



# Technology transfer, adoption and performance evaluation of pearl culture technology at selected ecosystems of India

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## Abstract

ICAR-CMFRI has developed technologies for breeding and seed production of many commercially important molluscs. One such is the marine pearl culture technology. The technology has been developed way back in 1973, pearl culture was undertaken by the fishers of Veppalodai, Thoothukudi district under the guidance of ICAR-CMFRI and established the interest and farming skill by producing quality pearls. Subsequently many aspects of pearl oyster resources were studied in detail by various researchers and a rich knowledge was obtained on the subject. The technology developed by ICAR-CMFRI has been transferred to various State government, private and joint ventures in Tamilnadu and Andhra Pradesh. Partial technology transfer to fisherfolks of Mundalmunai village, Mandapam through financial support of M.S. Swaminathan Research Foundation (MSSRF, Chennai) and good amount of pearls were produced but, due to non sustenance of funding it couldn't continue beyond the project period. At this juncture the current programme was implemented in three different centres viz., Kollam (Kerala), Kalpeni (Lakshadweep islands) and Sippikulam, Thoothukudi, Tamil Nadu with an aim of training and total transferring of the technology of image ('mabe') and spherical pearl production to the fishers and empower them in marine pearl culture production technology. In this paper an attempt is made to detail the experience and results of adoption of village/SHG's respectively, feasibility study for pearl culture using Indian pearl oyster *Pinctada fucata*, development of infrastructure, training imparted, skill evaluation and the

results of independent pearl culture by the beneficiaries at the respective centre/SHG. The trained group at Sippikulam, Thoothukudi was capable of producing 4.4-7.7% commercial grade spherical pearls, the SHG's at Kollam and Kalpeni centres developed expertise and produced 15-20% good quality 'mabe' pearl. As an encouragement/proof, the product was given to the team concerned. A project proposal was also prepared for the follow up and continuance of the culture with State Fisheries Department for funding was handed over to the group. Strong linkage was developed by liaisoning the groups with the State Department Officials of the respective centre for further follow up. The success of the implementation of the project at the three centres was evaluated by seven indicators.

**Keywords:** Pearl oyster, mabe pearl, technology transfer, performance evaluation

## Introduction

ICAR-Central Marine Fisheries Research Institute, (ICAR-CMFRI) in its early 1970's conducted research on bivalve molluscs and came out with an indigenous technology for production of spherical pearls in Indian pearl oyster *Pinctada fucata* and

rolled out its first cultured pearl from Tuticorin Research Centre (TRC) in 1973 (Alagarswami, 1974). Following the success various allied researches were conducted on seed production of oyster under hatchery conditions (Alagarswami *et al.*, 1983, 1987), its biology (Chellam, 1978, 1987), ecology (Nair and Mahadevan, 1987; Victor and Velayudhan, 1987), resources (Alagarsami *et al.*, 1987, Chellam *et al.*, 2003), small scale hatchery seed rearing (Anuradha and Alagarsami, 2003; Jetani *et al.*, 2003; Panikkar *et al.*, 2003; Lipton *et al.*, 2003), Linoy *et al.*, 2013 and growth, predation, fouling and boring in farming (Pandya, 1975; Chellam, 1978, 1987; Alagarsami and Chellam, 1978; Dharmaraj and Chellam, 1980; Dharmaraj *et al.*, 1987; Ramachandran *et al.*, 2003; Said Koya *et al.*, 2003; Velayudhan *et al.*, 2003 and Mohamed *et al.*, 2003) and smaller magnitude of cultured pearl production (Alagarsami, 1977; Alagarsami and Chellam, 1980; Dharmaraj and Sukumaran, 2003 a, b), experimental sea ranching (Chellam *et al.*, 1987), hatchery seed production, growth and production of mother oysters from hatchery produced seeds (Jagadis *et al.*, 2006) production of Akoya pearls (Kripa *et al.*, 2007) etc. are worth mentioning. ICAR-CMFRI also transferred the technology to entrepreneurs like TNFDC-SPIC, in 1983, TNFDC singly in 1991-94 & 1995-2000, Indo Japanese venture Oriental Kitachi Aquaculture Ltd, Mandapam, Indian Tropical Agro Products Ltd, Thoothukudi, Master pearls, Chirala, and Pearl Beach Hatcheries, Visakhapatnam. Partial technology transfer to fisherwomen with collaboration of MSSRF at Mundalmunai, Mandapam (Victor and Jagadis, 2007) was also done. However, all these efforts did not yield proper dissemination of technology for various reasons and shortfalls in implementing the technology though it is viable. Again ICAR-CMFRI during 1997-2003 on its own redemonstrated the viability of the technology at Mandapam Regional Centre of CMFRI, Mandapam Camp and successfully developed commercial scale hatchery and commercial farming of marine pearls with funding from ICAR (Jagadis *et al.*, 2015).

