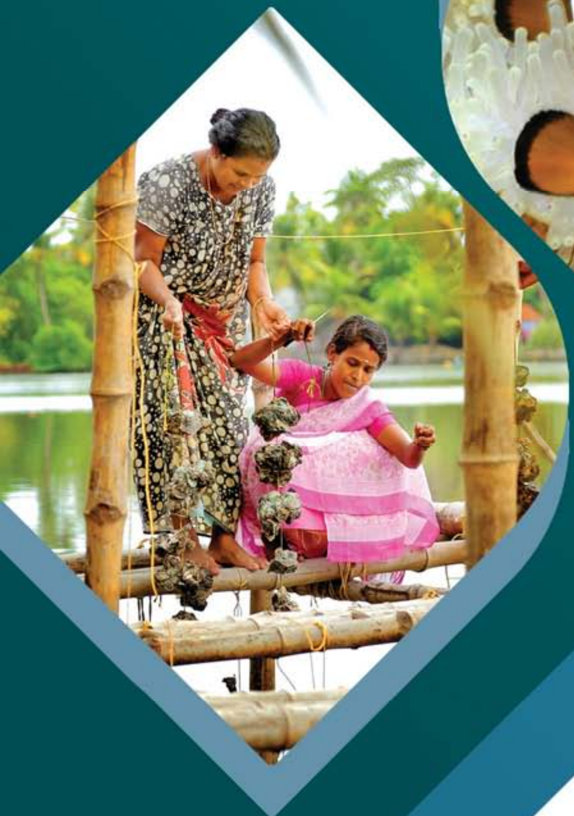
CMFRI Training Manual Series No. 47/2025

Training programme on
Cage, Pen, Ornamental fish, Biofloc, Mussel and Oyster culture
for Tribal Department officials, Scheduled Tribes (STs) Promoters and Farmers

Under Tribal Sub Plan (TSP) Scheme of ICAR-CMFRI, Kochi

7th January, 2025



Training Manual

भाकृअनुप
ICAR

सी एम एफ आर आइ
CMFRI

ICAR-Central Marine Fisheries Research Institute
(Department of Agricultural Research and Education, Government of India)
P.B. No. 1603, Ernakulam North P.O., Kochi - 682 018, Kerala, India

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Training programme on
“Cage, Pen, Ornamental Fish, Biofloc, Mussel and Oyster culture”: for Tribal Department Officials, ST Promoters and Farmers.
(Tribal Sub Plan Scheme)

CMFRI Training Manual Series No: 47/2025

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Foreword

Aquaculture has emerged as an important means for producing aquatic organisms, serving diverse purposes ranging from nutrition and therapeutic applications to ornamental and industrial uses. The sector is poised for significant and sustained growth in the coming decades, propelled by advancements in technology. As global marine capture fisheries continue to decline, primarily due to overfishing and overcapitalization, aquaculture presents itself as a critical solution to meet the world's growing demand for highly nutritious food in the 21st century. Over the past two decades, the ICAR-Central Marine Fisheries Research Institute (CMFRI) has made substantial progress in advancing mariculture practices and disseminating knowledge to a wide array of stakeholders, including researchers, educators, and extension personnel in State Agricultural Universities, ICAR Institutes, and traditional academic institutions. This pioneering research has laid a strong foundation for the future of sustainable aquaculture. India, with its rich aquatic resources, holds significant potential for aquaculture to enhance food security, economic development, and employment, improving livelihoods in both rural and urban areas. However, the sector remains underdeveloped, requiring increased focus and support from government, industry, and entrepreneurs. As a leader in aquaculture research, CMFRI has pioneered advancements in sustainable mariculture, fish production, and alternative livelihoods. The institute has developed innovative technologies for farming shrimps, finfish, mussels, marine ornamentals, oysters, crabs, lobsters, and seaweeds, with a particular emphasis on optimizing open-sea cage farming for broodstock development, maturation, and spawning of both finfish and shellfish. CMFRI also plays a key role in human resource development and capacity-building in areas such as marine fish breeding, seed production, aquatic environment management, nutrition, biotechnology, and genetics. India's socio-economic landscape includes marginalized communities, particularly the Scheduled Tribes (STs), who face barriers in accessing resources and opportunities. To address these challenges, the Government of India launched the Tribal Sub Plan (TSP) Scheme for their upliftment. In line with this, ICAR-CMFRI has implemented the TSP Scheme at eight of its research centres, focusing on the socio-economic development of tribal communities across India. As part of this initiative, CMFRI will conduct a specialized training program on Cage, Pen, Ornamental, Biofloc, and Mussel Culture aimed at enhancing the skills of Tribal developmental officers, ST promoters, and farmers, enabling them to engage effectively in the growing field of mariculture. I would like to extend my heartfelt thanks and sincere gratitude to the Tribal developmental officials, ST promoters, and all the authors for their valuable contributions to this important work. Their expertise and dedication have been instrumental in bringing together the diverse aspects of aquaculture research, development, and training presented in this publication. Their efforts are pivotal in advancing both the science of aquaculture and the socioeconomic well-being of the communities we aim to support.

Dr. Grinson George
Director

PREFACE

Aquaculture is essential for addressing food security by providing nutritious food, especially as the global population grows. Known as the "dawn of the blue era," aquaculture can revolutionize seafood production sustainably, offering an alternative to overfishing. By raising fish in controlled environments, it eases pressure on marine ecosystems, reduces reliance on wild fisheries, and ensures a more efficient and predictable supply of seafood. As a result, aquaculture has become an important solution to meet the rising global demand for seafood. Technologies developed by ICAR-CMFRI, including cage and pond fish farming, biofloc, ornamental fish culture, seaweed farming, and shellfish farming, are widely accepted by farmers for income generation and livelihood improvement across India.

Cage fish farming, which uses floating enclosures in water bodies, helps optimize space, minimizes environmental impact, and promotes income diversification, especially in tribal areas with water bodies. Pond fish farming, a traditional yet effective method, utilizes local resources like ponds to improve food security and boost local economies. Biofloc technology, which uses microorganisms to break down organic waste while cultivating fish, reduces feed costs and water usage, benefiting small-scale farmers. The ornamental fish industry offers growing economic opportunities, with low space requirements and high-value markets, both locally and internationally. Seaweed farming, an environmentally friendly practice, generates income for coastal tribal communities through various commercial uses, such as cosmetics and biofuels. Oyster and mussel farming provide profitable opportunities for farmers. By adopting these aquaculture practices, tribal communities can achieve long-term sustainability, improve living standards, and contribute to both national and global markets.

To further these goals, ICAR-CMFRI is organizing a training program on January 7, 2025 for tribal department officials, ST promoters and farmers under the Tribal Sub Plan (TSP) scheme. The program aims to disseminate aquaculture technologies to enhance skills in the sector.

I express my sincere gratitude to Dr. Grinson George, Director of ICAR-CMFRI, for his support, and to the coordinators of the training program—Dr. Rema Madhu, Dr. Suresh Babu and Dr. R. Vidya for their timely contributions. I also thank all faculty members for their active involvement and support, as well as Dr. VVR Suresh, Head of Mariculture, and the hatchery staff, contractual workers, and the administrative and technical teams for their invaluable assistance in organizing this event.

(K. MADHU)
Principal Scientist & Organizer)

CONTENTS

Tribal Sub Plan (TSP) / Scheduled Tribe Component (STC) and Scheduled Caste Sub Plan (SCSP) Scheme : An overview.

K. Madhu, Rema Madhu and Grinson George
ICAR-Central Marine Fisheries Research Institute, Kochi.

I. BACKGROUND :

India is endowed with much caste, of which many have economic disparity. People belong to some caste are very penurious especially Scheduled caste (SC) and Scheduled Tribe (ST). It is therefore, Govt. of India initiated may schemes for the upliftment of these communities. They have been given special representation based on the constitutional provisions given in CHAPTER X1 SPECIAL REPRESENTATION IN SERVICES FOR SC/ST 1. CONSTITUTIONAL PROVISIONS 1.1 Definition of Scheduled Caste/Scheduled Tribe. Articles 341 and 342 of the Constitution of India define as to who would be Scheduled Castes and Scheduled Tribes with respect to any State or Union Territory. CONSTITUTIONAL PROVISIONS 1.2 " Article 46 "The State shall promote with special care the educational and economic interests of the weaker sections of the people, and, in particular, of the Scheduled Castes and the Scheduled Tribes, and shall protect them from social injustice and all forms of exploitation." Article 335 "The claims of the members of the Scheduled Castes and the Scheduled Tribes shall be taken into consideration, consistently with the maintenance of efficiency of administration, in the making of appointments to services and posts in connection with the affairs of the Union or of a State. CONSTITUTIONAL PROVISIONS 1.3" List of Scheduled Castes and Scheduled Tribes —The existing lists of Scheduled Castes and Scheduled Tribes are to be found in the following Orders and Acts :— (1) *The Constitution (Scheduled Castes) Order, 1950; (2) *The Constitution (Scheduled Tribes) Order, 1950; (3) *The Constitution (Scheduled Castes) (Union Territories) Order, 1951. (41 *The Constitution (Scheduled Tribes) (Union Territories) Order, 1951. In this backdrop, ICAR (Indian Council of Agricultural Research), Govt. of India proposed schemes such as TSP (Tribal Sub Plan) or STC (Scheduled Tribal Components) and SCSP (Scheduled Caste Sub Plan) with the following guidelines Number M-11012/03/2013-SG &SW Planning commission (SG &E Division Dated 18th June 2014), and M-11012/03/2013-SJ&SW Planning Commission (SJ & E Division). Based on this ICAR-Central Marine Fisheries Research Institute (CMFRI) launched the TSP and SCSP project and operated in its 11 centres (Veraval, Karwar, Mangalore, Kozhikode, Kochi, Vizhinjam, Tuticorin, Mandapam, Chennai, Visakhapatnam and Puri) for SCSP and 7 centres (Veraval, Mumbai, Kozhikode, Lakshadweep, Kochi, Visakhapatnam and Puri) for TSP in various parts of India with following objectives.

II. OBJECTIVES

- ❖ To bridge the gap between SC/ST population and others through accelerating the fisheries developmental activities.
- ❖ Enhance the quality of life by providing basic amenities in SC/ST areas/localities.
- ❖ Substantial reduction in poverty and unemployment, creation of productive assets and income generation opportunities.
- ❖ Enhance the capacity to avail opportunities to gain rights and entitlement and improved facilities at par with other areas, and protection against exploitation and oppression.

III. IDENTIFICATION OF THE TARGET GROUPS

The SECC (Socio- Economic Caste Census) 2011 data base should be utilized in those states where the data has been published in order to identify the beneficiaries and map the families residing in the state. SECC database can be accessed on clicking the link http://censusindia.gov.in. The target group/beneficiaries can also be selected through Panchayat / Municipality / Corporation / Village Officer / Gramasabha/ tribal extension office/ tribal welfare office, etc.

The implementing centre should clearly determine the SC/ST families residing in their domain and assign a unique identity number to the families (same as Aadhaar-where this number has been assigned to the individuals), since government benefits mostly accrue to the families and not to individuals. After identification, the target groups can be linked with the various programmes of the State and Central government that are meant for the SC/STs.

The group of the selected beneficiaries should be member of registered Societies/NGOs/SHGs (Self Help Groups). The beneficiaries/members and their unique identity number or AADHAR number and caste certificate to be certified by the Presidents of respective panchayat. In case societies/SHG are not available, 5-10 ST members or beneficiaries can make new groups which should be registered under the respective Panchayat /Corporation/Municipalities/Gramasabha, Kudumbasree etc. These groups may be provided a package of practices of proven technologies for fish culture and allied fisheries activities, so that it gives them livelihood, job opportunity and self employment. They may be provided inputs like quality seeds, feeds, other accessories etc. for implementing the scheme. Before implementation of the projects, the farmers were given hands on training and equipped them to undertake the work. The work was monitored at their field every 15 days and proper guidance were given for day to day activities. All inputs may be procured for the beneficiaries as per the codal formalities and official procedure of government of India by the operating centers. Centers should also obtain receipt from the beneficiaries of SC/ST community group for the assets/ benefits they received.

In order to avoid life risk factors during operation of scheme/project in the open water systems, the beneficiaries are also provided with life jackets, life buoys/floats, etc. Implementing centre may ascertain that all beneficiaries can be able to conduct the formulated project without any risk factors. However implementing centres may be obtained an undertaking from beneficiaries stating that all members of selected group knew swimming and have capacity to implement the scheme/ project.

IV. TYPE OF SCHEMES/PROGRAMMES

- ❖ Scheme should provide clearly defined direct and quantifiable benefits to SC/ST individuals or their households or their areas.
- ❖ Create the potential to accelerate the pace of the development of SC/STs and to bridge the gaps in socio-economic development indicators between SC/STs and other sections of the society
- ❖ The focus for such schemes should be on income generation, entrepreneurship development, employment and skill development and access to basic amenities.
- ❖ Have in-built mechanisms/surveillance system to ensure utilization of funds meant for the intended purpose.

