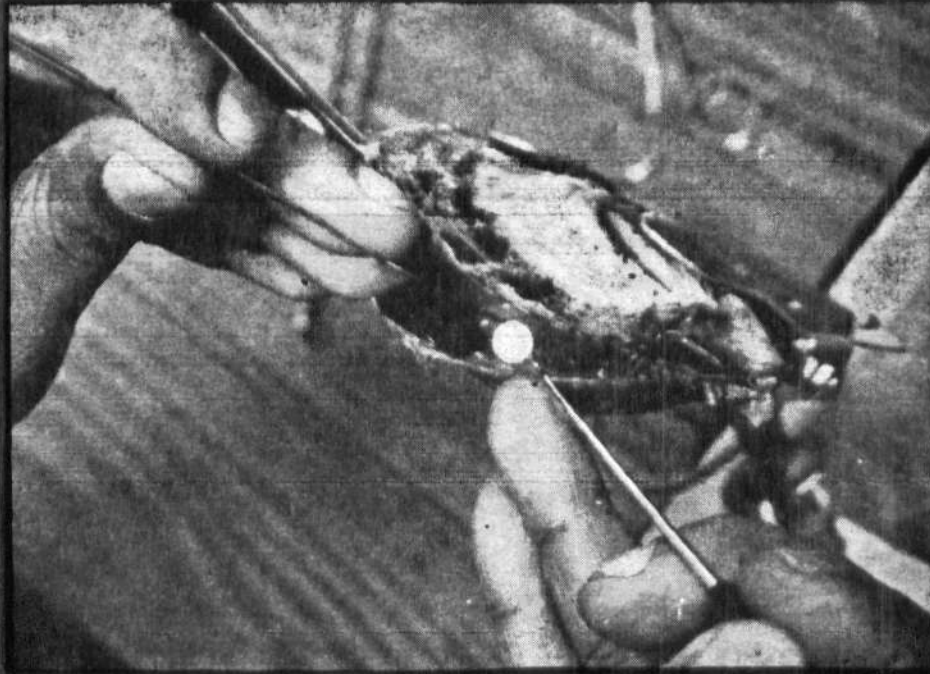




CMFRI SPECIAL PUBLICATION

Number 20

# MANUAL ON PEARL CULTURE TECHNIQUES



**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE**

Indian Council of Agricultural Research

Post Box No. 1912, Cochin 682 018, India

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*Cover photograph : Nucleus implantation in pearl oyster *Pinctada fucata*.*

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*Back Cover : Cultured pearls from Pinctada fucata.*

# MANUAL ON PEARL CULTURE TECHNIQUES

K. ALAGARSWAMI AND S. DHARMARAJ



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## INTRODUCTION

Pearl culture is an art concerned with biological production of one of the finest gems, the pearl, nature's perfection of beauty and splendour. It is produced by the pearl oyster, a bivalve mollusc, living on an insignificant ground at the sea bottom. Man has known this gem right from the period of early human civilization and had adorned himself and his woman with pearls and had offered them to his gods. The soft colour and cool lustre of pearls produced by the oyster remain unmatched by any of the gems processed by man.

Ages ago, the ancient Greek philosophers gave explanations on the origin of pearl, the great explorers and travellers offered their opinions and the naturalists tried to unravel this mystery of nature through scientific theories. Carl Linnaeus developed a 'secret process' of forming pearls in a freshwater mollusc. The first practical work to produce pearls artificially was done by the Chinese in the 13th century, producing the classical pearly Buddha images in the freshwater mussel in Lake Tahu in central China.

However, the credit for the development of modern pearl culture goes to Japan. They developed and perfected the techniques of pearl culture in the marine pearl oyster in the early part of the present century, starting from the initial success achieved by late Mr. Kokichi Mikimoto in 1893. They also improved the Chinese techniques of freshwater pearl culture for production of the so-called 'natural' pearls. The Japanese marine cultured pearl production has dropped in the recent years from 127 tonnes (all-time peak) in 1966 to 34 tonnes in 1973 which has been stabilised at that level in subsequent years. The annual freshwater cultured pearl production has been around 7 tonnes recently. Pearl culture has spread to other countries, in all cases with the Japanese help perhaps with the exception of China. Australia has a sizable production but the other countries in South-east Asia such as Burma, Philippines, Malaysia, Thailand and Indonesia have very modest production limited by the availability of pearl oyster resource.

The major species of pearl culture in Japan is *Pinctada fucata* from the sea and *Hyriopsis schlegelii* from the lake. In Australia and South-east Asian countries it is the silver-lip pearl oyster *Pinctada maxima*. The black-lip *P. margaritifera* forms a small component at some centres as also black-winged pearl oyster *Pteria penguin*. The abalone *Haliotis* sp. is used in Japan at a few centres. Round pearls are produced in *P. fucata*, while both round and half-pearls are produced in *P. maxima*. Pearls produced in the freshwater mussels are largely baroque.

India's potential for pearl culture with its resource of *P. fucata* was realised long ago and efforts were made to develop the techniques since the early thirties. However, technological success came about only in 1973 in an experimental project of the Central Marine Fisheries Research Institute based at Tuticorin. With this breakthrough, further research at the Institute has been focused on several scientific and technical aspects of pearl culture and pearl oyster production.

The main objective of this manual is to present the basic techniques of pearl culture in simple language which could be easily understood and practised by those interested. The techniques for hatchery production of pearl oyster have not been included as breeding and larval rearing are multidisciplinary problems and cannot be covered here. The techniques given are those developed at the Institute which have proved successful in farming of pearl oyster and cultured pearl production. Surgical procedures vary from species to species and based on kinds of pearls. Only those relating to *Pinctada fucata* for the production of round cultured pearls have been given in the manual. Some data which are necessary for judging the success of production are given but these cannot be held true for all situations in view of several variable factors. Every technician or manager of pearl culture may be able to improve upon the results depending on his skill and judgement of the problems and their solutions. It should be appreciated that it is finally the pearl oyster which is responsible for pearl production and, being a biological process controlled by many variables, production cannot always be the same as targets fixed. Nevertheless, the three basic rules of right oyster, right surgery and right environment, if practised carefully, should ensure success of production.



**MORPHOLOGY AND ANATOMY OF  
PEARL OYSTER****Shell—external features**

The shells of pearl oyster *Pinctada fucata* are reddish brown but may exhibit different colour patterns. Externally 6-8 radial reddish brown bands emerge from umbo towards the free margin of the shell. The hinge line is fairly long. The hinge teeth are well

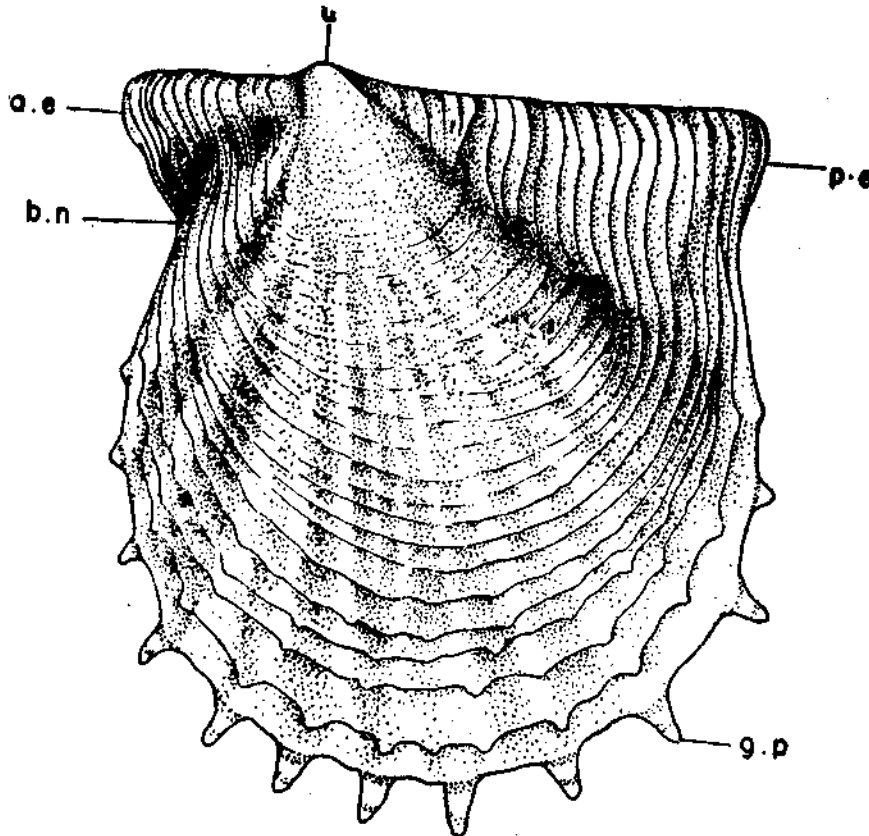


Fig. 1. External features of shell of pearl oyster *Pinctada fucata*. (a.e.—anterior ear, b.n.—byssal notch, g.p.—growth process, p.e.—posterior ear, u—umbo).

defined, one on either end of the ligament. The anterior and posterior ears are well developed. The anterior ear is ventrally bound by the byssal notch. In fresh specimens, prominent scaly growth processes can be seen at the distal border (Fig. 1).

#### Shell—internal features

The left valve is deeper and more convex than the right one. The nacreous portion of the shell has bright metallic lustre. The non-nacreous border has brownish or reddish patches corresponding to the external radial markings. The adductor scar is large

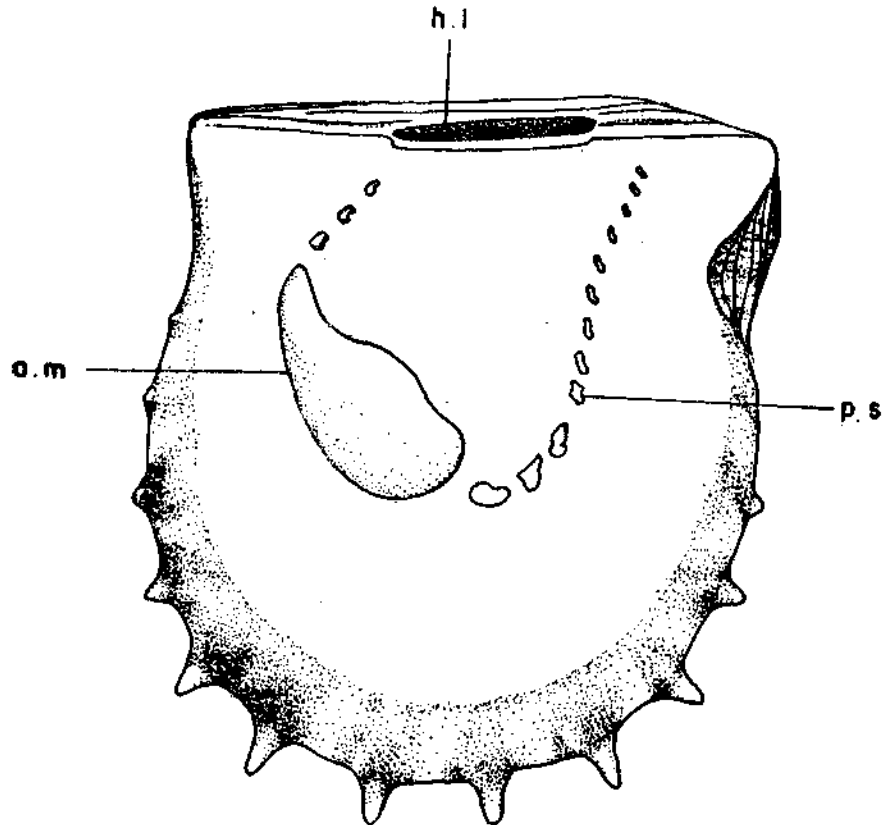


Fig. 2. Internal features of shell of *P. fucata*. (a.m.—adductor muscle scar, h.l.—hinge line, p.s.—pallial muscle scar).

and subcentral. Small scars, 12-15 in number, are present for the attachment of pallial muscles (Fig. 2).