With this background a demonstration and transfer of technology project for the fisherfolks was envisaged for funding from CMLRE, Kochi, Ministry of Earth Sciences. The programme was aimed at conducting trainings on various aspects of marine pearl culture including farming, skill development and evaluation and independent handling of entire process of pearl culture. It was carried out in three different places *ie.*, Kollam (Kerala), Kalpeni (Lakshadweep Islands) and Sippikulam village, Thoothukudi (Tamil Nadu) while emphasis was given to 'mabe' (image) pearl production at the former two centres and spherical pearl production at the latter. The paper discusses the details of experience and results obtained in the training and transfer of both the forms of marine pearl culture technology at different centres and adoption psychology of fisher folk. The shortfalls/bottlenecks in adopting the technology by the fisherfolk and the possible role of CMFRI in training and demonstration and the

major role of State Fisheries Department in the form of sustained funding and assistance in marketing for the sustenance of the project are discussed.

## Material and methods

### a) Spherical pearl production-Sippikulam

**Village identification, coordination and selection of beneficiaries:** Sippikulam village was selected as the name implies the availability of pearl oysters around this area and fishermen from this area is known to involve in pearl fishing from time immemorial. The sea is calm for most of the year and has sufficient depth at the shore (5m), Fishermen were selected for training cum pearl production from this area. Series of meeting was conducted for the fishermen in the presence of village priest and headman for creating awareness about the usefulness of pearl culture and thereby generating revenue. Finally around 10 women and one men were identified for adoption of technology.

**Demography of the village:** About 50 fisherfolks ranging from 25 to 62 year old were interviewed and data on the demography was collected.

**Culture system and Infrastructure development:** Site selected for culture operations was near shore and had a water depth upto 5m. Hence, it was decided to erect floating raft (6 x 5 m), Water quality parameters such as air, water temperatures, salinity and bottom nature of culture site were sampled and studied adopting standard techniques. Fishermen were taught in fabricating and mooring a floating raft in the selected site. Floating raft (6 x 5 m) was erected. A small school building was repaired for conducting the training programme and subsequent use for surgery on regular basis. Nucleation was done by 5-6 nucleating technician at a time. Other facilities such as plastic wares, surgical instruments, nucleating tables, glass wares and chemicals were also arranged in the Training cum Nucleation centre at Sippikulam.

**Stock building and maintenance:** Mother oysters were collected from few known 'paars'(pearl beds) by engaging the local fishermen on payment basis. Regular trips were made to maintain the sufficient stock. Collected oysters were identified, cleaned, segregated size wise, stocked in cages and transferred to floating rafts.

**Technology transfer:** Technology transfer was done by adopting three stages of activities for the identified beneficiaries.

**Hands on training and erection of culture system:** The materials required for the fabrication of a floating raft was procured and supplied to the fishers. Basics of farming

were taught. Fishermen were assembled at the shore and demonstration was carried out, technical features involved in fabrication of the raft were taught. Fishers were involved in fabrication of rafts and the entire activities were supervised. The fabricated raft was towed into the sea with the help of a fishing vessel. Mooring sites were selected by diving and observing the underwater conditions. Floating rafts were moored by installing anchors (Fig. 1a-b).



Fig. 1. a-b. Farm erection by fisher folks at Sippikulam, Thoothukudi

**Training in spherical nucleation:** For pearl oyster surgery and nucleus implantation, selected fisherwomen were taken to the laboratory of TRC of ICAR-CMFRI, Thoothukudi and trained. Trainees were individually trained in all the steps of surgical nucleation for ten days. First the basics of the pearl formation, graft preparation and surgical nucleation were taught in the class room aided with live specimens followed by hands on practical demonstration in laboratory. Trainees were given an opportunity to do the nucleation by themselves (Fig.2) and after the training certificates were given to them.

