THE CULTIVATION AND BIOLOGY OF OYSTERS AT BACOOR BAY, LUZON [1]

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FIVE PLATES

INTRODUCTION

The cultivation of the oyster is not at all a new venture to increase one of man's shellfish foods, for it started in China some 2,000 years ago. The early Romans also cultivated oysters. Today, oyster culture is at its peak of development in France, Holland, Norway, United States, Japan, Canada, England, and Australia. In the Philippines the culture of this important shellfish is just in its initial stage of development.

Within Bacoor Bay, Cavite Province, Luzon, alone there are about 200 hectares of oyster farms belonging to private individuals who have adopted the artificial cultivation of four species of oysters—*Ostrea iredalei* (talabang chinelas), *O. malabonensis* (kukong kabayo), *O. cucullata* (pulid-pulid), and *O. palmipes* (culot) by the stick (tulus), the hanging (bitin), the line (sampayan) and the tray (bangsal) methods. The rapid development of the oyster culture industry in this bay is due to the desire of local fishermen to have other sources of income aside from actual fishing and other home industries. There are many private oyster growers who have utilized every space of their enclosed areas so as to increase the production of oyster to the maximum. Bacoor Bay is ideal for the culture of oyster owing to the availability of heavy spats every year in the month of August and of materials for making oyster cultch and to the abundance of its natural food. In the government oyster experimental station at Binakayan, Kawit, Cavite, oysters are

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grown from one to two years and are harvested before the height of the breeding season which occurs in May, June, July and August.

The Binakayan Oyster Farm of the Bureau of Fisheries was established in May 1935 by Messrs. Heraclio R. Montalban and Florencio Talavera. The purpose of the project was to help the oyster farmers of Bacoor Bay develop their oyster industry along the scientific methods of oyster cultivation. A small area in Bacoor Bay was obtained by permission from the municipal council of Kawit through the help of Mr. Julio Handog, an oyster farmer of Binakayan.

A local method of raising oysters by planting bamboo brushes and bamboo trunks, or "puno," for catching oyster spats has been an early practice by a few oyster farmers of Bacoor Bay. Recently it is supplemented by the introduction of the hanging and the improved tulus methods.

Any study along the proper utilization and conservation of fishery resources is the work of the State and not the concern of the individual. Fishermen are extended help and receive benefits from the results of investigations conducted at the fishery experimental station along the field of fishpond culture, oyster cultivation, fish capture, or fish processing. The rapid development of our fishery resources is the result of the application of modern and up-to-date technique and methods in fisheries biology and technology gained in the experimental stations of the Bureau of Fisheries.

Since liberation, the Binakayan Oyster Farm has been rehabilitated with an initial investment of 15,000 pesos.[2] Its area was increased from one-fourth to one hectare. The farm has a station building 30 by 20 ft. of floor space, built with cresoted post, bamboo, and nipa. At the time of the rehabilitation of the station, the cost of labor and material was four to five times higher than that before the war so that the initial capital of fifteen thousand pesos allotted for the station could not go very far. A drawback to the work was the scarcity of building materials. Iron wires were not available at the start and bamboo butts or trunks were used instead, employing the stick or tulus method of oyster cultivation.

The station serves as a demonstration and stock farm. In this station, oysters are allowed to grow from one to two years in order to produce quality oysters for breeding and stocking

[2] One peso equals 50 cents United States currency.

purposes. It supplies the Philippine Fishery Program of the U. S. Fish and Wildlife Service with oysters for canning and bacteriological analysis. It also serves as a training ground for students of the Philippine Institute of Fisheries Technology, Bureau of Fisheries, in fish culture and fish preservation.

DISCUSSION AND METHODS

The stick (tulus) method (Plate 1, A).—It was proven years before that one of the methods tried with success at Binakayan was the tulus method in which dried bamboo trunks, puno, were used. They were cut into pieces 4 feet long and then split into 4, 5, 6, 7, or 8 pieces, the number depending upon the diameter of the puno. For each tulus were impaled 4 old oyster valves. The cultch are usually stored and then planted before the spatting season in July since spatting of oysters takes place from August to the early part of September of every year at Bacoor Bay.

Between July to September 1946, there were planted in the area adjacent to the station 22 plots of 28,000 tulus. A plot consisted of three rows of tulus, about 240 ft. long and 2.5 ft. wide, and the tulus were 5.7 inches apart. Plots Nos. 1 to 11, about 80 meters long, were laid out in August 1946; and plots Nos. 12 to 22 in the later part of September and early part of October 1946. Plots Nos. 17 to 22 were planted with tulus without the impaled shells.

The intensity of spatting on the different plots was observed and results recorded. Plots Nos. 1 to 11 which were planted with tulus in the later part of July and August of 1946 were heavy with oyster spats forming an average of 79 oysters spats to the shell. Then the barnacles came in later and set sparsely on the shell of the oyster.

The whole puno posts of the fence enclosing the one-hectare farm together with the bamboo slats attached to the posts were thickly covered with oysters.

Plots Nos. 17 to 22 planted with tulus without the impaled shells were stocked in the later part of September and early part of October 1946, hence oyster spats were not expected to attach heavily as the time was not within the period of heavy setting of oysters. During the succeeding spatting season of oyster in 1947, plots Nos. 17 to 22 were improved as there had been additional oyster spats on the oysters previously attached, although they were not so heavy. It has been proven that the life of a tulus submerged in water is from two to

three years as the bamboo (cultch) is not free from the molluskan as well as the crustacean borers. The sea water with silt and sticky mud hastens the deterioration of the tulus. With the added weight of the clusters of oysters that had grown for two years on the cultch, the upper part of tulus becomes heavy with mature oysters, causing them to fall to the bottom.

