BIVALVE MARICULTURE

TRAINING MANUAL

Central Marine Fisheries Research Institute
(Indian Council of Agricultural Research)
Kochi

भाकृअनुप
ICAR

January 2005

केंद्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

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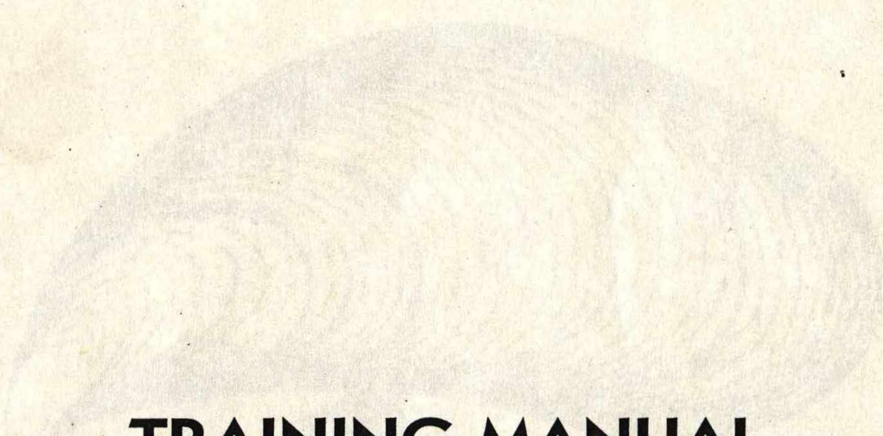

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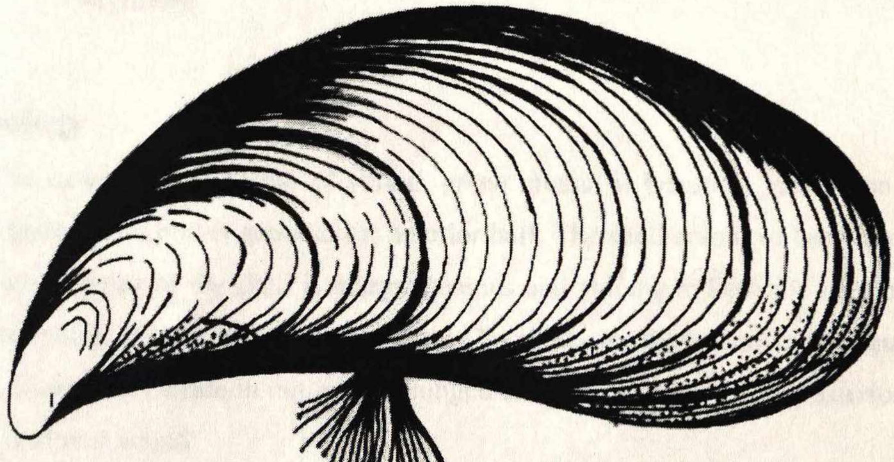
MUSSEL



MUSSELS

They are cultivable marine bivalve molluscs coming under the family Mytilidae they prefer hard rocky or laterite substratum are found in subtidal and intertidal zone up to 15 m depth.

Taxonomy

Phylum - Mollusca

Class - Bivalivia

Sub class - Pteriomorpha

Order - Mytiloida

Super family - Mytilacea

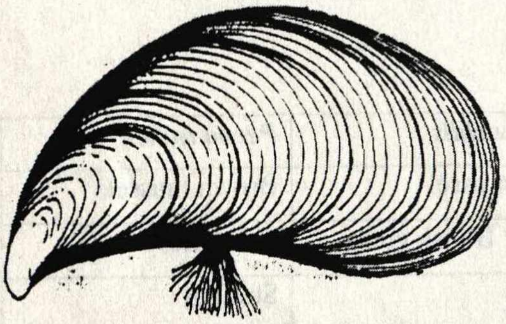
Family - Mytilidae

Morphology

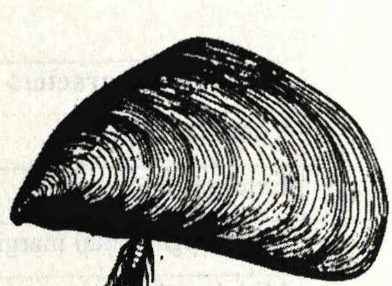
The external shell colour of young green mussel is beautiful jade green and in older specimens it is bluish-green at the anterior half. The shell colour of brown mussel is dark brown. Interior of the shell is margaritaceous and shining in both the species. Two equal sized shells protect the internal 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*	*Perna indica*
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	Mouth oval and wide;	Mouth and passage

opening	passage into the mantle cavity small; restricted by septum, rectum and posterior adductor not visible through the opening.	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, extensible, smooth, tentacles or papillae absent.	Inner fold of the posterior margin very thick not 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



P.indica

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 25-40g in 5months 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.

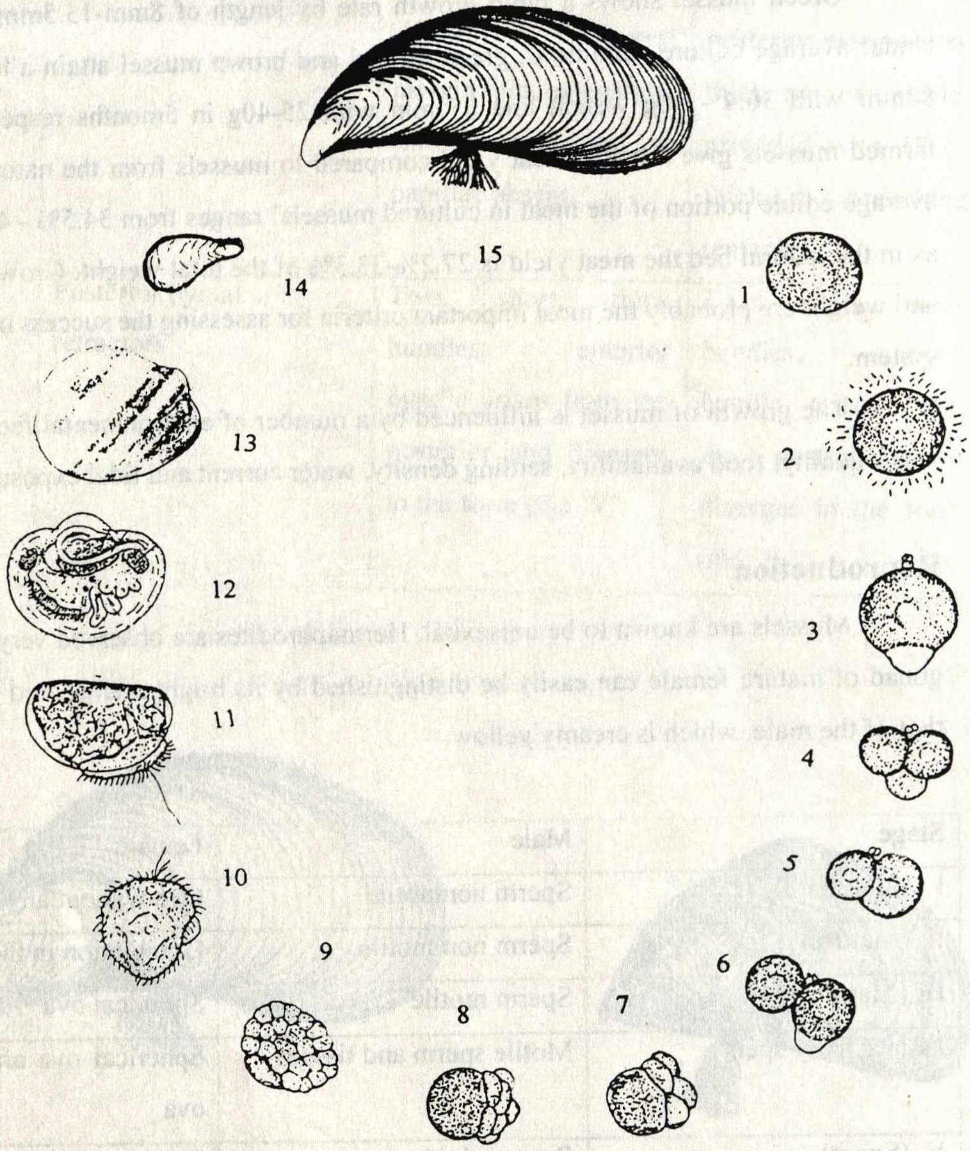
Reproduction

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.

Stage	Male	Female
I (Immature)	Sperm nonmotile	Ova without any shape
II (Maturing)	Sperm non motile	Granulation in the ovary
III (Mature)	Sperm motile	Spherical ova
IV (Partially spent)	Motile sperm and tissues	Spherical ova and ruptured ova
V (Spent)	Ruptured tissues	Ruptured tissues
(Indeterminate)	Differentiation impossible	

Mussels attain sexual maturity in two months (15-28 mm). Spawning period is prolonged extending from January –August 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 August and attains seeding size in September.



Life cycle of green mussel (*Perna viridis*)

(1) Egg (2) Egg with sperm (3) 3-9Early developmental stages (10) Trochophore (11) Veliger (12) Eyed/ Umbo stage (13) Plantigrade (14) Spat (15) Adult.

Condition index

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

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

* 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 *P. canaliculus* or the green-lipped mussel is restricted to New Zealand while 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 "or " Kadukka" in Malayalam. Green mussel Perna *viridis* and brown mussel *Perna indica* are available along the Indian coast. Green mussel is widely distributed along the intertidal coasts of India and found extensively around Kollam, Alappuzha, Kochi, Kozhikode, Kannur and Kasaragod in Kerala and in small beds in Chilka lake, Visakhapatnam, Kakinada, Chennai, Pondichery, Cudalloor, Mangalore, Karwar, Goa, Ratnagiri and in Gulf of Kuch. *Perna indica* has a restricted distribution and is found along the southwest coast (Varkala to Kanyakumari) and southeast coast (Kanyakumari to Tiruchandur) of India.

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.

Along the Karnataka coasts the mussel beds are mostly seen in subtidal beds and major resources are located in Uchila, Someswara, Suratkal, Matukopal, Malpe, Coondapur, Byndur, Bhatkal, Basaldurga, Dhareshwar, Gokarn, Ramakkal, Kodar, Karungadi, Karwar, Angola, and Gangoli.

In Goa, mussels beds have been observed at Mapusa, Panjim, Margoa and Canacona. Along the Maharastra coast, mussels beds are seen in rocky coastal regions as well as in the small creeks. Extensive mussel resources are available along Dahoi, Jaigad, Kalbadevi, Bhatye, Purnagad Taramumbri, Devgad, Chowl, Alibag and Urar Along the Gujarat coast, mussel population is sparse, observed only in Jamnagar region at Sikka, Baid, Same, Sachana and near Dwaraka.

In the Tamil Nadu, Pondicherry and Andhra Pradesh extensive beds have not been reported. However, mussel resources have been observed at Chunambaru estuary, Ennore, Kandaleru, Visakhapatnam, Kakinada, Nellore, Vudukunnappalli, Pathapalam and Ponnapudi. In Chilka Lake meager occurrence of mussel has been reported. Sparse mussel beds have been observed at some locations in the Andaman and Nicobar Islands and it is absent in Lakshadweep islands.

Table – 1.Mussel seed availability along Indian coast

State	Location
Kerala	Ashtamudi Lake, Thangaserry Bay, Azheekode, Malinkara, Chettuva, Ponnani, Kadalundi, Dharmadam, Valapattanam, Padanna, Neelaswaram etc.
Karanataka	Mulky, Suratkal, Traisi, Baindur, Gokarn, Belikeri, Arga, Amdalli, Harwada, Karwar Bay, Manjali etc.
Tamil Nadu	Coleroon estuary, Gadilam estuary, Kovalam, Kadiyapatnam, Coached, Kodimuna, Vaniakudikurumpana, Melemidalam, Aazhimalapulinkidi, Mullor etc.
Pondichery	Kadaloor
Andra Pradesh	Bhimunipatanam, Kakkinada, Dommulpeta, Chinamylavarilanka etc.
Maharashtra & Goa	Bhatye creek, Kalbadevi creek, Jaigad creek, Dabhal creek, Purnagad creek, Budhal coast, Tulsunde creek etc.
Andaman & Nicobar Islands	Sippighar, Bimbleton, Kalpather, Garacharma, Mittagari, Haathitope, North Bay, Minnie Bay etc.
Gujarat	Navabander
Orissa	Gopalpur port (Badrajpally), Gopalpur Rocky shore, Gopalpur backwater, Bahuda estuary etc…

Some common species of mussel in the world

Scientific name	Common name	Country
Perna viridis	**Green mussel**	**India, China,Indonesia,Malaysia, Philipines,Singapore,Thailand**
Perna indica	**Brown mussel**	**India**
Perna canaliculus	**Green lipped mussel**	**New Zeland**
Mytilus edulis	**Blue mussel**	**China, Korea(Rep.)**

Fishery

In India annual mussel production which was less than 10,000 tonnes in the beginning of this decade, has been doubled by 2002 through increased exploitation and farming in coastal waters. In Kerala, traditional mussel fishery exists along the coast and mussel farming is now a flourishing activity in the state. Among the maritime states, Kerala stands first contributing 95% of the total mussel production. In the year 2003-04 farmed mussel production was 2000 tonnes.