V. FORMULATION OF SCHEMES/PROJECTS

Project may be formulated, after estimating the gaps in the development of SC/STs with other castes, will prioritize their development needs through a consultative process with line department such as department of fisheries/Panchayat/Municipality/Corporation/VillageOffice/Gramasabha/tribal extension office/tribal welfare office/department of forest.

VI. IMPLEMENTATION OF SCHEME

- ❖ Identify socio-economic indicators to highlight development deficits of SC/ST population.
- ❖ Conduct a critical gap analysis to assess the deprivation of SC/ST on identified socio- economic parameters.
- ❖ Identify priority-areas under SCSP and TSP in consultation with line department such as department of fisheries/Panchayat/Municipality/Corporation/VillageOffice/Gramasabha/tribal extension office/tribal welfare office/department of forest.
- ❖ Prepare a comprehensive perspective of SCSP and TSP documents.
- ❖ Examine various on-going schemes and their budgetary allocations and suggest new schemes on the basis of assessment and discussions with the concerned line Departments such as department of fisheries, Panchayat or Municipality or Corporation or Village Office or Gramasabha, and tribal extension office and tribal welfare office and department of forest.
- ❖ The scheme strategy is that only those schemes/programmes, that full-fill the criteria of securing direct benefits to SC/ST individuals, households and localities to be selected.
- ❖ Design a comprehensive monitoring framework with well-defined indicators.
- ❖ Ensure transparency and accountability at all levels in the implementation of schemes and dissemination of information electronically relating to schemes/programmes, along with physical targets and achievements, placing this information in public domain.
- ❖ In order to effective implementation of the project, electronic surveillance intimation and connection need to be given the Chairman SCSP/TSP and department of Police (Local or coastal police or coast guard or Navy) as a surveillant.
- ❖ Intimation regarding launching of SCSP/TSP programme in one location may be intimated to the line department such as department of fisheries/ Panchayat/ Municipality or Corporation / Village Office/ Gramasabha/ tribal extension office/ tribal welfare office and department of forest and police (Local or coastal), coast guard and navy.

VII. MONITORING SCHEMES

The centres should coordinate the progress of the various schemes/ programs and design a comprehensive monitoring framework with well-defined indicators, covering provisioning, service delivery standards as well as outcomes. The Quarterly Performance Review Report (QPRR) (Q1-April to June; Q2 July to September; Q3 October to December; Q4 January to March of every calendar year) of centres should be communicated to Chairman TSP as well as to Director, CMFRI. Monitoring on the progress of SCSP and TSP work were done timely, for correction and improvement of the activities they perform under this project.

VIII. MANPOWER PLANNING, TRAINING AND ORIENTATION

The capacity building of the personnel at all levels shall also be taken up on priority for yielding the desired outcomes. Training and orientation should involve strategic planning and project management so that the problems faced by SC/STs and their point of view are addressed in the formulation and implementation of TSP. Trainees/beneficiary shall be providing a field manual in regional languages to facilitate effective implementation and monitoring of various schemes/programmes.

XI. CREATION OF GENERAL AWARENESS OF SCHEMES

Implementing centers shall take initiatives to generate awareness among the general public about the schemes to be implemented/being implemented for the development of SC/STs by the different departments of the State Governments such as Department of Fisheries, Panchayat, Corporation, Municipality, Forest Department, Police Department (Coastal and Local), Agriculture offices, Village offices, etc. through electronic and print media.

X. UTILIZATION OF FUNDS

The funds can be utilized for only those schemes which ensure direct benefits to individuals or families belonging to SC/ST

XI. Technologies transferred to SC& ST by CMFRI under TSP & SCSP projects:

Cage fish farming in sea and open water, Pond fish farming, pen culture, Biofloc fish culture, Ornamental fish breeding and culture, seaweed farming, lobster fattening, crab fattening, Oyster and mussel farming, small scale unit for seed production of food fish and grow out culture, etc. developed by ICAR -CMFRI has been transferred to the farmers field of SC &ST through CMFRI Head quarters and its Regional Centres and Regional stations. Effective implementation of the scheme is planned at each centres yearly and the technologies perfected haven been implemented at Scheduled tribe and Scheduled caste farmers field for their social and general upliftment.

XII P.I. AND CHAIRMAN, CENTRE CO-ORDINATORS, **CO-INVESTIGATORS. IN OPERATING CENTRES,**

H.Q - Kochi TSP&SCSP

Role/Position	Address
Director & Co- Ordinator	Dr. Grinson George , Principal Scientist, CMFRI, Kochi.
Chairman & Principal Investigator	Dr. K. Madhu, Principal Scientist, Mariculture Division, CMFRI, Kochi.
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Co-Principal Investigator	Dr. Ritesh Ranjan, Senior Scientist, Mariculture Division, Visakhapatnam Regional Centre, Visakhapatnam
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Co-Principal Investigator	Dr. Akhilesh K V, Sr. Scientist, FFD, Kozhikode Regional Station, Kozhikode

Mumbai Regional Station of CMFRI – TSP

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Co- Principal Investigator	Dr. Bhendekar Santhosh, Scientist, SFD Division, Mumbai Regional Station, Mumbai.

Karwar Regional Station of CMFRI – SCSP

Role/Position	Address
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Co-Principal Investigator	Shri.D.Linga Prabu, Scientist, Marine Biotechnology Division, Tuticorin Regional Station, Thoothukudi

Madras Regional Station of CMFRI – SCSP

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Co- Principal Investigator	Dr. A. Margaret Muthu Rathinam, Principal Scientist, Madras Regional Station, Chennai
Co- Principal Investigator	Srinivasa Raghavan V. Scientist, Madras Regional Station.
Co- Principal Investigator	Dr R. Jeyabaskaran, Senior Scientist, Madras Regional Station

Digha Research Centre of CMFRI – TSP & SCSP

Role/Position	Address
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Puri Field Centre of CMFRI – TSP & SCSP

Centre Co-ordinator& Co-Principal Investigator	Dr. Rajesh Kumar Pradhan, Scientist, SFD Division, Puri Field Centre, Puri
Co- Principal Investigator	Dr Gyannaranjan Dash, Principal Scientist, Puri Field Centre of CMFRI

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ENTREPRENEURSHIP IN MARINE ORNAMENTAL FISH CULTURE: A PROFITABLE VENTURE FOR SELF EMPLOYMENT

K. Madhu, Rema Madhu, Binoy Bhaskaran, Abhilash K.S., Liyakhath Ali A. and Veena George and N.H. Harikrishna

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Introduction

The trade of marine ornamentals has been expanding in recent years and has grown into a multimillion dollar enterprise mainly due to the emergence of modern aquarium gadgets and technologies for setting and maintenance of miniature reef aquaria. Aquarium keeping is amongst the most popular of hobbies with millions of enthusiasts worldwide and the trade of marine ornamentals has been expanding in recent years and grown into a multimillion dollar enterprise. The recent emergence of modern aquarium gadgets and technologies for setting and maintenance of miniature reef aquaria made the aquarium keeping much easier than previous. Since the marine ornamental trade is operated throughout the tropics, the global marine ornamental trade is estimated at US$ 200-330 million. India is endowed with a vast resource potential of marine ornamentals distributed in the coral seas and rocky coasts with patchy coral formations. In the context of the expanding global scenario and the increasing demand in the domestic trade, it appears very much lucrative for India to venture into this industry. But it is a multi stakeholder industry ranging from specimen collectors, culturists, wholesalers, transhippers, retailers, hobbyists, researchers, government resource managers and conservators, and hence involves a series of issues to be addressed and policies to be formulated for developing and expanding a sustainable trade. In recent years it has been reported that nearly 1500 species of marine ornamental fishes are traded globally and most of these are associated with coral reefs. Nearly 98% of the marine ornamental fishes marketed are wild collected from coral reefs of tropical countries such as Philippines, Indonesia, Solomon Islands, Sri Lanka, Australia, Fiji, Maldives and Palau. This has been threatening the long term sustainability of the trade due to indiscriminate exploitation of coral reef areas. The three key words in the development of marine ornamental fish trade are collection, culture and conservation. The development of technologies for hatchery production of selected marine ornamental fishes is the only option for evolving a long term sustainable trade without damaging the coral reef ecosystem. Even at an international level, the technologies for hatchery production of ornamental fishes are limited to a few species. The main steps in captive production of ornamental fishes are broodstock development, breeding, live feed culture, larviculture protocols, grow out methods, aquarium technology, diseases, packing and transportation, etc. Nearly 98% of the marine ornamental fishes marketed are wild collected from coral reefs of tropical countries. This has been threatening the long term sustainability of the trade due to indiscriminate exploitation of coral reef areas. The only alternative for the sustainable trade is the captive productions which involved broodstock development, breeding, live feed culture, larviculture, grow out, aquarium technology, diseases, packing and transportation, etc. The ICAR-Central Marine Fisheries Research Institute (CMFRI) has been focusing on this vital aspect for the past few years. CMFRI is successful in developing hatchery technology for 27 species of marine ornamental fishes. The marine ornamental fish trade is low volume and high value industry in rural and urban areas, and hence it is very lucrative to initiate a trade purely based hatchery produced species. The setting up of a small-scale hatchery with details of economics are also included in this manuscript.

Captive breeding of marine ornamentals in India: Initiatives by ICAR-CMFRI.

The investigations made in ICAR-CMFRI has resulted in the development of hatchery technology for 27 species of marine ornamental fishes such as clown fishes *Amphiprion percula* (True percula/ clown anemone fish); *A. ocellaris* (Common Clown/False clown aenemonefish); *A. sandaracinos* (Yellow Skunk Clown)*; A. frenatus* (Tomato clown), *A. clarkia* (Clark's anemone fish), *A. sebae* (Sebae clown)
A. perideraion (Pink anemone fish) *A. ephippium (Red saddle back anemone fish), A.nigripes (*Lakhadweep clownfish)*, Premnas biaculeatus* (Maroon clown/ Spine cheek anemone fish. The species under damsels for which technology developed under captivity included *Dascyllus trimaculatus* Three spot damsel);*D. aruanus* (Striped damsel)*; Pomacentrus caeruleus* (Blue damsel)*; P. pavo* (Sapphire or Peacock Damsel)*; Neopomacentrus nemurus* (Yellow tail damsel)*; N. filamentosus* (Filamentous tail damsel)*; Chrysiptera cyanae* (Sapphire devil);*C. unimaculata* (One spot damsel), and *Chormis viridis* (Green chromis), and also dotty back *Pseudochromis dilectus* (Redhead Dottyback), purple fire goby *Nemateleotris decora* (Madhu et al., 2014) for the first time in the world and three species of marine ornamental shrimps (Madhu and Rema Madhu,2002,2006; Madhu *et al.,* 2006a,b,c; Gopakumar *et al.,* 2007; Rema Madhu, *et al.,* 2007; Madhu *et al.,* 2008, Madhu and Rema Madhu, 2014, Madhu et al.,2016), *Pseudanthias marcia* (Marcia's anthias) (Anil et al., 2018) *Dascyllus carneus* (Cloudy Damsel (Muhammed Anzeer, et al.2019,**)** and designer clown fishes (Anikuttan *et al.,* 2022). It is well accepted that the trade developed from tank reared fish and other ornamentals is the final solution for a long term sustainable trade.

Entrepreneurship development:

The economic viability of ornamental fish production is more lucrative when compared to other mariculture species, due to their high unit value. The complete package of practices developed for their production can be taken up as an alternative livelihood option for small and large scale fish farmers. The transfer of technology to the public and private sector entrepreneurs who have approached for the technology is being planned by imparting hands on training through different modes under the Consultancy Processing Cell (CPC) of the CMFRI and organized trainings.In addition, the hatchery produced seeds are also being sold to the farmers and aquarium hobbyists and traders through Single Window System and seed counters are operational at marine hatcheries of CMFRI at Cochin, Vizhinjam and Mandapam. Public awareness on marine ornamental fish breeding and seed production is further enhanced through organizing awareness programmes, exhibitions, students awareness camps, exhibits in marine research aquaria under ICAR mega seed project, open house exhibitions, organized trainings for farmers, individual training to farmer on request, winter and summer school, CMFRI-HRD training, NFDB training on ornamental fish culture , Public –Private Partnership(PPP) programme, backyard hatchery setting, establishing ornamental fish rearing units under SCSP Schemes, Grow out units establishes by woman self help groups with close monitoring by CMFRI Scientist, PPP programme under AINP Ornamental fish breeding and culture and also provided consultancies for marine ornamental fish breeding and juvenile production. Established or given guidance for setting up marine ornamental fish breeding units for private entrepreneurs at Bangalore (2 units), Delhi (One unit) Kerala (5 units), Tamil Nadu (4 units) and Calcutta (1 units). This has resulted in the emergence of several ornamental fish trade shops all over the country. Recently the National Fisheries Development Board (NFDB) has also developed schemes to fund for ornamental fish culture in the unutilized hatcheries of the prawn farmers in India.

Major steps in captive breeding

For the breeding of ornamental fishes under captive condition, the following few important steps are to be followed apart from maintenance of high water quality, provision of suitable environmental parameters, creating suitable condition for spawning and system for raising the larvae and juveniles.