The hanging (bitin) method (Plate 1, C).—This method shows the manner in which the plots Nos. 1–14 are arranged. Each plot is 100 meters long and one meter wide. It is formed by three rows of bamboo butt posts about four feet apart. On the parallel series of posts are whole bamboo stems nailed horizontally at bout 2.5 ft. from the muddy bottom and supported with short puno halves, each one meter long, nailed at the posts across the three rows of parallel bamboos.

The cultch or seedling collectors are about 2.5 ft. long, from Nos. 8, 9, 10, 11 and 12 G. I. wires (Plate 5). To each cultch are threaded 5 old oyster shell valves and 4 small "usiw bungbong" tubes, *Schizostachym toppingii* Gamble, 5–6 inches long in between the threaded shells. The cultch of threaded shells are prepared in the month of June and July and stored ready for attachment in August in the constructed plots that were also built in June or July. The cultch were attached to staples fastened 5 inches apart to the parallel bamboo of each of the plots.

There are 14 plots for the hanging method of oyster growing. Plots Nos. 1 to 4 were constructed on June 15–30, 1947; plots Nos. 5 to 10 on July 1–31, 1947; and plots Nos. 11 to 14 on August 1–15, 1947. The attachment of the cultch was also gradual in the plots constructed in June, the attachment occurring in July; in the plots constructed in July, the cultch were attached in August; and in those plots built in the early part of August, the cultch were attached in the later part of the same month.

The intensity of spatting in the hanging, or bitin, methods for all the plots, Nos. 1–14, was not uniform. In the seed collectors hanged in plots Nos. 1–14 in July, the oyster spats were abundant but later covered sparsely with barnacle shells. The posts in plots Nos. 1–14 and the parallel bamboos nailed to them were covered thickly with young oysters three months after they were built. In the cultch hanged in plots Nos. 5 to 10 in August, oyster spats were also abundant but fewer

barnacle shells were growing on the young oysters three months after.

The line (sampayan) method (Plate 2).—A plot 120 meters long by a meter wide was constructed about the later part of August 1947 when the intensity of oyster spatting was at its ebb. It consists of several series of inverted V-shaped pairs of full length bamboo puno frames which are 4 meters apart. Each frame has across each base short No. 10 wire tied about 2½ feet from the bottom. The cultch for the line (sampayan) consists of a long line of threaded old oyster shell valves spaced by usiw tubes 5–6 inches long. The line cultch, 120 meters long, are six in number and are parallel to each other at a space of six inches and are each tied from one end to the other end of the plot. Other line (sampayan) cultch were placed along the fence in three layers at the posts of the fence in between the bamboo railings. The oysters in the line (sampayan) devices were not very thick and hence the growth after 10 months was better and larger in size, as there was no over crowding.

The tray method (Plate 1, D).—At the oyster farm there are placed in a portion of the area between the plots of bitin and tulus four rectangular bamboo trays each about four meters long and one meter wide. They have split bamboo floor and partitions. Each tray has four compartments and is elevated and supported with bamboo posts. Oyster seedlings, when about six months old, are removed from the string of oyster cultch and then placed in each of the compartments of the trays. Culling the oysters is an important practice to separate the marketable oysters from the undersized. The accumulation of mud and debris on the tray prevented the oysters from feeding readily, hence did not fatten as expected.

Three screen trays of three meters in length and one meter in width, provided with wire screen covers, were hanged on bamboo poles supported with puno posts. The fallen oysters were recovered and placed in these trays for a period of from three to four months where they improved.

To remedy the entire loss of oysters, farmers every now and then gather the fallen oysters and place them in the elevated bamboo rectangular trays or in the rectangular wire screen trays. This saves the fallen oysters from suffocation. If let alone at the mercy of sedimentation of sticky mud, the fallen oysters would eventually die. Gathering fallen oysters and placing them in said trays facilitate oysters harvest.

Other methods of oyster cultivation unsuccessfully tried at the experimental farm in 1938 consisted of the use of wire bags filled with oyster, scallop, and clam shells; twigs and branches of trees; bamboo and wooden screens; shells threaded on rope (kabo-negro), *Arenga pinnata* (Wurmb.) Merr. hung from frames of floats; shells threaded on round rattan of ¼" in diameter hung from fences and floats; kabo-negro and abaca wound about frames and lowered in the spawning area; and other materials.

FOOD VALUE OF OYSTERS

Oyster meat either fresh or preserved is in great demand. It is prepared and served as oyster stew, oyster chowder, oyster omelet, oyster cocktail, salted oyster or "ginamos." It plays a significant rôle in one's diet for it is a rich source of iron, copper and iodine containing one-half as much as calcium, three times as much as magnesium and much more phosphorus than an equal quantity of milk. It is comparable to liver and milk in its rich sources of nutrients as well as Vitamin A, thiamine, riboflavin and ascorbic acid (Newcombe, 1944).

MARKETING OF OYSTERS

Oysters grown in suitable areas are marketable when they are six months old, they are better suited for the market in their first or second year under Philippine climatic conditions. Oyster harvest occasionally takes place in December, January, February, March, and April. The best time for harvesting them is during June and July, when they are fat. There are times when oysters eight to twelve months old are offered for sale in the markets of Cavite City, Kawit, Binakayan and Bacoor. Usually a basket (kaeng) of oysters sells at 4 pesos. Shucked oysters are oftentimes offered for sale.