Fig. Mussel production in India (Tonnes)

	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004
Culture	609	308	950	1250	2000
Capture	5340.5	14970	14216	20213	7168.4

FARMING TECHNIQUES

Site selection

Open sea and estuarine areas free from strong wave action are suitable for farming. Clear seawater with high 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 selected 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 poaching and unpredicted climatic 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 / casurina poles vertically and horizontally tying and lashing with nylon/ coir ropes. Bamboo or Casurina 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 together 5 barrels of 200-litre capacity (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.

Horizontal culture

This method is ideal in shallow areas with a minimum level of water column. Seeded ropes were suspended by tying upward by ropes to horizontal poles; but both the ends will be stretched and tied in vertical poles erected in opposite sides of the farm structure. In the estuaries of Malabar, most of the farmers are following this method.

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 may be 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 5months with an average weight of 35-40g and an average production of 10 - 12 kg/m rope

Calendar of activities

Activity	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Awareness Programmes	✓	✓	✓									
Training (Phase-I)				✓	✓							
Site Selection		✓	✓									
Farm Construction					✓	✓						
Collection of seed and seeding				✓	✓	✓						
Farming Activities							✓	✓	✓	✓	✓	
Training programme and workshop (PhaseII)										✓	✓	
Harvest												✓
Marketing												✓

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 manual removal of fouling organisms like barnacles, tubiculous polychaetes and ascidians is to be done for improved growth.

Diseases and Poisoning

Mussels are said to be harmful when consumed during periods of red tide (in Malayalam it is called Pola vellam). This mainly occurs due to when dinoflagellates bloom or bloom of diatoms, or cyanobacteria. They will produce potent toxins that can find their way through the food chain to humans, causing a variety of gastro-intestinal and neurological illnesses, such as: paralytic shellfish poisoning, diarrhaeortic shellfish poisoning, amnesic shellfish poisoning, neurotoxin shellfish poisoning. Another new toxin identified is yessotoxin, which affects the nervous system.

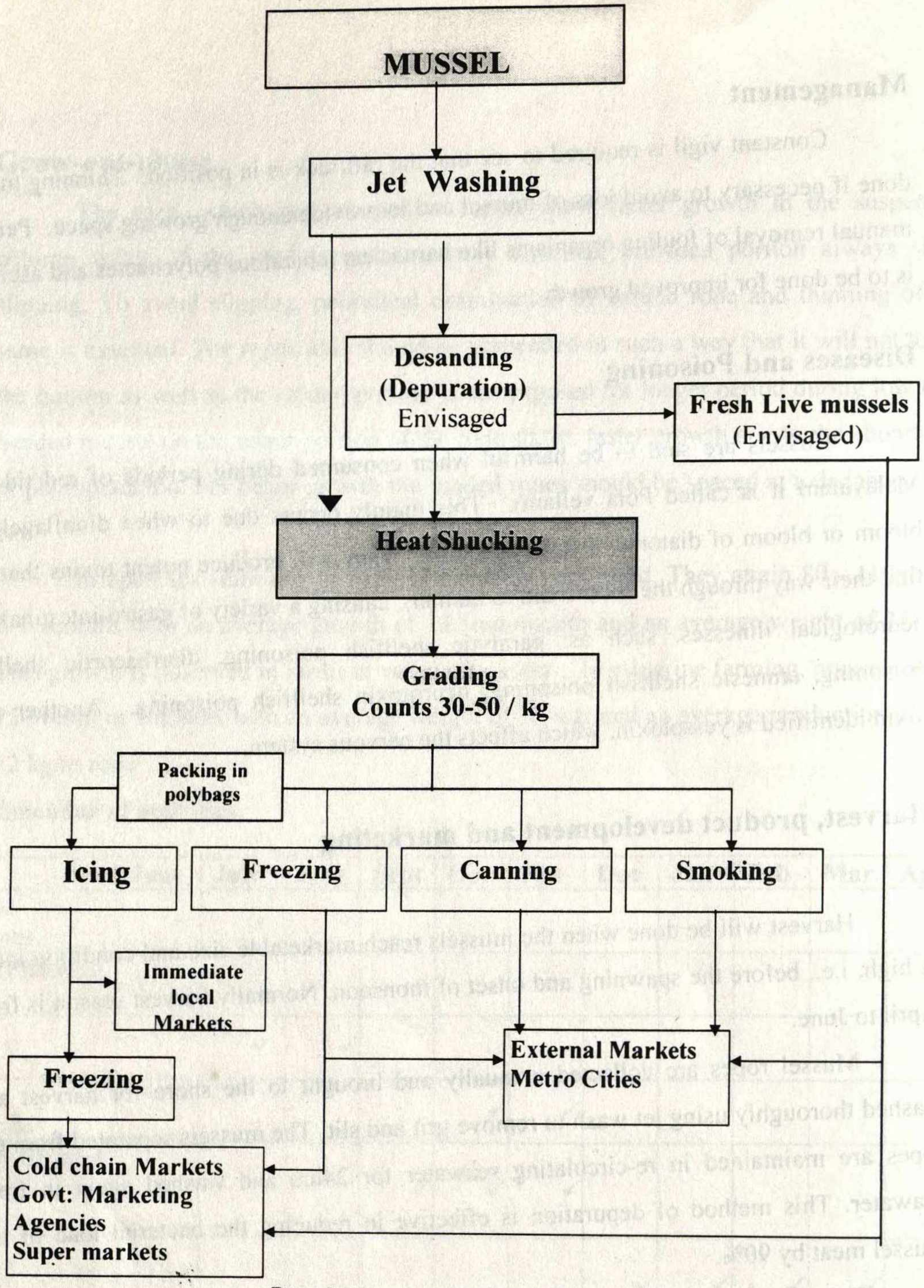
Harvest, product development and marketing

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 take 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.



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.

Product		1999	2000	2001	2002	2003
Dried mussel meat	Q (Tonne)	32.77	31.47	3.47	0	10.36
	V (Crore)	0.17	0.22	0.07	0	0.04
Frozen mussel meat	Q (Tonne)	36.0	106.44	482.10	106.94	74.98
	V (Crore)	0.11	0.74	2.90	0.92	0.5

Value added products

1. Iced and frozen mussel meat
2. Canned mussel meat
3. Smoked mussel meat
4. Dried mussel meat
5. Marinated mussel meat
6. Mussel pickle
7. Mussel chutney powder

Some special Kerala dishes are

1. Arikadukka
2. Mussel stew
3. Mussel biriyani
4. Mussel fried rice

Proximate composition (%)

Moisture	82.95
Protein	8.94
Fat	1.95
Ash	1.62
Calcium	0.85
Acids insoluble	0.05
Glycogen	3.91
Phosphorous	0.33

Nutritional value of 100g heat blanched mussel meat

Composition	Quantity	Adult male (%) of daily requirement	Adult female (%) of daily requirement
Energy	172 Kcal	2.9	3.8
Protein	23.8g	19	24
Oil (fat)	4.48g	2.2	2.9
Omega 3 fatty acids	782 mg	*	*
Cholesterol	27 mg	-	-
Calcium (Ca)	56 mg	7	7
Iodine (I)	0.065 mg	43	43
Iron (Fe)	7mg	70	47
Phosphorous (P)	285 mg	29	29
Potassium (K)	270 mg	11	11
Selenium (Se)	0.038 mg	19	19
Sodium (Na)	410 mg	13	13
Zinc (Zn)	0.95mg	6	8
Vitamin A (Retinol)	0.05 mg	5	5
Vitamin E (Tocopherol)	1.9 mg	19	19
Vitamin B1 (Thiamine)	0.009mg	.6	0.6
Vitamin B2 (Riboflavin)	0.28 mg	16	21
Vitamin B6 (Pyridoxine)	0.19 mg	9.5	12
Vitamin B12 (Cobalamine)	0.009 mg	0.5	0.5
Niacin	1.4 mg	7	9.3
Pantothenate	< 1 mg	<20	20
Vitamin C (Ascorbic acid)	4.4 mg	7	7

Ratio Omega 3 to Omega 6 is 13:5

Source: United States Dept. of Agriculture Handbooks

" Composition of Foods"No.s 8.15,1987 & 8.13,1989.

Medicines from mussel meat

Mussel is known to contain pharmacologically important ingredients for arthritis and sinusitis.

Medicines produced from the tissue of mussels have distinct immunity protection features. Natural antioxidants have been found in the lipid fraction of mussels. Omega-3, a type of unsaturated fatty acid is also found in mussel. Mussels are **rich** in Omega-3 fatty acid and have more of Omega-3 than any other shellfish.

It is well known that mussels accumulate large amount of zinc and has a number of health benefits, it is a proven immunity booster, promotes growth, mental alertness and aids in proper brain function. 100g of mussel provides close to entire daily dietary requirement.

Recent research on a specific protein derived from mussels called **Lyprisol** is believed to have benefits in deterring from cancer.

1. ***Food Science of Vermont Sea mussel 90c.***

Sea mussel Caps (Green Lipped Mussel 500mg.) are a natural source of protein, chelated minerals and glycosamino glycans, which play a beneficial role in joint health and function.

2. ***Mussel Hydrosate BIPOLAN***

This is a biologically active food additive extracted from mussels (*M. galloprovincialis, M. edulis*) cultivated in ecologically clean areas of the Black Sea. This is a highly active product because it contains amino acids, oligopeptides, microelements, free fatty acids and melanotidins. It combines immunobilitive and radioprotective properties. Mussel Hydrolysate is used in medical – prophylactic feed.

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, Sigapore, Srilanka,Australia, Greece, Japan, Lebanon, Mexico, NewZeland and Rep. Korea. The export of mussel products shows an increasing trend.

Quality standards

Quality standards followed for mussel includes the Bureau of Indian Standards (BIS), Hazard Analysis Critical Control Point (HACCP), International Organisation of Standards (ISO 9002) and European Economic Community norms.

With globalisation, seafood trade will be subjected to increasingly greater regulation, control, issues related to environmentally sustainable practices. Seafood safety would assume greater significance in the future. Eco-labelling and HACCP certification would be made mandatory for all seafood products. Contaminants frequently monitored include bacterial loads, heavy metals, antibiotics and pesticides, algal blooms for HAB (Harmful Algal Bloom) toxins.

EEC standards at a glance

Sl no:	Parameters	Mandatory level
1.	Colour	>10mg Pt/l
2.	Temperature	>2°C from normal sea temperature
3.	pH	7 – 9
4.	Salinity	12 – 48 ppt
5.	Dissolved oxygen (saturation)	>80%
6.	Suspended solids mg/l	30%
7.	Petroleum hydrocarbon	Should not be deposited in the flesh
8.	Organohalogenated substances	Should not exceed harmful levels in shell fish and larvae

Sl.no.	Heavy Metals	Maximum permissible residual level (ppm)
1	Mercury	1.0
2	Cadmium	3.0
3	Arsenic	75
4	Lead	1.5
5	Tin	250
6	Nickel	80
7	Chromium	12

Sl.no.	Pesticides	Maximum permissible residual level (ppm)
1	BHC	0.3
2	Aldrin	0.3
3	Dieldrin	0.3
4	Endrin	0.3
5	DDT	5.0

Sl. no.	Antibiotics and other pharmacology active substances	Maximum permissible residual level (ppm)
1	Tetracycline	0.1
2	Oxytetracycline	0.1
3	Trimethoprim	0.05
4	Oxolinic acid	0.3

Sl.no.	Bacteriological parameters	Maximum permissible limit (No. / 100 ml)
1	Faecal coliforms	< 300 in the shellfish flesh & intervalvular liquid.

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 Kasargode district.

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

Diary of events in development of mussel Mariculture in India

Year	Activities
1973	Development of brown mussel culture technology at Vizhinjam
1974	Green mussel successfully cultured at Kozhikode
1976-82	Raft / long-line culture of mussel tried at Madras, Karwar, Goa, Ratnagiri, A&N Islands, Vishakapatnam & Kakinada.
1979	Pilot scale culture at Kozhikode
1984-85	Experimental brown and green mussel hatchery setup at Vizhinjam and Madras respectively
1997-99	Production of green mussel spat at Kozhikode RC of CMFRI under DBT sponsored project
1995-2000	Intensification of transfer of technology programmes through farmers participation, establishment of small rack units through group farming activities under DWCRA/IRDP programmes, open sea farms setup by fishers along Kerala & Karnataka coast.
1996	Estuarine farming started in Kerala (Padanna, Kasaragode district)
1997-2000	Technology up gradation of mussel culture – use of low-cost seeding material (flexible plastic strip), pre-stitched wrapping material, PVC poles of 5cm diameter filled with concrete instead of bamboo poles.
2000-2002	Mussel seeding device developed to automate the process and save time

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)

Impact of research and development in mussel culture

Scientific outcome		**Social impact**
Open sea mussel farming		
Phase I: 1995-96	High Production rates	Participation of fishers only in the institutional activities
Phase II: 1997	High production rates and growth rate (15kg/m)	Motivation for farmers to set up own farms.
	Possibility of two crops, Nov.-Feb; Mar-May.	Approval of financial aid to mussel farmers
		Emergence of open sea farming as a group farming activity.
Estuarine mussel farming		
Phase I: 1996	High survival (>95%) and growth of mussels in estuaries.	Privatization of mussel farming
	Low fouling	Group farming activities by women under IRDP/ DWCRA /TRYSEM
Phase II: 1997	Integrated bivalve farming of mussel and oyster	Motivation for farmers to set up own farms
	Harvesting mussel in a phased manner	Approval of financial aid to mussel farmers
		Employment opportunities for women during seeding and harvesting
		High consumer demand for farmed mussel

Advances in mussel culture technology

Use of cement filled PVC tubes instead of costly wooden and bamboo poles, use of low cost materials like plastic strips and used nylon ropes instead of costly new nylon ropes, development of a seeding machine to seed mussel ropes to reduce time and labour are recent developments. Pre-stitched tubes of degradable cloth for mussel seeding, modifications of grow out structures to suit shallow estuaries and deeper coastal water are some of the recent developments. Spat collection methods and development of low cost efficient spat collectors like old fish net, shading materials for seed collection were developed. Depuration protocols for simple and effective purification method of harvested mussels were also developed.

