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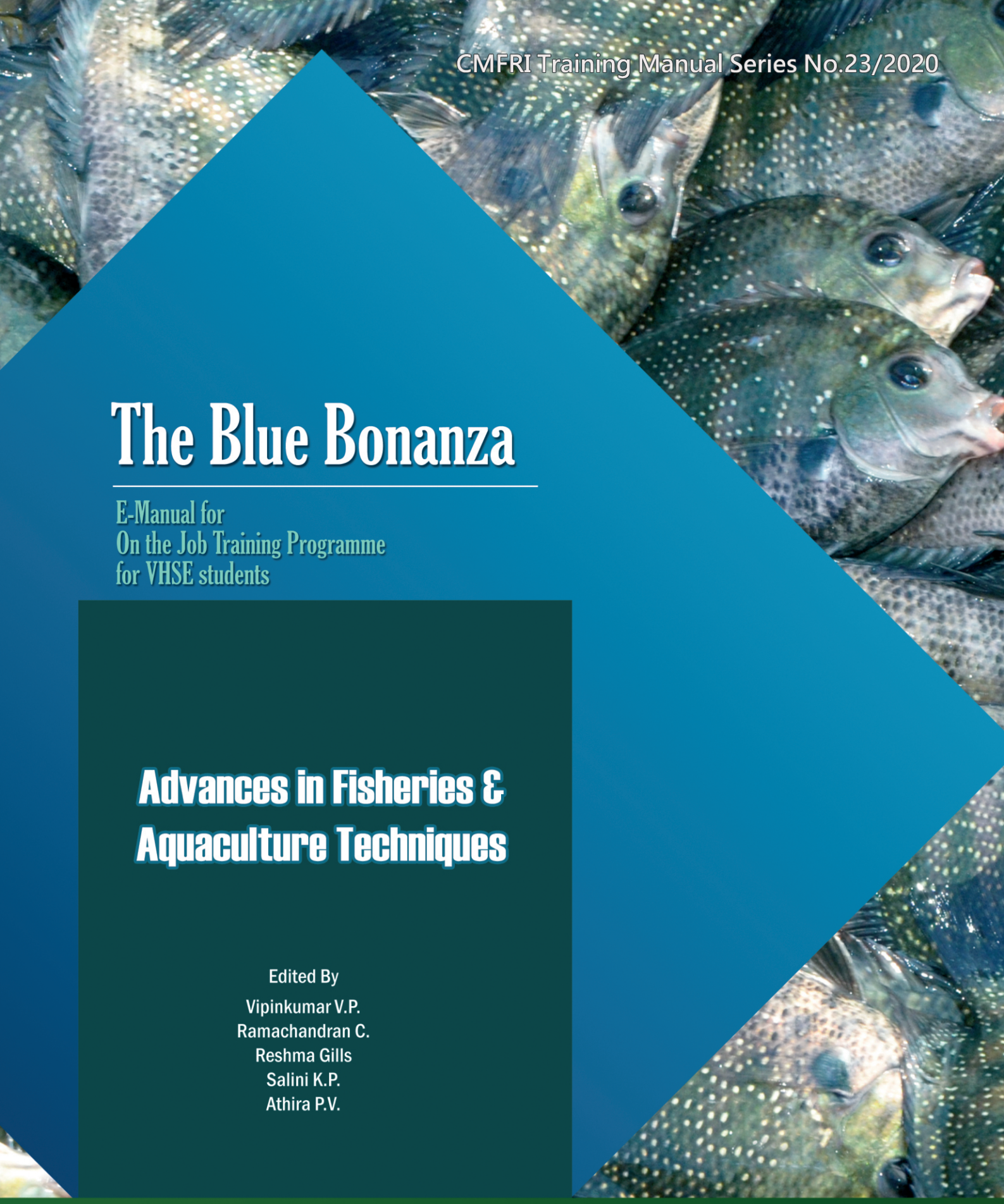

The Blue Bonanza

E-Manual for
On the Job Training Programme
for VHSE students

Advances in Fisheries & Aquaculture Techniques

Edited By

Vipinkumar V.P.
Ramachandran C.
Reshma Gills
Salini K.P.
Athira P.V.

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

The Blue Bonanza: A Manual for on the job Training Programme for VHSE students on Advances in Fisheries & Aquaculture Techniques (18th September to 1st October, 2019)

Course Director: Dr.Vipinkumar V.P, Principal Scientist & ATIC Manager
Course Coordinator: Salini K.P, Senior Technical Officer, ATIC

Edited by
Vipinkumar. V.P.
Ramachandran. C.
Reshma Gills
Salini K.P.
Athira. P.V.

Research Guidance:
Dr. A. Gopalakrishnan, Director, CMFRI &
Dr.R.Narayanakumar, Head in Charge, SEETTD, CMFRI.

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David. K.M

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Foreword...

The fisheries and aquaculture sector play a pivotal role in Indian economy with a contribution of around 1% to India's Gross Domestic Product (GDP) and over 5% to the agricultural GDP. The potential of the fisheries resources in employment generation and considerable scope of export augmentation attracted implementation and initiation of many policies, developmental programme and infrastructure creation like by the Central Government under the umbrella of "Blue Revolution Scheme" in recent past. Though the sector is offering a sea of employment and livelihood opportunities, the innate hardiness of this sector needs skilled persons to harness its potential in its fullest. Since, Vocational education and training (VET) is an integral part of skill development in any sector, in fisheries also, it is very decisive to create a pool of skilled human power.

As highlighted in many studies, mere inclusion of vocational course in curriculum does not guarantee the enhanced employability among the youth. It needs concerted and exceptional efforts to bring necessary changes in the educational pattern to attain the projected scope. A vocational training program which includes practical skills and knowledge to pursue a noteworthy career in mariculture/aquaculture/fisheries/fishery industries is most suitable to generate self-employment and to bag employment opportunities in different sectors of fishery industry.

CMFRI as the premier institute in the marine fisheries research sector has undertaken many capacity development programmes through its outreach extension activities. Regular specialized training in mariculture and related fisheries technologies used to be provided to the vocational higher secondary school students for more than a decade through CMFRI-ATIC and KVK. The current training batch consists of Aquaculture students of VHSc Njarakkal and VHSc Arthungal. Scientists of CMFRI with the initiative and leadership of ATIC had done an excellent effort to impart selected aquaculture and mariculture skills among the students. In this compendium the CMFRI has tried to highlight the importance of practical dimensions of the selected areas in the marine fisheries with the aim of improving the vocationalism of the course along with the procedural explanation of enhancing personal effectiveness. I hope this publication entitled 'The Blue Bonanza" will act as an elegant ready reckoner for the students with respect to important aspects of aquaculture and fisheries management. I appreciate the ATIC team and the contributors of the publication for their dazzling efforts to bring out this innovative e-publication in a well composed manner.

A.Gopalakrishnan
Director, CMFRI

Preface...

Fisheries is a sector of immense potential of the Indian economy which provides income and employment to more than 14.5 million people, with a growth rate of 11.9 per cent in 2017-18. Foreseeing the abundant resource potential and fantabulous possibilities in this sector, the government has initiated a basket of employability enhancing development programmes and infrastructure creations like fish landing centers, fish feed mills/plants, setting up of disease diagnostic and aquatic quarantine facilities, creation of cold chain infrastructure facilities such as ice plants, cold storage, fish transport facilities, fish processing units, fish markets, etc. All those initiatives can contribute a large proportion of employability of the skilled manpower. Therefore, an astounding demand for knowledgeable and skilled human resource is to develop standard products and to deliver meticulous services in the sector. Now the striking question is how we can fill the market demand for the skilled manpower? Vocational education in this sector is considered the basic foundation for the development of the skilled workforce in it. Though the initial form of scheme of Vocationalisation of Education based on the "Kothari Commission 1976-77'' has undergone many time relevant changes, the core is still to facilitate the self-employment and enhance the employability.

CMFRI, a leading tropical marine fisheries research institute in the world has done many strides to reach its current status of research excellences through its dedicated perseverance in scientific and human resource development activities. Through its extension and outreach programmes, it has contributed to shorten the demand gap for knowledgeable and skilled human resource to develop standard products and to deliver spectacular services in the fisheries sector. It has a glorious and exquisite history of more than a decade, of giving regular and specialized skill training in mariculture and aquaculture to the vocational higher secondary school students through CMFRI-ATIC and KVK. This time, 59 students from VHSc Njarakal and VHSc Arthungal were attached with the CMFRI-ATIC for the skill development training. Various improved technologies like mariculture, cage farming, fish feed preparation, water quality testing, culture of ornamental marine fishes, aquarium making etc. were discussed with the students in the field to provide first hand experience on it. This compendium entitled ''The Blue Bonanza' is prepared as a reference material for the students, to polish their accrued knowledge on different technical skills they gained through this training.

(**Vipinkumar V.P. & Crew**)

Index…

1

Technological advancement in Mariculture in India for production enhancement and sustainability

Boby Ignatius, Rajesh N and Imelda Joseph
Mariculture Division, CMFRI

Mariculture is the farming and husbandry of marine plants and animals in the marine environment. Mariculture produces many high value finfishes and shellfishes (crustaceans, and molluscs - oysters, mussels and clams). As the production from the capture fisheries reached its sustainable limits, mariculture is the next viable alternative for increasing seafood production of the country. Indian coastline offers immense potential for the expansion of mariculture activities. CMFRI through its research programmes over the years has developed technologies for seed production and farming of bivalves, marine pearl oysters, marine food fishes and ornamental fishes, marine crustaceans and seaweeds.

Existing major mariculture species and farming technologies

Mussel farming

Commonly adopted species for mussel farming are *Perna indica and P. viridis*. Various methods for mussel farming like raft method (in bays, inshore waters), rack method (in brackishwater, estuaries) or long line method (open sea) were developed by CMFRI to suit Indian conditions..

Recently CMFRI has perfected spat production and nursery rearing system for green mussel at its Vizhinjam Centre. An average small scale unit can produce 10 million spats /annum. Nursery production of green mussel spat can significantly reduce wild collection of seeds.

Edible oyster farming

Commercially important edible oyster species are *Crassostrea madrasensis*, *C. cucullata* and *C. Gryphoides*. CMFRI has developed methods for edible oyster (*Crassostrea madrasensis)* culture and has produced a complete package of technology, which is presently being widely adopted by small scale farmers in shallow estuaries, bays and backwaters all along the coast. Technology for production of oyster spat was also perfected by CMFRI.

Marine pearl culture

Technology for the production of spherical pearls from *Pinctada fucata and Pinctada margaritifera* was developed by CMFRI. Raft culture and rack culture in nearshore areas are the two methods commonly adopted techniques for rearing pearl oysters. Shell bead nucleus (3-8 mm) implantation along with graft tissue is done in the gonads of the oyster through surgical incision for production of pearls. Implanted oysters were stocked in suitable cages for rearing in the farm. Harvesting of Pearls was carried out after 3-12 months and harvested pearls were graded based on their quality as 'A', 'B' and 'C" grades for marketing.

Mabe pearls

Technology for production of image pearls/designer pearls is very simple and can be easily carried out by farmers, unlike the technology for free round pearl production. A Mabe pearl is a dome-shaped or image pearl produced by placing a hemisphere or miniature image against the side of the oyster shell interior. The result is an exquisite pearly nacre-coated miniature image which can be made into pendants, eardrops, rings etc.

Clam Culture

Package of clam culture practices has been developed for the blood clam *Anadara granosa* and *Paphia malabarica,* where production of 40 tonnes/ha/6 months and 15-25 tonnes/ha/4-5 months have been achieved in field trials. Induced spawning and larval rearing to setting of spat has been perfected for clams like *P. malabarica, Meretrix meretrix and Marcia opima.*

Lobster farming and fattening

Increasing demand for live lobsters in the export market led the farmers and entrepreneurs to collect juvenile lobsters from the wild and grow to marketable size in ponds, cages and tanks by feeding trash fishes and other discards.

Crab farming / fattening

Seed production of the blue swimming crab, *Portunus pelagicus,* has also been developed. Protocols for fattening and grow out in salt water ponds have been successfully developed.

Seaweed Culture

Since 1972 the CMFRI is engaged in the cultivation of important seaweeds such as *Gracilaria edulis*, *Gelidiella acerosa, Sargassum wightii, Acanthophora spicifera* and *Ulva lactuca.* Earlier, mariculture of seaweeds in India mostly deals with cultivation of *Gracilaria edulis.* Very recently the cultivation of *Kappaphycus sp*, gained popularity among farmers. There are two methods for cultivation of seaweeds - Vegetative propagation using fragments and also by different kinds of spores.

Marine ornamental fish culture and trade

Based on the Global Marine Aquarium Database (GMAD) the annual global trade is between 20 - 24 million numbers for marine

ornamental fish, 11-12 million numbers for corals and 9-10 million for other ornamental invertebrates. A total of 848 numbers of reef associated fishes are reported in Indian waters. Out of which about 350 species are reported to be of ornamental value. Some important ornamental fish families are Family Pomacentridae (Clownfishes and damsel fishes), Family Labridae (Wrasses), Family Scaridae (Parrot fishes), Family Chaetodonidae (butterfly fishes and banner fishes) and Family Acanthuridae (Surgeonfishes).

Marine ornamental fishes are caught in India either as a by-catch in collection practices followed at coral reef habitats inflict damage to the ecosystem.

Hatchery Production of marine ornamental fishes

CMFRI developed package of technologies on broodstock development, captive breeding and larval rearing of several species of marine ornamental fishes. The methodologies developed can be scaled up for commercial level production and a hatchery produced marine ornamental fish trade could be developed in the country. It is high time that the fisheries developmental agencies should come forward with attractive schemes to popularize the technology.

Hatchery technology for following species marine ornamental fishes was developed at CMFRI and these technologies are being transferred to fishermen/women SHG's at various maritime states of the country.

Clown fishes: *Amphiprion sebae, A. ocellaris, A. percula, Premnas biaculeatus, A. sandaracinos, A. frenatus, A. clarkii.*

Damsels: *Dascyllus trimaculatus, D. aruanus, Pomacentrus caeruleus, P. pavo, Neopomacentrus nemurus, N. filamentous, Chrysiptera unimaculata, C. cyanea, Chormis viridis, D. carneus*

Dottybacks: *Pseudochromis dilectus*

Marcia'santhias: *Pseudanthias marcia*

Marine invertibrates: *Rhynchocinetes durbanensis* (Camel shrimp)

Marine Cage farming

In India, the first marine cage (15 m diameter HDPE) was launched by ICAR – Central Marine Fisheries Research Institute in Bay of Bengal off Visakhapatnam coast during May 2007. With further modifications, a revised version of marine cage was fabricated and launched and successful harvest was obtained 2008. Subsequently, for easy manoeuvring and cost effectiveness in terms of reduced labour, the size of the HDPE cages has been reduced to 6 m, which were found to be successful in all maritime states along the coastline. Also cost effective GI cages have been designed for low investment farming operations. Presently, the country has close to 2000 marine cages, wherein marine finfishes (seabass, cobia, grouper, pompano and snapper) and shellfishes (lobster) are commercially reared by private enterpreneurs/fishfarmers with production estimates exceeding 2000 tonnes. Operating Ratio or Cost Benefit Ratio varies between 0.35 to 0.5, depending on the site and the species being farmed. ICAR – Central Marine Fisheries Research Institute has demonstrated that production per m^3 in cage farming is 50 times more than shore based (coastal) aquaculture systems Also, recurring expenditure associated with development and maintenance of infrastructure are lower in cage farming. Stock monitoring is easy and harvesting can be planned as per the demand offering better quality product at higher price.

Production of finfishes from marine cage varies from 15 to 25 kg/m^3. Dimensions of the cage, size and density at stocking, species, feed and feed management, cage management and culture

duration are found to significantly influence cage production. Circular HDPE cages of 6 m diameter and 4 m net depth and rectangular or circular GI cages of similar water volume are found best suited. The optimum stocking density is 8 - 10 numbers / m^3 for cobia (15 cm/35 g), 15 – 20 numbers / m^3 for seabass and grouper (15 cm/40 g) and 30 – 40 numbers / m^3 for pompano (10 cm/30 g). Pelleted feed (40 - 45% CP and 10% CF) with FCR of 1:2 provides best production. Culture duration of 6 – 8 months is found to be conducive for all finfish species. Lobster rearing in marine cages has proved to be highly lucrative with fish farmers able to raise more than four times revenue by rearing it within a span of 3 months.

Mapping of suitable cage culture sites

The primary requirement for development of sea cage farming is the selection of suitable sites with required depth, current and water quality parameters. Suitable locations all along the East and West Coast of India for sea cage farming of high value marine finfishes were mapped in GIS platform. Satellite data were also used in identification of satiable sites for cage farming. The available physico-chemical and oceanographic parameter data obtained from Landsat 8 and MODIS satellite data were pooled and used on GIS based platform. The maps were layered, and were combined to generate a final output showing the "most suitable, suitable, moderately suitable and unsuitable", locations for open sea mariculture development along the Gujarat coast. Such maps were developing almost all coastal districts for the easy execution of sea cage farming.

Integrated Multi-Trophic Aquaculture (IMTA)

On a global basis the current mariculture practices are dominated by intensive monocultures which have led to sustainability problems, environmental degradation and consequent disease

outbreaks. Integrated Multi Trophic Aquaculture (IMTA) is the practice which combines in appropriate proportions, the cultivation of fed aquaculture species (eg. finfish/shrimp) with organic extractive aquaculture species (eg. shellfish/herbivorous fish) and inorganic extractive aquaculture species (eg. seaweed) to create balanced systems for environmental stability (bio-mitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices).

The CMFRI has successfully conducted the demonstration of IMTA under participatory mode with fishermen groups by integrating seaweed with cage farming of cobia. A total of 16 bamboo rafts (12× 12 feet) with 75 Kg of seaweed per raft can be integrated with one cobia (*Rachycentron canadum*) cage of 6 meter diameter. It has been proved that in one crop of 45 days the seaweed rafts integrated with cobia cage will give an average yield of 260 Kg per raft while the same was 150 Kg per raft for the rafts which were not integrated.

Recirculating Aquaculture system

Recirculation aquaculture is essentially a technology for farming fish or other aquatic organisms by re-using the water in the production. The technology is based on the use of mechanical and biological filters, and the method can in principle be used for any species grown in aquaculture such as fish, shrimps, clams, etc. In a recirculation system it is necessary to treat the water continuously to remove the waste products excreted by the fish, and to add oxygen to keep the fish alive and well.

A recirculation system is in fact quite simple. From the outlet of the fish tanks the water flows to a mechanical filter and further on to a biological filter before it is aerated and stripped of carbon dioxide and returned to the fish tanks. This is the basic principle of recirculation. Several other facilities can be added, such as

oxygenation with pure oxygen, ultraviolet light or ozone disinfection, automatic pH regulation, heat exchanging, denitrification, etc. depending on the exact requirements.

Hatchery technology for marine finfishes

Non availability of the seed for farming in quantity and quality at the right time, will affect the production plans of an aquaculture enterprise. . Most of the world's fish aquaculture still depend on the fry almost comes exclusively from wild. Seed supply from the wild is often unpredictable and seasonal. Hatchery production of seeds of economically important finfish ensures a steady supply of quality seeds for aquaculture operations.

CMFRI has developed hatchery production technologies for marine food fishes like Cobia (*Rachycentron canadum*), Silver Pompano (*Trachinotus blochii), Indian Pompano Trachinotus mookalee),* Orange spotted grouper *Epinephelus coioides and* Pink ear emperor *(Lethrinus lentjan)*. A constant survival rate of 10-25% was obtained in hatchery production of these species in hatcheries.

Operating procedures for broodstock mainteneance, induced breeding, larval rearing and nursery rearing of all these 5 species was standardised and the technology packages were transferred to promising entrepreneurs through consultancy services of the institute.

Live feeds

Live feeds like microalgae, rotifers and copepods are very much essential for larval rearing of marine finfish larvae. The technologies were developed for culture of these live feeds in large quantities in tanks as a feed for larvae at CMFRI.

Conclusion

India is still in infancy in mariculture production in comparison with the global scenario. When we compare the situation in the Asia-Pacific region also, we can find that a lot of advances have been made in the development and expansion of mariculture. Since, mariculture is the only sunrise sector for increasing seafood production in the coming years, the research and development in this sector is of paramount importance to develop mariculture as a substantial contributor of seafood production in the country.

2

Storage and quality assessment of ingredients and formulated feeds

Sanal Ebeneezar, Linga Prabu D, Chandrasekar S, Sayooj P. and Vijayagopal P.
Marine Biotechnology Division, CMFRI

Appropriate storage of ingredients and feeds is an important aspect in feed manufacturing process. Good storage is essential because the value of the feed presented to fish depends on it. Feed spoils during storage and the extend of deterioration depends very largely on the storage conditions. Since fish feeds usually contain relatively high amounts of fish meal and/or fish oil, they are very much susceptible to rancidity. In addition, loss of certain nutrients occurs during prolonged periods of storage. For these reasons, fish feeds should not be stored for longer periods (not more than 3 months). Ingredients and feeds should be stored in a cool, dry place away from direct sunlight.

Factors which affect the quality of ingredients and feeds during storage

(i) Physical loss-due to human theft, fire and the consumption of scavenging animals, such as rats and birds

(ii) Insect damage- various species of moths, weevils and beetles consume the feed and cause damage through weight loss and expose the feed to microbes (fungi, bacteria) for further contamination and oxidation. They grow well at normal temperatures (26-37 ℃) in feed stores and can reach epidemic proportions. Insects thrive better on ground materials. Therefore, oil cakes and whole cereals can be stored for longer period than meals made from them.

(iii) Fungal damage- In general, fungi grow at relative humidity above 65%, moisture contents generally above 15% and temperatures above 25° C which are specific to the fungal species. Higher temperatures and moisture levels favour increased growth. Even though most fungi are killed during the processing of ingredients, their spores are resistant and have the potential to re-infect the material later if the environmental conditions become favourable for their development.

Fungal growth causes weight loss, increases in temperature and moisture, staleness (off-flavour), discolouration and, production of mycotoxins. Mycotoxins such as aflatoxins, are known to be toxic to some species of fish at least. Sorghum, maize and its by-products, groundnut, cottonseed, cassava, coconut and sunflower are ingredients particularly prone to contamination with mycotoxins.

(iv) Chemical changes- changes in the chemical quality of the feeds occur due to enzymatic actions, loss of vitamin potency and the development of oxidative rancidity. The free fatty acids which develop due to lipid break down make the feeds more prone to the development of rancidity. High lipid ingredients and materials with high levels of poly-unsaturated fatty acids are more prone to the development of rancidity than others. Ingredients such as expeller vegetable oil cakes, fish meals, and rice bran are mostly vulnerable. Rancid fats present in feeds reduce its palatability and contain toxic metabolites which may depress growth. The fermentation of carbohydrates produces alcohols and volatile fatty acids.

The availability of amino acids in the feed proteins may be reduced during long term storage due to the development and interaction of certain chemicals and due to increase in temperature. The potency of vitamins (particularly vitamins C and B1) decreases

significantly during storage (and processing). Naturally occurring vitamins in feed-stuffs also deteriorate on storage.

(v) Environmental factors- Several factors such as moisture (feed moisture content and relative humidity), temperature, light, and oxygen influence deteriorative changes and losses in feedstuffs. Temperature increases sufficient to cause fire. 'Spontaneous combustion' can occur in stacked feeds and if they are constantly full of fine atmospheric dust from grinding processes within the store or adjacent areas. Heat is also generated by the growth of fungi and insects.

Storage plan of feeds and ingredients

The prepared feeds should be treated in the same way as dry ingredients but should not be stored for a long time. Formulated feeds are more susceptible to quality deterioration than individual ingredients. This is because of interactions between different ingredients and due to cross contamination with insects and fungi. The potency of vitamins in feed declines during storage. This is because many of these organic compounds are highly reactive/ unstable and can be easily denatured by oxygen, heat, moisture and ultraviolet light. Therefore, direct exposure of feed to sunlight and moisture should be avoided.

The lipids (fish oil, sunflower oil, lecithin etc.) should be kept in sealed, preferably plastic, containers, in a cool dark place. Ensure that antioxidants are added to them while manufacture.

Table 1. Average vitamin stability in stored feeds (Source: Coelho, 1991)

Vitamin	**Ingredient Source**	**% Vitamin retention at months**		
		1	**3**	**6**
A	Beadlet	83	69	43
D3	Beadlet	88	78	55
E	Acetate	96	92	88
K	MSBC 1	75	52	32
	MPB 2	76	54	37
Thiamin	Hydrochloride	86	65	47
	Mononitrate	97	83	65
Riboflavin	Riboflavin	93	88	82
Pyridoxine	Hydrochloride	91	84	76
B12	Cyanocobalamin	97	95	92
Pantothenic Acid	Calcium d-Pantothenate	97	95	92
Folic Acid	Folic Acid	97	83	65
Biotin	Biotin	90	82	74
Niacin	Nicotinic Acid	88	80	72
Vitamin C	Ascorbic Acid	64	31	7
	Fat Coated Ascorbic	95	82	50
	Ascorbyl Phosphate	98	90	80
Choline	Chloride	99	98	97

1 MSBC = Menadione Sodium Bisulfite Complex

2MPB = Menadione Dimethyl PyrimidinolBisulfate

General recommendations/ guidelines for storage

- Provide a building for storage which is secure, with proper roofing, water proof and can be adequately locked
- Provide it with ventilation points. Ventilation entry points should preferably be low on the side facing the prevailing wind and high on the opposite side
- All entry points must be meshed to avoid entry by birds, rats, other pests etc.
- Raw materials which are visibly damp or mouldy or which are obviously infested with insects should not be accepted
- Ingredients should be stored for a minimum period as possible and compounded feeds used quickly, especially in tropical conditions
- Make small stacks. Even though large stacks of sacks lessen insect damage, which occurs mainly at the surface, but cause heat generation, with other consequential damage
- The feed/ ingredient sacks should be raised off the ground by stacking them on wooden pallets (platforms)
- Ensure that ingredients are clearly labelled
- Avoid walking on the stacks of compounded feeds unnecessarily to avoid the breakage of pellets and the production of wasteful fines (dust)
- Don’t keep the sacks to rest against the outer walls of the store. Leave a space between the stacks and the wall to facilitate air circulation
- Don’t allow staff to sleep, eat or smoke in the feed store
- Always keep the store clean. Floors and walls should be regularly swept
- Arrange the store in such a way that new deliveries are not put in front of old stocks so that the oldest materials can be used first
- As a general rule, don't keep materials longer than the following guidelines (Source: FAO):

Table 2. Shelf life of feed ingredients

Material	Tropical Zone	Temperate Zone
Ground Ingredients	1-2 months	3 months
Whole Grain and Oilcakes	3-4 months	5-6 months
Compounded Dry Feeds	1-2 months	1-2 months
Vitamin Mixes (kept cool etc.)	6 months	6 months
Wet Ingredients	2-3 hours	2-3 hours
Frozen Materials	2-3 months	2-3 months

Quality evaluation of ingredients and feeds

(i) Physical

The physical indices include colour, texture, odour, particle size, shape, damage and deterioration, pest infestation, fecal material contamination, hair, bulk density, water stability, leaching, pellet hardness, durability, settling velocity measurement, presence of adulterants etc.

(ii) Chemical

The chemical evaluation includes proximate composition, pepsin digestibility, pesticide estimation, elemental analysis, estimation of Trimethyl amine (TMA) and Total Volatile Base Nitrogen (TVBN), biogenic amines, urea, NPN, peroxide value, free fatty acid value, iodine number, anisidine value, saponification number, TBARS value, antibiotics and antioxidants estimation, protein solubility etc.

(iii) Microbiological

Ingredients and feeds may be contaminated during processing, storage or transport, which may cause disease when consumed.

Therefore, it is necessary to establish surveillance programs for microbiological feed hazards. Some microorganisms introduced

during storage such as moulds, can negatively affect feed quality including reducing dry matter and nutrients, causing musty or sour odours, and producing toxins. The microbiological indices of feed quality include Total plate count (TPC), yeast and mould count, *Escherichia coli* count, coliformes, *Enterobacteriacea* count etc.

Table 3. Common adulterants of feed ingredients

Feed ingredient	Adulterant
Fish meal	Common salt, urea, sand
De-oiled rice bran, wheat bran	Saw dust, ground rice husk
Soy bean meal	Urea, raw soy bean
Maize	cobs
Mineral mixture	Limestone, common salt, marble powder, sand
Ground nut cake	Ground nut husk, urea, non-edible oil cakes
Mustard cake	*Argimona mexicana* seeds, urea, fibrous feed ingredients

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Coelho, M. B. (1991). Feed Management. 42:10, 24-35.

3

Introduction to mariculture techniques: Cage farming

Rajesh N, Boby Ignatius and Imelda Joseph
Mariculture Division, CMFRI

Site selection

Ideal sites for cage culture are lakes, bays, lagoons, straits and inland seas. Important criteria to be considered in site selection are water current, depth, dissolved oxygen levels, salinity, temperature, pollution etc.

A depth of >3 m is essential for effective cage culture practices. Sufficient depth is needed to maximize exchange of water, and to keep the cage bottom well above the bottom of the water body. Dissolved oxygen is required for respiration, production of energy for essential functions such as digestion and assimilation of food, maintenance of osmotic balance and activity. Oxygen requirements vary with species, stage of development, size and also influenced by environmental factors such as temperature, suspended particles etc. If the supply of oxygen deviates from the ideal; feeding, feed conversion, growth and health are adversely affected. For most fishes, a temperature of 26 - 28^{o}C with no abrupt changes is considered suitable. Preferred salinity range is from 5 – 25 ppt, in brackishwater cage culture.