#### Shell—structure

The shell of pearl oyster is composed of three layers (Fig. 3). The outermost layer is the organic conchiolin layer or periostracum. The middle prismatic layer is composed of several layers of calcite crystals of calcium carbonate arranged vertical to the surface of the shell. The calcite crystals are cemented to one another by a thin layer of conchiolin. The innermost nacreous or mother-of-pearl layer is composed of microscopically small irregular, roundish or polygonally formed laminate of aragonite crystals which are the pseudo-hexagonal modification of calcium carbonate. The aragonite laminae lie terrace-shaped, one above the other, and are arranged parallel to the surface of the interior of the shell.

#### Soft body

The soft body of the pearl oyster consists of a pair of mantle lobes, visceral mass, gills, foot, posterior adductor muscle and other musculature. The mantle which follows the contour of the valves (shells) envelops all the other soft parts of the body. It is soft and creamy yellow in colour. The right and left lobes unite dorsally below the hinge line, while they are free on the anterior, posterior and ventral margins.

The visceral mass consists of the organs concerned with feeding and digestion, reproduction, blood circulation and excretion (Fig. 4). The neuroendocrine system is composed of cerebral, pedal and visceral ganglia with commissures and connectives. The mouth is a small slit-like opening at the anterior end of the alimentary canal. The labial palps are on either side of the mouth. The mouth leads to a short oesophagus which passes into a thin-walled stomach lined by hard cuticle. The stomach is surrounded by a mass of sage-green hepatopancreas (also referred to as liver or digestive gland). The crystalline style extends from the stomach to the descending portion of intestine. The

intestine, arising from the posterior end of the stomach, passes downwards up to the ventral margin of the visceral mass and ascends to the heart region. This is followed by a short rectum descending on the posterior margin of the adductor muscle, ending with an anal opening.

The sexes are separate without any external differences. The reproductive system consists of a pair of gonads which, when in mature state, spreads superficially over the hepatopancreas and intestine. It is pale yellow in colour in male and is of a deeper shade in the female. The eggs or sperms are spawned through the paired gonoducts ending in the genital openings located at the anterior ends of the gills.

The heart consisting of a ventricle and two auricles is enclosed by a pericardium. The colourless blood is carried away from the heart by two arteries which distribute purified blood to all parts of the body. The purification of blood takes place in the gills and the mantle.

The excretory system consists of a pair of simple tubular chambers lined with secretory cells. Each opens at one end into the pericardium and at the other to the outside.

The gills are a paired structure on either side of the visceral mass. The rhythmic lashing of cilia causes a water current

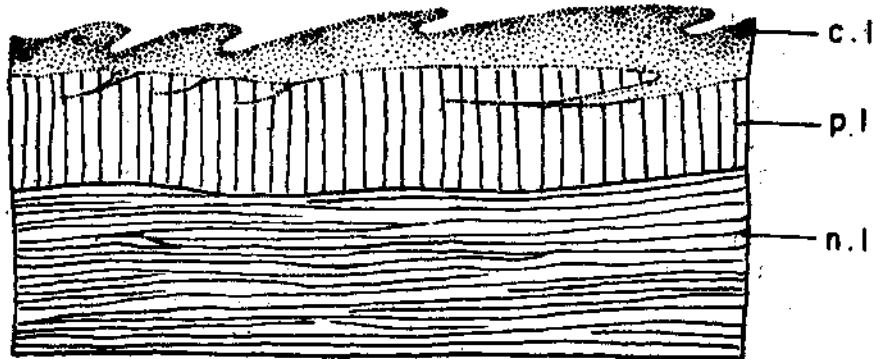


Fig. 3. Transverse section of shell. (c.l.—conchiolin layer, n.l.—nacreous layer, p.l.—prismatic layer).

## STRUCTURE AND HISTOLOGY OF MANTLE

The mantle of pearl oyster is essentially a secretory organ responsible for the formation of the shell. It is an epithelial tissue, consisting of an outer epithelium, middle connective tissue and the inner epithelium. The mantle lobe can be divided into three regions, namely the marginal mantle with folds, the pallial mantle immediately inside the folds and the central mantle which forms the larger area of the lobe (Fig. 5). The histological structure of the mantle in the above three regions differs from one another in cellular details.

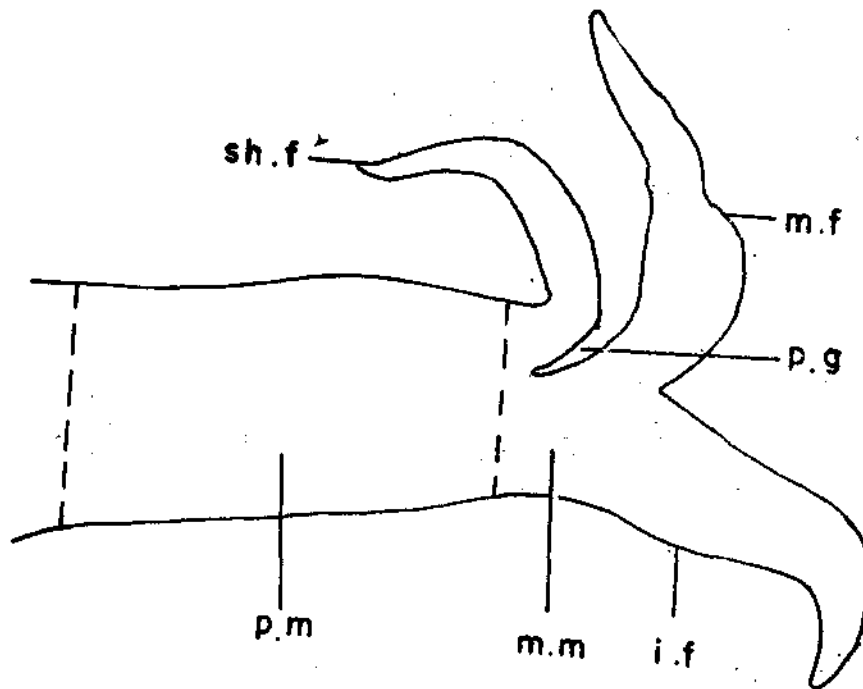


Fig. 5. Transverse section of mantle of pearl oyster. (i. f.—inner fold, m. f.—middle fold, m. m.—marginal mantle, p. g.—periostacal groove, p. m.—pallial mantle, sh. f.—shell fold).

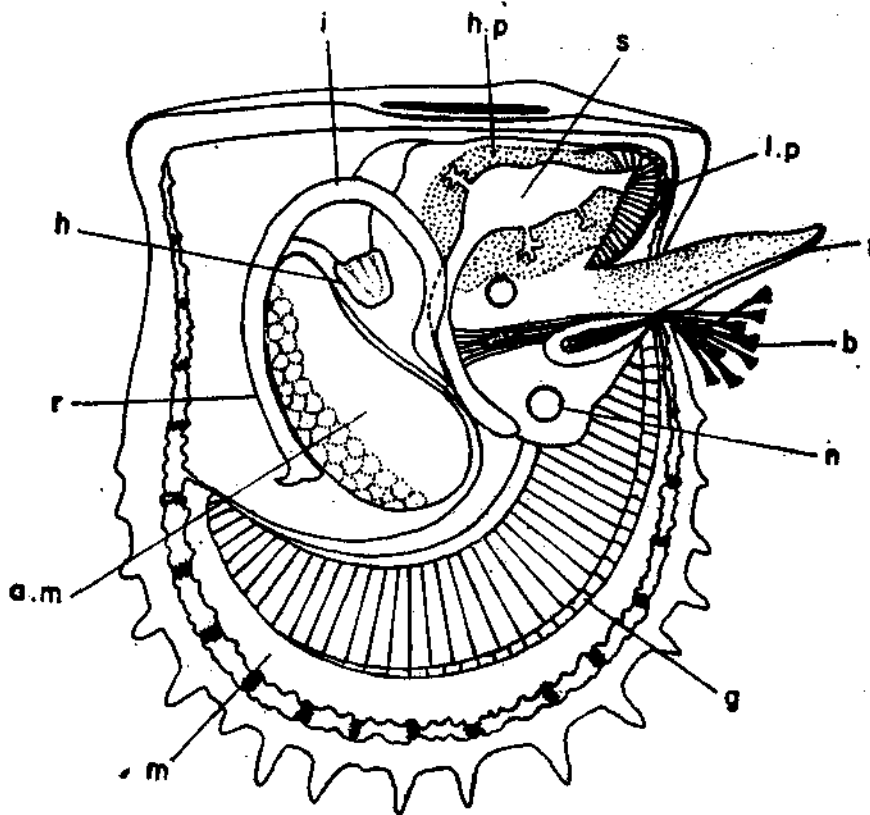


Fig. 4. Anatomy of *P. fucata* also showing sites of nucleus implantation. (a.m.—adductor muscle, b—byssal threads, f—foot, g—gills, h—heart, h.p.—hepatopancreas, i—intestine, l.p.—labial palp, m—manile, n—nucleus, r—rectum, s—stomach).

Besides exchange of oxygen in the blood, the mucus secreted by the gills helps in collecting the food particles. The food-laden mucus sheets are wafted by cilia towards the labial palps.

The marginal mantle is composed of three folds, namely the outer fold or shell fold, the middle fold (the two separated by the periostracal groove) and the inner fold (Fig. 5). Stratified columnar epithelial cells of 40-50  $\mu\text{m}$  size occur at the bottom of the periostracal groove of the outer fold which secrete the periostracal shell material. Mucus cells are common along the inner and outer fold surfaces. In the pallial mantle, inner and outer low columnar epithelial layers (cell size 10-15  $\mu\text{m}$   $\times$  4-6  $\mu\text{m}$ ) enclose muscular connective tissue (Fig. 6). The inner epithelium is characterised by dense cilia, melanin pigment in the cytoplasm and deeply staining basal ovoid nuclei. Cilia and cytoplasmic pigmentation are absent in the outer epithelium and the ovoid nuclei are placed basally to centrally with clearly distinguishable chromatin. Large secretory cells of the outer surface occur in the subepithelium as well as epithelium. In the central mantle, the outer epithelium consists of low columnar cells (8-10  $\mu\text{m}$ ) beneath which, and opening through, is a layer of concentrated secretory cells. The inner epithelium is similar to that of the inner pallial mantle.

The structural differences in the mantle layers of different regions may be related to functional differences. The inner, middle and shell folds of the marginal mantle are primarily muscular, sensory and secretory respectively. The outer epithelium of the central and pallial mantle, with uniform, low, non-ciliated, simple epithelial and subepithelial secretory cells, secretes nacre (mother-of-pearl).

**PROCESS OF PEARL FORMATION**

The pearl is formed by the same process as the shell of the pearl oyster due to secretion of the mantle tissue. The outer epithelial layer of mantle is responsible for the secretion of the nacreous layers of which the pearl is composed of. The outer epithelium has the capacity to rearrange and regenerate itself and remain viable when disturbed within or removed from its original position and transplanted in other tissues of the animal. On the other hand, the inner epithelium and the connective tissue would disintegrate when transplanted.