Mussel watch

Mussel is used as an indicator species for biomonitoring of heavy metals, organochlorines, and petroleum. *Perna viridis* (green mussel) is one the indicator species used for biomonitoring.

Eco-labeling

Under eco-labeling systems, fish/shellfish farmed or captured in accordance with certain environmental guidelines are sold with a special label. By purchasing a fish tagged with that label, consumers can be sure that it was caught or farmed in a sustainable manner.

Role of Fisheries Institutions in mussel farming

Central Marine Fisheries Research Institute

1. Technical support for mussel farming
2. Setting up of demonstration model mussel farms
3. Training to state officials, bank officials, farmers and other developmental agencies
4. Ensuring supply of mussel meat with the support Matsyafed
5. Arrangement of financial support from various developmental agencies
6. Assistance in management practices
7. Support for marketing
8. Farming technology developed by CMFRI offers scope for small scale farming of mussel in Kerala
9. Collection of feed back and improvement of technology
10. Survey and identification of brackish water areas for mussel culture
11. Design and construction of mussel farms
12. Establishment of seed banks

Central Institute of Fisheries Technology

1 Technology for developing value added products from mussel meat and transferring the technology to traders and exporters
2. Issue of quality assurance certificate of farmed waters and mussel meat for export
3. Dissemination of technology for new value added products to the end users (SHG,s, Kudumbhasree,etc.,)
4. Development of low cost technology for processing of mussel meat

Integrated Fisheries Project

1. Procurement of mussel meat for processing and marketing
2. Imparting training on processing, packing and marketing of mussel meat.

Brackish Water Fish Farmers Development Agency

1. Popularization of mussel culture technology.
2. Providing technical, financial and extension support for mussel farmers
3. Preparation of bankable projects on mussel farming.
4. Providing input subsidy (seed, feed, farm materials) to mussel farmers.
5. Arranging marketing assistance for farmed products
6. Selection of beneficiaries (SHG's Kudumbhasree) for mussel culture
7. Preparation of project on mussel culture at the local body level

Agency For Development of Aquaculture Kerala

1. Providing working capital and subsidy for setting of mussel farms.
2. Selection of groups, finalization of schemes for mussel farming
3. Imparting training to mussel farmers
4. Procurement of material required for mussel farming and related activities

Kerala State Co-operative Federation For Fisheries Development

1. Providing infrastructural support for setting up of mussel farms.
2. Group insurance scheme for compensating the loss due to natural calamities
3. Matsyafed can act as a chanalization agency for financial assistance from the national minority community development and financial corporation
4. Supply of nylon rope at reduced rate from their nylon net making factories will be added help to the mussel/oyster farmers
5. Procurement of meat directly from the mussel/oyster farmers minimizing the involvement of middle men
6. Matsyafed can arrange loans from Gramin bank and subsidies under IRDP schemes

Economics for a model mussel farm

Mussel Farming by Rack culture in Estuary

Area of Rack	**5X5m (0.0025ha.)**
No. of seeded ropes	**100 nos**
Length of seeding in each rope	**1m**
Culture period	**6-7 months (Nov.-May)**

Expenditure

Item	Quantity	Rate (Rs)	Amount(Rs)
Capital cost			
Bamboo poles	16nos	125	2000
Rope for rack construction	0.5 kg	110	55
Seeding rope	13 kg	110	1430
Total			**3485**
Recurring cost			
Cotton netting material	25m	12	300
Nylon rope for attaching sinkers and mussel ropes	1 kg	110	110
Needles	10 nos	2	20
Nylon rope for stitching	0.5 kg	110	55
Cost of mussel seeds	170 kg	6	1020
Canoe hiring charges	12 trips	80	960*
Labour for seeding	8 man days	150	1200*
Miscellaneous			850
Total			**4515**
Total Financial outlay			***8000***

*Rs 2160 will go back to farmer hence actual recurring cost will be Rs .2355

INCOME GENERATED

Total yield (100m x 12 kg) 1200 kg Rs.12/Kg 14400

Income realized 14400

Net Income (Rs 14400 -4515) 9885

Repayment Schedule

(5 years with one-year grace)

Years **1**	**Bank loan Outstanding** **2**	**Net Income** **3**	**Repayment Interest** **4**	**Repayment Principle** **5**	**Total (4+5)** **6**	**Net Surplus (3-6)** **7**
1	6800	9885	816	0	816	9069
2	6800	9885	816	1700	2516	7369
3	5100	9885	612	1700	2312	7573
4	3400	9885	408	1700	2108	7777
5	1700	9885	204	1700	1904	7981

Capital cost (CC) 3485 Rate of interest 12%

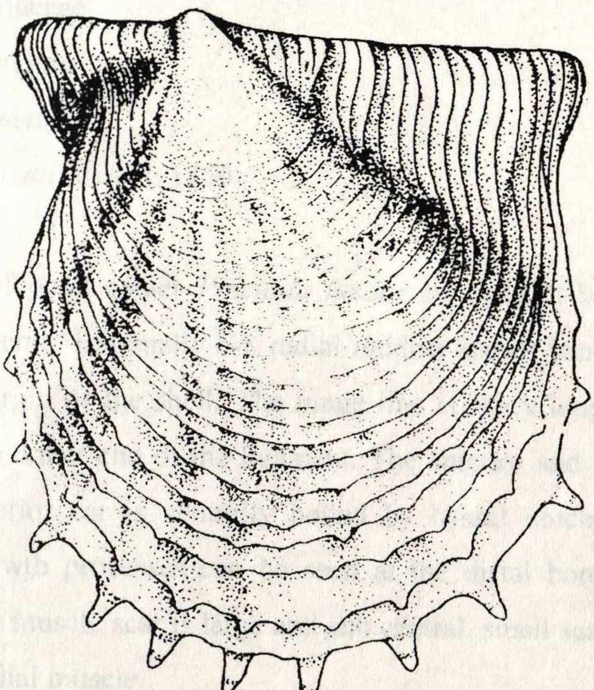
Recurring Cost (RC) 4515

Total Financial Outlay 8000

15% Margin 1200

Bank Loan (BL) 6800

PEARL OYSTER



PEARL OYSTER

Pearl oysters are soft bodied marine pearl producing bivalve mollusk with hard protective shell. These animals produce pearls. About 29 species of pearl oysters are available in the world and distributed in tropical and subtropical regions.

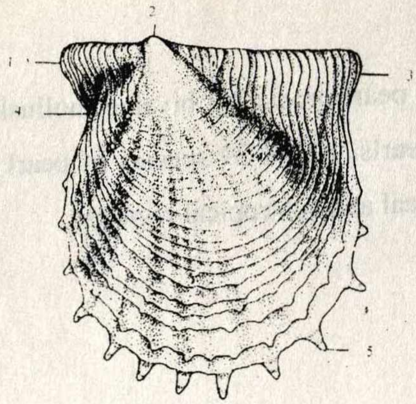
Taxonomy

Phylum	: Mollusca
Class	: Bivalvia
Subclass	: Pteriomorpha (Suzuki, 1985)
Order	: Pterioidea (Suzuki, 1985); Mytiloidea (Richard, 1985)
Sub-order	: Pteriaceae
Family	: Pteriidae
Genus	: *Pinctada*
Species	: *fucata* (Gould, 1850)

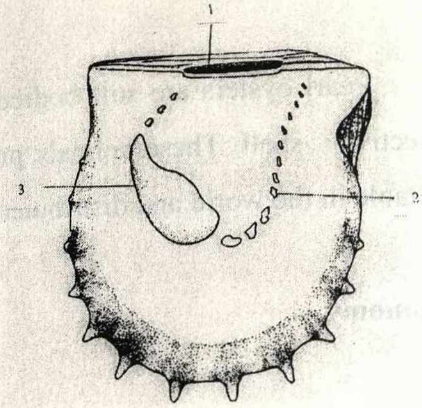
Morphology

The shells of pearl oyster *Pinctada fucata* are reddish brown but may exhibit different colour patterns. Externally 6-8 radial reddish brown bands emerge from umbo towards the free margin of the shell. The hinge line is fairly long. The hinge teeth are well defined, one on either end of the ligament. The anterior and posterior ears are well developed. The anterior ear is ventrally bound by byssal notch. In fresh specimens, prominent scaly growth processes can be seen at the distal border. The left valve is deeper. The adductor muscle scar is large and sub central, small scars are also present for the attachment of pallial muscle.

The shell of pearl oyster is composed of three layers; the organic conchiolin layer (or Periostracum), the middle prismatic layer and the innermost nacreous (mother-of-pearl) layer.



External features of shell
1. Anterior ear 2. Umbo 3. Posterior ear
4. Byssal notch 5. Growth process



Internal features of shell
1. Hinge line 2. Pallial mussel scar
3. Adductor muscle scar

Anatomy

The soft body of the pearl oyster consists of a pair of mantle lobes, visceral mass, gills, foot, posterior adductor muscle and other musculature. The soft creamy yellow coloured mantle that follows the contour of the valves (shells) envelops all the other soft parts of the body.

Mantle

Mantle is a fold of skin covering the soft body below the shell. It is formed of two lobes on either side. The two lobes are fused together dorsally below the hinge line, from which point they hang down on both sides of its body. The most important function of the mantle's external surface is the secretion of shell's organic matrix and deposition of calcite crystals. The edge of the mantle has three folds viz. the ciliated inner fold, the middle fold and the outer fold. The outer fold is shorter and flattened against the valve's interior face. It is separated from middle fold by the periostracal groove, from the bottom of which arises a translucent organic membrane, the periostracum. This covers the edge of the shell and isolates the liquid between the mantle's external epithelium and the valves interior, from the seawater. The peripheral cells of this epithelium secrete a glycoprotein substance, formerly called conchiolin, which serves as an organic grid for crystallization of prismatic calcite. The matrix controls the crystal's shape and distribution by enclosing them in an organic wall. The prisms have a polygonal section and are oriented perpendicularly to the mantle surface. They ensure the longitudinal growth of the valves, which is sporadic, due to periods when growth stops, when temperature and nutritional conditions are unfavorable. The center of the mantle precipitates aragonite as polygonal tablests, which add to the thickness of the shell. It is in this part that the graft tissues are cut. If graft tissues are taken from the mantle edge, the pearl sac will secrete prismatic layers and the pearl will not be a nacreous one.

Gills

The branchial organ, the ctenidium is an active filter, which takes from the water the animal's, needs –oxygen and organic matter and rejects anything that hinders the filtration. The gills are a paired structure attached to the visceral mass at the front and its distal end is free in the pallial cavity. The gill consists of a longitudinal axis from which hang down two lamellae of ciliated filaments. Each blade is folded in a V-shape, which increases the length and number of filaments. These thousands of filaments develop an immense exchange surface with seawater. The inhaled water current enters the shell anteriorly and reaches the gills. The ciliary movements redistribute the water by channeling it along the filaments.

Two veins follow the bronchial axis; the afferent vein brings blood coming from the kidneys and the efferent vein takes it away towards the auricle. A network of capillaries, which follow the filaments where blood is oxygenated, links the two veins.

Heart

The heart consisting of a ventricle and two auricles enclosed by the pericardium it is located ventral to the intestine. The auricles are covered with pericardial glands, which function as excretory organs. From a single ventricle, arise the short posterior aorta, which supplies blood to the rectum and the adductor muscle, and the anterior aorta, which continues as arteries and arteries and arterioles. These minor arteries open into lacunae of connecting tissue, where blood circulates freely before reaching some large spaces called sinuses. The deoxygenated blood is collected in veins and carry into the nephredia where it is purified before it reaches the gills.