The major aspects involved in ornamental fish culture are:

- Collection and transportation of broodstock
- In case active broodstocks are not available, pair formation and broodstock developments to be under taken in captive conditions
- Breeding system/ broodstock rearing setup and management
- Provision of Substrate for egg deposition
- Feed formulation and broodstock feeding and feeding schedule
- Incubation of eggs, parental care and management of parameters.
- Morphology and embryology of eggs
- Egg hatching and larvae handling techniques
- Larval rearing
- Nursery rearing
- Grow out culture
- Quarantine
- Harvest of juveniles for trade
- Packing and transportation

Allied section to substantiate larval rearing

- Microalgae stock and mass culture (freshwater and marine)
- Zooplankton stock and mass culture (rotifers, copepods and cladocerans) for marine.
- Zooplankton stock and mass culture (rotifer, moina, daphnia and copepod) for freshwater species
- Zooplankton harvesting and handling
- Artemia cyst hatching and harvesting
- Live zooplankton bio enrichments

Setting up of a small-scale hatchery

Small-scale hatcheries for marine ornamental fish are those where the capital costs and technologies are accessible for relatively low cost which focuses on broodstock development, larviculture, nursery rearing and grow-out to marketable size. The small scale hatcheries can be easily adapted to culture a range of different species. A typical small-scale hatchery for marine ornamental fish consists of the following units and facilities.

1. Broodstock tanks
2. Larviculture tanks
3. Live feed unit
4. Nursery rearing and grow-out tanks
5. One sand filter
6. Outdoor live feed (Phyto and zooplankton) production tanks
7. Seawater and freshwater supply system.

Hatchery equipment and accessories

(i) Water Pump: Two types of pumps are required for the small-scale hatchery operation.
A pump of 5HP is required to pump seawater to the hatchery's sand filter tank. A separate submersible pump is required to distribute water within the hatchery system.
(ii) Generator: A generator of 1 KVA is essential as backup electricity supply for the hatchery.
(iii) Aeration system: Small 100 watt air pump with at least one backup is needed.
(iv) Other hatchery equipments

a. An ordinary microscope.
b. Thermometer
c. Salinometer
d. pH meter
e. Water analysis kit
f. Hand nets
g. Plastic wares like buckets, bins, hoses etc.

Optional

i. RAS
ii. Protein skimmer
iii. Chiller
iv. Aquarium Heater

(v) Manpower: The small scale hatchery can be managed by two full time staff – One technician and two workers. Basic training on technical aspects is needed for day to-day hatchery operation. Daily routine works include cleaning broodstock and larval tanks, feeding broodstock and larval tanks, harvesting microalgae, rotifers, *Artemia* etc.

Advantages of small-scale hatcheries

1. Low capital inputs
2. Simple construction
3. Ease of operation and management
4. Flexibility
5. Quick economic returns.

Economic Assessment

The candidate species selected for economic analysis is the true clown *Amphiprion percula.*

Capital Investment

This component involves all the expenditure on the infrastructure and establishment of the hatchery. The items included in this component generally have a life span larger than one year and they are used to generate the future income from the hatchery. The items include-:

Capital Investment items	**Quantum**	**Cost in Rupees**
Temporary Shed	144m2 (12 X 12m)	1,10,000
Tanks		6,40,000
i. Broodstock	12	
ii. Larval rearing	12	
iii. Nursery and grow out	18	
iv. Microalgae (outdoor)	4	
v. Rotifer (outdoor)	3	
vi. Sand filter /Over head tank	1	
Artemia hatching tanks (Transparent Perspex)	3	10,000
Power installation		10,000
4 HP diesel pump	1	19,000
1/2 HP submersible pump	1	6,000
Generator 2 KVA	1	30,000
Air pumps	2	40,000
PVC piping, plastic wares (water supply/aeration/drainage)		45,000
Netting, miscellaneous etc.		40,000
TOTAL COST		**9,50,000**

Operating expenses

This component is for the expenses that are spent during each production cycle and are essential for the routine operation of the hatchery. The items included are:

	Items	1st year	2nd year	3rd year
1	Broodstock fishes/Anemone	25,000	5,000	5,000
2	Feeds	12,000	12,000	12,000
3	Artemia	4,000	12,000	12,000
4	Chemicals for microalgal culture	6,000	6,000	6,000

5	Electricity	36,000	36,000	36,000
6	Diesel	24,000	24,000	24,000
7	Maintenance	12,000	18,000	18,000
8	Workers salaries(1xRs. 8000; 2xRs.5000)	2,16,000	2,16,000	2,16,000
9	Miscellaneous expenditures	12,000	12,000	12,000
	TOTAL	**3,47,000**	**3,41,000**	**3,41,000**

Non-operational expenses

These are related to the capital cost and investment write off. There are two items under this component for small-scale hatcheries.
i) Depreciation
ii) Interest on capital investment

Technical assumptions for production

It is assumed to be an indoor system located in a coastal area with access to both salt and freshwater and easy transportation access to market. There are 12 broodstock pairs. At any time there are 10 active spawning pairs. Each pair will spawn 2 times per month. An average of 400 larvae are produced during each spawn. The survival rate of the larvae to the grow out phase is 50%. The period from larvae to juvenile is 30 days. There is a 60% survival rate for juveniles to market size, which are saleable. The period from nursery to market size is 120 days. In a month, 240 saleable sized fishes can be produced from one pair of clown fish. Each fish can be sold at a rate of Rs.100. The sale of the fishes will start from second year onwards. The first year of operation will be construction and set up of the building, procurement of equipment and collection and maintenance of brooders. The first spawning is expected in eighth month of first year. The first harvest and sale will occur at the first month of second year.

Amount in Rs.			
	Year 1	**Year 2**	**Year 3**
Revenue			
Sale of clownfish fingerlings @ Rs.100/fingerlings(240 juveniles x 10 pair x12 month =28,800 numbers 28800 x Rs 100 = Rs. 2880000)		28,80,000	28,80,000
Non operating expenses			
a. Depreciation (20%)	1,90,000	1,90,000	1,90,000
Interest rate on capital investment @12%	78,000	78,000	78,000
Operating cost TOTAL EXPENSES	2,63,000	2,57,000	2,57,000
	5,31,000	**5,25,000**	**5,25,000**
Profit	———	**23,55,000**	**23,55,000**

Opportunities for Aquarium and allied business

Since marine ornamental fishes are a low volume high value species, the economic return is high when compared to other farming methods and it also creates other allied employment avenues such as aquarium tank designing, reef tank setting, Aquarium landscaping, planted aquarium, aquarium gadgets and accessories business, aeration system, filtration system, RAS, protein skimmer, creation artificial coral for aquaria, feed, live feed, feeding and colouring additives, coral and zoanthid propagations etc. Thus the opportunities offered by marine aquaria are enormous and the economic return in each sector is also high. As a result in the ornamental sector is advancing day by day and more and more entrepreneurs are emerging worldwide. Since India is endowed with a vast resource potential of marine ornamentals distributed in the coral seas and rocky coasts with patchy coral formations and the increasing the demand in the domestic trade, it appears very much lucrative for India to venture into this industry. But it is a multi stakeholder industry ranging from specimen collectors, culturists, wholesalers, transhippers, retailers, hobbyists, researchers, government resource managers and conservators, and hence involves a series of issues to be addressed and policies to be formulated for developing and expanding a sustainable trade.

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SEA CAGE FARMING

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Introduction

Cage culture involves growing fish in the sea while being enclosed in a net cage that allows free water flow. This production system consists of a floating frame of varying dimensions and shapes, net materials, and a mooring system to hold and culture a large number of fish. For economic feasibility, selecting proper designs, ideal construction materials, suitable mooring systems, and good management practices is crucial. Sea cage farming has gained significant attention in recent years from researchers and fishermen. Many small or resource-limited farmers are exploring alternatives to traditional fishing practices. Cage aquaculture is rapidly expanding and offers opportunities even on a small scale.

Understanding its importance, the Central Marine Fisheries Research Institute (CMFRI) initiated cage culture as a research and development activity in 2006-07 to identify appropriate designs and cage suitability for Indian conditions. The first open-sea cage, an indigenously designed and fabricated 15 m HDPE cage with a catwalk for onboard operations, was launched in the Bay of Bengal off Visakhapatnam in May 2007. After several trials and refinements, smaller 6 m diameter cages were developed for ease of operation and economic viability. CMFRI projects that utilizing even 1% of India's inshore waters could accommodate 820,000 cages, with a production potential of 3.2 million tons. Demonstrations continue across all maritime states to promote open-sea cage culture.

Advantages of Sea Cage Farming

Sea cage farming offers distinct advantages over traditional practices:

1. **Cost Efficiency**: Fabricating cages is faster, simpler, and more cost-effective than onshore farms. Initial investments are only 30-40% of those required for conventional pond aquaculture.

2. **Space Utilization**: Utilizes natural water bodies, preserving valuable land resources.
3. **Flexibility**: Cage location and size can be easily adjusted, enabling operational expansion.
4. **Unutilized Areas**: Open seas, lagoons, or sheltered bays can be used with proper permissions.
5. **Ease of Harvesting**: Fish are easier to harvest from cages.
6. **Market Stability**: Enables a steady fish supply to meet market demands.
7. **Livelihood Opportunities**: Provides an alternate livelihood and additional income.

Types of Cages

Cages are categorized based on installation:

1. **Fixed Cages**:
   - Suitable for shallow water bodies (<3 m depth).
   - Basic and low-cost, commonly used in small-scale aquaculture.
2. **Floating Cages**:
   - Supported by a buoyant collar.
   - Designs include square, rectangular, or circular shapes.
   - Materials: GI pipes, bamboos, or plastic pipes.
   - Suitable for water depths of 10-15 m.
3. **Submersible Cages**:
   - Variation of floating cages, allowing depth adjustment.
   - Often used in marine environments.
4. **Submerged Cages**:
   - Made of wooden boxes with gaps for water flow.
   - Anchored to the substrate with poles or stones.

Cage Design

Design considerations include species behavior, site conditions, and economic feasibility. Pelagic species require larger net spaces, making circular or hexagonal cages preferable. Conversely, demersal species thrive in square or rectangular cages, which are easier to assemble and manage.

Key Design Features:

- Technically simple and cost-effective.
- Supports sufficient water exchange.
- Securely holds fish during the culture period.
- Tailored to individual farmer requirements.

Cage Materials and Sizes

1. **Frames**:
    - Materials: Mild steel (MS), galvanized iron (GI), PVC, or HDPE.
    - Circular frames are preferred for better resistance to sea conditions.
    - Low-cost options include epoxy-coated GI frames (lasting 2-3 years).
2. **Net Cages**:
    - Made of HDPE, resistant to seawater and easy to handle.
    - Types:
        - **Predator Nets**: UV-treated HDPE, 3 mm thickness, 80 mm mesh size.
        - **Inner Nets**: HDPE, 0.75-1.5 mm thickness, 12-40 mm mesh size.
        - **Bird Nets**: HDPE or nylon, 60-80 mm mesh size.
    - Ballast pipes maintain net shape, with HDPE pipes preferred for durability.
3. **Sizes**:
    - Marine cages: Larger than freshwater cages.
    - CMFRI's standard designs include 6 m, 10 m, 12 m, and 15 m diameter cages.

Mooring Systems

Mooring systems secure cages against environmental forces such as wind, currents, and waves. The design depends on cage type and site conditions.

Components:

- Anchor or seabed unit.
- Rising line connecting the anchor to the surface system.
- Surface or subsurface mooring grid.

Types of Mooring:

1. **Single Point**:
    - Allows cage rotation.
    - Efficient in waste distribution.
2. **Multipoint**:
    - Retains cages in a fixed orientation.
    - Commonly used in aquaculture.

Stocking and Feeding

1. **Stocking**:
    - Use healthy, uniform-sized fingerlings.
    - Stocking density varies by species.
    - Nursery rearing is essential for hatchery-produced spawn.
2. **Feeding**:
    - Accounts for 60% of input costs.
    - Protein-rich diets (35-40%) are essential.
    - Feeding frequency and pellet size are adjusted based on fish growth.
    - Feed conversion ratio (FCR): 1:2 recommended.

Criteria for selection of fishes

- Survive in marine condition
- Fast growth
- Good FCR

- Minimum culture duration
- Good market price
- Seed availability
- Feed availability
- Disease resistance

Species available for marine cage culture

- Cobia
- Silver Pompano
- Indian Pompano
- Orange spotted grouper
- Seabass
- Red snapper
- Lobster

Species available for marine cage culture

- Silver pompano
- Groupers
- Red snapper
- Seabass
- Pearl spot

Harvesting

Harvesting can be partial or complete based on market demand. Fish are harvested once they reach marketable size, typically after six months. Cage farming enables easy, less labor-intensive harvesting.

Best Management Practices

1. Monitor cages regularly for maintenance and prevent fish escapes.
2. Optimize feeding protocols and use quality feed.
3. Maintain proper stocking densities to reduce stress.
4. Regularly monitor water quality parameters.
5. Clean and exchange nets periodically.
6. Inspect and maintain mooring systems.
7. Implement cage rotation or fallowing practices.
8. Avoid environmentally sensitive areas and ensure site sustainability.

