

JAPANESE OYSTER-CULTURE.

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European oyster-culture, especially as practiced in France and Holland, is generally regarded as the most refined development of this ancient art; and from our knowledge of this—if we admit that those cultural methods are the most perfect which produce the greatest number of oysters in a given area—we can reasonably conclude that some of the devices at least of the European culturist will ultimately come to be adopted in our own system. In view, accordingly, of the prospective value of foreign methods in the development of American oyster-culture, the United States Commission of Fish and Fisheries has already published (in its bulletins^a for 1890 and 1891) reports upon the practical workings of the best forms of European oyster parks. From the character of the methods there in use, we can, I believe, conclude positively that similar establishments could be operated successfully at suitable points—e. g., in Chesapeake Bay or Long Island waters, as soon, that is, as the demand for oysters will warrant the use of what will prove at first a more expensive system.

While these European methods are applicable on our Atlantic coast, it still remains to be determined whether they include the best that could be employed along the Pacific, should artificial oyster-culture be here attempted. For in these waters different conditions have produced oysters which differ widely from those of the North Atlantic. The Pacific culturist may therefore feel a more lively interest in the oysters of Japan, for not merely are they closer akin to his own, in structure and in habitat, and therefore more readily acclimatable, but they are larger, better shaped, and certainly of greater value, commercially speaking, than the local product, *Ostrea californica*. Moreover, the Japanese oysters have long been cultivated, and with great success. Indeed, by some experts the Japanese methods have been commended as the simplest and most practicable of all forms of "artificial" oyster culture, and thus of possible interest in somewhat broader lines.

Unfortunately there is no literature accessible dealing in detail with the culture or living conditions of this western Pacific oyster, and it is with the aim of filling this gap that the present report was prepared. Its material was collected by the writer during a stay in Japan in 1900–1901. He there acted under special instructions from Commissioner George M. Bowers, and in aid of his inquiries was designated as a biologist of the United States Commission of Fish and Fisheries.

^aReport on the Present Methods of Oyster-culture in France. Bulletin U. S. Commission of Fish and Fisheries, 1890, pages 863–888, plates LXVIII–LXXVIII.

Report on the European Methods of Oyster-culture. Op. cit. for 1891, pages 357–406, plates LXXV–LXXXVIII. (Italy, Spain, Portugal, Germany, Holland, Belgium, and England.)

For the rest, Japanese oyster-culture proved to be worthy of careful study, not only for its merits, but because of the suggestions it affords for cultural experiments. One may frankly doubt whether it can *at once* be employed profitably—for example, at many points on the Oregon coast—in view of the expense for labor which it entails, but I believe that there is a reasonable chance that it could be made profitable if employed in a favorable locality. In any event, so far as the Pacific coast is concerned, the Japanese methods are the most practicable, and experiments with them could be made readily and at little expense, and would soon demonstrate whether artificial oyster-culture can here be employed commercially.

The Japanese industry is largely seated along the north shore of the Inland Sea near Hiroshima, in the gulf-like Sea of Aki, famous for its oysters. From what period, indeed, this oyster-culture has been carried on is not known accurately, but from its present condition it is evidently the product of centuries. As early as 1708 records show that concessions at Osaka were granted to an oyster company or to oyster companies of Aki for storage of their output pending the final marketing.^a

Regarding the origin of the oyster-culture in this region I may here quote a paragraph from a tract on fishery matters published by Hiroshima-Ken.

In ancient times certain shellfish, *Tapes*, were gathered in great numbers on the flats of Aki; and while awaiting their shipment to market the fisher people came to keep them in shallow-water inclosures, the fences of which they formed of bamboo stalks. The discovery was then made that the brushy fences became incrustated with young oysters, and thus it soon became evident that under certain conditions and at certain places it would be more profitable to plant bamboo and to cultivate oysters than to continue the *Tapes* industry. This was the first instance, it is said, that bamboo collectors, or "shibi," were employed in oyster-culture.

The first detailed report upon the oyster industry of Aki was prepared for the Japanese government by Prof. Kakichi Mitsukuri, the head of the department of zoology of the Imperial University of Tokyo. It was published in 1894 (Tokyo) by the department of agriculture and commerce, a royal octavo of about 50 pages, containing many figures and several plates.^b Unfortunately for the foreign reader it has not yet been translated into a European language. My own knowledge of it is due to my friend (who has also kindly drawn for me the text figures here reproduced), Mr. Naohidé Yatsu, Rigakushi, a pupil of Dr. Mitsukuri. I have availed myself freely of its substance, and if there is anything of value in the present paper it owes its merit to my Japanese colleague. He has, moreover, given me generous assistance in connection with my visit to Aki, advising me as to ways and means and providing me with personal and official letters to the local authorities.

In Hiroshima I was courteously received by his honor Governor Senshi Egi, of the prefecture of Aki, and to him and to his staff I am indebted for favors extended me in many ways. To Mr. Shinobu Suda, official engineer of the oyster properties, and to Mr. Masugi Shiraiishi, a government expert in oyster matters, I am under especial obligation for information regarding details in cultural methods; and finally to Mr. Y. S. Murai, for many personal courtesies.

^a A probable trace of this early privilege is seen at the present day, for the people of Aki are granted the best places in the river mouths of Osaka.

^b All the present text figures, except fig. 27, are reproduced with unimportant changes from the Japanese report. Plates 4 and 5 are from photographs taken by an artist in Hiroshima, and are copied by Dr. Mitsukuri; Plates 3 and 6 are original.

THE JAPANESE OYSTER—ITS KINDS AND NATIVE CONDITIONS.

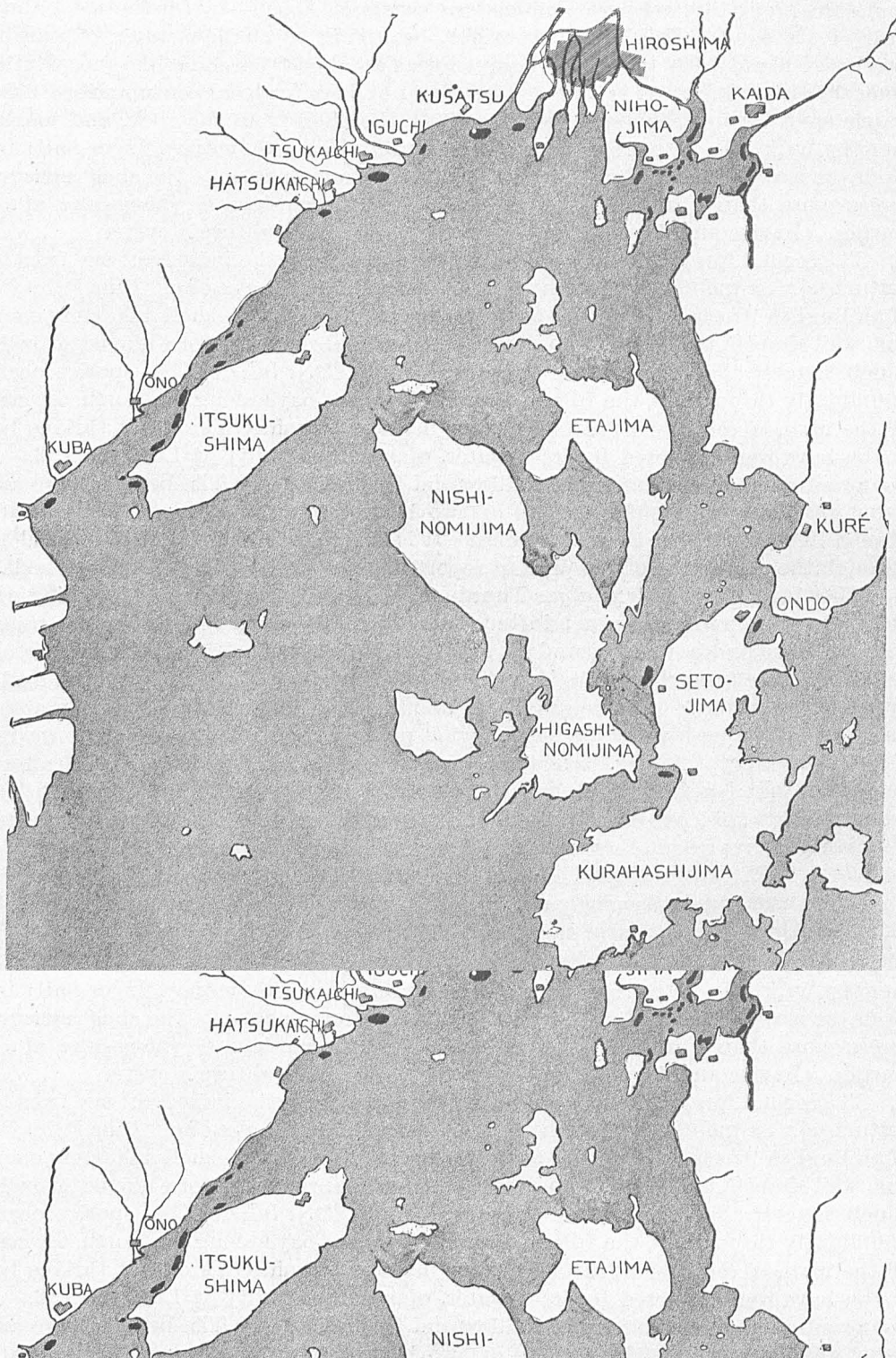
Three kinds of Japanese oysters are to be considered in this connection. First, a small one, probably a dwarfed salt-water variety of *Ostrea cucullata* Born., is abundant along the southern and eastern coasts of Japan—by far the most abundant of its kind. This is a bay oyster, occurring in shallow water of specific gravity of about 1.020 to 1.026, where it forms an almost barnacle-like incrustation upon the tidal rocks. It is collected in great numbers for local consumption; fisher people open them on the spot, not detaching the shell from the rock, and market them by bulk. In actual size this oyster is rarely larger than one's finger nail; but its flavor makes amends for its size. It is plumbeous in color. The shell measures rarely more than 2 inches in length; it is deeply crenulate, Gryphæa-like, at the margin. In size and flavor it suggests very closely the California oyster.