**Trial implantations and Technical evaluation of team:**

On gaining confidence, a test of their skill was conducted by allowing the beneficiaries to do the entire practice



Fig. 2. Spherical Nucleation by trainees at Sippikulam, Thoothukudi

of oyster selection, conditioning, surgically nucleating and transplanting to the farm, farm management and harvest. The team member's performance was adjudged by the project team based on the quality of graft tissue preparation, surgical nucleation of spherical nucleus, post surgical survival on harvest.

**Pearl farming and production:** Six of the successful trainees nucleated on regular basis and oyster were farmed for nine months. After a culture period of about 9 months, the oysters were harvested phase wise and the products were separately packed for each of the technicians to collect data on their efficiency to produce quality pearls.

**b) 'Mabe'-Image pearl production technology transfer - Kollam (West Coast) and Kalpeni (Island Ecosystem)**

**Kollam, Kerala**

**Group Identification and Infrastructure development and culture site:** Three self-help group namely Chakara, Kadalamma and Chaithanya (SHGs) consisting of five members each were selected to undertake the pearl culture training and subsequent adoption. These fisherwomen were given an intensive training on the 'Mabe' pearl nucleation specifically for a period of ten days during June 2009. Infrastructure development such as the field requirements of plastic wares, chemicals and nucleating instruments and other items were procured. Fabrication of a raft 5 x 5 m size was done with the involvement of fisherfolk and was successfully moored at Kollam Bay for rearing of implanted oysters. The suitability assessment of the Kollam Bay was assessed by conducting rearing experiments of transplanted oyster spat and adults.

**Training assessment of the fisherwomen:** On completing the training, these groups were asked to continue the 'mabe'

implantation. The skill was evaluated by the project personnel. The fisherwomen showed tremendous interest and developed the skill to independently handle the 'mabe' implantation work (Fig. 3 a-d).



Fig. 3. a-d. 'Mabe' implantation and farming at Kollam centre *Kalpeni (Lakshadweep Islands)*

**Site selection and training:** To implement the project on the west coast of India in an Island ecosystem, Kalpeni Island was selected in the Lakshadweep group of Islands. The trained project staff at Tuticorin RC was taken to Kalpeni and training was imparted to selected fisher folks involving the local officials like the Chairperson of Village Panchayat (DWEEP) and the Sub Divisional Officer, Kalpeni.

**Fabrication and deployment of culture system in Kalpeni / Cheriyam lagoon:** A conventional bamboo raft of 4 x 4 m with 5 PVC barrel floats was fabricated and deployed at Kalpeni / Cheriyam lagoon on December 2009 with the involvement of the fishermen. (Fig. 4 a-c)

**Stock building and suitability studies:** Since, there was no sizeable population available at Kalpeni Island, various sizes of pearl oysters were transplanted from mainland to Islands. Spats (900 nos. with an average of 6.6 mm DVM) were also transported in oxygen filled plastic bags for studying the survival and growth in farm.



Fig. 4. a-c. 'Mabe' implantation and farming at Kalpeni Is, Lakshadweep.

**Success indicator analysis:** The project was evaluated by weighing the scores on seven success indicator factors which is considered as important to classify the suitability of the sites for adoption. The scores were assigned accordingly to each of the seven success indicator and the average for each of the experimental sites was arrived. The scores up to 5 are considered less suitable for adoption; 5-7 are graded as moderate, 7-8 as good and above 8 as very good for adoption.

## Results

### *Spherical pearl production at Sippikulam*

**Demography of the village:** Sippikulam village adopted for Spherical pearl production is situated about 40 km north of Thoothukudi (Lat. 8.9886°N Long 78.2503°E). The village has 267 households and most of them are christian. Average income of a house hold ranged from Rs.2000-2,500/ month. Population of the village is 873 and the ratio of male to female is nearly same. Main occupation of the villagers is fishing, women help the men in fishnet mending, sorting out fishes and marketing. There is about 65 number of fishing boats comprising 45 fibre glass boats and 20 canoes. The major fishery resource is sardine. The village has a RC middle school and a Post office. The GOMBRT (Gulf of Mannar Biosphere Reserve Trust) has an Eco Development project in the village. A Fishnet making unit is functioning. The literacy rate of the village was 62.8%.

