which the spat are most liable are sediment, drying, frost, and crowding. It must be remembered that spat are unable to creep out of any deposit of sand, mud, or weeds, and from their small size and tender structure are easily covered and crushed or smothered. There is sure to be warm weather succeeding the set and before winter, and those uncovered by the tide are at first just as liable to be dried up and killed by the hot sun or dried out by a warm atmosphere as are the larvæ. A little later in place of heat there is the question of frost. Frost and ice are destructive—the first from the formation of crystals in the soft parts of the spat, rending the tissues, the latter from weight or grinding movements. Cultch with its set of spat that is already in safe places needs no immediate attention, but that in less favourable places should be looked after at the first opportunity. At this period the culturist can employ his time to more advantage in rescuing unfortunately placed spat than in any other way. He cannot have another like opportunity for a year—and a year's growth of the thousands of spat he may save is an important item, not to mention the addition to his future breeding stock. After overcoming all the risks to this point it is too bad to allow spat to be destroyed in masses for want of attention at this time. Unfavourably disposed cultch that is sufficiently well dotted with spat should be transferred to better places below low-tide level, in sloughs, in dykes, etc. During the cold part of the autumn, winter, and spring the spat do not grow much, but they thicken their shells and become better protected against accidents. By the time the warm weather of the succeeding spring and summer sets in many of them may be crowding one another for space and food, but they are still too small to separate from the cultch and the latter is still too hard and strong to permit of breaking in pieces in order to relieve the pressure of growth of the spat. The crowding individuals will begin to curve and diverge from one another and to bend away from the cultch, so that with the rapid growth of the summer there will be left only a comparatively small surface of attachment to the original cultch. The culturist can decide when it will be best and when he can best spare the time to break apart the growing bunches and spread them over more ground. He can also judge by the growth whether they are in good locations as regards food-supply or if they had better be removed to richer feeding-grounds. Generally speaking, the localities having a blackish mud bottom and in or near beds of eel-grass can supply a greater amount of food than those on harder and lighter-coloured grounds. The black mud is itself especially due to plant and animal decay and is an indication of the abundance of organic matter that can either serve for food or can support food-supplying organisms. Spat that have already grown somewhat can hardly sink into the mud by their own weight, and, besides, their rapid growth will help to keep their edges above the surface.

Adult.—Since the spat passes insensibly into the adult without any change of habits, much of the preceding treatment is applicable to the adult also. There comes a time when it is necessary to break apart the bunches of oysters that have grown up from the more or less thickly clustered spat on single pieces of cultch. If left as they are the oysters of a bunch have to grow up side by side and will become long and slim and perhaps somewhat warped for

lack of space. The food that comes their way has to be divided up among the individuals of a bunch and the chances are against every oyster getting its full share, with the result that growth is unequal and some may be starved. The larger and faster-growing individuals may even grow over the smaller ones in such a way as to hold their valves closed so they cannot feed. When a bunch is lying in sand or mud some of the under oysters may be buried and suffocated. There will be much variation in size, shape, appearance, and condition of the oysters, so they will present an uneven sample. As soon as the culturist finds this state of things arising he should go over the bed and break the bunches apart, distributing the oysters so as to allow each proper space and a fair chance for food. At the same time he should thin out the more thickly clustered spots and transplant part to thinly planted patches, to the edges of the bed, or to other areas.

In transplanting at this stage the oysters are of a sufficient size to lie on some mud bottoms without being lost. When lying flat an oyster will rarely sink. As is well known, mud bottoms occasion rapid growth. Even a moderate amount of decaying weeds will either furnish food direct or will supply microscopic organisms, such as bacteria, that may either serve as food for the oyster or its developing young or for still other organisms that in their turn come to the oyster. Where weeds are so plentiful as to form matted, rotting masses over the oysters the latter will be killed; but where living weeds straighten up in the rising tide and permit fresh sea-water to come in contact with the oysters they are an advantage in many ways, protecting the oysters both at high and low tide, absorbing carbon dioxide, and liberating oxygen, and giving attachment to hosts of diatoms that form the chief food of the oyster. Where weeds fall over and cover oysters during low tide, it is true, they tend to smother the oysters, but it is only for an interval when the oysters, if left uncovered, would have to close their shells and remain in a state of defence, while the weeds hold back some water, keeping the oysters moist and protecting against sun and dry air. Eel-grass is liable to be cut off by the sharp edges of the oysters and may be carried away by the tide or partly left to decay on the grounds. I have known a bed of eel-grass on which oysters had been planted to be stripped in one year, leaving the oysters exposed at low tide, silting up and not doing well, while beyond the oysters the eel-grass still remained.

Oysters are likely to be better for removal to new places, unless the latter are altogether unfavourable. Like people, they enjoy a change. In fact, the mere handling of them on the same bed does them good. If sunk somewhat in the soft bottom, or lying on the flat side, or on edge, or with the broad end sticking in the mud, a change to a fresh position will be welcome. The best position is lying flat with the deep (left) valve underneath, but, of course, it cannot be expected to place every oyster separately. Any change of position, change of bed, change of water, or change of food is likely to benefit them. They must not, however, be put where they will be overwhelmed with drift or sediment, or where too much exposed to sun, air, frost, fresh water, or water of too little salinity.