Filtration

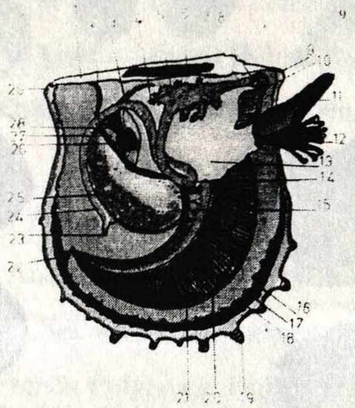
Sea water contains suspended particles of varying sizes, shape and nature. The gills must expel them immediately upon contact or suffocate. They sort out the organic and inorganic materials and pass them towards the digestive tube. Larger particles are discharged at the rear end of the shell through the exhalent current. The ciliary movements of the filaments bring small plankton and other nutrients to the mouth. Bacteria and mud are aggregated by mucus secreted by the gills before they are sent to the labial palps. When the water is highly turbid, the filaments become chocked and cannot maintain oxygenation; they therefore stop filtering.

Labial palps

The mouth is framed by labial palps which are two superposed curved leaves whose opposing faces are stripped with grooves. The small plankton brought in by branchial currents undergoes another selection. Some organisms are undesirable, because of their spiny ornamentation or chemical character. They are directed along the furrows to the end of the palps, where they fall into the pallial cavity and are periodically ejected as pseudo-faeces into the sea water. The accepted food is passed to the mouth and oesophagus and finally into the stomach. In the stomach the food particles are mashed. impregnated with enzymes liberated from a gelatinous rod known as the crystalline style. The larger particles are directed towards the intestine; while the other nutrients are dispatched to the digestive diverticula's which surround the stomach. The intestine extends through the visceral mass and forms a loop, ascends above the heart, ends to a long rectum along the adductor muscle. The anus is encircled by a funnel shaped anal appendix which ejects the faeces outside the mantle.

Sensory organs

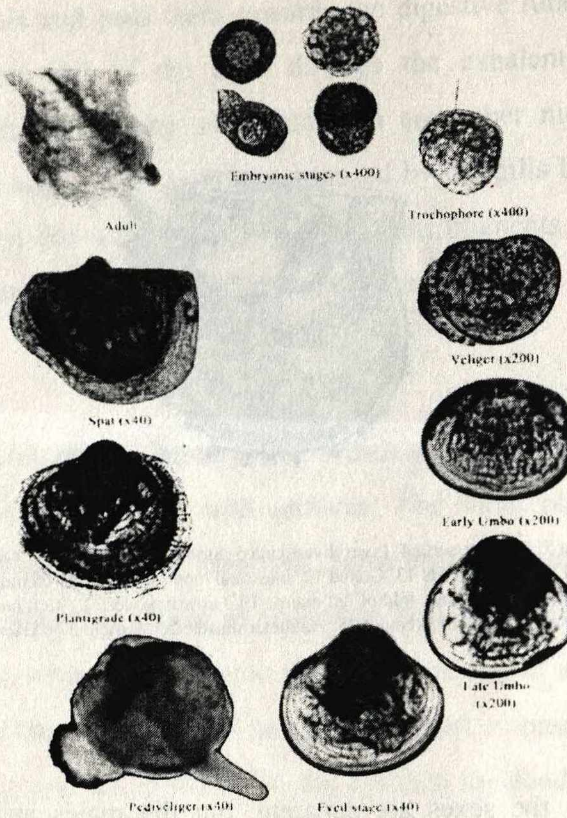
The nervous system consists of 3 pairs of ganglia viz. cerebropleural, pedal and visceral from which the nerves arise. A complex network innervates the mantles, the pallial plexus which make it react at the least tactile or chemical stimulus. The gill responds to stimuli. A branchial eye is present on the first left hand branchial filament. It can detect variation in light intensity.



1.Hinge line 2. Posterior aorta 3. Anterior aorta 4. Liver diverticula 5. Stomach 6. Ligament 7. Oesophagus 8. Mouth 9. Anterior ear 10. Labial palps 11. foot 12. byssal threads 13. Gonad 14. Intestinal loop 15. Muscular ctenidial axis 16. Outer fold of left mantle 17. Middle fold of left mantle 18. Inner fold of left mantle 19. Growth process 20. Left outer ctenidial 21. Left inner ctenidial 22. Pallial fold 23. Anal process 24. Rectum 25. Adductor muscle 26. Auricle 27. Pericardial cavity 28. Ventricle 29. Posterior ear

Reproduction

In pearl oyster, the sexes are separate, but the males and females cannot be distinguished from the characters of the shell. The reproductive system consists of a pair of gonads, which spreads superficially over the hepatopancreas and intestine in mature state. It is pale yellow in colour in male and is of a deeper shade in the female. The eggs or sperms are spawned through the paired gonoducts ending in the genital openings located at the anterior ends of the gills. *P.fucata* attains first sexual maturity when it is about 15.5mm, i.e when about 3-4months old, Pearl oysters spawn twice in a year. In the Gulf of Mannar, the spawning season is June-August and November- January coinciding with the southwest and northeast monsoons respectively. The male and female oysters release their spermatozoa and ova respectively into the sea and the eggs are fertilized.



Life cycle of pearl oyster

Age and growth

The age and growth of pearl oysters in the Gulf of Mannar have been studied in detail. Observations made on cultured pearl oysters collected near Krusadai Island and at Tuticorin show that the oysters can grow to a height of about 35-45mm at the end of the first year.50-55mm at the end of the second year,55-60mm at the end of the third year,60-65mm at the end of the fourth year and 65-70mm at the end of the fifth year. The weight of the oysters was 10,30,45,60 and 70g at the end of the first, second, third, fourth and fifth years respectively. Tracing the growth history of *P.fucata* produced in the hatchery and grown in the farm at Tuticorin Harbour revealed that the species attains a modal size of 47.0mm at the end of the first year,64.5mm at the end of the second year and 75.0mm at the end of the third year. The corresponding weights at ages 1 to 3 years were 8.3, 31.6 and 45.4 g respectively. The pearl oysters have been estimated to have longevity of 5.0-5.5 years in natural beds, but have been observed to live up to seven years when reared in the farm.

Where pearl oysters are found

In India *P.fucata* were found along the east coast especially in the pearl banks of Gulf of Mannar**("paars")** and in Gulf of Kutch **(Khaddas).** It is also distributed in the Red Sea, Persian Gulf, China, Korea, Japan, Indonesia, Australia, Margarita, Africa and Venezuelan Islands.

The Black-lip pearl oyster *P. margaritifera* is famous for black pearls. In India its distribution is restricted only in Andaman & Nicobar Islands. This cosmopolitan species found in the Persian gulf, Red Sea,Seychells, Philippines, Thailand, Malaysia, Indonesia, Micronesia, South Sea Islands. French Polynesia, Papua New Guinea, Gulf of California, Gulf of Mexico, Panama Bay and Peru.

Other species found along Indian coast are *P.chemnitzii, P.sugillata, P.anomioides* and *P.atropurpurea* .

How pearls are formed

In salt-water lakes and rivers, mussels produce pearls. Natural saltwater (also called oriental) pearls are formed when sand or hard particle entered inside into an oyster. The irritant settles in the soft body of the mollusk between the shell and mantle, finally that particle being entrapped into the epithelial layer. The oyster secretes a fluid (called nacre), which solidifies to avoid the irritation and smoothen the foreign body. Nacre secretion surrounds the particle ("nucleus or core material") and it gives the iridescent color to the precious pearl.

Pearl sac theory

Most accepted theory to be known as the pearl-sac theory explains that a pearl is formed when the pearl-secreting cells of the mantle migrate into the body of the oyster under the stimulus of a foreign body (undischarged eggs of the oyster; sand grains got into the shells and formed pearls; and that parasites or other eggs or other organic matter formed the core of the pearls); and form a pearl-sac that secretes nacre which gets deposited on the foreign body and in course of time a pearl is produced according to the shape of the foreign body.

Cultured pearl

The pearls produced by the oysters through the implantation of a nucleus along with a mantle piece. They have become highly desired because of their uniformity in size and shape. Most of the world's cultured pearls are produced in Japan, Australia and the South Seas.

The term "cultured pearl" was used for the first time in 1920 for the pearls produced in Japanese pearl oyster "akoya gai " and marketed in Europe. The name **Mikimoto** is the first man when cultured pearls are mentioned, the Australian Savillekent is now believed to deserve the credit for the original development of the technique. His technique involved taking a piece of mantle tissue from one oyster and implanting it in another. The term `artificial pearl` dose not denote a cultured pearl, but would refer to cheap imitation made of plastics, glass etc; by using the extract" guanine" from fish scales for artificial shine. The tissue culture pearls may be in trade in large quantities from some of the countries the secrets are not exposed wherein large quantities of pearls could be produced from the isolated cells of the mantle in the controlled laboratory conditions. For the production of a cultured pearl a shell bead nucleus is implanted into the gonad of the oyster along with a mantle graft tissue by a skillful surgery. The core material called shell bead nucleus is produced from the fresh water mussel shells from America which is imported to Japan, China, Thailand and Australia where they produce the spherical beads of 2-22mm size according the size of oysters to be used for pearl production. The surgical tools have designed and developed by CMFRI. Implanting the images of required object in between the mantle and shell cavity without affecting the mantle produces the "Mabe" image pearls. This technique has been developed by CMFRI, during 2002. The tissue culture pearl production is under perfection.

Implantation and rearing

A skilled technician opens the live oyster, makes an incision in the gonad (A, B, C & D positions) and inserts a nucleus. The nucleus usually made from fresh water mussels 'pig-toe "shells. Following the insertion, the oyster is placed in a tray of water to rest. The live oysters are then transferred to a cage and lowered into the sea to live while the nacre builds the pearl. These pearls are harvested after 3 to 22 months according to the size of the nucleus .

The operated oysters are put in iron cages with lid netted with synthetic threads/plastic baskets/netlon bags and suspended from the raft, rack, long line or kept on the under water platforms land bases culture tanks with sufficient water air and feed etc; according to the area in an air conditioned room without contamination.

In Indian pearl oyster the nucleus of 2-8mm can be used and the duration for sufficient coating of nacre on the implanted nucleus varies from 4-22 months. The oysters could be checked after 3 months to assess the retention of the nucleus by narcotizing the oysters or by X-ray screening.

In Indian waters, the deposition of nacre on nuclei is much faster than in sub-tropical and temperate waters. The duration of post-operative culture varies from four to eighteen months depending on the size of nucleus and the maturity of pearl. When a 3 mm nucleus is introduced in an oyster, it takes a minimum of 4 months for the pearl to attain maturity and it is 5-7 months for a 4mm dia nucleus.

Floating rafts are used for farming oysters in the open sea. In shallow sheltered bays, racks are employed. In rack system which is a fixed structure, teak wood poles are driven vertically into the sea bottom and a rack is constructed by lashing horizontal and cross poles on them with coir ropes at a convenient height of 0.5 m above the water level so that the rack thus erected remains always above the water. The oyster cages are suspended from the wooden frame.

The success of farming pearl oysters greatly depends on the environmental condition prevailing in the area. In India, the pearl culture is being undertaken in the Gulf of Mannar and the Gulf of Kutch. Cyclones, storms, strong currents and violent waves are not uncommon in these regions. Dilution of sea water during monsoon months and high saline condition during summer months are quite common in some parts of the east and west coasts of India and such areas are not suitable for farming pearl oysters.

Useful tips in pearl culture

Selection of suitable sites	Areas with Salinity above 30ppt Good food (Phytoplakton) availability Mild/ moderate current Low siltation Depth 2-3 m and above
Selection of oysters for operation	Age of oyster - 1.5-2.0 years Weight - >25g (40mm) Stage of maturity - Spent resting stage Overall health - Good, free from polychaets/ sponge, trematode infection.
Conditioning	Arranging oysters in a container with their hinge pointing downwards. Narcotization of selected oysters by sprinkling menthol in the seawater Insertion of a small wooden peg between the two valves to facilitate nucleus implantation.
Preparation of Graft Tissue	Select healthy non narcotized oyster cut mantle into thin strips of 5 cm length and 0.5 cm width Remove mucous and muscle from the mantle cut the mantle strip into 20 to 25 pieces of 2-3 mm squares keep cells live by adding Azumin/Eosin solution in sterilized SW and use within 15 minutes.
Implantation	Mounting oyster in the stand with the valves facing upwards Making incision at the right place and placing the graft mantle piece 1.Single implantation -in the gonad near the intestinal loop 2. Double implantation- additionally, close to hepatopancreas 3. Multiple implantation –more than double implantation Placing the sterilized nucleus on the graft mantle piece.
Convalescence	Placing the implanted oysters in fresh seawater with mild circulation for two to three days Maintaining water quality by water exchange Removing dead oysters and shifting the healthy implanted oysters into the natural environment

Implantation technique

The healthy adult pearl oysters are anesthetized using mentholated seawater in closed containers or pegging in between shells with wooden pieces. A passage is made from the base of the foot towards the gonad of the host oyster without damaging any of the vital organs of the oyster, for which it is mounted on an oyster stand. After that skillful surgery, the mantle piece (graft tissue) and the shell bead (nucleus) are implanted into the gonad (through the passage already made) to lie in contact and proper orientation. The oysters are maintained in the laboratory for two to three days for convalescence with sufficient fresh seawater and aeration for healing of the wound. The care is given to form the pearl-sac over the nucleus by implanted grafted mantle piece to get a good quality pearl from each oyster.