Cage design and construction

A good and practical design of a cage will meet the requirements of the species farmed and the staff who will operate the system. The structure must be strong to withstand the forces of winds, waves and water currents while holding the stock securely. They must be durable and resistant to corrosion since they are exposed to highly

corrosive effects of seawater. The net bags must be strong enough to hold the stock securely and must be weather resistant. The floatation system must support the combined weights of the walkways and framing, the people working on the raft, net full of fish during harvest and fouling organisms of the net. The structure must be securely anchored to avoid being carried away by strong currents.

The low cost cage developed by CMFRI made of good quality 1.5" GI pipe (B class). The diameter of the cage is 6 m and the height is 120 cm from base to the railings. All the joints are double welded for ensuring extra strength. After fabrication the structure was provided with single coat epoxy primer and double coat epoxy grey paint to prevent rusting. The total weight of the cage is about 700 kg.

Puff or foam field HDPE cage is buoyant enough to float in the water. However, metal cage needs additional floatation. Ten fiber barrels of 200 l capacity filled with 30 lb air are used for floating the cage. The cage when floated on inflated barrels provides a stable platform around the cage where fisherman can stand and safely carry out works like net clearing, net replacement etc.

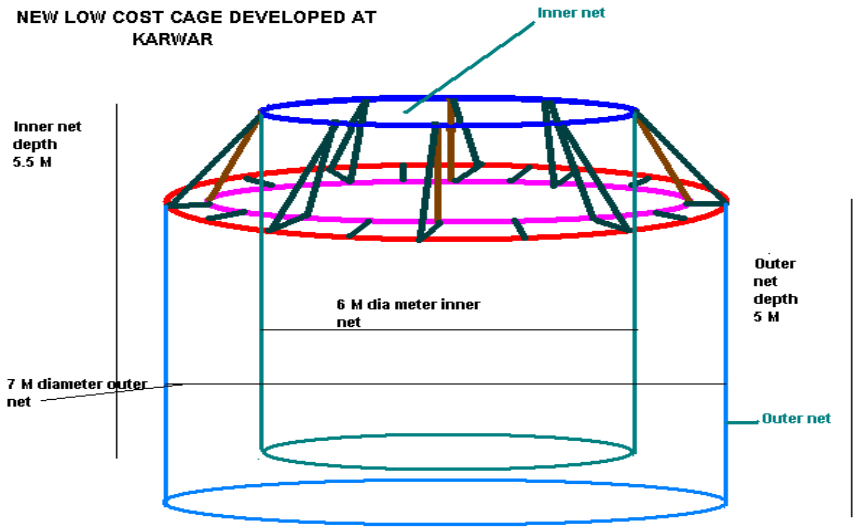
Shape: Shapes of the cages are likely influenced by the swimming behaviour of the fishes. Circular shape cage bag offers the most economical cost of netting materials of the same area and deep than the other shapes such as squares, rectangular, octagon etc. Rectangular cages have a greatest water exchange to volume ratio when the broader side is exposed to current.

Size: The common sizes used for floating net cages are 6 m and 10 m diameter and 4x4 m and 4x5 m and 5x5 m floating cages with a net deep of 3.5-5.0 m including freeboard. Larger size floating cages will require equipment and manpower for its management.

Materials: The main criteria for selecting the materials for the construction of cages are light weight, strong, weather and corrosion resistant, fouling resistant, drag free, smooth textured, easy to construct and repair, cheap and locally available. Netting materials must not be harmful or stressful to the cultured species.

Mooring systems: Most of the mooring systems consist of lines and anchors that secure cages in a particular location. Mooring lines must withstand forces acting on the floating cage system and transmit this to anchors. The total length of mooring lines must be at least 3 times the maximum depth of the water. Depending on the set up of floating cages, mooring system can be single or multiple point. Anchors must be strong enough to resist the forces acting and to secure the floating cages system in place.

Components of a cage includes cage bag, floats, frame, service system, mooring system and anchor system.



Cage nets

Net bags fabricated with synthetic nylon or polythene netting reinforced with polythene ropes are used for farming. Recently new stronger materials from different manufactures are available in the market. Netting material is twisted, braided or even knotless.

Types of net bags are used in cage culture

Outer net or predator net for protection from competitors and predators in open waters: Braided HDPE net 3 mm/80 mm mesh (square) of required size with 14 mm PP vertical rope lining

Inner net for holding the fish: For fish Nylon / Sapphire/ HDPE net with 15 -40 mm mesh, for periodic change are used.

Bird net: Birds should be particularly prevented from cages because they prey on fish and are in many cases are carriers of disease agents and parasites. Bird nets are made with 1.25 mm/80 mm twisted HDPE, provided with rings to connect to the inner cage net, prevent birds from picking caged fish.

Service system

Service system helps the farmers for feeding, cleaning, monitoring, grading etc during cage farming. Max height of handrail should be about 100 cm.

Mooring system

Two functions of mooring line are to withstand and transmit forces. This must be powerful enough to resist the worst possible combination of forces. There are two types of mooring system exist single point & multi point mooring systems in open sea cages. Fixed mooring system is more commonly used in backwaters/ rivers etc. Different types of anchor systems are using in cage culture practices. Some common types of anchors are dead weight

anchors, block of concrete stones, gabion bags filled with stones, scrap metal etc.

Selection of species for farming

The species selected should have a ready market for local consumption or for export. The farmer should decide whether he would culture high volume, low priced species or low volume, high priced species.

Attributes for an ideal candidate species for cage culture

- Hardy species that tolerates crowding and wide physiological tolerances.
- High fecundity of female fish with plenty of material for hatchery production of seed.
- Hatchery production of seed to be relatively simple.
- Those feed well on pellet diets, and juveniles easy to wean to pellets.
- Those which grow rapidly, reaching a harvestable size (350 g – 3 kg) in six to eight months.

Potential species for India

- Marine: Cobia, Sea bass, Groupers, Snappers, Mullets, Lobsters etc.
- Inland: Carps, Pangasius, Tilapia etc.

The stocking densities for cage culture generally range from 15 to 40 no/m^3, although densities can be as high as 60 no/m^3. Cannibalistic fish should be graded into several size groups and stocked in separate cages. The stocking should be done in the early hours (06 00–08 00 hours) or late in the evening (20 00–22 00 hours) when the temperature is lower.

Two to three months thereafter, when the fish have attained a weight between 150–200 g, the stocking density can be reduced to

10–20 fish per cubic meter. Higher stocking densities require more frequent monitoring of water quality and more feeds.

Feed and feed management in cages

Main components of fish feeds are Protein, Carbohydrate, Fat, Minerals, and Vitamins etc. Deficiency of a nutritious feed leads to growth retardation and subsequent disease outbreak. Marine fish require high protein (35-40 %) for their optimal growth. Overfeeding leads to wastage and pollution. Feeding rate, frequency of feeding and time of feeding are important factors to be considered in cage farming. Feeding rate and frequencies are related to age and size of fish. Larval fish and fry need to be fed on high protein diet more frequently. As fishes grow bigger, feeding rate and frequencies can be reduced. Feeding is labour intensive, so frequency has to be adjusted to become economically viable. Growth and feed conversion increases with increase in feeding frequency. Feeding of fish also influenced by the time of the day, season, water temperature, dissolved oxygen level and other water quality parameters.

Farming details of food fishes in cages

Sl No	**Species**	**Length** (cm)	**weight** (g)	**Stocking density (nos/ m^3)**	**Culture period (months)**	**Weight** (Kg)
1	Sea bass	12	10	35	8-10	1-1.5
2	Cobia	15	15	12	6-8	3
3	Snapper	5	4	30	10-12	1.5
4	Mullet	8	5	35	8-10	1

4

Disease Management in Aquaculture

Sanil N K
Marine Biotechnology Division, CMFRI

Aquaculture is one of the fastest growing industries worldwide. When the ability of traditional food production systems such as agriculture and animal husbandry has shown stagnation, an alternative source has to be found out. In this endeavour, `aqua farming' is to play a major role in our country, considering the vast water bodies of India, where aquaculture can be practised.

Shrimp and Carp farming has been the mainstay of Aquaculture in India. But by 1993, diseases, especially those of viral etiology have emerged as the major constraint to the sustainability and growth of shrimp aquaculture. The growth and economic viability of any aquaculture venture primarily depend on the successful prevention/control of disease outbreaks. Unlike the land based farming, the disease problems in aqua farming are complicated and more difficult to control/ treat due to the three-dimensional nature of culture system where the dynamic interaction of various factors comprising the host, opportunistic pathogens and abiotic factors takes place. Disease prevention in aquaculture is not merely a case of dealing with the pathogen and its elimination, but it has to be dealt with a broader perspective, popularly termed as "aquaculture health management". Disease problems were not a major deterrent when the aquaculture activities were of extensive in nature. Intensive systems lead to higher stocking densities and increasing stress which often leads to disease outbreaks. Creation of Intensive rearing systems aiming for more and more production and profits, without proper planning and management, invite problems of infection and disease.

Any impairment that interferes with the performance of normal functions including responses to environmental factors, toxicants, climate, nutrition, infectious agents etc can be termed a disease. Diseases can be caused by a variety of factors, the most important being pathogens. Other factors contributing towards the development of disease conditions include stress, environmental/water quality, physical agents, nutritional imbalance, toxins etc or a combination of these. Disease outbreak is thus a complex situation resulting from the interaction/modification of the primary disease condition by these biotic and abiotic factors. The effect of disease on animals range from morbidity/reduced production in some cases to mass mortalities. In nature we are less aware of fish disease problems because sick animals are quickly removed from the population by predators. In addition, fish are much less crowded in natural systems than in captivity. In aquatic ecosystems pathogens are always present and a delicate balance exists between the host, pathogen and environment. Any changes in any of these factors may disturb the equilibrium and may lead to increase or decrease in the disease condition. The most obvious sign of disease in any system is the presence of weak, dead or dying animals. However, the careful observation can usually tell that fish are sick before they start dying because sick fish often stop feeding and may appear lethargic. Fish that are gasping at the surface, abnormalities in the feeding pattern (poor feeding or overfeeding) or rubbing against objects indicate something may be wrong. These behavioral abnormalities indicate that the fish are not feeling well. In addition to behavioral changes, there could be physical signs also that indicate potential disease problems in fish.

There are two broad categories of diseases that affect fish, infectious and non-infectious diseases. Infectious diseases are caused by pathogenic organisms present in the environment or

carried by other fish. Majority of diseases affecting fishes are infectious, caused by opportunist viruses, bacteria, and parasites.

These pathogens multiply in vast numbers in the fish, causing massive damage to the organism by depriving it of life-essential substances and/or by producing ichthyotoxic substances. In both cases the health of the fish is affected and results in diseases, unless appropriate treatment is given. In contrast, non-infectious diseases are caused by environmental problems, nutritional deficiencies, or genetic anomalies; they are not contagious and usually cannot be cured by medications.

The Genesis of Disease in Aquaculture: There exist a delicate balance between the host, pathogen and the environment. When this delicate balance gets upset, diseases can result. In an aquaculture pond, the health status of the animal can become weak due to different stress factors. These include (a) chemical stressors (b) biological stressors (c) physical stressors and (d) procedural stressors.

Role of Stress in Disease Development: the role of stress in predisposing the fish/shrimp to infections is widely recognized and many of the routine aquaculture practices are known to induce stress. Stress is a non-specific response and it involves series of changes in the animal in trying to adapt to the changed situation. The adaptive responses of the animal when extended beyond the normal range, disturbs the normal functions. The series of changes termed "stress response" in fact tries to help the animal restore the normal homeostasis. This process has both advantages and disadvantages. During stress, hypothalamus- pituitary-interrenal axis (hpi axis) gets stimulated and increases the output of stress hormones called corticosteroids. These stress hormones help to mobilize additional energy during the response to regain the internal homeostasis. At the same time, these stress hormones are

zooplankton which could be easily cultured on a large scale. Different varieties of rotifer sp., copepods and cladoceran are used for the culture. All these organisms which have high reproductive rate, short generation time, and the ability to live and grow in crowded culture conditions have been found to be useful as live feed organism for larval rearing of cultivable species of fishes. Among them *Brachionus plicatilis, B. rotundiformis, Pseudodiaptomus annendeli, P. serricaudatus and Moina* sp. have been the most successfully cultured in small and large scale in the mariculture hatchery of the Central Marine Fisheries Research Institute, Kochi, and given as feed for fish larvae.

Importance

Zooplanktons play an important role in the pelagic food web by controlling phytoplankton production and shaping of pelagic ecosystem. It plays critical role as food source for larval and juvenile fishes. The zooplankton population dynamics, reproduction and survival rate etc. are important factors for recruitment to fish stock. Zooplankton occupies a key position in the pelagic food web as it transfers organic energy produced by unicellular algae through photosynthesis to higher trophic levels. It is regarded as the most important environmental factor controlling the year class strength of a large number of commercial fish stock. The ecological significance of zooplankton communities depends on the diversity, behavior and interaction of their species, which play the main role in channeling energy up the food web and exercising top-down control through grazing or predation. Natural (variation in current) and man-made factors can strongly affect zooplankton density and distribution. Zooplankton contributes to the removal of surplus anthropogenic carbon dioxide from the atmosphere through sedimentation and burial of organic and inorganic carbon compounds.

basically immuno-suppressive in nature, reducing the efficiency of both non-specific and specific immune systems of fish significantly, rendering the animal susceptible to diseases. Common husbandry practices like handling, netting, transportation and the normal features of an intensive culture system like suspended solids, low oxygen, high organic matter, overcrowding, high ammonia, etc. can elevate the level of corticosteroids in the blood. Similarly, many of the pollutants even at very low levels can also stress the fish and make them relatively more susceptible to infection. Most of the stressors encountered in intensive culture systems are of chronic nature and can keep the level of corticosteroids above basal levels for longer duration. In such stressful situations opportunistic pathogens including parasites, bacteria, fungi, and virus in the surrounding medium invades the animal body, resulting in an infection.

Disease process:

A pathogen can cause a clinical disease only when it can establish on or in the host, proliferate, overcome the non-specific and/or specific defense barriers of the host, produce the pathogenic factors, cause cellular and tissue damage, produce significant pathological changes, impair the function of the target tissue and cause mortality. All infections need not result in disease manifestation. Only when the pathogen build up disrupts the threshold of animal resistance, the animal succumbs to disease condition. The sequence of events in an acute infection is as follows.

- Contact with the pathogen
- Infiltration into the body
- Development / proliferation - incubation (usually short in fishes)
- Spreads throughout the body
- Symptoms appear
- Pathogen restricts itself to specific target organ (mortality)

The sequence of disease development will to a large extent depend on the nature of the pathogen (parasite, bacteria, fungi, virus), environmental factors, size of the host, pathogen load or intensity per unit area or unit weight of the host. The situation is a complex one making the health management a difficult proposition. This can be further complicated with the involvement of more than one pathogen resulting in a mixed infection. A mixed infection can lead to faulty diagnosis. This spells the need for an integrated management approach to tackle the disease problems with respect to the animal, environment and pathogen using diagnostics a functional tool.

Bacterial Diseases: Fish are susceptible to a wide variety of bacterial pathogens. Many of these bacteria become pathogens when fishes are physiologically unbalanced, nutritionally deficient, or there are other stressors, which allow opportunistic bacterial infections to proceed. Important bacterial diseases in fishes include Bacterial Hemorrhagic Septicemia caused by *Aeromonas hydrophila* and *A. sobria*, Furunculous caused by *Aeromonas salmonicida*, Enteric septicemia of catfish caused by *Edwardsiella ictaluri*, Bacterial gill disease caused by *Flavobacterium branchiophilum*, Columnaris caused by *Flavobacterium columnare*, Fish Mycobacteriosis caused by *Mycobacterium marinum*, Emphasematous Putrefactive Disease of Catfish or "Fish Gangrene" caused by *Edwardsiella tarda*, Vibriosis caused by *Vibrio anguillarum*, & *V. alginolyticus*, Enteric Redmouth Disease caused by *Yersinia ruckeri*, Bacterial Kidney Disease caused by *Renibacterium salmoninarum*, Coldwater Disease caused by *Flavobacterium psychrophilum*, Streptococcus Infection caused by *Streptococcus iniae.* Bacteria are known to cause infections / diseases in shellfish farming also.

Viral Diseases: Viruses are obligatory intracellular parasites requiring a living cell to replicate. Outcome of diseases due to virus infection is complex and depends on several factors including the immune status of individuals and infectious dose of virus.

Mortality need not always be 100%. In some cases, virus remains at a low level of infection establishing a delicate balance with the host. In addition, there are carriers, which are survivors of a mass scale infection and mortality. Usually it is difficult to detect virus in carrier or latent infection stage. Important diseases of viral etiology in fish include Channel Catfish Virus Disease a herpes virus infection of fry and fingerling channel catfish, Lymphocystis, a disease caused by an iridovirus, Infectious Hematopoietic Necrosis, a rhabdoviral disease of salmonid fishes, Infectious Pancreatic Necrosis, a birnavirus infection of salmonids and Viral Hemorrhagic Septicemia a rhabdovirus infection of salmonids. Viral diseases are known to cause havoc in shrimp culture. Some of the prominent viruses causing disease and mortality in shrimp culture farms include white spot syndrome virus (WSSV), Monodon baculovirus (MBV), *Baculovirus penaei* (BP), Baculoviral midgut gland necrosis virus (BMNV), Infectious hypodermal and hematopoietic necrosis virus (IHHNV), Hepatopancreatic parvo-like virus (HPV), Yellow head virus (YHV) and taura syndrome virus (TSV). Specific drugs for viral disease treatment are not available or difficult to develop since virus is host cell dependent for all its metabolic machinery and vaccines in general are not found to be effective in fish viral disease management. In the absence of a successful drug or vaccine, avoidance of the virus in culture system is the best strategy. Crop holiday is one of the best strategies to prevent viral disease in aquaculture and is still practised in salmonid culture to prevent IPN disease.

Fungal Diseases: Generally fungal diseases can be external or systemic and are difficult to cure. Important fungal pathogens infecting fishes include *Aphanomyces* sp. causing the Epizootic Ulcerative Syndrome (EUS), *Saprolegnia, Achlya, Dermocystidium*, *Branchiomyces*, *Aspergillus, Ichthyophonus* and those infecting shrimps include *Enterocytozoon Hepatopenaei* (EHP).

Parasitic Diseases: Parasitic diseases in fishes range from extremely pathogenic ones to those, which are practically harmless. Important protozoan diseases of fishes include Velvet Disease, Cryptobiasis, Ichthyobodosis (Coastiasis), Coccidiosis, Microsporidiosis, Myxosporidiosis, Ichthyophthiriasis (white spot disease), Chilodonellosis, Trichodina infection and diseases caused by surface fouling organisms. Generally metazoan parasites are less pathogenic in fishes and include various monogeneans, trematodes, cestodes, acanthocepahalans, nematodes and crustaceans.

Non-infectious Diseases: Feed-derived wastes also affect the culture environment through direct pollution, which in turn affects the culture organisms. Uneaten feeds, faeces and metabolic wastes contribute to nutrient and particulate loading of the water and substrate which in turn induce stress, depress the growth of cultured organisms and increase their vulnerability to diseases. Improper diets can negatively influence the health of a fish by inducing nutrient deficiencies, imbalances or toxicoses. An impaired nutritional status contributes to defective host resistance. Malnourished fish may harbor latent infections, and certain physiological conditions and environmental stress may predispose them to infection.

Disease Diagnosis in Aquaculture:

Diagnosis forms the first step in any disease control programme, which determines the ultimate success or failure of the programme.

Diagnostic Procedure: Once an infection or disease is suspected, the next step is to draw a diagnostic procedure, to fix the root cause of the problem. The diagnostic procedure may include a single diagnostic test or a combination of tests. In the case of routine pathogen watch or health monitoring, a set of selected diagnostic tests are performed to cover the potential pathogens. The approach generally followed is location specific and problem specific, where

the first consideration is the availability of the diagnostic facility and expertise. There is no hard and fast method, which can be applied for all cases.

A general approach in disease diagnosis is given below:

Records/History on	Water source and Pond, Water parameters Stocking, feeding, growth performance, handling, Recent pathologies and treatments Epizootiology The more precise and consistent the farm records are the more likely it is for the pathologist to reach a sound diagnosis
On site observation of	Water conditions / soil / benthos and plankton samples Live / sick fish for shoaling behaviour, reactions to stimuli and feeding. Presence of dead and moribund fish. External lesions (ulcers, exophthalmus, reddening, fin erosion)
Examination	Gross external examination for parasites Preparation of smears
Sampling for	Laboratory examination (whole fish, organs) for Bacteriological, fungal examinations Blood tests / Rapid diagnostic tests Electron Microscopy
On site necropsy	Skin, fins, gills, internal organs Sampling for histopathology / virology
Laboratory analysis	Bacteriology, Parasitology, Histopathology, Serology, PCR / DNA Probes

Once the right diagnostic picture along with the water and soil parameters are available, control measures with respect to the causative factor(s), can be initiated. However, the diagnosis often gets complicated in the cases of mixed infections, with the involvement of primary, secondary and even tertiary pathogens.

Treatment: Treatment or therapy is intended to restore the normal health of the diseased or infected animal. Based on the nature of the etiological agent, suitable chemicals/drugs are administered in the required doses for their control. Drugs can be given orally, intramuscularly, intraperitoneally, intravenously or topically as baths or dips. Selection of the proper route depends on the environmental situation, the species and condition of the animal, and the drug being delivered. Failure to consider any of these factors can result in unsatisfactory treatment. Unlike the land-based animal rearing systems, where the diseased animals can be identified and treated individually, the scope for disease control in aquaculture through detection and treatment is of limited value. Aquatic animals are constantly exposed to potential pathogens and separating the infected or diseased animals from the population and subjecting them for a treatment regime is impractical and is not economically viable. Chemotherapy is not advised in culture systems and should be used only as a last resort since the use of antibiotics can lead to residues in tissues as well as development of antibiotic resistant microbes in the environment, which in turn can create other public health issues. So chemotherapy, if at all required, should be practised judiciously and restricted to broodstock alone. Hence disease prevention is the only natural choice available.

Prevention: The cornerstone of disease prevention is the creation and maintenance of excellent water and soil quality conditions in the rearing systems. Good sanitation practices are also important to reduce the load of potential pathogens. Quarantine is another extremely important concept since it helps to prevent the entry of

disease causing pathogens and thereby avoid serious problems, mainly related to infectious diseases. The term quarantine originally indicated an isolation period of 40 days, and generally it can be defined as a six weeks period of segregation away from the final destination tank. Quarantine helps in the (a) evaluation of the health condition of the new fish (b) reduction of disease transmission risk to pre-existing fish (c) gradual acclimatization of the new fish and (d) convenient administration of drugs. Avoidance or at least minimizing the introduction of known infectious pathogens is also important. Preventative treatments ("prophylactic" treatments) can be helpful in removing initial loads of external parasites.

Aquaculture Health Management: The management practices that are designed to prevent the occurrence of disease in a grow out system is termed as the AQUACULTURE HEALTH MANAGEMENT. It is a holistic approach where the focus is given to the health of the animal rather than treatment. Therefore different components viz., animal quarantine, screening of broodstock and larvae/fingerlings, Specific Pathogen Free (SPF) animals, pond and water quality management etc. are involved. Aquaculture health management primarily constitutes two aspects, the **farm health management** and the **fish health management**. Successful integration of these two aspects only can deliver a disease free environment.

Farm health management: It constitutes the maintenance of (a) good soil quality (b) good water quality (c) good farm productivity (d) feed management and (e) maintenance of proper farm quarantine to prevent horizontal transmission of disease causing pathogens.

Fish health management: It constitutes (a) proper animal quarantine b) screening of Broodstock and larvae/fingerlings and (c) crop health monitoring and pathogen watch. Effective

implementation of all the above three aspects of fish health management depends entirely on the early and accurate diagnosis of the disease causing agents. The failure of which can lead to faulty treatment resulting in multiple problems like indiscriminate use of chemicals and drugs, drug resistance, large-scale mortality causing crop failure and economic loss. Timely and early use of proper diagnostics can be used as an effective tool for health care management.

Individual health management models with broader management approaches to control farm level environmental deterioration and preventive measures against pathogen introduction, depending on the availability of sensitive and specific diagnostics can be adopted for specific diseases caused by the pathogens such as bacteria, parasites, fungi, considering the economic aspects.

5

Fish feed ingredients and additives – Classification, composition and anti-nutritional factors

Sanal Ebeneezar, Linga Prabu D, Chandrasekar S, Sayooj P and Vijayagopal P
Mariculture Division, CMFRI

Introduction

Ingredients are the basic raw materials of fish feeds. No single feed ingredient is nutritionally complete and can supply the nutrients and energy required for growth of fish. Therefore, a mixture of ingredients in a carefully formulated feed can provide balanced levels of nutrients and energy for optimum growth performance.

Classification of feed ingredients

1. Based on source (Table 1)

The ingredients are classified as plant source and animal source based on their source of origin. Animal protein sources are generally considered to be superior because of their balanced amino acid profile.

2. Nutritional value

Based on nutritional value, ingredients are classified as protein rich and energy rich. Feed ingredients in which the crude protein content is 20% or more and with less than 20% crude fibre are considered as protein rich, while energy rich ingredients contain less than 20% crude protein and less than 20% crude fibre. Examples of protein rich ingredients include fish meal, shrimp meal, clam meal, squid meal, meat and bone meal, fish solubles, blood meal, poultry by-product meal, hydrolysed feather meal, soybean meal, cotton seed meal, ground nut oil cake, distillers dried grains with solubles, sunflower meal, canola meal etc. Energy rich ingredients include cereals such as corn, rice and wheat products, plant and animal fats and oils. Every ingredient source may have different nutritional value, therefore they should be

analysed for nutritional composition and if needed modify the feed formulations.

Table 1. Proximate composition (on % dry matter basis) and approximate price of common fish feed ingredients (Per Kg dry weight)

Ingredients of Animal origin								
SI No.	**Ingredients**	**DM %**	**CP %**	**EE %**	**CF %**	**ASH %**	**NFE %**	**Approx. price (Rs/ Kg)**
1	Fish meal	95.16	68.5	8.79	0.3	11.9	5.67	90
2	Shrimp meal	93.25	67.45	6.43	5.07	14.25	0.05	65-110
3	Clam meal	93.17	58.15	12.19	3.22	6.47	13.14	320
4	Meat and Bone meal	92.37	51.36	5.71	1.82	24.87	8.61	95
5	Squid meal	92.36	71.88	5.41	1.62	4.33	9.12	200
6	Silk worm pupae meal	94.87	59.38	24.12	3.08	8.18	0.11	40
7	Casein	91.5	86.5	0.2	1.0	3.7	8.60	400
8	Blood meal	88.0	81.5	1.0	1.0	3.2	13.30	30
9	Krill meal	92.9	58.0	18.0	6.0	13.0	5.0	250
10	Poultry feather meal	89.2	77.9	4.2	0.6	5.4	11.90	35
11	Shrimp shell meal	92.6	36.3	7.0	20.0	30.4	6.30	40
Ingredients of Plant origin								
SI No.	**Ingredients**	**DM %**	**CP %**	**EE %**	**CF %**	**ASH %**	**NFE %**	
1	Rice bran	89.9	12.60	11.30	19.3	10.20	36.50	28
2	Wheat flour	87.40	14.50	3.70	2.70	2.30	64.20	30
3	GNOC	97.90	36.23	7.31	8.23	24.05	21.40	45
4	Mustard oil cake	90.80	23.60	9.60	6.30	10.40	40.90	40
5	Soya flour	94.38	53.82	0.58	4.64	7.92	27.42	60
6	Cotton seed meal	93.00	37.00	6.70	13.0	1.00	35.30	42
7	DDGS	90.66	42.43	6.07	7.05	6.15	28.96	25
8	Wheat gluten	90.14	65.54	2.70	1.20	2.10	18.74	700
9	Tapioca flour	87.13	2.82	0.29	1.79	2.02	82.23	30
10	Yeast (Brewers)	94.7	48.5	3.0	1.9	9.2	37.4	200
11	Yeast (Torula)	93.0	41.0	3.0	1.9	7.8	46.3	150-200

Feed additives

Feed additives are products used in feeds in addition to major ingredients in order to improve the quality of feed and to enhance the growth and overall performance of animals/ fish. Generally, additives are added at low concentrations (<2 %) in the diets. The examples of additives are given in Table 2

Table 2. Additives used in fish feeds

Types	Examples
Binders	Agar, carrageenan, corn starch, tapioca starch, potato starch, carboxymethyl cellulose (CMC), lignosulphonates, hemicelluloses bentonites
Feeding stimulants	Betaine, Choline chloride, L- amino acids
Pigments	Carotenoids, oleoresins
Vitamins	Vitamin C, multi-vitamin mix
Minerals	Ca, Mg, Na, K, P
Antioxidants	Butylated hydroxyl toluene, sodium metabisulphate, butylated hydroxyl anisole
Growth promoters	Probiotics, prebiotics, synbiotics, acidifiers, exogenous enzymes
Immunostimulants	Chitin, chitosan, levamisole, levans, plant based nutraceuticals, propolis, seaweed based sulphated polysaccharides etc.