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SUCCESS STORIES ON EMPOWERMENT OF AND ADOPTION OF CAGE FARMING OF FISHES BY ULLADEN TRIBES IN SOUTHERN KERALA THROUGH TSP OF ICAR -CMFRI, KOCHI

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The Ulladan are an indigenous Scheduled Tribe group found in Kerala, south India, and they are so named because they come from the interior forests, and some of them still live near the forests of Kerala and Tamil Nadu, though government has taken initiatives for their settlements. Hunting and fishing are the major source of revenue and way of life. Despite government control over growth, they have a low standard of living and a dated educational system. The community might gain a lot from improvements to these conditions, and preservation of their distinctive cultural legacy could also be aided. Considering these facts, CMFRI has taken initiatives to transfer the technology developed for fish farming in cages to the tribal population. For this CMFRI officials had visited various tribal extension offices, including Kottayam District and Ernakulam Districts and visited the tribal settlement colonies at Thandaserry, Chemmanathukara, North Paravoor and Thathappally. The farmers from these settlement colonies were given Hands on training on various aspects of cage farming right from cage fabrication, float tying, launching, mooring, net tying, seed handling and transportation, seed treatment prior to stocking, hapa rearing of seeds, daily feeding, release of seeds from hapa to cage, feed management during different phases of culture, net cleaning and exchange, monthly sampling and growth monitoring. Partial and need based harvest.

Under the Tribal Sub-Plan (TSP) programme of Head quarter of CMFRI, Kochi has selected farmers from Thandassery colony and formed a self-help group named "Sreelekshmi" with 20 participants and launched four cages in the brackishwater area near to their residence for carrying out the cage culture activity. The cages (4x4x3m) were stocked with Pearl spot *Ertoplus suratensis* (600Nos) and *Tilapia mossambica* (600Nos) in 1:1 proportion in each cage. The fishes were fed with Growel feed of size 0.5 to 4mm ranging protein level 32 to 40% and 10 % crude fat at different stages of culture.

At Chemmanathukara, Vaikom Kottayam District, the Jelarani Self Help Group was formed for undertaking cage fish farming and were provided 3 cages and launched it in Kariyar brackish water for undertaking culture of *Ertoplus suratensis*. Each cage were stocked with 1200 Nos of *Etrolpus suratensis*. The fishes were fed with assorted size of Growel feed during the culture period and successfully harvested four crops during 2020 to 2023 and earned 1.5 to 1.75 lakh/cage /year by the farmers, and the farmers are continuing the cage culture and adopted cage culture as a livelihood option.

All the support in terms of inputs (Cage unit, Inner and outer HDPE Nets, hapa nets, walkway, seed, Feed, fish scoop nets, Camera units, solar light etc.) and scientific and technical guidance were provided through TSP scheme of CMFRI throughout the culture period.

Calicut Regional Station of ICAR-CMFRI, Mavilan tribe, residents of Kurichikunnu colony of Pariyaram Gram Panchayath, Bekal, Kasargod were selected and formed two self-help groups namely "Navodya" and "Sangamithra" for carrying out the cage culture activity. Totally, 22 Mavilan tribal beneficiaries were involved under this programme. Calicut Regional Station of ICAR-CMFRI offered training and onsite demonstrations on grow-out culture of marine fishes in cages. The culture of Asian seabass, *Lates calcarifer* (Kalanji) and Pearl spot, *Etroplus suratensis* were carried out in five cages of 4x4x3m(48 m^3). Fishes were fed with nutrilla floating pellet feed (45% protein and 10 % crude fat). All the technical and financial support for the cage farming practices was provided by ICAR-CMFRI. After 8-9 months culture period, the sea bass reached an average size of 1-1.5 Kg and pearl spot reached 200-250 gm size. The 48 m^3 cage with a stocking density of 600 numbers of seabass yielded gross revenue of Rs. 1.8 lakhs and net profit of Rs. 86,200 per cage in 8 months culture period. The internal rate of return was 88.5% with a benefit cost ratio of 2.29. The pearl spot required culture duration of 8 months in cages to reach marketable size (200-250 gm). Two thousand fingerlings (4 cm) purchased @ Rs. 10/ fingerling were stocked in 4 m x 4 m x 3m size cages. During the culture period, the fishes were fed with pellet feed initially at 12 percent of the body weight, then reducing to 3 percent of the body weight as the culture progressed. Pearl spot is also having a very good market demand (about Rs 500-600/ kg) in local market. The 48 m^3 cage with a stocking density of 2000 numbers of pearl spot yielded a gross revenue of Rs. 1,75,000 and a net profit of Rs. 55900 per cage within a culture duration of 8 months. The internal rate of return was 86.9% with a benefit cost ratio of 4.25. The partial harvest of cage culture turned out to be an encouraging economic support to the Mavilan tribal community.

Initially, during the first four years of fish farming, beneficiaries received comprehensive support encompassing both technical guidance and financial assistance from ICAR-CMFRI. However, in subsequent farming seasons, the assistance transitioned to solely technical support. This successful demonstration on the culture of high value marine finfishes in low-cost estuarine cages provided an opportunity for improving their livelihood status as well as empowered them to continue the cage culture activity in the upcoming years without any financial support. This endeavor not only provided economic support but also empowered the Mavilan tribes of Kasargod to sustain cage culture independently. The successful cultivation of high-value marine finfishes in low-cost estuarine cages not only diversified income sources but also significantly enhanced the livelihoods of the tribal population, offering a sustainable pathway for their future.

	
4×4 m dia GI cages installed at Nettoor	**Transportation of seabass seeds in insulated truck**
	
Demonstration on preparation of floatation system for cages at Bekal, Kasargod	**Certificate distribution to tribal beneficiaries**
	
Stocking of seabass seeds in cages	**Distribution of weighing balance to women beneficiaries**


Harvest of pearl spot, *Etroplus suratensis*


Harvest of seabass, *Lates calcarifer*


Marketing of fish by Mavilan beneficiaries

Harvest of *E. suratensis*

BIOFLOC TECHNOLOGY (BFT) FOR FARMING OF FISH IN LAND LOCKED AREAS

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Introduction

Biofloc technology (BFT) is an innovative aquaculture system that focuses on maintaining a healthy and sustainable aquatic environment for the production of food fishes in captivity. The basic principle of BFT is the retention of waste (such as uneaten feed, feces, and other organic matter) and its conversion into natural food called biofloc which consist of a mixture of suspended organic matter, microorganisms, and small particles, through the activity of microbes, particularly bacteria, algae, and other microorganisms within the culture system. This is done by beneficial bacteria under constant aeration and addition carbon sources. The organic matter undergo aerobic decomposition and maintain high levels of microbial floc in suspension in biofloc tank or fertilized ponds (Avnimelech *et al*.,1986, Avnimelech1999, 2007).

The key principles of BFT:

1. **Waste Retention**: Instead of discharging waste into the environment or relying on water exchanges to maintain water quality, BFT systems maintain and manage waste in the culture system. This waste is primarily from uneaten feed and fish excretion, which are naturally converted into beneficial bioflocs.
2. **Biofloc Formation**: The waste organic matter (e.g., uneaten feed, feces) serves as a nutrient source for microorganisms. These microorganisms, including bacteria, algae, and protozoa, break down the organic matter into simpler compounds, and this process results in the formation of biofloc—aggregates of microbial biomass, detritus, and particles suspended in water.
3. **Conversion to Natural Food**: The biofloc itself becomes a **natural food source** for the cultured organisms, such as fish or shrimp. The microorganisms in the biofloc are consumed by the aquatic organisms, providing them with nutrients such as proteins, vitamins, and minerals. This reduces the need for external feed, which can lower feed costs and increase sustainability.
4. **Water Quality Management**: The microbial community in the biofloc system helps maintain water quality by converting toxic ammonia and nitrite (produced by the fish) into less harmful compounds, thus enhancing the overall health of the aquaculture system. The presence of biofloc helps in maintaining a balanced nitrogen cycle and controlling water pollution.
5. **Sustainability**: Biofloc technology promotes a more **sustainable** aquaculture system by recycling nutrients and reducing the reliance on external feed and water exchange. The system can significantly reduce water usage and waste output, making it suitable for areas with limited water resources.

Biofloc Technology (BFT) is considered as new "blue revolution" since nutrients can be continuously recycled and reused in the culture medium, benefited by the minimum or zero-water exchange. The BFT creates a self-sustaining aquaculture environment where waste is not merely a pollutant but a resource that can be converted into useful food, improving both the environmental impact and productivity of the system. BFT is an environment friendly aquaculture technique based on *in-situ* microorganism production.

Advantage of BFT

Eco-friendly fish culture system .
Enables high density fish farming
It reduces environmental degradation .
Effective and judicious use of land and water
Limited or zero water exchange system
High survival, growth and feed conversion
Reduces the need for external feed
Enables fish culture in land locked and interior locations
Alternative method for production of fish protein
Reduces threat of poaching.
Less land is required.

Criteria for Selection of species for BFT

- Species should able to derive nutrients from floc by directly consuming biofloc.
- Should able to tolerate high solids concentration in water.
- Should able to tolerate fluctuating water quality.
- High Growth rate
- Consumer preference

Fish Species suitable for Biofloc Culture

Non air-breathing fishes like **Gift Tilapia,** Tilapia (*Oreochromis niloticus*), Common Carp (*Cyprinus carpio*), Rohu (*Labeo rohita*), Milkfish (*Chanos chanos*)

Air breathing fish like Anabas/Koi (*Anabas testudineus*), Magur (*Clarias batrachus*), Singhi (*Heteropneustes fossilis*), Pabda (*Ompok pabda*), Pangasius (*Pangasianodan hypophthalmus*)

Murrels***:*** Snakehead murrel *Channa striatus* (CS) (in clear water)

Shellfishes like Vannamei (*Litopenaeus vannamei*) and Tiger Shrimp (*Penaeus monodon*)

Biofloc Tank size and capacity

Sl No	*Tank Diameter (Meters)*	*Approximate volume maintained (Litres)*
1	*2 m dia*	*4000*
2	*3 m dia*	*14000*
3	*4 m dia*	*25000*
4	*5 m dia*	*39000*
5	*6 m dia*	*56000*
6	*20 m dia*	*628000*

Biofloc Base and Tank preparation

A cylindroconical basement (sloping towards centre) for the biofloc tank is made for the required diameter with central drain out lines and over flow pipe. After the construction, the biofloc frame is placed on the basement and the sides of frame are fixed with nut and bolt. After this the pond is lined with anti-rat sheet, soft net sheet or polyform sheet and then lined with 600 GSM pond liner with fixing central drain. The pond is also connected with syntex tank for water connection and a float valve is fixed in the biofloc tank to enable automatic filling of water.

The tank is also provided with aeration so that an oxygen level of 5.0 to 6.5 mg/l is maintained. Once the pond is filled with water, the tank is aerated for 24 hrs for conditioning the water and to maintain water quality.

Fig 1.Leveling of the plot and construction of a platform for a 5 diameter biofloc tank.


Fig 2. Biofloc unit (5 meter dia) installed with shed at farmers field

Floc preparation (5 m dia tank with 39000 L)

Take 3-5 kg of Jaggery and boil in 5 litres of water and cool it over night. Next day sieve this jaggery solution and add to 100 to 200 litre water in a bucket and aerate vigorously. Dissolve 15-50 gm floc powder in 1 litre water with constant stirring. Add this inoculum to the 200litre jaggery solution and aerate for 24 hrs. After 24hrs, add this cultured inoculums to biofloc tank water, provide aeration and allow the pond to mature for 5 to 7 days. Daily floc level need to be examined using Imhoff cone. If the floc level is less, additional carbon source (Sugar/ Jaggery, Wheat flour /Tapioca flour) can be added to maintain CN ratio in the biofloc system. After 7 days the tank will be ready for stocking fish seed.

Seed Stocking & Feeding

The seeds of required fish can be stocked as per tank size. Feeding of fishes with pellet feed (0. 5 to 1.0mm) depending on size of fish can be started after 2 - 12 hrs of stocking depending upon species. The feed ration can be from 2 to 3 % of body weight per day. The feed size can be increased from 0.5mm to 0.6, 0.8, 1.0, 1.2, 1.8, 2.5, 3.0,4.0, 5.0 and 6.0mm during the period of 10 months culture period after ensuring growth. The major pellet feeds used are Growel, Nutrilla, Cargill Unomei and Skretting fish feed. Feeding should be done 3 to 4 times per day in split dose depending upon species.

Environmental parameters

Daily bottom water need to be drained out in the morning and evening to remove feces. Top up the tank with fresh water to maintain water level. Environmental parameters like Dissolved oxygen (DO), pH, floc levels need to be measured once in a week and corrective measures to be taken. Daily monitoring of Floc level, its colour and liveness of floc may be monitored for corrective measures.

Growth measurements

The fish growth need to be ascertained every month and health of fish also should be considered. Depending upon growth, the feed size and feed quantity need to be adjusted.