Harvesting

The pearls are harvested by cutting and separating the two valves and squeezing out the pearl from the gonad of the oyster. The harvested pearls are washed in distilled water, polished with concentrated salt solution and again washed in distilled water wiped with soft cloth and dried and stored. The percentage of pearl production varies with efficiency of the operation, environmental and health conditions of the animal.

Oysters of choice

- Silver-lipped oyster (Pinctada maxima)
- Gold-lipped oyster (*Pinctada fucata*)
- Akoya oyster (*Pinctada martensii*)
- Black-lipped oyster (*Pinctada margaritifera*)

Pearl sorting and grading

Pearls are measured in millimeters across the diameter of the pearl.

Once removed from the oyster, pearls are first sorted by size and then by colour and shape. Because they are created by nature, pearls will have their own birthmarks-blemishes or irregular surfaces. The pearls are graded as"A" with spherical and good luster, "B"some times a pimple like spot with good shining and all the characters of "A" and "C" with more teeth.

Pearls with only a single blemish will be used for earrings, cuff links and the tacks. If a pearl has blemishes on opposing sides, a hole will be drilled through the middle so the pearl can be strung for use in necklaces.

Pearls of similar size, shape and color are strung together with silk thread. The thread is knotted at the drilling point to prevent the pearls from rubbing against each other and destroying the natural luster. This practice also gives the necklace more flexibility and prevents the loss of more than one pearl should the string break.

Characterizing pearl quality

Seven key factors define the quality of pearl. Here's how each one affects the value and beauty of pearl jewellary.

Lustre

Lustre is the direct result of the amount of nacre used in the formation of the pearl. It's what gives a pearl its unique glow and beauty. Factor such as water temperature and the diet of the oyster can affect the luster of the pearl, colder waters produce pearls with smaller amounts of nacre, while warmer water provide a thicker layer of nacre.Pearls that are semi-transparent display a higher degree of luster there by increasing their value.

Size (diameter)

As with most gems, the larger the size of a pearl, the greater its value. Pearls are generally between 3mm and 10mm in diameter. Pearls of a larger size than this are extremely desirable and expensive. Size is determined by the combination of nucleus size, nacre depth and length of growing time.

Colour

The color is largely determined by the species of oyster that produced the pearl. Different colors are more highly desired in different cultures around the world. This creates a market where all colours, such as cream, off white /ivory, rose, gold, gray and golden yellow , pea-cock hue are equally in demand. The value of the pearl is then determined by the demand in particular parts of the world.

Pearls can be dyed or bleached with medicinal dyes to enhance their look; black, gray and blue pearls from the South Seas come by their color naturally, which makes them extremely valuable.

Some pearls have one or more colours which overlay the basic color known as an overtone. Pearls whose overtone colors enhance the original color are considered very valuable.

4. Nacre thickness

The thickness of nacre affects the durability and sometimes the beauty of a pearl. A thick nacre will sustain more handling and normal wear. A thin coating can be more easily worn away, thereby exposing the nucleus of the pearl.

5. Blemishes/ Spotting

Perfect pearls are extremely rare. The value of a pearl is determined by a lack of blemishes and other imperfections. Blemishes affect the value of pearl. Most pearls are considered slightly to heavily blemished.

6. Shape

The most desirable pearls are perfectly round or spherical in shape. The shape of a pearl is determined by a combination of factors including the shape of the nucleus, quality of graft, nutrients, water current, water temperature and the location of the implant.

7.Consistency

Consistency in size, colour, shape, blemishes and transparency help to define the value of a pearl/ pearl strand.

8.Drilling

The quality of the drilling in the pearl/ pearl strand is also important. Pearls that are drilled off center lowers its value.

Options in pearls

Tips to buy a pearl

- Minimal skin blemishes
- Roundness
- Luster
- Tint
- Size
- Matching

Marine pearls includes

South Sea pearls /Black pearls : South Sea pearls are both very rare and valuable. They are quite large, ranging from 10-22 mm in diameter, compared with a typical cultured pearl of 2-10 mm. Black pearls are cultured in the South Pacific, primarily Tahiti.

Seed / Blister pearls : Created by farm-raised oysters when sand particles enters the shell during feeding and is surrounded by nacre.

Mother of pearl : A secretion from the oyster that is thinner than nacre and protects the mollusk from its own shell. Its iridescent layers are used in decorative purposes.

Mabe pearls : Image pearls. Placing an image, flat side againt the shell of the oyster, produces Mabe. Mabe are used for making high fashion jewellary

Fresh water pearls includes

Rice pearls : Produced in China, these naturally occurring pearls have a long, irregular, dented shape resembling Rice crispiest.

Biwa pearls : Originating in Japan's Lake Biwa, these naturally occurring pearls are larger and flatter than the Chinese pearls, with a fine colour and luster.

Cultured fresh water pearls: These fresh water pearls cultivated to produce a smooth, more uniform pearl. Fresh water mussels produce them.

Marketing.

In the international market pearls of larger size are highly valued. India is importing pearls worth Rs.29 crores every year. The major countries involved are Bahrain, Hongkong, Japan, the UAE and the U.K. In the present condition in India some private companies have produced pearls and sold internally and exported very little.

Role of CMFRI

Based on the packages developed, CMFRI has been offering regular training to officials from State Government, Universities, Research Institutes, Krishi Vigyan Kendras, industry and progressive farmers on pearl oyster hatchery, pearl culture and SCUBA diving for studying the under water ecology of pearl oyster beds and resources. India is offering pearl culture training to candidates from other nations. The Swaminathan Foundations have come foreword to finance the fishermen of the coastal villages of Ramnad District in Tamil Nadu to do pearl culture and CMFRI, giving training in pearl culture and also supplying implanted oysters to the farmers and they grow them in the rack constructed in the sea. The final harvest was encouraging and this will certainly given an impact to subsidise the fishermen/women groups in other parts of the country. The Central Marine Fisheries Research Institute is now handling an NATP project worth 1.3 Crores under World Bank in "Breeding culture of pearl oyster and pearl production. The Department of Ocean Development is funding another commendable project cost Rs.1.6 crores at Andaman for "Production black pearls in *Pinctada margaritifera*" if succeeds the black pearl production will increase export and income of the country. India has to go forward to commercialize the pearl culture programme and production of large quantity of bigger and quality pearls both marine and freshwater to compete in the world pearl trade market.

Recently CMFRI has conducted First Indian pearl congress and exposition during 5-8th February, 2003 inviting all the pearl workers in the country to discuss and sort out the problems encountered in the pearl research and production of pearls in India.

The researchable issues are production of pearl oysters to hold larger nucleus 6-8mm dia and the preliminary works already started. Since the pearl production is a long term process the diversification of the process to hatchery/production of young ones from nature. Mother oyster culture, implantation and convalescence, postoperative culture, harvest of pearls and processing, marketing/jewellary products, by products etc; and export. All these aspects come into limelight if marine Pearl Park is identified and demarcated to avoid communal and socioeconomic conflict in the sea based aquaculture programmes.

Transfer of technology

Pearl culture training given in National and International level to 11 South East Asian countries . Egypt and Bahrain .

Advances in Pearl culture in India

Many attempts were made over the years to entice oysters to produce a greater number of high quality pearls. But success didn't come until the 20th century. In early 1900 Japanese scientists discovered a method of inducing pearl growth that gave rise to the modern cultured pearl industry. Now India, the proud owner of a technology developed for tissue culture pearl production.

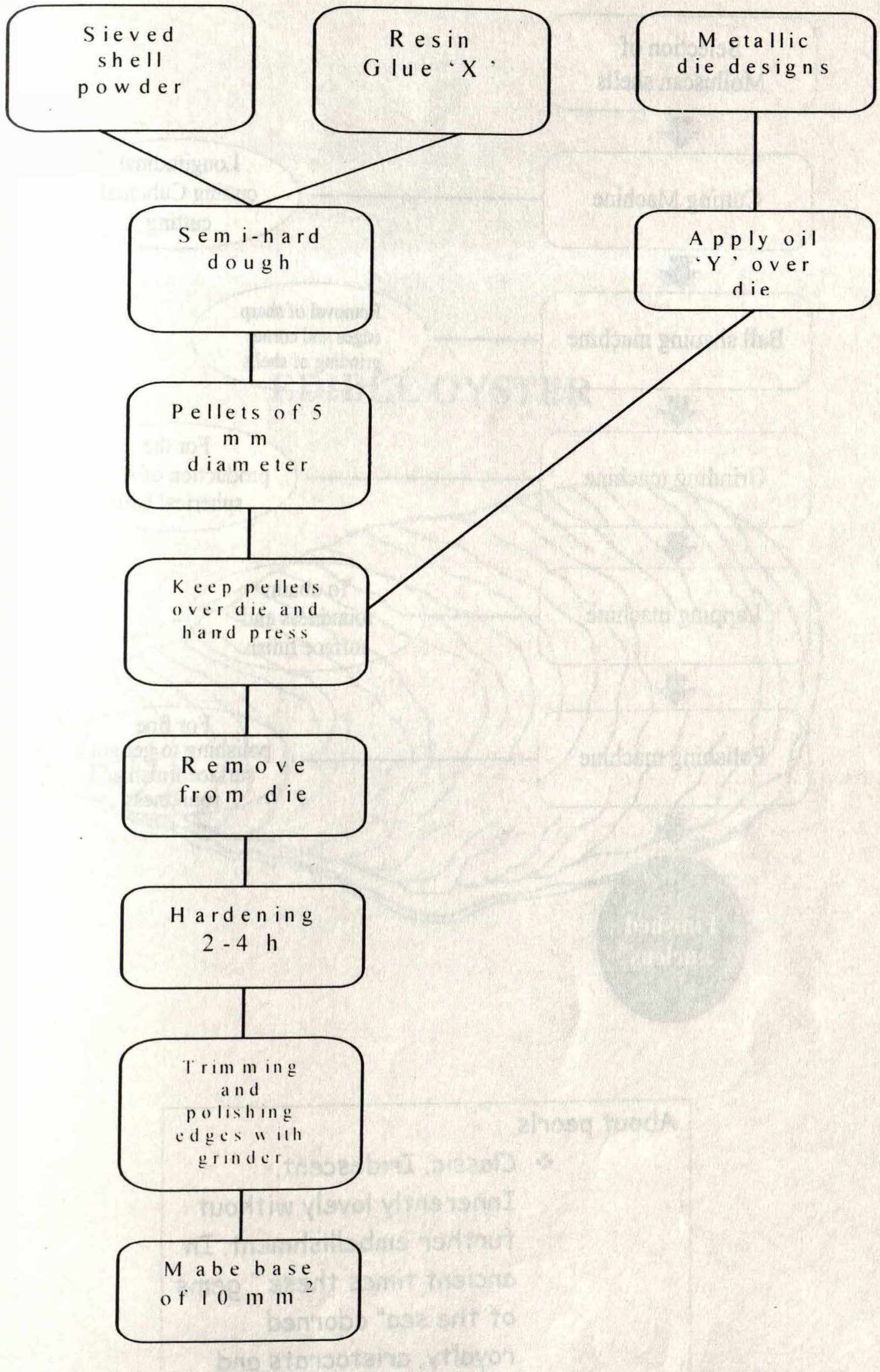
***In-vitro* pearl production**

First time in the world, India has developed an indigenous technology for in-vitro pearl production in Indian pearl oyster *Pinctada fucata* and the abalone *Haliotis varia*.