One way of solving the marketing of this perishable product is the preservation of oyster meat by canning, smoking, and salting it into bagoong. As there is overproduction of oysters at Bacoor Bay almost every year, one should look into the possibilities of growing seed oysters for transplantation in other suitable areas in the Philippines. The American slogan for the conservation of oysters is "Harvest the Crop, and Keep the Seed." This holds true in Bacoor Bay where there is always an abundance of seed oysters. The replenishment every year can keep up with the demand in the markets and the possibility of canning oysters or making bagoong for exportation has a bright future for this young industry.

Oyster shells can be manufactured into poultry grit and lime for construction and other industrial purposes. They can be sold for oyster cultch as well as for road-building purposes.

SYSTEMATIC POSITION OF OYSTERS OF THE GENUS OSTREA LINNAEUS

Twenty-three species of oysters of the genus *Ostrea* have been reported or described in the Philippines. This number is being reduced to twelve due to synonymy, misplacement to proper genus, and status of fossil species. The oysters that are of doubtful existence in the Philippines are *Ostrea mytiloides* Lamarck, *O. orientalis* Jay, *O. paulucciac* Crosse, *O. isognomon* Linnæus and *O. malleus* Linnæus.

Dillwyn (1817) stated that *O. mytiloides* Lamarck reported from Zamboanga, Mindanao, was a fossil species. That *O. orientalis* Jay was synonymous to *O. bilineata* Rolding (1798) which is *O.* (*crassostrea*) *gigas*, according to Thunberg, and *O. iredalei* of Faustino. According to Reeves' Conchologia Iconica, *O. orientalis* Chemnitz is a species not properly identified. Faustino (1932) redescribed *O. orientalis* Jay as *O. iredalei* on account of the improper identity of *O. orientalis* by Chemnitz.

The species *O. isognomon* Linnæus and *O. malleus* Linnæus are species not of the genus *Ostrea* of the family Ostredæ but species of the genus *Isognomon* Solander (1886), *Malleus* Lamarck (1799), of the family Isognomonidæ Kuroda (1940).

The genus *Ostrea* of the family Ostredæ is being represented in the Philippines by the following: *O. affinis* Sowerby; *O. cucullata* Born; *O. cumingiana* Dunker; *O. denticulata* Born; *O. echinata* Quoy et Gaimard; *O. glomerata* Gould; *O. hyotis* Linnæus; *O. imbricata* Lamarck; *O. iredalei* Faustino; *O. lugubris* Sowerby; *O. malabonensis* Faustino; and *O. palmipes* Sowerby.

Superfamily OSTREACEA

Family OSTREDAE

Genus OSTREA Linnæus, 1758

Shell of two unequal valves unimascular, foliaceous; hinge toothless with linear margin; ligament, partly external and lamiscated upon trigonal area in each valve.

The species of oysters under this genus have a wide range of geopraphical distribution and are found inhabiting seacoasts and deep seas in the tropic, temperate, artic and antartic zones. Their form depends largely upon the mode and object of attachment, making it difficult to distinguish the different species (Smith 1878).

Shell transversely oblong, solid, rough, purplish in color, with undulated margin and large acutely angular plicae. Inside golden brownish with margin broadly purple. Cicatrix large, ash in color, posteriorly lateral. Hinge nearly terminal in front, small and trigonal.

OSTREA CUCULLATA Born. The wild oyster.

Shell subtrigonal, solid, plaited, whitish toward apex, purple toward margin, lower valve extending deeply beyond flat opercular upper valve. Interior yellowish brown with slight purple tinge. Upper valve brownish near base, purple toward margin, denticulated to about two-thirds from hinge line.

Habitat.—Numerous places in the Philippines.

OSTREA CUMINGUIANA Dunker. The milky oyster.

Shell radiately plicate, transversely subovate, solid, milk-white, tinged with rose and fawn, bluish underneath; inside painted chestnut, greenish gold, blue margins. Muscular impressions deep chestnut. Lateral margins denticulated towards umboes. Ribs of upper valve rounded, rather depressed. Lower valve slightly angular, deep wrinkled over-reaching upper valve at margin.

Habitat.—Philippines.

OSTREA DENTICULATA Born. The denticulated oyster.

Shell subround, thick, glabrous, slightly margaritaceous. Lower valve, large, flattened, widely foliaceous with greenish-white borders. Upper valve convex, obscurely tuberculated. Hinge flattened, golden brown. Internal margin strongly denticulated. Inside part of shell brownish purple, iridescent.

Habitat.—Samar.

OSTREA ECHINATA Quoy et Gaimard. The echinated oyster.

Shell compressed, thin, accuminated towards hinge, roundish beneath. Lower valve sometimes deeply concave; upper valve armed with tube-shaped purple outstanding spines.

The species occurs attached to rocks just below high tide mark on both coasts of the Pacific Ocean and Japan Sea.

Habitat.—Philippines.

OSTREA GLOMERATA Gould. The conglomerated oyster.

Shell thick, irregular, sharp ribbed, with margin dentated, wrinkled or lobed. Upper valve opercular, compressed with thick concentric laminae. Lower valve cucullated, purple. Hinge generally attenuated, produced, pointed. Differs from *O. cucullata* Born. in having numerous strong ribs. Inside edge purple or black. Lateral margin denticulated.

Habitat.—Bacoor Bay, Cavite Province.

OSTREA HYOTIS Linnæus. The hyotoid oysters.

