Saltwater Pearl Fisheries And Pearl Culture In India: An Update

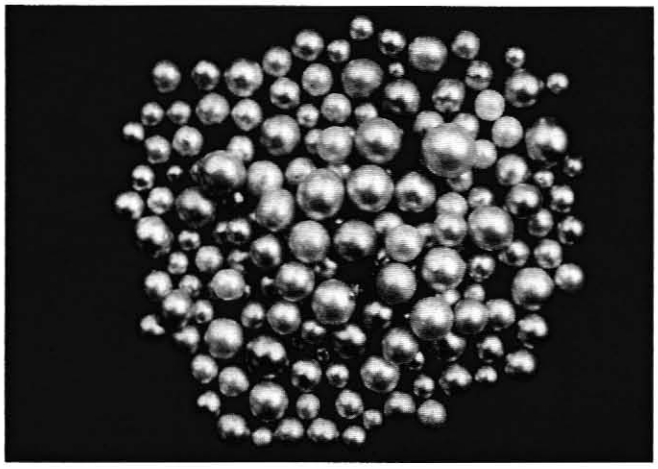
By P.S.B.R. James and K.A. Narasimham

Recently, C. Richard Fassler (1991 a, 1991 b, 1992) gave an overview of pearl culture in the world and discussed both "opportunities and obstacles" for the development of pearl culture. While Japan still holds the monopoly, China is fast catching up and several countries are producing pearls on commercial lines, mostly with Japanese collaboration, the notable being Australia, French Polynesia, Indonesia, New Caledonia and Cook Islands, Fassler (1991 a) stated that though the Indians have developed their own pearl industry, there is little published information.

The natural pearls from the Gulf of Mannar in India and the Persian Gulf are famous throughout the world as "Orient pearls" and held in esteem in the world trade from time immemorial. Unfortunately, the pearl fisheries of India came to a grinding halt in the 60's, with no hope of revival in the near future. Working at the Central Marine Fisheries Research Institute (CMFRI), India, Alagarswami (1974) achieved a breakthrough in 1973 in the production of spherical cultured pearls in the pearl oyster *Pinctada fucata* (Gould). Since then, with considerable thrust given to R & D programs on pearl culture by CMFRI, significant advances have been made in the hatchery production of pearl oyster seed, mother oyster farming, production of cultured pearls, training in all aspects of pearl culture both at national and international level and transfer of technology. In the past two decades more than 70 scientific papers have been published mainly based on the work done at CMFRI, and except for 4 papers, they all appeared in Indian journals. Important general accounts on pearl culture in India are by Alagarswami (1987 b, 1991), Anonymous (1991), James et al (1991) and James and Narasimham (1993).

Pearl Oyster Resources and Fishery

Resources and distribution: In Indian waters six species of pearl oysters, namely *Pinctada fucata* (Gould), *P.*



ollection of cultured pearls.

margaritifera (Linnaeus), *P. chemnitzii* (Philippi), *P. sugillata* (Reeve), *P. anomioides* (Reeve) and *P. atropurpurea* (Dunker) have been recorded. Among these, the first two are of commercial value in pearl production and the remaining four species are broadly called as "flat" oysters.

P. fucata is the most dominant and occurs in large numbers in the pearl banks, made of hard ground, called 'paars' in the Gulf of Mannar. There are about 65 paars located at a distance of 12 - 20 km away from the coast at 15 - 25 m depth. The extent of these paars varies from a few hundred square meters to a few square kilometers. In the Gulf of Kutch, *P. fucata* is found in small numbers in the intertidal coral reefs known as "Khaddas." There are about 42 reefs covering 24,000 ha.

The black-lip pearl oyster, *P. margaritifera* is confined to the Andaman & Nicobar group of islands. Recently few specimens were collected from the Gulf of Mannar.