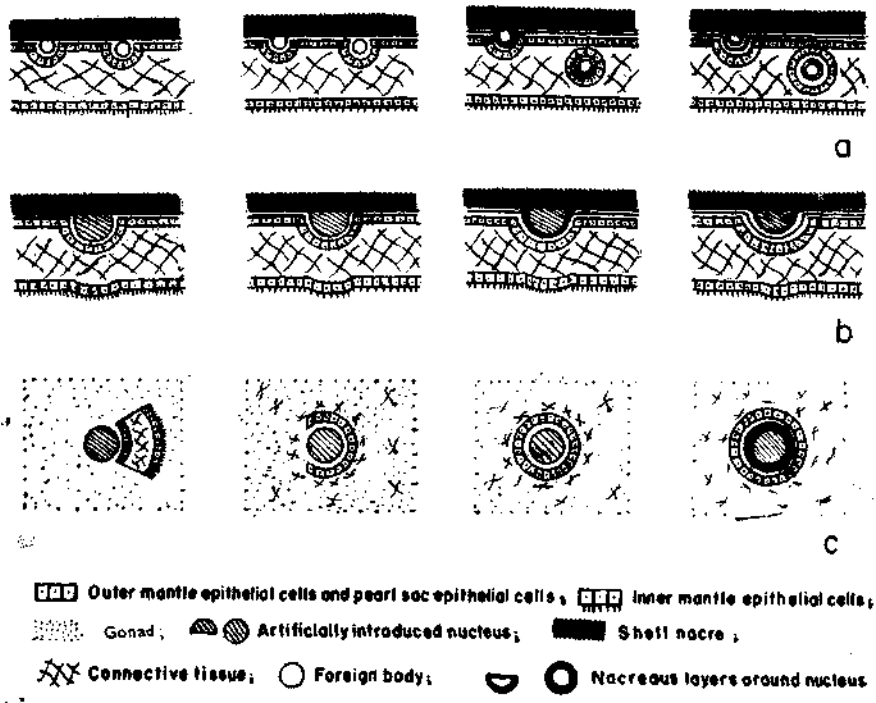


Fig. 6. Processes of pearl formation. a—Round and half natural pearls; b—Half cultured pearl and c—Round cultured pearl with artificially introduced nucleus.

(After Wada, K. 1973. *Underwater Journal*, 5(1): 28-23, Fig. 1).



The outer epithelial cells of the mantle may fall accidentally into the body of the pearl oyster, regenerating a sac consisting of a single layer of cells, the so-called pearl-sac, inside which a natural pearl grows as a result of the secretion of nacre. This process continues till the life end of the pearl oyster producing a free, beautiful, natural pearl.

The formation of natural pearl is influenced by foreign bodies accidentally entering the body of the oyster. Tiny particles and organisms enter the oyster when the shells remain open and also normally leave the oyster (except for those phytoplankters ingested as food). But in certain situations the foreign bodies may get trapped between the shell and the mantle. Under the stimulus of the foreign body, the outer epithelium of the mantle invaginates and forms a pearl-sac. Fig. 6 a represents such a situation leading to the formation of a blister pearl (when the foreign body gets fixed to the inner shell surface by the secretion of epithelium) or a free pearl inside the mantle. Every natural pearl has an inner core or nucleus, however tiny it is (be it the disintegrating connective tissue of the mantle or a foreign body).

It is evident from the above, that the two pre-requisites for formation of a pearl are the outer epithelium of the mantle lobe and a core substance or nucleus.

In the cultured pearl technique, the process is manipulated in the pearl oyster. A small piece of mantle from a donor oyster is grafted into the gonad of the recipient oyster together with a nucleus by a skilful surgery. The outer epithelium of the mantle piece regenerates itself around the nucleus to form a pearl-sac which faithfully secretes and deposits nacre or mother-of-pearl on the nucleus, eventually resulting in a pearl. Since this pearl is produced in the oyster by manipulation at surgery and by further cultivation of the seeded oyster, it is called the cultured pearl. Fig. 6 b and c depicts the formation of half and round cultured pearls. The half pearls are produced by fixing the nuclei on the nacreous face of the shell at appropriate sites.

## PEARL OYSTER FARMING

### Farm site

Pearl oyster farms are ideally located in sheltered bays which offer protection to the rafts. They can also be set up in the coastal waters where sea conditions do not get too rough. The operations are year round in a pearl culture farm. Depth should be around 10 m and silting should be minimal. The ambient tropical sea temperature and salinity are suitable for pearl oyster. If salinity falls below 15 ppt, it might lead to mortality under prolonged low saline conditions as during unusual heavy precipitation of rain and heavy discharge of rivers in the vicinity of farms. Areas rich in phytoplankton, which is consumed by the oyster as food, are good but it should not lead to noxious blooms. A mild current of about 2 knots helps bringing fresh food as well as removal of metabolic products, faecal matter and other farm droppings.

### Raft culture

Raft culture is the typical method of pearl oyster farming in sheltered bays. Long-line culture is better suited for open coastal conditions. The raft structure is illustrated in Fig. 7a. The overall dimensions of a raft are variable and are decided based on convenience of handling. A raft of about 6 m × 5 m may be a standard size. The raft is constructed of logs (any second class wood as venteak or casuarina pole) of about 10 cm diameter tapering to 6 cm of chosen lengths. The logs are coated with coal tar. These are arranged as illustrated in Fig. 7a and lashed with nylon ropes. Floats are attached to the raft to give buoyancy, their number being usually 4 for a standard raft which may be increased if there is sagging. Sealed empty diesel drums (200 l capacity) with fibreglass coating, mild steel barrels given coatings of anticorrosive paints, or more modern styrofoam or FRP/synthetic floats are used for buoyancy (Pl. I A). The choice depends on cost and long-term economics. The raft is individually moored at the farm site with anchors (grapnel or

admiralty type) on opposite sides connected to raft with tested quality chain. The long-line system uses floats, spherical or cylindrical, which are connected by synthetic rope or chain (Fig. 7 b).

Pearl oysters are carried in varied types of nets/cages which are suspended from the raft or long-line by synthetic rope at appropriate depths. The typical ones are the frame net (Fig. 7 c) and the nylon-mesh cage (Fig. 7 d). The frame-net is useful to

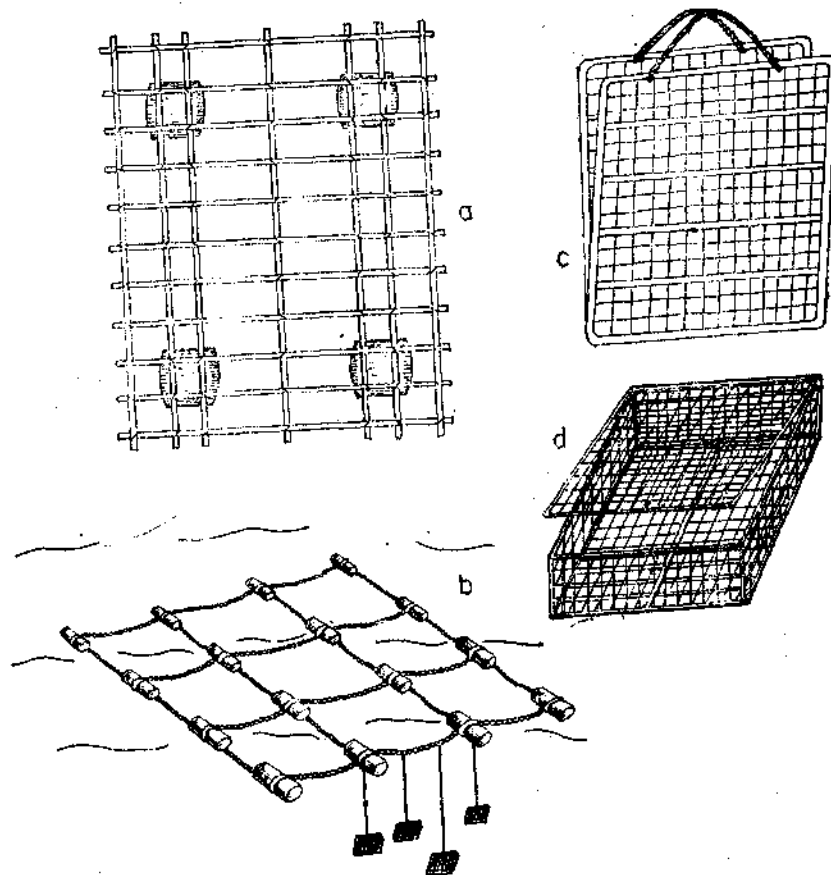


Fig. 7. Structures of pearl oyster farm. a—log raft ; b—long-line ; c—frame net and d—cage.

avoid crowding of oysters and to follow the performance of individual oyster post-operative (Pl. I B). The cage is good for general mother-oyster culture. All iron frames used are given anticorrosive treatment with paint. All structures in the farm should be periodically checked and maintenance repairs done which would help in extending the life of rafts and materials to a period of 3-5 years or even more.

#### **Mother-oyster culture**

Mother-oyster culture refers to the farming of pearl oysters from the time they are brought to the farm till they are used in surgery. The source for pearl oysters are (a) the natural beds, (b) spat collected in the sea and (c) pearl-oyster hatchery.

The pearl oyster populations in the natural beds, the 'paars' of Gulf of Mannar and 'khaddas' of Gulf of Kutch, are subject to wide fluctuations. The unproductive spells are far more numerous than the productive periods. If and when the stocks are good, they should be collected and used for pearl culture. In the Gulf of Mannar, the collection is done by diving up to a depth of 20 m. SCUBA-diving (Pl. I C) enables search of a wider area and good collections as compared to skin-diving. In the Gulf of Kutch, they are collected from the intertidal flat by hand-picking.

Spat collection using cedar leaves, hyzex film or old fishing nets supplies almost the entire requirement of mother-oysters for the Japanese pearl culture industry. In India, it has not so far been successful due to the open conditions of the natural beds. In inshore regions, particularly in the recently constructed harbour basins as Tuticorin and Vizhinjam, some spatfall of pearl oyster takes place, but it is of multispecies composition, *P. fucata* component being very small.

The source of hatchery is more reliable and can supply the required stock for pearl culture. Recently, the techniques for hatchery production of pearl oyster have been developed in India and it remains to be commercialised.