In collecting for the market large oysters may be picked out at low tide, leaving small ones for further growth. Or they may be all raked in heaps and carried by hand-barrows to a scow, on which men may work at sorting during high tide. Or the scow may be towed to wharf and the sorting take place with more comfort. In any case not only should the small free oysters be saved and replanted, but the small oysters and spat attached to the shells of the marketable oysters should be chipped off and returned to the water. They should not be kept long out of the water. Oysters procured by tongs or dredges can be treated in a similar manner. Unless the bed is purposely cleaned off for replanting there should be left scattered old oysters to serve as spawners. All empty shells and half-shells or shells of other molluscs should be left on the bed or, better, taken ashore and cleansed in sun and air to be used as cultch.

WORK ON ENVIRONMENT.

Our first knowledge of the proper environment of the oyster is obtained by observation of the best natural oyster areas compared with non-oyster-producing areas (report for 1915). Verifications and additions to this knowledge are made by experimenting with oysters in different localities or under different conditions to find what kind of a location or what condition is most successful (report for 1916). The knowledge may then be applied in converting poor areas and oysterless grounds into good oyster-producing areas. This is not always possible, but, unless the locality is altogether unfavourable, a good deal may be accomplished. It is more likely to

be successful on a coast or in a district where there are already some oysters or where oysters formerly existed than in places where oysters never have occurred. In the first case the temperature, salinity, depth of water, and nature of the bottom are more likely to be favourable, whereas in the last case the physical conditions may be quite incapable of adaptation. Old oyster-grounds may frequently be extended at the sides or similar grounds may be selected and improved in other parts of the bay or in other bays. It is a clear gain if unoccupied areas can be adapted and rendered productive.

Having selected a plot, the surface should be levelled in order to prevent oysters from being rolled into hollows by the tides and being covered with drift. Soft spots may be mixed with sand or gravel to give a uniformity of surface and keep tidal currents from cutting it into channels or hollows. A substratum of deep, soft mud may have the surface similarly stiffened to prevent oysters from sinking into it. At places where eel-grass grows too abundantly and too long it may be cut and sent adrift with the tide. A mowing-machine has been invented that can be attached to the front of a scow and have the cutting part lowered to suit the depth of the water. The knife is driven by a small engine on the scow and the latter is propelled or pulled along a rope that may be changed in position to cut successive swaths.

At some places various kinds of animals prey upon oysters with considerable destruction and need to be combated by the culturist. One of the most destructive is the starfish, which sometimes migrates in great numbers on to the oyster-beds. A starfish creeps over an oyster, fastens its numerous sucker-feet—some on one valve and some on the other—and exerts such a constant pull that in time the oyster tires and allows its shell to gape, when the starfish presses an arm between the valves and eventually brings its mouth with its everted stomach in contact with the soft flesh of the oyster. Small loose oysters may be swallowed whole and small attached ones may be covered and sucked to death. At no place on our coast have I found starfish in great abundance on oyster-beds, but I have been told they are more plentiful now than a few years ago on the Prince Edward Island beds. Starfish cannot withstand any great admixture of fresh water or a great degree of warmth, so that shallow water and exposed flats are unfavourable to their presence. They may be picked up at low tide and carried ashore. On deeper beds they may be taken on tangles or by a dredge and similarly treated.

Whelks, drills, or borers also do damage, but never to an alarming degree along our coast. They belong to the head-bearing molluscs with protrusible proboscis and rasping tongue by means of which they drill round holes through oyster or other shells and suck the soft flesh. At places they may occur in bunches on a water-soaked log, a seaweed, or the body of a dead fish, and may be scooped up and taken ashore. Where they are plentiful, as on parts of the coast of the United States, a sort of dredge is used having a slantlug sieve through which the whelks can fall into a collecting-chamber while loose oysters and most other larger animals pass over the sieve and are left behind.

Many other animals work small damage, but small and constant losses amount to considerable in the aggregate. Sea-anemones, brittle stars, worms, crabs, fish, birds, and seals can all do some injury to smaller or larger oysters, while eggs and larvæ may fall prey to great numbers of other animals that live by sweeping great quantities of the minutest organisms into their mouths. These animals are too small, too much hid, or too scattered to be effectively attacked by man without also doing injury to oysters. The only thing that can be done is to count on them and to raise such quantities of oysters that there will be plenty left after the toll is taken.

At low tide the best parts of natural oyster-grounds or planted beds or prospected areas may be staked out so that the tops of the stakes can be seen above high water, when scows loaded with oysters, shells, gravel, working implements, etc., may be left anchored or removed as required and planting, dredging, or other work done. Exposure of beds at low tide facilitates satisfactory observation of the distribution of the oysters, their condition as regards substratum, sediment, drift, undermining, healthfulness, growth, fattening, and many other things. The culturist will find plenty to occupy his time, attention, grasp of conditions, invention, and application of methods.

Construction-work such as depositing of gravel to prevent erosion and cutting of channels, the building of dykes to retain water and prevent exposure of oysters or their young to air, sun, and frost during the periods of low tide, the collecting of shells from unused areas and the depositing of them on the oyster-beds to improve the surface and increase the amount of cultch—these are some of the things to be attended to. The many possibilities in physical conditions and

outlay of the plant make it difficult to foresee all that may be required, but the intelligent and practical culturist will soon recognize from results what his particular case requires.