**Infrastructure development-Culture site and system:** The fishermen showed good interest and understood the science behind the erection of farm structure. In their maiden effort they completed the task of fabricating one 6x5 m floating raft within 4-5 hours. The fabricated raft was towed to the farm site by engaging fishing vessel and was appropriately moored under the supervision of the project team on the same day. They also excelled in understanding the fabrication of culture cages, need for periodical maintenance and monitoring the farm structures.

Routine bimonthly farm visits and eradication of fouling and boring in the oysters, removal of kept the stock in good status. The initial transplant mortality of oyster was 15-20%, however, the stocked oysters were found to adjust with the transplant and survive better.

**Trial implantations and Technical evaluation of team:** The team member's individual nucleating potential was assessed and presented in Table 1.

**Performance evaluation of spherical pearl production:** A total of 3271 oysters were successfully nucleated by six of the successful trainees from both the batches. They were transplanted

Table 1. Nucleating potential of trained beneficiaries - Sippikulam (Spherical Nucleus), Thoothukudi

S.No.	Beneficiary	No. of implanting days	No. of oysters implanted	No. of live oysters	% survival
1	Mrs. Sangeetha	101	675	251	37.2
2	Mrs. Regina	29	197	55	27.9
3	Ms. Vinnarasi	107	1021	308	30.2
4	Ms. Sindhuja	106	839	337	40.2
5	Mrs. Thilagavathi	22	185	120	64.9
6	Mrs. Jayarani	36	162	70	43.2
7	Mrs. Rani	36	192	80	41.7

to the farm and maintained by the group. The results of the individual technician varied between 1.6-7.7% on survival of commercial grade quality pearls with a team average of 5.2% (Table 2). A total of 61 commercial grade pearls were produced by the group in their first attempt. The percentage compositions of different commercial grade pearls and their values are given. (Table 3 and Fig. 5 a-c). The beneficiaries have also acquired the knowledge in harvesting of pearls and grading them for marketing.

Table 2. Details of results of pearl production trials by the beneficiaries of Sippikulam village, Thoothukudi

S. No.	Beneficiary	No. of implantation	% of oysters survived	% retention	% quality pearls in survival
1	Mrs. Sangeetha	675	20.5	28.8	6.4
2	Mrs. Regina	197	30.4	3.3	1.6
3	Ms. Vinnarasi	1021	26.4	18.1	7.7
4	Ms. Sindhuja	839	27.9	23.1	6.9
5	Mrs. Jayarani	162	41.9	23.5	4.4
6	Mrs. Rani	192	11.9	13.1	4.3

Table 3. Percentage composition of the commercial grade pearls by the fishermen, Sippikulam, Thoothukudi

Grades of pearls	Number	Weight (mg)	% composition	Value (Rs)
Grade "A"	08	1448	13.1	2172
Grade "B"	18	3096	29.5	3096
Grade "C"	35	5038	57.4	2519
Total	61	9582	100	7,787

### *Kollam, Kerala*

**Growth, survival and 'mabe' pearl production:** Around 16,000 hatchery produced pearl oyster spats (average size  $3.8 \pm 0.4$  mm DVM, HL  $4.1 \pm 0.49$  mm and thickness  $0.8 \pm 0.13$  mm) were transported from Tuticorin shellfish hatchery had grown to a size of  $36.1 \pm 1.32$  mm DVM, HL  $31.9 \pm 0.95$  and thickness  $11.9 \pm 0.66$  mm over a period of five months. The average monthly growth rate of transplanted spats was  $6.5 \pm 0.36$  mm DVM,  $5.6 \pm 0.34$  mm HL and  $2.2 \pm 0.33$  mm thickness. The transportation survival of 1,500 adult pearl oyster of average size  $54.2 \pm 1.3$  mm DVM, HL  $52.1 \pm 1.15$  mm and thickness  $22.3 \pm 0.78$  mm to Kollam from Tuticorin shellfish hatchery was 100%.

A total of 902 'mabe' implanted *Pinctada fucata* were reared in the floating raft moored at Kollam Bay. At harvest 162 (18%) oysters survived and the rest were either poached or dead of which 12.3% were good and 45% were semi coated mabe pearl. About 37 numbers of mabe pearls with nacre coating were retrieved. The quality 'mabe' pearl production was worked out to be 10-15%. Poaching of the pearl oysters in the farm was a problem. The results of the 'mabe' implantation by the groups are given in Table. 4.