Harvesting

The harvesting can be done during 8 to 10 months of culture period depending upon growth.

Fig 3 . Seed stocking in 5 meter dia biofloc tank

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CASE STUDY: BIOFLOC FISH FARMING OF GENETICALLY IMPROVED FARMED TILAPIA (GIFT) UNDER TSP SCHEME AT VAIKOM (KOTTAYAM DISTRICT) AND KANNICKAL, IDUKKI DISTRICT KERALA

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The Ulladan are an indigenous Scheduled Tribe group found in, Kerala, south India, and they are called so, as they come from the interior forests, and some of them are still living adjacent to forests of Kerala and Tamil Nadu. Hunting and fishing are a main source of income and way of life. Each locality has one elder called Ooru moopan (village head man), who will oversee significant problems and issues. Although development is taking place under the control of the government, their standard of living is low and educationally backward. Efforts to improve these conditions could greatly benefit the community and help preserve their unique cultural heritage. With a view to empower these community , CMFRI has selected willing Ulladan farmers form IHDP colony, Chemmanathukara, Vaikom, Kottayam district and Kannickal, Moolamattom Idukki District for biofloc fish culture. The farmers were given on hand training on various aspects of biofloc fish farming, water quality analysis and exposure visits to biofloc culture sites.

Biofloc technology (BFT) is an emerging fish culture method that is ensuring sustainable aquaculture production, where the water treatment is done *in-situ.* The BFT indeed revolutionizes aquaculture by creating a closed system that mimics natural ecosystems. In this method, high-density aquatic organisms are reared in tanks with limited water exchange. Instead of relying solely on external feed, the system promotes the growth of beneficial microorganisms within the water, which form aggregates called bioflocs. These bioflocs serve as both a source of nutrition and a natural water filtration system. As organic matter is converted into microbial biomass, it provides a sustainable food source for the cultured organisms, reducing the need for external feed inputs and minimizing environmental impact. BFT has gained popularity for its potential to improve water quality, increase production efficiency, and reduce operating costs in aquaculture operations worldwide. CMFRI has initiated Biofloc farming.

Biofloc technology is a promising fish culture method to undertake fish farming in the landlocked interior areas of tribal and SC community locations that have no access to coastal water, brackishwater or any other open water system. Under TSP, CMFRI Head Quarter has established 5 meter dia Biofloc units at farmers' site depending upon their land availability and amenity to water and electricity. The units were stocked with 2000 nos of GIFT Tilapia. The work was undertaken under full support and guidance from CMFRI (HQ) through its Tribal Sub Plan Scheme. The farmers were trained for the various aspects of biofloc : such as fish seed transport, seed disinfection, seed handling, seed stocking, daily water quality checking& maintenance, floc level monitoring, feeding, growth monitoring and water exchange. Since the maintenance of BFT is easy and the work is done near to their house premises, it was an added advantage for the women and old age persons to involve in this fish culture method and it has got wide spread popularity and acceptance among farmers.


Training programme on Biofloc farming


Trainees at Biofloc site


Seed Stocking at Vaikom, Kottayam


Fishes in the biofloc tank


Harvest Mela at IHDP Colony Vaikom


Team Trust- Kannickkal, Idukki

The culture period was lasted for 8 to 10 months and during this period, pellet feed (0.5 to 4 mm) were supplied at each phase of culture after analyzing growth. After 8 months , the farmed fish reached 400 to 500 gm and the farmers harvested 900 to 1000kg fish/ 5 meter biofloc tank and earned 1,80000/- to 200000/-. Since the fishes are sold in live condition, consumer demand was more. Since this approach is simple and practical and can be undertaken at their house premises (backyard), the beneficiaries (women and age old people) are more interested in the biofloc technology. After the successful harvest of biofloc farmed fishes, the farmers took this method of farming as a livelihood option and continuing the farming of fishes in Biofloc system.

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EDIBLE OYSTER FARMING IN INDIA

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Introduction

The oysters are highly esteemed sea food and considered a delicacy in USA, Europe, Japan etc. In India there is a growing demand for oyster meat in some parts of the country. It is said that 'oyster' is scientifically the best known marine animal. It is one of the most widely cultivated species. As early as the first century BC the Romans were the first to develop simple methods of collecting oyster seeds and growing them for food. The Japanese developed 'Habitat culture technique i.e. culture in nets fixed to bamboo poles during the seventeenth century and at the turn of the 20th century they evolved off bottom culture, especially hanging methods. These methods yielded good results and were adopted by majority of oyster farmers of Japan as the environmental conditions of the coastal areas were highly favourable for practicing these methods. Until recently, oyster farming has been considered as a traditional practice followed only in the temperate countries. The awareness about the vast potentialities for development of oyster farming in tropics is recent. Serious efforts are now being directed in its development under tropical conditions.

Scope for oyster farming in India

In India pioneering attempts were made by James Hornell in 1910 in developing Oyster Culture in erstwhile Madras state. Central Marine Fisheries Research Institute undertook scientific investigations at Tuticorin from early 70's and as a result, complete package of the technology is now available in the country. Vast stretches of backwaters, estuaries and bays spread over several lakh ha. are present along Indian coast harbouring natural population of the oyster suggesting suitability of the habitat for oyster culture. Being filter feeders, the oyster converts primary production in the water into nutritious sea food. Since the oysters are filter feeders, in oyster farming supplementary feeding is not required. However the quality of water should be good and should contain sufficient feed for the oysters.

Oyster Resources of India

The average annual production of edible bivalves during 1996 to 2000 is estimated as 1.52 lakh tonnes, about 2.5 times more than the average landings during the period prior to 1996. Clams and cockles form 73.8%, followed by oysters (12.5%), mussels (7.5%) and window pane oysters (6.2%).

Oysters which are cemented to the substratum are fished by separating them from the rocky substratum or dead oysters to which they adhere using tools that have a flat end like chisel or knife. In Kerala, oyster fishery is limited to certain estuaries like Dharmadam, Kayamkulam and Ashtamudi Lake. About 1200tonnes of oysters comprising both *Crassostrea madrasensis* and *Saccostrea cucullata* are landed in Kerala state. *Crassostrea gryphoides*,*C.rivularis* and *Saccostrea cucullata* are fished from the creeks of North western maritime states but a well organized fishery is not in vogue. The oyster production is mostly utilized for local consumption. *C.madrasensis* is the dominant species from the fisheries point of view. It is euryhaline, tolerates wide variations in salinity and inhabits backwaters, creeks, bays and lagoons and occurs, from the intertidal region to 17 m depth.

Food and Feeding Habits

The food consists of organic detritus and phytoplankters such as diatoms and nanoplanktons. The food particles are entrapped in the mucus of the gills and are passed in the water currents towards the mouth by the rapidly beating gill cilia (fine hairs).

Reproduction

In the genus *Crassostrea* sexes are separate but occasionally hermaphrodites occur. During spawning, ripe eggs and sperms are discharged into the exterior where fertilization takes place. Temperature food availability and salinity are considered as important exogenous factors, in influencing the maturation of gonads. A single female measuring 80-90 mm spawns 10 to 15 million eggs at a time.

Condition Index

The condition index of the oysters denotes the quality of the meat and it is useful to determine the best period for harvest. It is also helpful to assess the suitability of a locality for culture. High condition indicates greater proportion of meat in the whole weight of the oyster; those in prime condition are tasty when compared to the flaccid and watery meats of oysters in poor condition.

The soft body of the oyster undergoes changes, which are usually related to the reproductive cycle. During the maturation process the gonad increases in weight resulting in increase in the weight of soft body. Before the commencement of spawning the condition index reaches high value and with the release of gametes, the soft body of the oyster loses weight. The condition factor is studied based on weight, volume of both. The percentage of wet flesh weight in total weight gives the condition.

Condition Index = Weight of dry meat weight x 1000 / Volume of shell cavity

In *C. madrasensis* the condition is considered as high if it is above 140 and poor if it is below 70.

Edible Oyster Farming in India

Oyster farming technology developed by Central Marine Fisheries Research Institute is a simple and easily adaptable technique. Since 1993 concerted effort has been put in by CMFRI to popularize this technology. Kerala, is the first state to commercialize this technology and many coastal villagers have benefited from this. These farming activities have increased national production of farmed oyster from nil to 140 tonnes in 2000. One of the significant factors is that more than 80% of the oyster farmers in Kerala are women and they have emerged as productive, self reliant participants for improving the families' nutritional and living standards.

Culture Technology

Edible oyster culture is a very simple technology, which can be easily practiced. There are a few critical factors (such as seed collection and harvesting period) which are governed by the biology of the species which affect the profit of the farming operations. The farmer can easily understand these aspects by observation and practice. The oyster culture protocol practiced in India is given.

Seed Collection

Oyster seed are collected from estuaries by placing suitable collectors called cultch in the water column at appropriate period. During spawning seasons the spat collectors are suspended from racks. *Crassostrea madrasensis*, commonly known as the Indian backwater oyster is the major oyster resource of India. Apart from this species, there are three more species which are of lesser importance viz. *Crassostrea gryphoides, C. rivularis* and *Saccostrea cucullata.* Spawning season of *Crassostrea madrasensis* along Kerala (Ashtamudi) is November-December. In Ashtamudi a growth rate of 70 mm in 7 months is obtained

How to prepare a cultch?

Cultch is the term used for spat / seed collector. For suspended method of oyster culture cutch made of oyster shells have been found to be ideal. Empty oyster shells are cleaned manually to remove the foulers and then washed to remove silt. A small hole is made on the shell and these are strung on 3mm dia nylon rope with a spacing of 15 to 20 cm between each shell (5 shells per meter rope). Such strings are called ren. The spaced rens can be used as such for grow out system. For seed collection purposes the shells are strung continuously without spacers (10 to 15 shells per meter) and after the attachment of seed they shells can be removed and restrung at the rate of 5 shells per meter which is the ideal density for grow out. If the oysters are to be grown by the tray method then empty shells or lime coated tiles can be placed in the trays for seed collection. Lime coated tiles gave encouraging results and on a single tile, as many as 120 larvae are known to settle.

When to place the cultch for seed collection?

One of the main factors that determine the success of the farming operation is the period when the clutches are placed for seed collection. If they are laid in advance of spatfall, they may be covered with silt or settlement of foulers , making them unsuitable for the oyster larvae to settle. The larval period in *C. madrasensis* is 15-20 days. The ideal time for laying the spat collectors in the water is about 7 -10 days after peak spawning (as determined by gonad examination and abundance of early larval stages in the plankton). Strong currents interfere with larval settlement and may result in poor spat collection.

Selection of farm site

For site selection several factors are to be considered

	Parameter	***Range***	***Methodology for determination of the parameter***
1	Salinity (ppt)	10 to 38	By titration or refractometer
2	Depth (m)	1.5 – 4	By sounding or manual
3	Temperature ^{0}C	23- 34	Using thermometer
4	Dissolved oxygen mg/l	3 – 5	Winkler method or by using probe
5	pH	6.5 – 8.5	pH meter or pH paper
6	Turbulence due to wave (m)	< 0.5 to 1	By observation and local enquiry

Contd.	Parameter	Range	Methodology for determination of the parameter
7	Water current m / second	1 – 5	Current meter or from literature
8	Clarity (m)	0.5 –1.5	By Sechii disc
9	Availability of seed	Within 100 m	By enquiry / observation
10	Local market	Average to good	By enquiry / observation
11	If free from various pollution like	Fecal	By enquiry / observation
		Industrial	
		Agriculture	
		Sewage	
		Retting	
		Oil	

Sheltered areas offering protection from strong wave action are preferred. From intertidal region to areas extending upto about 5 m depth can be considered for adopting suitable culture method. Similarly the culture technique is adopted depending upon the type of substratum. On-bottom culture method is substrate-specific while off-bottom method has little to do with the nature of substratum. Large-scale moralities have been reported in salinities below 10 and above 40 ppt when the natural oyster populations of *C. madrasensis* were exposed for prolonged periods. The natural populations occur at a temperature range of 21 to 31 ^{0}C.

Farming methods

They are broadly grouped as bottom (on bottom) culture and off-bottom culture. Raft, rack, long-line and stake are used in the various off-bottom culture practices. The off-bottom culture methods are advantageous over the bottom culture in the following respects.

1. Relatively rapid growth and good meat yield from farming.
2. Facilities three-dimensional utilization of the culture area.
3. The biological functions of the oyster such as filtration feeding etc. are carried out independent of the tidal flow,
4. Silting and predatory problems are negligible.

On bottom culture

The oysters are grown either in the intertidal or subtidal area directly on hard substratum. For intertidal culture a minimum of 16 hours submergence is suggested to ensure adequate food supply. Oyster seed attached to the collectors are planted on the bottom and allowed to grow for the market. The disadvantages of this method are increased exposure to benthic predation, siltation and low production. In U.S.A. the production is estimated at 5 t/ha/year and in France 7.5 t/ha/year. This method is yet to be experimented in India.