WORK ON CULTCH.

The importance of cultch can hardly be overestimated. Without cultch oyster-culture consists of little more than holding quantities of oysters over in a more or less safe and convenient place awaiting a good market price. They may be bought when the demand is low and oysters cheap; they may be transplanted when work is slack and least expensive; and they may be sold when they will net a profit. During the time of holding there may be some growth, but there will also be some loss. Extension of the time of storing and contribution of better attention may result in greater growth and more profit. A fresh stock has to be bought, shipped, handled, and cared for in the same manner. While both seller and buyer may make some gain, there is no increase in numbers of oysters and little increase in the amount of food-supply to the country. Any gain there is arises from speculation rather than from production. To increase the production other and better methods of handling oysters must be used, and of these the employment of cultch easily occupies first place.

In places where oysters live and reproduce naturally, and in places where oysters can be transplanted and live and reproduce, the natural rocks, stones, gravel, shells, and other hard objects may serve as natural cultch. But these are generally too much scattered, or are too few, or are in wrong places to serve the culturist. Rocks and stones are too permanent and the oysters that become fixed to them are either too difficult to separate or are not of sufficient numbers and size to be worth while collecting. These oysters, however, serve a good purpose in supplying eggs and keeping up the succession of generations. Patches of gravel and of shells are often too few or are in poor locations. Where practicable, stones and shells may be removed to better places. Heaps of stones were used in the ancient methods of Italy; but shells are lighter to handle and are easier from which to remove the oysters. The aggregation of oysters in the brush of fallen trees, the logs of wharves, the stakes, posts, or spars that mark out channels, the bottoms of boats, etc., is sufficient to suggest the putting-out of lumber for the collection of oysters. But lumber is expensive and not durable, and becomes covered with seaweeds, hydroids, barnacles, and other marine plants and animals. Many other materials have been experimented with, such as earthenware, scrap-tin, leather, canvas, netting, etc.; but even if these were satisfactory they are too expensive (excepting the small quantities discarded from their proper use). Old netting that is tarred has shown itself better than the untarred. Tarred brush, bark, shingles, etc., have been used. In Italy bundles of faggots (fascines) have been much employed; in Japan untrimmed stems of bamboo; in France, Belgium, and Holland split drain-pipes. These can be built up crossways so as to allow the sea-water (with the oyster larvæ) to perforate the piles and present an extensive and suitable surface. The rounded surfaces are placed upwards so as to shed the sediment while the hollow, under surfaces are kept clean and fresh. The practice of dipping in cement to give an artificial coating of a suitable smoothness or roughness has also made headway. This facilitates the chipping-off of the spat oysters when they are being thinned out. In the United States many tests have been made of the foregoing and other methods, but all forms of artificial cultch have gained little favour.

Shells are the most natural and best cultch. In places along beaches and on flats the bottom is white with them. Shell-heaps are to be found along shores where Indians formerly camped. Certain canneries throw out great heaps of shells as waste. In some places such shells have been used in making roads. Shucking-houses are sometimes glad to get rid of them. These are opportunities for the oyster-culturist. Where they occur such shells can be procured more conveniently and cheaper than any other form of cultch. Besides, in ease and cleanliness of handling, in extent and suitableness of surface, and in their gradual decay and the readiness with which the attached oysters become naturally or artificially separated, they can hardly be surpassed. The shells of oysters, clams, scallops, mussels, cockles, whelks, abalones, or other molluscs are all good, but those of oysters are best and most likely to be procurable in greatest abundance.

Old natural beds on the east coast often cover many acres of bottom, consisting of shells infiltrated with sediment several feet in depth. In Prince Edward Island great quantities of these shells used to be dredged up in winter through holes cut in the ice, by means of huge

frameworks supporting a beam and dredge worked by horses; and the shells with their contained sediment and disintegrated shell-matter were drawn away and left to soften and rot in heaps on the land, to be afterwards used as a fertilizer. This was rich in lime, but did not come up to expectations in enriching the soil and increasing the crops. Besides, the method of procuring it injured the beds by destroying their continuity, cutting great trenches through them and permitting the edges to fall in. Living oysters from the surface were taken among the rest or were buried by collapse of the banks, and mud was stirred up to settle upon and cover others. The harder shells could have been much more profitably used as cultch, but the farmers who took away the so-called "mussel-mud" were not generally oyster-fishers, and there was no inclination to work either for the good of the oysters or for the oyster-fishermen. It is only in recent years that claims can be obtained to private use of portions of oyster areas, so that a man may reap the benefits of his own improvements.

In the West there are no such beds, but what are called oyster-beds are no more than disconnected single layers of more or less separate and free oysters scattered over limited portions of beaches or flats. On account of the small size, thinness, and softness of the shells they do not last many years as cultch before they are completely broken up or crumbled away. But they are very efficient while they do last, for the spat collected by them is soon liberated by decay of the cultch, obviating much of the necessity of going over them to break apart the bunches. Cultch collected from this source does not accumulate very fast. A greater mass can be more easily obtained by raking up clam and cockle-shells where they keep working out of the mud, sand, or gravel bottom.