Shell irregularly subquadrate, solid, armed with tube-shaped spines standing out upon angles of about seven large folds. Color greenish brown. Auricles rather compressed, plicated, widely bordered with brown inside.

Habitat.—Daet, Camarines Norte, Luzon; Zamboanga and Basilan, Mindanao.

OSTREA IMBRICATA (Lamarck). The imbricated oyster.

Shell foliaceous, thin, radiately plicated, pink, ornamented with large purple irregular spots of pale fawn tinted with reddish brown; middle folds large, bifurcated, angularly rounded with imbricated tubes at angles. Lower valve very often foliaceous.

Habitat.—Cebu.

OSTREA IREDALEI Faustino. The slipper-shaped oyster.

Shells variable in shape depending on the mode of attachment. Those growing in bunches elongate, sometimes tongue-shaped. Other subtrigonal, sometimes oblong. Very foliaceous, with prominent beak, lower or left valve excavated generally with purple tint. Upper valve smaller, thinner, flatter, generally yellowish brown, sometimes with faint radiating rays of purple, covered with thin laminae, scaly at margins.

Hinge toothless, valve margins inside smooth. Shells interior chalky white. Muscle scar purple, located near center.

Habitat.—In many parts of the Philippines.

OSTREA LUGUBRIS Sowerby. The lugubrius oyster.

Shell thin, obliquely subtrigonal, slightly auriculated, greyish purple, obscurely rayed, rather smooth, shining whitish within. Anterior side produced at ventral margin. Upper valve flattened, subopercular. Lower valve convex, obscurely ribbed, expanded at margin beyond upper valve. Muscular impression reniform, nearly black.

Habitat.—Philippines.

OSTREA MALABONENSIS Faustino. The horse-nail-shaped oyster.

Shell subtrigonal or irregularly oblong, generally not found in bunches but attached singly to other objects of shells. Lower valve concave, deep, plaited with large, rounded numerous plaits. Upper valve plain or partly plain at middle, plaited at margin. Interior of shell with greenish brown spots, margins toothed.

Habitat.—In many places of the Philippines.

OSTREA PALMIPES Sowerby. The palm-rooted oyster.

Shell much compressed subquadrate, thin very inequivalve, inequilateral, fulvoid, rayed with purple or black. Anterior side very short, sloped. Dorsal margin straight while ventral margin rounded, lobed. Umboes small, accuminated. Upper valve small, smooth. Lower valve more expanded, radiately striated, ribbed, tuberculated, produced at margin, flattened interstices.

The peculiar characteristic of this pretty oyster is in the outer surface of the lower valve, which from the radiating ribs ending in lobes and the flattened surfaces between, presents the appearance of the webbed food of a bird.

Habitat.—Philippines.

LIFE HISTORY OF THE OYSTER

Species of the genus *Ostrea* may be either a male or a female. It may usually start as a male and then change into a female or vice versa in its first, second, or third year depending upon favorable environment factors as observed by biologists in the sex behavior of *Ostrea virginica.* In one spawning season as many as half a billion eggs may be liberated into the water by a single female and more so of sperms by the male oyster. The high rate of mortality of larval oysters is due to its "planktonic" state. They are being utilized as food by fish, sandworms, sea-squirts and mussels and other aquatic animals. Climatic factors like wind and tide may strand them on the shore. In tropical as well as temperate countries sudden change of temperature kills the larvae. Industrial wastes discharged into the water poison the young oysters.

Another type of oyster reproduction in temperate countries is the "incubatory larviparous type" where there is a regular and frequent alternation of sexual phases.

Out of the half billion eggs spawned by each female only a few hundred survive to settle as "spats" and with the subsequent loss of spats and growing oysters, on the average only two from each spawning mother come to maturity under natural conditions (Thompson 1946). The high mortality of the larval oysters is compensated by the great fecundity of this mollusk.

In Philippine waters oysters spawn in May, June, July and August at a water temperature ranging from 18°C. to 20°C. There is nothing new in the embryological development of the oyster as it has been well worked out. Oyster eggs and sperms

unite shortly after spawning to form the fertilized eggs. Each fertilized egg undergoes cleavage and umbo stages with cilia for locomotion in its early "plankton" larval embryonic life. After about twenty-four to thirty hours a "straight line" hinge larva about 1/400 of an inch in length is formed. This stage possesses the minute shell which later develops into an "umbo" larval stage after three or four days. It differs from the preceding stage in size and shape. After eight to ten days the "umbo larva" which is also planktonic becomes attached to a suitable rough object or a "cultch" and as such it is referred to as "spat."

FEEDING OYSTERS

The larval oyster is equipped with organs of locomotion and digestion, hence in its planktonic stage it feeds upon nannoplanktonic material which is abundant in the oceanic zone. The availability of such food is a critical factor for the survival of the larvae which are abundant in the oceanic zone and estuarine systems, the best spatting grounds.

Studies on oyster's nutrition (MacGinitie 1937) revealed that the cilia on the gill apparatus in many animals have been credited the selective function of obtaining food and is actually performed by mucous sheets through which the water is strained, and that the cilia on the gill apparatus furnish the mechanical power for creating current. Further investigation on the Lamellibranch mollusks including the oysters emphasizes the fact that a sheet of mucus entirely covers the gill during active feeding and it is this mucus which strains out food from the water. The cilia only creates the current and moves the mucus by which the food-laden mucus is transported to the mouth (MacGinitie 1941).

The adult oyster obtains food by straining water through its gills and retaining food particles which are later directed toward the mouth. The gills of the oysters are very important part in feeding in addition to their respiratory and excretory functions.