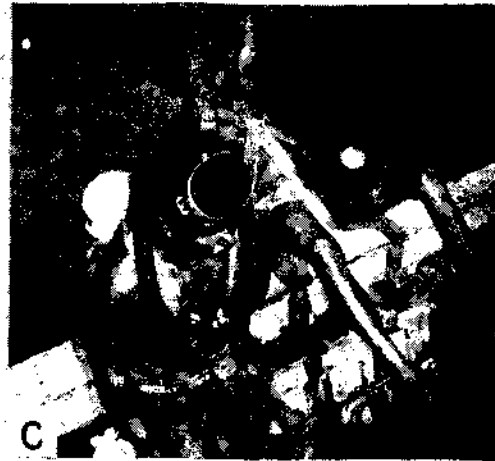
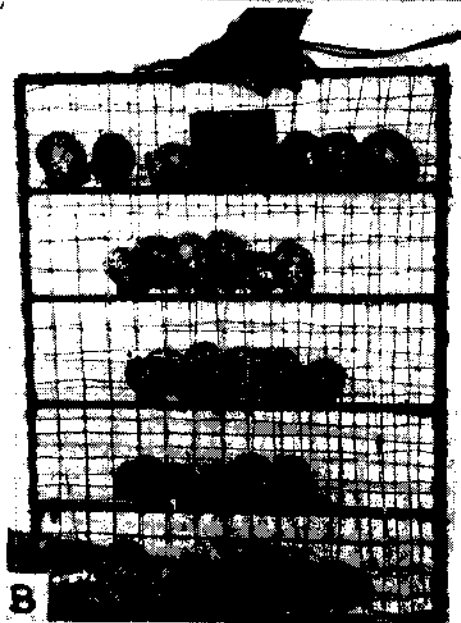
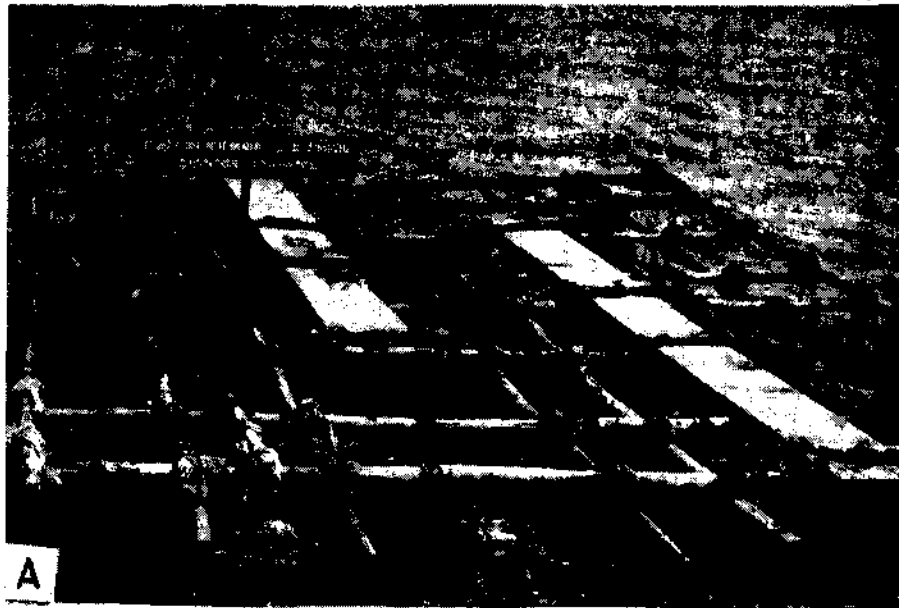


PLATE I. A—Raft in sea off Veppalodai; B—Frame net with oysters; C—SCUBA-diving from boat for cyster collection.

The pearl oysters are grown in the farm till they reach a suitable size, a minimum of 20 g in weight, for use in the surgery for graft and nucleus implantation. The oysters draw nutrition from the phytoplankton in the sea and no artificial feeding is necessary and possible in the farm. Mortality of stock should be kept to the lowest minimum level through appropriate farm management.

## 6

### BIOFOULING, BORING AND PREDATION

Major problems in maintenance of pearl oyster stocks in the farm are the biofouling organisms which settle and grow on the shells, the boring organisms which riddle through the shells and render them weak and friable and the predatory organisms which feed upon the pearl oysters. Singly, or in combination, these factors can cause heavy mortality to the farm stock through physiological stress and disease. Routine control measures should be adopted periodically and against specific problems.

#### Biofouling

The dominant fouling organisms are the barnacles (*Balanus amphitrite*) (Pl. II A), bryozoans (*Membranipora* sp., *Thalamoporella* sp. and *Lagenipora*), simple and compound ascidians (Pl. II B), the spat of bivalves (*Avicula vexillum* and *Crassostrea madrasensis*) and hydroids. The weaving mussel *Modiolus* sp. forms extensive carpet-like colonies over the natural pearl oyster beds but has not been a serious threat in the farm. Encrusting tubicolous polychaetes (Pl. II C) may be dominant in seasons. Seaweeds (Pl. II D) settle and grow on the oysters and cages. Others noticed are amphipods, isopods, sponges, polyclad worms, nematodes, opisthobranchiate molluscs, *Pinna* sp., egg capsules of gastropods and crinoids. While barnacle settlement is noticed almost throughout the year, settlement of others are seasonal. In inshore waters, under hanging culture at shallow depths, fouling load is always moderate to heavy.

#### Boring organisms

The boring organisms include the two dominant groups of serious pests, the polychaetes and sponges. The boring polychaetes *Polydora* sp., *Cirratulus cirratus*, members of families Syllidae, Nereidae and Terebellidae burrow through the shells and cause extensive blisters on the nacreous face (Pl. III A).

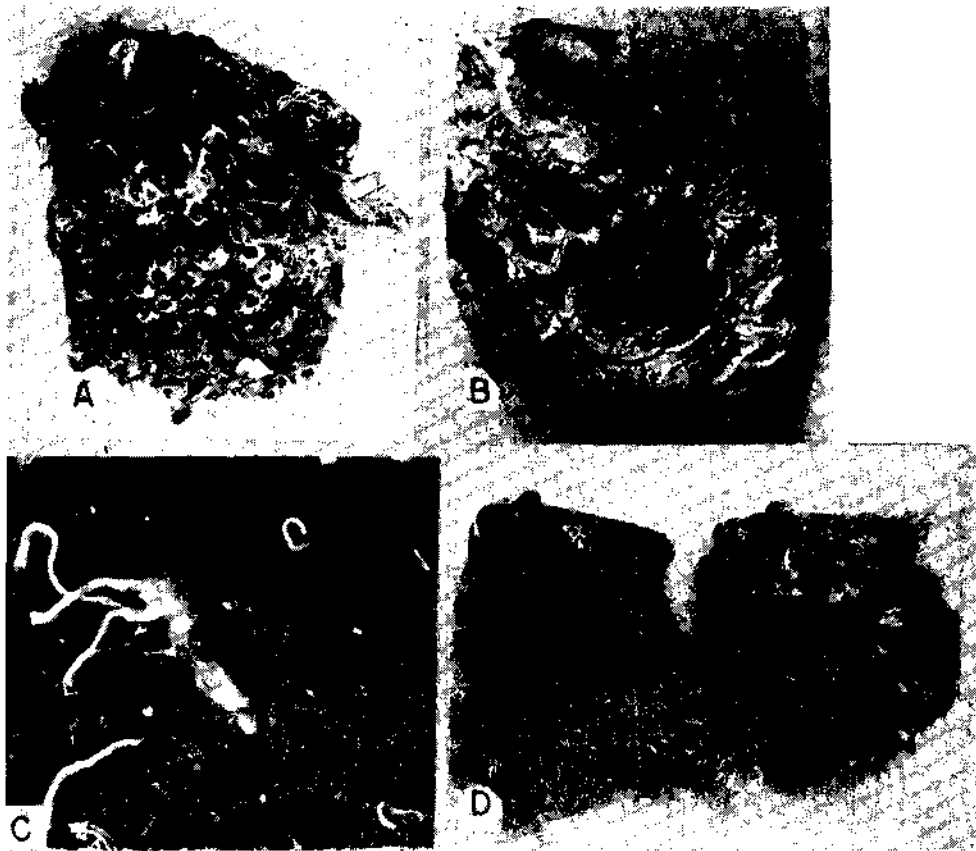


PLATE II. A—Fouling of pearl oyster by barnacle; B—Compound ascidians;  
C—Encrusting tubicolous polychaetes; D—Seaweed fouling on oyster.



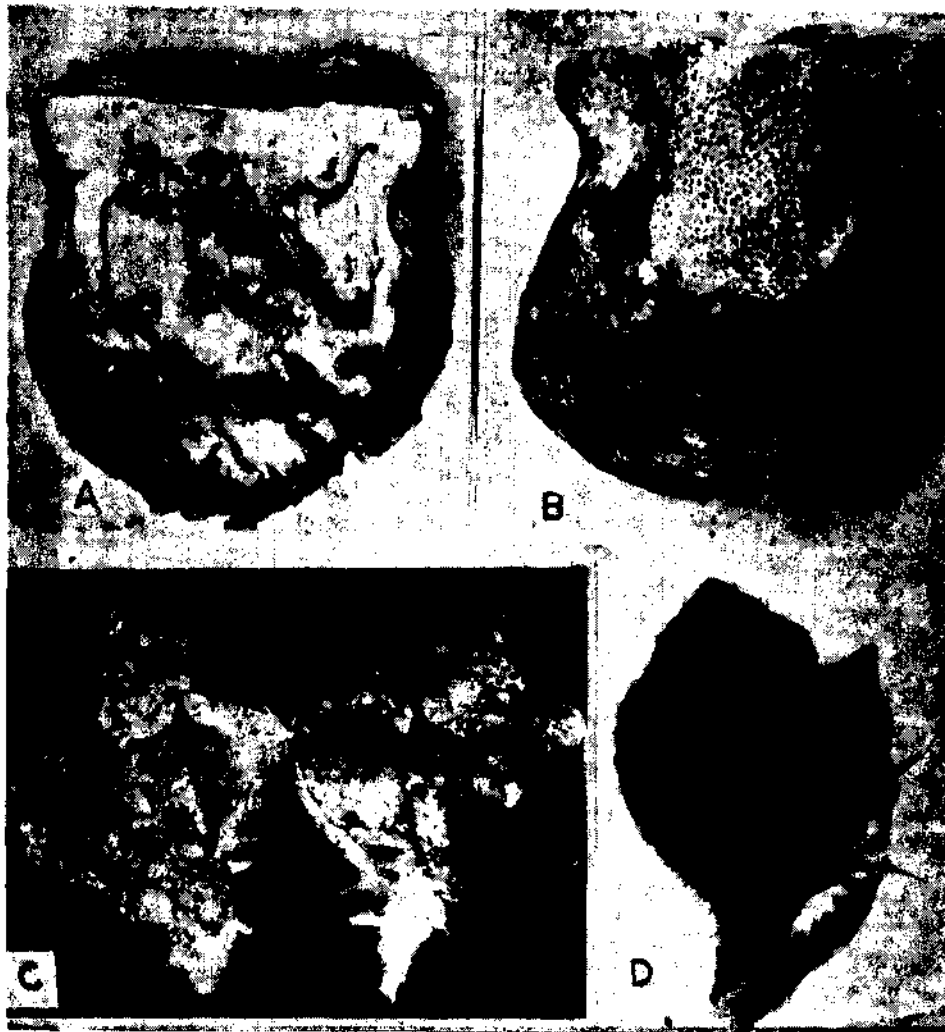


PLATE III. A—Pearl oyster shell with extensive polychaete blisters; B—Shell showing boring by sponge; C—Gastropod predator *Murex virgineus*; D—Predator *Cymatium cingulatum* attacking oyster.

The boring sponge *Cliona vastifica* and *C. celata* form honey-comb-like ramifications in the shell with numerous openings on the nacreous surface (Pl. III B). The above two groups cause great physiological strain to the oyster, while attempting to repair the shell damage, and cause mortality to the farm stock. The boring molluscs *Lithophaga* sp. and *Martesia* sp. and isopod *Sphaeroma* sp. are also occasionally found on the shells.

#### **Predators**

The major predators of pearl oysters in the farm are the gastropods *Murex virgineus* and *Cymatium cingulatum* (Pl. III C, D). The rate of predation by these gastropods is about an oyster per day per animal. They make their appearance seasonally. Crabs *Charybdis lucifera* and *Atergatis integerrinus* also prey upon the pearl oysters. In the natural beds, rays, fishes such as rock-perch and trigger fish and octopus may be notorious predators but these are not generally found in the shallow farm areas.