On account of the large size, thickness, and hardness of the eastern oyster-shell, it is a good thing to bring eastern oysters to the West and plant them out to grow for a year or two before sending to market. There will not be so many living oysters at the end of the period as at the beginning, but the growth may more than make up for the loss, and at the same time the shells of those that die will add to the cultch on the beds.

Eastern oysters marketed in the West are all sold complete—in the shell, the shell going with the meat and being carried off the beds and indeed away from the premises. In a similar manner they are retailed in the shell and become distributed in small quantities. They are generally served on the half-shell, but if any are shelled to be used otherwise the shells are thrown out, are carried away in the garbage, or form such small quantities as to be not worth the trouble of the culturist to have hunted up and returned. Western-oyster shells are easier to procure in this way on account of their being more often shelled in quantity at definite places. When bought back by the culturist they make excellent cultch. They are clean, so that all the surface is available for spat; they are not so large as to have vast numbers of spat fixed to one piece; they soften and break up easily, freeing the spat from undue crowding.

In collecting oysters for market, sorting, breaking apart bunches, thinning out, transplanting, and such operations, there occur numerous empty shells and separate valves of oysters, as well as some of other molluscs, and if all these are taken care of they soon accumulate to great heaps. Depending on the manner of working the beds, these may be wholly or in part left on the beds or aggregated at the wharf. Those collected at the wharf could be returned to the beds irregularly, at the convenience of the culturist, or could be kept in store for a more definite occasion. The oysterman who engages in the industry solely for the profit from handling more or less grown foreign oysters will perhaps regard these heaps as so much dead loss—indicating the hardships of his business. I have known of masses of such shells having been wasted to no better purpose than filling in a gully. This is still worse than in making a road-bed or in burning to lime. The shells left on the beds or returned to the beds not only improve the surface, but their decay adds to the available calcium carbonate required for the shells of growing oysters. The culturist who is engaged in the industry to satisfy both mental and bodily needs of employment, and at the same time to make the best use of every advantage that occurs, will preserve all shells for use as cultch, and in doing so will accomplish the before-mentioned purposes as well. To this end it becomes necessary to decide whether it is better to leave the shells on the beds or to take them ashore to be returned at a suitable later occasion.

In natural oyster districts oysters have been present for untold ages, and yet at most places the surface shells available as cultch continue to be limited in quantity. The natural accumulation of cultch is a slow process. It depends upon the capacity for production by the species and the capacity for destruction by the environment. Shells that have been buried under succeeding

layers, as in the great oyster-banks of eastern waters, or that have been covered with accumulated earth, as in Indian shell-heaps, have been longest preserved, because removed to the greatest extent from the action of the elements. The solvent action of water and the corrosive action of air, and the alternations between wet and dry and heat and cold, are chiefly instrumental in the decay of shells. On western beds the destruction soon balances up the production. The culturist cannot hope to maintain a stock except by continually collecting and preserving shells. They are less prone to decay on the land than on flats, but there is another and a better reason for retaining them on the land—viz., that it improves their effectiveness.

Oyster-culturists who have given attention to this point cannot have failed to observe that catch which has been kept out of the water and cleansed is more successful than that which has remained in the water from year to year. My own observations of the several hundreds of tons of shells planted at Crescent during the four summers I was there were perfectly convincing. The scores of experiments I set partly for this purpose and partly for other purposes verified over and over the correctness of the conclusion. Day after day for long periods I have put out prepared shells in closed wire cases and examined the catch of spat and compared with the catch on old shells lying about the same places. When the former caught few to many spat the latter caught none to only an occasional one.

The reasons for this difference are not hard to find. It is self-evident that it is not due to the larvæ, for they are equally plentiful about all the shells. It is only necessary to compare the surfaces of the fresh and of the old catch or to note the changes that come over fresh catch as it stays in the water from day to day. The good catch consisted of shells selected from the surface of heaps of shells that had been exposed for months to the air, sun, and rains, and had become quite clean and white. The old shells with which they were compared had lain in the water for indefinite periods and were discoloured, slimy, and dirty. The changes that come over freshly deposited clean shells are largely dependent upon the locality, the temperature and salinity of the water, and the amount of sediment in suspension. It is generally possible to note a difference in a single tide or a single day, but in two or three days the difference becomes marked. A fine dust-like deposit may be first observed; then a somewhat slimy surface which soon shows specks and patches of organic matter that are fixed to the surface and do not wash off by moving the shell through the water; these accumulate a greater deposit and increase in size and number until a great part or the whole of the shell is covered and dirty. If instead of shells strips of glass are used the surface can be examined with a microscope and the nature of the deposits recognized. The organic matters are minute, separate, or colonial plants or animals or exudations from them causing the slimy surface and the retention of silt.