The second form, *Ostrea cucullata* (cf. pl. 6, fig. D), is the important one from the culturists' standpoint. Although not large, it averages the size of a "Blue Point," or of an English "native." The oyster itself is cream-colored, its shell delicately nacreous, well shaped, thin, deep, and with a series of imbricating, horn-like outgrowths, which suggest the shell of the European oyster, *O. edulis*. This species occurs abundantly throughout the Inland Sea, in the small bays along the northeast coast of the main island and at certain points in the Hokkaido (Yezo). It thrives best in the bays well tempered by fresh water, of specific gravity of 1.017 to 1.023. Its young are more abundant in the shallow and fresher water. The best that are marketed grow at a depth of a fathom or two below low-water mark; it is practically absent in water deeper than 8 fathoms. It is this species which will be considered through the remainder of the present report in connection with cultural methods.

The third form, *Ostrea gigas* Thunb., is of large size, specimens weighing with shell 4 or 5 pounds being not infrequent. It rarely occurs in water less than 2 fathoms deep and is most abundant in about 10 fathoms. The specimens which I examined were taken by divers in water of about 35 feet. It is a typical sea oyster, occurring in water of specific gravity of about 1.026. As far as I have been able to ascertain, its value is purely local, no region producing sufficient numbers to warrant a definite fishery. A large bank of oysters occurs in the Hokkaido, off the northeast coast, not far from the town of Akkeshi. The oysters here are said to be of extraordinary size, but during my visit to the Hokkaido I was not able to ascertain whether they represent this third species or whether they are large examples of *O. cucullata*. The latter species certainly occurs in the neighborhood.

The oyster-producing region of Japan is *par excellence* the Inland Sea, and it is here that the culturists have carried on their industry with greatest success. This body of water can indeed be looked upon as one of the most important natural preserves of fish and shellfish in the world. It can be compared to a deep marine lake, but it is sufficiently open to the sea to insure favorable conditions of density and of renewal of its waters, while its occupants are free from the dangers of an open gulf. From the oyster-culturists' standpoint the Inland Sea is remarkable in that its connection with the ocean is established both at its ends and near its middle point. Thus at the extreme east it opens to the ocean through the Straits of Naruto, as well as at the mouth of the Izuminada. At the west, 240 miles away, it opens again, this time to the Japan Sea, through the Straits of Shimonoseki, and to the south

again to the Pacific through Bungo Channel. In this middle region the large island Shikoku approaches closely the mainland, and the Inland Sea is broken up by a maze of islands extending from Shodoshima on the east to Iwai on the west, a stretch of 130 miles; and it is here that the most favorable conditions exist for the



and gravelly bottom, thus enabling the culturist to operate his submerged farms conveniently. Throughout this entire region oyster-culture is carried on more or less generally, but the most important seats of the industry are at Okayama in the east and near Hiroshima (prefecture of Aki) in the west. In the former locality a small nearly-inclosed bay, which suggests that of Arcachon in France, proves very productive and supplies no little part of the market of Kobe and Osaka. Here also are canning factories. Near Hiroshima, however, the industry is conducted on a somewhat larger scale, although on the same general lines.

It is in the latter region, as already noted, that Professor Mitsukuri secured the material for his report upon Japanese oyster-culture.



FIG. 2.—Fisherwoman opening oysters. The drawing shows the block and opener, oyster basket and trays.

OYSTER-CULTURAL METHODS IN THE NEIGHBORHOOD OF HIROSHIMA.

In addition to its natural advantages the region of Aki is especially favorable for oyster-culture, since close by is Hiroshima, a city of nearly 100,000, to furnish a ready market for its product, and to provide the necessary capital and labor for the material for his report upon Japanese oyster-culture.



cultural area, it may be noted, corresponds closely to that of Tarente in the south of Italy, of Arcachon in France, and of the best part of Long Island Sound.

It is an interesting fact that the culturists in Aki have at certain points developed independently branches of the industry which are strikingly similar to those employed, for example, in France. We thus find that a clear distinction is made between the regions in which young oysters—"spat"—can be obtained and those having the best



FIG. 3.—Hand pick used for making sockets in gravelly bottom for insertion of shibi.

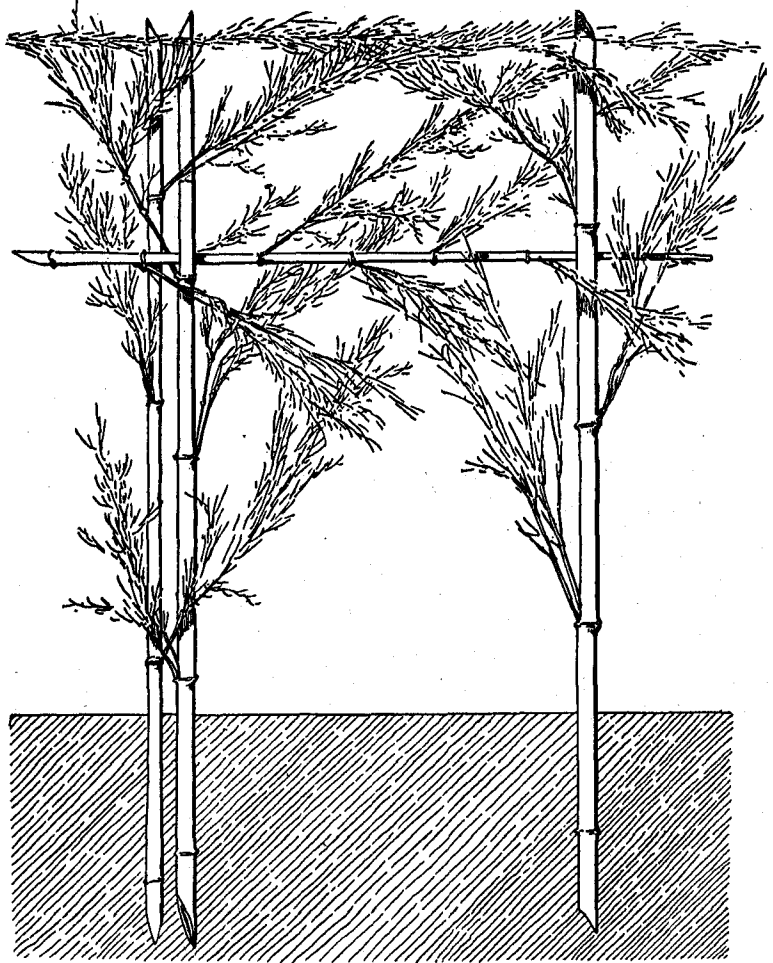


FIG. 4.—Bamboo collectors, shibi, arranged so as to form a boundary hedge of an oyster farm.

conditions for different stages of growth; also regions in which the final touches are given in preparing the oyster for market. It is convenient, therefore, to describe the Japanese cultural methods from the standpoint of locality. Thus at Nihojima, where the water is freshened by the entrance of the Otagawa, the "production" of young oysters is an especial feature of the industry. At Kaida Bay there is a region favorable for a combination of production and growth (*élevage*), and at Kusatsu, and further along in the direction of Miyajima, are the best conditions for *élevage*.

In the description of the methods employed in these three localities, it will be best to consider them in the order from the simplest and the most complex, (1) Kaida, (2) Kusatsu, (3) Nihojima, for at Kaida Bay all stages of the industry are represented in the same oyster park; at Kusatsu the methods become more complicated, and finally, in the region of Nihojima, specialization in the cultural devices has reached a point surpassed in but few European localities.

CULTURAL METHODS OF
KAIDA BAY.

In this well-protected region (cf. the accompanying map of the sea of Aki, fig. 1) there is a large area of shallow water, and at low tide great flats are exposed. Here it has been ascertained that the conditions of water density are favorable rather for the growth of young oysters than for the production of "spat," but at certain points production is carried on with marked success. The greatest disadvantage of the region is the lack of space in which the oysters can be kept covered by water during all times of the month. Probably it is for this reason that the growth of the oyster comes to be checked, since it is well known that they rarely increase in size after the end of the second

year. At this age, then, they are marketed, their small size distinguishing them from the oysters of Aki cultivated in other localities. The bay of Kaida is, however, so fertile in its class of production that it takes a high place among Japanese oyster-

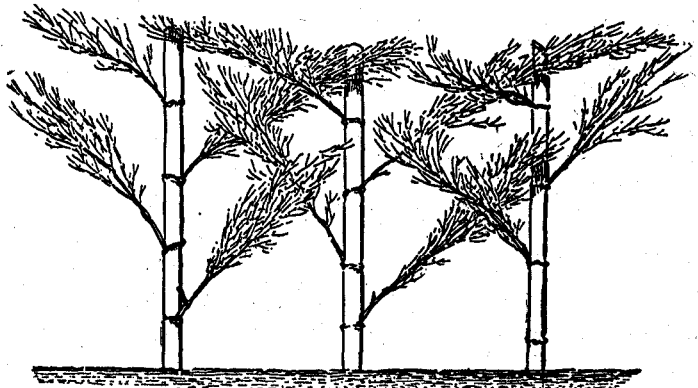


FIG. 5.—Arrangement of branched collectors as a close-set fence to form one of the lines of an oyster park.