Coloured pearl production (Make-up pearl production)

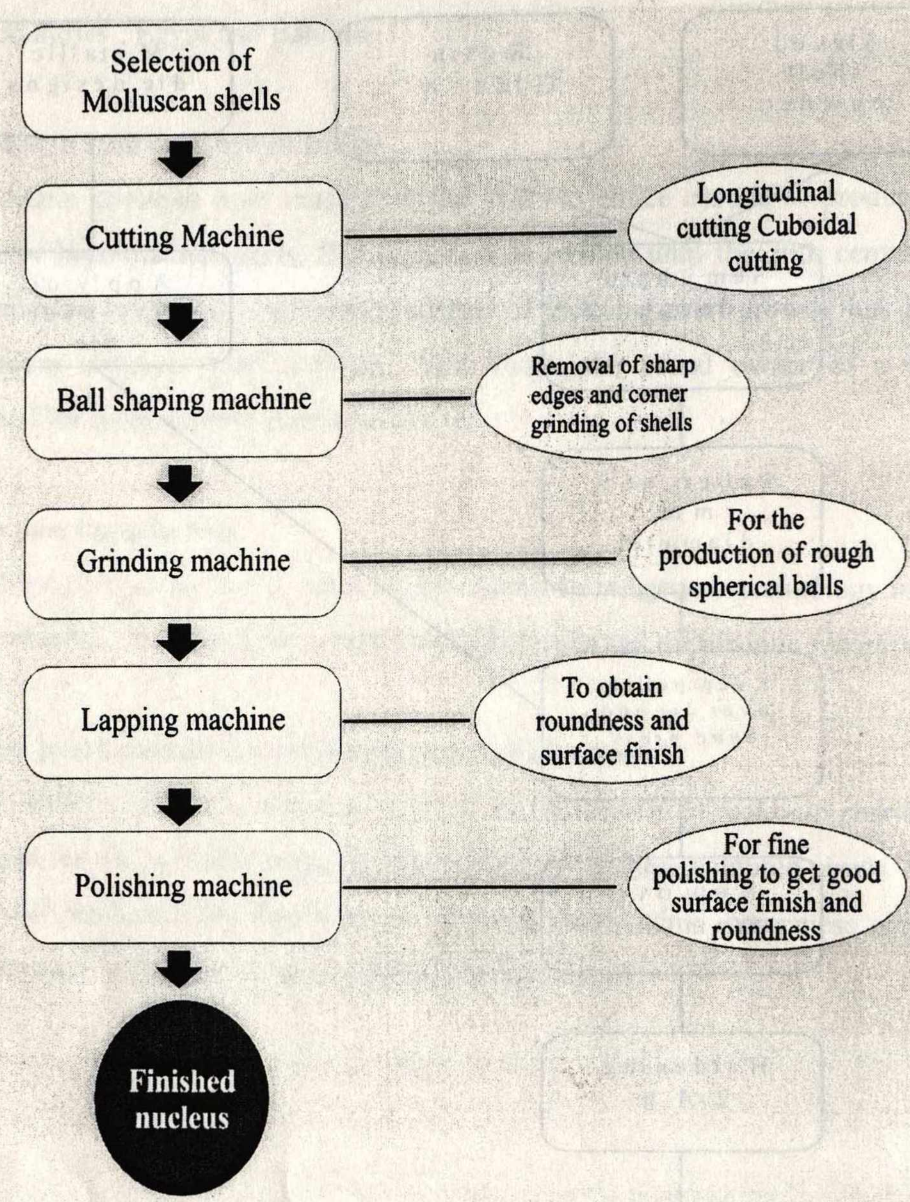
CMFRI is also in a proud position in the production of make-up pearls. Iron and manganese are the two salts using for the production of these coloured pearls. Iron added oysters will produce violet and mercury coloured pearls while manganese enriched will make the pearls with light orange to grayish orange colour.

Mabe Pearl production



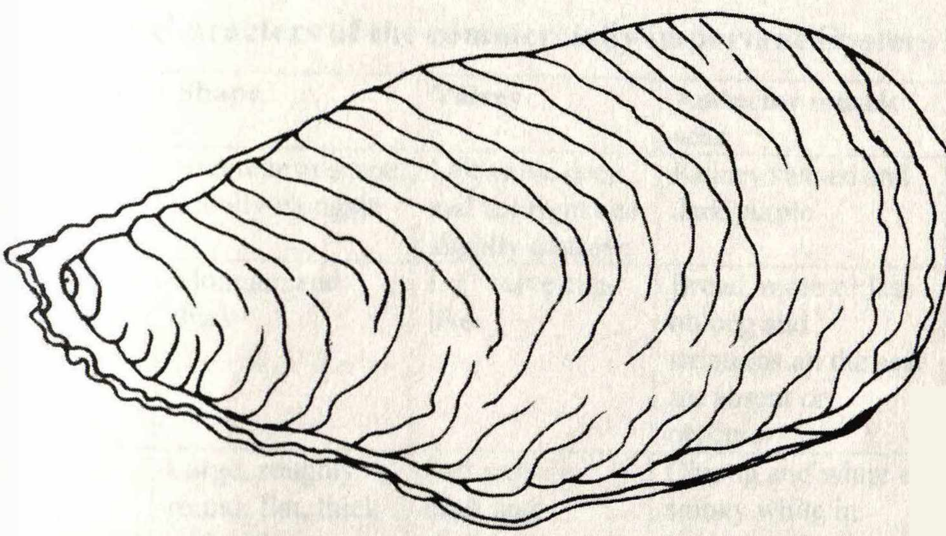
Indigenous technology for nucleus production

CIFT has developed a technology for nucleus production.



> About pearls
>
> - Classic. Iridescent. Inherently lovely without further embellishment. In ancient times these " gems of the sea" adorned royalty, aristocrats and the wealthy.

EDIBLE OYSTER



EDIBLE OYSTER

The name oyster is used for a number of different groups of molluscs, which grow for the most part in marine or brakish water. The true oysters are the members of the family *Ostreidae* and this includes the edible oysters, which mainly belongs to the genus *Ostrea, Crassostrea* or *Saccostrea*. The most common Indian oysters are *Crassostrea madrasensis, C.gryphoides, C. rivularis* and *Saccostrea cucculata* .

Taxonomy

Phylum - Mollusca

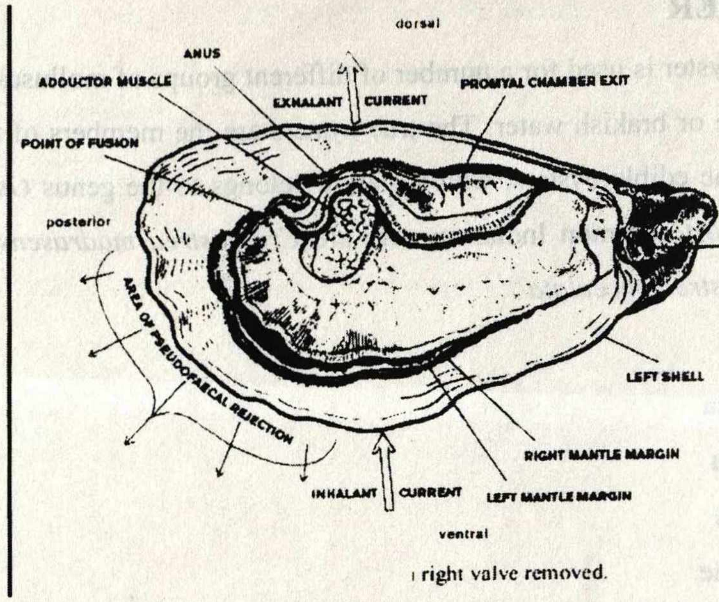
Class - Bivalvia

Order - Ostreina

Family - Ostreidae

Identification characters of the commercially important Oysters in India

Scientific name	Shape	Valves	Adductor muscle scar	Hinge
Crassostrea madrasensis	Irregular in shape usually elongate	Left valve deep and the right one slightly concave	Kidney shaped and dark purple	Narrow and elongated
Crassostrea gryphoides	Elongate and thick	Left valve cup-like	Broad, more or less oblong and striations on the scar are absent or obscure	Well developed and has a deep median groove with lateral elevations
Crassostrea rivularis	Large, roughly round, flat, thick and with a shallow shell cavity	Left valve is thick and slightly concave and the right one is about the same size or slightly larger	Oblong and white or smoky white in colour	
Saccostrea cucculata	Hard, strong, trigonal and pear-shaped	The margins of both the valves have well developed denticals	Cream coloured	Hinge strait, divided if teeth and umbonal cavity well developed



Oyster anatomy - Adult

Ecology

The oysters of the world are grouped into one family- Ostreidae. Within this family the edible oysters comes under the genus *Ostrea/ Crassostrea* or *Saccostrea*. The genus *Ostrea* that is widespread through most part of the world is generally considered to be adapted to clear water with little sediment and high salinity. *Crassostrea* exist in estuaries where the silt load is high and fluctuating salinity. The various species inhabit coastal water within the broad belt of the seas limited by the latitudes 22 ° S and 64°N. They are found attached on rocks, underwater structures or embankments. These aggregations of live oysters and empty shells are termed as oyster beds or oyster bottoms or oyster reefs. Descriptions of oyster bottoms usually provide information about their location, nature of bottom and depth. The oyster bed is an example of "biocoenosis", where parallel communities aggregate.

Some of the common edible oyster species in the world

Scientific name	Common name
Crassostrea belcheri	Lugubrious cupped oyster
C. eorteziersis	Cortez oyster
C. gigas	Pacific cupped oyster
C .iredalei	Slipped cupped oyster
C. madrasensis	Indian back water oyster
C. rhizophorae	Mangrove cupped oyster
C. rivularis	Suminoe oyster
C. virginica	American cupped oyster
Ostrea chilensis	Chilean flat oyster
O. edulis	European flat oyster
O. lurida	Olympia flat oyster
Sacostrea commercialis	Sidney rock oyster
S. cuccullata	Hooded oyster/rock oyster
S. echinata	Spiny oyster

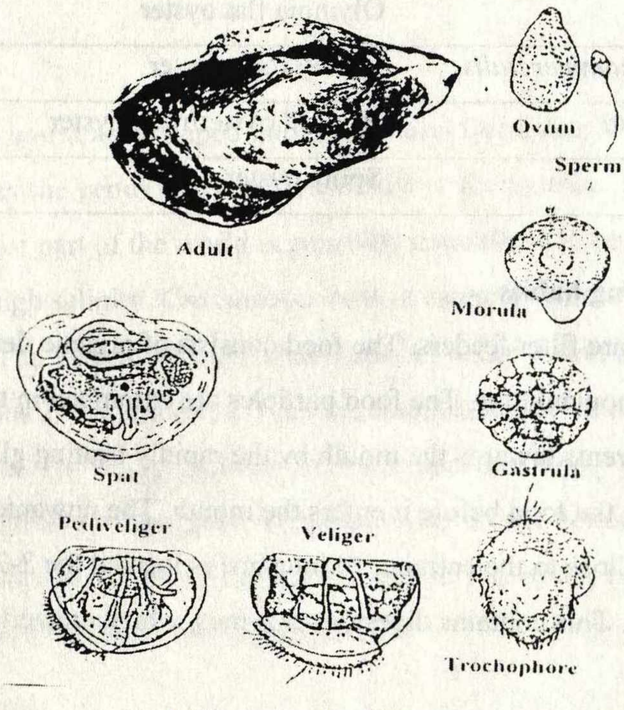
Food and feeding habits

Oysters are filter feeders. The food consists of organic detritus and phytoplankton such as diatoms and nanoplanktons. The food particles are entrapped in the mucus of the gill and passed in the water currents towards the mouth by the rapidly beating gill cilia (fine hairs). The four labial palps sort the food before it enters the mouth. The unwanted food particles are rejected as psuedofaeces. Close to the entrance to intestine is located the 2-3 cm long crystalline style made of mucoprotein. This contains digestive enzymes, which convert starch into sugars.

Reproduction

In the genus *Crassostrea* sexes are separate but occasionally hermaphrodites occur. The ovary and testis consist of a series of branching tubules also called follicles, on either side of the body. During spawning, ripe eggs and sperms are discharged into the exterior where fertilization takes place. During the non-breeding season the gonad is replaced by connective tissue called Leyding tissue, which mostly consists on glycogen. In this stage the sex of the oyster cannot be determined. The sex of the oyster may change during the breeding season. Temperature, food availability and salinity are considered as important exogenous factors, influencing the maturation of gonads.

Sperm and eggs are released and fertilization occurs in the water column. Fertilized eggs develop rapidly into microscopic swarming trochophore. After 24 to 48 hrs non-feeding trochophore develops into the feeding veliger stage. At this stage the larvae have a thin shell and feed primarily on algae. After 24 to 21 days, larvae develop a foot and eye sport and are referred to as "eyed larvae". Pediveligers settle to the bottom and are capable of crawling short distance to find a suitable site to set. Setting occurs when the larvae cement themselves to a hard substrate (usually oyster shells) and metamorphose to a tiny oyster -spat.



Life cycle of edible oyster

Condition index.

The condition index of the oysters denotes the quality of the meat and it is useful to determine the best period of 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 meat of oyster 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 looses weight. The condition factor is studied based on weight, volume or both. The percentage of wet flesh weight in total weight gives the condition index, also called percentage of edibility. A commonly followed method is the ratio of the dry meat weight (oven-dried at 90-100°C to constant weight) of the oyster to the volume of the shell cavity, and is expressed as:

Condition factor = 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. The other important measurements in oyster farming are length and meat weight. The antero-posterior axis (long axis) is called length and dorso-ventral axis is referred to as width.

Oyster resources of India

Different species are identified based on the shape, size, colour and other characteristics of the shell, anatomical feature of promyal chamber, gill ostia, heart, gut and the breeding habits. *C. madrasensis* is the main species in India. It is euryhaline and tolerates wide variations in salinity and inhabits backwaters, bays and lagoons; and generally found in the intertidal region up to a depth of 17m.