When single valves of shells are dropped into the water separately they fall with the convex surface downwards and concavity upwards. A good portion of the under side rests on or becomes pressed into the substratum and the concavity soon comes to be partly filled with sediment. The only portions left exposed are the upper and lower margins and edges of the shell, which are themselves subject to the organic deposits already referred to. This is why so many shells are found with spat clustered round the margins. The at first complete and suitable surfaces of the shells are liable to be soon reduced to narrow rims of a less suitable surface. At some places this can happen in a few days; at others it may take as many weeks. This is why prepared catch, if put down at the proper time, is more efficient than old catch. Shells that fall without interference light on the convex surface, only part of which touches, and all the rest of both surfaces are at first free and suitable to catch spat. Spat that becomes attached in the centre of the concave surface may be afterwards covered with sediment and smothered or starved. When shells are shovelled from a scow into the water at high tide they may, in falling through the water, interfere with one another or be affected by a current, so that some of them will light with the hollow side downwards. If they fall on hard bottom the greater part of the under surface is likely to be still accessible to larvæ and offers very satisfactory conditions. The worst chance is that depositing sediment may rise round the edges, cutting off communication with the outside. The upper side is also favourable because of its rounded surface allowing the sediment to slip off. But both surfaces are exposed to organic growths. Some of the densest clusters of spat are to be found on the insides of cockle-shells where the valves have been retained intact and so closely fitting that one at first wonders how the spat got inside, which becomes plain when it is remembered that it is not the spat but the minute larva that searches out the place for fixation.

From the preceding considerations it follows that the work on cultch should consist of collecting shells from all possible sources (even to buying them), spreading them out on hard ground (or lumber platform), and shovelling them over once in a while to let the dried mud fall out of them and expose all surfaces until they are clean, dry, and white. In this condition they can be held in readiness for the proper time to plant. The planting itself is best carried out, like the planting of seed-oysters, by being scattered at high tide from a scow as it is being towed back and forward over the bed.

THE TIME TO PLANT CULTCH.

The importance of cultch has been already insisted on. But this presupposes a proper handling of the cultch. To be successful, it must be good cultch, it must be put down in a suitable place, it must be spread in an approved manner, and, above all, it must be planted at a well-judged time.

The more or less accidental observations that originally suggested the possibility of oyster-culture could have no reference to such special points. Oysters large enough or plentiful enough to attract the attention of men engaged in other pursuits were already too old to furnish a clue as to their origin. An unused boat, an anchor, a fallen tree, or some such object with spat attached may have first served to limit the time to within a few months. It might even have been observed that spat did not come into existence in the winter, but in the warm season of the year.

To follow the subject more closely required progress in the knowledge of the developing young, the small size of which rendered this impossible before the microscope came into use. The egg was first observed in 1699. Isolated scraps of information were added by a long list of noted zoologists, but especially by Brach (1800), Leeuenhoek (1805), Baster (1759), Home (1826), Davaine (1852), Lacaze-Duthiers (1854), Coste (1861), De la Blanchère (1866), Gwyn-Jeffreys (1869), Saunders (1873), Salensky (1883), Möbius (1877), Bouchon-Brandeley (1882), Horst (1883, 1884), Hubrecht (1883), Huxley (1883), Hoek (1884), all working on the European oyster. The American species was especially investigated by Brooks (1879), Ryder (1881), Rice (1883), Winslow (1884), Jackson (1888), Nelson (1888-1915). United States investigators have been prone to believe that the straight-hinge larva becomes transformed into the spat, and many expensive experiments have been carried out and failed because of this mistake. Even Nelson, whose work began in 1888 and continued to 1915, did not begin to get away from this idea until 1907, and he appears to have been still under its spell when he wrote his very last report, where he states: "The Canadian oyster-spat, at the time of fixation to cultch, is a fourth larger than the spat in the corresponding stage of development in New Jersey waters."

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As the spat at the time of fixation has the same size and organization as the larva immediately before fixation, it would follow that the full-grown New Jersey larva is a fifth smaller than the full-grown Canadian larva—and the larva or spat of 55 units length in Canada would correspond with a larva or spat of 44 units length in New Jersey. I have elsewhere shown ("The Canadian Oyster" and other reports) that the common size for fixation of the eastern oyster of Canada is 35 units (=0.379 mm.) and of the western oyster of Canada is 37 units (=0.255 mm.). The circumstance is suggestive that the New Jersey oyster may be a different species from the more northern Canadian, and, in fact, Nelson makes the statement: "It is still somewhat doubtful whether the Canadian oyster may not be a distinct variety, breeding true to its kind." But there is another alternative which seems to have escaped Nelson—viz., that the larvæ of the same species might set at different ages and sizes in northern and southern climates.

In looking through Nelson's former publications for some reference to measurements of New Jersey larvæ, I find (1907): "The actual size of the larval shell at times of setting is one-fiftieth of an inch in length" (=0.5 mm.). Measurements of "newly attached spat" of his Plate II, when divided by their stated magnifications give 0.5 and 0.425 mm., which are larger than Nelson's own measurements of the largest Canadian larvæ (400 microns=0.4 mm.). According to his own figures, I do not see how it is possible to make the statement about the relative sizes of New Jersey and Canadian spat, unless in his latest paper he meant to retract his earlier measurements as being inaccurate. My own largest measurement of a Canadian larva is 0.386 mm. in length, and I find no constant or noticeable difference in larvæ of the same species at the extremes of northern and southern distribution, either on the Atlantic or on the Pacific.