### Kalpeni (Lakshadweep Islands)

**Training of identified groups:** A team of 29 educated youths of Kalpeni Island, Lakshadweep was trained for 12 days. The trainees acquired the skill effectively on raft fabrication and deployment, spat collectors, pouch and cage fabrication, image making, graft preparation, conditioning the implanted oysters, 'mabe' and spherical nucleus implantation, oyster cleaning and growth measurement studies. The trainees were adjudged as acquired skill by the project personal on observations of their efficiency in independent handling of oysters.

**Growth and survival of transplanted oysters:** A batch of 900 spats was transported successfully, involving 24 h journey with transportation mortality of less than 2 % only. Growth of spats was worked out to be 5.2 mm / month.

Experiment conducted on transportation of 320 nucleated and 94 non nucleated oysters from Thoothukudi to Kochi and to Kalpeni, involving nearly 100 h of road and sea journey showed a survival of 22.2 % of implanted and 7.4 % of non implanted oysters by 'dry method'. The average survival of similar oysters by 'wet method' was 71.6 % indicating the suitability of 'wet method' for longer duration transportation.

The growth, fouling and spat settlement studies were carried out on a monthly basis revealed the initial good growth of 5.2mm/month and subsequent period it was less than 4 mm/month. The fouling on the oysters and cages was less compared to the Minicoy lagoon. However, heavy fouling with filamentous algae *Chaetomorpha spp* was occurred on the anchor ropes and the cages which caused restricted water flow and have affected the growth of the oysters. No spat settlement was observed during 2010, however, very low settlement was observed during January /February of 2011.

**'Mabe' pearl production:** Harvest of implanted mabe pearl oysters was done in July 2010. The quality of the 'mabe' pearls was poor due to over coating. This was mainly due to logistics reason and delay in harvest (= 180 days). Of the 120 oysters implanted with images only 20 (17%) was harvested alive and the images were of encouraging quality during 2010. The second set was harvested for the 'mabe' pearls during April 2011. Of

the 90 implanted oysters only 57.8% oysters had 'mabe' pearls. 28.2% oysters died during the post implantation and 14.0% rejected the images. Quality of the harvested 'mabe' pearls in 52 nos was very poor.

### Success indicator analysis

The scores obtained for various success indicators of all the three experimental sites are presented in Table 5. From the table it could be understood that among the three sites, Sippikulam, Tamil Nadu and Kollam, Kerala are considered 'good'. Kalpeni Island, Lakshadweep due to its distance, transport difficulties