#### **Control**

The fouling organisms can be controlled only through periodic cleaning and scraping of foulers or through judicious choice of depths for growing the oysters. The deeper waters are relatively less loaded with the foulers. The intense spawning season of the major fouling organisms should be avoided while introducing new stocks in the farm.

The boring polychaetes are killed by immersing the oysters in freshwater for 6 hours. Treatment in a saturated solution of common salt for 40 minutes can also eliminate the polychaetes. Brushing the affected oysters externally with 1% formalin kills the boring sponge and *Martesia* sp. These techniques of control should be carefully applied in each situation without causing mortality of the pearl oyster.

## PEARL OYSTER SURGERY

In cultured pearl production, a mantle piece from the donor oyster is grafted into the gonad of the recipient oyster, along with a spherical nucleus to provide the two required conditions for the formation of pearl. The operation on the pearl oyster is carried out by a skilful surgery. The processes involved are selection of oysters, graft tissue preparation, conditioning, graft tissue and nucleus implantation and post-operative care.

A set of special surgical tools is used in surgery. These are oyster knife, clamp, speculum, graft knife, incising-cum-grafting needle, nucleus implanting needle, needle hook, spatula and scalpel (Pl. IV A). These instruments can be made to specifications by any surgical instrument manufacturer.

### Selection of oysters

In selection of oysters the factors to be considered are the weight of oyster, reproductive phase and health. A weight of 25 g and above is the ideal size for implantation but 20 g weight can also be considered for implantation of nuclei of smaller size such as 2 mm and 3 mm diameter. Fully mature oysters are not suitable as during surgery the gametes flow out and cloud the site; also proper orientation of mantle piece and nucleus cannot be ensured. Hence oysters in the immediate post-spawning/recovery phase and also in the early phase of gametogenesis may be selected. This factor, in turn, decides the annual season(s) for surgery. The oysters should not suffer from polychaete blisters, sponge boring and trematode infection. Oysters selected should be cleaned and all the fouling organisms removed.

### Graft tissue preparation

From the lot, a few donor oysters are selected for mantle tissue preparation. These oysters are not subjected to any conditioning process as is the case with the recipient oysters. Small pieces cut

from the pallial mantle region are used as graft tissues for transplantation.

The oyster is cut open by the following steps :

- Hold the oyster dorsal side down and posterior side facing the technician.
- Insert the curved end of oyster knife between the two valves on the posterior side.
- Push the knife straight through the oyster until the knife tip reaches the anterior end.
- Press the knife sharp and straight downwards cutting through the adductor muscle.
- Open the valves and separate them tearing the hinge, *without disturbing the two mantle lobes*. If disturbed, the lobes would shrink and cannot be used.

Steps in the removal of mantle (marginal and pallial regions) are given below :

- Deal with one valve with the adhering body tissue at a time.
- Brush aside the gills gently with the tip of spatula exposing the mantle lobe taking care that the mantle does not shrink.
- With the graft knife, starting from the posterior margin cut the mantle tracing a curve upto the anterior margin.
- With the forceps, lift the mantle gently (Pl. IV B) and place the tissue on a soft, clean, moist wooden block without changing the side. Now the inner epithelium of the mantle faces the technician.

Further steps in the preparation of graft tissues are as follows (Fig. 8) :

- Gently stretch the tissue end to end.
- With a wet sponge, gently wipe the mucus and dirt.
- With the graft knife cut away the marginal mantle which has folds and pigmentation.

- By the same way cut away the inner muscular portion of the mantle on the opposite side.
- Again wipe the mucus and dirt with wet sponge.
- Holding one end, lift the mantle ribbon, reverse the side (top to bottom) and place it on the block. Now the outer epithelium faces the technician.

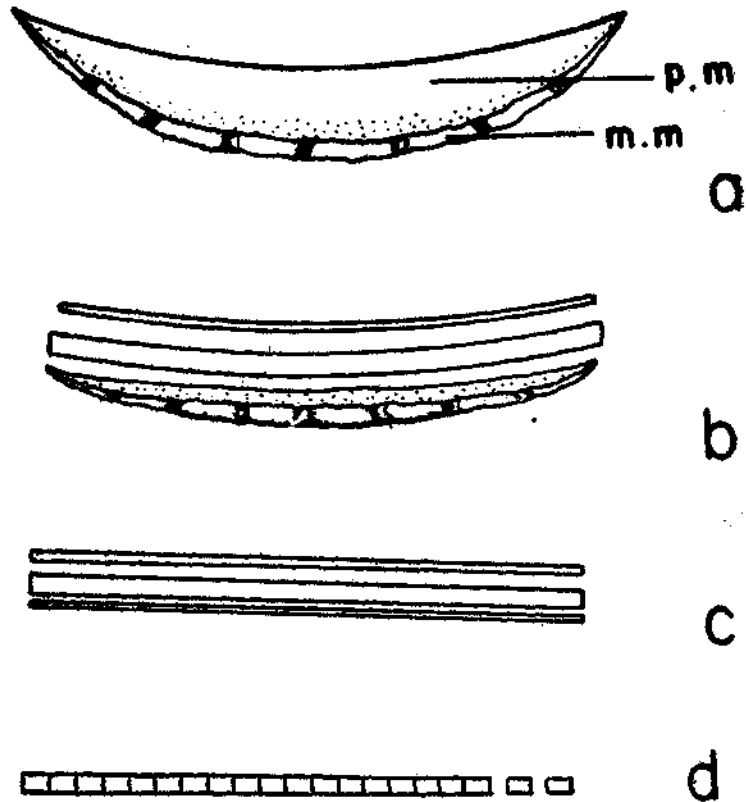


Fig. 8. Steps in graft tissue preparation. a—mantle tissue as removed from oyster; b—trimming the margins to remove marginal mantle and inner muscular tissue; c—further trimming to get mantle ribbon of pallial region; d—mantle pieces cut from ribbon.

(m.m.—marginal mantle, p.m.—pallial mantle).

- Wipe the mucus and dirt very softly without causing damage to the outer epithelial layer.
- Further trim the margins on either side until a mantle ribbon of about 3 mm width is obtained.
- Remove all the dirt and mucus from the wooden block. If necessary, transfer the mantle ribbon to a new block without changing sides.
- With the graft knife sharply cut the ribbon into small pieces (2-3 mm). The size of the piece has to be in proportion to the size of nucleus.
- Smear the mantle pieces or graft tissue with a very dilute solution of water-soluble eosin with a brush.
- Keep the tissues moist until they are used within about 30 minutes.

**Precautions :**

- Take care to see that the oyster knife does not slip and injure your palm while inserting it between the valves which requires some force.
- Use only clean, sterilised, filtered sea-water in the entire process.
- All instruments must be clean, having been dried in sunlight prior to use.
- Sponges must be clean and moist and different portions must be used for each wiping of mucus and dirt.
- Wooden blocks must be clean, smooth and moist all the time until the graft tissues are used up.
- Do not continue with the mantle lobe if it has shrunk due to bad handling.

**Nucleus**

For production of round cultured pearls spherical shell-beads are used as nuclei. These beads are prepared out of thick shells of other molluscs, usually freshwater mussels. These shells are imported into Japan from the U.S.A. where the freshwater

mussels, popularly called pig-toe shell (*Tritogonia*), three-ridge shell (*Pleurobema*) and washboard shell (*Megalonais*), themselves known for pearl production, occur in the tributaries of Tennessee River. Alternatively locally available thick molluscan shells which have a composition akin to pearl oyster shell, for example the gastropod shell *Xancus pyrum*, can be used after considering the specific gravity of the material and other factors. Molluscan shell material is preferred due to phylogenic affinity, chemical composition, binding strength and heat-resistance properties which are closely similar to the calcite crystalline substance of pearl oyster shell. The shells are processed into spherical beads of different diameters, generally 2-7 mm for *Pinctada fucata*, through the steps of cutting, grinding, shaping and polishing using appropriate machines and tools. Dimensional accuracy, smooth finish and high polish are important factors. The beads should be cleaned and dried before use.

#### Conditioning for surgery

Natural physical conditioning methods are ideal and inexpensive but can be practised only in regions where there is stratification of temperature in the sea and sharp difference in food availability. It works very well in the temperate sea of Japan. Using the thermal difference the oysters are spawned in higher temperature of the surface water. With this loss of stored energy due to spawning, the oysters become weak and they are further subjected to starvation stress in depths of low phytoplankton production to reduce metabolic rate. Such conditioned oysters can be readily used in surgery.

Where such techniques do not work, as in the Indian waters, chemical conditioning is resorted to. Menthol crystals are sprinkled over the seawater in tubs in which the oysters are placed. In about 60-90 minutes, the oysters get narcotised under the effect of menthol. The adductor muscle relaxes and the valves open. The response time varies with temperature. The oysters become almost non-responsive to touch. They are taken one by one, washed in seawater and used in surgery. The conditioned oysters should be used in surgery as quickly as possible since prolonged exposure causes swelling of tissues,

copious secretion of mucus and mortality. A duration of about 30-45 minutes after response is the safe limit. Therefore, the pearl oysters should be treated in batches.

### Surgery

The number of nuclei to be implanted in an oyster is predetermined and such decision is applied for the batch of oysters dealt with at any one time. Single and double implantations are common while multiple implantations are done for production of large number of small pearls of about 2-3 mm. The larger diameter range of 6 mm and 7 mm nuclei are generally used in single implantation, one nucleus in each oyster. Diameters 4 mm and 5 mm/6 mm are used for double implantation, a large and a small one in each oyster. Diameters 2 mm and 3 mm are generally used in multiple implantations, five or more nuclei in each oyster.

The best site for nucleus implantation is the gonad of the oyster, particularly its ventral portion. Single implantation is always done at this site. In double implantation, the above site is used for the larger nucleus and a site in the dorsal region of the gonad close to the hepatopancreas is used for smaller nucleus (Fig. 4). Multiple implantation is carried out at many sites in the region of the gonad.