Rack and Ren Method

It is also called ren method. The racks are constructed in 1 to 2.5 m, depth There are several variations in the types of racks. The single beam rack consists of a beam placed and secured to the top of posts driven into the bottom. A series of single beams are placed in a row. The crossbeam rack is constructed by placing cross bar on top of single posts and two long beams are secured on the end of cross beams. In the farm, the shell strings are suspended from racks. The mortality (including those fallen) is about 45%.

Rack and Tray Method

The nursery-reared single spat (cultch-free) measuring about 25 mm are transferred to trays of size 40 x 40 x 10 cm at a density of 150 to 200 oyster lings/ tray. The tray is knitted with 2 mm synthetic twine of appropriate mesh and is suspended from rack. Once the oysters reach 50 mm length they are segregated and transferred to rectangular tray of size 90 x 60 x 15 cm these trays are placed on the racks. Each tray holds 150 to 200 oysters. The average growth rate of the oyster is 7 mm/month and at the end of 12 months the oysters attain an average length of 85 mm in Tuticorin. The production is estimated at 120 t/ha/year. Compared to the string method, this method gives production but the production cost is high.

Farm management

Periodic checking of the farms is essential. The main points to be checked are replacement of broken farm structure and resuspending loosened rens which touch the estuarine bottom. High mortality rates have been observed when the rens fall on the ground. To tide over these problems periodic checking is essential.

Predators and foulers are also a menace to oyster farmers. Crabs, fishes, starfishes, polychaetes and gastropods are the predators of oysters. At Tuticorin predation of the oysters by the crabs *Scylla serrata* and *Pagurus* sp. has been observed on a small scale.

Barnacles are fouler that settles on the wooden structures, trays and oysters. It competes for food with the oysters. It also increases the weight of the ren causing damage to the farm structure.

Large scale moralities of oysters due to the diseases caused by the fungus *Perkinsus marinus*, and the protozoan parasite *Minchinia nelsoni*, have been reported from temperate countries. Oysters in the natural bed at Tuticorin have been observed to be infected by *P.marinus*.

Harvest of oysters

The oysters are harvested when the condition is high. At Tuticorin good meat yield is obtained during March-April and August-September and along Kerala harvest is ideal during May in Vembanad and Chettuva estuary and during August – October in Ashtamudi Lake. Generally high condition index is obtained when the gonad is ripe prior to spawning. Harvesting is done manually.

Post Harvest Processes

The technology adoption of oyster farming has been slow, mainly because of the difficulty in post harvest handling of oysters and the limited markets. Even among oyster consumers, the preference is for cooked meat, rather than whole and live, making heat shucking a necessity. Heat shucking is tedious in the case of oysters as compared to mussels, as they open their valves only on strong steaming.

Besides, oyster processors in- variably complain about cuts and bruises on their hands while shucking the oyster meat. So much so, many first-time oyster farmers in Ashtamudi, Kayamkulam and Vembanad Lakes of Kerala have switched to mussel farming. However, this trend is recently being reversed due to better market price and also the realization that oysters are more euryhaline than mussels, and hence more conducive for culture in an estuarine environment.

Depuration

Oysters, like other filter-feeding bivalves, accumulate pathogenic organisms in their body. The bacteria of concern are *Vibrio, Salmonella* and *Escherichia* (Coliform type). Members of the *Salmonella* group cause typhoid fever, while coliforms and vibrios cause gastroenteritis. By depuration the bacterial load is brought down to permissible levels, also feces, sand particles and silt are removed from the alimentary canal of oysters.

The oysters are placed for 24 hours in cleaning tanks under a flow of filtered seawater. About 10-20% of the seawater is continuously replaced. At the end of 12 hours the water in the tank is drained and oysters are cleaned by a strong jet of water to remove the accumulated feces. The tanks are again filled with filtered seawater and the flow is maintained for another 12 hours. Then the tanks are drained and flushed with a jet of filtered sea water. The oysters are held for about one hour in 3 ppm chlorinated seawater, and then washed once again in filtered seawater before marketing.

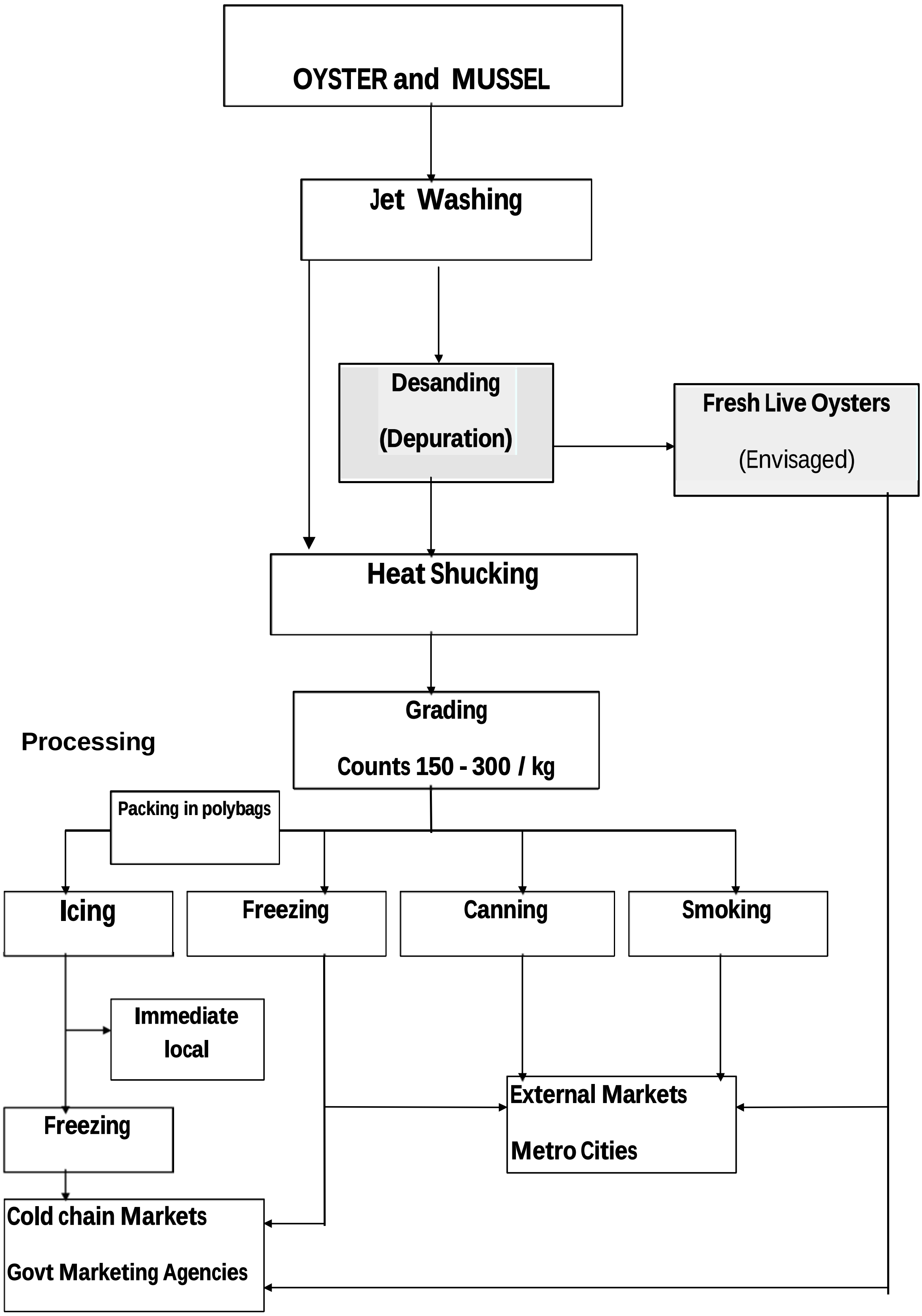
Transport and storage

Oysters kept under moist and cool conditions survive for several days. However it is desirable that they reach the consumer within three days of harvest. Studies indicate that oysters packed in wet gunny bags are safely transported for 25-30 hours without mortality and in good condition.

Shucking

The removal of the meat from the oyster is called shucking. A stainless steel knife is used for the purpose. To render shucking easy, oysters are subjected to a wide range of treatments such as exposure to week hydrochloric acid, heat cold, vacuum, microwaves and lasers. Freezing the oysters, or immersing them in hot water are the two methods commonly followed. However in India steaming the oysters for 5 to 8 minutes has been found to be ideal to make the oysters open the valves

POST-HARVEST FLOWCHART



Oysters are eaten in fresh condition in the half shell in many countries. The oysters are processed in several ways.

Frozen oysters

After depuration whole oysters (shell-on) are frozen by spreading them in a single layer of trays in an air blast freezer with polypropylene film stretched over each tray. Frozen whole oysters packed in polythene bags remain in good condition for six months in cold storage at 25 o C. The liquid within the shell acts as a glaze to protect the meat from dehydration. Shucked oyster meat is also frozen either in blocks or individually.

Canned oysters

Oyster meat is chilled, washed and blanched in 3% brine containing 0.1% citric acid for 4 to 5 minutes. The balanced meat is packed in cans, and hot 2% brine with 0.1% citric acid is added to the cans. The cans are seamed, sterilized at 115º C for 25 minutes and immediately chilled and stored

Smoked oysters

The meat is washed, treated with 5% brine for 5 minutes, drained, dipped in edible oil, spread in a single layer on a nylon wire mesh, drained again and loaded into a smoking chamber. The meat is held in dense smoke and maintained at a temperature of 40 o C for 30 minutes and later at 70 o C for 90 minutes. The smoked oysters are filled in cans with hot refined oil. The cans are seamed, sterilized at 115^{o}C for 25 minutes and immediately chilled and stored.

Oyster stew

Oyster which are too large or badly cut while shucking or those in low condition, are prepared as for canning but are chopped into small pieces and added to milk and spices.

Byproducts and utilization

The two shell valves constitute about 85% of the total weight of oyster and contain 52-55% calcium oxide. They are used in the manufacture of calcium carbide, lime, fertilizers and cement. They are useful spat collectors in oyster culture. The shells are broken to pieces and used as poultry grit.

Quality of Oyster Meat and Shell

Oyster meat is relished in most nations. The proximate composition of the oyster meat and the medicinal values attributed to it are given below.

- ❖ Oyster meat consists of 52% protein, 14% glycogen and 11 % fat
- ❖ Oyster powder contains wide range of minerals and vitamins and the amino acid taurine, which has complex medical properties.
- ❖ Oyster powder has shown good results in skin care, numerous heart ailments, blood pressure, liver problems, arthritis and rheumatism, diabetes, water retention, premenstrual tension etc.

Some useful information for planning oyster culture in Kerala

Ideal location	Estuaries with salinity 10 to 32 ppt
Duration of culture	6 to 8 months
Season for culture	Post and pre-monsoon (November to May)
Source of Seed	Natural oyster beds
Method of seed collection	By placing rens during post-monsoon period
Ideal grow out structure	Rack
Material necessary for oyster farming	3mm nylon rope Empty oyster shells Bamboo / casuarina poles
Source of funding	Subsidy given by FFDA/ADAK
Market	As Fresh oysters locally Or to IFP, Cochin as heat shucked meat
Disease problems	Till now no reports
For training for farmers/ officials Pl. contact -	CMFRI, Kochi.

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MUSSEL FARMING: AN AVENUE FOR INCOME GENERATION IN COASTAL STATES

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Introduction

Mariculture of bivalves assumes greater importance in meeting the increasing protein demands of the human population. Bivalve groups such as oyster, mussel and clams are the most important cultivable organisms all over the world. Of these, *P.viridis* and *P.indica* forms the most dominant cultivable species. The Central Marine Fisheries Research Institute (CMFRI) has developed eco-friendly techniques for mussel culture. Recently, CMFRI has taken up efforts to popularize mussel culture in all coastal districts of Kerala.

Scope for mussel farming

Kerala state is endowed with rich mussel resources and survey reveal that two species viz., *Perna viridis* (green mussel) and *Perna indica* (brown mussel) are present along the rocky shores. The latter is mostly restricted up to the south of Kollam from Cape Comorin in West Coast and the former is distributed throughout. Annually about cape Comorian is west coast and the former is distributed throughout. Annually about 15000 t of mussels are exploited from these regions. During post – monsoon period there is heavy settlement of mussel spat along the entire Kerala coast. This seed can be used for farming (See Annexure for a recent estimate of mussel seed resources in central Kerala). Mussels reach harvestable size (55-70 mm) within 4-5 months when cultured.

Experiments indicate if farming activities confined to November to May, mussels can be successfully cultured in most estuaries of Kerala since ecological conditions will be congenial for good growth and survival. Similarly the Arabian Sea bounding the shores of Kerala can also be used to culture of mussels during the fair season (Oct to May).

Background information

The CMFRI has developed technologies for farming of mussels in early seventies and since then it have been upgraded and refined for commercial production. The Institute has conducted a series of experiments on location testing in various estuaries and sea along the west coast of India. In Kerala, location testing in various estuaries and sea along the west coast of India. In Kerala, location testing for mussel culture has been done in estuarine areas using rack and rope method.

The Calicut Research Centre of CMFRI, Calicut took steps to expand mussel culture practices in the north Kerala region in small-scale with the involvement of fishermen. The Research Centre successfully demonstrated mussel culture in the Dharmadam Estuary during 1995-96. This created some awareness among the local fishermen.