Antinutritional factors

Antinutritional factors are substances which directly, or through their metabolic products are able to interfere with nutrient assimilation. They may be endogenous or extraneous factors occurring in feeds and ingredients during storage and processing.

Even though plant-derived ingredients are less expensive and more sustainable alternative to fishmeal in fish feeds, the presence of anti-nutritional factors within these ingredients is the major constraint that limits their use.

Table 3. Anti-nutritional factors in common plant based ingredients

Sl No	Ingredients	Anti-nutritional factors
1	Ground nut oil cake	Protease inhibitors, phytohaemagglutinin, phytic acid, saponins, oestrogenic factor, aflatoxin
2	Soybean meal	Protease inhibitors, lectins, phytohaemagglutinin, phytic acids, saponins, phytoestrogens, antivitamins
3	Cottonseed meal	Phytic acid, oestrogenic factor, gossypol, anti-vitamin E factor, cyclopropenoic fatty acid, aflatoxin
4	Corn/maize	Protease inhibitors, phytic acid, tannins, invertase inhibitor, aflatoxin
5	Tapioca	Protease inhibitors, cyanogens, aflatoxin
6	Bengal gram/chick pea	Protease inhibitors, cyanogens, phytic acid, oestrogenic factor, flatulence factor, aflatoxin
7	Mustard oilcake	Glucosinolates, tannins

Online resources

Aquaculture Feed and Fertilizer Resources Information System
http://www.fao.org/fishery/affris/feed-and-feed-ingredient-standards/

Feedipedia- Animal feed resources information system
https://www.feedipedia.org/

Online database of anti-nutritional factors in feed ingredients:
http://www.fao.org/fishery/affris/feed-resources-database/major-anti-nutritional-factors-in-plant-derived-fish-feed-ingredients/en/

6

Zooplankton Culture for Mariculture

Binoy Bhaskaran and Imelda Joseph
Mariculture Division, CMFRI

Introduction

Plankton is vast and diverse group of organism incapable of free swimming. They drift in the mercy of water current. Plankton is described as the smallest group of plants and animals in the aquatic ecosystem. The term 'plankton' was coined by the Germen founder of Quantitative Plankton and Fishery Research, Victor Henson in 1887. It is derived from a Greek word 'Plano' meaning 'to wander' and it has the same etymological root as 'planet'. They are seen in both marine and freshwater ecosystems. Planktons are broadly classified into two major groups 'Phytoplankton and Zooplankton'. Phytoplanktons are microscopic plant community in the aquatic environment. They synthesize organic carbon from inorganic material by the process of photosynthesis. They are considered as the primary producers in the aquatic ecosystem. Major phytoplankton groups are diatoms, dianoflagellates, blue green algae, *etc.* Zooplankton is the small animal community in the aquatic environment considered as the primary consumers or the secondary producers of aquatic ecosystem. The zooplankton occurrence and distribution influence the pelagic fishery. Major zooplankton group present in the aquatic environment are Copepoda, Decapoda, Amphipoda, Ostracoda, *etc*.

Zooplankton

Zooplankton (fig: 1) is the diverse delicate and very useful group of animals that drift in water current in the aquatic ecosystems. It plays a very important role in shaping the aquatic ecosystem. They are distinguished from phytoplankton on the basis of morphology or the mode of nutrition. They are the heterotrophic group of the

plankton community. They can feed on phytoplankton, other zooplankton and detritus. They range in size from single celled protozoa to large jelly fishes. Generally zooplankton is distributed according to the availability of the phytoplankton and suitable environment.

Classification

Zooplankton can be categorized into different groups according to their mode of life, size and feeding habit.

Based on the life pattern

- Holoplankton: -Spending their whole life as plankton. E g: Amphipod, copepod, ostracods, etc.
- Meroplankton: -Plankton forms that do not spend their entire life as plankton.
  E g: -Cephalopods, Fish, Scyphozoan, *etc*.

Based on the size of the plankton

- Micro zooplankton:-Size ranges from 20 µm to200µm and it is the main source of production in the sea
- Macro zooplankton :-Size ranges from 200 µm to 2mm
- Mega zooplankton: -Size >2mm

Based on the food preference

- Herbivores:-they consumes phytoplankton
- Carnivores: -they consumes small animals
- Omnivores:-they consumes mixed diet of plant and animal material
- Detritivores:-they consumes dead organic material

Zooplankton Culture

Successful hatchery production of fishes and other organisms in aquaculture depends on the availability of the planktonic organisms of appropriate size for feeding their larvae. Freshly hatched Artemia nauplii have been the popular larval feed used by the aquaculturists for a long time. But the high cost of Artemia cyst has led to the aquaculturists to search for other suitable

zooplankton which could be easily cultured on a large scale. Different varieties of rotifer sp., copepods and cladoceran are used for the culture. All these organisms which have high reproductive rate, short generation time, and the ability to live and grow in crowded culture conditions have been found to be useful as live feed organism for larval rearing of cultivable species of fishes. Among them *Brachionus plicatilis, B. rotundiformis, Pseudodiaptomus annendeli, P. serricaudatus and Moina* sp. have been the most successfully cultured in small and large scale in the mariculture hatchery of the Central Marine Fisheries Research Institute, Kochi, and given as feed for fish larvae.

Importance

Zooplanktons play an important role in the pelagic food web by controlling phytoplankton production and shaping of pelagic ecosystem. It plays critical role as food source for larval and juvenile fishes. The zooplankton population dynamics, reproduction and survival rate etc. are important factors for recruitment to fish stock. Zooplankton occupies a key position in the pelagic food web as it transfers organic energy produced by unicellular algae through photosynthesis to higher trophic levels. It is regarded as the most important environmental factor controlling the year class strength of a large number of commercial fish stock. The ecological significance of zooplankton communities depends on the diversity, behavior and interaction of their species, which play the main role in channeling energy up the food web and exercising top-down control through grazing or predation. Natural (variation in current) and man-made factors can strongly affect zooplankton density and distribution. Zooplankton contributes to the removal of surplus anthropogenic carbon dioxide from the atmosphere through sedimentation and burial of organic and inorganic carbon compounds.

Sample collection

For culture zooplankton samples are collected during early morning hours from the coastal waters of Kochi, Kerala (N 10° 01.764'; E 076° 12.955'). Sampling is done using 60-µm-mesh plankton net. Thus collected contents are transferred to 1L sample bottle containing pre-filtered water from the collection site itself. Almost immediately, the samples are transported to laboratory for processing. On arrival, the salinity of the sample water is checked using Hand Refractometer/Salinometer and the salinity of filtered seawater is adjusted accordingly. The samples are then rinsed thoroughly using filtered seawater of salinity 25-35 ppt. for removal of contaminants.

The zooplanktons are segregated based on their size using sieves of different mesh size in order to obtain adult planktons and later stage planktons. Initially, a 500-µm-mesh sieve was used to remove fish and prawn larvae and later a series of sieves 300-µm-mesh size to 60-µm-mesh for screen to eliminate smaller zooplanktons such as rotifers, copepod nauplii and barnacle nauplii, etc. The selected zooplanktons for culture are then rinsed vigorously several times with filtered seawater (25-35ppt) to prevent contamination. Rinsing is also done periodically to reduce the rotifer numbers in copepods and other planktonic cultures. After rinsing, the remaining adult zooplanktons are maintained in 1L to 3L culture flasks and fed with phytoplankton/algal culture.

Algal Culture as phytoplankton feed

Algal culture was separately maintained for feeding the zooplanktons. The algae we maintained for feeding the zooplanktons are *Tetraselamis gracilis, Nanochloropsis* sp., *Chlorella* sp., *Chaetoceros calcitrans* and *Isochrysis galbana.* The cultures of these species are maintained in controlled conditions in the laboratory. Stock cultures are maintained in 500 ml conical flasks and 4000 ml Haffkine flasks containing filtered seawater at 23 °C temperature,

with 32ppt. salinity and 2100 W tube lamps are used to provide artificial illumination and fertilized with Wallness medium.

Figure 1 stock and mass culture of algae

Meanwhile, the collected zooplanktons are identified under light microscope (4 x magnification) using the key given by Kasthurirangan (1963). Based on diagnostic morphological characters, the zooplanktons are sorted as individuals of single discrete culture in each culture flask and labeled accordingly.

Copepod culture

Copepods constitute the first vital link in the marine food chain leading from primary producer to fish. Copepods are mostly marine and many of the species occupy freshwater or estuarine habitats. Almost one-third of marine copepod species are parasites or live in symbiotic relationship with other organisms. The most commonly used species in aquaculture are free-living copepods belonging to three of the ten orders of copepods (reviewed by Huys & Boxshall 1991): Calanoida, Harpacticoida and Cyclopoida.

Axenisation

Prior to start of stock culture of copepod, the axenisation of copepods has to be done by antibiotic treatment method. The antibiotics Benzyl Pencillin Sulphate, Streptomycin Sulphate and Chloramphenicol are mixed in different proportions (400mg+80mg+10mg) respectively and stored as "dry mix". 50ml

sterile sea water is used for the mixing the antibiotic dry mix. 6 sterile test tubes are taken and the first one was kept empty added 6 ml of the sterile sea water to the second tube and continued up to the sixth tube. To the empty first tube added 6 ml of sea water and 6 ml of the antibiotic mix. The tubes are shaken well and the 6 ml solution from the first tube was added to the second tubes which already contain 6 ml sea water. Later took 6 ml from the second tube and transferred to the third tube. Likewise all the tubes are mixed with antibiotics and 30-60 numbers of zooplanktons are added to all the tubes. A few drops of sterility test medium are added to all the tubes. The cultures are then incubated at 37 °C for 24 hrs in dark. The bacterial growths were checked by streak plate method. After axenisation culture is sub cultured and maintained (Droop1967).

Production of copepods

Batch culture of copepods is relatively straight forward once proper environmental and nutritional conditions are met. The culture flasks are stocked with adult copepods (10-25 individuals/ml). The cultures are maintained in 1L conical flask containing filtered sea water (25-35 ppt.) and fed with live algae in the ratio 1:25 (v/v). The algal feed was given on alternate days. The cultures are rinsed with filtered sea water and the eggs, nauplii, and adult from the detritus are separated into fresh culture flasks every week either manually or through filtration. The adult would begin producing eggs, sperms in 9-12 days; thereafter egg production would initially raise, and then reaches the peak and finally it falls.

Stock culture

Culturing large volumes of copepods on algae and baker's yeast diets always involve some risks of sudden mortality of the population. Technical or human failures and also contaminations with pathogens or competitive filter feeders are the main causes for lower reproduction which can eventually result in a complete crash of the population. Relying only on mass cultures of copepods for

inoculating new tanks is too risky an approach. In order to minimize this risk, small stock cultures are generally kept in closed vials in an isolated room to prevent contamination with bacteria and/or ciliates. These stock cultures which need to generate large populations of copepods as fast as possible are generally maintained on algae.

Figure 2 Stock culture of copepod

Stock cultures of calanoid, cyclopoid and harpacticoid copepod are maintained in 1 to 3L flask with culture media. The culture media was chlorinated sea water, salinity of the water 25-30ppt as measured by hand held refractometer. Feed is added every day depending on the size of the container and care must be taken to avoid over feeding, which is indicated by cloudy media or excess precipitation food. No aeration is provided for stock culture upto 3 L. Culture water is renewed once a week, by passing the culture through a series of mesh size 500 µm, 300 µm, 200 µm, 100 µm and 60 µm sieves. These sieves of varying mesh sizes are used in order to collect the copepods at different stages of their lifecycle. The cultures were maintained at 23-33°C (Rhodes, 2003).

Mass culture

The cultures are maintained in 50 L square tank, 3000 L cylindro-conical tank and 1 tone round outdoor culture tanks with continuous aeration (Merrylal James and Martin Thompson 1986).

Figure 3 mass culture of copepod

Rotifer culture

Rotifers have been used as food organism for cultured marine fish larvae. A continuous and stable supply of nutritionally adequate rotifers is the key to the flourishing culture of marine finfish in various parts of the world. They also used as a food for culturing penaeid shrimp (Samocha et al. 1989) and crabs (Keenan & Blackshaw). It serve as a 'living capsule', providing the nutrients required by the cultured marine fish larvae for proper development. Large number of rotifers may be required per day for raising marine fish larvae in commercial hatcheries (Lubzens et al. 1997, 2001). The range of 20,000 to 100,000 rotifers per fish larvae during the 20 to 30 days of culture (Kafuku& Ikenoue1983; Lubzens et al. 2001). The methods developed for providing an adequate supply for rotifers to a variety of small mouthed fish larvae rely on extensive studies into their biology, feeding, reproductive strategies, genetics, physiology and biochemistry. Most rotifers are free-crawling or swimming and colonial forms are also known

(Ruttner-Kolisko 1974; Pontin 1978; Wallace & Snell 1991; Nogrady et al. 1993). About 20000 species populate in freshwater and several species are known from the brackish water and marine water.

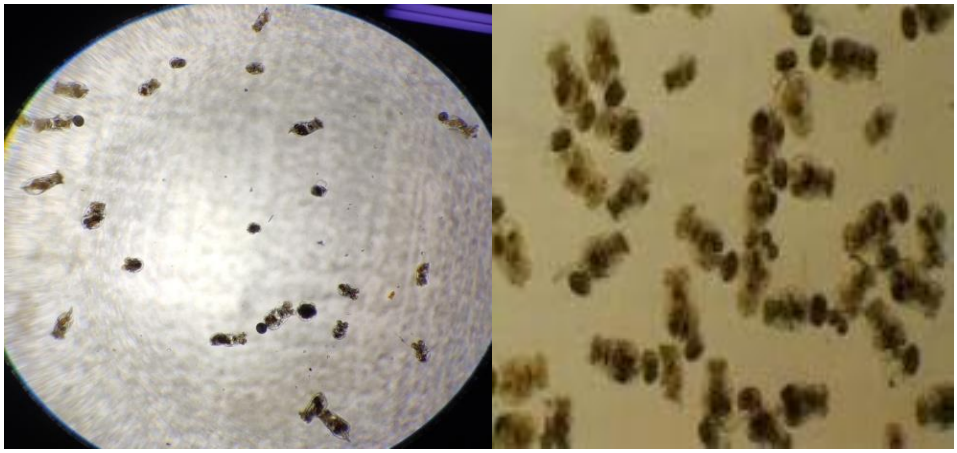


Figure 4 *Brachionus plicatilis* (Rotifer)

Isolation

The brachionidae family comprises a large number of species but most of them are in fresh water, only few species are in marine form. Two of these (*Brachionus plicatilis and B. rotundiformis*) are being used extensively in mass cultures and serve as early developmental stages of marine fish larvae. Rotifers grow naturally in brackish water ponds and can be easily isolated under a binocular microscope with a fine pipette. As the rotifer is parthanogenitic, it is easy to isolate a few egg-bearing female in a petri dish containing filtered brackish water and by feeding them with a suitable algal food to build up a stock culture within a few days.

Stock culture

Selected species of rotifers such as *Brachionus plicatilis* and *B. rotundiformis* are isolate and take 10 to 20 numbers of egg-bearing rotifers are put into 5 numbers of 250 ml flask contain 200 ml of filtered brackish water/sea water (15 to 25 ppt.) and add phytoplankton such as *Nanochloropsis* sp. and *chlorella* sp. are given as feed . Daily monitoring of the culture, water exchange and routine filtering of the water are necessary to prevent contamination and also to maintain the water quality.

Mass culture

Three methods are used today for obtaining large number of rotifers: batch culture, semi-continuous culture and continuous culture.

Batch culture

Rotifers are introduced at low density into 'green water' produced in fertilized tanks or ponds. Rotifers are harvested after all the algae have been consumed and used as food for fish larvae. A small number is used to inoculate newly prepared 'green water' ponds or tanks. A recent adaptation (Lubzens et al. 1997) for batch culture relies on a series of tanks. The culture system depends on short production cycles (1 week) with a cleaning interval of tanks and aeration tubing. The culture started in each tank (500L to 1 tone tank) filled with sea water salinity of 25ppt, in a one fifth of its volume sterilize with hypochlorite solution. Introduce rotifers with a density of 200-300per ml. rotifers are mainly fed with Baker's yeast, daily ration is divided into 3 to 5 meals. Daily increase the volume of the water, to increase the rate of rotifers in the tank. At the end of the culture period density may reach to 300-500numbers per ml. The final volume of the tank reaches after 4-5 culture days. The rotifers are then sieved and concentrated, and the culture tank and its accessories are sterilised in hypochlorite solution (10ppm of commercial grade bleach) for 24h, followed by through rinsing with sea water before reuse. The concentrated rotifers are immersed in a brief period in fresh water, for remove the contaminants. Most of the concentrated rotifers are enriched with essential fatty acids and proteins before being to feed the fish and a small fraction is used for new culture.

Semi continuous

This is a periodic harvesting of rotifers by removal of part of the culture medium and replacing it with new sea water (Hirata 1980). This method has been termed the 'thinning method' (Fukusho 1989b). The volume removed depends on the reproductive rate of

the rotifer and harvesting removes only the number of rotifers gained by reproduction from the previous harvesting period. 6-7% of biomass can be removed daily in rotifer culture maintained in Baker's yeast (Hirano 1987). Culture continues for several days.

Continuous culture

This is based on the chemostat or turbidostat models of micro-organisms and is fully controlled and highly dependable (temperature, pH, oxygen supply and density of cultured organism) (Walz 1993; Walz et al 1997). They offer easy manipulation of rotifer physiological and nutritional quality. Log-phase produced rotifers can be harvested and their nutritional quality is maintained by providing adequate food organisms (James et al. 1983; James and Abu-Razeq 1989a,b,1990).

Artemia Nauplii Production

All Brine shrimp eggs are need to be stored in a tightly sealed container , free from moisture and in a cool environment at or below 28^0C (Refrigeration is need for short term storage, for a long term storage eggs are best kept at below freezing).

Figure 5 The cyst pack, cyst and the nauplias of Artemia (Brime shrimp)

Hatching environment

For hatching the cyst was done in a conical container. The salinity of the water is 30 ppt and the pH is 8. The optimum temperature may be 26 to 28^oC, maintaining a light source during the entire

incubation period is recommended to obtain optimum hatch result and for temperature control. Constant aeration is necessary to keep cyst in suspension and to provide sufficient oxygen levels for the cysts to hatch. Strong aeration should not damage or hurt the brine shrimp cyst or nauplii. The stocking density of the cyst is 1gram per liter. Cone or 'V' bottomed containers are best to ensure that cyst remain in suspension during hatching. Be sure to thoroughly wash the hatching cone with a light chlorine solution, rinse and allow to air dry between uses. Avoid soap, soap will leave a slight residue which will foam from aeration during hatching and leave cysts stranded above the water level. Generally the optimum incubation time is 24 hours. Egg which has been properly stored for more than 2-3 months may require additional incubation time up to 30-36 hours. Oftentimes eggs will hatch in as few as 18 hours. If smaller size nauplius (instar1) is desired, a harvest time of 18 hours is recommended.

Set up of hatching procedure

Place hatching cone or similarly shaped vessel in well-lit area. Cone should be semi-translucent for ease for ease of harvesting and light transmission. Fill cone with water and adjust salinity to 25 ppt. and the optimum temperature is 28^0 C. add the cysts at the rate of 1 gram per liter. Provide adequate aeration to keep cysts in suspension. Depending upon water temperature, cysts should hatch in approximately 18-36 hours. After hatching Brine shrimp, turn off or remove aeration and wait several minutes for the shells and the baby brine shrimp to separate. Newly hatched nauplii will settle to the bottom of the cone or move towards a light source; the shells will float to the surface. Once separated, the nauplii can be siphoned from the bottom with a length of air tubing or gently drained through the bottom of the cone through a valve. The warm incubation temperatures and metabolites from the hatching medium create ideal conditions for a bacteria bloom. Rinsing of the nauplii in a fine mesh net or sieve using clean fresh or salt water is important before feeding them to your fish. Tanks and brine

shrimp hatching equipment should be cleaned and disinfected routinely.

Culture of Moina

The fresh water cladoceran moina is frequently found in ponds. It is readily eaten by bigger fish fry. Moina reproduced by parthenogenesis under favorable condition and forms resting eggs through sexual reproduction under unfavorable conditions. The embryos develop inside the dorsal brood pouch and the young ones hatch out fully formed. It is a filter feeder living on a variety of unicellular fresh water algae. Chlorella species are appears to be the best feed.

Figure 6 Moina

Stock culture

Moina can be collected from ponds and a stock build up starting from a single parthanogenitic female. From a single female kept in a 2 liter beaker containing Chlorella water, it has been possible to obtain about 5000-10000 Moina within 10-15 days. Stock culture maintained in 1-2 liter flask. Good tap water or well water can be used for growing Moina. Salinities above 5ppt are not tolerated by them.

Mass culture

Mass culture done in 100 liter to 1 tone tanks in outdoor. The tanks are cleaned and fill it with fresh water then sterilized with hypochlorite solution. After sterilization inoculated with culture chlorella, fertilized with urea (8g/l), Zinc Superphosphate (4g/l) and Ammonium sulphate (4g/l) give good aeration should be provided. On the second day after the water becomes slightly greenish, inoculate the pure culture of Moina 20-50 per ml were added. The Moina multiplies rapidly and attains a concentration of 10 to 20 thousand individuals per liter in 6-7 days. At this stage 1/3-1/2 the volume can be harvested and replaced by freshwater along with the proportional amount of the above fertilizers or by chlorella water cultured in a separate tank using the same fertilizers. If the latter method is followed 1/3 of the culture volume can be harvested every day.

Appearance of males in the culture is increased in number this will leads to the decline of the population by formation of resting eggs. When this happens it is better to remove all the water leaving only the sediments at the bottom and filling up the tanks with chlorella water again. Moina culture revives in a few days.

Harvesting is done with plankton net in the exponential growth phase when the females are reproducing actively by parthenogenesis. The parthanogenitic females containing8-12 embryos in the brood pouch are rich I organic matter and are evidently more nutritive than females with resting eggs or the males. Harvested Moina are washed in water and give it as a feed for fish larvae.

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7

Water Quality Management in Aquaculture

Prema D, Jenni B, Reena V Joseph,
Vysakhan P, Prajitha K and Kripa V
Fishery Environment Division, CMFRI

In aquaculture, water quality is one of the prime factors that determines the success of that particular culture. Primarily the water quality parameters are divided into three major categories, physical, chemical and biological. But a slight change in some of the parameters especially pH, temperature, DO will lead to stress in the organism and it may be of physiological or behavioral. Deteriorated or changed water quality will affect growth, reproductive capacity. Susceptibility to diseases is also more in such environment. Water quality management measures aim at improving water quality. Aquaculture entrepreneurs should know the basics of water quality management measures in aquaculture to reduce the problems related with water quality so as to utilize the of water body with viable profit as well as environmental sustainability.

Water Sampling

It is necessary to make sure that there is no contamination during sampling and all the samples are properly sub-sampled and preserved to avoid/minimize changes in the water quality during storage.

How to collect samples?

- Niskin bottle sampler is used for collecting water samples from specific depths (Fig. 1). Niskin samplers can be used for sampling surface water also. Samples of surface water can also be collected by merely dipping with open dip

samplers. When Niskin bottles are not available, a weighted bottle sampler can be used to collect water at specific depths (Fig. 2). Surface and bottom water samples are to be collected separately for the near shore and offshore.

Fig. 1 NISKIN BOTTLE SAMPLER

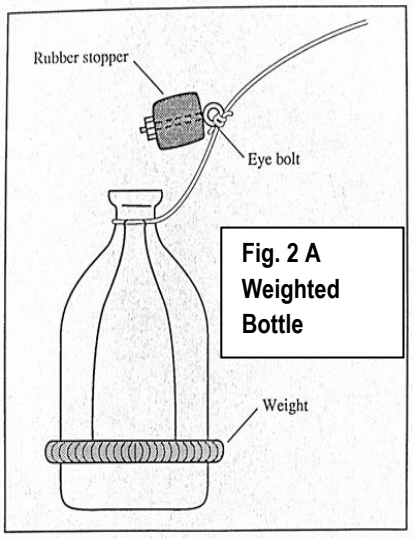


Fig. 2 A Weighted Bottle

- Prior to sampling, the sampler and sampling bottles should be acid washed with 1N HCl in the laboratory.
- Sample bottles should be rinsed twice with clean water
- The desired samples should be collected from the place away from where the sampler and sample bottles were washed.
- Care should also be taken to avoid the sewage flush out from the boats/ships at the time of sampling.
- Proper sampling is of utmost importance
- Take adequate number of samples to have representative sampling of the water body
- Sampling should be contamination free to avoid erroneous results on analysis
- Samples should be appropriately sub-sampled for the different types of analyses needed , such as

- for dissolved gases, alkalinity and pH
- for nutrients and physical parameters
- for trace metals
- for biological - Chlorophylls and plankton
- for bacteria etc.

- Preservation methods (Table 1) are to be adopted to avoid/minimize changes in the water composition during storage. The processing protocol should be meticulously followed for individual samples. For dissolved oxygen, the samples need to be fixed by employing Winkler's reagent on board vessel itself. Collection of samples for measurement of DO, other gases like CO_2, pH and alkalinity must avoid atmospheric contamination during sampling and subsampling

Table 1. Requirements for handling water samples for water quality assessment

Parameter	Preservation	Storage	Sample Holding (duration)	Sample volume	Type of container
Alkalinity		4^oC	14 days	100 ml	Plastic / Glass
Ammonia	H_2SO_4 to pH <2	4^oC	28 days	100 ml	Plastic / Glass
Chloride	None		28 days	50 ml	Plastic / Glass
Chlorophyll a		4^oC	12 hrs	500 ml	Plastic / Glass
Colour		4^oC	48 hrs	50 ml	Plastic / Glass
Conductivity		4^oC	28 days	100ml	Plastic / Glass
Dissolved Oxygen	Fix immediately with Winkler A and B reagents	Away from sunlight	8 hrs	125ml	Glass

Nitrate		4°C	48 hrs	100 ml	Plastic / Glass
Nitrate-Nitrite	H_2SO_4 to pH<2	4°C	28 days	100 ml	Plastic / Glass
Odor		4°C	24 hrs	200ml	Glass
Orthophosphate	Filter immediately	4°C	48hrs	50ml	Plastic / Glass
Particulate organic matter		4°C	24hrs	200ml	Glass
pH	None		In situ	25ml	Plastic / Glass
Silicate		4°C	28 days	50ml	
Total Dissolved Solids (TDS)	None		7 days	100ml	Plastic / Glass
Temperature	None		*In situ*		Plastic / Glass

Source: APHA (1995)

Water Quality

Water Temperature

- Water temperature is a physical property of water which expresses how hot or cold the water is. Air and water temperature is directly depends upon the solar radiation.

  Temperature can alter the physical and chemical properties of water (Fig. 3).

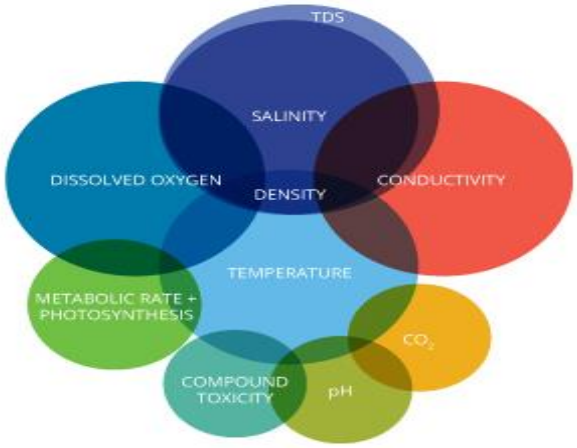


Fig. 3 Water quality paramters being influenced by water temperature

- In water, light energy is absorbed exponentially with depth and so most heat is absorbed within upper layers of water, by dissolved organic matter and particulate matter. Water temperature influences density of water.
- Water temperature affects the metabolism, growth and reproduction in aquatic animals. Many animals use temperature as a signal for when to reproduce and when to migrate. Generally, animals and plants grow faster at warmer temperatures, although all organisms have an upper temperature limit.
- Congenial species are to be selected for aquaculture as per temperature preference for maximum growth rate.
- Temperature measurement of water samples collected should be done immediately using mercury / digital thermometer, by immersing the calibrated thermometer into the water
- The atmospheric temperature is also measured in a well-ventilated area and in the shade, at 1.2 to 1.5 m above the ground, using a 50^{o}C calibrated (liquid in glass) thermometer.

Turbidity

- Turbidity refers to the decreased ability of water to transmit light caused by suspended particulate matter ranging in size from colloidal to coarse dispersions.
- Light penetration in to the water is measured by using a Secchi disc.
- The Secchi disk (Fig. 4) is a weighted disk, 20 cm in diameter and painted in alternate black and white quadrants, which easily measures turbidity in pond water. The average of depth at which the disk disappears and reappears is the Secchi disk visibility. Optimum Secchi disk visibility for shrimp ponds is 40 - 60 cm. It must be noted that the Secchi disk visibility isaffected by both types of turbidity ie (1) that resulting from phytoplankton blooms and (2)that caused by suspended soil particles. The individual taking Secchi disk reading must decide

if the turbidity is from phytoplankton or suspended soil particles or both. The following guidelines may be used in evaluating Secchi disk visibilities for ponds (Table 2).