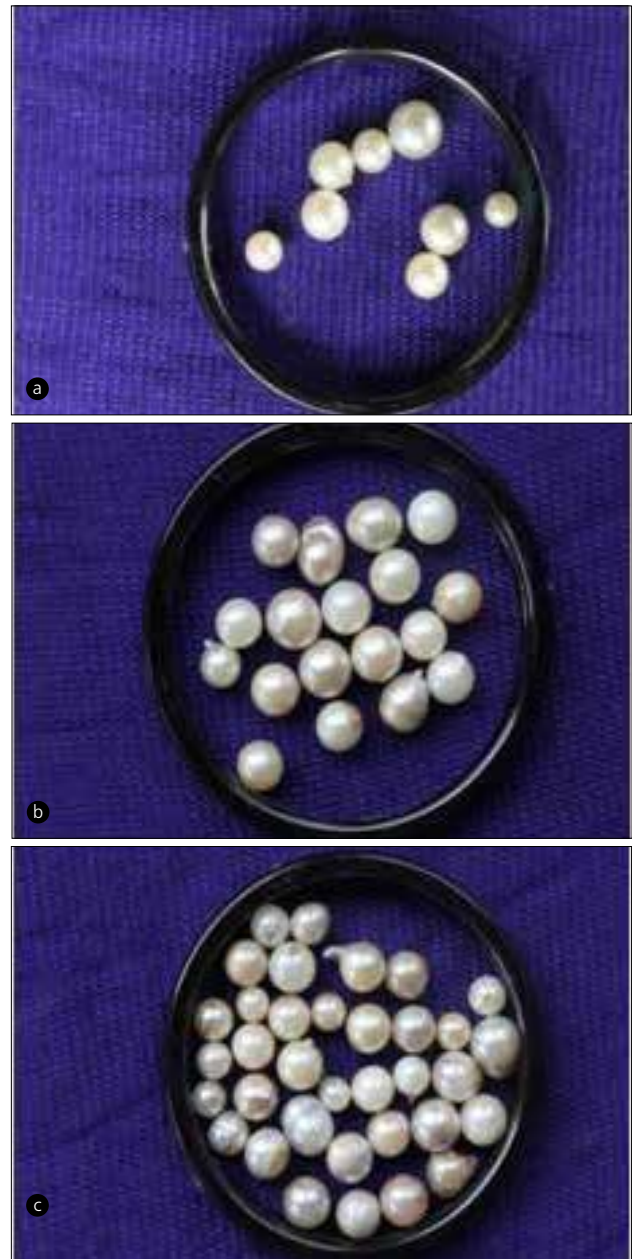


Fig. 5. a-c Commercial grade spherical pearl produced at Sippikulam, Thoothukudi.

Table. 4. Results of the experimental 'mabe' implantations at Kollam and Kalpeni Is.

Centre	Mabe implanted	Nucleus implanted	Rejected	Dead and poaching	Harvested	Quality of images					No. of SHG s
						Good	Semi coated	Wormed	Blistered	Poor coating	
Kollam Bay, Kerala, Thangaserry	902	nil	176	564	162	20	73	31	23	15	3
Lakshadweep Is. Kalpeni	7	120	80	20	20						nil

and non availability of natural resources locally, slipped to 'moderate' in spite of its pristine culture environment.

Table. 5. Relative score of success indicators at various experimental sites (in a scale of 0-10)

S. No.	Success indicator	Sippikulam, Thoothukudi	Kollam, Kerala	Kalpeni Is.
1	Site and Environment	8	7	8
2	Logistics for project running	8	6	5
3	Resources	8	7	5
4	Skill development	8	8	8
5	Adoption interest	8	8	8
6	Post training Performance	7	7	6
7	Independent handling ability	7	7	7
	Average Score	7.7	7.1	6.7

## Discussion

The present attempt was first of its kind in training and transferring both 'mabe' and 'spherical' pearl culture technology using Indian Pearl oyster *Pinctada fucata* in Mainland and Island ecosystem simultaneously. From this experience, many useful and vital outcomes have been achieved. Major scientific, manpower development and societal outcomes from all the three centres of operation is described below.

Growth of pearl oysters at Kollam was fast comparing to other centres, however, boring and fouling were the major natural hindrance for the culture apart from poaching. Experimental results indicated growth, survival and production of 'mabe' pearls were encouraging and positive. At Kalpeni Island, growth and production of mother oysters from transplanted spat was 15.4% which can be further increased with proper management. Growth, survival and production of 'mabe' pearls tested experimentally. At Sippikulam, successful transplant of hatchery produced oyster, growth and production of adult oysters were achieved. Environmental monitoring for farming proved Sippikulam area a suitable site for farming of nucleated oysters for pearl production, fouling and boring was negligible. Fisherfolk successfully carried out the nucleation, culture of oysters and spherical pearl production in the village and produced commercial grade pearls in their 'First attempt'.

A total of 15 fisher folks from Kollam and 29 educated youths

and an Asst. Director of Fisheries from Kalpeni have been successfully trained. A total of 32 fisherwomen at Sippikulam were trained in 'mabe' pearl farming (2009). Around 10 village women from Thoothukudi and Pudukottai area were also trained in 'spherical nucleus implantation' during 2009. Similarly two batches of beneficiaries (10 Fisherwomen) were trained in 'spherical nucleus implantation' during 2010 and 2011. Five fisherwomen were trained in 'mabe pearl' at Sippikulam during January-February 2011. A total 86 fisherfolks and one government officer was trained under this project.

At Kollam centre, the technology of 'mabe' or image pearl production was introduced successfully to three SHGs namely Chakara, Kadalamma and Chaithanya. They were trained and were capable of producing about 10% quality 'mabe' images. The Self Help Group, "Manakkam" was established at Kalpeni. At Sippikulam, 10 trained villagers were formed as a group and a project proposal was prepared for continuation of activity and handed over to the beneficiaries for submission to State Fisheries Department and follow up.

Apart from the above cited outcomes, the experience also clearly indicated the following positive and negative key issues in the transfer of technology of marine pearl culture.