The bearing of the subject upon some phases of culture and of transplantation induced me to write to the United States Bureau of Fisheries, asking if it were possible for one of their investigators

to procure and send me samples of plankton taken above oyster-beds and of young spat. The plankton was not successful, but the spat were satisfactory. Comparing them with some of my own from eastern Canada, I find they agree in every respect.

The full-grown larva of the Atlantic oyster was first discovered and described by the writer in 1904. Its external features, size, shape, asymmetry, high umbos, internal structure, foot, gills, and many other organs were then comprehended for the first time in the history of the subject. At the same time the other phases of the life of the larva—viz., the place and time at which it is to be found and the manner in which it may be obtained, as well as the bearing up the subject of oyster-culture—were referred to. These have all been further elaborated in my later works, so that it would now be possible to write a more complete and comprehensive account of the life-history of the oyster than has ever hitherto been presented.

The Pacific oyster agrees in all essential features with the Atlantic species. All lines of research—embryology, anatomy and physiology, environment, culture—have been investigated by the writer and have received equal attention. Before 1911 there was nothing known of it but its external features and its distribution, and these only very imperfectly. All the rest has been written by myself.

The final application of the knowledge gained from both species, so far as oyster-culture is concerned, centres in the intelligent use of cultch, or, to be still more precise, in the proper time to plant cultch. This point, although insisted on in several of my earlier works, has not yet received the attention that is its due. It takes a long time for most scientific facts, principles, or methods to filter down among the masses.

In the northern part of British Columbia I met a man working in a salmon-cannery who told me he had formerly been employed by an oyster company at Whitstable, England, and that he knew "all about the oyster." So insistant was he in repeating the statement that I ventured to ask: "Perhaps you won't mind telling me how long it takes an oyster-egg to become a spat?" He was somewhat staggered, but replied: "Oh, I don't know anything about that."

At Willapa Harbour (Shoalwater Bay), Washington, in talking to a culturist from the East, I was asked a similar question, and upon its being answered he appeared bewildered, and said: "Well, that is very different from what we have always heard."

A seed-oyster producer of New York, after having written many times, called on me. In discussing the points about which he was particularly interested he became frank in expressing his views—one of which was that "The professors have never done anything for oyster-culture and do not attack the problems that occur at the great oyster centres." I did not waste time to disillusion him. Any man in a receptive mood and seeking for information should be helped, but one so badly informed and decided in his views is beyond hope. I might have answered: "On the contrary, zoologists have done nearly everything that has been done; oyster fishermen, growers, and handlers would never have got the information; Brooks, Nelson, and others have certainly worked at the best centres; but it is not necessary to even do this; where nature unassisted produces a lavish supply there is little credit to be taken by the culturist; if good results can be obtained in poor centres it is a sure proof of the value of the method."

When I first went to Crescent and a notice of my purpose had got into the papers I was bombarded with letters asking for "private tips." These were not from oyster-culturists and I did not answer them. I am not concerned with greedy money-grabbers who are looking for unfair advantages. I care only for the subject—the gaining of correct information, the improvement of the industry, the furnishing of a larger food-supply. I write for the masses; it is their privilege to make use of or to reject my methods.

From the observation that small oysters are sometimes found attached to hard objects in the water of shallow bays and estuaries it is but a short step to the putting-out of cultch for the purpose of collecting spat. There is little use of planting cultch in autumn, winter, or early spring—it does not catch spat then. There has grown up a practice among oyster-culturists of putting out cultch at certain times in much the same way as farmers plant seeds or sow grain at certain times. Seeds planted too soon might rot before the proper conditions for their germination arrived, while if planted too late the growth might not reach maturity before the cold weather interfered. In the case of the oyster the egg and succeeding stages (which correspond to the seeds of plants) are not matured and extruded into the water until the warm weather arrives. If they were under the control of man he would no doubt make mistakes and bring about spawning at wrong times, but fortunately they are under the control of natural forces. That which is under the control of man is the power of putting out cultch at the proper time to accommodate the developing oyster. If cultch is put out too soon it is liable to sink into the soft substratum, to become covered with sediment, to be overgrown with plant or animal colonies, and to become coated with an organic slime. To such an extent may one or more of such processes take place that the available exposed surface is much restricted and the efficacy

of the cultch reduced to only a small fraction of what it was originally. The longer the cultch is in the water the more this is the case. It is of great advantage to delay planting cultch until the very beginning of the time when it will be useful. To determine this time is the problem.

The time to put out cultch has been and still is largely judged by the results of previous plantings—i.e., by experience. A sort of customary time—about the last of June or first of July—has been arrived at. But this is not equally good for all places. It may be a little late for places to the south or somewhat early for those to the north. Then, again, it is not equally good for all years, for the warm weather of one summer may be considerably earlier than for another. There are other things that may interfere, such as sudden changes of temperature or a heavy fall of rain. It is useful to have in mind some approximately correct time as a reminder that certain preparations should be commenced, but the actual time cannot be foretold with accuracy for any considerable period in advance. It has to be determined for each year and, in fact, for each locality, except where places are near together and under like conditions.

Another way of obtaining information about the time to put out cultch is to open oysters from time to time to find out if they are becoming richer in colour and more swollen with reproductive matter. When ova or sperm are approaching ripeness some may be squeezed from the reproductive openings by lightly stroking the side of the abdomen. If the cells cling to one another in masses they are not yet ripe, but if they separate into individuals they may be fully mature. To be still more certain they may be examined with a microscope and a fertilization experiment may be performed.