The steps involved in pearl oyster surgery are as follows :

- Insert the end of the speculum through the postero-ventral corner of the oyster and open it out by slipping down the gap-regulator ring. If opened too much, the adductor muscle snaps and the oyster dies.
- Mount the oyster with the speculum in position on the clamp fitted on to a wooden board. The oyster should be kept in proper position between the two plates of the clamp so that it does not slip. The speculum is now towards the left-hand side of the technician.
- With the spatula gently move the free margins of the gills to a side so that the gonad is exposed to view.
- Hook the tip of the foot with the needle hook in left hand and gently pull it so that the base of foot is slightly



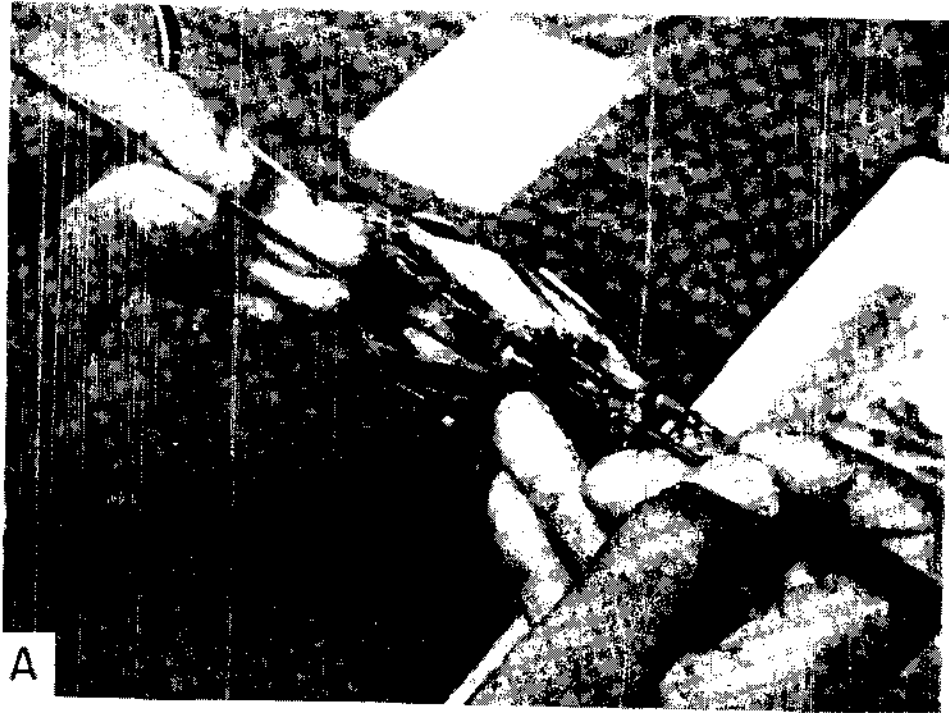
elevated. Hold the needle in position till the operation is completed.

- With the oval knife end of the incising-cum-grafting needle in right hand, make a sharp incision at the base of the foot and through this opening, the needle passing below the outer skin, steadily and gently cut a passage through the gonad connective tissue upto the site of implantation. Gently withdraw the needle.
- Pick a piece of the graft tissue, already on the block, with the tip of the needle (same needle as above but reversed) and gently insert it through the passage cut in the gonad (Pl. V A). On reaching the site, gently deflect the needle and allow the graft tissue to drop. Withdraw the needle. Now the outer epithelium of the graft tissue is facing the passage.
- Lift a nucleus with the cup end of appropriate nucleus implanting needle. The cups are specific to sizes of nuclei. The cup must be dipped in water to have a thin film and should be placed on the nucleus and lifted. The nucleus sticks to the cup. Gently insert the nucleus through the incision made at the foot and the passage cut through the gonad. On reaching the site, deflect the needle gently so that the nucleus drops. Now the nucleus must be in contact with the outer epithelium of the mantle tissue which was grafted into the gonad by the preceding step. Withdraw the needle gently through the passage.
- Smoothen the incision with the cup end and let the two margins of the incision to come in contact. With this step the nucleus implantation operation is over.
- Remove the oyster from the clamp, withdraw the speculum by slipping the gap-regulator ring forwards and place the oyster in fresh seawater.

PLATE IV. A.—Surgical tools used in nucleus implantation (from L to R : oyster knife, 3 numbers of incising-cum-grafting needles, 3 numbers of nucleus insertion needles, spatula, needle hook, graft knife, forceps, speculum and oyster clamp). B—Showing the removal of mantle tissue from pearl oyster for graft preparation.

*Facing Page 24*





A



B

## POST-OPERATIVE CULTURE

The operated oysters should be placed in gently flowing seawater or the water should be changed frequently until the effect of narcotisation is overcome. On placing in seawater the oyster would shut the valves within a few minutes and later slowly resume its normal function of opening/shutting of valves. This would be an indication of recovery. The incision would normally heal in a day or two. If the surgery has been rough and the incision large, the nucleus may slip out through the incision.

It is advisable to keep the operated oysters for 3-4 days in the surgery facility under observation before they are returned to the farm. In Japan, the bays being calm, the operated oysters are returned to the farm immediately after surgery. But in rough sea conditions, these oysters would be exposed to undue stress if they are suspended immediately after surgery. Hence the need for keeping under calm conditions for convalescence.

In Japan, oysters implanted with 7-8 mm diameter nucleus are checked by soft X-ray to make sure of nucleus retention. Those which have rejected the nuclei are taken back to mother-oyster culture to be used again.

During the post-operative duration of culture the density per cage should be low and the oysters should not be disturbed too frequently. They must be suspended in areas of high phytoplankton production and also at greater depths than the mother-oysters. The length of culture duration of this phase would depend on size of nucleus and maturity of pearl. The range is about 3-24 months for the 2-7 mm diameter nuclei under tropical conditions. Periodic monitoring should be done on each batch by sampling to decide actual time of harvest. If harvested too soon, the nacreous layer of the pearl would be too thin to give the required lustre and iridescence.

**Precautions**

- Prior to and after use, quickly wash the instruments in seawater.
- Adjust the pressure on the foot in such a manner that the foot does not get torn while pulling it with the needle hook to get the elevation of pedal base.
- The incision should be a sharp cut and of just required length for the size of nucleus to be inserted through. If the incision is too large the nucleus may slip. If there is too much tear of tissues, do not proceed. Place it back in fresh seawater and it can be taken to farm with the general stock.
- While cutting the passage through the gonad, if there is copious flow of gametes, do not proceed and get the oyster back to the farm with general stock.
- Do not cause damage to the vital organs such as stomach, intestine and heart at surgery.
- Always remember the orientation of graft tissue (outer epithelium) and nucleus.
- Skill and patience are the key words for success in surgery. It is not the target in number which is important but how perfect is the surgery done.

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**PLATE V.** A—Showing implantation of graft tissue. B—Training programme in pearl culture. (In front is Mr. Emeterio Borlongan of SEAFDEC, Philippines).  
*Facing Page 25.*

## PRODUCTION OF CULTURED PEARLS

The rate of production of cultured pearls depends on many variables. Formation of cultured pearls is a biological mechanism and it is left to the pearl oyster after the nucleus implantation. Human control would be in the success of surgery and in providing suitable environmental conditions through selection of ideal farm sites.

Mortality of oysters can take place due to effects of surgery and infection and due to many other factors such as disease, shell boring and biofouling. Annual mortality should be kept within 10% of the stock through proper farm management.

Nucleus rejection is a common feature, particularly in the higher diameter range of nucleus. This should be kept to a minimum through improvements in surgical procedure.

Even where nuclei are retained, they may not have formed into pearl due to non-formation of pearl-sac. This is due to defect in surgery, the graft tissue and nucleus not remaining in contact. This can also be brought about by wrong epithelial orientation of the graft tissue to nucleus. In cases where pearl formation has not taken place, the nuclei may either remain intact or may even be eroded. Such failures should be kept within 5% level through greater care in surgery.

Gross production is the number of cultured pearls produced by the surviving operated oysters in the farm. In single implantation, production rate achieved is about 65%. In multiple implantation, production achieved is about 180% with reference to number of nuclei implanted. These rates can be improved further.

The gross production consists of all types of cultured pearls and also trash. Grade-A would include all those round, lustrous pearls of pink, silver or light cream colour without any flaw or with very minor flaws such as a small dimple or with a protuberance of the size of the tip of a pin. Grade-B would include

round, lustrous pearls of similar colour as 'A' with the flaws a little more pronounced but which can be treated at processing to make them indistinguishable from Grade-A pearls. Grade-C would include those with larger flaws, stains or irregularities in shape such as baroques. Grade-D, the last, would include all the malformed and badly coated ones.

The first three grades should together account for about 60% of the gross production of cultured pearls from the farm. The remaining 40% (Grade-D) would almost be rejects. If these cannot be used, at least the nuclei can be salvaged and reprocessed.

Pearl harvest or 'beaching' is done during periods of low temperature and pH. In Japan, pearl collection is carried out either with the help of machines or by hand. When re-use of oysters for a second crop of pearls is desired, and is possible, the pearls alone are carefully removed by opening the pearl-sacs through the gonad and the oysters are returned to the farm to await their turn for surgery a second time.

## QUALITY IMPROVEMENT

The quality of pearls finally determines the economics of pearl culture and, therefore, considerable attention should be paid to this aspect. The size, shape, colour and lustre determine the quality and value. Apart from the bulk rates by weight, individual pearls of exceptional quality would command special premium price.

The quality of cultured pearls cannot be absolutely controlled under the present state of pearl culture technology but can be considerably improved through appropriate care at surgery and farming. Size and shape can be better controlled at surgery. But colour and lustre which are the products of the individual pearl oyster can be improved only through a proper understanding of the several variable factors of biology and physiology of the pearl oyster and the environmental conditions of the farm.

There are genetic differences between the different genera and species of molluscs which produce pearls. In respect of colour and lustre the first indications of these differences are the differences in the nacreous layers of shells of different species. The nacre differs substantially in colour and lustre among the shells of *Pinctada maxima*, *P. fucata*, *P. margaritifera*, *Pteria penguin* and *Haliotis* sp. which are the major marine species involved in pearl culture. In general, pearls produced by these molluscs have the same colour and lustre as the nacreous layers of their shells.

The environmental factors play a predominant role in determining the colour and lustre of nacre. Depth is one of the most important factors as quality pearls are produced in deeper waters, beyond 10 m. Pearls produced by oysters in the deeper beds (15–20 m depths) of Gulf of Mannar are better in quality than those produced by oysters on intertidal flats. Fouling and boring problems are insignificant at depths below 10 m as compared to the subsurface waters.

Temperature generally controls the metabolic rate of the molluscs. Higher temperatures lead to faster growth of oyster



and also higher rate of deposition of nacre. While this gives a general advantage in pearl culture, the quality would suffer. Thinner laminar nacreous layers which result from lower temperature are more desirable than the thicker layers resulting from higher temperature, at least in the later phase of post-operative culture. Therefore, within the given ambient annual range of temperature, pearl harvest should be done during the period of low temperatures. The pH should also be low when harvest is done.

Minerals and trace elements in the seawater are considerably important as these influence the colour of pearls. Other chemical factors of the environment should also be better understood. The abundance and quality of phytoplankton in pearl culturing grounds determine the state of nutrition of the oyster. The chemical composition of the phytoplankton components influences the colour of pearls.

It follows from the above that the ecology of pearl culture grounds should be thoroughly understood. The Japanese pearl culturists shift the rafts from region to region seeking grounds of better conditions for the 'make-up' culture during the last phase before harvest. Several old pearl culturing grounds are abandoned as culture in the same ground year after year results in poor quality of pearls. Alternation of grounds is considered important. Areas of pollution should be totally avoided.

The quality of mantle of the donor oysters which contributes to graft tissues would influence the quality of the pearl produced by the pearl-sac formed from such tissue. Utmost care should be taken in selection of donor oysters and in the process of graft tissue preparation. The site of nucleus implantation and the tissues with which the pearl-sac is in contact are other factors which influence colour. Pearls produced in the ventral gonad region are generally superior. Pearl-sacs formed within or in contact with the hepatopancreas produce largely grey coloured pearls, though good cream coloured pearls may also be produced. Pearl-sacs growing in the gonad region should be free from contact with other organs such as intestine, hepatopancreas, pedal retractor muscle and the byssal gland.

Pearls can be broadly classified into nacreous layer pearl, prismatic layer pearl and organic layer pearl. These are determined by the quality of secretion of the pearl sac. The nacreous layer pearl is composed of aragonite crystals of calcium carbonate and this alone is valued as jewel. The prismatic layer pearl is formed by calcite crystals and the organic one by proteinous layers of conchiolin.