General information on oysters in India

Scientific name	Common name	Local name
Crassostrea madrasensis(Preston)	Indian back water oyster	Kadal muringa(Malayalam)
Sacostrea cucullata(Born)	Rock oyster	Ali,Kalungu(Telugu)
Crassostrea gryphoides(Schlotheim)	West coast oyster	(Patti (Tamil) Muri Kannada)
Crassostrea revularis(Gould)	Chines river oyster	
Saxostrea cucullata (Awathi and Rai)	Bombay oyster	
Hyostissa hyotis(Linnaeus)	Giant oyster	Rare-East coat

Oyster resources of maritime states

Species	State
Crassostrea madrasensis	**Ker, Kar, Goa, Mah, Guj, TN, Pon, AP**
Crassostrea rivularis	**Kar, Goa, Mah, Guj, TN, Pon, AP**
Crassostrea gryphoides	**Ker, Kar, Goa, Mah, Guj, TN, Pon, AP**
Saccostrea cucullata	**Kar, Goa, Mah, Guj, Pon, AP**

Major areas/ locations having rich oyster bed

State	Areas/ locations
Orissa	Bahudi estuary near Sonaour and at the mouth of the Chilka lake
Andhra Pradesh	Sarada estuary, Bhimunipatanam backwater, Upputeru canal (Kakinada), Krishnapatnam and Gokulpalli
Tamil Nadu	Gokulpalli, Ennore, Muthupet swamps, Killai backwater, Pazhayar, Vaigai and Tambaraparn estuaries,Pulicat and Tuticorin.
Andamans	Port Blair, Havelock Island, Mayabender and Dighlipure
Kerala	Ashtamudi and Vembanad lakes, Cochin backwaters, estuaries and the creeks of Dharmadom, Valapatanam, Nileswaram and Chandragiri.
Karnataka	Nethravathi, Mulki, Udayavara, Venkatapur, Coondapoor and Kali estuaries

Edible Oyster Farming in India

For edible oyster farming, a simple and easily adaptable technology has developed by Central Marine Fisheries Research Institute. Through training and demonstration programmes conducted by 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 villages have benefited from this. These farming activities have increased national production of farmed oyster from nil to 500 tonnes in 2003. 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.

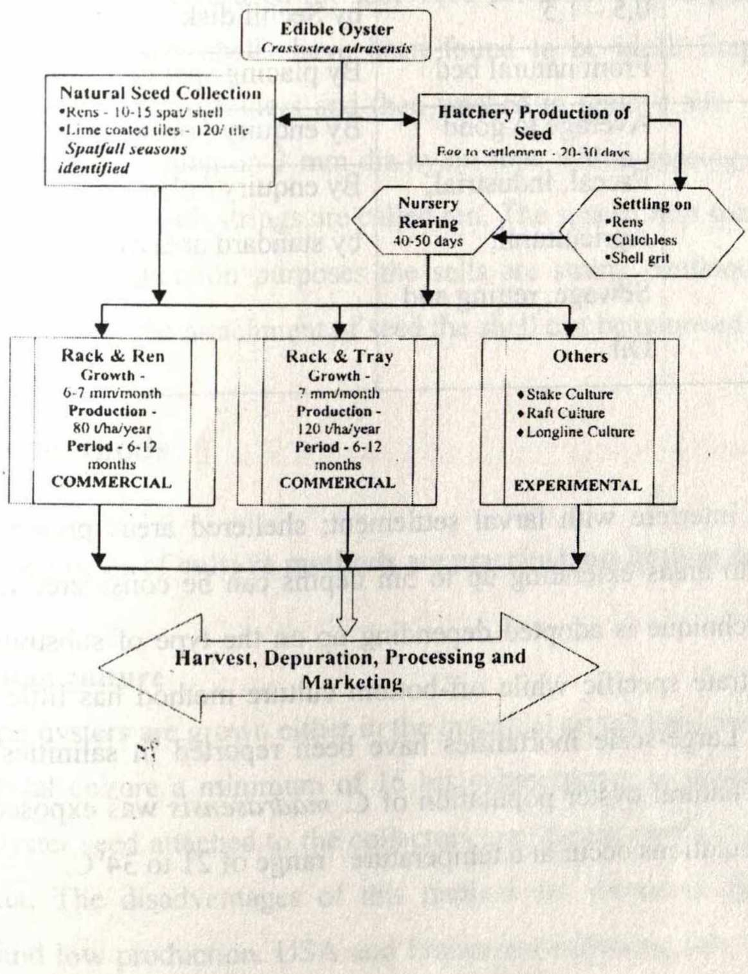


Table: Site specifications

Parameter	Range	Methodology for determination of the parameter
Salinity (ppt)	10 - 38	By titration or refractometer
Depth (m)	1.5 – 4.0	By sounding or manual
Temperature (^{0}C)	23-34	Using thermometer
Desloved oxygen (ml/l)	3 – 5	Winkler method or by using probe
p^H	6.5 – 8.5	p^H meter or p^H paper
Turbulence due to wave(m)	<0.5- 1	By observation and local enquiry
Water current (m/second)	1 - 5	Current meter or from literature
Clarity (m)	0.5 – 1.5	by Sechii disk
Availability of seed	From natural bed	By placing spat collectors
Local market	Average to good	By enquiry / observation
Pollution factors	Faecal, Industrial, Agricultural, Sewage, retting and Oil	By enquiry / observation; by standard analytical procedure

Strong currents interfere with larval settlement; sheltered areas preferred for farming. From intertidal region to areas extending up to 5m depths can be considered as suitable sites. Similarly the culture technique is adopted depending up on the type of substratum. On-bottom culture method is substrate specific while off-bottom culture method has little to do with the nature of substratum. Large-scale mortalities have been reported in salinities below 10 and above 40 ppt when the natural oyster population of *C. madrasensis* was exposed for prolonged periods. The natural populations occur at a temperature range of 21 to 34°C.

Seed collection

Oyster seed is collected from estuaries by placing suitable spat/seed collectors in the water column during spawning seasons. If the oysters are to be grown by the tray method, empty shells or lime-coated tiles can be placed in the trays for seed collection. One of the main factors that determine the success of the farming operation is the period when the clutches are paced for seed collection. If they are laid in advance of spat fall, they may be covered with silt or settlement of foulers, making them unsuitable for the oyster larvae to settle. The larval period in *Crassostrea 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.

How to prepare a cultch

Cultch is the term used for spat /seed collector. For suspended method of oyster culture cultch 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 3 mm dia nylon rope with a spacing of 15 to 20 cm between each shells (5 shell/m). Such strings are called ren. The spaced rens can be used as such for grow out system.For seed collection purposes the sells are strung continously without space (10 –15 shells/M) and after the attachment of seed the shell can be removed and restrung as 5shells/m.

Farming methods

Two types of **culture methods** are practiced, **on-bottom** and **off-bottom** culture.

On – bottom culture

The oysters are grown either in the intertidal or sub tidal area directly on hard substratum. For intertidal culture a minimum of 16 hrs 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. USA and France are following this method. This method is yet to be experimented in India.

Off-bottom culture

In this method raft, rack, long-line and stakes are used. The off-bottom culture methods are advantageous over the bottom culture in the following aspects. Rapid growth and good meat yield, three-dimensional utilization of the culture area, biological functions of the oyster such as filtration, feeding etc. are carried out independent of the tidal flow, silting and predatory problems are also negligible.

Rack and Ren/ Ren method

It is also called ren method. The racks are constructed in 1 to 2.5m,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 pots driven into the bottom. A series of single beam are placed in a row. The crossbeam rack is constructed by placing cross bar on the top of single pots and two long beams are secured on the end of the cross beams. In the farm, the shell strings are suspended from racks.

Rack and Tray Method

The nursery reared single spat (cultch-free) measuring about 25 mm are transferred to trays of size 40x40x10 cm at a density of 150 to 200 oysterlings/tray. The tray is knitted with 2 mm synthetic twine of appropriate mesh and is suspended from rack. Once the oyster reach 50mm length they are segregated and transferred to rectangular tray of size 90x15 cm and these trays are placed on the racks. Each tray holds150 to 200 oysters. The average growth rate of the oyster is 7mm/month and at the end of the 12 months the oyster attain an average length of 85mm in Tuticorin. The production is estimated at 120 t/ha/year. Compared to the string method, this method gives better production but the production cost is high.

Stake culture

A stake is driven into the substratum and on the top end one nail and on the sides two nails are fixed. The nail holes in position a shell with spat attached. The stakes are placed 60 cm apart. In this method, the nursery rearing of spat is carried on the same stake. For about two months the spat on the top end of the stake are covered by a piece of velon screen. Once the oyster attains 25 – 30 mm the velon screen is removed and in another 10 months they reach the marketable size. The growth rate of the oysters in this method is the same as that of the oysters raised by the string method. The production is estimated at 20 t /ha/ year.

Growth

Growth rate depends on environmental conditions. Changes in environmental or physiological conditions can take a greater toll on slower growing populations (disease predation).

Genetic engineering has resulted in increased growth rate and disease resistance.

Factors affecting oyster growth and survival.

Salinity

Salinity	- 10-35ppt
Poor	-< 10
Good	-10-25
Best	-18-28

Oxygen

Oxygen	- 0-10ppm
Greater than 3ppm	-Best

Temperature

Growth	- 25-30 °C
Spawning	- 25-27 °C

Food availability

Food availability is an important factor which will directly affect growth.

Farm management

Periodic checking of the farm is essential. The main points to be checked are replacements of broken farm structure and resuspending loosened rens, which touch the bottom.

Harvest

The oysters are harvested when the condition index is high. Generally high condition index is obtained when the gonad is ripe prior to spawning. Along east coast the season for harvest is March-April & August-September; west coast May and August-October.

	2000-2001	2001-2002	2002-2003	2003-04
Capture	422	591	1543	1099.1
Culture	1.6	200	350	500

POST HARVEST PROCESS

Depuration

Oysters, like other filter-feeding bivalves, accumulate pathogenic organisms in their body. The bacteria of concern are *Vibrio sp*, *Salmonella* and *Coliforms* (*E. coli*). Effective depuration will help to eliminate or to decrease the bacterial load; sand particles, silt and faeces are also removed from the alimentary canal.

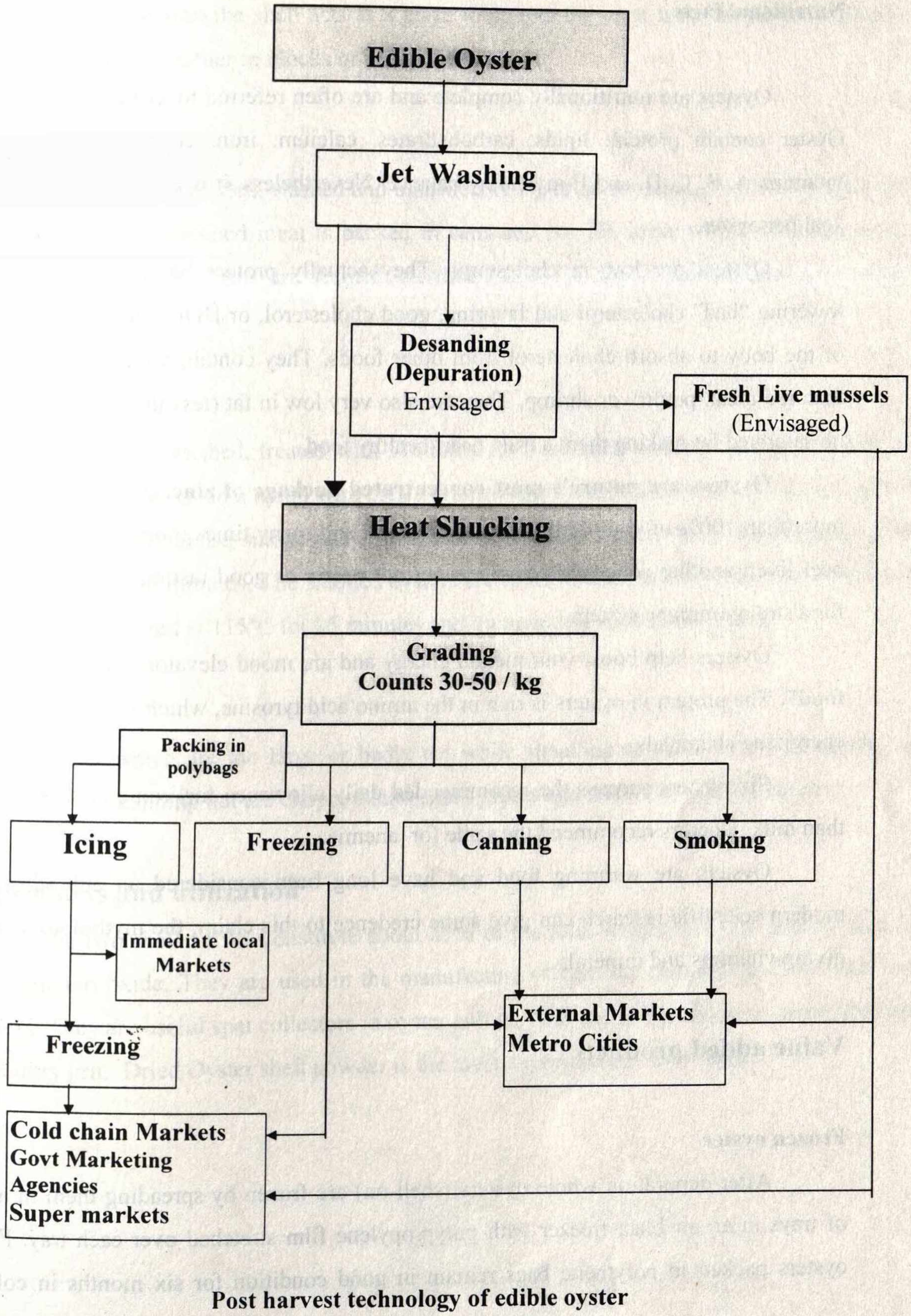
The oysters are placed in cleaning tanks under a flow of filtered seawater. About 10-20% of the seawater is continuously replaced. At the end of 12hrs the water in the tank is drained to remove the accumulated faeces. The tanks are again filled with filtered seawater and the flow is maintained for another 12hrs. The tanks are drained and flushed with a jet of filtered seawater. The oysters are held for about one hour in 3ppm chlorinated seawater and washed once more 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. Wet gunny bags are the safest and cheapest method for transportation.