Observation of the actual process of spawning can be seldom carried out. It is not a sufficiently conspicuous phenomenon to be depended upon as an indication of the time of ripeness and may slip by without being noticed. I have seen both Atlantic and Pacific oysters in the act of spawning. In the first the very small eggs (or sperm) are expelled with a squirting noise and can be seen as a little white cloud in the water, dispersing as it settles to the bottom. When the oysters are lying on the warm flats instead of being covered with water, the squirt can be heard and seen and the spawn remains as a white deposit on the oyster or other near objects. This phenomenon is, as stated, rarely to be observed, but what can be noted is the occurrence of thin, dark-coloured, spent individuals, that have spawned out, increasing in numbers, while the plump, fresh, healthy individuals, that have not yet spawned, are decreasing in numbers. In the Pacific species the much larger and heavier eggs drop into the gill-cavities and mantle-chamber, where they lie for some days undergoing development, and only pass to the outside when they have attained to some stage of the straight-hinge larva. This is an advantage that the western oyster offers over the eastern, for on opening them the culturist can easily recognize the soup-like spawn lying about the gills. It varies in colour from white through grey to brown, according to the age. The young white eggs are quite motionless, but the late grey or brown larvæ are active swimmers, best seen under a lens or microscope.

As long as it was believed that eggs become spawned, fertilized, developed, and set as spat in a few hours (or days), the time of spawning could be accepted as near enough to the time of spatting to be used as a sign for the planting of cultch. As already mentioned, the writer showed that this was a mistake and that it required a month instead of a few hours for the process. The elaborate experiments of Ryder, as well as the simpler ones of Rice, Winslow, Nelson, and others in the United States, could hardly have succeeded against such miscalculation. Any results that were obtained were due to other (earlier) eggs than those counted on. Cultch put out a month in advance of the time when the young oysters will be ready to make use of it will become greatly reduced in efficiency in the meantime. There is no use of going to the expense of time, labour, or money in collecting, preparing, and cleansing cultch for that purpose. Besides, many things can happen the developing young in this period. Of the myriads of eggs spawned at the beginning of the period there may be very few larvæ to represent them towards the end of the period. Records of previous plantings, evidence from the appearances of the oysters, ripening of eggs, spawning, fertilization, beginning of development, are all helpful as bits of information, but they are all too far anterior to the setting of the spat to be depended upon. It is evident something more is required.

The only accurate, strictly scientific, and satisfactory method of acquiring the knowledge of when to plant cultch is the plankton method. It begins where the other methods leave off and continues the following-up of the young throughout the period of time that elapses between spawning and spatting—i.e., throughout the month required for the development to the full-grown

larva. It supplies the information of where the young are and what they are doing during this period. For the eastern oyster all stages of development between the egg and the spat are in the water about the parent oysters. For the western oyster the eggs and younger stages of development are retained in the mantle-cavity of the mother for about half the period, and the later stages from the straight-hinge to the full-grown umbo stage of the larva, are free in the water above oyster-beds. The free-living larvæ of both species can only be obtained for observation by some adaptation of the plankton method such as was first applied by myself. All the literature of this subject, with the exception of the little that has been copied by others without acknowledgment, has been written by myself. It includes the facts of their existence, their appearance, measurements, shape, and organization, the distinctions from other bivalve-larvæ and other plankton organisms, the time of year, place of occurrence, manner of life, rate of growth, age, when and at what size full-grown—in fact, all that seems useful to know about when, where, and how to procure, observe, and recognize the larvæ.

Up to the time of the earliest spawning and for one or two weeks afterwards there are no shell-bearing oyster larvæ in the water and consequently none in plankton collections. About two weeks after spawning has begun there appear little straight-hinge oyster larvæ in the catches. From this time onwards there come to be several sizes; the earliest have grown older and larger and other broods of younger and smaller larvæ have come on. The oldest grow to a limit in size beyond which there are no representatives in the plankton collections. They either become set as spat or they perish for lack of cultch or from other causes. In good places it is possible to go on taking plankton with oyster larvæ of various sizes in it for two or three months. As soon as one brood grows up and disappears a new brood ordinarily takes its place, so that the collections preserve a certain uniformity of appearance, although it is not from the same larvæ or the same broods. But the broods are not equal in numbers of individuals. The first that come on are few because they are from eggs that were spawned at the beginning of the warm weather, when only those oysters were ready to spawn that were in most favourable places. A little later a much greater number of oysters would be ready to spawn at one time. If the culturist has kept in touch with the conditions of the oysters on the beds he will know when the greatest amount of spawning has taken place and at what time to expect the largest swarms of larvæ. His plankton catches should agree with and verify this information and show when there will be the greatest number of full-grown larvæ in the water ready to set as spat. *This is the time to plant cultch.* As soon as the first of these larvæ attain to the maximum size the prepared shells should be distributed so as to offer a vast and suitable surface for attachment at a time when the masses are ripe for fixation. Good, fresh, clean, white shells put out at the time when there is an abundance of full-grown oyster larvæ in the water searching for places for attachment cannot fail to catch a good set of spat.