FIG. 6.—Arrangement of branched collectors in close-set hedge, common in most types of Japanese oyster farms. Vertical projection.

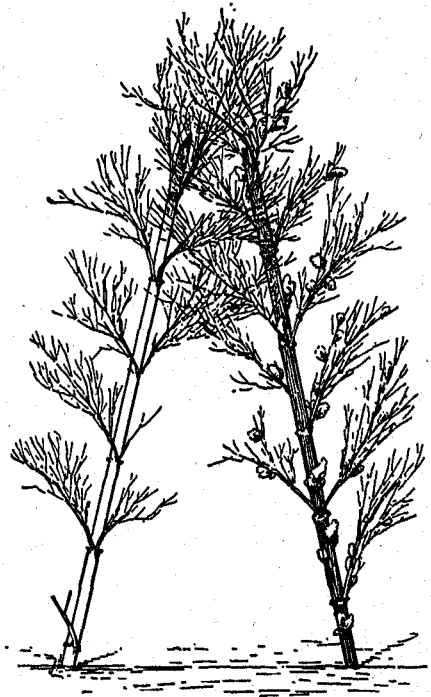


FIG. 7.—Shibi of different rows, new and old, in boundary hedge, showing how they are implanted to give mutual support.

grounds and its concessions are keenly sought. At low tide it bristles with closely set oyster farms and from a distance reminds one, save in color, of a region of European vineyards. Each farm is a simple inclosure formed by "shibi" or bamboo stalks, with or without interlacing branches. (Cf. figs. 4 to 9.) Bamboo in this, as in many other arts and trades of the Japanese, possesses many advantages. It is durable even in salt water (good material lasting three years or thereabouts); it is

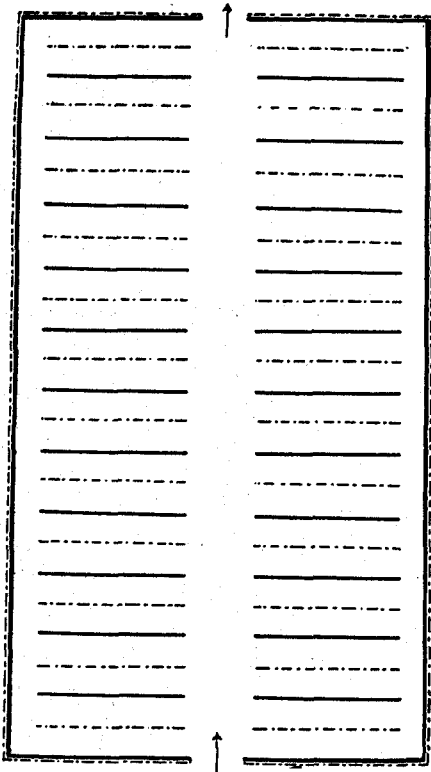


FIG. 8.—Typical oyster farm, Kaida Bay.

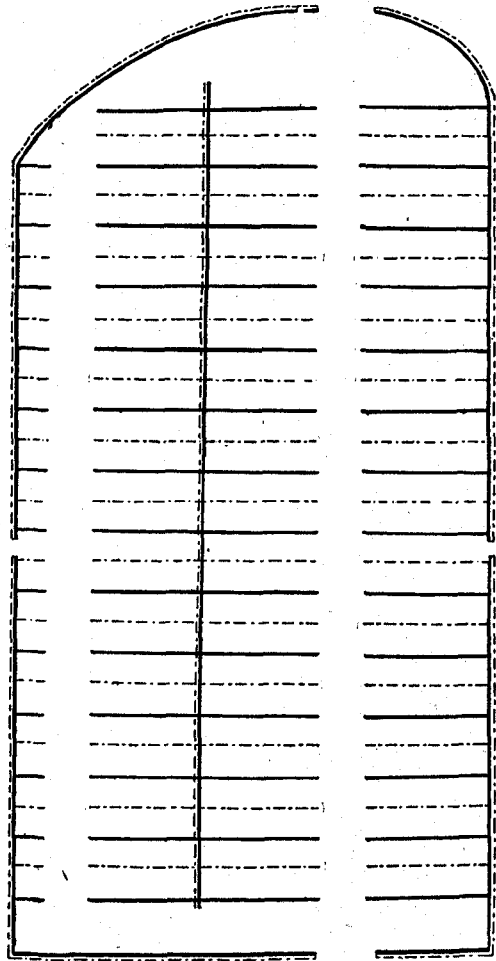


FIG. 9.—Diagram of well-developed oyster farm.

The black lines in figs. 8 and 9 represent newly arranged bamboo collectors, the dotted lines the collectors of the second year. Direction of current is indicated by arrows.

light and strong, gives an interlacing series of branches and leaves which in texture serve admirably for the attachment of spat, and which give, moreover, a great extent of attachable surface. In addition the bamboo stalks can be readily put in place and removed; they are easy to obtain in any locality, and their cheapness is not one of their smallest virtues.

In the present farms shibi are planted in position every spring at a time which the



culturists have determined by experience to be most favorable for the set of spat, usually about the middle of April. Their arrangement and mode of replacement are as follows: Shibi are brought to the oyster-grounds in skiffs and deposited on the flats as they become exposed by the receding tide. The culturist will have had the boundaries of his concession staked out, and he has but to construct his fences of shibi as quickly as possible to take advantage of the hours of low tide. As a time-saving device, he has already had the ends of the shibi sharpened so that they can be thrust deeply (one-quarter or one-fifth their entire length) into the soft bottom. Should the bottom prove hard, however, holes are first made for the shibi by means

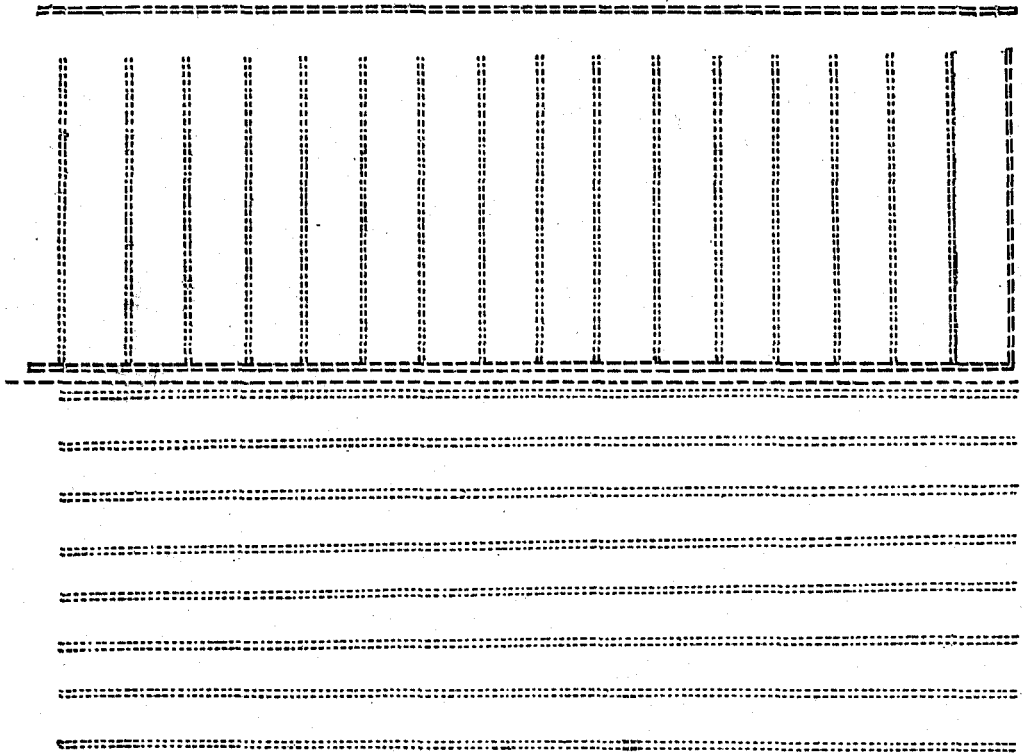


FIG. 10.—Diagram of an oyster farm in which are combined the longitudinal and transverse modes of arranging the bamboo collectors. Kusatsu.

of an iron-shod pick, shown in fig. 3. This the workman sometimes presses down with his foot, hence the lateral support near the head of the implement.

According to the usual type of oyster farms in Kaida, the main boundaries are planted nearly parallel to the tide marks. Similar rows of shibi are next thrown out in the direction of the middle line of the park. (Figs. 8, 9.) They do not, however, meet, but leave an open median space passing through like an aisle. Thus on either side of the main aisle of the oyster park there are rows of transverse alleyways, each about 6 feet wide, which terminate often blindly at the main fence of the park. Details in arrangement are given in figs. 4, 5, 6, and 7, fig. 6 showing a horizontal projection of the shibi of fig. 5. The fences and partitions of shibi stand about waist high.