The lustre of pearl is due to two sensations of light, namely 'lustre' and 'iridescence', and is brought about by absorption and reflection of the waves of incident light. The nacre is composed of several concentric layers of mineral lamellae of aragonite, each layer of the thickness of 0.29-0.60 $\mu$ m. Conchiolin forms the organic matrix on which the aragonite crystals are laid and the layers bound. Homogeneity, thinness and smoothness of these layers are responsible for the great play of lustre due to absorption and reflection of incident light at different laminar planes of aragonite layers. Therefore, it is very important that the final phase of post-operative culture of every batch of oysters should be done under ideal conditions.

## PEARL CULTURE ESTABLISHMENT

Pearl culture in Japan is carried out by small-scale units, on cooperative or family basis, save for a few large-scale operations by companies. In the peak period of production (1966), there were 4710 pearl culture units of which 49.8% were operating 1-14 rafts, 20.8% 15-29 rafts, 12.0% 30-49 rafts and the remaining 17.4% more than 50 rafts. The total number of units came down to about 2500 by 1973. This would show that small-scale operations are the mainstay in pearl culture. The Japanese pearl culturist has the advantage that he can buy the mother-oysters for his farm from those who are solely engaged in seed collection and mother-oyster culture. In India such small-scale operations at the family level can become possible only if commercial hatcheries produce pearl oysters and sell them to pearl culturists.

The activities, major inventory and manpower of a pearl culture establishment is summarised briefly to give an overview for an easy understanding of the nature of this industry. Major work is in the sea involving pearl oyster collection and farming. Details of hatchery are not included for reasons already stated. Manpower needs and inventory items would vary according to the scale of operation. These are not strictly applicable to family-based operations which are not feasible in India for the present.

### 1. Raw material : Pearl oyster (*Pinctada fucata*)

#### 1.1 Oysters from natural bed

*Activity*—Seasonal survey of beds and collection by diving.

*Inventory*—Boats; self-contained underwater breathing apparatus (SCUBA) and diving accessories such as fins, masks, snorkel, depth-gauge, knife and belt; compressed air charging units (main and portable compressors); collection kit and oyster bins.

*Manpower*—Boat crew, navigator, divers, diving assistants.

#### 1.2 Oysters from spat collection

*Activity*—Collection of pearl oyster spat by suspending spat collectors from rafts at suitable sites in the sea/bay.

*Inventory*—Rafts, lighted buoys, anchors, chain, and spat collectors ; linked with item 1.1 seasonally.

*Manpower*—Linked with item 1.1 seasonally and farm labour.

### 1.3 Pearl oyster hatchery

## 2. Pearl oyster farm

*Activity*—Mother-oyster culture, post-operative culture, farm maintenance and stock maintenance.

*Inventory*—Log-rafts, long-lines, lighted buoys, floats, anchors, chain, rope, cages, framenets, dinghy, out-board motor, floating sheds and miscellaneous tools ; linked with item 1.1.

*Manpower*—Farm superintendent, technical assistants, farm labour ; linked with item 1.1.

## 3. Shore establishment

### 3.1 Surgical Unit

*Activity*—Pearl oyster surgery and convalescence.

*Inventory*—Surgical tools and accessories, furniture, shell-bead nuclei, chemicals, glassware, plasticware, ultraviolet lamps and raceway.

*Manpower*—Chief technician and technicians.

### 3.2 Farm house

*Activity*—Shore support for maintenance of farm and farm stock.

*Inventory*—Oyster cleaning tools, farm structure maintenance requirements (repairs and maintenance of raft, long-line, floats, anchors, chain, cages, frame nets) and oyster tanks.

*Manpower*—Linked with items 2 and 3.1.

### 3.3 Pearl collection centre

*Activity*—Collection of cultured pearls and incidental natural pearls.

*Inventory*—Plasticware, chemicals, oyster knife, vats.

*Manpower*—Technical assistants.

### 3.4 Pearl processing centre

*Activity*—Cleaning, sorting and grading of pearls ; treatment of pearls for removal of minor blemishes ; bleaching, dyeing and colour improvement.

*Inventory*—Sorting trays, miscellaneous tools, chemicals and glassware.

*Manpower*—Pearl processing expert and technical assistants.

### 3.5 General services

#### 3.5.1 Seawater supply

*Activity*—Supply of quality seawater to surgery, raceway and oyster tanks.

*Inventory*—Pump house, filterbed, sump, overhead tank, supply channels with regulators ; air blowers with air supply tubings and regulators.

*Manpower*—Electrical supervisor and assistant.

#### 3.5.2 Power and freshwater supply

### 3.6 Laboratory

*Activity*—Monitoring of oyster health and condition ; sea water analysis ; advice to farm superintendent and chief technician ; feed-back to research system.

*Inventory*—General biological laboratory equipment and analytical equipment for seawater analysis.

*Manpower*—Biologist, chemist, laboratory technicians.

### 3.7 By-products unit

*Activity*—Conversion of by-products of pearl culture to value-added items.

*Inventory*—If the unit is self-contained, all items required for utilisation of shell and meat ; otherwise, collection, preservation and storage of materials until sale to outside agencies.

*Manpower*—Specific manpower for handling by-products processing work, if self-contained ; otherwise linked with other items.

## 4. Management and administration

*Activity*—Planning, execution and administration of project.

*Manpower*—General Manager, administration, accounts and stores staff.

**TRAINING COURSE IN PEARL CULTURE**

The Central Marine Fisheries Research Institute offers a training course in pearl culture as a programme of transfer of technology. It aims at extending the technical knowhow to the prospective end-users. Since fisheries development in India is the responsibility of the States/Union Territories, the target group for the training consists of technical officers of Fisheries Departments of the maritime States and Union Territories. The Fisheries Colleges of Agricultural Universities also carry out location-specific fisheries research and scientists from such institutions are also considered for training. The candidates are officially sponsored by the respective departments. The courses are not open to private candidates, unless they are sponsored by the Fisheries Departments of the concerned State.

The first training course was of six months duration and was a comprehensive one giving a course curriculum on pearl oyster resources, biology, mother-oyster culture, pearl oyster surgery, pearl collection and management with 10 units of theory and 130 units of practicals/field work, each unit accounting for 6 hours of training. Subsequently the course was changed to a short-term programme of 4-6 weeks confining the curriculum to mother-oyster culture, pearl oyster surgery and pearl collection required at the technician's level. A view of the pearl oyster surgery at the training course is shown in Pl.V B. The Institute also organises refresher training course on request.

The officers/nominees who have undergone courses in pearl culture are given below :

**I. Long-term Training Course**

24-9-1976 — 23-3-1977

1. Shri M. S. Nazir Ahmed Marine Survey Officer  
Department of Fisheries  
Govt. of Kerala

2. Shri N. M. Patel                      Senior Research Assistant  
Department of Fisheries  
Govt. of Gujarat
3. Shri M. A. Varghese                  Senior Research Assistant  
Department of Fisheries  
Govt. of Gujarat
4. Shri S. M. Irulandy                  Laboratory Assistant  
Department of Fisheries  
Govt. of Tamil Nadu
5. Shri S. Velpandian                  Sub-Inspector of Fisheries  
Department of Fisheries  
Govt. of Tamil Nadu
6. Shri A. Srinivasan                  Junior Technical Assistant  
C.M.F.R.I.
7. Shri A. Deivendra Gandhi          Junior Technical Assistant  
C.M.F.R.I.
8. Shri S. Benit Fernando              Private Candidate  
Sponsored by Dept. of  
Fisheries, Govt. of  
Tamil Nadu
9. Shri J. Antony Pitchai              Private Candidate  
Sponsored by Dept. of  
Fisheries, Govt. of  
Tamil Nadu

## II. Short-term Training Course

22-8-1977 — 24-9-1977

1. Shri Anil Madhav Ranade          Assistant Research Officer  
Marine Biological Station  
Konkan Krishi Vidyapeeth  
Ratnagiri
2. Shri H. Umesh Shetty              Inspector of Fisheries  
Dept. of Fisheries  
Karnataka
3. Shri B. M. Rajagopal              Sub-Inspector of Fisheries  
Dept. of Fisheries  
Karnataka

- |    |                             |  |
|----|-----------------------------|--|
| 4. | Shri D. Gunalan             | Sub-Inspector of Fisheries<br>Dept. of Fisheries<br>Tamil Nadu         |
| 5. | Shri M. R. Venkatanarayanan | Sub-Assistant Inspector of Fisheries, Dept. of Fisheries<br>Tamil Nadu |
| 6. | Shri V. A. Narayanankutty   | Junior Technical Assistant<br>C.M.F.R.I.                               |
| 7. | Shri B. Narayana Rao        | Junior Technical Assistant<br>C.M.F.R.I.                               |
| 8. | Shri. P. Ramadoss           | Junior Technical Assistant<br>C.M.F.R.I.                               |

### III. Short-term Training Course

9-7-1979 — 18-8-1979

- |    |                            |  |
|----|----------------------------|--|
| 1. | Shri Emeterio L. Borlongan | Fisheries Technician<br>South-East Asian Fisheries<br>Development Centre<br>Tigbauan<br>Iloilo<br>Philippines    |
| 2. | Shri Mukund M. Jani        | Senior Research Assistant<br>Department of Fisheries<br>Govt. of Gujarat<br>Digvijaygram<br>Sikka<br>Gujarat     |
| 3. | Shri M. C. Muthukoya       | Fisheries Officer<br>Department of Fisheries<br>Lakshadweep Administration,<br>Agathi<br>U.T. of Lakshadweep     |
| 4. | Shri M. K. Syed            | Field Assistant<br>Department of Fisheries<br>Lakshadweep Administration,<br>Ameni Island<br>U.T. of Lakshadweep |



5. Shri M. Ramakrishnan      Sub-Inspector of Fisheries  
Department of Fisheries  
Govt. of Tamil Nadu  
Tuticorin
6. Shri D. Sivalingam      Scientist  
C.M.F.R.I.
7. Shri R. Thangavelu      Junior Technical Assistant  
C.M.F.R.I.
8. Shri M. Manivasagam      Field Assistant  
C.M.F.R.I.
9. Shri Jaganath Achary      Private candidate  
Sponsored by Department  
of Fisheries, A & N  
Administration  
Port Blair  
Andamans.

**PUBLICATIONS OF C. M. F. R. I. ON**

**PEARL OYSTER RESOURCE AND PEARL CULTURE**

- ALAGARAJA, K. 1962. Observations on the length-weight relationship of pearl oysters. *J. mar. biol. Ass. India*, 4(2) : 192-205.
- ALAGARSWAMI, K. 1970. Pearl culture in Japan and its lessons for India. *Proc. Symp. Mollusca*, Mar. biol. Ass. India, Pt. 3 : 975-993.
- 1974. Development of cultured pearls in India. *Curr. Sci.*, 43 (7) : 205-207.
- 1974. Pearls : Cultured in India. *Gems & Jewellery*, 8 (6) : 13-16.
- 1974. Development of pearl culture technology in India and scope for a pearl culture industry. *Proc. Group discussion on pearl culture*, C.M.F.R.I., Cochin, pp. 4-19.
- 1974. Results of multiple implantation of nuclei in production of cultured pearls. *Indian J. Fish.*, 21 (2) : 601-604.
- 1975. Preliminary study on the growth of cultured pearls. *Indian J. Fish.*, 22 (1 & 2) : 300-303.
- 1975. Pearl culture. *Indian Farming*, September 1975, Indian Council of Agricultural Research, New Delhi.
- 1976. Pearl culture and its potential for development of coastal villages. Indian Sci. Congress, 63rd Session, Waltair, January 3-7 (Zoology Section). *Ent. & Fish.*, Symp. Inland and Coastal Aquaculture, Abst. No. 2.
- 1977. Larval transport and settlement of pearl oysters (Genus *Pinctada*) in the Gulf of Mannar. *Proc. Symp. warm water Zoopl.*, Spl. publ. UNESCO/NIO, 678-686.
- 1977. Towards commercial production of cultured pearls. *Gems & Jewellery*, 11 (8 & 9) : 25-28.