The natural foods of the adult oysters vary as to locality and the season of the year. However, phytoplankton such as Dinoflagellates especially *peridinium,* diatoms (*Navicula, Nitzschia, Rhizosolonia*), and zooplankton as *Protozoa* and copepod larvae compose the food of oysters.

In estuaries of low salinity, oysters feed mostly on flagellates and in small bays or coves of high salinity, they feed on diatoms.

Other feeds found in the oyster stomach consisted of larvae of bivalve shells, barnacles, and bryozoans.

The availability of food depends also upon the manner of cultivation of the oyster. For instance oysters cultivated by the "hanging method" in deeper portions of the bay have more chances of obtaining planktonic food as they are not crowded in clusters and under this condition they sway and feed readily.

This brings us to the point of the difference of abundance of planktonic food in an estuarine environment and that in an open bay or cove. During the dry season, in small bays or coves, where oysters are grown, there is always a deficiency of available food owing to physical and chemical changes such as high temperature and salinity of the water, etc., so that in March, April, and May oysters are clean and watery. The absence of admixture of fresh water obtain in bays and coves during dry weather affects the abundance of planktonic foods for the oysters; for instance, planktonic organisms are few.

In an estuarine environment, biotic factors present are entirely different from those in a bay or cove. There is the mixing of fresh and salt-water components and the consequent accumulation of salt material, the proportion of salt and fresh water varying from season to season and from locality to locality and, therefore, there is a very wide range of salinity and other properties which constitute a favorable environment. Hence, there are always available planktonic foods streaming in and out of the estuary for the oysters.

Problems concerning the food and feeding of oysters are numerous and remain still unsolved regardless of the intensive studies of the physiology of oysters. Biologists do not agree on the effects of different quantities of materials suspended in water upon the efficiency of the feeding of oysters. Some maintain that oysters and other mollusks are able to feed only when the water is comparatively clear while others believe that they can feed even in the presence of turbid water.

Experiments on the feeding of (*Ostrea virginica*) with *Chlorella* sp., *Nitzschia closterium*, *Euglena viridis*, and other species (Loosenoff and Engle 1937) have shown that there were definite concentrations above which the density of the microorganisms begins to interfere with the feeding of oysters. The above authorities had worked on the concentrations corresponding to approximately 2,000,000 *Chlorella*, 70 *Nitzschia* and 3,000 *Euglena* to 1 centimeter of water. It was found that much higher number of small cells like *Chlorella* was

needed to produce the same effect as that of much smaller number of larger organisms; that in concentrations higher than those given above, the feeding slowed down and the shell movement changed noticeably. When plankton were given abundantly, little or no feed was taken in by the oysters. They eject large quantities of feces to cleanse their gills and palps of the excessive plankton. Their shells sometimes remained opened for several hours without inhaling water. When oysters were subjected to heavy concentrations of food for long periods of time they become sluggish.

The oysters in light concentrations, which contained fewer cells than those mentioned above, exhibit normal rate of feeding and shell movements. The rate of feeding in many instances was fast when the oysters were kept in running sea water. It was observed that the presence of small quantities of plankton in sea water stimulates the pumping activities of the oysters. Oysters were found to feed in water containing relatively large number of microorganisms although the feeding activity is very much produced. When the plankton was too heavy the oysters stopped feeding.

INTENSITY OF SETTING OF OYSTER SPATS

In June of 1948 there were prepared at the Binakayan Oyster Farm 600 strings of seed oyster collectors ready for the August oyster spatting season. Oysters locally called "talabang chinelas" "kukong kabayo"and "pulid-pulid" spawn at Bacoor Bay intensely in August when biotic factors as salinity, temperatures, and conditions of water are favorable. The collectors were set around the fence above the sampayan of oysters in August 1948 to catch the spats. Samples of five strings of cultch were examined daily for the presence of spats up to the end of the month. There was an average of 875 spats to a string of cultch of 35 oyster shells.

The vertical distribution of oyster spats in Bacoor Bay was worked out by Villaluz (1938). It was found that the average number of spats per string collector at sitio Binakayan was 96 out of 16 string collectors of 1,544 spats. In Noveleta, 4 string collectors were found with 291 spats or an average of 72 spats; at sitio Dalahican 7 string collectors had 139 spats or an average of 34 to the cultch. At Bacoor Bay, spats are available at a depth of from 42 to 112 centimeters from the surface of the water, so that the greatest intensity of setting is obtained at 84 centimeters from the surface of the water.

At constant temperature of 23.3°C. the optimum range of salinity for development of the larvae of *O. gigas* was from 22.2 to 27.5 parts per thousand (Kusakabe, 1926). At about 25°C. the optimum salinity for the development of the larvae is about 20 to 26 parts per thousand with the minimum at about 8 parts per thousand and the maximum about 26 per thousand (Amemiya, 1928). At lower temperature the oyster larva would develop into greater range at 15°C. the optimum salinity was between 17 and 26 parts per thousand, with a minimum and maximum, respectively, at about 6 and 37 parts per thousand.

The pacific oyster (*O. gigas*) in Japan begins to spawn when the water temperature reaches 15°C. (Fujita, 1928). The spawning of the Pacific oyster takes place from the middle of May to late in June when the temperature of the water is around 25°C. (Amemiya, 1928). Galtsoff (1930) was able to make female oyster in aquarium to spawn at 30°C. and when stimulated by sperms at 25°C. Females normally spawn in tanks at 24°C. and when stimulated with sperms suspension they spawn at 20°C. (Elsey, 1933). Pacific female oysters were observed to spawn in the laboratory by Schaefer (1938) at temperature ranging at 17.4°C., 16.4°C., and 21.5°C. Hopkins (1936) observed a female Pacific oyster to spawn at 8°C.