Such an inclosure in Kaida Bay is practically the whole stock in trade of the culturist, for in it spat is taken and the oysters grow attached to the bamboo until the time when they are sent to market. From the permanent character of the park, therefore, the culturist has been led to ingenious arrangements by which the shape of the park can be retained and the oysters grown, young and old, side by side. To accomplish this each fence is usually formed of a double row of shibi, as indicated in

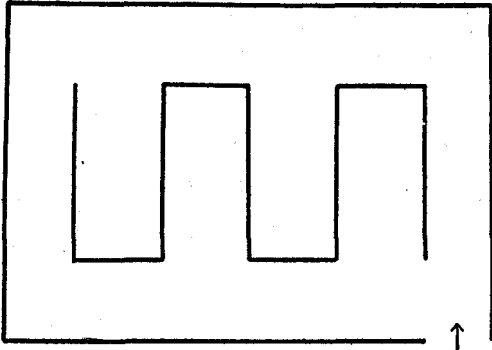


FIG. 11.—Diagram of a small oyster farm of labyrinthine pattern. Ondo.

rarely, some in which the double rows of shibi are placed parallel instead of transverse to the main axis of the park, as in fig. 10. An excellent example of this type is pictured in plate 3, from a photograph which was taken at the end of a season, the shibi showing well-grown oysters (from park at Tanna). Rarer still is a form in which a labyrinth-like arrangement of the hedges of shibi prevails (fig. 11), or even a concentric pattern (fig. 12). In all these forms, however, the arrangement is such that many eddies will be formed about and within the rows of the shibi, since these eddies have been found conducive to the attachment of the young oyster.

In the foregoing types of parks the visitor notes that the height and strength of the shibi, their simple or branching character, together with the closeness in their arrangement, vary somewhat widely in different localities. Occasionally an arrangement which alternates old and new shibi in the same row is found to be adopted advantageously.

At the close of the cultural process, that is, at the end of the second year, it remains only to remove the marketable oysters from the shibi. This is done during the favorable tides, the culturist using a pick-like instrument (fig. 13) with one hand and seizing the shibi with the other. For the protection of this hand a curious heavy but open mitten is used, figured in fig. 17. After the oysters are detached

figs. 8, 9, of which one row is of the second year and the other a new one. The latter is often added as the older row is removed. The fences in this locality are made of the more delicate species of bamboo, "hachiku." The stalks are trimmed in lengths of about 5 feet and are inserted a foot deep in the bottom. The distance between the double rows of shibi is intentionally narrow, so that their opposing branches can interlace. (Fig. 7.)

The foregoing description refers to the commoner type of park in Kaida. Occasionally some are seen of a more complicated pattern, as in fig. 9, and,

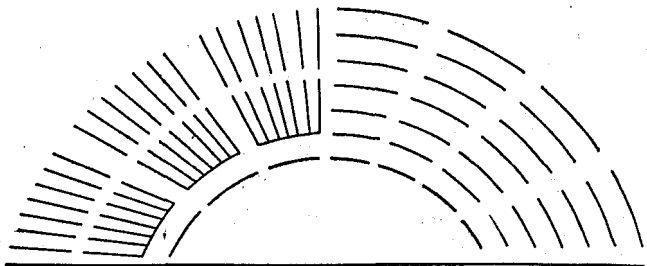


FIG. 12.—Diagram of an oyster farm in which the collectors are arranged in circular and concentric order. Middle clear space used as a living ground. Itsukushima.

they are taken from the ground by means of the rake shown in fig. 15, placed in baskets, fig. 18, and carried thence in the usual oyster boat often to the mouth of some adjacent river, where they are thrown out and raked over. By the latter process, "drinking" the oysters in fresher water, they increase in size and become cleaner, a process, by the way, quite similar to that employed in France, in England, and often in America.

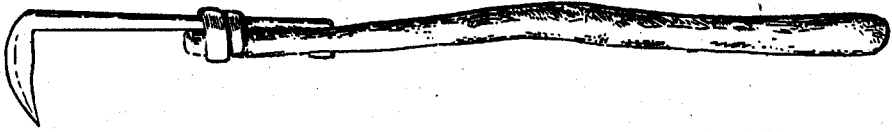


FIG. 18.—Oyster hook used for dislodging well-grown oysters from the shibi.

At Kanawa, an important cultural ground, a similar method to that of Kaida Bay is employed. The cultural area is not large but it is very productive, and here they have found it profitable to plant shibi in close rows at right angles to the coast line, as shown in fig. 19.

OYSTER-CULTURAL METHODS OF KUSATSU.

The oyster-grounds of Kusatsu are the best of those situated west of Hiroshima, but all of these, and of this entire region, are essentially the same, as far as cultural

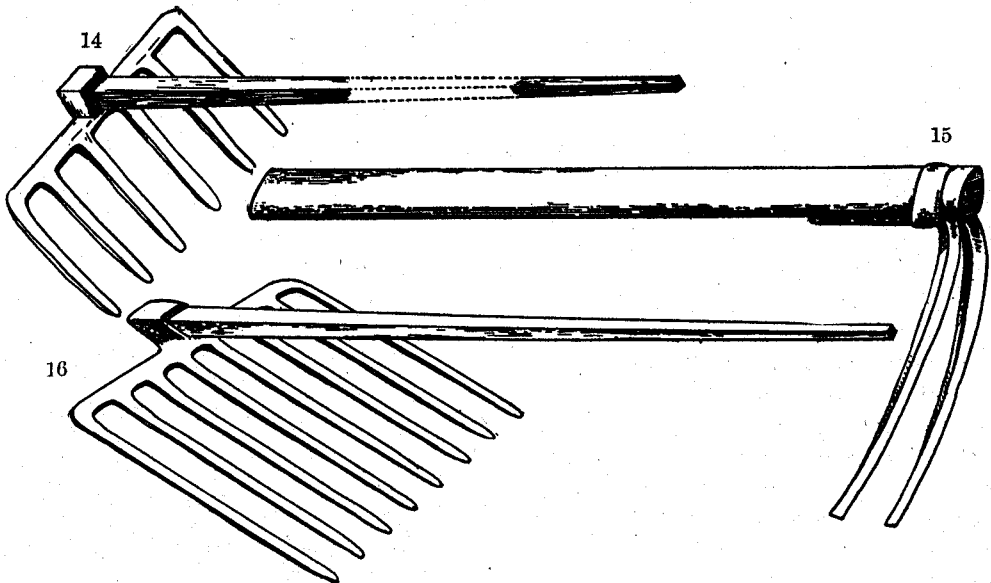


FIG. 14.—Oyster rake, *gofusé-guwa*, used for "cultivating" the oysters, i. e., stirring them about roughly as they lie on the living grounds, so as to break off the delicate shell margin.

FIG. 15.—Oyster rake, *nihon-zumé*, used to gather oysters fallen from the shibi, or to select oysters to be detached.

FIG. 16.—Oyster rake, *yatsugo*, used to collect marketable oysters from the living ground.

methods are concerned. They extend along the western coast 7 or more miles from Hiroshima, at points indicated on the map (fig. 1). In these localities oysters are cultivated at greater depths than in other waters of Aki, for it has here been found that under the deeper conditions the shellfish continue to increase in size after the

second year, unlike those at Kaida. Therefore, at Kusatsu, to the end of growing a larger oyster, the culturist divides his parks into three classes: those of shallow water (largely for spat collecting), early rearing, and deep water (for late rearing).

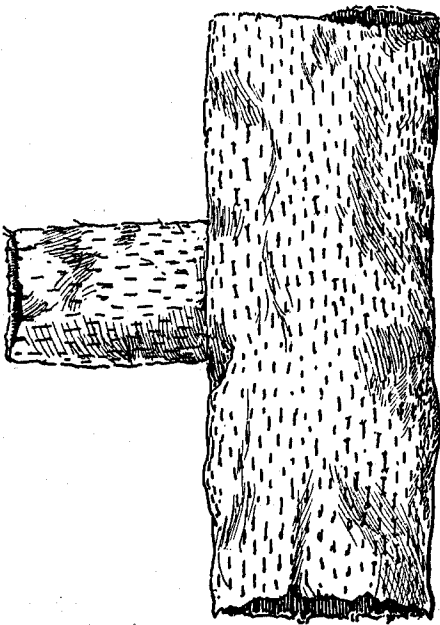


FIG. 17.—Mitten of heavy sack cloth, open at thumb and finger tip, used to hold the oyster-bearing shibi while separating the oysters.

The cultural concessions accordingly have come to be arranged with their long axes at right angles to the shore, thus providing a range of water passing from shallow water to deep, each lot measuring, in round numbers, a thousand feet by fifty. In shallower waters, tempered by fresh streams from the direction of Hiroshima, are the best conditions for spat-collecting. Here the specific gravity is very nearly the same as in Kaida Bay—in summer about 1.018; in winter 1.020. The density of the water rises gradually and attains about 1.025 in the deepest zone. Accordingly, the shallowest region in each park usually becomes laid out in a zone of collectors, or shibi-ba, and resembles somewhat Kaida Bay. In the next and deeper ground are the rearranged and oyster-bearing shibi (of the shallower zone), toya-ba, and in the deepest water are the typical oyster beds, or miire-ba. Of course such an arrangement is sometimes modified, since practice demonstrates that the local conditions of an oyster park, *e. g.*, water currents, are apt to warrant widely different treatment.