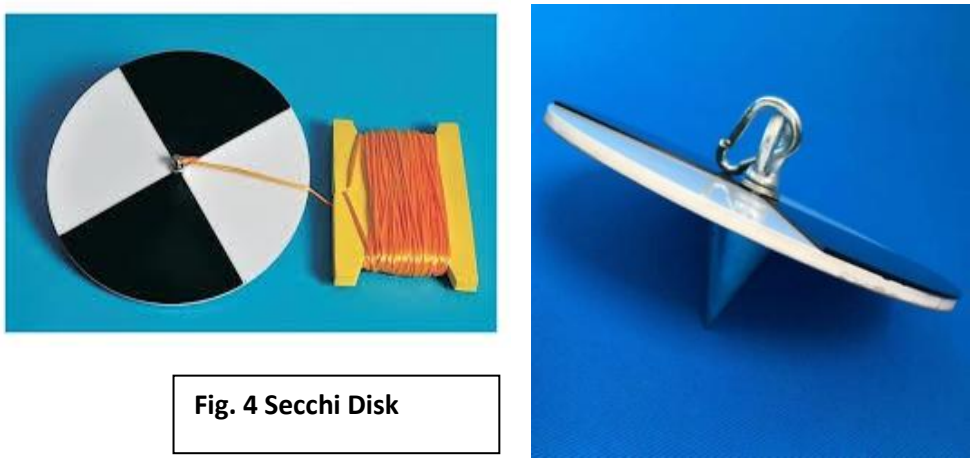


Fig. 4 Secchi Disk

Table 2. Guidelines to evaluate Secchi disk visibilities for pond aquaculture

Secchi disk reading	Remarks
< 20 cm	Pond too turbid. If pond is turbid with phytoplankton, there will be problems with low dissolved oxygen concentrations. When, turbidity is from suspended soil particles productivity will be low.
20 - 30 cm	Turbidity becoming excessive
30-45 cm	If turbidity is from phytoplankton, pond in good condition
45 - 60 cm	Phytoplankton becoming scarce
>60 cm	Water is too clear. Inadequate productivity and danger of aquatic weed problems.

Salinity

- Salinity is the concentration of total concentration of all ions in a given volume of water. Salinity is an important characteristic of natural waters.
- Salinity determines what species of aquatic animals to be present in that water body.
- Salinity is expressed in parts per thousand by weight (ppt, or ‰) or in practical salinity units (PSU). For example, 1 gram of salt in1000 grams of water means its salinity is 1 g/kg, or 1 ppt. Salinity ranges from 0 ppt in fresh water to 35 ppt in the open ocean. For culture ponds of fresh water species the salinity should be in the range of 0.01 to 1 ppt and for brackish water species it is 20-35 ppt for optimum production.

Measurement of salinity

1.*Using Refractometer* (for *in situ* measurement)

- Open the daylight plate (Fig. 5) and apply one or two drops of the water sample to the surface of the prism, using a glass rod. Hold the prism at an angle close to parallel with the floor so that the sample will not run off.

Fig. 5 Refractometer

- Softly close the daylight plate. The sample should make a thin film over the entire surface of the prism. No bubbles should be there.
- Look through the eyepiece. Focus the scale until it is sharp to your eyes by gently turning the eyepiece either clockwise or counter clockwise.

- The upper field of view appears blue and the lower field will be white. The reading is taken at the line where the blue and white fields meet.
- For salinity, read the scale on the right side. It is marked as a "o/oo". This is read "parts per thousand".
- After taking a salinity reading, gently wipe the prism with a tissue paper and water.
- The refractometer needs to be calibrated periodically. To calibrate it, take a reading using distilled water. With distilled water on the prism, turn the calibration screw with the included screwdriver while looking through the eyepiece until the boundary line falls on "0".

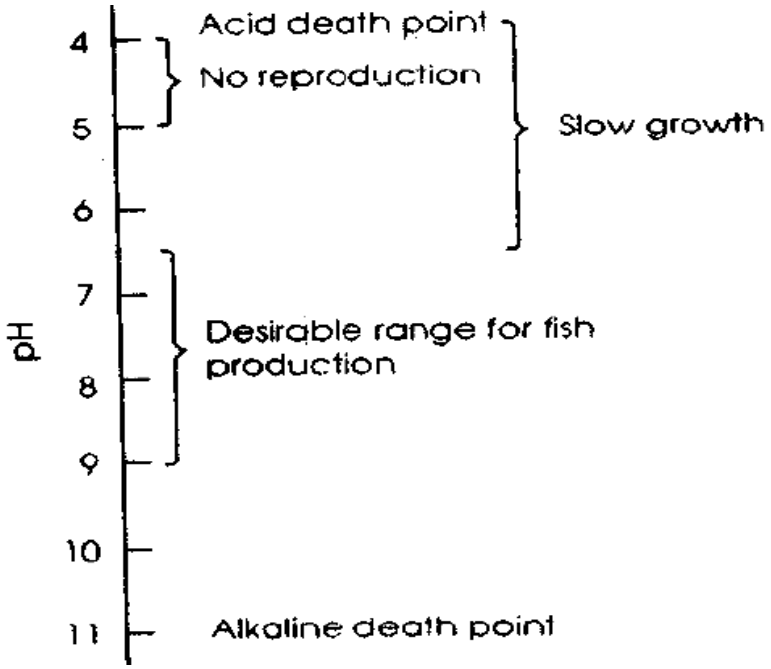
2.*Titrimetric method*(for lab analysis)

In this method the dissolved halogen ions present in water (chloride, bromide and iodide) are titrated with silver nitrate using potassium chromate as indicator. The halogen ions (other than fluoride) freely react with silver to precipitate silver halides. In this method silver will react with chromate only after all the halide ions, except fluoride, are precipitated and immediatelyas a slight excess of silver ion is present, red silver chromate is formed. A faint red colour of the solution point towards the end point of the titration.

Water pH

- Water pH is the measure of hydrogen ion activity or a measure of acidity and alkalinity ranging from 0-14. The natural water pH ranges 5-10.
- The optimum water pH range in the aquaculture is 6.5-9.
- A pH of 7 is considered neutral. The lower the pH than 7, the more acidic the water is. The higher the pH than 7, the more basic or alkaline it is.
- The pH in ponds will rise during the day as phytoplankton and other aquatic plants remove CO_2 from the water during photosynthesis. The pH decreases at night because of respiration and production of CO_2 by all organisms.

- If high or low pH extends for a long time, it can cause stress, less survivals, poor growth, susceptibility to diseases and can to low production.
- Signs of less than optimal pH include increase mucus on the gill surfaces, black gill disease, damage to the eye lens, abnormal swimming behavior, loose shell, soft shell, irregularity in molt, poor phytoplankton and zooplankton growth.
- Higher pH can increase the toxicity of ammonia, especially so when the water temperature is high.
- The acid and alkaline death points for pond fish are approximately pH 4 and pH 11 respectively.



The pH will vary in pond environment depending on a number of factors as follows

- Acid sulfate soil, acidic source of water
- Rate of rainfalls in pond areas
- Poorly buffered water
- Stocking density of resources
- Feeding and rate of sludge formation in pond bottom.
- Presence of micro/ macro organisms.
- Existence of phytoplankton in pond water.
- Rate of carbon dioxide production in pond water

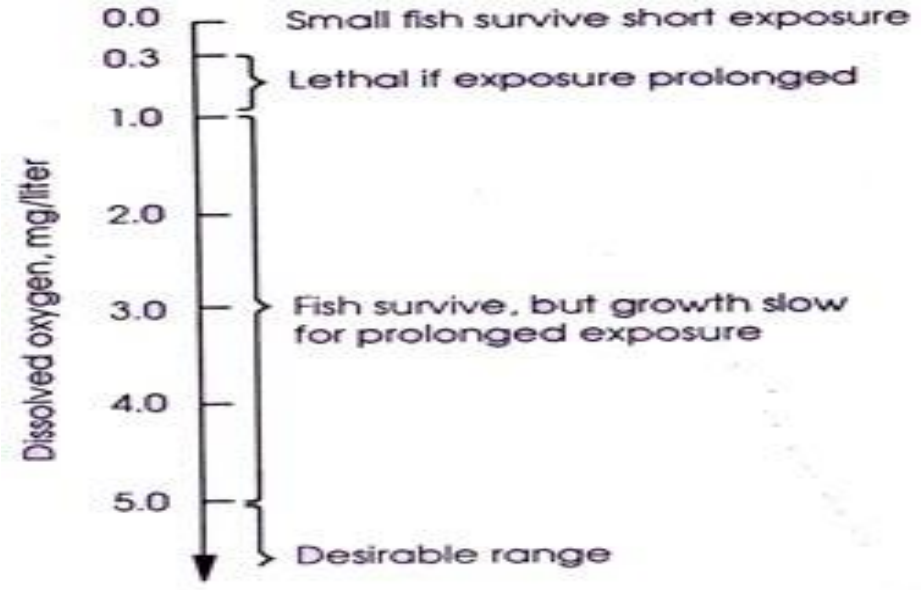
How to measure pH

- pH of water is measured with a pH meter. When the electrodes are dipped in two solutions of different pH levels and connected, a potential difference is set up between the two electrodes, which is measured by the potentiometer. This is directly related to the pH of the solution.
- In the laboratory, a bench top pH meter is used to measure pH. For field measurement of water pH, portable pH meters can be used (Fig. 6).

Fig.6 A. Bench top pH meter B. Portable pH meter

Dissolved Oxygen (DO)

- It is an important parameter in assessing water quality because of its prime impact on the living organisms living in the water.
- The dissolved oxygen level that is too low or too high can harm aquatic life and affect water quality.Free oxygen (O_2), is oxygen that is not bonded to any other element. Dissolved oxygen is this free gaseous oxygen(O_2) dissolved in the waterand remain within water.
- In a water body, the source of DO is mainly the atmospheric diffusion and photosynthetic activity. When photosynthesis exceeds respiration DO is more.
- The solubilityof oxygen decreases with increased temperature and salinity. As depth increases DO will decrease.
- In shrimp farming, dissolved oxygen levels at the bottom is important, since shrimp spend a lot of time at the pond bottom.
- The desirable concentration of dissolved oxygen in water for fish is >5 mg per litre



- As mentioned before, for dissolved oxygen analysis, the samples need to be fixed by adding Winkler's reagent on board vessel /site itself. Surface and bottom water samples are to be collected separately for the near shore and offshore. The processing protocol should be meticulously followed for individual samples.
- The commonly used method of estimation of dissolved oxygen is by Winkler titration method. In this methodology, the oxidation of manganous dioxide (bivalent manganese) by the oxygen dissolved in the sample results in the formation of a tetravalent compound. When the water containing the tetravalent compound is acidified free iodine is liberated from the oxidation of potassium iodide. The free iodine is chemically equivalent to the amount of dissolved oxygen present in the sample and is determined by titration with a standard solution of sodium thiosulphate.

Carbondioxide

- The level of CO2 in the water varies with the respiratory and photosynthetic activity of animals and plants in the water body, the level of decomposition of organic material in that water (a significant supplier of CO2 in nutrient-rich waters), and the respiration of the fish themselves. Concentration of CO2 can rise to considerably high levels in systems with large numbers of fish and comparativelyslow water turnover.

How to measure CO_2

- Free CO_2 in natural water is determined by titration with sodium carbonate Na_2CO_3 to form $NaHCO_3$. Development of pink colour using phenolphthalein indicator in the natural water shows the absence of CO_2 in the sample.

- The water sample is collected without allowance for bubbles.in a DO bottle and is tightly closed. In the laboratory, an amount of 50 ml of this sample water is transferred to a conical flask, carefully, without bubbling and 2-3 drops of phenolphthalein is added. If the water turns to pink then there is no free CO_2 in water sample. If the sample remains colourless, it is titrated with standard Na_2CO_3 solution. The end point is the permanent appearance of the pink colour.
- Favorable range of CO2 in water is<5mg per litre.

Total Alkalinity and Hardness

- Total alkalinity represents the quantity of basic anions present in water -- bicarbonates, carbonates, phosphates, hydroxides, etc. Alkalinity measures the total amount of base present in water and indicates the ability of a water body to resist large changes in pH. In other words alkalinity shows the buffering capacity of the water body.
- Alkalinity is expressed as mg per litre CaCO3.
- The total alkalinity concentration should not be lower than 20 mg per litre CaCO3 in production ponds.
- The desired total alkalinity level for most aquaculture species lies between 50-150 mg per litre CaCO3
- It can be estimated by titrating the water sample with strong H2SO4, first to pH 8.3 using phenolphthalein as indicator and then further to pH between 4.2 and 5.4 with methyl orange.
- Hardness is another significant water quality aspect for aquaculture management. Hardness represents the overall concentration of divalent salts (calcium, magnesium etc.).
- Calcium and magnesium are the most common sources of water hardness.
- Calcium and magnesium are essential in the biology (bone and scale formation in fish) of aquatic life.

- Calcium is the critical component of total hardness is the calcium concentration, as environmental calcium is crucial for maintaining exact levels of internal salts for normal heart, muscle and nerve function.
- An appropriate range of hardness is between 75 and 200 mg per litre $CaCO_3$.
- Alkalinity and hardness are reasonably stable but can change over time, usually during weeks to months, depending upon the pH or mineral content of bottom soils.

Decomposition of Organic matter

- In aquaculture, different kinds of organic and inorganic compounds (e.g. formulated food, manures, and fertilizers) are added to the water body to increase fish production. But, a large part of these inputs are not utilized by the fish and are decomposed / disintegrated in the water. The microbiological decomposition of the organic matter is a critical factor for water quality control and nutrient recycle.
- Aerobic decomposition of organic matter is an important drain of oxygen supplies in water. Many factors affect this decomposition. Aerobic decomposition of organic matter takes place with the help of aerobic microorganisms.
- The temperature optima of microorganisms differ among microbial species, but the rate of decomposition generally increase over the range of 5 to 35°C. A temperature increase of10°C often doubles the rate of decomposition and oxygen consumption.
- The pH preferences of different microorganisms also differ. Bacteria grow best in neutral to slightly alkaline habitats while fungi prefer acid environments.
- Generally organic matter is degraded faster in neutral to alkaline systems than in acid systems.
- Aerobic decomposition requires a continuous supply of oxygen and proceeds more rapidly when dissolved oxygen concentrations are near saturation.

- Anaerobic decomposition of organic matter takes place with the help of anaerobic microorganisms.
- The rate of degradation of organic matter is not as rapid under anaerobic conditions as under aerobic conditions.
- The end products of anaerobic decomposition are alcohols, organic acids etc. whereas CO_2 is the end product of aerobic decomposition.
- The decomposition of organic matter varies with the type of carbonaceous material to be decomposed. Some organic compounds are more resistant to decay than others. For example sugar is decomposed faster than cellulose and cellulose faster than lignin.
- The C/N ratio of organic matter has been widely used as an index of the rate at which organic matter will decompose. Organic matter with a wider C/N ratio will decompose much slower than organic matter with a narrow C/N ratio.

Oxidation Reduction Potential

- Oxidation reduction potential (ORP) is a measure of the proportion of oxidized to reduced substances in water. It is also known as Eh.
- It is measured with respect to Hydrogen electrode, using an ORP meter (Fig 7).

Fig. 7 A Portable ORP meter

- Eh range of natural waters 0.45 – 0.52 V
- Appearance of Fe^{++} ion at 0.2 V coincides with depletion of oxygen

Total Ammonia Nitrogen

- In aquatic system the ionized ammonia (ammonium ie., NH_4^+) is less toxic but unionized ammonia (NH_3) is highly toxic to aquatic life. Together, ammonium and ammonia is known as total ammonia nitrogen (TAN).
- Toxicity of TAN increases with increased pH and temperature. The sources of TAN are organic mineralization, fish feed and direct excretion from fishes. The oxidation of ammonia by nitrifying bacteria will provide the bioavailable forms NO_2 and NO_3 to the aquatic life.
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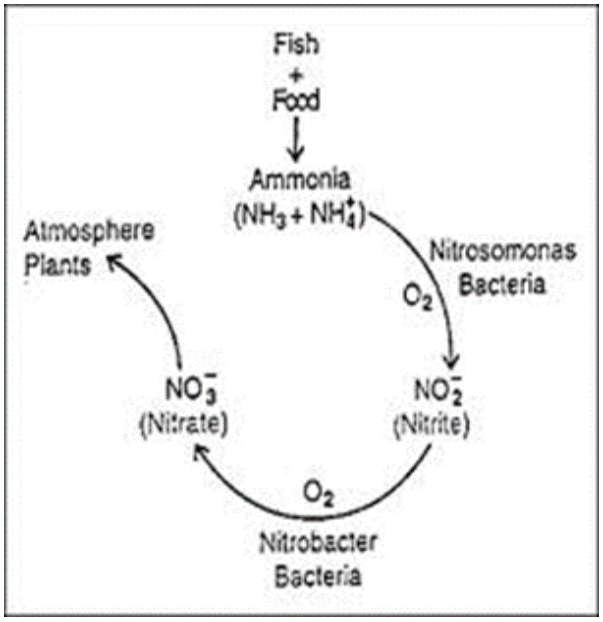

- Increased TAN will affect fish health and the major symptoms include increased oxygen consumption, damage of gills, histological changes, susceptibility to disease, reduced growth and the toxicity may lead to death.

- Aquatic autotrophs rapidly utilize ammonium ions, thus naturally preventing it from increasing to toxic levels. The total ammoniacal N content of water is an index of the degree of pollution. Its concentration in unpolluted water should never be more than 0.1 mg per litre.
- The TAN in water is measured making use of a spectrophotometer, using phenol hypochlorite method.
- In this method phenol and hypochlorite react in an alkaline solution to form phenyl quinone-monoimine, which in turn, react with ammonia to form indophenol.
- Indophenol gives the solution a blue colour, the intensity of which is proportional to the concentration of ammonia present in the sample.
- Sodium nitroprusside is added to intensify the blue colour. Both ammonia and ammonium are measured, because in a strong alkaline solution all the ammonium is converted to ammonia. This procedure gives an estimate of total ammonia nitrogen.

Nitrite N

- Nitrite N originates as intermediary product of nitrification of ammoniacal N
- The concentration of nitrite N in water should not exceed 0.5 mg per litre.
- Nitrite N is toxic to fish and shrimp because it forms methemoglobin, affects immune and circulation systems, and reduces the transfer of oxygen to cells.
- High chloride concentration reduces nitrite toxicity and so nitrite toxicity is less in brackish water.
- To measure nitrite, the nitrite in water is allowed to react with sulphanilamide in an acid solution.
- The resulting diazo compound further reacts with NNED and forms a highly colored azo dye, the absorbance of which is measured spectrophotometrically.

Nitrate N

- It is the end product of nitritication of ammoniacal nitrogen by aerobic autotrophs. The favorable range of nitrate in culture waters is 0.1 mg/l to 4.5 mg/l. Its higher concentrations may lead to inability to swim and reduced movement.
- The estimation of nitrate N in water is based on a method of reduction of nitrate to nitrite and then estimating the nitrite through spectrophotometrically.
- Nitrate in water is reduced almost quantitatively to nitrite when the sample is passed through a column containing cadmium filings coated with metallic copper (Fig. 8).

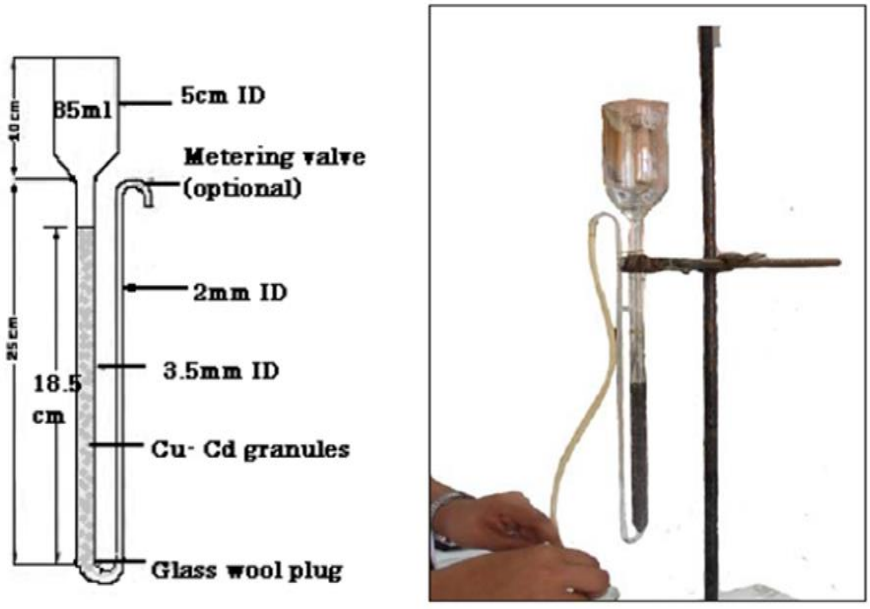

Fig. 8 Cadmium column apparatus

Dissolved inorganic phosphorus

- Phosphorous is a limiting nutrient needed for the growth of aquatic plants and algae alike. Excess concentrations of P can result in algal blooms.
- An algal bloom is a rapid increase in the population of algae in an aquatic system. It can occur in green, yellow- brown or red in colour (Fig. 9).

Fig. 9 Algal

- Algal bloom is caused by an imbalance of nutrients in an aquatic system (P and N mainly)
- For coastal waters the dissolved inorganic phosphorus (DIP) should not exceed 0.05 mg per litre and dissolved inorganic nitrogen (DIN) should not exceed 0.5 mg per litre.
- Harmful Algal Blooms(HAB) causes negative impacts to aquatic organisms via production of natural toxins, mechanical damage etc.
- Dissolved Orthophosphate can be determined by Ascorbic acid method. Ammonium molybdate and potassium antimony tartrate react in an acid medium with dilute solutions of orthophosphate to form phosphomolybdic acid that is reduced to the intensely coloured molybdenum blue by ascorbic acid.
- The intensity of the blue colour increases in proportion to the amount of phosphorous present and can be measured spectrophotometrically.

Hydrogen sulfide (H_2S)

- Hydrogen sulfideis a toxic, colorless gas with the distinctive foul smell of rotten eggs. It is formed in anaerobic situations (by transformation of sulfate to sulfide).
- Its toxicity increases with decreasing dissolved oxygen and decrease in pH.
- It is toxic above 0.1 µg per litre, that means detectable concentrations of hydrogen sulfide is undesirable for aquaculture.
- H_2S can be eliminated from ponds by the use of aeration or KMnO4 (potassium permanganate) to oxidizethe hydrogen sulfide into non-toxic sulfur compounds.
- The occurrence of hydrogen sulfide can be identified by its stinking odor of rotten eggs.
- For verification of presence of hydrogen sulfide, add 0.5 ml of saturated solution of potassium antimony tartrate and 0.5 ml of 6N hydrochloric acid to 200 ml of water sample and shake well. The yellow colour of antimony sulfide is a positive test for sulfide.

Water quality sampling frequencies for various aquaculture systems

Sampling for water quality assessment in different aquaculture systems can be done at frequent intervals as shown in Table 2.

Table 2 Water quality sampling frequencies for various aquaculture systems

Type of system	Sampling frequency			Remarks
	Twice daily	Daily	Weekly	
Brackish water				
Low density		DO, salinity. Temperature	NH_3, pH, Secchi disc	DO - early morning and next day late evening
High density	DO, pH, Temperature	Salinity, NH3, CO2, Secchi disc, Alkalinity	NO_2, Hardness, H_2S	DO - early morning and once in the late evening
Fresh water				
Low density		DO, Temperature	NH_3, pH, CO2	DO - early morning and next day late evening
High density	DO, pH, Temperature	CO_2, Secchi disc. Alkalinity	NO2, Hardness, H_2S	DO - early morning and once in the late evening
Hatchery				
Brackish water	DO, NH_3, pH, Temperature	NO_2, Salinity, Alkalinity, Hardness	H_2S	DO,pH - once in the morning and once in the evening
Fresh water	DO ,pH	NO_2, NH_3, Alkalinity, hardness	H_2S	

Water Quality Parameters - Problems and Corrective Methods

Frequently encountered water quality problems and their corrective measures are given in Table 3.

Table 3 Water Quality Parameters - Problems and Corrective Methods

Parameter	Problem	Cause	Effect	Optimal level	Corrective measure	Visible indication
Salinity	Fluctuations	Dilution & Evaporation	Stress	0.01-1 ppt for fresh water species and 20 - 35 ppt for euryhaline species	Water exchange	Hyper activity Mucous on body
Dissolved oxygen	Hypoxia	High organic matter load Plankton blooms Overstocking Overfeeding	Mortality Lethargy	4 -5 mg/1 for warm water fishes and 5-6 mg/1 for cold water fishes	Aeration Water exchange	Gasping at the surface Mucous accumulation on gills
CO_2	Buildup of CO_2 concentration in water	Over stocking Uptake of ground water rich in CO2 Plankton blooms	Prolonged exposure leads to mortality	<5 mgL^{-1}	Water exchange/ Aeration	Gasping at the surface. Mucous on gills

Ammonia	Buildup of NH_3 and NH_4^+concentration in water	Overstocking Decomposition of excess feed Use of ground water rich in ammonia Agricultural runoff rich in ammoniacal fertilizers	Mass mortality			
Nitrite	Nitrite poisoning	Overstocking Poor nitrification Decomposition of excess feed Algal blooms Faulty biofilters	Methemoglo-binemia	<0.5 mg/l	Aeration Water exchange	Hypoxia Lethargy
Nitrate	Nitrate poisoning	Poor nitrogen recycling Decomposition of organic matter Use of ground water rich in NO3	Toxic only on prolonged exposure	0.1 to 4.5 mg/l	Water exchange	Reduced movements
Hydrogen sulfide	Hydrogen sulphide toxicity	Decomposition of excess feed High organic load	Instant mortality	<0.1 µg/l	<0.1 µg/l	Gasping at the surface
pH	Acidosis and alkalosis	Acid sulphate soils Agricultural run off Excessive use of lime	Mass mortality	6.5 – 9.0	Use of lime or gypsum as the case may	

Water quality monitoring and management is essential for the smooth functioning of the aquaculture enterprises and a basic knowledge about all the above mentioned water quality parameters is a necessary pre requisite for its effective, sustainable and profitable implementation.

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In aquaculture, water quality monitoring and a basic knowledge about all the above mentioned parameters are necessary and pre requisite for an effective and profitable aquaculture.

8

Oyster Farming Techniques

Vidya R, Jenni B, Aloycious P.S., Venkatesan V, Sajikumar K.K, Jestin Joy K.M, Sheela P.P, and Mohamed K.S.
Molluscan Fisheries Division, CMFRI

Introduction

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

Scope for oyster farming in India

Central Marine Fisheries Research Institute undertook scientific investigations at Tuticorin from early 70's and as a result, complete package of the technology is now available in the country. Vast stretches of backwaters, estuaries and bays spread over several lakh ha.are present along Indian coast harbouring natural population of the oyster suggesting suitability of the habitat for oyster culture. Being filter feeders, the oyster converts primary production in the water into nutritious sea food.

Oyster resources of India

The average annual production of edible bivalves during 1996 to 2000 is estimated as 1.52 lakh tones, about 2.5 times more than the average landings during the period prior to 1996.clams and cockles form 73.8%, followed by oysters (12.5%), mussels (7.5%) and window pane oysters (6.2%). The various genera and species are identified based on the shape, size, colour and other characteristics of the shell, anatomical feature of promyal chamber, gill ostia, heart and gut and the breeding habits. Confusion still exists in the identification of oysters at species level. *C.madrasensis* is the main species in India. It is euryhaline tolerates wide variations in salinity and inhabits backwaters, creeks, bays and lagoons and occurs, from the intertidal region to 17 m depth.

General information on oysters in India		
Scientific name	Common name	Local names
Crassostreamadrasensis(preston),	Indian backwater oyster	Kadalmuringa(Malayalam); Ali, Kalungu(Telugu) Patti(Tamil),Muri(Kannada)
Saccoctreacucullata(Bom).	Rock oyster	
Crassostreagryphoides(Schlotheim),	West coast oyster	

Crassostrearivularis(Gould),	Chinese river oyster	
Saxostreacucullata(A wati and Rai)	Bombay oyster	
Hyostissahyotis(Linn aeus)	Giant oyster	Rare-east coast

Oyster resources of maritime states	
Species name	State
Crassostrea madrasensis	KER,KAR,GOA,MAH,GUJ,TN,PON,AP
Saccoctreacucullata	KER,KAR,GOA,MAH,GUJ,TN,PON,AP
Crassostrearivularis	KAR,GOA,MAH,GUJ,TN,PON,AP
Crassostreagryphoides	KAR,GOA,MAH,GUJ,PON,AP

Oysters and their Biology

The edible oyster is a sedimentary animal belonging to the class Bivalvia. Oysters have a soft body, which is protected by hard shells. The following are the main parts of the oyster.

Shell:

Lower valve which is larger, usually cupped and attached to the substratum

Upper valve smaller and usually flat

Umbo:

The apex region where the two valves are attached by aninternal ligament.

Adductor muscle:

About two thirds of the distance from the umbo is the adductor muscle which links the two valves. It works continuously against the spring action of the hinge.

Mantle:
Covers the soft body and plays an important role in secretion of shell, water movement and reproduction.
The shape of the oyster is extremely variable depending on the environment in which it is grown.

Reproduction
In the genus *Crassostrea* sexes are separate but occasionally hermaphrodites occur. The ovary and testis consists 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 Leydig tissue which mostly consists of 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, in influencing the maturation of gonads.