Fishery: The documented history of pearl fisheries in the Gulf of Mannar indicates that so far 38 pearl fisheries have taken place between 1663 to 1961. The pearl fisheries were irregular and inter-spaced with long gaps of unproductive periods due to the decline of the oyster population. The Tamil Nadu government exercises a monopoly and organizes the fishery after ascertaining the abundance of pearl oysters in the paars. Plank-built canoes are towed by a motorized boat to the predetermined pearl bank and the divers work without any diving aids. Each dive lasts for a maximum of 90 seconds. The 1955-61 series, the last conducted till date, is considered as the best held so far and the average annual yield was 12,322,116 oysters; the average annual revenue was Rs. 316,065.

The Gulf of Kutch pearl fishery is controlled by the Gujarat government. The fishermen wade through the inter-tidal beds and hand-pick the oysters. During 1913 to 1967 twenty five pearl fisheries were held and fewer number of oysters were collected when compared to the Gulf of Mannar fishery. From 1950 to 1967, the average number of oysters

fished per year was about 17,000; the highest value of pearls realized from the fishery was Rs. 619693 during 1943-44.

P. margaritifera occurs in low densities and does not form a fishery.

Current Status of Resources

Scuba diving was introduced in India in 1958 for the survey of pearl banks under the auspices of FAO. The surveys conducted by CMFRI during 1975 to 1986 in the Gulf of Mannar showed revival of pearl oyster population in some paars but the yield was inconsistent except for 3 or 4 paars. During this period, for a total diving effort of 595 hours in various paars, 239,000 oysters were fished. Pearl oysters other than *P. fucata* (flat oysters) formed 10.36% of the population. Predation of the oysters by the gastropods *Cymatium cingulatum* and *Murex virgineus* led to heavy mortality. In successive years the population was composed almost entirely of less than one-year old pearl oysters. These oysters are too young to be of use for the production of natural pearls. Experience showed that oysters above three years of age give satisfactory pearl yield.

There was no improvement in the Gulf of Kutch pearl oyster population since 1968.

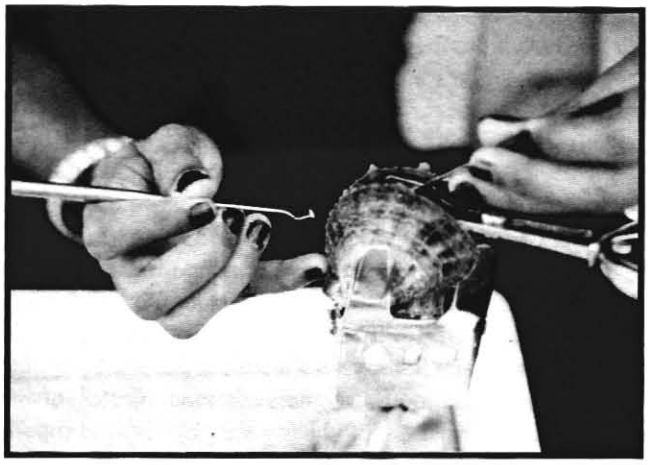
Sea Ranching of Hatchery Produced Spat

With the objective of enhancing the natural stocks of *P. fucata* CMFRI has embarked upon a sea ranching program of the hatchery produced spat in the Gulf of Mannar. During 1985-1990, a total of 1,025,300 spat of *P. fucata* placed in box-type cages covered with synthetic net webbing, have been ranched on 17 occasions. Due to practical difficulties in locating the cages, the ranched stock could not be monitored.

A view of the pearl oyster farm made of racks.

Spat Collection From Nature

Many attempts to collect pearl oyster spat by laying collectors such as empty pearl oyster shells, ropes, synthetic filamentous spindles, split bamboo and coconut shells made at Veppalodai and Tuticorin harbor farms of CMFRI during 1975-81 were futile either with no spat or very few spat. At



Graft implantation.

Vizhinjam, nylon ropes, hapa, or fish cages proved to be useful but profuse settlement of fouling organisms affected pearl oyster settlement.