TRANSPLANTATION OF SEED OYSTERS

On October 7, 1948, two hundred strings of seeds oysters from Binakayan Oyster Farm were shipped to Iwahig Penal Farm, through the request of the Director of Prisons. The shipment of the said seed oysters, the sizes of which were 1 millimeter to one centimeter, took 78 hours, which means that they were out of their natural habitat that length of time before reaching their destination at the oyster farm project in Palawan. The transplanting of the seed oyster from Bacoor Bay to Palawan was a success as there was only 25 per cent mortality according to the report of the Bureau of Prisons.

With the numerous private oyster farmers at Bacoor Bay, one branch of the oyster industry that could be properly developed is the growing of seed oysters in August for transplantation in other suitable known oyster areas in the Philippines. The encouragement of oyster farming to help alleviate the shortage of quality protein food demands a thoughtful consideration on the part of our fishing population. As it is now, oyster is still a "richman's dish." It is available only to a small portion of our population. As a food delicacy no other seafood surpasses oyster when it comes to its food value.

ESSENTIAL FACTORS FOR THE CULTIVATION OF OYSTERS

1. For the broadcasting method of oyster cultivation, hard non-shifting bottoms must be available where clean salt water with adequate food organisms circulates over the oyster bed. In the case of oyster beds of sticky blue mud, where nature is being helped to cultivate oysters artificially, usually small sheltered bays, or coves, or estuaries are selected.
2. Oyster breeding stocks must be present in sufficient quantity to supply the seed oysters.
3. Availability of adequate cheap materials for cultch [bamboos, puno, oyster shells, etc.] to offer clean, firm surface at the time the oyster larvae are ready to set.
4. Culling oyster for purposes of growing them faster and fatter should be an important general practice.
5. Harvesting should be done at the proper time when the oysters are in good sizes for marketing.
6. Oyster beds or areas must by all means be free from predators, enemies, and other competing organisms.

FACTORS AFFECTING PRODUCTION OF OYSTERS AT BACOOR BAY

During the year 1947 the Binakayan Oyster Farm did not escape the ravages of four successive typhoons. The plot for the oyster seedlings was partly damaged when about 20 per cent of the bitin seedlings fell off the bottom as they were detached from the staples due to the wave action. About 30 per cent of 28,000 stakes fell to the bottom. This was due to the condition of the tulus of bamboo trunks that had been eaten up by borers. The line, or sampayan, cultch that were placed at the puno and bamboo fence also gave way and even the fences around the area were also destroyed.

The most significant cause of mortality of the oysters in October, 1947 was the flood of oil from sunken oil drums and oil barges from the Navy Yard at Sangley Point, Bacoor Bay, during the typhoon "Jean." The oil pollution in the bay lasted for five days. The quality of six-month-old oyster that survived was affected by the flood of oil, and the harvesting of the oyster was suspended for a considerably long time.

During adverse conditions like drought when water temperature is high, oysters in shallow coves, bays, and estuaries die.

In cases of water above or below the optimum salinity oysters are affected by the absence of food suspended in water.

The common cause of the falling off of oysters is the attack of borers on portions of the stakes. If fallen oysters are not recovered within a few days from date they fall off, the majority of them dying due to suffocation as they become covered with silt and mud.

From time to time oyster valves are seen opened with the meat content entirely absent both in the bitin and in the tulus, while others are just beginning to open and some are freshly dead. The death of these oysters is caused by natural enemies like the starfish, oyster drill, and internal parasites like the polychaet worm, polydora, and annelids. The luxuriant growth of sponges and seaweeds on oyster beds also accounts for the suffocation of oysters in their natural habitat.

Another cause of low production of oysters is the loss of oysters due to silting or sedimentation in time of floods when oysters grown by the spreading methods are partly or wholly covered by sediments, mud, sand, and other debris.

SUMMARY

The artificial cultivation of oysters in Bacoor Bay is still in an experimental stage. Every conceivable oyster-culture practices here and abroad has been tried at the Binakayan Oyster Farm Station to popularize oyster farming in the Philippines. The utilization of our shallow seas, coves, bays, and estuaries to produce more food, for the growing population of our country is indeed a serious undertaking that necessitates moral as well as financial support. The Bureau of Fisheries shoulders the responsibility of planning a program of shellfish conservation for the State by educating our fishermen along modern methods of oyster farming through demonstration oyster farms built in strategic places throughout the Philippines.

As a food delicacy oyster meat is important in one's diet for it contains proportionate amount of calcium, phosphorus, iron, iodine, copper, Vitamin A, thiamine, riboflavin, and ascorbic acid. No other seafood surpasses it. It is as good as liver and milk for food.

One way of solving the marketing of this perishable product is by canning, smoking and salting oyster meat. The oyster shell is important for cultching and the manufacture of poultry grit and lime for other industries.

A review of the systematic position of the species of the genus *Ostrea* of the Philippines is embodied in this report.

A general information of the life history of the oyster together with a discussion of the intensity of spatting, feeding of oysters, as well as essential factors affecting production is discussed in this paper.

REFERENCES

ABLAN, G. L. (1949). The commercial production of oysters in the Philippines. Republic of the Philippines Dept. of Agri. & Nat. Resources. Popular Bulletin No. 26 (1949) 1–24.