- The fisher folks are interested in acquiring knowledge through trainings and adopting it. The number of participants trained is indicative of the encouraging attitude towards adoption of the programme as seen in the series of trainings conducted under the project.
- As regard to both the forms of pearl production, the skill development is a very vital factor for which the continuance of the programme on long term is very essential.
- The survival, growth and production of oysters observed in all the three centres indicate the suitability of the environment for undertaking the culture. Except for few problems like, heavy poaching at Kollam and fouling by the drifted sea weeds in the culture structure at Kalpeni, which can be overcome by proper management.
- The general negative mind set in waiting for longer period for returns can be eliminated by adopting the two forms of culture simultaneously, thus achieving the products at regular intervals and marketing for revenue generation.
- The team average of 5.2% in spherical cultured pearl and 10-15% in 'mabe' pearl production in their maiden attempts are the attestations for the fisherfolk's ability to acquire

the skills required for pearl production and the same could definitely be improved by continued farming.

- But, in the case of these three centres, the continuance of the programme was a problem as the project is time bound and scope was only to transfer the technology. Hence it is felt that the role of the respective state fisheries department is very crucial for the continuance and success of the transferred technology.
- Declaration of financial support for marine pearl culture activity by the Lakshadweep administration is a positive development and most prominent outcome of the project which will eliminate the problem of funding and could encourage towards adoption by the fisher folk on larger scale if similar things happen in other states also.