(a) In the shallow zone an arrangement of shibi in lines parallel to the shore is the common one. Between the rows are intervals of about 4 feet, the park in this case resembling one of the common type of Kusatsu (fig. 8). Often, however, the shibi are shorn of their branches and planted like canes (3 to 5 feet in length) in close-set rows. Such, for example, are the shibi photographed in plate 6, *A*, *B*, and *C*. The first of these, *A*, has had the oysters attached to it for about a month; the second, *B*, for about 6 months, and the third, *C*, for about 18 months. It is at the last period that the masses of oysters come to separate somewhat readily from the bamboo. In these parks the arrangement and treatment of the shibi varies greatly in accordance with local conditions. In rapid currents, which distinguish the region of Kusatsu, short and branchless shibi are commonest, these, too, made of the strong and short-jointed species of bamboo, "madake." Their arrangement is frequently in clumps, or toya, as indicated in figs. 20 to 23. Of these the toya

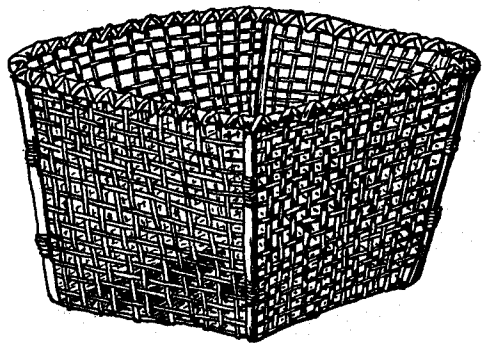


FIG. 18.—Basket, *taruyama kago*, for collecting and storing marketable oysters.



of figs. 20 and 21 are specialized for shallow water, and that of fig. 22 to a rapid current. In such clumps branching shibi frequently occur, and in this event the tips of the stalks are more apt to diverge than in Kaida (contrast figs. 23 and 24),

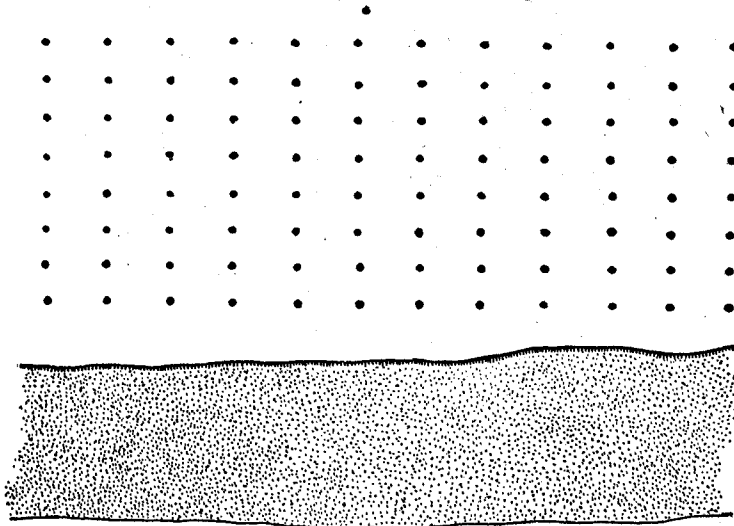


FIG. 19.—Diagram of oyster farm in which shibi are planted in rows parallel and at right angles to shore line.

another adaptation to more rapid current. In general the bases of the component shibi are implanted about a foot. Thus made the toya remain in position for about two years.

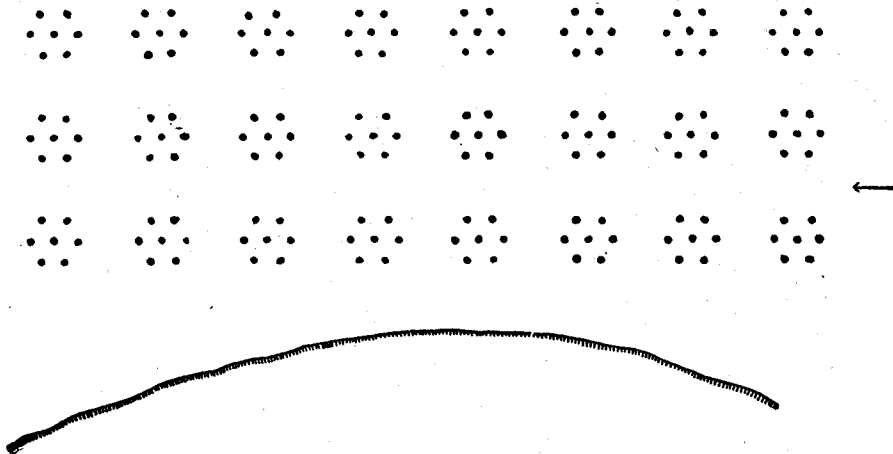


FIG. 20.—Arrangement of collectors in clumps, dotted parallel to the shore, leaving straight shoreward alleyways between. Clumps 3 or 4 feet apart, arranged for sluggish current, the direction of the latter denoted by an arrow.

(b) In the next deeper zone, typical toya-ba, the grouping of shibi becomes more massive, and when at low tide this region is exposed (10 to 15 feet is the tide fall) one sees them in long rows which suggest diminutive haycocks. An excellent idea of such toya-ba is had in plate 5. Closer inspection shows that each toya is

in nearly every case a complex of shibi of many ages. Transplanted shibi, with oysters of one or two years' growth, usually form the nucleus of the cluster, and around them are planted concentric rows, one, two, or three, of branched shibi, old and new, to the end that all ultimately bind or mat themselves into a living, springy, cone-shaped mass, well suited to resist currents or storms. (Fig. 25 and Pl. 5.) Such

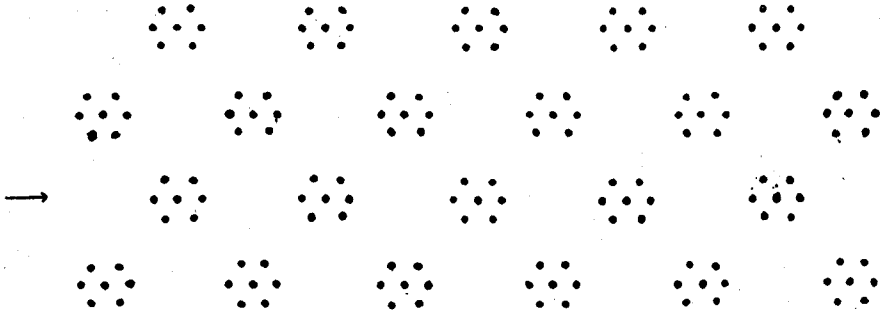


FIG. 21.—Arrangement similar to fig. 20, but in oblique order, adapted to a somewhat more rapid current.

toya are made, or remade, toward the end of each spawning season, *i. e.*, during the end of August or early part of September. They are then pulled to pieces (in this work the rake shown in fig. 14 is used), and from each bamboo there are shaken and broken off the oysters which are least securely attached. During this process the shibi found to be still useful are put aside to form the nucleus of new toya;

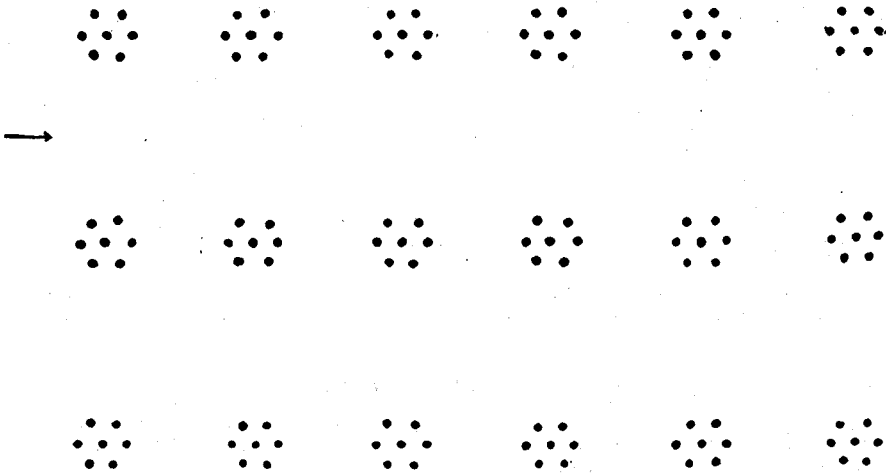


FIG. 22.—Arrangement similar to fig. 20, but adapted to rapid current, rows of collectors separated by intervals of 8 or 10 feet.

the gleanings, twigs, detached oysters, and all, are now raked up and carried to a third locality, the living grounds (*ike-ba*). Here in swifter current the *débris* washes away and the oysters remain, the shells usually becoming clean in the meanwhile.