Hatchery Production of Spat

Success was achieved in the breeding and production of spat of *P. fucata* at the Shellfish Hatchery Laboratory of CMFRI at Tuticorin in 1982 (Alagarswami et al 1983 b). The techniques are basically the same developed in the U.S.A. for several bivalves (Loosanoff and Davis 1963). Ripe pearl oysters are held in groups of 25 in the conditioning room around 25° C and fed with mixed micro-algae grown in outdoors tanks. Spawning is induced by slowly raising the water temperature to about 33° C. Spawning has also been induced by chemical methods (Alagarswami et al 1983 a) such as transferring the oysters to seawater containing hydrogen peroxide (62.5% success), tris buffer (78% success) and injecting hydrogen peroxide at the base of the foot (48% success).

The larvae are reared in 1 t FRP tanks and the seawater (sand filtered) is changed on alternate days. *Isochrysis galbana*, cultured in 100 liter perspex tanks at 25° C under axenic conditions is given as food. Spat settlement occurs in about 20 days with 20-30% survival from the initial larval stock. The spat are fed with mixed microalgae and reach 3 mm size in about 2 months from spawning. The hatchery has the capacity to produce one million spat per spawning run under favorable conditions.

Success was also achieved in the breeding and spat production of *P. margaritifera* (Alagarswami et al 1989).

Pearl Oyster Farming

This involves two aspects namely mother oyster culture and post-operative cultures. The former comprises growing the spat collected from the pearl banks/hatchery until the oysters reach nucleus implantation size. The farming techniques are broadly the same for these two phases of culture except that additional care is taken on the implanted oysters.

Wooden rafts measuring 6 x 5 m, moored in 5 m and above depth and also racks of 6 x 6 m size erected in 1 to 2.5 m for suspending the pearl oyster cages. Box-type cages of 40 x 40 x 10 cm or prism-shaped cages with 35 cm sides made of 6

mm steel rod and covered with 2 mm mesh velon screen are used for rearing spat. These cages are inserted into a bag made of 10-mm nylon fish net for protection against crabs and predatory fishes. As the oysters grow, the velon screen net is dispensed and the box-type cages are covered with nylon fish net of appropriate mesh. During the grow-out the predatory gastropods such as *Cymatium cingulatum* and *Murex virgineus* and crabs *Charybdis sp, Atergatis sp, Leptodius sp* and *Thalamitta sp* enter the cages in young stages and cause serious damage. Biofouling by barnacles, bryozoans, simple ascidians and bivalve molluscs is common. Boring sponges and polychaetes drill their way and form blisters in the pearl oyster shell. The cages and the oysters are periodically cleaned to remove the predators, foulers and borers; other remedial measures include immersion of oysters in freshwater for 3 - 10 hr depending upon size, exposure to air for 2 - 3 hr and immersion in 1% formalin for a few seconds. Hatchery produced *P. fucata*, grown in the Tuticorin Harbour farm attained 47.0, 64.5 and 75.0 mm at the end of 1 - 3 years respectively. The survival of both implanted and mother oysters in the grow-out of 10 - 12 months is about 80%.

Nucleus Implantation and Post-operative Culture

P. fucata measuring 45 mm and above and in inactive or resting reproductive phase are used in pearl production. Sprinkling of a small quantity of menthol powder into the seawater containing the oysters make them slowly open their valves in 60-90 minutes. Immediately a wooden plug is inserted in between the valves and thus the oysters are conditioned. The ventral part of the mantle of a donor oyster is cut into 2 to 3 mm long and 2 mm broad pieces for grafting. Mild solutions of eosin, mercurochrome or azumin in seawater are used in graft tissue preparation. The surgical instruments are indigenously fabricated and consist of oyster knifes incision-cum-grafting needles, nucleus insertion needles,