During 1996-97, mussel culture was done on a large scale at Padanna with the involvement of a group of twenty five fisherwomen. Financial support was extended by the DWCRA. These programme proved that mussel culture can be profitably undertaken utilizing the available water spread area in the estuaries of North Kerala. In Central Kerala it was demonstrated in the Chettuva estuary in Trichur district during 1997 and now it is extended upto Munambam estuary and nearby areas of Sathar Island.

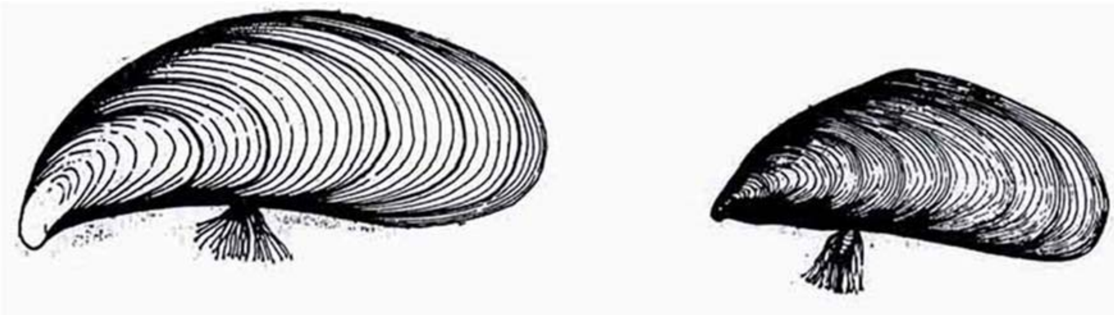
Open sea culture of mussels was initiated by the CMFRI off Vizhinjam and off Calicut during the 1970's. Recently, a pilot scale demonstration of long – line culture was also carried out off Andhakaranazhi near Alleppey. During 1998-99, a group of fishermen from Vypin Island took the initiative to launch raft culture of mussels in the sea off Narakkal with technical collaboration from CMFRI. Currently farmed mussel production from Kerala state is estimated to be nearly 20,000 t.

Common names
English: Green mussel / Brown mussel
Malayalam: Kallumaekai /Kadukka/ Chippi
Tamil Pachai Aali/ Kallikai

Morphology
The external shell colour of young green mussel is beautiful jade green and in older specimens it is bluish-green at the anterior half. The shell colour of brown mussel is dark brown. Interior of the shell is margaritaceous and shining in both the species. Two equal sized shells protect the internal organs. The shells are thick, equivalve, equilateral, elongate, triangularly ovate in outline and hinged at the anterior end. The posterior end of the shell is almost round.

Diagnostic characters	***Perna viridis* (Linnaeus, 1758)**	***Perna indica* (Kuriakose&Nair, 1976)**
Common name	Green mussel	Brown mussel
External shell colour	Green / Bluish green	Deep brown
Dorsal ligamental margin	Curved	Straight
Mid dorsal margin	Arcuate	Highly angular
Posterior margin	Rounded	Rounded
Ventral margin	Highly concave	Straight
Mantle margin colour	Yellowish green	Brown
Excurrent aperture opening	Mouth oval and wide; passage into the mantle cavity small; restricted by septum, rectum and posterior adductor not visible through the opening.	Mouth and passage into the cavity are of same width; rectum and posterior adductor prominently visible through the opening.
Ventral mantle margin	Inner fold of the posterior ventral margin thin,	Inner fold of the posterior margin very thick not

	extensible, smooth, tentacles or papillae absent.	extensible; provided with 18-22 thick branching tentacle.
Posterior byssal retractors	Two, short, thick bundles; anterior bundle arises from the posterior and diverges in the form of a 'V'	Two, short, thick bundles; anterior bundle arises from the posterior and diverges in the form of a 'W'



P.viridis (**Linnaeus, 1758**) ***P.indica (**Kuriakose & Nair, 1976**)***

Food and feeding

Mussels are ciliary-mucoid filter feeders, which feed on phytoplankton, zooplankton and detritus.

Growth

Green mussel shows a rapid growth rate by length of 8mm-13.5mm per month. Under average culture conditions, green mussel and brown mussel attain a length of 80-88mm with 36.4 - 40g weight and 65 mm with 25-40 g in 5 months respectively. The farmed mussels give a better meat yield compared to mussels from the natural bed. The average edible portion of the meat in cultured mussels' ranges from 34.5% - 40.5% where as in the natural bed the meat yield is 27.2%-33.3% of the total weight. Growth by length and weight are probably the most important criteria for assessing the success of the culture system.

The growth of mussel is influenced by a number of environmental factors such as water quality, food availability, settling density, water current and tidal exposure.

Reproduction

Mussels are known to be unisexual. Hermaphrodites are observed very rarely. The gonad of mature female can easily be distinguished by its bright orange-red colour from that of the male, which is creamy yellow.

Mussels attain sexual maturity in two months (15-28 mm). Spawning period is prolonged extending from January – September with peak spawning during June-September in Kerala. The four main stages in the reproductive cycle are spent/resting, developing, ripe and spawning. Fertilization is external. After fertilization, it attains pediveliger within 15-35 days. Pediveliger attaches to the settlers with the help of byssus threads and metamorphose to spat. Spat settlement takes place from July to September and attains seeding size in September.

Condition index

$$\text{* Condition index} = \frac{(\text{dry meat weight X 1000})}{\text{Volume of shell cavity}}$$

$$\text{** Percentage edibility} = \frac{\text{Meat weight x 100}}{\text{Whole mussel weight}}$$

* Condition index is generally related to the reproductive cycle. Condition of mussel indicates the degree of fatness of a mussel or the extent to which the meat fills the cavity. The ideal condition index of mussel is 70 - 140. This will be high during non-spawning period.

**Percentage edibility, the percentage edibility is high the mussels can be harvested. Percentage edibility varies from 20 – 45%.

Distribution of Mussels

The green mussel *P.viridis* is widely distributed throughout the Indo Pacific area. It has been reported to occur in China, Japan, Persian Gulf, Indonesia, Hong Kong and in the Pacific Islands. *Perna indica* is found only along the Indian coast. *Perna perna* is found along the coasts of the African continent, South America and Sri Lanka.

Mussel is popularly known as " Kallumekai / Kadukka/ Chippi" in Malayalam. Green mussel Perna *viridis* and brown mussel *Perna indica* are available along the Indiancoast. The green mussel*, P.viridis* is extensively distributed as subtidal and intertidal beds along both the coasts. Along the Kerala Coast, the major locations are Koduvally,Mahe,Chombala, Moodadi,Thikkodi, Elathur, Chaliyam and South Beach, Anchangadi, Ethai, Narakkal, Chellanam, Andakaranazhi, Azhikkal, Parimanam, Port Kollam and Neendakara.

FARMING TECHNIQUES

Site selection

Open sea and estuarine areas free from strong wave action are suitable for farming. Clear seawater with rich plankton production (17-40μg chlorophyll /l,) is ideal for mussel culture. Moderate water current (0.17-0.25m/s at flood tide and 0.25-0.35m/s at ebb tide) will bring the required planktonic food and will carry away the excessive build-up of pseudofaeces and silt in the culture area. The water should have a salinity of 27-35 ppt. and temperature of 26° C- 32° C. Site should be free from domestic, industrial and sewage pollution.

Open sea farming

In open sea farming, the depth at the site should be above 5m without strong wave action, less turbulent and with high primary productivity. Long line and raft culture techniques are ideal for open sea farming. Mussels grown on long lines become smothered by naturally settling juvenile mussels and other fouling organisms. Effective utilization of easily available material for fabrication of long line and rafts can be done. Disadvantages of this farming are the poaching and unpredicted climate changes. Protected bays are ideal for mussel farming.

Estuarine farming

Compared to open sea, estuarine ecosystems with less turbulent and shallow depth (<4m) are suitable for mussel farming. Culture of mussels on horizontal ropes results in high productivity due to the effective utilization of the primary productivity. Rack culture is ideal for estuarine conditions. Fluctuation in salinity during monsoon season and pollution through domestic and industrial waste are the main constraints in estuarine mussel farming.

Methods of farming

Rack method

This method is suitable for estuaries and shallow bays. The racks are fabricated placing Bamboo / Casuarina poles vertically and horizontally tying and lashing with nylon/ coir ropes. Bamboo or Casuarina poles are driven into the bottom and spaced at a distance of 1-2m**.** These stakes are connected horizontally with poles. The horizontal poles should be above the level of water at high tide and seeded ropes are suspended from the same.

Raft method

This method is ideal for open sea conditions. Square or rectangular rafts are fabricated with sturdy bamboo or casuarina poles. Buoyancy for the raft is provided by tying 5 barrels of 200-litre capacity one each at the four corners and one in the middle (metal oil barrel painted with anticorrosive paint or synthetic material). Ideal size of the raft is 5 x 5 m. The rafts are positioned at suitable site in the sea using 50-100kg of iron, granite or concrete anchors. Three seeded ropes can be suspended from one square meter area of the raft.

Long-line method

This method is considered ideal for unprotected open sea conditions. The main line is a synthetic rope of 16-20mm diameter. The long-line, which is supported by 200 liter barrels tied to it and spaced at 5m. The long–lines and barrels are anchored in position at both ends using concrete blocks and nylon ropes. Seeded ropes are suspended from the long line.

Seed collection and seeding on ropes

The site selected for collection of seed should be free from pollutants. Seeds collected from the submerged (sub tidal) areas will be healthier. After removing other organisms and weeds, the seeds were washed thoroughly in seawater. About 500- 750g of seed is required for seeding on one-meter length of rope. The ideal size of the seed is 15-25mm with 1-2g weight. The length of the rope is decided by considering the depth where the raft/ rack is positioned. While suspending the seeded rope on rack it must be tied in such a way that the upper seeded portion of the rope should not get exposed during low tide.

Nylon rope of 12-14mm or 15-20mm coir rope can be used for seeding .Old cotton net, cotton mosquito net or cheap cotton cloth are used for covering the seeds around the rope. Cotton netting of required width and length is placed on the floor and required quantity of seed is spread over the net from one end to another. The rope is kept above the net and is tightly stitched in such a way that the seeds spread uniformly around the rope. The cloth will regenerate within 2-3 days. By this time the seeds will secrete byssus thread and will get attached itself to the rope.

To avoid slipping of the mussels, knots are made on seeded rope at a distance of 25cm. Placing split bamboo pegs in the rope (12-14mm) at regular intervals will also serve the purpose.

Grow-out-phase

The seed, which get attached to ropes, show faster growth in the suspended column water. If the seed is not uniformly attached, crowded portion always show slipping. To avoid slipping, periodical examination of seeded rope and thinning of the same is essential. The ropes also should be suspended in such a way that it will not touch the bottom as well as the seeded portion is not exposed for longer period during low tide. Seeded mussel on the upper portion of the rope shows faster growth due to the abundance of phytoplankton. For better growth the seeded ropes should be spaced at a distance of 25 cm.

In open sea -farming, growth of mussel is very rapid. They attain 80 - 110mm in 5–6 months with an average growth of 13.5mm/month and an average weight of 35-45g. This growth is observed in farms at various locations. In estuarine farming, mussels attain 75-90mm in 5 months with an average weight of 35-40g and an average production of 10 - 12 kg/m rope

Management

Constant vigil is required to see that the raft/rack is in position. Thinning may be done if necessary to avoid loss of mussel and to provide enough growing space. Periodic removal of fouling organisms like Barnacles, Tubiculous polychaetes and Ascidians is to be done for improved growth.

Harvest, product development and marketing

Harvest will be done when the mussels reach marketable size and condition index is high, i.e., before the spawning and onset of monsoon. Normally harvest season is from April to June.

Mussel ropes are collected manually and brought to the shore for harvest and washed thoroughly using jet wash to remove grit and slit. The mussels separated from the ropes are maintained in re-circulating seawater for 24hrs and washed again in fresh seawater. This method of depuration is effective in reducing the bacterial load of the mussel meat by 90%.