This is the information to which all my observations of structure, development, habits, and surroundings converge, as well as to which all my experiments point—when to bring together these two most important factors of abundance of full-grown larvæ and abundance of suitable cultch. The successful capture of immense numbers of spat is not only the cheapest way of obtaining one's own seed, but is the most satisfying intellectual and practical achievement within the grasp of the culturist.

All the information gained from former experience, from the examination of ripening oysters, from the observation of the process of spawning, from the finding of spawned-out individuals, from the procuring of older and younger broods of larvæ in the plankton collections, even from the putting-out of a few shells to see if occasional specimens of spat can be secured from the earliest broods of larvæ; all this information fits together as one piece and points to one conclusion—the proper time to plant prepared cultch. If this occasion is allowed to pass by unused the labour of gaining the information as well as of procuring, preparing, and planting of the cultch is largely lost. Cultch is of no use unless it is planted. If put out late it may still secure a fair although not so great a set. It is not possible to catch too many spat. If not captured in this way they will inevitably be lost. There may be more attached to some pieces of cultch than can find room to grow, but other pieces will not be overstocked. The loss from the many accidents to which they are exposed will not fail to thin them out in the end.

There is another reason why it is advisable to get the cultch into the water for the first large swarm of larvæ. Early spat are likely to have advantages over late ones in the fact that they have before them a longer period of warm weather and abundant food and will be

larger, stronger, and better protected to withstand the approaching winter. But it may not be good policy to plant shells for the very first swarms of larvæ because of their small numbers. The culturist needs to know his grounds as well as to know his oysters. If the locality is one that rapidly reduces the efficiency of cultch there is all the more necessity to play for the quick capture of a great number of spat—i.e., to put out the shells to accommodate the largest brood. If, on the other hand, cultch does not become very rapidly coated it may be safe to risk the chances of obtaining small contributions from successive broods. When once in the water shells are likely to receive fresh additions of spat as long as there are any larvæ left. The cultch supplied for the largest brood also has this advantage.

It may appear that since larvæ are in the water for so long a period there need be no concern about putting out cultch to suit the requirements of the first or any other large brood—that the continual accession of occasional spat from small broods will total a fair set in the end. But this reasoning is not safe. The study of plankton collections shows that the total number of larvæ in the water from time to time is subject to great fluctuation, as is also the total number of full-grown larvæ. It is the latter the culturist should count on in putting out shells. There are times when for days there are scarcely any to be found, and if cultch happens to be put out at such a time there will be next to no spat secured and the cultch will be deteriorating while the younger broods are growing up to the spatting stage. The cause for the fluctuation may have existed a month previously, when the eggs were spawned, or may have happened at any time during the previous month, when great numbers of larvæ have been destroyed. A cold spell of weather, a protracted rain, or a scarcity of food may have operated to prevent the ripening of eggs, the spawning, the fertilization, or the development.

There is still left one method of judging the time to plant cultch, and that is to keep watch on old shells or, better, to put out a few good shells and examine them for spat. Of course, this method is open to the objection that the first good fall of spat may be past before the culturist becomes aware of the presence of spat and before he has the bulk of his cultch planted. The method, however, can be used in combination with the other methods to advantage, in that while the full-grown larvæ are still few in numbers the culturist may capture occasional spat and even recognize an increasing number which will add to his assurance that he is on the right road.

SPECIAL WORK.

The culturist who is in contact with the same areas from year to year is in the best position to detect and follow up the special problems of the district. He should become interested in the subject in other than financial aspects. He may not be able to apply the most technical methods and reach the most accurate conclusions, but he will soon discover whether he is increasing the production or not. Mechanical repetition of a set course of action is not likely to improve his methods. It is quite unnecessary to risk any suggested change on a large scale. A small, perhaps somewhat isolated, area may be set apart for an experiment. He should aim at finding the best grounds for spatting, for growing, for fattening, for keeping over winter, etc. He could make observations on the rate of development and rate of growth, the conditions under which discoloured oysters (black, green, red) are produced, and the local causes of death among the oysters.

A subject of great importance is that of food. The contents of the stomachs of oysters may be withdrawn by means of a pipette and examined under a microscope to see the kinds and quantities of food-organisms that have been swallowed. Search can be made on eel-grass and other seaweeds and in plankton collections for the same organisms in order to learn where they are produced. These places should then be tried by planting oysters on them and noting the growth.

Different conditions of the bottom and of the water may be tested; continuous submersion or periodical exposure, stagnant or flowing water, gravelly or muddy substratum, sloughs, pools, lagoons, artificial ponds, dyked areas, salinity, temperature, etc.

Oysters transplanted from other districts should be observed with a view to determining the best sources from which to draw. Observations having an apparent local value may be found by comparison to possess a broader significance.

TRADE AND COMMERCE.

There is no need to dwell here on such subjects as finding a market, sorting to a uniformity with the sample, the use of trade-names, catering to the tastes of the people, greening, bleaching, freshening, etc., that hardly fall within the scope of this work.

Fig. 1. Planting seed-oysters at low tide.

Fig. 2. Thinning out at low tide.

Fig. 3. Collecting native oysters.

Fig. 4. Towing to wharf at high tide.