(c) The living ground, or *ike-ba*, of which a good example is pictured in plate 4, is generally located in a zone of deeper water. It has a clean, gravelly bottom,

which in most cases becomes exposed only at the lowest tides. Here the oysters are brought together which have become detached from shibi in various parts of the farm, and thus they are retained in classified beds until they have attained their second year's growth. During this time the culturist has but to keep them well spread out and to see that the beds are kept clean. Always at lowest tides, and sometimes as often as fortnightly, the laborers give the oysters a vigorous raking (using for this purpose the short-toothed rake shown in fig. 14), which scatters them about the bed, removes foreign bodies, and, best of all, gives the shells a better shape and a firmer rim, for in this treatment the delicate, cuticular outgrowths of the shell are removed and a more symmetrical growth results. Of especial importance is the process of raking in cases where the oysters are sent directly from the living ground to market; for it has been found (here as elsewhere) that those oysters

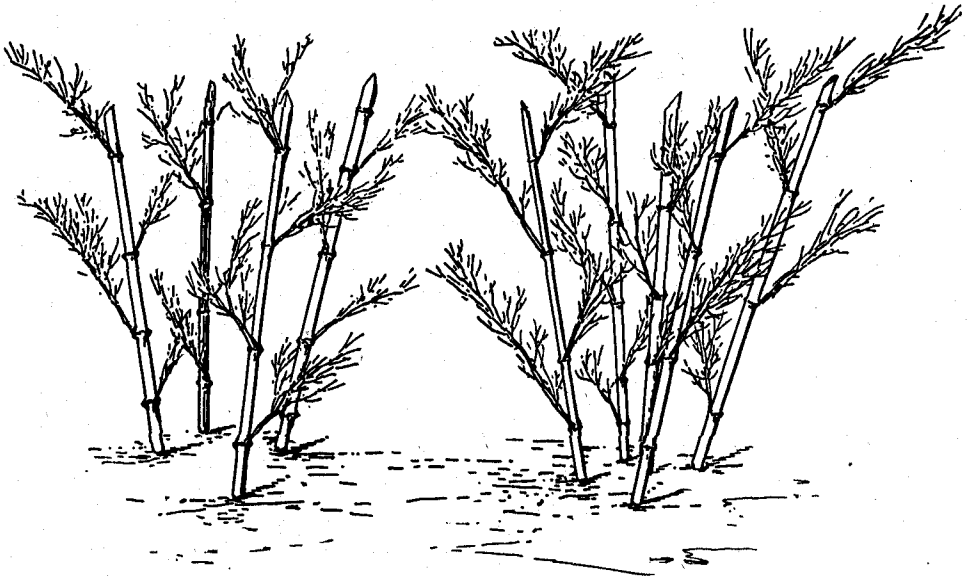


FIG. 23.—Bamboo collectors arranged after the fashion common in Kusatsu. The shibi stand about 3 feet above the bottom and their tips diverge; the clumps are set 4 or 5 feet apart.

whose shell rims are strong and accurately fitted together fare better during transportation and in the market. Those with delicate and brittle margins soon suffer injury and lose their fluid through leakage and evaporation.

In some farms, on the other hand, it is maintained that oysters of different sizes should be mixed on the same living ground. For it is claimed that the young oysters grow better side by side with the older ones, and even that if the more perfectly grown oysters of different grades can be mixed together during the process of raking, the better will be the general output.

(d) The final stage in the culture of Kusatsu takes place in maturing grounds, or miire-ba. Here the larger oysters of the second year's growth are laid down, transplanted from the one or more ike-ba of each establishment. Usually they are in the deepest water cultivated, *i. e.*, in water a few feet in depth at lowest tides up to water of 3 or 4 fathoms. I was told that in one miire-ba oysters were culti-

vated successfully in water of 50 feet. Each farm in Kusatsu has its separate miire-ba, and these adjoin one another, forming a continuous zone in deeper water, each miire-ba designated by a number. In the shallowest portions the oysters are usually protected against displacement and invasion of mud by means of low fences arranged with wing-like expansions, as shown in ground plan in fig. 26, and in detail in fig. 27. This device has been developed largely in view of the storms of the typhoon season. The effect of the maturing ground is to give the oysters greater size and

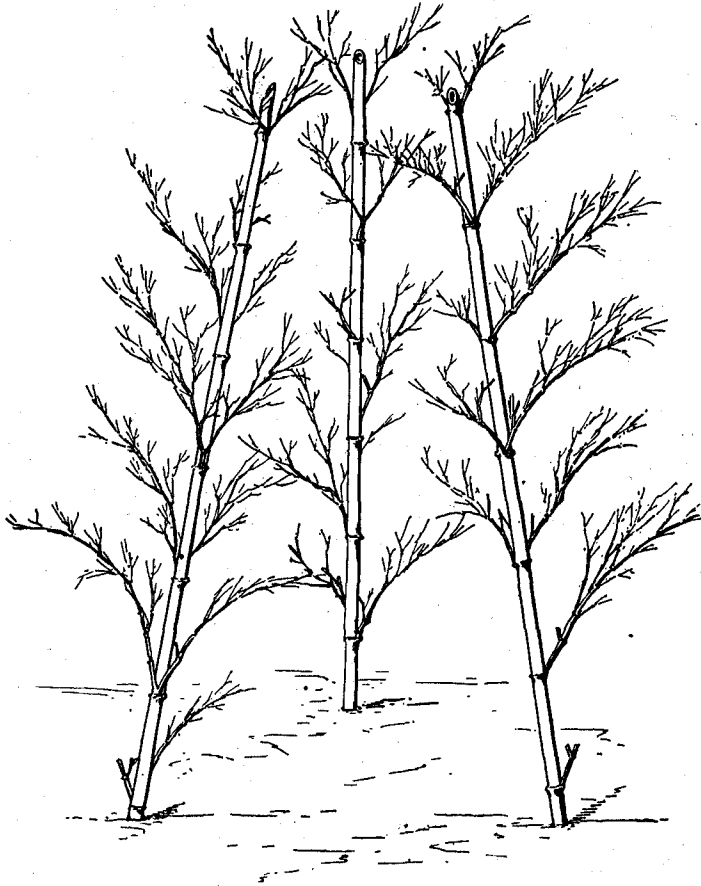


FIG. 24.—Collectors arranged in a way common in Kaida Bay. The shibi stand about 4 feet from the bottom and their tips converge.

weight, and to give the meat a whiter color. The finished product resembles closely a well-grown oyster of Long Island Sound. Marketing takes place after the oysters have remained from six months to a year in the deeper ground, making their total age about three years.

Each oyster farm has its separate houses, situated usually on the adjacent shore, and the details in handling and packing the oysters appear to be closely similar to those of Continental Europe—baskets, blocks, rakes, arrangement, and



storage. I may note in passing the curious "knife," a combination of knife, mallet, and lever, with which oysters are opened with surprising rapidity. The *modus operandi* is shown in fig. 2, page 21.

OYSTER-CULTURE AT NIHOJIMA.

In this locality (cf. fig. 1), finally, oyster-culture has been developed on more special lines than anywhere else in the East. As at Kusatsu, the industry embraces three distinct branches—(a) spat collecting; (b) rearing the young, and (c) maturing and fattening the oysters for market. But, unlike at Kusatsu, these three branches of the industry are carried on, not on the same shore reach, but at points widely

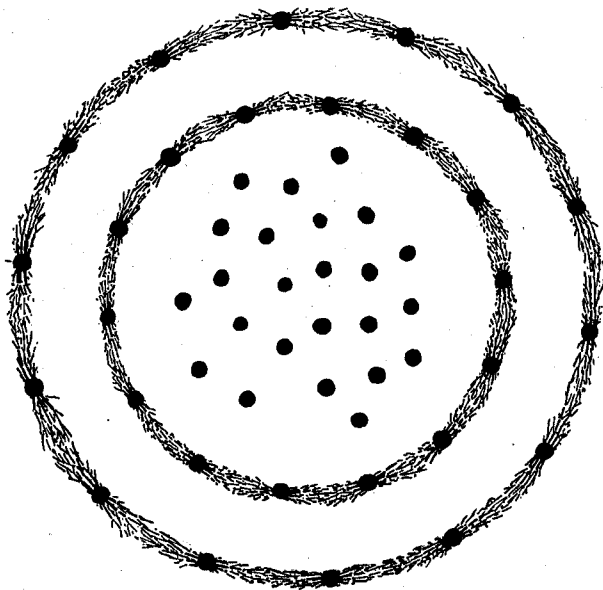


FIG. 25.—Ground plan of a mound toya of collectors. Shibi with well-grown oysters are indicated by the black spots within the two circles of branching shibi.

separate. In other words certain special tracts are taken advantage of in collecting spat; others are specially arranged for early rearing; others, in turn, for maturing. In these regards oyster-culture at Nihojima resembles closely that of the coast of Brittany or of Holland. The details of the management of the farms are in essentials, however, like those previously described.

(a) *Spat collecting*.—The spat is collected in very shallow water, less than a fathom deep at the usual tides, tempered considerably by incoming streams. The specific gravity is said to rarely exceed 1.017. In such a region shibi are put in position, usually in very close order, at the beginning of each spawning season, say from the middle of April to the middle of May. After a period of about three months the entire mass of shibi will be uprooted and transplanted, sometimes a mile or more, to a locality better fitted for rearing the young oysters. This transportation, I was told, is the most difficult part of the work of the culturist of Nihojima, for the minute oysters are, as everywhere, peculiarly liable to injury;

careless handling will destroy great numbers of the delicate shells; hasty packing of the shibi on the scows, whereby the branches are allowed to rub together, is another palpable source of loss; drying, direct sunlight, changes of temperature, are all deadly, and, above all, severe thunderstorms—the latter, according to my informant, causing death by *fear*. I suspect, however, in the last regard, that a fresh, cold shower bath is more apt to be a moving cause, although I was assured that the scows are covered with the ever-present Japanese oiled paper to guard against such a contingency.