In *C.madrasensis*, young oysters primarily function as males (60-75%) and later change their sex. Proper understanding of sex ratio in relation to size is necessary to select the brood from the hatchery work. The egg of *C.madrasensis* measure 48-60 um in diameter. A single female measuring 80-90 mm spawns 10 to 15 million eggs at a time.

The information on spawning period is necessary for seed collection

Condition Index
The condition index of the oysters denotes the quality of the meat and it is useful to determine the best period for harvest. It is also helpful to assess the suitability of a locality for culture. High condition indicates greater proportion of meat in the whole weight

of the oyster; those in prime condition are tasty when compared to the flaccid and watery meats of oysters in poor condition.

The soft body of the oyster undergoes changes, which are usually related to the reproductive cycle. During the maturation process the gonad increases in weight resulting in increase in the weight of soft body. Before the commencement of spawning the condition index reaches high value and with the release of gametes, the soft body of the oyster looses weight. The condition factor is studied based on weight, volume of both. The percentage of wet flesh weight in total weight gives the condition index, also called percentage edibility. A commonly followed method is the ratio of the try meat weight (oven-dried at 90-100^{0}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.

Quality of oyster meat and shell.

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

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

Edible Oyster Farming in India

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

Culture Technology

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

Seed Collection

Oyster seed are collected from estuaries by placing suitable collectors called cultch in the water column at appropriate period. During spawning seasons the spat collectors are suspended from racks.

Preparation of 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 3mm dia nylon rope with

a spacing of 15 to 20 cm between each shell (5 shells per meter rope). Such strings are called ren. The spaced rens can be used as such for grow out system. For seed collection purposes the shells are strung continuously without spacers (10 to 15 shells per meter) and after the attachment of seed they shells can be removed and restrung at the rate of 5 shells per meter which is the ideal density for grow out.

When to place the cultch for seed collection?

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

Selection of farm site

For site selection several factors are to be considered

Sl. No.	Parameter	Range	Methodology for determination of the parameter
1	Salinity (ppt)	10 to 38	By titration or refractometer
2	Depth (m)	1.5 – 4	By sounding or manual
3	Temperature ^{0} C	23- 34	Using thermometer
4	Dissolved oxygen mg/l	3 – 5	Winkler method or by using probe

5	pH	6.5 – 8.5	pH meter or pH paper
6	Turbulence due to wave (m)	< 0.5 to 1	By observation and local enquiry
7	Water current m / second	1 – 5	Current meter or from literature
8	Clarity (m)	0.5 –1.5	By Sechii disc
9	Availability of seed	Within 100 m	By enquiry / observation
10	Local market	Average to good	By enquiry / observation
11	If free from various pollution like	Faecal	By enquiry / observation
		Industrial	
		Agriculture	
		Sewage	
		Retting	
		Oil	

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

Farming methods

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

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

On bottom culture

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

Rack and Ren Method

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

Rack and Tray Method

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

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 holds 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 oysters attain 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.

Farm management

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

Predaters and foulers are also a menace to oyster farmers. Crabs, fishes, starfishes, polychaetes and gastropods are the predators of oysters.

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

Harvest of oysters

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

Post-Harvest Processes

The technology adoption of oyster farming has been slow, mainly because of the difficulty in post-harvest handling of oysters and the limited markets. Even among oyster consumers, the preference is for cooked meat, rather than whole and live, making heat shucking a necessity. Heat shucking is tedious in the case of oysters as compared to mussels, as they open their valves only on strong steaming. Besides, oyster processors in- variably complain about cuts and bruises on their hands while shucking the oyster meat. So much so, many first-time oyster farmers in Ashtamudi, Kayamkulam and Vembanad Lakes of Kerala have switched to mussel farming. However, this trend is recently being reversed due to better market price and also the realization that oysters are more euryhaline than mussels, and hence more conducive for culture in an estuarine environment.

Depuration

Oysters, like other filter-feeding bivalves, accumulate pathogenic organisms in their body. By depuration the bacterial load is brought down to permissible levels, also faeces, sand particles and silt are removed from the alimentary canal of oysters.

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

Transport and storage

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

Shucking

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

Processing

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

Frozen oysters

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

Canned oysters

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

Smoked oysters

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

Oyster stew

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

Byproducts and utilization

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

Quality of Oyster Meat and Shell.

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

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

9

Components of a Fish Feed Mill

Sanal Ebeneezar, Linga Prabu D, Chandrasekar S, Sayooj P and Vijayagopal P
Marine Biotechnology Division, CMFRI

The design of a feed mill depends on the intended production capacity. For a small scale feed mill (20-50 kg feed production per day), a total area of around 3000 sq. ft will be sufficient, while medium and large feed mills require more area. The major components of a feed mill are (i) Building and (ii) Equipment/ Machinery

(i) Building

The building should preferably be of concrete provided with for pest and rodent proof facility, with proper accessibility to road and electricity. For small and medium scale feed mills, the ingredient receiving and storage area can also be integrated with in the main building. For large scale mills, the ingredient storage facility should be kept separately.

(ii) Equipment/ Machinery

The major essential equipment/ machinery required for a feed mill and their purpose are listed in the following table.

Sl No	Equipment	Purpose	Image
1	Pulverizer/ hammer mill	To grind the ingredients and to reduce particle size	
2	Weighing balance	To weigh the ingredients and feeds	
3	Homogenizer/ bowl mixer	Uniform mixing of ingredients in a feed mix	

4	Extruder and/or pelletizer	To produce feed pellets. Different dies (1, 1.5, 2, 3mm etc.) are used for producing pellets of desirable sizes. Extruder can produce floating pellets, while pelletizer produces sinking pellets	
5	Hot air oven	To dry the feeds and ingredients by blowing hot air	

6	Sieve assembly/ shaker	To sort the feed pellets of desirable particle sizes	
7	Packaging system- impulse sealer	For air tight packing of feed pouches	
8	Fat coater	To coat oil on feed pellets	
9	Spheronizer	For preparation of spherical feeds for larvae	

10	Steam Conditioner	For conditioning/ maturing of feed mix/ dough prior to extrusion. To adjust the moisture and temperature for cooking during extrusion	
11	Spray drier	To produce dry powder from liquid slurry by rapid drying, preferably in the case of thermally sensitive materials	

Table 1: Model estimate for establishment of a fish feed mill

Si No.	Particulars	Approximate price range (Rs.)
1	Pulverizer/ hammer mill	25000-35000
2	Weighing balance	10000- 20000
3	Ingredient homogenizer/ bowl mixer	30000-40000
4	Extruder	25 lakhs- 2 crores
5	Hot air oven	15000-30000
6	Mixer/ Grinder	3000 -6000
7	Sieve assembly/ shaker	1.5- 3 lakhs
8	Packaging system-impulse sealer	5000 - 10000
9	Fat coater	1.5- 3 lakhs
10	Spheronizer	1.5– 7 lakhs
11	Steam conditioner	1.5- 3 lakhs
13	Spray drier	1.5 – 20 lakhs
14	Main building/ warehouse	As per local costs
15	Other civil works (silos, lab, office, road etc.)	As per local costs

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Fish Feed Processing and Production Technology

Sayooj P and Sanal Ebeneezar
Marine Biotechnology Division, CMFRI

INTRODUCTION

In animal production system, nutrition is a key factor to produce an economically healthy, high quality product. Feed is one of the major inputs in aquaculture production and there is also an increasing demand for quality feeds. Adoption of appropriate processing technology is an important factor to determine the final quality of feed. In Feed formulation, ingredients are selected in correct amount to form a single uniform mixture or pellets at possible low cost that will provide all the nutritional requirements of the target fish. The basic steps involved in fish feed manufacturing are

1) Selection of ingredients
2) Grinding
3) Feed formulation
4) Mixing
5) Pelleting
6) Drying
7) Packing
8) Storage

1) **Selection of ingredients**: The first operation in the feed processing plant involves the selection of raw materials. The quality of feed ingredients both dry and liquid form has an important impact on the quality of final feed. It should be fresh and free from contaminants like sand, stones, and others earthen materials. The ingredients should be examined for quality check and also for nutrient analysis.

2) **Grinding**: Grinding or particle size reduction is a major step in feed manufacture. Prior to use, ingredients must be powdered, in order to get uniform particle size. The grinding of ingredients generally improves feed digestibility, acceptability, mixing properties, pelletability, and increases the bulk density of some ingredients. It is accomplished by many types of manual and mechanical operations involving impact, attrition, and cutting. The most commonly used grinding machines are hammer mill, pulverizers, flour mill etc. The powdered ingredients are then passed through a standard mesh sieve to obtain a uniform particle size. Sieving the ingredients helps in preparing feed pellets with uniform and attractive physical appearance.

3) **Feed formulation**: In this process appropriate dietary ingredients are selected on the basis of availability, chemical composition, nutritional value and, cost. The ingredients are selected in appropriate amount and blended to produce a compounded feed which is nutritionally balanced, palatable, pelletable, and easy for storage. The important points to be considered for feed formulation are:
   - nutritional requirements of the species to be cultivated
   - feeding habits of the species
   - expected feed consumption
   - type of feed processing required

4) **Mixing**: Feed mixing may include all possible combinations of solids and liquids. Sieved ingredients were weighed and mixed in desired proportion according to the formulation. Generally dried ingredients are mixed first followed by liquid materials.

Liquid materials such as fish oil may be added at the end and further homogenized. Water is also added for increasing the moisture level may also be added. For proper mixing of different feed ingredients into a homogenous mass, the mixing may be 20 to 30 minutes. Mixing can be done in batches or in continuous mixers. Batch mixing can be done on an open flat surface with shovels or in any containers. Continuous mixers are such that the material moves through the mixers as it is being mixed. The types of mixers used are horizontal ribbon mixers, vertical mixers, and turbine mixers.

5) **Pelleting**: It is the process of compacting of feeds by extruding individual ingredients or mixtures of ingredients. Pelleting converts the homogenous mixture into a quality feed, having physical characteristics that make them suitable for feeding. Pelletization is mainly done using two types of machines namely extruder pelleting and compressed pelleting.

(i)**Extruder pelleting technology**

Fish feed extrusion process refers to cook the mixture of feed ingredients under high temperature, pressure, and moisture by the means of an extruder within a short time. The basic components in an extruder are, a barrel fitted with a die plate and a screw shaft conveyor connected to a high speed motor. The most important operating parameters are the temperature, pressure, diameter of the die apertures and shear rate.

(ii) **Compressed Pelleting technology**

The pelletizer works on the principle that the finely ground feed mixture is pelleted by compression process. Compressed pelleting then involves exposing the mixture to steam for 5-20 seconds obtaining 85^{o} C and 16% moisture followed by forcing

the mix through holes in metal die by the action of a roller located inside the die. This process is also known as steam pelleting, due to the use of steam to precondition the mix prior to compression. The combination of heat, moisture, and pressure in which gelatinization of the starch occurs. As the pellets emerge to outside surface of the die, they are cut off by a stationary adjustable knife to the desired length. Pellet quality is influenced by the fat level, moisture, and humidity. The fat level of the mixture should be not less than 2-3% to lubricate the holes in the die and to reduce the dustiness and not higher than 8-10% to avoid excessive lubrication causing insufficient compression of the feed mixture. The moisture level is also critical as the excessive moisture results in soft pellets and insufficient moisture results in crumbly pellets.

6) **Drying**: Immediately after pelleting the feed should be dried to reduce the moisture content below 10%. This is essential for good shelf life of the feed. Different type of dryers are used for drying feed pellets, like horizontal conveyer type, vertical hopper type, hot air oven and fluid bed dryers. The ambient temperature used for drying feed is at 65-75^{o}C. Higher temperature is not desirable.

7) **Packing**: The dried feed is cooled before packing. Good quality packing covers are used to prevent damage to the feed quality on transportation and storage.

8) **Storage**: The feeds are composed of biological material and may degrade upon prolonged storage. Therefor feeds should be stored in clean, cool and dry warehouses/ storage areas away from direct sunlight. The deterioration may be due to

oxidative damages or microbial damages. Provisions should also be made to avoid infestations from insects/ pests/ rodents etc. Storage condition accelerates the process of feed deterioration. Temperature and humidity represents the major environmental factor that determines the storage. Depending on the relative humidity stored feed will reach an equilibrium with the atmospheric moisture content regardless of the original moisture content. High moisture content favours the microbial growth. High temperature cause oxidative damage to feed additives like vitamins thus lowering the nutritional quality of feed and also accelerate deterioration process caused by microbes. Apart from these factors light and oxygen also effect feed decay. The feed should be stored for minimum time.

11

Mussel Culture

Alloycious P.S, Jenni B, Venkatesan V, Vidya R, Sajikumar K.K, Jestin Joy K.M, Sheela P.P, and Mohamed K.S.
Molluscan Fishery Division, CMFRI

Introduction

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

Scope for mussel farming

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

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

Background information

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

The Calicut Research Centre of CMFRI, Calicut took steps to expand mussel culture practices in the north Kerala region in small scale with the involvement of fishermen. The Research Centre successfully demonstrated mussel culture in the Dharmadam estuary during 1995-96. This created some awareness among the local fishermen. During 1996-97, mussel culture was done on a large scale at Padanna with the involvement of a group of twenty five fisherwomen. Financial support was extended by the DWCRA. These programme proved that mussel culture can be profitably undertaken utilizing the available water spread area in the estuaries of North Kerala. In Central Kerala it was demonstrated in the Chettuva estuary in Trichur district during 1997 and now it is extended up to Munambam estuary and nearby areas of Sathar Island.

Open sea culture of mussels was initiated by the CMFRI off Vizhinjam and off Calicut during the 1970's. Recently, a pilot scale demonstration of long – line culture was alsop carried out boffAndhakaranazhi near Alleppey. During 1998-99, a group of

fishermen from Vypinisland took the initiative to launch raft culture of mussels in the sea off narakkal with technical collaboration from CMFRI. Currently farmed mussel production from Kerala stateis estimated to be nearly 20,000t

Taxonomy

Phylum	-	Mollusca
Class	-	Bivalvia
Sub class	-	Pteriomorpha
Order	-	Mytiloida
Sub order	-	Mytilacea
Family	-	Mytilidae
Genus	-	Perna
Species	-	viridis

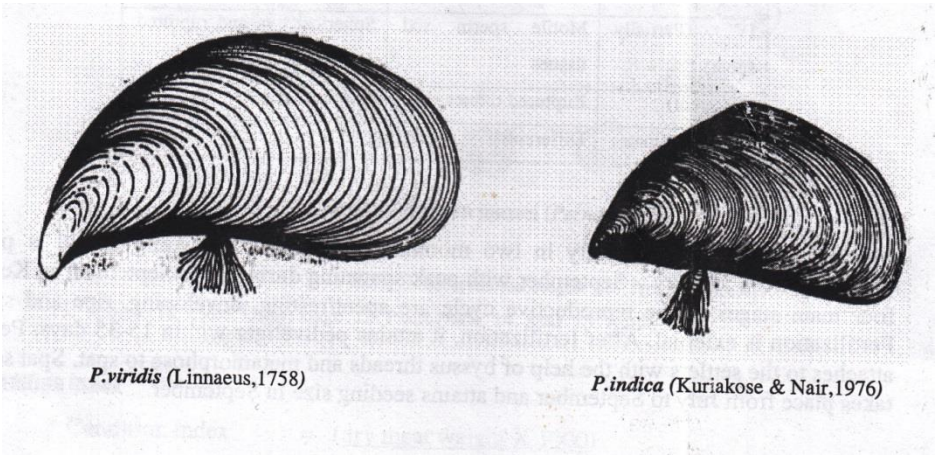
Common names

English : Green mussel/Brown mussel
Malayalam : Kallumaekai/Kadukka/Chippi
Tamil : PachaiAali/Kallikai

Morphology

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

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



Food and Feeding

Mussels are ciliary- mucoidfilter 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 36.5-40g weight and 65mm with 25-40g in 5 months respectively. The farmed mussels give a better meat yield compared to mussels from the natural bed. The average edible portion of the meat yied is 27.2%- 33.3% of the total weight. Growth by length and weight are probably the most importanr 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

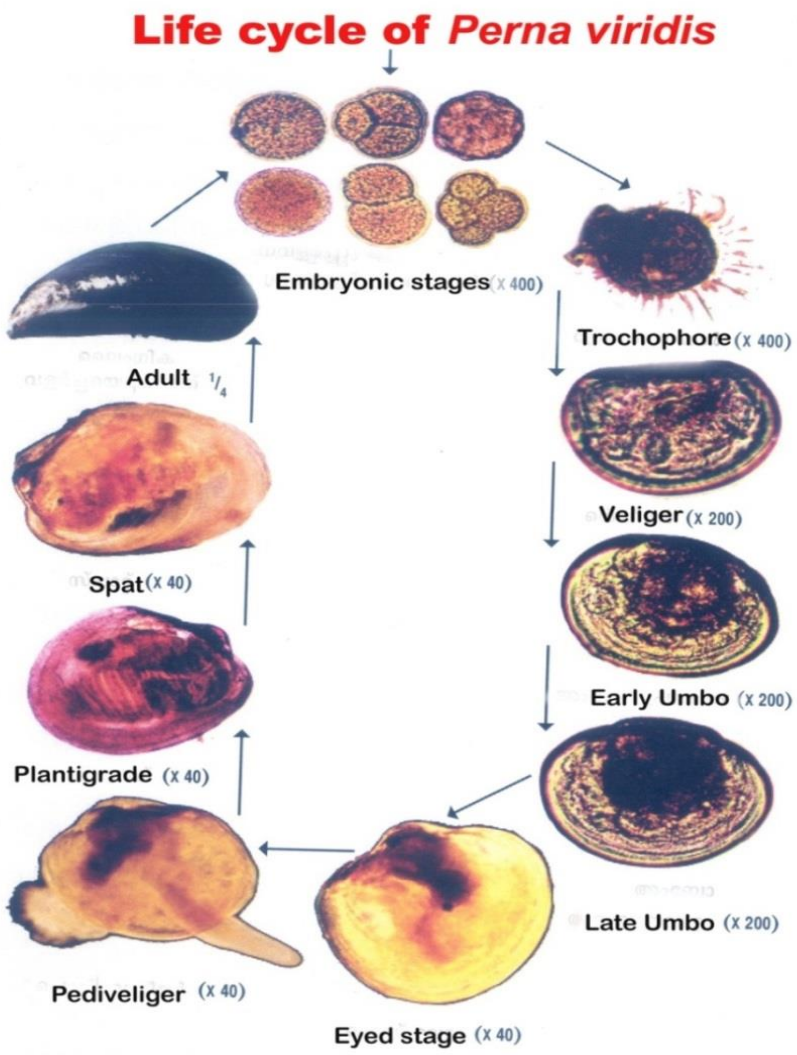
Mussels are known to be unisexual. Hermaphrodites are observed very raely. The gonad of mature female can easily be distinguished

by its bright orange-red colour form that of the male, which is creamy yellow.

Stage	Male	Female
I (Immature)	Sperm non motile	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 reputed ova
V (Spent)	Reputed tissues	Reputed tissues
(Indeterminate)	Differentiation impossible	

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

Male Female



1. Egg 2. Egg with sperm 3. 3-9 Early developmental stages 10. Trochophore
11. Veliger 12. Eyed/ umbo stage 13. Plantigrade14. Spat 15 Adult.

Condition index

*Condition index = (dry meat weight X 1000) / Volume of shell cavity

** Percentage edibility = Meat weight X 100 / Whole mussel weight

* Condition index is generally related to the reproductive cycle. Condition of mussel indicates 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 harvest3ed. 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. *Pernaindica*isfound only along the Indian coast. *Pernaperna*is found along the coasts of African continent, South Africa and Sri Lanka.

Mussel popularly known as "Kallumekai/Kadukka/Chippi" in Malayalam. Green mussel *Pernaviridis* and brown mussel *Pernaindica* are available along the Indian coast. The green mussel *Pernaviridis* is extensively distributed as sub tidal 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, Andhakaranazhi,Azheekal, Parimanam, Neendakara and Port Kollam.

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, Kodar, Karungadi, Karwar, Angola, and Gangoli.

In Goa, mussels beds have been observed at Mapusa, Panjim, Margoa and Canacons. Along the Maharastra coast, mussel 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, Devegad, Chowl, alibag and Urar. Along the Gujarat coast, mussel population is spares, observed only in Jamnagar region at Sikka, Baid, same, sachana and near Dwaraka.

In Tamil Nadu, Pondicherry and Andhra Pradesh extensive beds are not reported. However, mussel resources have been observed at Chunambaru estuary, Ennore, Kandaleru, Visakhapatanam, Kakinada, Nellore, Vedukunnappalli, 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 Island and it is absent in Lakshadweep Islands.

Mussel seed availability along the Indian coast / area suitable for farming

State	Location
Kerala	Ashtamudi lake , Thangaserry Bay, Azheekode, Maliyankara, Sathar Island, Chettuva, Ponnani, Kadalundi, Dharmaadam, Valapattanam, Padanna, Neelaswaram etc.
Karanataka	Mulky, Suratkal, traisi, Baindur, Gokarn, Belikeri, Arga, Amdalli, Harwada, Karwar Bay, Manjalietc
Tamil Nadu	Coleroon estuary, Gadilam estuary, Kovalam, Kadiyapatanam, Coachel, Kodimunna, Vaniakundikurumpana, Melemidalam, Aazhimala, Pulinkidi, Mulloretc
Pondichery	Kadaloor
Andhra Pardesh	Bhimunipatanam, Kakkinaada, Dommulpeta,Chinamylavarilanka etc.
Maharashtra & Goa	Bhatye creek, kalbadevi creek, Jaigad creek, Dabhal creek, Purangad creek, Budhal coast, Tulsunde creek etc.
Andaman & Nicobar Island	Sippighar, Bimbleton, Kalpather, Garacharma, Mittagari, Haathitope, North Bay, Minnie Bay etc.
Gujarat	Navabander
Orissa	Gopal pure port (Badrajpally), Gopalpur Rocky shore, Gopalpur back water, Bahuda estuary etc.

Some common species of mussel in the world

Scientific name	Common name	Country
Pernaviridis	Green mussel	India,China,Indonesia, Malaysia, Philipines, Singapore, Thailand
Pernaindica	Brown mussel	India
Pernacanaliculus	Green lipped mussel	New Zeeland
Mytilusedulis	Blue mussel	China, Korea(Rep.)

Fishery

In India annual mussel production wich was less than 10,000 tones in the beginning of this decade, has been doubled by 2002 through increased exploitation and farming in coastal waters. I 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 2005-06 farmed mussel production was 10060 tones.

Farming Techniques

Site selection

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

Open sea farming

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

Estuarine farming

Compared to open sea, estuarine ecosystems with less turbulent and shallow depth (<4m) are suitable for mussel farming. Culture of mussels on horizontal ropes results in high productivity due to the effective utilization of the primary productivity. Rack culture id ideal for estuarine conditions. Fluctuation is 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/casurinapolse vertically and horizontally tying and lashing with nylon/coir ropes.Bamboo or casurina poles are driare driven into the bottom and spaced at a distance of 102m. These stakes are connected horizontally with poles. The horizontal poles should be above the level of water at high tide and seeded ropes are suspended from the same.

Raft method

This method is ideal for open sea conditions. Square or rectangular rafts are fabricated with sturdy bamboo or casuarina poles. Buoyancy for the raft is provided by tying 5 barrels of 200 liter capacity one each at the four corners and one in the middle (metal oil barrel painted with anticorrosive paint or synthetic material). Ideal size of the raft 5 X5 m. the raft are Positioned at suitable site in the sea using 50-100kg of iron, granite or concrete anchors. Three seeded rope can be suspended from one meter area of the raft.

Long –line method

This method is considered ideal in unprotected open sea conditions. The main line is synthetic rope of 16-20mm diameter. The long-line, which is supported by 200 litters 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 in the long-line.

Horizontal Culture

This method is ideal in shallow areas with a minimum level of water column. Seeded rope 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 in the farm structure. In the estuaries of Malabar, most of the farmers are following this method.

Bouchot culture

Bouchot(stake culture) method was done in the shallow waters of Ashtamudilake at Dalawapuram, Kollam with farmers participation. Mussel seed (20-25mm) were collected from the estuary and seeded on casuarina poles, bamboo split of one meter length @1.5kg/pole, strip. Production of 12kg/pole, bamboo split were obtained with in a period 3 months. This method is very simple and received good response from the local farmers.

Seed collection and seeding on rope

The site selected for collection of seed should be free from pollutants. Seeds collected from the submerged (sub tidal) areas will be healthier. After removing other organisms and weeds, the seeds were washed thoroughly in sea water. About 500-750g of seed is required for seeding on one meter length of rope. The ideal size of the seed is 15-25mm 1ith 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 the low tide.

Nylon rope of 12-14mm 0r 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 seeds spread over the net from one end to the another. The rope is kept above the net and is tightly stitched in such a waythat the seeds spread uniformly around the rope. The cloth will disintegrate within 2-3 days . By this time seeds will secreted byssus thread and will get attached itself to the rope.

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

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

Calendar of mussel farming activities in Kerala

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

Diseases and Poisoning

Mussels are said to be harmful when consumed during periods of retide(in Malayalam it is called polavellam) . This mainly occurs due to dinoflagellates bloom or bloom of diatoms, or cyanobacteria. They will produce potent toxins that can find their way through the

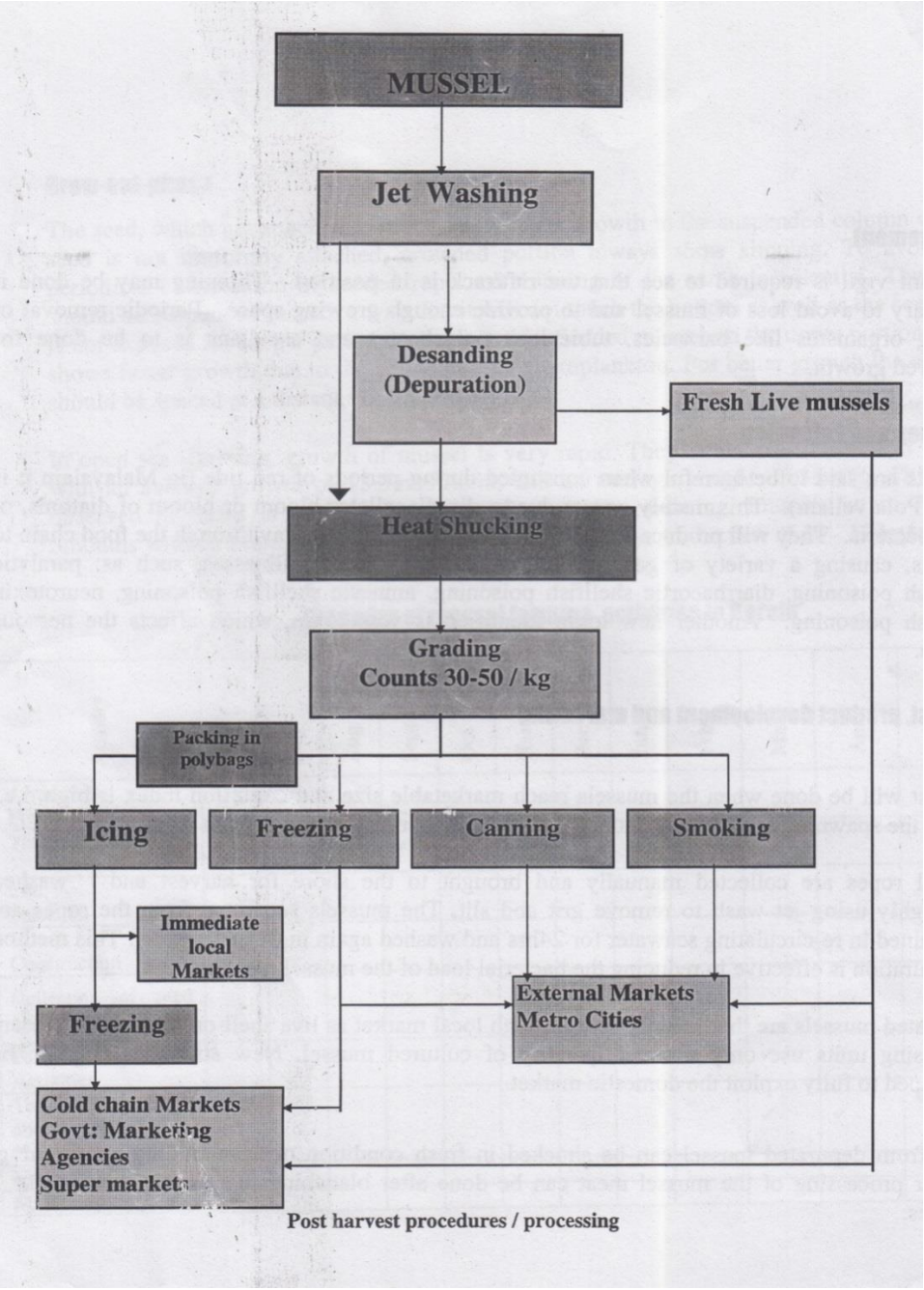
food chain to humans, causing a variety of gastro-intestinal and neurological illnesses, such as: paralytic shellfish poisoning, diarrhaeortic shellfish poisoning, amnesic shellfish poisoning, neurotoxin shellfish poisoning. Another new toxin identified is yessotoxin, which affects the nervous system.

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

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

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



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 mussel like seafood cocktails are prepared and marketed by seafood export firms in India. The export of these items from indiais showing an increasing trend.