Growth of Nacre: India vs. Japan

Country	Nucleus diameter (mm)	Thickness of nacre of cultured pearl (mm)	Duration of culture
Japan (Cahn 1947)	3.05	0.318	2 years
	4.10	0.363	2.5 years
	6.10	0.439	3 years
	7.90	0.500	3.5 years
India (Algarswami 1975)	3.00	0.32	191 days
	4.00	0.31	161
	5.81	0.26	159 days

spatulas needle hook, graft knifes, forceps, speculum and oyster clamp. The conditioned oyster is mounted on oyster stands speculum inserted between the two valves, a passage is cut through the gonad up to the spot selected for nucleus implantation and the mantle piece is placed at the selected site. The shell bead nucleus is placed in contact with the outer epithelium of the mantle piece. In multiple implantation the process is repeated for each nucleus through the same incision by cutting the passage, through the gonad in suitable directions up to the selected site. After implantation, the two ends of the incision at the base of the foot are brought in contact and smoothed out. In *P. fucata* 2-8 mm diameter nuclei, imported from Japan are used. Indigenously made nuclei from the chank, *Xancus pyrum* appear promising.

After implantation, on transfer to slowly moving seawater the oyster recovers in about 30 minutes. For 2-3 days the oysters are kept under observation in FRP tanks having mild flow of seawater. Then they are placed in box-type cages of 40 x 40 x 10 cm and transferred to the farm. The skill of the technician is an important factor in the surgery. A technician implants about 100 oysters per day. The common reasons for the rejection of nucleus are too wide incision and passage cut through the gonad, damage to vital organs, rough handling and exposure to strong stimuli such as currents, waves, tides etc. Good quality pearls are produced when oysters are cultured in 5 - 10 m depth. Strong sun light on oysters results in poor quality pearls. The duration of the post-operative culture for the production of pearls depends upon the size of the nucleus implanted, water temperature, food supply etc. In Indian waters due to favorable water temperature the pearl grows fast and reaches marketable size in 3 - 4 months with 2 - 3 mm nucleus and 15 - 18 months with nuclei of 6 - 7 mm diameter. The following table on the growth of nacre illustrates the advantage of pearl culture in India when compared to the temperate waters of Japan.

The pearls are harvested by cutting open the oysters with a sharp knife, thereby killing the oysters. During the post-operation culture some oysters die due to natural causes and surgery while some reject the nucleus.

Production of Cultured Pearls

Considerable variations in the production rate are discernible. In the Veppalodai (Tamil Nadu southeast coast) farm of CMFRI, gross pearl production of 62.8% in single implantation and 68.3% in multiple implantation with reference to the number of nuclei used has been reported (Alagarswami 1974). In a recent study (A.C.C. Victor, Personal communication conducted by CMFRI at Valinokkam (Tamil Nadu, southeast coast) by scaling up the operations, out of a total of 9414 oysters implanted (single implantation with 3-5 mm nuclei) mortality during one year post-operative culture was 2108 oysters (22.39%). On harvest, the remaining 7306 oysters have yielded 1849 pearls (25.31%). A total of 5457 oysters (74.69%) did not contain pearls due to rejection of nuclei or non-deposition of nacre. This variation in the

production of the pearls in these two studies is indicative of the range of production under variable conditions.

Grading and Processing of Pearls

Grading: The quality of the cultured pearls depends upon the thickness of the nacre; iridescence, lustre, color, size, shape and flaws. They are graded into the following three main categories (Shirai 1970).

A-grade: Flawless, one flaw, small flaws, small stain, pink, silver or light cream.

B-grade: Fairly large flaws, stains, cream color, irregular shape.

C-grade: Trash pearls, wild shaped, badly coated, heavily pock-marked, clayey lumps, half good and half bad.

In the earlier studies by CMFRI at Veppalodai, A-grade formed 37.6%, B-grade 37.6% and C-grade 24.8% (Alagarswami 1987). In the recent study at Valinokkam (A.C.C, Victor# personal communication) A-grade formed 36.15%, B-grade 54.03% and C-grade 9.82%.