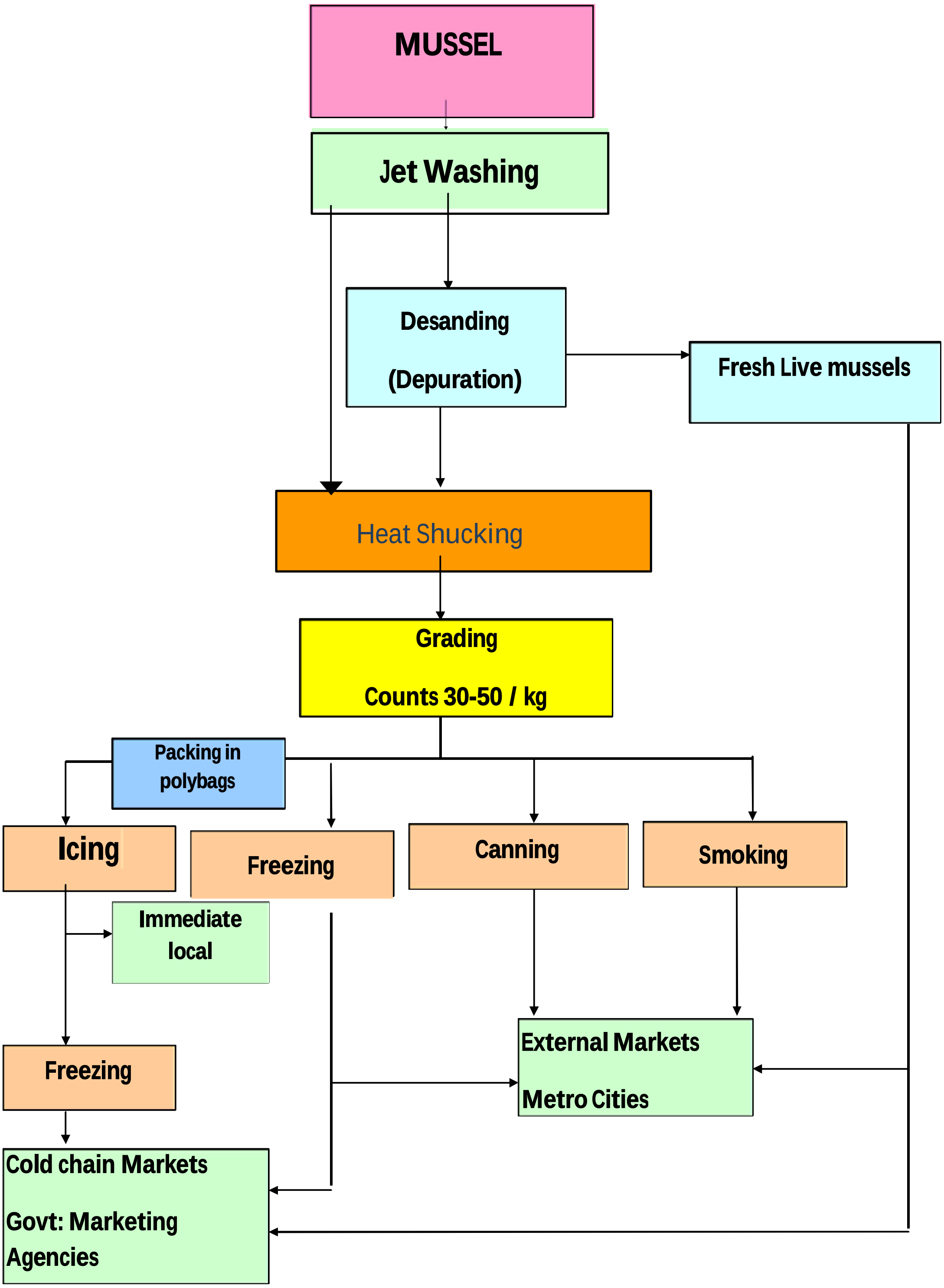
Depurated mussels are then mainly sold through local market as live shell-on mussel. At present processing units use only a small quantity of cultured mussel. New strategies need to be developed to fully exploit the domestic market.

Meat from depurated mussel can be shucked in fresh condition or after boiling or steaming. Further processing of the mussel meat can be done after blanching in 5% salt solution for 5 minutes.

Depuration

To avoid risk in consuming the mussel meat and to increase the quality of mussel, depuration is essential. During the process of feeding, mussels accumulate all suspended biological materials including harmful microorganisms. Before the product reaches the market, these materials have to be removed from their gut. The process of such purification is called depuration.

The mussels are placed for 24 hours in cleaning tanks under a flow of filtered seawater. About 10-20% of the seawater is continuously replaced. At the end of 12 hours the water in the tank is drained and mussels are cleaned by water to remove the accumulated feces. The tanks are again filled with filtered seawater and the flow is maintained for another 12 hours. Then the tanks are drained and flushed with a jet of filtered sea water. The mussels are held for about one hour in 3 ppm chlorinated seawater, and then washed once again in filtered seawater before marketing.



Post harvest procedures / processing

Products and export

A variety of products have been developed in India from mussel meat. These products have been developed by R & D activities of CIFT, Kochi.

In the retail market, few mussel products are available. The latest product in line is the condiment incorporated ready-to-eat fried mussel meat in vacuum packs.

For further economic utilization, value added products of mussels like seafood cocktails are prepared and marketed by seafood export firms in India. The export of these items from India is showing an increasing trend.

Overseas markets

Mussels are exported to different countries in the frozen and dried condition. They are also airlifted in the iced condition to the Gulf countries where mussels are in great demand. There is an increasing demand for mussels in the global markets, especially in UAE, China, Mali, Singapore, Srilanka, Australia, Greece, Japan, Lebanon, Mexico, New Zealand and Rep. Korea. The export of mussel products shows an increasing trend.

Present status of mussel culture

In India mussel production through culture shows an increasing trend. Now under NATP programme mussel culture became a popular one in most of the maritime states of India. In the Indian subcontinent estuarine farming of mussel was first started in Kerala particularly at Dharmadom in Kannur district, Padanna and Cheruvatur in Hosdurg Taluk of Kasargod district.

The establishment of mussel farms in Kerala State led to an increase in mussel production. In Kerala, the important event that has taken place in mussel farming is the women participation (Women Self Help Group).

Seed production in captivity

Keeping brood stock in captive tanks and by induced maturation and spawning, seed can be produced in hatchery. In India, CMFRI has developed hatchery technology for mussel seed production. But hatchery production of mussel seed is not yet commercialized.

Role of CMFRI in mussel farming

Training programmes are conducted in collaboration with Aquaculture Development Agencies to different categories of trainees like in-service personnel, private entrepreneurs, NGO´s, and fisher groups especially women. Demonstration farms are set up in all the suitable areas like estuaries and open sea. Creating awareness among funding agencies, other state government organizations and panchayats for release of funds under various developmental schemes have helped in the commercialization of mussel farming in all the maritime states especially in Kerala.

One of our farmers (Shri. G.S Gul Mohamed) received the "**KARSHAKA SIROMANI** "National award for the year 2002, constituted by the Ministry of Agriculture, Govt. of India for the best Mussel farmer. This is the first time that such a prestigious national award to a Keralite farmer from fisheries sector. Shri. Gul Mohammed started mussel farming in estuaries from 1996 utilizing the technology developed by Central Marine Fisheries Research Institute (CMFRI).

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Application Form/ അപേക്ഷ ഫാറം

Tribal Sub Plan (TSP) scheme/ ട്രൈബൽ സബ്പ്ലാൻ സ്കീം
&
Scheduled caste Subplan (SCSP) ഷെഡ്യൂൾഡ് കാസ്റ്റ് സബ് പ്ലാൻ സ്കീം

ICAR -Central Marine Fisheries Research Institute Kochi (ICAR-CMFRI)-18
കേന്ദ്ര സമുദ്രമത്സ്യ ഗവേഷണ സ്ഥാപനം, കൊച്ചി

Assistance for Fish culture/Cage culture/Pen culture/Biofloc/Oyster culture/ seaweed culture /Ornamental fish culture/ supply of Net and Cage accessories/supply of fishing & other accessories etc.
(മത്സ്യ കൃഷി: കൂട്, പെൻ, ബയോഫ്ളോക്, കല്ലുമ്മക്കായ, കടൽ പായൽ,അലങ്കാര മത്സ്യകൃഷി, കൂട് വല, മത്സ്യ വല, മറ്റ് ഇതര സഹായങ്ങൾ ലഭിക്കുന്നതിനുവേണ്ടിയുള്ള അപേക്ഷ)

TSP	SCSP

	Application Form/ അപേക്ഷ ഫാറം		
1	Name of Applicant /അപേക്ഷകന്റെ പേര്/	:	
2	Gender (M/F) സ്ത്രീ/ പുരുഷൻ	:	
3	Permanent Address/ സ്ഥിരമായ മേൽവിലാസം	:	
4	Phone No /ഫോൺ നമ്പർ	:	
5	email /ഇ മെയിൽ		
6	Date of Birth / ജനനത്തിയതി		
7	Age /വയസ്സ്		
8	Religion and Caste /മതം& ജാതി		
9	SC/ST/ എസ്‌സി / എസ്ടി		
10	Nationality / പൗരത്വം		
11	Aadhar Number / ആധാർ നമ്പർ		
12	Annual Income/ വാർഷിക വരുമാനം		
13	Ration Card Type / റേഷൻ കാർഡ് തരം		
14	Educational qualification വിദ്യാഭ്യാസ യോഗ്യത		
15	Current Job/ ജോലിയുണ്ടെങ്കിൽ		

	അതിൻ്റെ വിവരം		
16	Unmarried/ Married / Widow / അവിവാഹിതൻ/വിവാഹിതൻ/ വിധവ		
17	Required Fish culture method/ other needs /ആവശ്യമുള്ള മത്സ്യ കൃഷി		

18	Name Assigned for the Group / ഗ്രൂപ്പിനു നൽകുന്ന പേര്			
19	Details of Group Leader & Members/ ഗ്രൂപ്പ് അംഗങ്ങളുടെ വിവരം			
	Name/ പേര്	Phone No /ഫോൺ നമ്പർ	ആധാർ നമ്പർ	Signature/ ഒപ്പ്
(i)				
(ii)				
(iii)				
(iv)				
(v)				

20	Attested copy of Certificates/ അറ്റസ്റ്റ് ചെയ്ത സർട്ടിഫിക്കറ്റുകളുടെ കോപ്പി)	
		Yes/No
(i)	Caste certificate/ ജാതി തെളിയിക്കുന്ന സർട്ടിഫിക്കറ്റ്	
(ii)	Aadhar card/ ആധാർ കാർഡ്	
(iii)	Ration card/ റേഷൻ കാർഡ്	
(iv)	Election ID / ഇലക്ഷൻകാർഡ്	
(v)	Identification Certificate from authority of Govt Departments/ തിരിച്ചറിയൽ/ വെരിഫിക്കേഷൻ/ സർട്ടിഫിക്കറ്റ് a) For SHG- Application, Registration Certificate , list of members, and Ration Cards/Aadhaar Cards, Community Certificates of all the members. b) For Groups(which are not in SHG category, preferably less than seven) - Application, Identification and Recommendation letter from Village, District or State level	

	(Gramasabha/Panchayat President or Secretary/VEO/Tribal Extension Officer,/Agricultural Officer/BDOetc), list of members, and Ration Cards/Aadhaar Cards, Community Certificates of all the members. c) For individual – Application, Identification and Recommendation letter from Village, District or State level (Gramasabha/Panchayat President or Secretary/VEO/Tribal Extension Officer/Agricultural Officer/BDO etc), along with Aadhaar card, Community Certificate & Ration Card of the concerned individual. *(Strike off (a, b or c) whichever is not applicable.)*	

<u>Declaration/ സത്യവാങ്മൂലം</u>

I …………………………………………….. hereby declare that the information and details given above are correct, complete and true to the best of my knowledge and belief.

(-- എന്ന ഞാൻ മുകളിൽ സമർപ്പിച്ച വിവരങ്ങളും വിശദാംശങ്ങളും എൻറെ അറിവിലും വിശ്വാസത്തിലും ശരിയും, പൂർണവും, സത്യവും ആണെന്ന് ഇതിനാൽ സാക്ഷ്യപ്പെടുത്തികൊള്ളുന്നു.

Signature / ഒപ്പ്	
Name of the Applicant /അപേക്ഷകന്റെ പേര്	

Date/ തിയതി	
Place /സ്ഥലം	

To

The Chairman
Tribal Sub Plan(TSP) scheme /Scheduled Cast Sub Plan(SCSP)
CMFRI, P.B. No.1603, Ernakulam North P.O.
Abraham Madamakkal Road, Kochi,
Ernakulam District , Pin 682018, Kerala
Mob: 9895567454
Off:0484-2394867- Ext: 369

Letter Pad of Identification Officer

To
The Director,
CMFRI, Kochi

Subject: Identification of Scheduled Tribe (ST)/Scheduled Caste (SC) beneficiaries and their …………………….(Name of Individual/ Group/Self Help Group) for implementing TSP/SCSP scheme of ICAR-CMFRI, Kochi under the supervision Chairman, TSP/SCSP, CMFRI Reg.

Sir,

I wish to inform that the following people belong to Scheduled Tribe (ST)/Scheduled Caste (SC) and are permanently residing at …………….. Panchayat …………………………Village …………… …..District…. ………. State, and have formed a Group/Self Help Group named …………………../ Name of Person ---------------------. It will be very helpful, if this individual/Group is considered for TSP/SCSP scheme of ICAR-CMFRI, Kochi, for their livelihood under the supervision of Chairman, TSP/SCSP, CMFRI, Kochi.

Sl. No.	Name of beneficiaries	Aadhar No.	Phone number	Signature
1				
2				
3				
4				
5				

This is for your kind information.

(................................)
Name & Signature of Identification officer

Place:
Date :

ICAR-Central Marine Fisheries Research Institute
(Department of Agricultural Research and Education, Government of India)
P.B. No. 1603, Ernakulam North P.O., Kochi - 682 018, Kerala, India