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	23.8 g	19	24
Oil (fat)	4.48 g	2.2	2.9
Omega 3 fatty acids	782 mg	*	*
Cholesterol	27 mg	-	-
Calcium (Ca)	56 mg	7	
Iodine (I)	0.065 mg	43	43
Iron (Fe)	7 mg	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)	0.95 mg	6	6
Vitamin A (Retinol)	0.05 mg	5	5
Vitamin E (Tocopherol)	1.9 mg	19	19
Vitamin B1 (Thaamine)	0.009 mg	0.6	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
Nacin	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 State Dept. of Agriculture Handbooks
" Composition of Foods Nos. 8.15,1987 & 8.13,1989.

Overseas markets

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

With globalization, seafood trade will be subjected to increasingly greater regulation, control, issue related to environmentally sustainable practices. Seafood safety would assume greater significance in the future. Eco- labeling 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.

Microbiological criteria (as per guidelines)						
Directive – 91/492/EEC						
Bacterial sp.	**Limit**	**n***	**c***	**m***	**M***	**Production area specification**
Salmonella	Absence in 25 g					
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

A = Direct consumption, B = Need depuration, C= Not approved.

Animal Product – cooked crustacean and Molluscan shell fish						
Decision – 93/51/EEC						
Salmonella	Absence in 25 g	5	0			
S. aureus		5	2	100cfu/g	1000cfu/g	
Any pathogen	Quantities to effect human health					
Thermo tolerant coliforms	-	5	2	10cfu/g	100cfu/g	
E. coli	-	5	1	10cfu/g	100cfu/g	
Mesophilic aerobic bacteria	-	5	2	10^4cfu/g	10^5cfu/g	Whole product
		5	2	5x10^4cfu/g	5 x10^5cfu/100 g	Shelled / Shucked
		5	2	10^5cfu/g	10^6cfu/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

Present status of mussel farming

In India mussel production through culture shows an increasing trend. Now under NATP programme of 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 HosdurgTaluk of Kasargod district.

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

Seed production in captivity

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

Role of CMFRI in mussel farming

Training programmes are conducted in collaboration with Aquaculture Development agencies to different categories of trainees like in-service personnel, private entrepreneurs, NGO's and fisher groups especially women. Demonstration farms are set upin 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

Mohamed started musel farming in estuaries from 1996 utilizing the technology developed by Central Marine fisheries Research Institute (CMFRI).

Economics for a model mussel farm for 3 years
Rack and rope culture in estuary Mussel farm 5m x 5m
Seeded rope 100 nos.

1. Fixed cost (material cost)			
Item	**Quantity**	**Rate**	**Amount**
Bamboo poles (9= poles + 10 horizontal poles	30nos	350	10500
Nylon rope (3mm/4mm)	2kg	280	560
Nylon rope (12mm)	13kg	250	3250
PVC pipe (2.5 "/3") for seeding in pre stitched tubes	1m	100	100
Total			**14420**
2. Recurring cost (Labour charge)			
Stitching charge	100	7	700
Canoe hire charges	5 days	300	1500
Labour charges (farm construction, seeding and harvesting	8 days	1250	10000
Mussel seed (20-25 mm)	150kg	100	15000
Cotton netting materials	25m	40	1000
Marketing (shell on) **	800 kg	25	20000
Miscellaneous			1000
Total			**49200**

3. Labour charges (Meat shucking)			
Depuration charge *	800kg	10/kg	8000
Shucking charge	200 kg	50	10000
Fuel charges			3000
Marketing	200 kg	50	10000
Total			**31000**
Total financial expenditure			
Shell on (1+2+3 *) = 14420 +49200+8000= Rs. 71620			
Heat shucked meat (1+2**+3) = 14420+29200+31000= 74620			

**Except the marketing charge
*Depuration charge only

	Total yield		**Income**
Product	Total quantity	Rate	Amount
Shell on	800kg (8kg/rope)	Rs. 150/kg	1,20,000
Heat shucked meat	200kg (25% meat)	Rs.650/kg	1,30,000

Net profit

Shell on = 1,20,000 – 71,620 =48,380(67.5%)
Shucked meat = 1,30,000 – 74,620 =55,380 (74.2%)

*Meat percentage may vary according to the water body and climatic variations

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Marine ornamental fishes and their breeding: CMFRI initiatives

K. Madhu, Rema Madhu, M.P. Mohandas, M.T. Vijayan and Sibi T Baby
Mariculture Division, CMFRI

Abstract

The marine ornamental fish trade is a sunrise industry in aquaculture and has become a growing industry worldwide. As a result the trade of marine ornamentals has been expanding in recent years and has grown into a multimillion dollar enterprise mainly due to the emergence of modern aquarium gadgets and technologies for setting and maintenance of miniature reef aquaria. Since the marine ornamental trade is operated throughout the tropics, the global marine ornamental trade is estimated at US$ 200-330 million. Since India is endowed with a vast resource potential of marine ornamentals distributed in the coral seas and rocky coasts with patchy coral formations and the increasing the demand in the domestic trade, it appears very much lucrative for India to venture into this industry. But it is a multi stakeholder industry ranging from specimen collectors, culturists, wholesalers, transhippers, retailers, hobbyists, researchers, government resource managers and conservators, and hence involves a series of issues to be addressed and policies to be formulated for developing and expanding a sustainable trade. Nearly 98% of the marine ornamental fishes marketed are wild collected from coral reefs of tropical countries. This has been threatening the long term sustainability of the trade due to indiscriminate exploitation of coral reef areas. The only alternative for the sustainable trade is the captive productions which involved broodstock development, breeding, live feed culture, larviculture, growout, aquarium technology, diseases, packing and transportation, etc. The Central

Marine Fisheries Research Institute (CMFRI) has been focusing on this vital aspect of this low volume and high value industry for the past few years.

Introduction

Marine and freshwater aquarium keeping is amongst the most popular of hobbies with millions of enthusiasts worldwide. As a result the trade of marine ornamentals has been expanding in recent years and has grown into a multimillion dollar enterprise mainly due to the emergence of modern aquarium gadgets and technologies for setting and maintenance of miniature reef aquaria. Since the marine ornamental trade is operated throughout the tropics, the global marine ornamental trade is estimated at US$ 200-330 million. India is endowed with a vast resource potential of marine ornamentals distributed in the coral seas and rocky coasts with patchy coral formations. In the context of the expanding global scenario and the increasing demand in the domestic trade, it appears very much lucrative for India to venture into this industry. But it is a multi stakeholder industry ranging from specimen collectors, culturists, wholesalers, transhippers, retailers, hobbyists, researchers, government resource managers and conservators, and hence involves a series of issues to be addressed and policies to be formulated for developing and expanding a sustainable trade. In recent years it has been reported that nearly 1500 species of marine ornamental fishes are traded globally and most of these are associated with coral reefs. Nearly 98% of the marine ornamental fishes marketed are wild collected from coral reefs of tropical countries such as Philippines, Indonesia, Solomon Islands, Sri Lanka, Australia, Fiji, Maldives and Palau. This has been threatening the long term sustainability of the trade due to indiscriminate exploitation of coral reef areas. The three key words in the development of marine ornamental fish trade are – collection, culture and conservation. The development of technologies for hatchery production of selected marine ornamental fishes is the

only option for evolving a long term sustainable trade without damaging the coral reef ecosystem. Even at an international level,

the technologies for hatchery production of ornamental fishes are limited to a few species. The main steps in captive production of ornamental fishes are broodstock development, breeding, live feed culture, larviculture protocols, growout methods, aquarium technology, diseases, packing and transportation, etc. The Central Marine Fisheries Research Institute (CMFRI) has been focusing on this vital aspect for the past few years. CMFRI is successful in developing hatchery technology for 21 species of marine ornamental fishes. The marine ornamental fish trade is low volume and high value industry in rural and urban areas, and hence it is very lucrative to initiate a trade purely based hatchery produced species. The setting up of a small-scale hatchery with details of economics are also included in this manuscript.

CAPTIVE BREEDING OF MARINE ORNAMENTALS IN INDIAL: Initiatives by CMFRI

These investigations made CMFRI have resulted in the development of hatchery technology for 21 species of marine ornamental fishes such as clown fishes *Amphiprion percula*(True percula/ clown anemone fish);*A. ocellaris* (Common Clown/False clown aenemonefish); *A. sandaracinos* (Yellow Skunk Clown); *A. frenatus* (Tomato clown), *A. clarkii* (Clark's anemone fish), *A. sebae* (Sebae clown) *A. perideraríon*(Pink anemone fish) *A. ephippium (Red saddle back anemone fish), A.nigripes* (Lakhadweep clownfish),*Premnas biaculeatus* (Maroon clown/ Spine cheek anemone fish. The species under damsels for which technology developed under captivity included *Dascyllus trimaculatus* (Three spot damsel); *D. aruanus*(Striped damsel);*Pomacentrus caeruleus* (Blue damsel); *P. pavo* (Sapphire or Peacock Damsel);*Neopomacentrus nemurus* (Yellow tail damsel); *N. filamentosus* (Filamentous tail damsel);*Chrysiptera cyanae* (Sapphire

devil); *C. unimaculata* (One spot damsel), and *Chormisviridis* (Green chromis), and also dotty back *Pseudochromis dilectus* (Redhead Dottyback), purple fire goby *Nemateleotris decora* for the first time in the world (Madhu and Rema Madhu,2002,2006; Madhu *et al.,* 2006a,b,c; Gopakumar*et al.,* 2007; Rema Madhu, *et al.,* 2007; Madhu *et al.,* 2008, Madhu and Rema Madhu, 2014, Madhu *et al.,*2016). It is well accepted that the trade developed from tank reared fish and other ornamentals is the final solution for a long term sustainable trade. The economic viability of ornamental fish production is more lucrative when compared to other mariculture species, due to their high unit value. The complete package of practices developed for their production can be taken up as an alternative livelihood option for small and large scale fish farmers. The transfer of technology to the public and private sector entrepreneurs who have approached for the technology is being planned by imparting hands on training through different modes under the Consultancy Processing Cell (CPC) of the CMFRI and organized trainings.In addition, the hatchery produced seeds are also being sold to the farmers and aquarium hobbyists and traders through Single Window System and seed counters are in operationn marine hatcheries of CMFRI at Cochin and Mandapam. This has resulted in the emergence of several ornamental fish trade shops all over the country. Recently the National Fisheries Development Board (NFDB) has also developed schemes to fund for ornamental fish culture in the unutilized hatcheries of the prawn farmers in India.

CAPTIVE BREEDING

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

The major aspects involved in ornamental fish culture are:

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

ALLIED SECTION TO SUBSATAIATE LARVAL REARING

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

Collection and transportation of fishes

For the captive mass production of ornamental fishes, the basic requirement is to have a sufficient number of broodstocks or breeding pairs which can either be collected from the coral reef habitat or can be purchased from the pet shop depending upon the availability. In the wild, the clown fishes generally occupy in social groups cantered in a host sea anemone with a sexually active pair of adults and one to three juvenile or sub adult fish. Invariably the female was somewhat larger than the male, and showed monogamous pair formation, and these pairs are need to be collected for broodstock development and breeding programme. During transportation, the fishes and sea anemones should be kept in separate plastic transportation bags.

Quarantine

Newly acquired fish from wild as well as pet shops may carry disease and may infect valuable, healthy, broodstock. They are, therefore, kept separately in a tank or system, for three to four weeks where they are closely observed and treated with medications for possible disease outbreaks. Prior to sale also fishes should be screened and quarantined.

Pair formation

In case mated pairs are not available, the fishes having different size groups can be collected and made to pair under captive condition through pair formation for which five fishes of each sex of different size groups need to be stocked together along with single host sea anemone in a 500 L FRP tanks fitted with biological filter to reduce the aggression. The pair formation tanks need to be maintained in the hatchery where an incident light intensity of 2500 to 3000 lux was available as the sea anemones require sunlight for

its better survival under laboratory condition. The fishes and anemones should be fed two times per day with wet feeds such as meat of shrimp, mussel and clam at the rate of 15% of their body weight and live feeds like Brachionus *plicatilis,* artemia nauplii and adult artemia. Environmental parameters such as temperature 26 to 29^{o} C, salinity 33 to 36 ppt, dissolved oxygen 4.6 to 6.2 ml/L and pH 8.1 to 8.9 are need to be maintained in all the rearing tanks.

Sex change and pairing

As the clownfishes are protandrous (male first) sequential hermaphrodites, a pecking order is established in which the female is dominant, the male is subordinate to the female, and all the other juveniles are subordinate to the adult male and female. Thus generally all clownfish individuals start out as males and change into females when they reach larger sizes or under situation of loss of mate. The male and female form a monogamous pair bond that lasts until one member of the pair dies. If the female dies first, the largest male rapidly changes sex into a female and the second largest or dominant juvenile becomes an active male and that pairs up with the newly transformed female. By utilizing this adaptation, pairs of clown fishes can be developed under captive condition through creating social systems. After a period of 3 to 4 months rearing in the pair formation, in each tank one pair grew ahead of others and became the spawning pair. As the newly formed pairs will be very aggressive and spending time for fleeing the other subordinates rather than reproductive activity, it is very essential to stock each breeding pairs in separate broodstock tanks.

Broodstock development and maintenance

The pairs formed through pair formation should then be transferred to separate glass aquaria for broodstock development. Depending upon the production capacity and seed demand,

several pairs can be maintained for commercial hatcheries. The broodstocks need to be fed with wet feeds such as meat of green mussel, shrimp, and clam and fish egg mass, and can also be provided formulated feeds enriched with vitamins, minerals and algal powder at the rate of 10% of their body weight and supplied at an interval of every 3 hrs during day time. Apart from these, the broodstocks were also fed with enriched rotifer 800 to 1000 nos/ml and artemia nauplii (200-400 nos/ml) and adult artemia (3 to 5 nos/ml) every day. Provision of enriched live feeds which apparently improved egg quality and hatchability than the brooders fed with non-enriched live feeds.

Water quality maintenance

The maintenance of high water quality is possibly the critical factor for the breeding of marine fishes under controlled condition. As a measure for this, the sea water need to be filtered through a series of sand filters before being taken to the rearing tanks. The temperature in all the breeding tanks need to maintained between 26 to 30°C, and level of dissolved oxygen (4.8 to 6.3 ml/L), pH (8.0 to 8.9), salinity (32 to 36 ppt) and the water needs to be recirculated to ensure water movement and provided good water quality with the aid of a specially devised filter system during the period of rearing. Once in a week 25% of the water should be exchanged to avoid stress like a rapid increase in plasma cortisol concentration which will leads to Cushing's syndrome, depression of gonadal steroidogenesis, and subsequent development of gonadal atresia.

Substrate for egg deposition

In case of attached eggs a rough surfaced substrata near to the host sea anemone/ tank. It is very essential to provided suitable substratum preferably tiles or earthen pots or shells of oyster or PVC pipes for the egg deposition which will also be helpful for

the transfer of deposited egg without any mechanical injury to hatching tank.

Breeding and spawning

After bloodstock rearing, each pair will start breeding within a period of 4 to 6 months rearing under captive condition if the broodstoks are provided nutritious food and provided suitable rearing conditions. Few days prior to spawning, the male selected a suitable site near to sea anemone for laying the egg and cleared algae and debris with its mouth and on the day of spawning both the parents spent considerable time for the cleaning of site which indicated that spawning may occur within few hours. Under laboratory condition, the spawning can be obtained between 0500 hrs to 1530 hrs during day time and the spawning lasted for one hr to one and a half hour. Each female lays 300 to 1000 capsule shaped eggs at every 12 to 15 days interval depending on the species of clown fish, size of fish and previous experience. Generally the egg size of clown fishes ranges between 1.5 mm to 3.0 mm in length with a width of 0.8 to 1.84 mm and adhered to the provided substratum with stalk. An average of two spawning per lunar month per pair resulting in an estimated annual fecundity of 7200 to 24000 eggs/ breeding pair/ year can be obtained under laboratory condition.

Parental care and egg morphology during incubation period.

As parental care is inevitable for hatching out of the larvae, the parents should be allowed to remain in the parental tank itself till hatching. During incubation period, both the parents carefully look after the eggs during day time and it involved two basic activities *viz*. fanning by fluttering the pectoral fins and mouthing to remove the dead or weakened eggs and dust particles. The newly spawned eggs were white to bright orange in colour for initial two days and

as the embryo develop; these were turned to black on 3rd to 6th day and later turned to silvery the colour of the larvae's large eyes on 7th to 8th day of incubation. At this stage the glowing eyes of the developing larvae inside the egg capsule was clearly visible when viewed from a short distance. Male assumed nearly all responsibility of caring for the eggs and spent a higher percentage of time at the nest than the females, which increased gradually up to 70% of time as the day of hatching approached. When incubated at a water temperature range of 27 to 29° C, the hatchling emerged on 8th day of incubation and peak hatching took place shortly after sunset.

Hatching and larval transfer

The eggs of clownfishes usually take from 6 to 15 days to hatch depending on the water temperature. At temperature 26 to 33 ° C the incubation period ranges from 6 to 8 days. One day prior to hatching the larvae within the eggs capsule develop a silvery colour and the glowing larval eyes can be viewed form a short distance. This is the time when one must make a decision for the mode of larval rearing. On the expected day of hatching, two hours before sunset, the eggs along with substratum were transferred from the parental tank to hatching tanks (100 L) and provided with complete darkness for accelerating the hatching. The larvae broke the egg capsule and the hatchling emerged tail first and the hatching occurred soon after sunset and the peak hatching took place between 1900 to 2030 hrs under darkness. The newly hatched larvae measured 3 to 4mm in length and each had a transparent body, large eyes, visible mouth, and a small yolk sac and remained at the bottom of the tank for a few seconds and soon after became free swimming. The larval rearing can be carried out under green water system and feeding with super small rotifer *B. rotundiformis* and newly hatched artemia nauplii. The larval period of clown fishes generally last for maximum of 20 days and then after most of the fry resembled juvenile adult fish and began to shift from

partially pelagic to epibenthic and started eating minced shrimp, fish flesh, mussel meat, clam meat and formulated diets.

Methods for larval rearing

The larval rearing of clown fishes can also be carried out in three ways (i) Same tank or parental tank method, (ii)Transferring of eggs to hatching tank and subsequent larval rearing, (iii) Transferring of larvae to the larval rearing tank.

Larval feeding

The successful feeding strike is low at first feeding but rises rapidly during early development fishes. At this stage provision of suitable size and nutritionally adequate enriched feed in high density is one of the important factor for their survival as the larvae will be able to accept small size organism due to the small mouth gape, and if they do not encounter and successfully capture food before depleting their energy reserves, the larvae may starve and it will eventually lead to mortality. Moreover many of the larvae had only little quantity of yolk material and it starts feeding within few hours after hatching. As the mouth gape of clown fish larvae is between 80- 123 μ, the larvae need to be fed with live feeds measuring less than 100μ for its active feeding. All the rearing tanks need to be provided 24 hrs light up to 15 days of post hatch (DPH). During this time the larval tank must be kept very clean with the bottom siphoned off dead larvae, detritus and faeces twice a day. Water changes will also need to be performed at a rate of at least 25% per day. Feeding schedule of larvae of clownfishes can be performed in two stages: Stage 1: covered the rotifer with algae feeding phase from Day 1st to 8th day. Stage 2: the newly hatched artemia without any and rotifer enriched with algae feeding phase from 9th to 20th days. For the successful prey capture of larvae, 50-100 numbers ml^{-1}

supper small rotifer (*B. plicatilis*) having size 60 to 100 µ need to be provided after enrichment with vitamins and fatty acids.

Rearing conditions

The maintenance of high water quality is possibly the critical factor when larval rearing of clownfishes or any marine fishes is done under controlled condition. As a measure for this, the sea water needs to be filtered through a series of sand filter tanks before being taken to the larval rearing tank. However during larval rearing it was found that the period from 3rd to 8th day of post hatching (dph) was very critical may be due to the alteration or change in feeding (exogenous) whereas once the larvae of clownfishes completed 8 days after hatching, no further mortality was observed. Since the larvae are very delicate aeration was provided at four corners of larval rearing tanks through PVC column to maintain dissolved oxygen. During the larval rearing period, in all tanks, the environmental parameters were maintained to their optimum level with pH ranging from 8.0 to 8.2 water temperature 26 - 30° C, dissolved oxygen 5.5 - 7.8 (mg/L), salinity 33-35ppt, NH_{4+}/NH_3 and NO_2 values at 0 mg per L and NO_3 levels below 0.2 mg /L. Daily the tanks were cleaned with cotton and magnetic tank cleaner to remove the dust and slimy coating forming inside the tank and one fourth water is replaced with same amount of filtered sea water along with enriched rotifer and artemia and micro algae.

Light intensity

Head-butting syndrome was another the critical problem encountered during the larval rearing due to the immature development of the retina and subsequent hitting of larval head to the sides of the tank. In order to reduce this, two major measures have been taken that (i) all the 4 sides of the tanks were covered with black cloth or painted black to avoid reflection of the light.

ii). a low intensity light needs to be provided by hanging 2 nos. of 60 watt bulb or night lamp at a height of 15-20 cm from the surface of water level in rearing tank for 24 hours from 0 day to 20th day which enabled the larvae to detect and capture its feed and it also helped them to swim towards the surface at night rather than sinking to the bottom which otherwise show high overnight mortality.

Juvenile rearing

On 19-20 dph, the larvae became juvenile of clownfishes and shift from pelagic to epibenthic stages, and look like a miniature of adult fishes**.** The rate at which the young fish grow depends on the size of the rearing tank, stocking density, quality and quantity of food given and the water temperature. As the clownfish exhibit social hierarchy, dominant clownfish will grow faster and will suppress the growth of the fish below. This can largely overcome however by growing the fish up all together in a large tank with sufficient host anemones or culling the juveniles to several groups in different juvenile rearing tanks of size 250 to 1000 L capacity fitted with biological filters. At this stage, the stocking density need to be reduced to 90 -100 numbers of juveniles (size range between 8-10 mm) with single host sea anemone in glass or perspex tank- at 100 L capacity for initial 1 to 2 months rearing. During juvenile stages, the fishes show different banding pattern and growth rate, and on attaining a size of 24 to 35 mm in total length (TL), the stocking density need to be reduced to 30 to 50 number with single sea anemone in 100 L tank with 80 L bio filtered sea water until marketing. In the case of each 500 L FRP tanks, 130 to150 juveniles can be reared with 1 to 3 sea anemones.

Juvenile feeding

In the juvenile rearing, a survivability 100% were obtained through feeding with different wet feeds: mussel meat, prawn muscle, fish eggs and minced flesh of trash fish at the rate 15 to 20 % of body weight. Apart from these, artemia nauplii 10-15 numbers/ ml and rotifer (*B. plicatilis*) 50 - 55 nos. /ml were given after enrichment with brown algae (10^4 cells/ml) and green algae (10^6 cells/ml) with cod liver and fat soluble Vitamin A, D, E, K, twice a day which helped to retain the colour of fishes and provided adult artemia (2 - 4 nos/ml).

Packing and Transportation

Fishes are starved for about 2-3 days before being exported or transported. A small amount of fresh water is added to the packing water and chemicals may be added to tranquilize for longer journeys. Packing starts just prior to the transportation. Fishes are packed with oxygen and a little water either singly or multiple in double polythene bags to ensure that fish are not stranded without water. Polythene bags are packed in cardboard boxes for short journeys and for long journeys they are packed in Styrofoam boxes with some ice to keep the temperature down. Layers of paper may be inserted between plastic bags in the box to avoid catching sight of aggressive species. Packaging methods have improved considerably over the years mainly due to feedback from the customers and many exporters now guarantee almost 100% survival for most destinations provided that good connecting flights is available.

Setting up of a small-scale hatchery

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

1. Broodstock tanks
2. Larviculture tanks
3. Live feed unit

Nursery rearing and grow-out tanks

4. One sand filter
5. Outdoor live feed (Phyto and zooplankton) production tanks
6. Seawater and freshwater supply system.

Hatchery equipment and accessories

(i) Water Pump: Two types of pumps are required for the small-scale hatchery operation. A pump of 5HP is required to pump seawater to the hatchery's sand filter tank. A separate submersible pump is required to distribute water within the hatchery system.

(ii) Generator: A generator of 1 KVA is essential as backup electricity supply for the hatchery.

(iii) Aeration system: Small 100 watt air pump with at least one backup is needed.

(iv) Other hatchery equipments

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

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

Advantages of small-scale hatcheries

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

Economic Assessment

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

Capital Investment

This component involves all the expenditure on the infrastructure and establishmentof the hatchery. The items included in this component generally have a life span largerthan one year and they are used to generate the future income from the hatchery. Theitems nclude

Capital Investment items	**Quantum**	**Cost in Rupees**
Temporary Shed	144m2 (12 X 12m)	1,10,000
Tanks		6,40,000
i. Broodstock	**12**	
ii. Larval rearing	12	
iii. Nursery and grow out	18	

iv. Microalgae (outdoor)	4	
v. Rotifer (outdoor)	3	
vi. Sand filter /Over head tank	1	
Artemia hatching tanks (Transparent Perspex)	3	10,000
Power installation		10,000
4 HP diesel pump	1	19,000
1/2 HP submersible pump	1	6,000
Generator 2 KVA	1	30,000
Air pumps	2	40,000
PVC piping, plastic wares (water supply/aeration/drainage)		45,000
Netting, miscellaneous etc.		40,000
TOTAL COST		**9,50,000**

Operating expenses

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

	Items	1st year	2nd year	3rd year
1	Broodstock fishes/Anemone	25,000	5,000	5,000
2	Feeds	12,000	12,000	12,000
3	Artemia	4,000	12,000	12,000
4	Chemicals for microalgal culture	6,000	6,000	6,000
5	Electricity	36,000	36,000	36,000
6	Diesel	24,000	24,000	24,000
7	Maintenance	12,000	18,000	18,000
8	Workers salaries(1xRs. 8000; 2xRs.5000)	2,16,000	2,16,000	2,16,000
9	Miscellaneous expenditures	12,000	12,000	12,000
	TOTAL	**3,47,000**	**3,41,000**	**3,41,000**

Non-operational expenses

These are related to the capital cost and investment write off. There are two itemsunder this component for small-scale hatcheries.

i) Depreciation

ii) Interest on capital investment

Technical assumptions for production

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

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

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Fishery based Entrepreneurial Capacity Building through Self Help Groups: A short glimpse

Vipinkumar.V.P
Socio-Economic Evaluation and Technology Transfer Division, CMFRI

The basic reason for poverty is not nothingness..... It is the tendency of unwillingness of human mind for sharing the available, inability to make use of opportunities effectively and lack of willpower.....Technology for a micro-enterprise is a 'game' for the rich, a 'dream' for the poor and a 'key' for the wise… … … … … … … … … … … … ….(Kudumbashree, Kerala State Poverty Eradication Mission)

Fisheries sector occupies a paramount position in the socioeconomic development of our country. Fisheries, aquaculture and fish based enterprises are considered the sunrise sectors in India, providing nutritional security, contributing to the nation's GDP and offering employment to over 14 million people directly and indirectly. Constituting about 6.3% of global fish production, the sector contributes to 1.1% of the GDP and 5.15% of the agricultural GDP (NFDB, 2016). The extent of inland water resources of India prevailed hovering potential considering aquaculture-entrepreneurship development. In fisheries sector the input production and the input-delivery-systems like fish production, marketing and exports, processing and product developments needs emerging entrepreneurs. The professionals in the government sector cannot take up all the responsibilities in order to bring quantum change in the system. There exists a variety of initiatives around the globe by the individuals and institutions, involving in missions of philanthropic nature, which try to create viable and sustainable changes in person's lives. Social entrepreneurship will be demanded to replace the existing

aquaculture practices of India with more sustainable resilient practices and management strategy. This is one of the major lacunae of entrepreneurship development in fisheries sector. But according to Kahan (2012), farmers see their farms as a business and as a means of earning profit and thereby ultimately to bring about development. It would be pertinent to have a look into the scope and opportunities of fish based enterprises for livelihood security of fisherfolk in the chain of development.

The upliftment in the standard of living of the poorest of the poor in the society is actually development. Development of Indian fisheries sector in a broader visualization will be materialised with poverty eradication programmes though the transparent media namely Self Help Groups. Self Help Groups can play a vital role for the fisheries sector development. The utmost important requisite for this is ensuring participation of fisherfolk especially women in the planning and implementation of various coastal sector development progammes. Alternative livelihood options through appropriate and economically viable micro enterprises are the only solution for meeting the ever-increasing demand of population in coastal belt in the context of diminishing per capita fish catch. The means of livelihood of coastal fisherfolk in different maritime states vary from one another. Since the livelihood conditions and technological requirements of the fishing population have not been studied in depth, it is difficult for any technological intervention and implementing other management options for improving the livelihood status of the fisherfolk. An attempt is made for developing a theoretical framework based on the review of past research studies related to livelihood analysis both at national and international level.