ALAGARSWAMI, K. 1977. Pathology of pearls and pearl production. 31st Tamil Nadu State Medical Conference Souvenir, Tuticorin, I.M.A.

————— 1983. The black-lip pearl oyster resource and pearl culture potential. *C.M.F.R.I. Bull.* 34 : 72-78.

————— 1983. A critical review of progress and constraints in pearl culture in India. *Proc. Symp. Coastal Aquaculture*, Mar. biol. Ass. India, Pt. 2 : 574-583.

————— AND A. CHELLAM. 1976. On fouling and boring organisms and mortality of pearl oysters in the farm at Veppalodai, Gulf of Mannar. *Indian J. Fish.*, 23 (1 & 2) : 10-22.

————— AND ————— 1977. Change of form and dimensional relationship in the pearl oyster *Pinctada fucata* from Gulf of Mannar. *Indian J. Fish.*, 24 (1 & 2) : 1-14.

—————, S. DHARMARAJ, T. S. VELAYUDHAN, A. CHELLAM AND A. C. C. VIGTOR. 1983. On controlled spawning of Indian pearl oyster *Pinctada fucata* (Gould). *Proc. Symp. Coastal Aquaculture*, Mar. biol. Ass. India, Pt. 2 : 590-597.

—————, —————, —————, ————— AND —————, 1983. Embryonic and early larval development of pearl oyster *Pinctada fucata* (Gould). *Proc. Symp. Coastal Aquaculture*, Mar. biol. Ass. India, Pt. 2 : 598-603.

————— AND A. D. GANDHI. 1983. Larval rearing and production of spat of pearl oyster *Pinctada fucata* (Gould). *Aquaculture*, 34 : 287-301.

————— AND S. Z. QASIM. 1973. Pearl culture—its potential and implications in India. *Indian J. Fish.*, 20 (2) : 533-550.

————— AND ————— 1974. What are pearls and how are these produced. *Seafood Export Jour.*, 6 (1) : 1-10.

————— AND D. SIVARAJAN. 1975. Surgical equipment for pearl culture. *Indian J. Fish.*, 22 (1 & 2) : 231-235.

- ALAGARSWAMI, K. AND A. C. C. VICTOR. 1976. Salinity tolerance and rate of filtration of the pearl oyster *Pinctada fucata* (Gould). *J. mar. biol. Ass. India*, 18 (1) : 149-158.
- CMFRI, 1974. *Proceedings of group discussion on pearl culture*. Central Marine Fisheries Research Institute, Cochin, 34 pp.
- 1977. Pearl culture training : Long-term and short-term courses. *CMFRI Spl. Publ.*, No. 1, 39 pp.
- 1982. Proven technology, 2. Technology of cultured pearl production. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 45 : 22-23.
- 1982. Proven technology, 3. Technology for hatchery production of pearl oyster. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 45 : 23-24.
- CHILLAM, A. 1978. Growth of pearl oyster *Pinctada fucata* in the pearl culture farm at Veppalodai. *Indian J. Fish.*, 25 (1 & 2) : 77-83.
- 1983. Study of the stomach contents of pearl oyster *Pinctada fucata* (Gould) with reference to the inclusion of bivalve eggs and larvae. *Proc. Symp. Coastal Aquaculture*, Mar. biol. Ass. India, Pt. 2 : 604-607.
- AND K. ALAGARSWAMI. 1978. Blooms of *Trichodesmium thiebautii* and their effect on experimental pearl culture at Veppalodai. *Indian J. Fish.*, 25 (1 & 2) : 237-239.
- , T. S. VELAYUDEAN, S. DHARMARAJ AND A. C. C. VICTOR. 1983. A note on the predation on pearl oyster *Pinctada fucata* (Gould) by some predators. *Indian J. Fish.*, 30 (2) : 337-339.
- DHARMARAJ, S. 1983. Oxygen consumption in pearl oysters *Pinctada fucata* (Gould) and *P. sugillata* (Reeve). *Proc. Symp. Coastal Aquaculture*, Mar. biol. Ass. India, Pt. 2 : 627-632.
- AND A. CHILLAM. 1983. Settlement and growth of barnacle and associated fouling organisms in the pearl culture farms in the Gulf of Mannar. *Proc. Symp. Coastal Aquaculture*, Mar. biol. Ass. India, Pt. 2 : 608-613.

- MAHADEVAN, S. AND K. NAGAPPAN NAYAR. 1967. Underwater ecological observations in the Gulf of Mannar off Tuticorin, VII. General topography and ecology of the rocky bottom. *J. mar. biol. Ass. India*, 9 : 147-163.
- AND ————— 1973. Pearl oyster resources of India. *Proc. Symp. Living resources of the seas around India, C.M.F.R.I.*, 659-671.
- AND ————— 1974. Ecology of pearl oyster and chank beds. *C.M.F.R.I., Bull.* 25 : 106-121.
- AND ————— 1976. Underwater observations on the settlement of pearl oyster spat in the pears off Tuticorin. *Indian J. Fish.*, 23 : (1 & 2) : 105-110.
- RAO, K. VIRABHADRA, 1970. Pearl oysters of the Indian region. *Proc. Symp. Mollusca, Mar. biol. Ass. India*, Pt. 3. 1017-1028.
- AND K. SATYANARAYANA RAO. 1974. Pearl oysters. *C.M.F.R.I., Bull.* 25 : 84-105.
- SILAS, E. G., K. ALAGARSWAMI, K. A. NARASIMHAM, K. K. APPUKUTTAN AND P. MUTHIAH. 1982. Country Reports—India. In : F. B. Davy and M. Graham (Eds.), *Bivalve culture in Asia and the Pacific*. Proc. Workshop held in Singapore, 16-19 February 1982, pp. 34-43, International Development Research Centre, Ottawa.
- VELAYUDHAN, T. S. 1983. On the occurrence of shell boring polychaetes and sponges on the pearl oyster *Pinctada fucata* and control of boring organisms. *Proc. Symp. Coastal Aquaculture, Mar. biol. Ass. India*, Pt. 2 : 614-618.
- VELU, M., K. ALAGARSWAMI AND S. Z. QASIM. 1973. Technique of producing spherical shell beads as nuclei for cultured pearls. *Indian J. Fish.*, 20 (2) : 672-676.
- VICTOR, A. C. C. 1983. Ecological conditions of the pearl culture farm off Veppalodai in the Gulf of Mannar. *Proc. Symp. Coastal Aquaculture, Mar. biol. Ass. India*, Pt. 2 : 619-626.

## PREFACE

India, endowed with a pearl oyster resource and known for her glorious pearl fisheries of the historical past and recent times, had been interested in the possibilities of pearl culture from about the time the Japanese pearl culture industry was being built up. Late Mr. James Hornell, the renowned British biologist working in Ceylon (Sri Lanka), and later in India, during the early part of this century, averred that the only way of making the pearl oyster resource of the Gulf of Mannar remunerative was to go in for pearl culture. Later on, while working with the Fisheries Department of the erstwhile Madras Presidency, he proposed acquiring a whole island (Krusadai Island) in the Gulf of Mannar to establish a pearl culture experimental centre. The island was subsequently acquired after his retirement and a Marine Biological Station for pearl culture work was established in 1933. Gujarat had a parallel interest and started experiments in pearl culture in 1956; Hornell had already sown the interest in Sikka near Jamnagar by establishing a stone enclosure for farming pearl oysters.

However, the technological breakthrough in pearl culture in India was achieved only in 1973, after the Central Marine Fisheries Research Institute (CMFRI) commenced its experimental work at Tuticorin in late 1972. For a decade now, the CMFRI has continued its research in pearl culture. Equally significant has been the second breakthrough achieved in 1981 in developing a system for controlled production of pearl oyster in hatchery. The technology of pearl culture available at the Institute is total, except for a small, yet important, gap for production of shell-beads which is a mechanical engineering problem.

Since late Mr. Kokichi Mikimoto succeeded in producing a few half-pearls in the pearl oyster in 1893, pearl culture as a viable industry has been firmly established in Japan and has spread, with Japanese assistance, to Australia, Papua New Guinea, Philippines, Burma, Thailand, Malaysia and Indonesia.

India has a moderate potential for a pearl culture industry, particularly in the regions of the natural occurrence of *Pinctada fucata*, in the Gulf of Mannar and Gulf of Kutch. An indicative survey of the mariculture potential of Andaman and Nicobar Islands carried out by this Institute has shown the presence of the black-lip pearl oyster *P. margaritifera* which can be developed and used in pearl culture. The possibility of occurrence of the silver-lip pearl oyster *P. maxima* in the Andaman and Nicobar Islands or its transplantation from the neighbouring region has been indicated. The existing Indian pearl trade, dependent on import and reexport, is a favourable factor for local production. The price of cultured pearls has been steadily appreciating during the last few years due to problems of production in Japan and Australia.

The CMFRI has been keen that the technical knowhow on pearl culture should be used in India for commercial production. As a programme of transfer of technology, the Institute has organised training courses in pearl culture for the benefit of the fisheries officers of the maritime States and Union Territories and also scientists in the Agricultural Universities. A long-term training course of six months duration was organised from 24-9-1976 to 23-3-1977, which was followed by two short-term training courses of six weeks duration each, from 22-8-1977 to 24-9-1977 and from 9-7-1979 to 18-8-1979. The beneficiaries of the training programmes have been officials/nominees of Department of Fisheries of Gujarat (3), Karnataka (2), Kerala (1), Tamil Nadu (7), Lakshadweep (2), Andaman and Nicobar Islands (1) and Konkan Krishi Vidyapeeth, Maharashtra (1), besides scientists/technical staff of CMFRI (8). Recognising the quality of knowhow, the South-East Asian Fisheries Development Centre in Philippines deputed one of its scientists for the training course (1979). Refresher training programme is also organised based on demand. The Institute has proposed to organise another short-term training course during 1984.

It is gratifying to note that the pioneering efforts of this Institute in pearl culture have led to the development of a commercial pearl culture company based at Tuticorin/Mandapam which is a joint venture between the Tamil Nadu Fisheries

Development Corporation and the Southern Petrochemical Industries Corporation Ltd.

There are constant enquiries on pearl culture from the interested public, prospective entrepreneurs, government organisations and educational institutions. Our scientists have published several research papers in scientific journals but these are not readily available to all who need them. The need for a manual giving the basic information and techniques of pearl culture has been felt both for informing the people interested and to serve as a handbook for the trainees in Pearl Culture Training Course at this Institute.

This need is being fulfilled by the publication of the present Manual on Pearl Culture Techniques. The manual is restricted in its scope, providing only the basic techniques and procedures of pearl oyster farming and cultured pearl production. It does not include the hatchery production of pearl oyster. I must congratulate Dr. K. Alagarwami for planning and producing this manual with the assistance of his colleague Shri S. Dharmaraj. It is hoped that the manual would be found valuable to all those who wish to enrich their knowledge on pearl culture in general, and to the scientists and technicians working on pearl culture in particular.

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