Shucking

The removal of meat from the oyster is called shucking. 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. Commonly used methods are freezing / immersion in hot water. However in India 5-8minutes steaming is usually followed.



Post harvest technology of edible oyster

Nutritional facts

Oysters are nutritionally complete and are often referred to as the **"milk of the ocean "**. Oyster contain protein, lipids, carbohydrates, calcium, iron, copper, zinc, phosphorus and vitamins A, B, C, D, and E in healthy balance. Nevertheless, it is a low-calorie food, at about10 kcal per oyster.

Oysters are low in cholesterol. They actually protect blood vessels and arteries by lowering "bad" cholesterol and favoring, good cholesterol, or HDL. Oysters decrease the ability of the body to absorb cholesterol from other foods. They contain far less cholesterol per gram than red meat, poultry or shrimp. They are also very low in fat (less than 2%) and contain almost no saturated fat making them a truly heart healthy food.

Oysters are nature's most concentrated package of zinc. A 3-ounce serving supplies more than 100% of your daily zinc requirement, and many times more than the same amount of beef liver, another concentrated source but not nearly as good tasting. Adequate zinc is crucial for a strong immune system.

Oysters help boost your mental energy and are mood elevators- they really are a **"brain food".** The protein in oysters is rich in the amino acid tyrosine, which is converted into mentally energizing chemicals.

Six oysters surpass the recommended daily allowance for iron and supply more protein than milk. Doctors recommend the same for anemia.

Oysters are warming food and have long been considered an aphrodisiac. Although modern scientific research can give some credence to this claim, the mythology is more health-giving vitamins and minerals.

Value added products

Frozen oyster

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

25^0C. The liquid within the shell acts as a glaze to protect the meat from dehydration. Shucked oyster meat is 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 blanched 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 115^0C for 25 minutes and immediately chilled and stored.

Smoked oysters

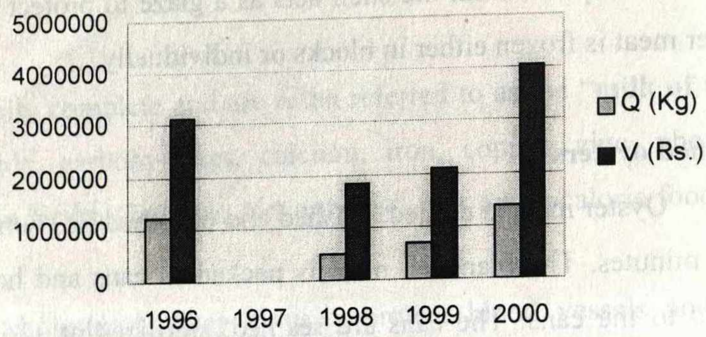
The meat is washed, treated with 5% brine for 5 minutes, drained, dipped in edible oil, spread in a single layer on a nylon wire mesh, drained again and loaded into a smoking chamber. The meat is held in dense smoke and maintained at a temperature of 40^oC for 30 minutes and later at 70^oC for 90 minutes. The smoked oysters are filled in cans with hot refined oil. The cans are seamed, sterilized at 115^oC 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 onto 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. Dried Oyster shell powder is the main exported item from India.



Dried shell powder export

Foreign Market

The main overseas buyers for dried oyster shell powder are Bahrain, Qatar/ Doha, UAE and Kuwait.

Hatchery production of edible oyster seed

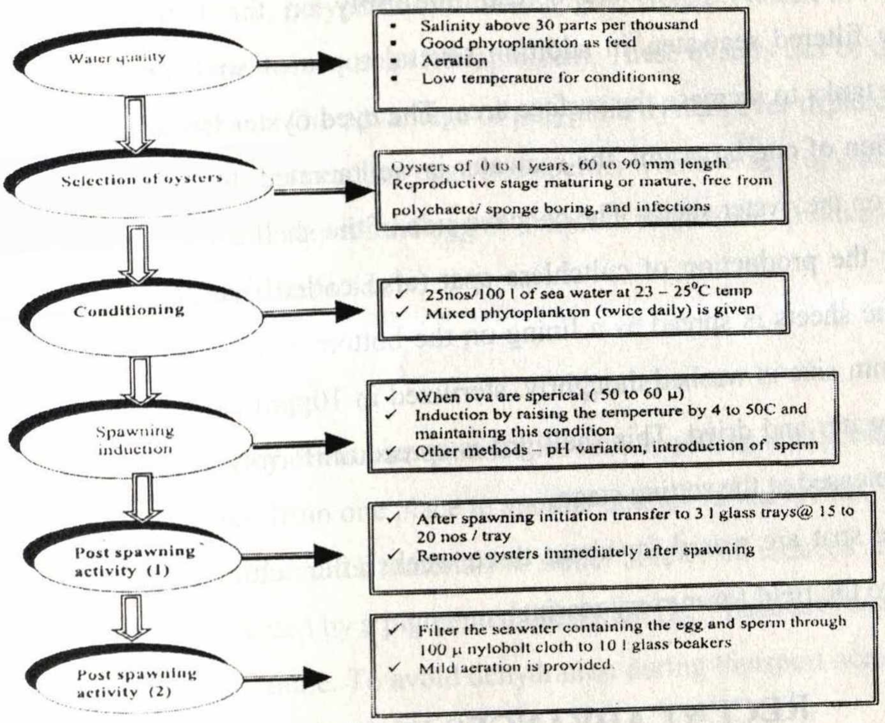
The technology for seed production of edible oyster spat has been developed by the CMFRI. Large-scale production of clutched and clutch-less spat can be produced by this technique. The process involves following steps

1) Brood-stock conditioning and induced spawning
2) Larval rearing
3) Phytoplankton culture.

The brood-stocks collected from the natural bed are conditioned and spawning induction given either by heat shock, variation in pH or adding sperm. After the spawning of oysters, the gametes are mixed. The fertilized eggs attain morula stage and begin to swim. At the end of 20 hrs the straight- hinge or D – shaped larval stage is attained.

The sequence of larval development

Stage	**Size in μ**	**Hours/ days**
Straight hinge	60-70	20 hrs
Early umbo	100	3rd day
Mid umbo	150	7th day
Advanced umbo	260 to 270	12th to 15th day
Eyed larvae	280 to 290	13th to 17th day
Pediveliger	330 to 350	14th to 18th day



Hatchery production of edible oyster seed

As the larvae grow, the stocking density is reduced and the feeding modified as given below.

Stage of larvae	**Density of larvae/ml**	**Algal concentration in ml/larvae/day**
Straight hinge	5	3000 – 4000
Umbo	3	4000 – 5000
Advanced umbo to eyed	2	5000 – 8000
Pediveliger	2	10,000 – 12,000

Spat settlement and Rearing

Non-toxic, hard, chemically stable and clean spat collectors are used to settle spat; usually oyster shells are used for the ren method of culture. The shell is brushed well, washed in chlorinated water followed by soaking and repeated washing in seawater, so that the pH of the water in the rearing tanks is maintained.

The shell collectors are spread uniformly on the bottom of one-tonne FRP tanks containing filtered seawater, in addition several ropes of shell rens are also suspended in the

The shell collectors are spread uniformly on the bottom of one-tonne FRP tanks containing filtered seawater, in addition several ropes of shell rens are also suspended in the settlement tanks to increase the surface area. The eyed oyster larvae are released in the tanks at a concentration of one larva /ml, the seawater is well aerated. In the following few days the larvae set as spat on the oyster shells. The concave side of the shell usually has more settlement.

For the production of cultchless spat (also called free spat or single spat) pre- treated polyethylene sheets is spread as a lining on the bottom and sides of an FRP tank. Oyster shells grit of 0.5mm size is washed thoughrly, sterilized in 10ppm chlorine, further washed in running filtered seawater and dried. This shell grit is spread uniformly at the bottom of the tank and the larvae are released at the setting stage.

The spat are reared for about three weeks after setting in the hatchery before they are transferred to the field for nursery rearing.

RECENT ADVANCES IN OYSTER CULTURE

Triploid oysters/ Genetic engineering

Oyster farming has slowly developed from the collection of wild spat for grow-out to hatchery-based production. As genetic improvements gain value, the trend will continue. An early breakthrough was the development of hatchery induced triploids which in the past few decades has grown to be an important part of oyster production in the Pacific- Northwest. In India the technology for producing triploids is in its infant stage.

Triploidy refers to a genetic condition in which there are three sets of chromosomes and the condition of having more than two chromosome sets is called polyploidy.

The technology for producing triploid was developed by researchers in the universities of Maine $ Washington in 1980. Coaxing an extra set of chromosomes into a newly fertilized egg produced these triploid oysters; induction is given by chemical/ heat/ pressure shock.

Advantages	**Disadvantages**
Faster growth, bigger size & high meat content.	**Induced triploids are never 100% triploid, early mortality (larvae) is high & reproductively sterile*.**

* for Traders, this is an added advantage and reffered as "triploid advantage." This will give an year round availability of good quality oysters.

At Rutgers University, polyploid oysters (*C.gigas*) were produced in 1993, and these oysters having four sets of chromosomes (tetraploides). These oysters can be used as broodstocks for producing triploid oysters. The advantage of polyploid oysters over triploid oysters is that they are fully fertile and able to produce eggs and sperms with two sets of chromosomes. The sperm of a tetraploid male fused with the egg of a diploid female will produce pure triploids and are termed as "natural/ mated triploids"

Remote setting

Hatchery produced oyster larvae are used for remote setting operations. Ready-to-set oyster larvae are transferred from one place to another and the larvae are acclimatized to new conditions; thereafter provide cultch materials to settle. Studies on induced settlement showed that, naturally it can be effected by a pigmented bacterium (LST) and artificially by the amino acid L-3,4-dihydrophenylalanine. To avoid dehydration during transport necessary precautions must be taken.

Advantages

1. Availability of spat all round the year
2. Oyster growers can purchase eyed larvae from hatchery and set them on shell in their own tanks.
3. Transportation of huge quantities of spat is very easy.
4. Transportation of spat to far away places.

Disadvantages

Hatchery production and rearing of spat is expensive.

Advanced Quality Standards

1.Microbiological criteria for foodstuff ((as per EEC guidelines)

Animal product – Live bivalve mollusc						
Directive– 91/492/EEC						
Bacterial sp.	**Limit**	**n***	**c***	**m***	**M***	**Production area specification**
Salmonella	Absence in 25g					
Faecal coli	< 300/ 100g					Production area A
	< 6000/ 100g					Production area B
	< 60000/ 100g					Production area C
E.coli	< 230/ 100g					Production area A
	< 4600/ 100g					Production area B
Animal product – Cooked crustacean and Molluscan shell fish						
Decision – 93/51/EEC						
Salmonella	Absence in 25g	5	0			
S.aureus		5	2	100 cfu/g	1000 cfu/g	
Any pathogen	Quantities to affect human health					
Thermotolerant coliforms	-	5	2	10 cfu/g	100 cfu/g	
E.coli	-	5	1	10 cfu/g	100 cfu/g	
Mesophilic aerobic bacteria	-	5	2	10^4 cfu/g	10^5 cfu/g	Whole product
		5	2	$5x10^4$ cfu/g	$5x10^5$ cfu/ 100g	Shelled/ Shucked
		5	2	10^5 cfu/g	10^6 cfu/g	Crab meat

*n = number of units comprising the sample

*m = limit below which all results are considered satisfactory

* M = acceptability limit beyond which the results are considered unsatisfactory

*c = number of sampling units giving bacterial counts of between m and M

Economics for a model farm

Area – 5 X 5
Number of ren – 500

1. Material cost			
a) Poles			Rs
Horizontal	5m length 14 nos @ 80		: 1120.00
Vertical	3m length 16 nos @ 60		: 960.00
		Total	**2080.00**
b) Nylon rope 10kg @ 100			: 1000.00
c) Oyster shells	2500 @ 0.10		: 250.00
		Total (a + b + c)	**: 3330.00**
II Labour and other charges			
a) Fabrication of oyster strings (500 nos)			: 250.00
b) Fabrication of rack			: 300.00
c) Harvesting charges			: 300.00
d) Heat shucking chares			: 3750.00
e) Cleaning charges			: 750.00
f) Marketing			: 400.00
		Total	**5750.00**
III 1. Depreciation rate 50%			: 1665.00
2. Labour			: 5750.00
	Total		: **7415.00**

PRODUCTION AND REVENUE

1. Shell-on weight of oysters	: 2500Kg
2. Meat weight (7%)	: 175 Kg
3. Value of meat @Rs.60/kg	: 10500/-
Gross Revenue Rs.	: 10,500/-
Total expense	: 7415.00
NET PROFIT	**: 3085.00**