National Level Perspective Reviews:

Livelihood analysis indicates the way in which the farmers belonging different category of wealth make their livelihood

including the crisis management. (Sabarathnam 2000) Viswanathan *et al* (2002) informed that fisheries in developing countries are under intense pressure from increasing coastal populations, over exploitation of resources and conflicts over access to degraded livelihood resources. This is one of the techniques of Participatory Rural Appraisal (Bhat,2003) for an expeditious analysis of the rural situation to plan and act. Livelihood analysis of coastal fisherfolk in any region is inevitable for the appropriate micro enterprise selection for the location for empowerment. (Kurien, 2003). Similarly several micro and macro level socioeconomic studies had been conducted by various agencies and research workers in different regions of our country on the livelihood problems of fisherfolk. (Srinath 1987; Sathiadhas and Panikkar,1988; Aujimangkul *et al*, 2000). The generalized objectives of such socio-economic studies stress on the assessment of human resources of identified geographical location, features of the target groups of specific developmental programmes, poverty, hunger, mal-nutrition and health status of fisher households, impact of introduction of new technologies and practices on income and employment, alternate fishing strategies and mariculture practices, infrastructure facilities and potential for development, rural indebtedness and supply of credit by various agencies, inter and intra structural conflicts in harvesting and post harvesting activities of marine fisheries, role of women in small scale fisheries sector, feedback information from the field to revise the strategy or devise to follow up action etc. Gender based studies and impact microfinance and SHGs also gained significance to a great extent in the present topic of discussion. (Vipinkumar et al, 2013)

International Level Reviews:

Livelihoods are attracting increasing attention in the context of Community Based Coastal Resource Management (CBCRM). The livelihood analysis encompasses all the strategies and assets that individuals and households use to earn a living (DFID, 2001;

CBCRM Resource Center, 2003; Graham and Tanyang, 2001; Arciaga *et a*l, 2002; Ashby, 2003). This definition is extremely broad, and its implications and local understanding of the term can only be understood through context specific participatory research and dialogue. There are three specific areas where livelihoods connect directly with CBCRM initiatives and all have relevance. First of all, from a livelihoods perspective, natural resource use by an individual or a group of people is part of their livelihood strategy. "A reversal of environmental degradation require new livelihood options that change people's incentives, in particular the benefits and costs of resource use" (Ashby, 2003; p2). Many livelihoods in coastal communities are based on the sea, therefore resource management activities, such as those commonly carried out through CBCRM initiatives, are livelihoods activities that reduce local vulnerability and enhance natural capital (Graham and Tanyang, 2001; Arciaga *et a*l, 2002, Vipinkumar *et al,* 2015, 2017).

A glance of the general observations in Fisheries sector

In fisheries sector, generally because of the lack of saving tendency, whatever the fisherfolk earn are being spent. Nothing is generally left for tomorrow. Entire family may starve unless he goes for fishing. While becoming sick, they may depend on private moneylenders for sustenance, food and medicine. If he falls in the trap of huge interest, the major potion of his earnings will be for paying interests. If the repayment is obstructed, the interest amount will grow bigger than the amount borrowed. The debt may transfer to the subsequent generations also. The formal financial organsiations and banks are even at present unapproachable to these poor fisherfolk. It is not due to lack of interest that the fisherfolk don't save anything, but it is the lack of opportunity to save, which becomes the major obstacle preventing them from saving something. Even if they are interested in savings, there are a lot of obstacles to deposit in banks. For opening an account, another person possessing account in the bank has to introduce.

Photographs and identity documents are required. Similarly, he has to remit a fixed amount to open an account. In addition to this, he has to forgo / sacrifice one day's labour for this purpose. Here comes the relevance of Self Help Groups.

Community Cohesion and Self Help Groups

A couple of differences are observable while comparing savings and thrift. Saving is the balance amount from expenses out of total earnings. But for the poor income groups, expenses are more than earnings. Therefore, savings will be meager. Thrift is just like an item of expenditure compulsorily kept aside for future use and is not the balance from earnings. This is strictly kept apart. In olden era, a handful of rice kept apart every day when gets accumulated was being used during off seasons for sustenance. Thrift is just like that. A few women fisherfolk when mobilized as a group, members can contribute the fixed nominal amount as thrift in every week in the group meetings. This collective amount can be deposited in banks as joint account the very next day. Slowly this thrift amount gets grown to a considerably big amount Say for example, 25 members in an SHG when collect Rs 20/- each every week as thrift, it becomes Rs 500/- in the first week. It will be Rs 2,000/- in the first month and Rs 12,000/- within 6 months. As the thrift collection regulates the judicious spending habit among members, economic discipline in the SHG will be easily feasible. After 6 months of initiating the thrift collection, the members for the Self Help Groups can be given loan for their emergency expenditure at a nominal interest rate. The members themselves can decide the norms for the credit. Since the SHG members are known to each other, the needs can be prioritized as per their importance / significance and it meets the essential requirements of the members throughout 24 hours just like an informal bank in front of their house. The members will decide the duration of loans and interest particulars. By solving the problems of the SHG members on group basis the skills and ability of the members in handling financial matters get enhanced and the group slowly gets led to Self Helping Stage.

For some income generation activities for the members, a suitable micro enterprise is to be found out for the Self Help Group and then SHG can be linked to other financial organizations like NABARD, *Rashtriya Mahila Ghosh*, other banks etc for availing better credit facilities. The savings of the SHG when gets deposited in formal banks, there commences the relationship with the financial organizations. Since the welfare of the SHG naturally becomes the responsibility of the banks also, they actively involve in further activities, growth and progress of the SHG. Banks give loan assistance without supporting documents to SHG and in turn the SHG gives it to the members.

Taining programme of Srayidthode SHGs on cage farming

The SHG which functions as thrift-credit group for a minimum period of 6 months, can avail double of the thrift amount as loan from well- established financial institutions, The increase in thrift amount and punctuality in repaying the loans make these SHGs' deserve multiple times of thrift amount as loan further based on the norms of the institution. There are a lot of other financial organizations giving loans to SHGs'. Experiences and observations

indicate that, for a group to be developed as a Self Help Group, normally a period of 36 months (3 years) will be required. Within this gestation period when the group passes through three distinct phases, up to 4 months as the Formation Phase, up to 15 months as Stabilisation Phase, and up to 36 months as the Self Helping Phase, the group gets led to the stage of a flourishing Self Help Group as per the indications given by social research results on Self Help Groups. The fisheries Self Help Groups have to focus attention on joint efforts co-operatively for finding out suitable micro enterprises, which can assure a constant income for the fisherfolk, based on locally available resources for poverty eradication.

Training of SHGs on online fish marketing in Thevara

The meaning of a micro enterprise

A micro enterprise is an activity which requires less capital, less manpower, local raw materials and local market. It is an individual enterprise whether known or unknown. (Vedachalam,1998). In fisheries sector, for the upliftment of fisherfolk below the poverty line, some successful micro enterprises developed based on the location specific resource availability and experience and some alternate avocations and subsidiary entrepreneurial ventures successfully being undertaken by Self Help Groups in coastal sectors and allied areas as follows :

SHG training on Fish amino acid production at Elamkunnappuzha

Value added fish producing units, Dry fish unit, Fish Processing unit, Ready to eat fish products, ready to cook fish products, Ornamental fish culture, Mussel culture, Edible oyster culture, Clam collection etc. are very important. In agricultural sector, Vegetable cultivation, Ornamental gardening, Floriculture, Kitchen Garden, Orchards, Fruit products, Fruit processing, Sericulture, Mushroom cultivation, Medicinal Plants, Vermi compost, Snacks units, Catering Units, Bakery Units, Cereal Pulverizing units are some micro enterprises undertaken by Self Help Groups.

SHG meeting at Vishakhapatnam of Andhra Pradesh

Based on the resource availability and circumstances the micro enterprises those the SHGs' can generally bring to practical utility in allied sectors are Wood work units, Stone work units, Soap units, Garment units, Computer centre, Poultry centre, Cattle rearing, Piggery unit, Bee Units, Stitching units, Hand Weaving Units, Candles, Chalks, Umbrella units, Foam Bed Units, Bamboo based handicrafts, Paper cover, Scrape selling, Vegetable seeds, Marriage bureau, Medicine collection, Patients service, Real estate, Medicine processing, Direct marketing, Coir Brush, Plastic weaving, Second sails, Meat *masala*, *Rasam* powder, Curry powder, Pickle powder, *Sambar* powder, Consumer service centres, Home delivery package, Repacking business, Cleaning powder, Phenol lotion, Liquid soap, Washing soap, Toilet soap, Kids' garments, Toffee & Sweets, Photostat, Washing powder of best quality and medium type, Emery powder, Domestic animals, Nursery plants, Note book, Book binding, Rubber slipper production, Pillow cushion,

Incense stick production, Cloth whiteners, Eucalyptus oil, Dolls, Hand shampoo, Soap shampoo, detergent shampoo, Jackfruit jam, Chips, Hotel, Catering service, Grape wine, Pineapple wine, Soft drinks, Chicken farming, Dried mango wafer, Dried chilli, Gooseberry wine, Ginger wine, *Pappads*, Tomato sauce, Day care centre, Coconut water vinegar, Syrups, Artificial vinegar, Mixed fruit jam, Milk chocolate, Tomato squash, Gum production, Cleaning lotion, Soft drink shop, Reading room, Private tuition, Counseling-guidance, Rent sales, Paying Guest service, Repairing centre and handicrafts are some of the employment opportunities that the SHGs' can venture throughout Kerala depending on the suitability of situations and availability of resources.

Cage culture in Srayithode


Women SHGs in fish markting in Bendarvanipetta of Andhra Pradesh

The suitability of the enterprise varies from situation to situation. The essential features for the success of a viable micro enterprise are :

1. The availability of sufficient quantity of raw materials locally.
2. The identified enterprise is known or easy to learn and practice.
3. The cost of production must be low.
4. The products must be of very good quality.
5. The availability of market for the products.

Training on cage farming in Alappuzha

The major financial organizations giving financial assistance to SHGs' are Khadi Village Industries Board, Department of Commerce & Industry, *Jawahar Rosgar Yojana*, Women Industrial Cooperative Societies, Kerala State Social Welfare Advisory Board, Kerala Financial Corporation, National bank of Agriculture and Rural Development, District Rural Development Agency, Other Non Government Organizations, *Kudumbasree ayalkoottam* groups etc.

Mussel cultue SHGs in Padanna

A case study undertaken on preference of fisherfolk by ranking of priorities for some selected viable micro enterprises in fisheries, agricultural and allied sectors in Milkatkar and Navgav locations of Alibag district in Maharashtra are presented Table 1. Technology status and technology needs were prioritized and ranking of priorities based on the Rank Based Quotient (RBQ) on fishery based micro enterprises was in the order as Preparation of value added products, fish processing, dry fish products, mussel culture, ready to eat & ready to cook fish products, ornamental fish culture, and edible oyster culture. With regard to Agriculture based micro enterprises

the ranking was in the order of Kitchen garden, Vegetable Cultivation, Planting mangroves and acacia trees, Catering units, Cereal Pulverizing units, Ornamental Gardening enterprise etc. With regard to allied sector micro enterprises, the ranking was in the order of Cattle unit, Poultry unit, Bamboo based handicrafts, Wood – Stone carpentry, Computer centre, Candle unit, Chalk Unit, Umbrella Unit etc.

Fish amino SHG in Puthuvype

Table 1 : Ranking for priorities of women fisherfolk for the technology needs/ micro enterprises in fisheries sector based on the suitability of location

No	Fishery based micro enterprise	Rank
1.	Preparation of Value Added products in Fisheries	I
2.	Preparation of Dry Fish products	III
3.	Fish Processing Unit	II
4.	Ready to eat fish products	V

5.	Ready to cook fish products	VI
6.	Ornamental Fish culture enterprise	VII
7.	Mussel culture	IV
8.	Clam collection	IX
9.	Edible oyster culture	VIII
10.	Pearl culture	XII
11.	Mud Crab culture	XI
12.	Any other	-
Agriculture based micro enterprise		
1.	Vegetable cultivation	II
2.	Ornamental Gardening enterprise	VI
3.	Floriculture	VII
4.	Kitchen garden	I
5.	Orchards	XII
6.	Fruit products	VIII
7.	Fruit Processing	X
8.	Snacks bar	IX
9.	Catering Unit	IV
10.	Bakery Unit	XI
11.	Cereal Pulverizing Unit	V
12.	Sericulture Unit	XIII
13.	Any other : Planting mangroves & acacia trees	III
	Allied sector micro enterprises	
1.	Soap unit	X
2.	Clothes unit	XI
3.	Garments	XII
4.	Wood – Stone carpentry	IV
5.	Computer centre	V
6.	Cattle unit	I
7.	Poultry unit	II
8.	Hand weaving	XIII
9.	Candle unit	VI

10.	Chalk Unit	VII
11.	Umbrella Unit	VIII
12.	Foam Bed Unit	IX
13.	Bamboo based handicrafts	III
14.	Firewood	XIV

Certain important facts will be revealed as the consequences of Coastal Zone Development when gets practically materialized through SHGs'.

Clam processing SHGs in Pookaitha

- Since the empowered SHGs' assist the members by undertaking thrift-credit activities through own savings and loans from banks though suitable micro enterprises, they adequately earn and make the members capable to stand in their own legs.
- Since the problems faced by the members are being presented and resolved on consensus every week, in the SHG meetings, they become able to exist with extreme protection feeling and mental health built by wholeheartedness developed through this coordination.

Training of SHGs in Pookaitha in Clam processing

- Women's savings have a profound influence on the family safety and set up. The self-confidence that they can also work for the welfare of their family can be built up through these Self Help Groups.
- Since the SHGs' meet every week, all the members get a very good grasp about the beneficiaries in the respective locality and thereby making the election process of beneficiaries very transparent.
- The beneficiaries can be persuaded to utilize the eligible benefits for the purposes for which those were intended.
- Self Help Groups created a remarkable change in the social responsibility feelings for the fisherfolk. The incidents in which certain women SHGs' significantly contributed to the disaster relief funds are the clear-cut examples of the transformations created by economic empowerment.

Women SHG in Seafood kitchen in Poyya

- Irrespective of the political / religious restrictions, the ways by which Self Help Groups started taking lead role in cultural activities like celebrating special days, organizing common action programmes with involvement of cultural leaders, conducting arts and games competitions and literacy classes etc. are the examples of social responsibilities of Self Help Groups.
- These SHGs' as the symbol of 'collective cooperation' can function as an informal bank in front of home, a genuine friend in emergencies, a protector from exorbitant interest for loans etc.

Fertifish SHG in Engandiyoor

- Based on the thrift deposits generated by an SHG, constituted with exact norms and standards, clear cut rules and regulations, the fisherfolk can come forward to identify suitable income deriving micro enterprises with the effective utilization of loans available from banks and other financial institutions and thereby escape from the 'permanent debt trap' for ever.

Seaweed farming in Mandapam

Mussel farming SHG in Kadalundy

From the light of experiences, it can be stated undoubtedly that, by solving common problems of coastal sector such as literacy, drinking water, lack of health and sanitation, housing/ shelter with extreme cooperation and commitment, the fisherfolk can improve the 'local economy' of the SHG and progress towards prosperity through empowerment of SHGs' based on participation.

Fish cold storage SHG in Aroor

Fish drying SHG in Thuravoor

Gender Mainstreaming and impact of SHG based fishery enterprises for livelihood security in Coastal India

Similarly in another research study on Gender mainstreaming and impact of SHGs emphasized on selected 750 'Self Help Groups' in Gender mainstreaming in marine fisheries sector, an assessment of the level of performance and extent of empowerment through appropriate indices of measurement from 25 nos. of fishery based micro enterprises from Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Odisha was undertaken. In this study, identified the relevant fishery based and allied sector micro enterprises catering to the location specific needs of the SHG members and imparted 45 Entrepreneurial Capacity Building (ECB) Training programmes on the identified micro enterprises by appropriate HRD intervention programmes and organized 120 fisherfolk interaction meets.

Fish Drying SHG in Aroor

Prawn Peeling women group in Alappuzha

Data were gathered with standardized protocols, scales and indices developed in Mararikkulam, Thannermukkam, Kumarakom, Vadakkekkara, Vallikkunnu and Kasaba in Kerala, Bengare, Surathkal and Ullala villages of Dakshina Kannada district in Karnataka and Pampan, Rameswaram, Thankachimadam and Mandapam locations in Tamil Nadu and Arakuda and Astaranga villages in Puri district of Odisha for standardization.In Andhra Pradesh, farmer interaction meets and video documentation were conducted for women SHGs of Bandarvanipetta of Sreekakulam district, Chinthappaly of Vijayanagaram district and Pudimadakka, Lawson's bay and Jalaripetta of Visakhapatnam district assessed the impact of SHGs. Documented 200 success cases on ECB of SHGs with special reference to gender perspective. Brought out 20 movies as Gender Mainstreaming series on Impact of SHGs, (Table 2) one book on, Gender Mainstreaming and Impact of SHGs in Marine Fisheries Sector and one Interactive Multimedia on Gender Mainstreaming and SHGs: A cyber extension package.

Cage farming by SHG in Edavanakkad

Training of SHG in Lakshadweep

Table 2: Fishery based Enterprises and details of SHGs covered are given in Table

Sl. No	Enterprise	Number of SHGs	Avg. Level of Performance	Avg. Empowerment Index
1	Fertifish unit	15	72.75	0.82
2	Chinese dip net	10	79.16	0.89
3	Aqua-tourism	8	78.92	0.88
4	Fish Aggregating Devices	10	79.95	0.89
5	Hand picking fishing unit	15	50.11	0.65
6	Clam processing	75	56.33	0.67
7	Pickling unit	75	72.26	0.83
8	Fish drying	60	69.95	0.78
9	Dry fish & fresh fish procuring	45	79.53	0.87
10	Fish vending /selling	70	69.16	0.78
11	Mussel culture	50	75.95	0.84
12	Prawn culture	30	59.61	0.69
13	Quarry fish culture	16	78.75	0.89
14	Cage farming	27	72.23	0.82
15	Ornamental fish culture	49	63.5	0.74
16	Fish culture	30	65.5	0.76
17	Paddy cum fish culture	30	74.91	0.83
18	Seaweed farming	30	77.63	0.86
19	Fish Amino units	10	75.35	0.84
20	Ready to Eat Fish Products	15	74.36	0.83
21	Ready to Cook Fish Products	20	71.35	0.81
22	Crab Processing	15	68.34	0.77
23	Aquaponics	5	70.21	0.61
24	Bivalve collection	30	69.16	0.77
25	Fish feed production	10	59.25	0.61

Irrespective of the enterprise, the selection or identification of the fishery based micro enterprise is the crucial and major deciding factor according the technical viability and economic feasibility. It varies from time to time, from place to place, from situation to situation and from occasion to occasion. The economic feasibility analysis of these enterprises representing the indicative economics such as profitability, B:C ratio, Market Potential, Break Even Point, Pay Back Period etc. have been worked out through Business Plans developed under the project and these business plans can be used as a practical manual for implementing the appropriate fishery microenterprise based on the scope and opportunities. (Vipinkumar *et al,* 2017, 2018) This paper is a pertinent effort to make an overview of some viable micro enterprises through community participation and Self Help Group mobilization for rural livelihood enhancement, particularly in the fisheries sector and an analysis of livelihood options of fisherfolk. Paper also focuses on rural mobilisation through Self Help Groups as an inevitable requisite for poverty eradication in a developing country like India. How a meticulously mobilized SHG with an appropriate micro enterprise in fisheries, agricultural or allied sectors can progress towards prosperity within a short span of time is also depicted. A study undertaken on livelihood analysis showed the priorities on fishery based, agri-based and allied sector based micro enterprises based on the preferential ranking as per suitability. These prioritized micro-enterprises identified based on the suitability of the SHG through livelihood analysis in turn can bring about a desirable impact on technological empowerment in the coastal fisheries sector to a great extent.

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14

Responsible Fisheries in India

Ramachandran C
Socio-Economic Evaluation and Technology
Transfer Division, CMFRI

The concept of Responsible Fisheries can be considered as a set of guidelines for ensuring sustainable utilization of fisheries resources of the world. In that sense, it is synonymous with the FAO Code of Conduct for Responsible Fisheries (CCRF). The Code is often referred to as the Bible of Global Fisheries Management.

The CCRF is an international policy instrument for fisheries management. This was developed and released by Food And Agriculture Organisation (FAO) functioning under the United Nations on 31 OCTOBER 1995. The code was developed after a series of international deliberations that began in 1992. More than 160 countries, including India are signatories to this international instrument. The Code is considered as a landmark document symbolizing the international consensus achieved on the necessity for providing guidelines to ensure.

The most salient feature of this global instrument is its **voluntary** nature.

Foundations of the Code

That the sustainability of marine capture fisheries at the current level of harvesting is at stake is no longer a moot point. It is being realized that fisheries anywhere in the world is more a socioeconomic process with biological constraints than anything else. The open access nature of the resource coupled with unregulated penetration of advanced, but not necessarily eco-friendly, harvesting technologies (a phenomenon called

technological creep) has enacted a virtual "tragedy of the commons" in our seas. Making the issue still more complex, especially in the context of the Millennium Development Goals, is the rampant poverty existing among our fisher folk though the capture fisheries makes significant foreign exchange contribution in our country. The plateauing of the resource as revealed by recent trends in landings doesn't augur well for the ecologic and economic sustainability of the marine fisheries sector.

If there are no technological magical bullets for the current impasse what is the way out? This is precisely the question the FAO code is trying to answer. "*The right to fish carries along with it anobligation to do it responsibly*" is the cardinal principle of the code. This principle is built on the foundation of what is known as a **Precautionary Approach.**

Precautionary approach, which originally was proposed as Principle 15 of Agenda 21 the Rio Earth Summit meeting in 1992, enunciates that
"*where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*".

While in simple terms the precautionary approach means "better safe than sorry", it clearly recognizes that changes in fisheries systems are only slowly reversible, difficult to control, not well understood, and subject to changing environment and human values.

It involves the application of prudent foresight. It is about applying judicious and responsible fisheries management practices, based on sound scientific research and analysis proactively rather than reactively to ensure the sustainability of fishery resources and associated ecosystems for the benefit of future as well as current generations.

Taking account of the uncertainties in fisheries systems and the need to take action on incomplete knowledge, it requires, *interalia:*

a. consideration of the needs of future generations and avoidance of changes that are not potentially reversible;

b. prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly;

c. that any necessary corrective measures are initiated without delay, and that they should achieve their purpose promptly, on a timescale not exceeding two or three decades;

d. that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource;

e. that harvesting and processing capacity should be commensurate with estimated sustainable levels of resource, and that increases in capacity should be further contained when resource productivity is highly uncertain;

f. all fishing activities must have prior management authorization and be subject to periodic review;

g. an established legal and institutional framework for fishery management, within which management plans that implement the above points are instituted for each fishery, and

h. appropriate placement of the burden of proof by adhering to the requirements above.

The reversal of burden of proof means that those hoping to exploit our marine resources must demonstrate that no ecologically significant long-term damage will result due to their action. Or in other words human actions are assumed to be harmful unless proven otherwise.

Contents of the Code

The code provides a necessary framework for national and international efforts to ensure sustainable exploitation of aquatic living resources in harmony with the environment. It is achieved through **12 articles** covering areas like

a) Nature and scope of the code (article 1)
b) Objectives of the code (article 2),
c) Relationship with other international instruments (article 3),
d) Implementation, monitoring and updating (article 4),
e) Special requirements of developing countries (article 5),
f) General principles (article 6),
g) Fisheries management (article 7),
h) Fishing operations (article 8),
i) Aquaculture development (article 9),
j) Integration of fisheries into coastal area management (article 10),
k) Post-harvest practices and trade (article 11), and
l) Fisheries research (article 12).

(The full text of the FAO CCRF (hereafter referred to as the Code) translated into Malayalam was published by CMFRI in 2002 under an agreement with the FAO (Ramachandran, 2002). Thus, Malayalam became the second language, after Tamil, to have a translated version of the most important international fisheries management instrument. You can access it at www.cmfri.org.in. The pdf of the English full text is supplied with the Winter school CD rom).

Characteristics of the Code

As we have seen, the most salient feature of the code is that it is *voluntary* in nature. Unlike other international agreements like UN Agreement to Promote Compliance with International Conservation and Management Measures by Fishing vessels on the High Seas or the Straddling Stock Agreement, 1995, it is not legally binding and violation of the code cannot be challenged in a court of law.

A **fundamental objective** of the Code is "to serve as an instrument of reference to help states to establish or to improve the legal and institutional framework required for the exercise of responsible fisheries and in the formulation and implementation of appropriate measures." The policies of the state for managing the fisheries resources should be based on the provisions of the code.

Implementation of the code is primarily the responsibility of states. The code will require regional and sectoral implementation in order to address the particular needs of fisheries in different regions or sub-sectors.

Relevance of the Code

The most important problem a fishery faces is what is known as Over Fishing. It takes place over time as the fishing is intensified. It is the stage where a stock of fish loses its capacity to keep on providing the Maximum Sustainable Yield. It is at this stage that the fishery is at the verge of an almost irredeemable loss, economically and biologically. MSY is like a *Laxman Rekha*. The most frightening aspect about this *Laxman Rekha* is that we need to cross it to realize that we have trespassed it. Hence we can build our defense against the specter of overfishing only on the basis of a stronger understanding and contextual analysis of its symptoms.

Will our waters also witness collapses like that of the Canadian Cod? That such a tragedy has not happened so far is not a guarantee that it will not happen here. But we have a better sense of optimism thanks to the resilience of our marine ecosystem which is mainly due to the rich bio diversity. However, we need to be concerned if recent events like pelagic fatigue in Kerala are of any indication. The decline experienced by our fishers vouch for a serious rethinking on our laid back attitude. Our fishers also share the veracity of different ways in which symptoms of overfishing are being manifested. They are:

a) severe decline or total absence in those fish which used to be abundant,

b) decline in the size range of major species ,
c) excessive catch of juveniles,
d) increase in fishing time and distance,
e) frequent fluctuations in the total catch, and
f) changes in species composition.

Our Tool Box

There are five types of remedies for the disease called "over fishing".

1. Based on the total catch of the fish (yield or Output)
2. Based on fishing effort or input
3. Based on time or season (temporal)
4. Based on space or depth (spatial)
5. Based on technical things

A typical example of the first type of remedies is the Quota system of fisheries management which is common in countries like EU, USA. This demands the assistance from a very precise stock assessment science. These measures which are similar to rationing of the catch, can be considered as the last ditch effort feasible in areas of lower species diversity that makes determination of MSY much less cumbersome. The second type of measures aims rationalizing the fleet size. Licensing based on an optimum fleet size is an example here. The next type of measures based on time and space is well known to us through the Monsoon Trawl Ban. Other examples are Marine sanctuaries, and no- fishing zones. Technical measures include Mesh size regulations, and Minimum legal size.

(For an overview of the status of the tool box (interpreted in a slightly different mode) in our context see Shinoj and Ramachandran 2017).

As long as a fishery remains a common property resource, a regulated fishery is more profitable than an unregulated fishery in

the long run. Our fishers have started accepting this truism. But they are helpless to avoid competitive fishing due to two main reasons. One is the increase in fuel cost. And the other is the high demand for fish which has led to a situation where you are economically rewarded whatever be the catch. So fishers tend to do indiscriminate fishing. This has resulted in an illusion of super abundance which again drives more fishing effort. This is leading to a very dangerous situation. There are fishers (like Mr Jossy Palliparambil, Munambam Kerala) who characterize this ugly scenario as a phase of "Foolish Fishing". It is high time each fisher take more care in analyzing the fluctuations observed in the economics of their operations.

The Code and CMFRI Initiatives

Our fisheries have undergone tremendous changes during the past six decades. Before the advent of modernization, (motorization, mechanization, refrigeration, export orientation and transportation) the access to sea was limited to a few skillful and adventurous people who were by birth fishers. The community could afford to have self-regulations oriented towards resource conservation which were arrived through the ecological experience of the community over generations. These concerns were institutionalized too. An example of such an institution still, surprisingly, surviving in Kerala is the *Kadakkody* of the Malabar coast (Ramachandran,2006). The self-regulations and community regulations which were rooted in the traditional wisdom have given way to technological skills. These skills, unleashed by what we generally refer to as an era modernization, most often take a dehumanized manifestation thus weakening the hold of the community. This is where the crucial role of the State comes into play in the management as well as development of the fishery. This is better known as fisheries governance.

Fisheries governance is dependent on the particular stage of economic development and local ecological status of the fishery

resources. This varies with each country. It is because of this contextual nature that the Code has been made as a voluntary tool. Each government is free to make its own rules, regulations and strategies based on the guidelines and principles elaborated in the Code. Thus article 4.3 says "FAO through its competent bodies, may revise the code, taking into account developments in fisheries as well as reports to COFI on the implementation of the Code. (But in recent times an argument against this position has also emerged).

It is in this context that the actions and initiatives being taken by CMFRI, mainly through an NATP funded research project titled "Designing and validation of communication strategies for responsible fisheries –a co-learning approach" become relevant. A Responsible Fisheries Extension Module (RFEM), which consists of 13 tools including a Malayalam translation of the code, animation films in all maritime languages etc. developed have been widely used to create awareness among the fisherfolk. A state-wide campaign on Responsible Fisheries was launched and the RFEM was released for further scaling up by the respective State Fisheries Departments. These mass communication tools have the potential to reach almost 85 % of the fisher folk and other stakeholders in the country. It is reasonable to conclude that CMFRI has made a pioneering initiative in the cause of popularization of the concept of Responsible Fisheries in India (Ramachandran, 2004)

There is now widespread scientific consensus on the ecological impacts of continued over-fishing and the threats to seafood security and broad agreement on policy issues such as curtailing illegal catches and minimizing the impacts of fishing on marine ecosystems. The basic requirement for adoption of Ecosystem Approach is a dynamic knowledge base on stock assessment. The stock assessment knowledge base generated and continuously maintained by CMFRI is a unique achievement among the developing tropical context countries.