(b) *Rearing the young oysters.*—The shibi, covered with young spat, are now arranged in toya-ba, like those of Kusatsu, but closer in arrangement and usually of many varieties. Here they remain from one to two and a half years. In the

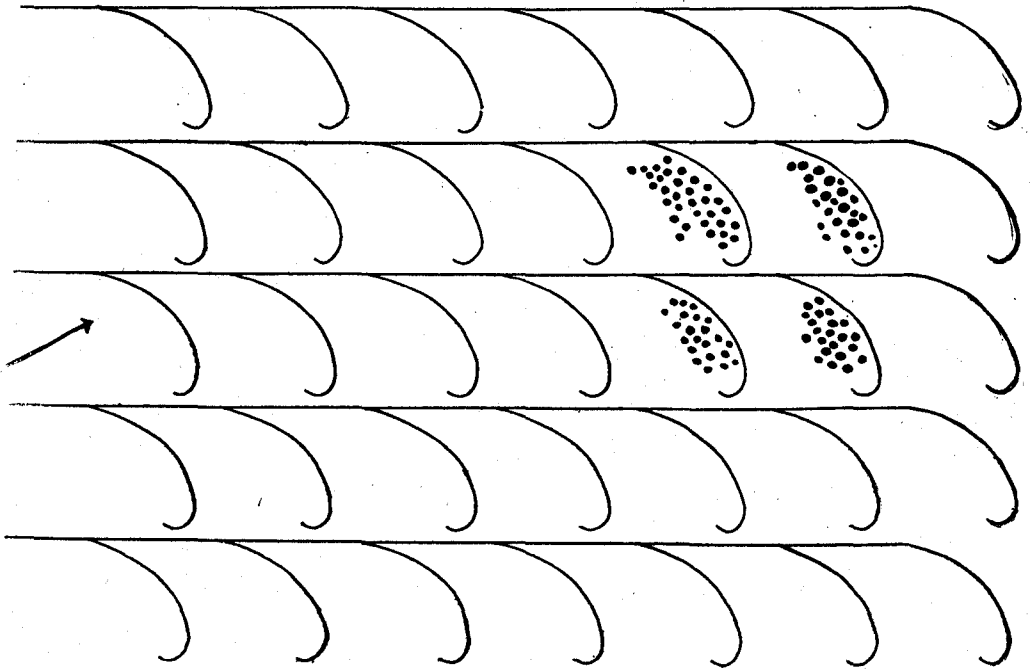


FIG. 28.—Diagram of living ground of two to three year old oysters. The spots represent oysters and the dark lines are rows of shibi placed so as to provide shelters against currents or storms. The arrow denotes direction of strongest current.

case of the older and rearranged toya a long, mound-like type is commoner than the circular ones described above. As a rule the toya are covered with water save at lowest tides.

(c) *Later rearing; Maturing.*—The living inclosures in deeper water, ike-ba, correspond to those of Kusatsu. They contain the oysters which have been separated or are readily separated from the brush of the toya. A similar process prevails of raking the oysters roughly, and I was shown some shells of the older oysters from this region which were of very regular shape. At favorable tides, furthermore, the oyster beds are cleaned and the boring whelks—*Purpura clavigera* Kaster

and *Rapana bezoar* L.—are removed. Starfish are not troublesome. Further transplanting takes place, usually at the end of the second season, and in still deeper water the oyster attains finally its marketable size.

REGULATION OF OYSTER-CULTURE BY THE JAPANESE GOVERNMENT.

All cultivable grounds, whether for oysters, other shellfish, or seaweed, are—in Aki, at least—the property of the prefecture and can be neither sold nor sub-rented. All cultivable tracts are surveyed, the lots tending to decrease in size as the estimated value of the property increases. The mode of laying out concessions can perhaps be best understood by reference to plate 7, copied from a Government

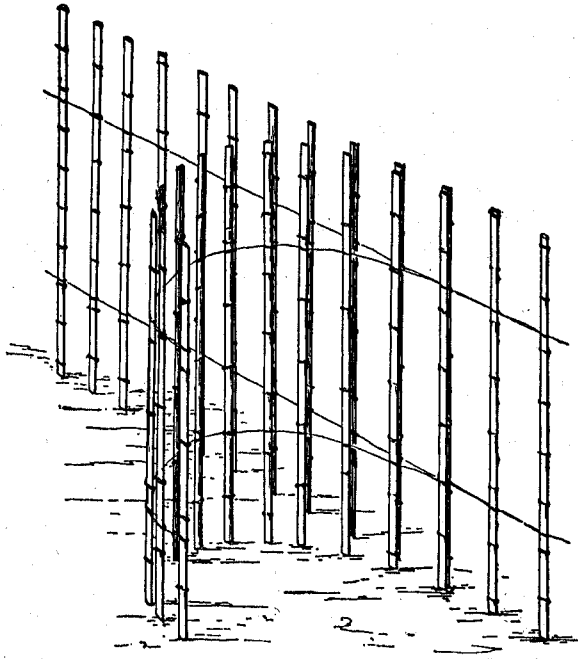


FIG. 27.—Detail of the living ground shown in ground plan in preceding figure.
Bamboo rods 3 to 4 feet high.

chart. The farms are rented auction fashion to the highest bidder, and the tenants have the privilege of renewing their leases indefinitely at the original rentals, a privilege, however, which can not be used speculatively. When at the termination of a lease the property passes again into the hands of the prefecture it is at once advertised and re-rented. In addition to the yearly rental the property is subject to a small local tax upon the total area of each farm, and to a charge of 1 per cent of the rental to cover the expenses of administering the oyster-cultural bureau of the prefecture. This series of taxes impresses the stranger as formidable, until he learns that it does not represent an accumulation of taxes, but rather an itemized statement as to the apportionment of public funds made thus in accordance with local custom. Rental of concessions from the prefecture, it should further be said, brings with it certain privileges in marketing the oysters in Osaka.

THE QUESTION OF INTRODUCING AND CULTIVATING THE JAPANESE OYSTER
IN THE UNITED STATES.

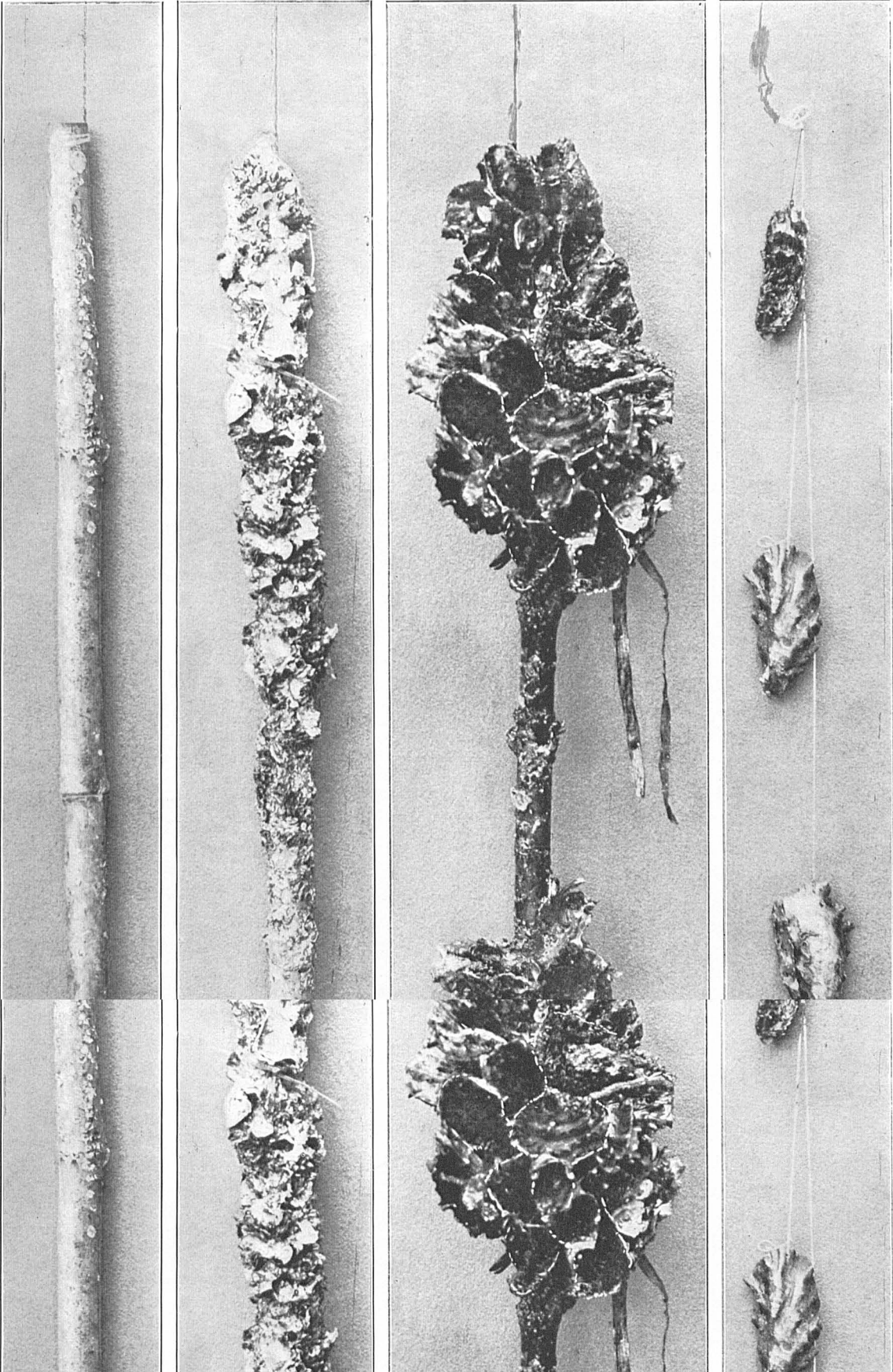
To what degree the Japanese oyster would flourish on our coast can be determined, obviously, only by experiment; and if experiments are to be made, the following suggestions seem to me of some practical value:

On the Pacific coast, on grounds which have been found especially favorable for the reproduction and growth of our Western species, *O. californica*, consignments of Japanese oysters may be planted—in the north with oysters from the Hokkaido beds, preferably from the region of Mororan or from Akkeshi Bay, and in the south from the region of Hiroshima. In this way similar conditions of temperature will be obtained. To fulfill a second favorable condition an effort should be made to secure oysters from water of nearly the same specific gravity as in the chosen American localities. There would be, I fancy, little difficulty in the matter either of securing oysters from equivalent localities or of transporting them. Through the Imperial Bureau of Fisheries, under the able headship of Dr. K. Kishinouyé, one could promise, *à priori*, prompt and efficient aid in getting in touch with the Japanese oyster-culturists whose establishments are known to be favorably located. And with fast freight service from Yokohama the oysters could be transported with a minimum of loss, as similar exportation (*e. g.*, of American oysters to England) demonstrates. In a case of this kind, however, extra precautions would not be out of place. Large oysters should first be selected, and, preferably, treated with the raking process on ike-ba for a few weeks. By this means the shell margins will be thickened, and thus the oysters will lose a minimum amount of fluid during transportation. Care should also be taken to pack the oysters each with the more concave valve downward and to mark the cases so that during shipment they shall be kept in the right position. Other details—if not indeed the above—can safely be left to the skilful Japanese work people.

A further suggestion is that the shipments be made during the months of February and March, to the end that the coldest season on our coast would be avoided, and thus the oysters would have the chance of becoming in good condition and somewhat acclimated by the following winter. Moreover, at this season of the year it has been found that the oysters have laid up the maximum supply of nutriment against the breeding time, a supply which could be used as reserve nutriment during transportation.

No experiment, however, could be regarded as a fair one, I believe, which did not deal with an adequate number of the imported oysters. If but a few oysters—a score or two—are laid down in each experimental locality they may be lost through accidents which would not befall a larger number. For in oyster banks there is certainly strength in numbers, an ecological feature in oyster-culture which governmental regulations in France, Holland, and Germany keenly recognize. By this numerical factor it appears a true paradox that one thousand planted oysters have *more* than ten times the chances of survival than a hundred. As oysters are cheap, it seems to me better economy therefore to make the more convincing experiment.

To what degree is it practicable to introduce the methods of Japanese oyster-culture into the United States? This, I take it, is a question which can be answered



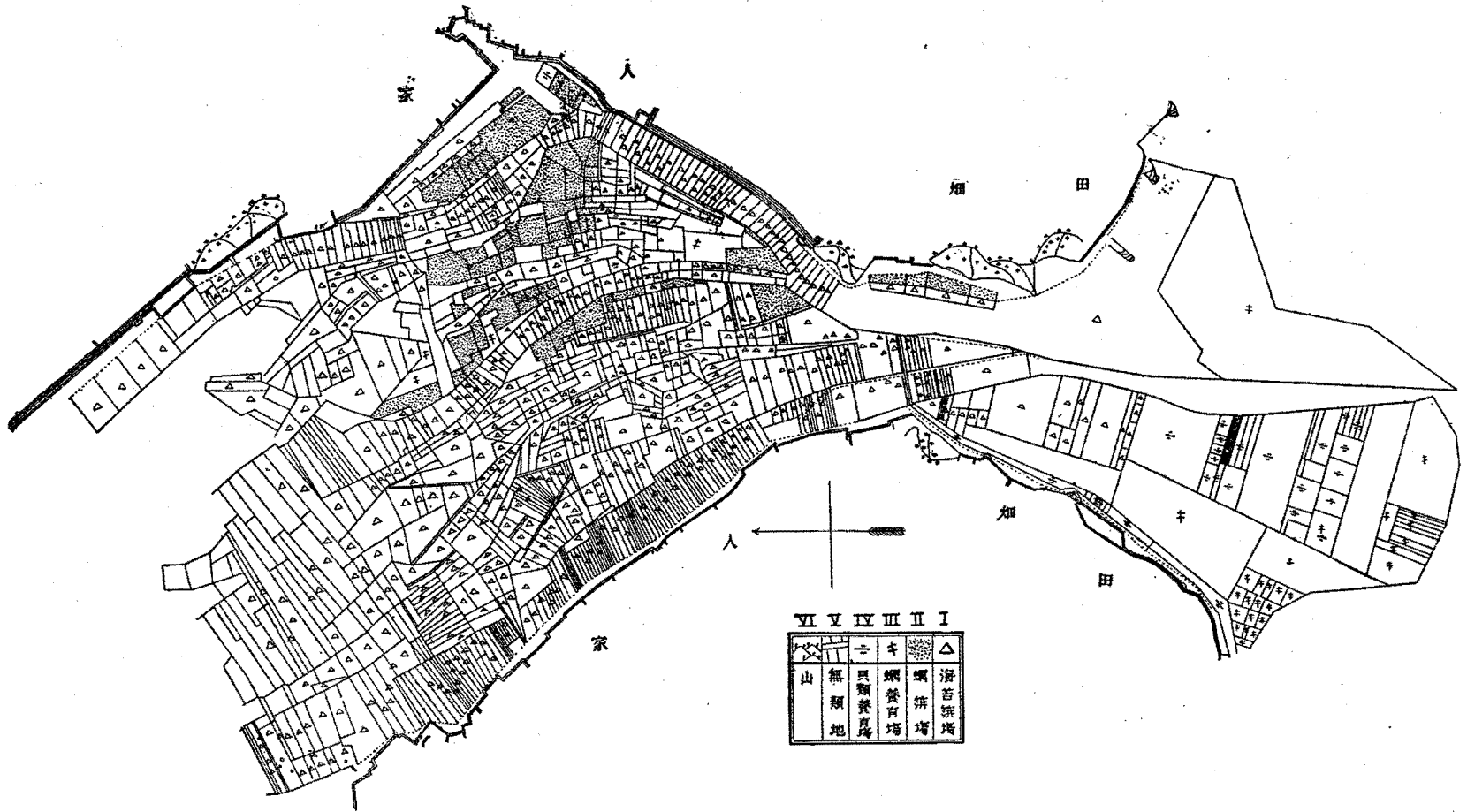
as well by individual culturists as by the U. S. Fish Commission. The culturist who takes keen interest in his work should be looked to, I think, to select some especially favorable spot on his grounds and lay out an experimental farm, which need not be large and would not be costly. Brush to take the place of the bamboo shibi can be obtained readily, and one has merely to follow the broad lines of procedure laid down by the Japanese.

Culture with the Japanese oyster on the Pacific coast is clearly out of question until it can be demonstrated conclusively that the imported oysters are breeding prolifically. The greater importance of these methods is as clearly in the line of improving our native Western oyster, for if they are grown by means of shibi and subsequently laid down in deeper and deeper water they will, in all probability, increase in size and improve in flavor. Similar experiments with the Virginian oyster would also be of considerable interest.

In the general problem of artificial oyster-culture one is not surprised to find that Japanese methods have paralleled closely those developed in Continental Europe. The principles are clearly the same, the means alone have varied. In Japan, as in Europe, those localities alone possess oyster-culture which are peculiarly favorable for it. Not every locality where oysters naturally occur offers a place for developing oyster farms, and he will surely be disappointed, whether in the United States, Italy, France, or Japan, who believes that his collectors are powerful magnets capable of attracting like iron filings, the entire yield of young oysters of the neighborhood. Tiles, fascines, jingle shells, or shibi are excellent mediums for the attachment of oysters, but are valueless save in the event of an abundance of fry.

He, therefore, who wishes to experiment in this form of oyster-culture will fare badly, I am sure, in spending time and substance in attempts to lay out a collecting ground in any locality in which spat does not occur every year and in great abundance. In fine, the experience of foreign culturists has gone so far as to determine that even in a *good* collecting ground there are tracts which, owing largely to currents, are of great value, and that neighboring ones, sometimes but a few yards away, are to be avoided. But such delicate adjustments are the true product of a long-used system, whether European or Japanese.

In the matter of *élevage* the Japanese do not rank as high as the French *parqueurs*, for they have not developed a system of tidal closures, or *claires*. These, I believe, would prove an important adjunct of the establishments of the shallower region of Aki, especially if carried out after the fashion of Brittany.



MAP OF THE OYSTER AND SEAWEED CONCESSIONS IN ONE OF THE ESTUARIES OF NIHOJIMA, TO SHOW HOW COMPLETELY THE CULTURAL AREA IS DEVELOPED.

I, Shibi bearing purple seaweed; II, Shibi bearing oysters; III, grounds for rearing oysters; IV, cultural area for other mollusks, Tapes, Arca, etc.