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## References

- Alagarswami, K. 1974. Development of pearl culture in India and scope for a pearl culture industry. In: R.V. Nair (Ed.), Proceedings of the Group discussion on pearl culture, CMFRI, Cochin, p. 4-19.
- Alagarswami, K., S. Dharmaraj, T. S. Velayudhan, A. Chellam, A.C.C. Victor and A. D. Gandhi. 1983. Larval rearing and production of spat of pearl oyster *Pinctada fucata* (Gould). *Aquaculture*, 34: 287-301.
- Alagarswami, K. 1977. Preliminary study on the growth of cultured pearls. *Indian J. Fish.*, 22 (1&2): 300-303.
- Alagarswami, K. and A. Chellam. 1978. On fouling and boring organisms and mortality of pearl oysters in the farm at Veppalodai, Gulf of Mannar. *Indian J. Fish.*, 23(1&2):10-12.
- Alagarswami, K. and A. Chellam. 1980. Change of form and dimensional relationship in the pearl oyster *Pinctada fucata* from the Gulf of Mannar. *Indian J. Fish.*, 24 (1&2): 1-4.
- Alagarswami, K., S. Dharmaraj, T. S. Velayudhan and A. Chellam. 1987. Hatchery Technology for pearl oyster production. *Bull. Cent. Mar. Fish. Res. Inst.*, Cochin, 39: 62-71.
- Anuradha Krishnan and K. Alagarsami. 2003. Spatial and feed requirements of larvae of the Indian Pearl oyster *Pinctada fucata* (Gould). In: First Indian Pearl Congress and Exposition-Book of Abstracts, p. 47-49.
- Chellam, A., A.C.C. Victor and I. Jagadis. 2003. An unusual pearl oyster fishery at Tuticorin. In: First Indian Pearl Congress and Exposition- Book of Abstracts, 67pp.
- Chellam, A. 1978. Growth of pearl oyster *Pinctada fucata* in the pearl culture farm at Veppalodai. *Indian J. Fish.*, 25 (1&2):77-83.
- Chellam, A. 1987. Biology of pearl oyster. *Bull. Cent. Mar. Fish. Res. Inst.*, 39: 13-20.
- Chellam, A., T. S. Velayudhan and A. C. C. Victor. 1987. Pearl oyster farming, in 'Pearl Culture'. *Bull. Cent. Mar. Fish. Res. Inst.*, 39: 72-77.
- Dharmaraj, S. and A. Chellam. 1980. Settlement and growth of barnacle and associated fouling organisms in pearl culture farm in the Gulf of Mannar. Proc. Symp. Coastal Aquaculture, *Mar. Biol. Ass. India*, 2: 608-613.
- Dharmaraj, S., A. Chellam and T. S. Velayudhan. 1987. Bio fouling, boring and predation of pearl oyster. *Bull. Cent. Mar. Fish. Res. Inst.*, Cochin, 39: 92-97.
- Dharmaraj, S. and N. Sukumaran, 2003. Role of post operative culture period on culture pearl production in the Indian Pearl oyster *Pinctada fucata* (Gould). In: First Indian Pearl Congress and Exposition-Book of Abstracts, 57 pp.
- Dharmaraj, S. and N. Sukumaran, 2003. Effect of oyster size on culture pearl production in the Indian Pearl oyster *Pinctada fucata* (Gould). In: First Indian Pearl Congress and Exposition-Book of Abstracts, 58 pp.
- Jagadis, I., Ignatius Boby, A. C. C. Victor and K. Ilangoan. 2006. Production of mother oysters of *Pinctada fucata* (Gould) by manipulation of stocking density. *Indian J. Fish.*, 53 (3): 297-305.
- Jagadis, I., A. C. C. Victor, Boby Ignatius, D. Kandasamy and A. Chellam. 2015. Indian experience of large scale cultured marine pearl production using *Pinctada fucata* (Gould) from southeast coast of India: A critical review. *J. Mar. Biol. Ass. India*, 57 (2): 58-64.
- Jetani, K. L., M. P. Patel and S. R. Ghodasara. 2003. Seed production of *Pinctada fucata* (Gould) in captivity at Experimental Hatchery of Fisheries Research Station, GAU Sikka. In: First Indian Pearl Congress and Exposition- Book of Abstracts, 45 pp.
- Kripa, V., K. S. Mohamed, K. K. Appukuttan, and T. S. Velayudhan. 2007. Production of Akoya pearls from the Southwest coast of India. *Aquaculture*, 262: 347-354.
- Linoy Libini, C., C. C. Manjumol, K. A. Albert Idu, V. Kripa and K. S. Mohamed. 2013. Effect of pedi veliger densities and cultch materials on spat settlement of black lip pearl oyster *Pinctada margaritifera* (Linnaeus, 1758) in hatchery. *J. Mar. Biol. Ass. India*, 55: 3-34.
- Lipton, A. P., S. K. Subhash, R. Paulraj and A. Anitharani. 2003. Influence of environmental factors and microbial load on the spat settlement of pearl oyster *Pinctada fucata*. In: First Indian Pearl Congress and Exposition- Book of Abstracts, 52-54 p.
- Mohamed, K. S., K. K. Appukuttan, V. Kripa, T. S. Velayudhan, P. S. Alloyicious and Leena Ravi. 2003. Production of Mabe pearls in *Pinctada fucata*. In: First Indian Pearl Congress and Exposition-Book of Abstracts, p. 97-98.
- Nagappan Nair, K. and S. Mahadevan. 1987. Ecology of pearl oyster beds. *Bull. Cent. Mar. Fish. Res. Inst.*, Cochin, 39: 29-36.
- Pandya, J. R. 1975. Age and growth of the pearl oyster *Pinctada vulgaris* (Schumacher), of the Gulf of Kutch. *J. Indian Fish. Ass.*, 2 (1&2) (1972): 47-54.
- Preetha Panikkar, R. Paulraj and D. Kandasami. 2003. Feeding and ingestion rate in different size group of pearl oyster *Pinctada fucata* (Gould). In: First Indian Pearl Congress and Exposition-Book of Abstracts, p. 47-49.
- Ramachandran, N., M. K Anil, Joseph Andrews and K. T. Thomas. 2003. Settlement and growth of the pearl oyster *Pinctada fucata* (Gould) under off-bottom culture in Vizhinjam Bay. In: First Indian Pearl Congress and Exposition-Book of Abstracts, 43 pp.
- Said Koya, K. P., S. Vinod and R. K. Pandey. 2003. Growth of pearl oyster *Pinctada fucata* (Gould) in Minicoy Island. In: First Indian Pearl Congress and Exposition-Book of Abstracts, 78 pp.
- Velayudhan, T. S., K. S. Mohamed, V. Kripa, Leena Ravi, R. Ramalinga, R. Sreejaya and K. K. Appukuttan. 2003. Growth of *Pinctada fucata* (Gould) in a semi enclosed artificial bay along the south west coast of India. In: First Indian Pearl Congress and Exposition-Book of Abstracts, p. 85-87.
- Victor, A. C. C. and T. S. Velayudhan. 1987. Ecology of pearl culture grounds. *Bull. Cent. Mar. Fish. Res. Inst.*, Cochin, 39: 78-86.
- Victor, A. C. C. and I. Jagadis. 2007. Marine pearl culture as an alternate income generation activity for fisherfolk - A model. In: C. Vasudevappa, Y. Basavaraju, D. Seenappa, S. Ayyappan and S. Ravichandra Reddy (Eds.), Proceedings of the Seventh Indian Fisheries Forum. p. 108-115.