AMEMIYA, I. (1928). Ecological studies of Japanese oysters with special reference to the salinity of their habitats. Jour. Coll. Ag. Imp. Univ. Tokyo **95** (1928) 333–382.

ANGAS, G. F. (1867). List of species of marine molluska in Port Jackson. Proc. Roy. Sec. Lond. (1867).

AWAITI, P. R. and H. S. RAL. (1931). Ostrea cucullata (Bombay Oyster). Indian Zool. Mem. 3 (1931).

BELL, A. (1921). British Oysters: Past and Present. Essex Naturalist **19** (1921) 183–221.

COX, J. G. (1883). On the edible oysters found on the Australian and neighboring coasts. Proc. Linn. Soc. N. S. W. **7** (1883) 122–134.

ELSEY, C. R. (1933a). Oysters in British Columbia. Biol. Bd. Canada Bull. **34** (1933) 1–34.

FUGITA, T. (1929). On the early larval development of the common Japanese oyster. Jap. Jour. Zool. **23** (1929).

GALTSOFF, P. S. (1930). The role of chemical stimulation in the spawning reactions of *Ostrea virginica* and *Ostrea gigas*. Proc. Nat. Acad. Sci. **16** (1930) 555–559.

HOPKINS, A. E. (1936). Ecological observations on spawning and early larval development in the Olympia oyster (*Ostrea lurida*). Ecology (4) **17** (1936) 551–556.

IREDALE, T. (1936. Australian Molluscan Notes. Rec. Australian Mus. 19 No. 2 (1936).

IREDALE, T. and T. ROUGHLEY. (1933). The scientific name of the commercial oyster of New South Wales. Proc. Linn. Soc. N. S. W. **58** (1939) 278.

KORRINGA, P. More light upon the problem of the oyster's nutrition? Bijdragen Tot De Dierkunda, **28** (1949) 437–248.

MACGINITIE, G. E. (1937). The use of mucus by marine plankton feeders. Science N. Y. **136** (1937) 398–399.

MACGINITIE, G. E. (1911). On the method of feeding of our four pelecypods Biol. Bull. **130** (1941) 18–25.

NEWCOMB, C. L. (1944). The nutritional value of seafoods. Vo. Fish. Lab. College of William and May Commission of Fisheries. Richmond (1944).

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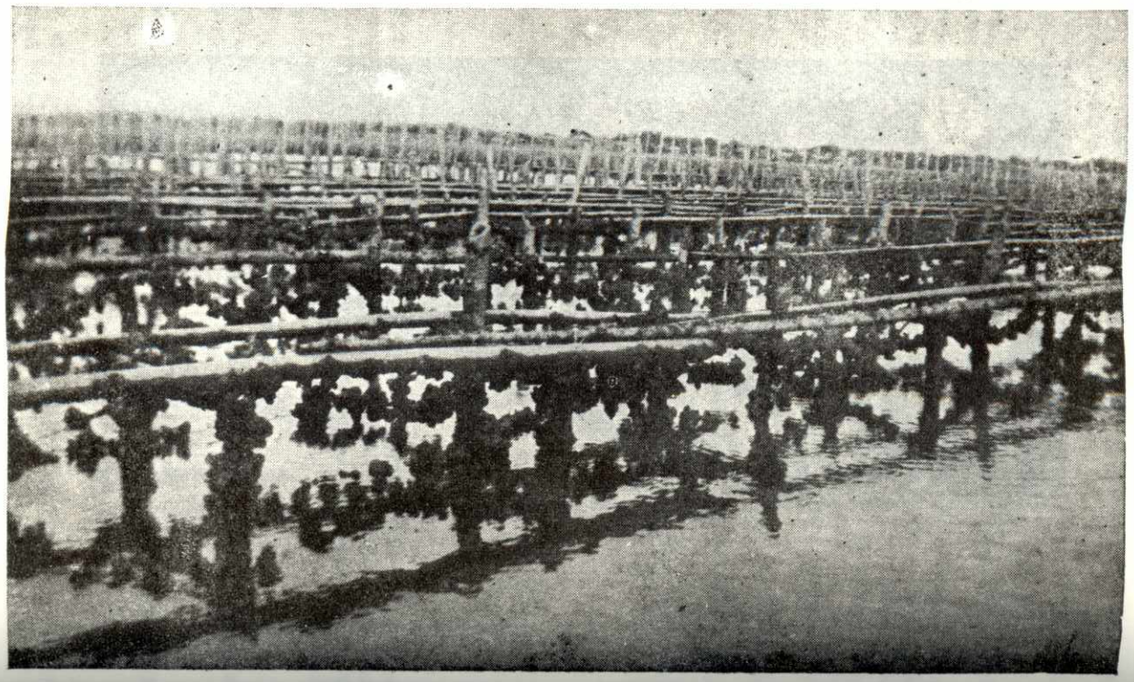
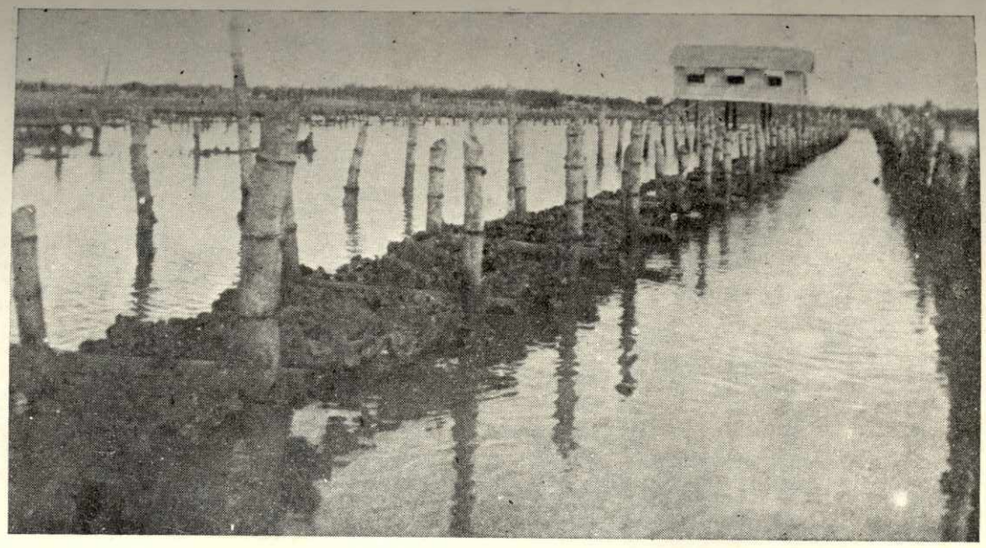