Processing: In surface processing the pearls are mixed with salt in equal volume and placed in a tub with little water. The residual mucus on the surface of the pearl is removed by rubbing with salt to obtain good lustre. To improve the quality the drilled pearls are bleached with hydrogen peroxide.

Technology Transfer

Concurrent with the development of pearl culture technology, CMFRI has given priority to train the man power for operating the pearl culture ventures, Beginning from 1976 officials sponsored by foreign countries and the fisheries departments of Tamil Nadu, Kerala, Karnataka, Gujarat, West Bengal, Andaman & Nicobar Islands and Lakshadweep and also pearl farmers, numbering 72 have been trained in eight training programs organized by CMFRI. The training course is 4-6 weeks long, specially designed for technicians, and covers all aspects of pearl culture. CMFRI adopted an open policy in dissemination of technology and subject to the Indian Council of Agricultural Research guidelines foreigners had the benefit of these programs. In 1979 a technician from the South East Asian Fisheries Development Center, Philippines participated in a training course. The Regional Seafarming Development and Demonstration Project of the Network of Aquaculture Centers of Asia (NACA), Bangkok has recognized CMFRI as a Lead Center to train the Aquaculturists of southeast Asian Countries on pearl culture. Under this program an International Training Course was organized by CMFRI at Tuticorin from February 1, 1991 to February 28, 1991 and 26 candidates from 10 countries have been trained.

Tamil Nadu Pearls Ltd., a joint sector company was the first to commercialize the technology developed by CMFRI and produced over 13 kg of cultured pearls and marketed. With the same technology Gujarat State Fisheries Department at Okha and Sikka and the Lakshadweep Fisheries Department at Bangaram have produced cultured pearls in small quantities.

Current status

Based on the technology developed by CMFRI the Tamil Nadu Fisheries Development Corporation (TNFDC) is operating a pearl culture project at Krusadai since 1990 and has produced more than 3 kg of pearls and marketed them. Since the revival of the natural stock of pearl oysters in the Gulf of Mannar pearl banks is uncertain, to meet the requirements of the commercial venture, TNFDC has set up a hatchery in 1992 with technical assistance from CMFRI. The TNFDC pearl farms are located at Krusadai and Tuticorin.

Currently the R & D programs of CMFRI on pearl culture are carried on at the Institute's farms located at Tuticorin and Valinokkam. Local fishermen are actively participating in the farm work at Valinokkam and recently they have been trained in nucleus implantation also. As a result they have developed the necessary skills to take up pearl culture on their own.

India has the advantage of possessing a complete package of tested technology (except for the import of nuclei), solely developed by indigenous efforts. Another advantage is the presence of strong R & D base and also well trained manpower to operate pearl culture ventures. However, entrepreneurs and farmers are yet to take up pearl culture in the country for reasons such as the need to locate suitable culture sites along the mainland coast, lack of awareness, hesitancy due to risk-prone nature, absence of laws for the usage of bodies of water, governmental monopoly over resources, constraints by way of input supply etc. Suitable sites for pearl culture are indicated in the Gulf of Mannars, Bangaram in Lakshadweep and Andaman and Nicobar group of Islands.

Future Outlook

In recent times, with the Indian cultured pearls available in the market, there is increasing awareness among the people about the technology and product. It will not be long before the message "pearls give the highest profit return of all marine products cultivated in coastal waters" (Wada 1973) reaches the entrepreneurs and farmers, venturing into pearl culture.

At CMFRI, priority is given for short range projects on location testing of pearl culture at several places along the Indian coast. R & D efforts, already directed to take the technology to the grass root level as is being done at Valinokkam, will be strengthened. While the program on the upgradation of the technology in *P. fucata* would continue, pearl production in *P. margaritifera* would receive attention. Also plans are underway to initiate a project on *P. fucata* mantle epithelium culture, leading to in vitro production of pearls of desired color.

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