PLATE 2.



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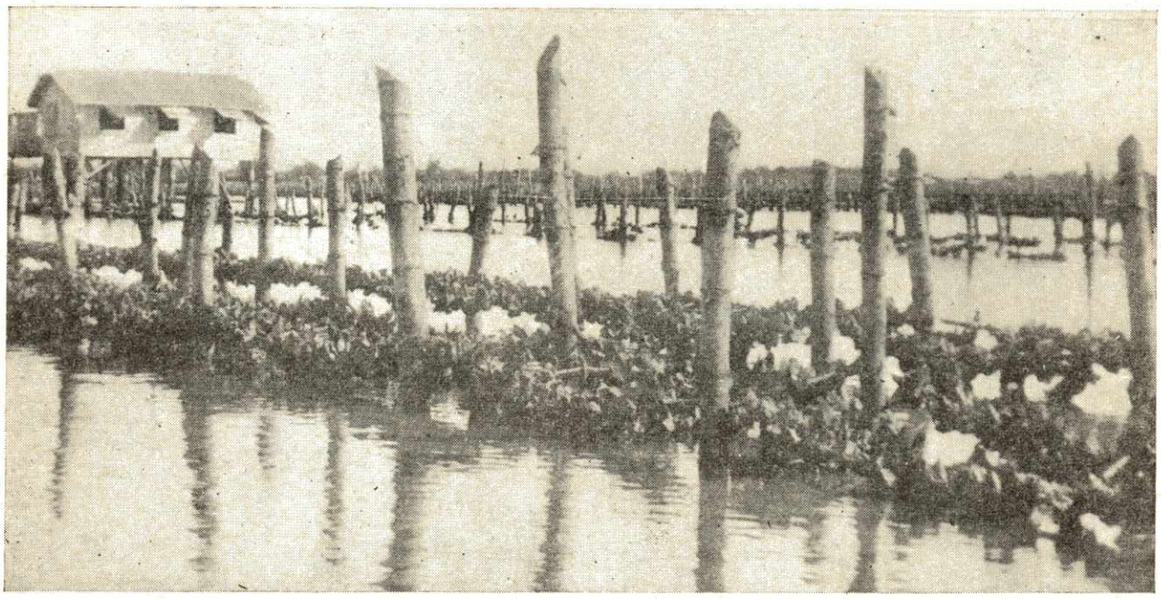

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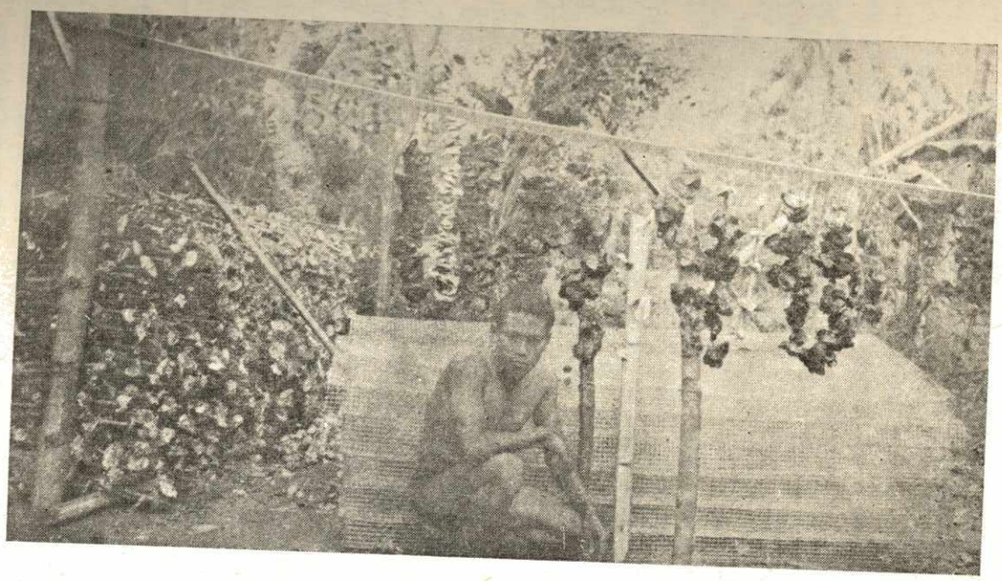

PLATE 5.