Though the communication tools and strategies already developed by the institute have been useful in creating awareness on the need for sustainable /responsible fisheries there is a need to develop and scale up specific communication interventions to sensitize the stakeholders in making a transition towards ecosystem based approaches that ensure responsible management of our waters. Fisheries management is fisher management and participatory approaches informed/initiated by a proactive research system taking place in a democratic and decentralized civil society space is globally accepted as the key to Ecosystem Based Fisheries Management. The future is decided by the capacity we build today amongst the different stakeholders responsible for sustainably utilizing the marine fisheries resources of our country. It is with this objective that we are continuing the efforts in this line through innovative research projects in Capacity Development for compliance to Ecosystem Based Responsible Fisheries Management in India through Co-Learning and Multi-disciplinary action research under the leadership of Extension scientists in CMFRI.

Pathways before us

Engendering a scientifically informed fisheries management governance system is the need of the hour. As recent events like the Kochi Initiative (Ramachandran and Mohamed 2015) is of any indication, formation of multi stakeholder platforms of responsible fisheries co-governance is not an impossible task in our context. The response of the State in facilitating this transition is essential. With the landmark promulgation of insisting Minimum Legal Size for 55 species of fish by the Government of Kerala (GoK,2017) done based on the recommendation of CMFRI (Mohamed et al 2014), the State of Kerala has shown an instance of proactive engagement with responsible fisheries governance which is worthy of emulation by other maritime states. It is however, worth remembering that regulatory measures like MLS would become impotent in the absence of strong arm efforts to eliminate (or at least rationalize) external drivers like demand for the juveniles

either for reduction or consumption. As scholars of regulatory politics argue, legislative coercion though necessary cannot be open to tendencies for inefficient rent seeking in a public good.

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15

Economic performance of cage fish farming

Aswathy N
Socio-Economic Evaluation and Technology Transfer Division, CMFRI

Introduction

Mariculture has the potential to augment production and incomes through coastal as well as open sea farming. The global aquaculture production increased by about 25 times in the last 30 years when compared to only seven times increase in capture fisheries production during the corresponding period. Mariculture systems include in-shore and off-shore and maintain a constant high saline water conditions. In-shore mariculture systems include clams, oysters and other molluscs, which are wild-caught or hatchery-reared seed grown on the sea floor or on suspended nets, ropes, or other structures. Off-shore mariculture refers to large intensive fisheries in off-shore fish pens.

India has vast areas of coastal waters, lagoons and bays which can be utilized for mariculture. Seed production and culture of marine finfishes has been expanding in the recent past in many parts of the world, but in India, it is only an emerging sector. The potential cultivable candidate finfishes are groupers, cobia, rabbitfish, seabass, pompano, snappers and sea bream. Lack of availability of hatchery-produced seed on a commercial scale is the major bottleneck for large-scale marine finfish farmingand hence, development and standardization of seed production techniques for a few commercially important species is gaining importance.

Indicators of Economic performance

The economic performance of any mariculture activity can be assessed by working out the following cost and return indicators and financial feasibility indicators (Narayanakumar, 2009, Sathiadhas&Narayanakumar, 2010).

Table 1. Indicators of economic performance of a mariculture enterprise

Sl.No.	Economic Indicators
1.	**Initial investment** a)Fixed installations b) Major accessories c) Minor Accessories d) Others
2.	**Total Investment**
3.	**Fixed cost** a)Depreciation b) Interest on Fixed capital (12%) c) Administrative expenses
4.	**Total Annual Fixed cost (A)**
5.	**Operating costs** a) Cost of seeds b) Cost of feeding and other labour charges c) Interest on working capital (6%)
6.	Total Operating or Variable cost (B)
7.	Total cost of production [Row(4)+Row(6)]
8.	Yield of the fish variety (in kg)
9.	Gross revenue [(8) * Price per kg]
10.	Net income [(9)-(7)]
11.	Net operating income [(9)-(6)]
12.	Cost of production (₹/kg)[(7)/(8)]
13.	Price realized (₹/kg) (9)/(8)

The economic indicators of cage farming varies with cage size, species of fish, stocking density, quantity and cost of feed, expenses for cage maintenance, survival rate, yield and prices of fish. Based on the experimental cage farming demonstrations, CMFRI has recommended6m dia HDPE cage for commercial cage farming in the maritime states of the country. The initial investment for 6m dia HDPE cage frame with mooring and accessories in the open sea is ₹3 lakhs. The annual fixed cost is calculated from depreciation and interest on fixed capital(Table 2).

CMFRI has standardised culture of Asian seabass, cobia and silver pompano in different types of cages in the marine, estuarine and brackishwater areas with good economic returns (Rao *et al.*, 2013). The indicative economics of cobia farming in 6m dia HDPE having an average yield of 2.4t realised a net profit of 3.44 lakh per cage.Sea cage farming of cobia proved to be an economically viable technology generating an internal rate of return of more than 60% and benefit -cost ratio of more than one calculated for a project period of 7 years with 15% discount rate. The culture of seabass in HDPE cages of 6m dia in the open sea yielded gross revenue of ₹10 lakhs and net profit of ₹5.59 lakhs within a culture period of 7 months. (Table 2).

Table 2. Economic performance of open sea cage farming of cobia and seabass (in ₹)

Cage dimension: 6 m dia x 5 m depth

Culture period: 7 months

	Particulars	Cobia	Seabass
I.	**Annual fixed cost (A)**	83429	83429
II.	**Operating costs**		
1.	Cost of 1000 numbers of cobia seeds @ ₹25/seed or 3000 no of seabass seeds@ ₹30/seed	25000	90000
2.	Feed cost	200000	200000
3.	Labour Charges	42000	42000
4.	Boat Hire & Fuel Charges	10000	10000
5.	Miscellaneous Expenses	15000	15000
6.	Total operating cost (B)	292000	357000
7.	Total cost(A+B)	375429	440429
III.	**Returns**		
8.	Production	2.4 tonnes	2.5 tonnes
9.	Gross revenue @₹300/kg for cobia and @₹400/kg for seabass	720000	1000000
10.	Net profit	344571	559571
11.	Cost/ kg of fish(₹)	156	176
12.	Price/ kg of fish(₹)	300	400

Economics of coastal cage farming

The major species suitable for culture in the brackish water are Asian seabass (*Latescalcarifer)*, pearlspot (*Etroplussuratensis)*, tilapia(*Oreochromis sp.*), mullet (*Mugil*cephalus.), red snapper and caranx. The economic performance of cage farming for different cage dimensions and species of fishes were calculated for comparing the profitability. Composite farming of seabass along with pearlspot was found to be more profitable than farming of

single species. Based on economic feasibility, CMFRI has recommended square GI cage of 4x4x3m^3(48m^3) for the coastal waters. However cage dimensions adopted by the farmers varied depending on the depth of water, ease of operations and resource availability. A standard 48 m^3 cage with a recommended stocking density of 1500 numbers of seabass along with 500 numbers of pearl spot yielded gross revenue of ₹6.27 lakhs and net profit of ₹3.28 lakhs in a 7 months culture period (Table 3).

Table 3.Economics of composite culture Sea bass with Pearl spot
(Cage Dimension 4x4x3 m^3 (48m^3)
Culture period: 7 months

Particulars	**Amount(₹)**
Capital investment	85000
Operational costs	
License fee	1500
1400 seabass seeds @ ₹30/seed	42000
Pearlspot seed @500nos@₹15/seed	7500
Nursery rearing (Hapa)	2000
Feed(Trash fish/ floating feed)	156700
Labour	42000
Harvesting and miscellaneous expenses	20000
Total operational cost(B)	271700
Total cost(A+B)	298900
Returns	
Production((kg)	1567kg
Gross revenue(@₹400/ kg of fish)	627000
Net profit	328100
Cost/ kg of fish(₹)	191
Price/ kg of fish(₹)	400

Marketing& challenges for cage farming

The cage farmed fishes are marketed either directly at farm gates, through local markets, fish harvest melas, live fish sales or online sales. With limited supply of fish and huge demand for quality fishes,at presentthere are no marketing constraints. However with more and more famers adopting cagefish farming may lead to decline in prices. The farmers can be trained for developing entrepreneurial skills or form co-operativesor farmer producer companies to initiate the exports orundertake domestic marketing on a commercial scale. The major constraints faced by cage farmers include poor water quality, changes in water currents due to flood or extreme climatic events, water pollution, damage to nets by rodents and mussels, financial constraints and non-availability of quality seeds. With adequate policy back up for the establishment of mariculture enterprises in the open waters, the seacage farming is expected to contribute substantially for increasing fish production and generating income and employmentto thecoastal population.

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16

Entrepreneurial Motivation

Reshma Gills
Socio-Economic Evaluation and Technology Transfer Division, CMFRI

The importance of fisheries sector in Indian economy is well reflected with its contribution in India's Gross Domestic Product (1%), creation of gainful employment and livelihood support to more than 14 million people and input in total exports of the country (10%) (NFDB, 2019). The national umbrella scheme of 'Blue Revolution' for integrated development and management of the fisheries arestarted to reap the foreseen resource potential and possibilities in built in it (PIB, 2019). Owing to the Skill India initiatives it is very important and time relevant to impart knowledge about the different start-up options and motivating the youth population to be a job provider instead of holding the age-old name tag job seekers after their education. Achieving a healthy blue economy in the country it is important to strengthen the entrepreneurship initiatives in aquaculture sector including marine and inland sectors through vocational training and education (Nandan, 2017; Yasin and Dwivedi, 2003).

Well, all these are factual information.
What do you feel about your job future? Do you feel that you would be getting a better or best job in the sector in which you have done specialization? Do you have any plan to make the skill gained in this vocational education system as a tool to make your own careers?? I assume, you might have asked yourself all these questions in many times… Did you get an answer? Or still searching to find a fine solution for it?

Yes, you might have heard about many job options after this course. Did you ever think that you will be become your own boss or you would be boss for many other people in your future work field? I hope this might be the notion which had created many philanthropists like Bill Gate, Ratan Tata, Azim Premji etc. in the world. They are called the real entrepreneurs-who could able to detect and sense the availability of different opportunities and who could utilize these opportunities to create profit and who could able to provide a livelihood option to many folds number of people all around the world. According to Peter Druker (1985) who is known for his works related to entrepreneur and entrepreneurship –'the entrepreneur always searches for change, responds to it, and exploits it as an opportunity." We can say that entrepreneurship is not a mere business activity, it's a mindset integrated with a behaviour of seeking opportunities, taking risks beyond security and having the stubbornness to push an idea through to reality by different way of actions.

Do you ever thought what inspired them to think differently? Do they have any supernatural power to work so?Why do they do what they do?

Many factors and many explanations may be there…External and internal…we can call those factors as motivators. Let's have some discussion about motivation and motivators.

What is motivation?

Many scientists define motivation as persons general readiness to do something. It is the set of external and psychological powers that compel you to take action in a particular direction. Yes, that's nice and all, but we can see many writers defined motivation in different ways. The most acceptable definition and the explanation was given by Abraham Maslow (1943)in a paper "A Theory of Human Motivation" which was published in *Psychological Review*. In that Maslow explained the factors which force a man to do things in the next best level in which he stands now, with the help

of hierarchy of needs is portrayed in the shape of a pyramid with fundamental needs at the bottom and the need for self-actualization at the top.

Fig1: Maslow's hierarchy of needs

Picture source: https://www.verywellmind.com/what-is-maslows-hierarchy-of-needs-4136760 (Adopted for illustrative purpose only)

Every person who stands in the lower level is trying to reach next higher level after satisfied the felt needs of the present level. This is how the motivation works. More precisely we can tell that motivation is behaviour over time which passes through the following basic phases.

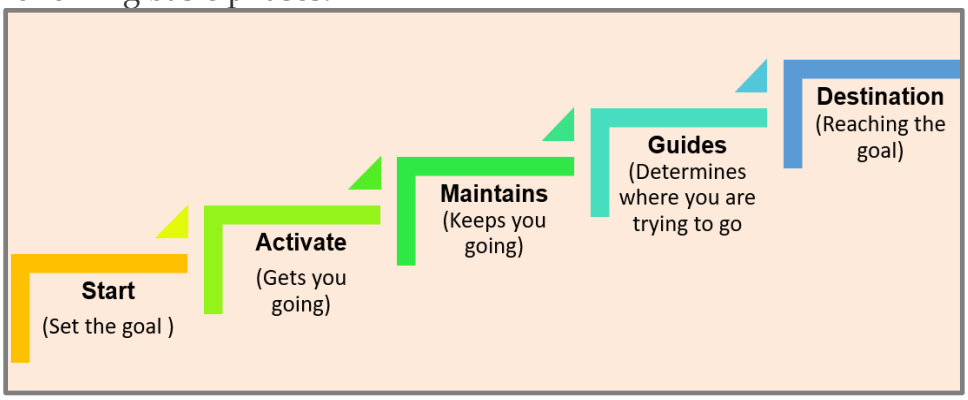


Fig 2: Phases of motivation

Types of Motivation

As we discussed earlier for achieving any goal set buy a man many factors may motivate him. Some of these are innate to person and some others are induced. Depending on the locus of control motivators are of two types; 1. Intrinsic Motivation and 2. Extrinsic Motivation

Intrinsic Motivation	Extrinsic Motivation
• This is an internal locus of causativeness. • Student involved in activities or works by own wish. • It can see even in the absence of extrinsic reward or purpose. • The strong inner desire drives them to do things. • The main feeling will love to work or love to study • Pride, Interest, achievement curiosity etc. are main characteristics	• This is an external locus of origin. • Student involved in activities to receive prize or please another person or avoiding punishments some other reason other than personal preference • It does not have the inner love to do work • Compulsion, Punishment etc. (Stick) or rewards, money, praise etc. (Carrot) pushes them to do work

Well, where do you stand? What about the so-called business tycoons or entrepreneurs? Is it sole intrinsic or some degree of combination of both?

Yes, it's a combination of both which gives a synergistic effect in action and called as achievement motivation.

Achievement motivation: Few insights

Before jumping to theoretical aspect, can I ask a question?

How many of you have stopped your efforts to get 'A' grade in Physics (As I was told that you are much afraid of physics than any other subjects) but it just because you were failed two times?

Fine, I will tell a real-life story of a man who made success after a failure of 1009 times. He is a seventh grade dropped out, who tried many endeavours in life but not tasted a victory till his late 40s. He wanted to be an owner of a restaurant with this dream he started to sell chicken at his age of 40. In order to achieve the dream goal, he tried to franchise his restaurant with the unique recipe for making tasty chicken. His recipe got rejected umpteen times (1,009 times) before its acceptance. After the ignition it became a huge hit in the world with its presence in more than 22,621 locations. Its none other thanColonel Harland David Sanders the creator of the 'Kentucky Fried Chicken' (KFC).

Can you imagine a failure of 1009 times in any of the attempts which you are making? Many time people used to quit after the fist sip of failure. But the inspiring story of Sanders gives the lesson that 'you can make success despite the countless failures, if you try hard and believe in yourself with a well-directed goal'. He is an entrepreneur who made success with his achievement motivation.
Back to our topic !!!!

What you mean by achievement motivation?

One of the very fine definition as '*Achievement motivation is affect in connection with evaluated performance in which competition with astandard of excellence was paramount*' (McClelland, Atkinson, Clark, & Lowell, 1953).
Can we identify a person with achievement motivation? Yes, we can !!!!!

As evident from the story of Sanders, great achievers generally show the following characteristics.

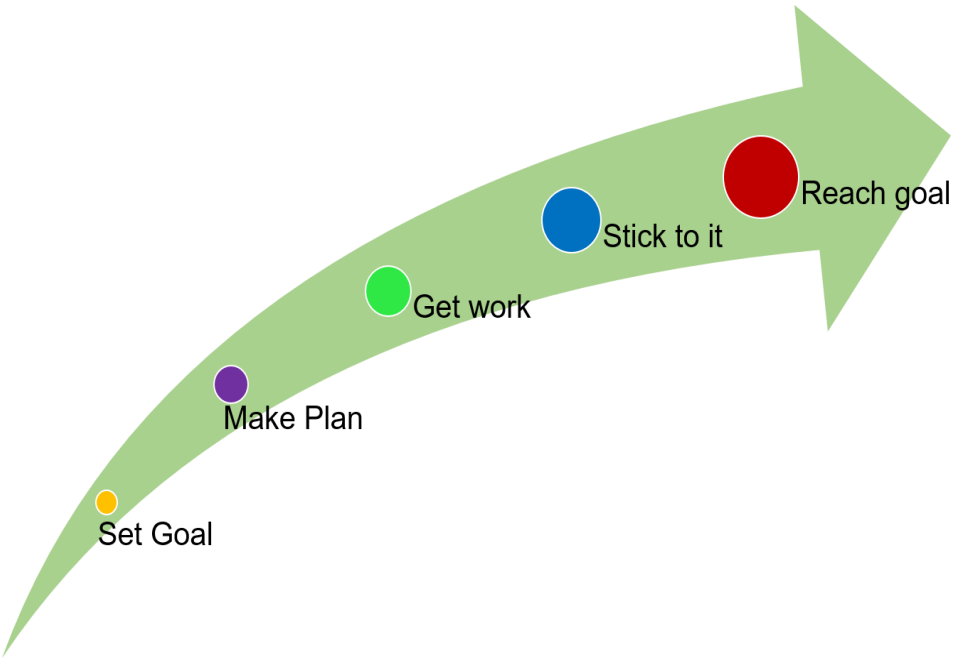
- They like situations in which they take personal responsibility for finding solutions to problems
- They are moderate risk-takers rather than high or low risk-takers
- Acceptance of feedback for improved performance
- Often tend to be leaders and not team players
- More creative and innovative
- More adaptable with change
- Persistence in action
- Strong purpose for success and a weak fear of failure

Many research works have been conducted in this area.

Let's consider our own class, say for example physics class…. How you are studying? What motivated you to study or not to study? Look at the following table.

	1	**2**	**3**
My goal	I want to learn physics as much as possible from this class/ session	I want to secure more marks than my friend who is outperforming.	I just want to avoid my teachers scolding and getting the tag of poor performer
Motive	*The desire to lead in the subject and knowledge (intrinsically motivated)*	*Compared to others performance a person set his goals (Competitive motives)*	*Goal set to avoid criticism or negative judgements.*
Achievement type	Mastery	Performance approach	Performance avoidance

In which column you are standing (1,2,3)? If you stand on 1 and 2, you are a high achiever. Otherwise you can be a low achiever. For excellence in work or study it is preferable to be a high achiever. In the case of every successful entrepreneur, the mastery and Performance approach are generally over performing the performance avoidance. Edwin Louis Cole(1993) in his famous book entitled **"Winners Are Not Those Who Never Fail, But Those Who Never Quit"** rightly pointed that man's character cannot be developed in ease and quiet. Its all through the experience. Experiences make strengthened personality, with clear vision and inspired ambition which ultimately lead to success. Try to learn from each experience that you get from your life to make gaols with achievement motivation. Follow the easy steps listed below for achieving the goal in your life;



Be the change you want to see in the world!!!!!

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17

An introduction to Seaweeds

Athira P V
Socio-Economic Evaluation and Technology
Transfer Division, CMFRI

Seaweeds are macroscopic marine algae, form one of the important living resources of the ocean.

The geographical distributions of seaweeds is very extensive and are found mainly in Chile, Japan, India, Sri Lanka, Indonesia, Brazil, Madagascar, Vietnam, Philippines, North Korea, Taiwan and South Africa. A total of nearly 700 species of marine algae have been recorded from different parts of Indian coasts, of these about 60 species are commercially important.

Classification

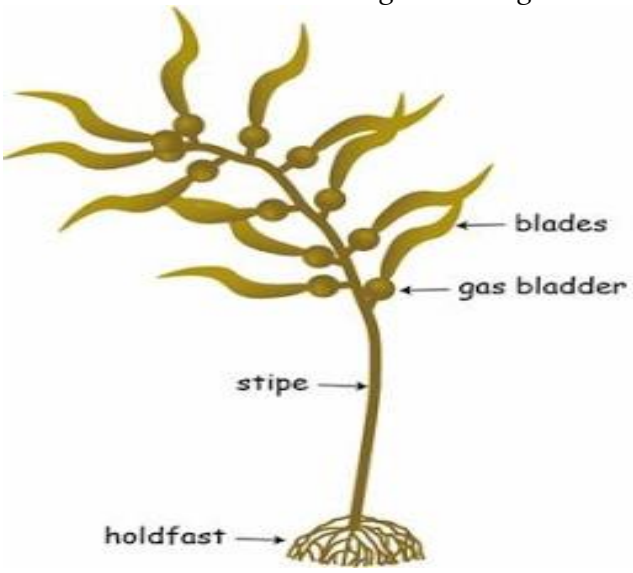
Seaweeds are of three types based on the presence of pigments; green (Chlorophyta), red (Rhodophyta) and brown (Phaeophyta). Greens have chlorophylls a and b, and reds have chlorophylls a, and browns have chlorophylls a and c. Reds have accessory pigment phycoerythrin that gives them distinct red color while browns have accessory pigment fucoxanthin that gives characteristic brown color. Most important seaweeds in India in terms of ubiquitous nature are *Ulva* and *Caulerpa*among greens, *Gracilaria, Gelidiella, Hypnea* and *Kappaphycus* among reds and *Sargassum* and *Turbinaria* among browns. The coasts of Gujarat, Kerala and Tamil Nadu have most of the seaweeds described in India. The main uses of seaweeds are as foods and as the raw material for the extraction of the hydrocolloid, alginate, agar and carrageenan etc.

Caulerpa racemosa

Gelidiella acerosa

Gracilaria edulis

Sargassum wightii



Morphology

Seaweeds are made up of three distinct parts. At the lower end a root-like structure called, the holdfast, which, secures the plant to its environment. The stem-like structure called stipe on each side is attached with leaf-like structures called; blades.Some species have air-filled bladders eg: *Sargassum sp.*

Seaweed culture

Site selection: Select area with moderate to strong water currents and wave action but not strong enough to damage the farm. Site should be distant from freshwater sources as it affects salinity and seaweed growth.The water should be generally clean and away from urban waste and pollution.Keep away fromsubstrate covered with sea grass and algal beds. The site should have a water temperature of 24-30 ^{o}C and salinity of 27 to 35 parts per thousand.

Selection of seedlings

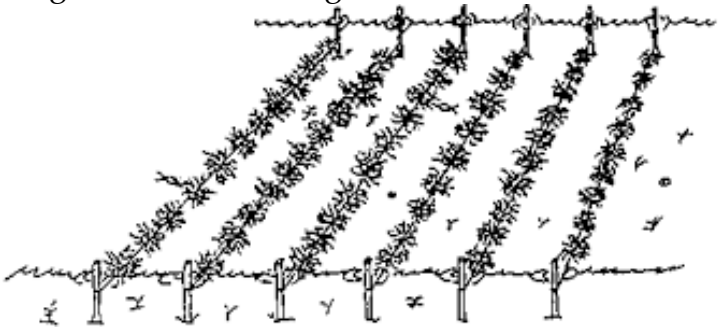
Vegetative propagation of seaweed is commercially feasible. Select seaweed with healthy branches with no signs of diseases or infection. Seedling must be smooth, slippery, and brittle, use sharp stainless steel knifefor cutting. Seedlings should be tied at the strongest point of seedling and avoid the rupturing of the branches.

Raft cultivation

Bamboo poles are preferred for raft preparation; rafts of 3x3 to 12x12 mare made with diagonal bamboo support. The depth of the sea where the rafts were placed is 0.5-1.0 m. Seaweed fragments are tied to the polypropylene-twisted ropes safely for cultivation. Plantings of approximately 100-150 g are fixed on each rope, at 15 cm intervals. To protect the seedlings from grazing, a piece of fish net is tied at the bottom of the raft. Anchors or wooden poles can be used to hold the rafts in position. Floating rafts or fixed rafts can be selected for seaweed culture.

Monoline/ longline Cultivation

In monoline culture seaweeds are grown in the main rope that is floated via buoys installed at specific intervals and ends fixed by means of anchors or wooden poles. Seaweed fragments/ seedlings are inserted on each rope. The general approach is to suspend a series of longlines of 10m in length between two wooden stakes.



Tube-net method of cultivation

In this method the seed material is not fastened with rope but held compactly, inside tube- nets having 10-15 cm dia. and mesh size of 3 cm. The algal seed material is loaded into the tube-nets with the aid of a small plastic pipe having little fewer diameters than tube-net.

Farm management

The rafts transplanted in the ocean are probable to have infestations with undesired suspended materials, drifted from different sources. In order to attain optimal production, the farmer has to visit the farm frequently, and undertake periodic cleaning of rafts and weeding of any foreign materials. The damaged rafts must be repaired to obtain satisfactory yields.

Harvest

The seedlings grown for 40-45 days attain their full growth. These rafts ready to harvest are towed ashore and the ropes are separated from raft and seaweeds are pulled out from the loops manually. The harvested crop is solar dried or the fresh crop itself procured by buyer for sap production in the factory.

Economic Importance of seaweed

Agar: Agar is a polysaccharide made up of agarose and agaropectin that had traditionally been used as a jellifying agent for foods. Agarose is a standard biochemical used by almost all molecular genetics laboratories. Agar is also used to make typical solid microbial culture medium. Major seaweeds, producing agar are called 'agarophytes', include *Gracillaria* and *Gelidiella*

Carrageenan:A high-value sulfated polysaccharide extract derived from certain species of red algae, which is used as a jellying substance. Most carrageenan is extracted from *Kappaphycussp*. Carrageenans are used in a variety of commercial applications as jelling, thickening, and stabilising agents, especially in food products and sauces. Aside from these functions, carrageenans are used in experimental medicine, pharmaceutical formulations, cosmetics, and industrial applications.

Alginic acid (Algin): The term "algin" is a generic name for the salts of alginic acid. Algin is used for sizing textiles and paper thickening textile paints and for boiler water treatment. This is the most useful colloidal carbohydrate in cosmetic industry. It is also used in the preparation of tablets and pills as granulating and

binding agents, liquor clarification in varnishes, paints, adhesives, leather polishing materials etc. Alginic acid and its salts are used as blood anticoagulants also.

Mannitol: Mannitol is an alcohol extracted from mushrooms and certain types of algae. Using in foodstuffs and as dusting powder for chewing gum as well as in the manufacture of varnishes, coatings for fancy papers and leathers, shoe polishes, soldering fluxes, and pharmaceutical products such as metal complexes and colloidal suspensions

Furcellaran (Danish agar): Based on the red seaweed *Furcellariafastigiata*, which is present along many coasts of the North Atlantic and its adjacent sea is the primary source of furcellaran**.** It is used as a substitute for agar but has found many special uses as gelling and thickening agent.

For human consumption: They are utilized as food in several countries especially in Japan, China and Korea. Seaweeds like *Porphyra, Laminaria, Undaria, Caulerpa*etc are popularly used in traditional food items and soups.

Animal feed: Seaweeds are a good source of minerals, vitamins, pigments, trace elements etc; hence they are widely used as a constituent in poultry, cattle and fish feeds. In many places in world fresh seaweeds has been used as fodder.

Fertilizers: The most established and effective use of seaweed is as a fertilizer. In coastal areas from several centuries seaweeds has been used as direct and simple manure. The large brown algae, *Macrocystis* and *Ascophyllum,* are the principal species used for manure. They are also used as soil conditioner and growth promoter because of their unusual properties.

Biofuel: Several countries including India have reported efficient conversion of macroalgae to biofuels such as bioethanol, biobutanol, biomethane and biohydrogen. Indian seaweed genera for biofuel production in India include *Ulva, Kappaphycus, Gracilaria, Gelidium, Sargassum*, etc.

Ecological Importance

Protection: Seaweeds play a major role in marine life. Seaweeds are the living, feeding, breeding and hiding places for numerous marine creatures. Seaweeds also serve as a nursery ground for many fishes, crustaceans and molluscs. Seaweed protects marine life by absorbing CO2, reducing the acidity in the water. Sea otters, urchins, and fish also find shelter within the seaweed. The seaweed is home to large and small creatures. Plankton and diatoms especially find shelter in the seaweed forests.

Food: Seaweeds form organic food molecules from CO2 and water through photosynthesis, in which they capture energy from sunlight. Similar to land plants, seaweeds are at the base of the food chain. Seaweeds produce O2 as a by-product of photosynthesis for the respiration of marine life.

Cleaners: Seaweed removes gases from the marine environment by absorbing them into its leaves. Seas with many kelp forests are healthy and clean. Thus, the organism living in the environment also is healthy.

Prevent erosion: Seaweed forest in the sea floor maintain the sand and rock from drifting away. Areas with seaweed are more constant than areas lacking seaweed.

18

Applications of Geoinformatics in Fisheries and Natural Resource Management

Shelton Padua
Fishery Environment Division, CMFRI

Geoinformatics is the art, science or technology dealing with the acquisition, storage, processing production, presentation and dissemination of spatial data or the geoinformation. Geoinformatics has been extensively used in almost all the fields of study, be it natural sciences, social sciences, archaeology, surveying, marketing etc. and you name any field of study for that matter. It shows the importance of Geoinformatics in the present world. Geographic information system (GIS) is the platform on which spatial data is collected, stored, analysed and the information is extracted. The strength of GIS is its ability to integrate data from different sources and carryout spatial analysis to arrive at meaningful conclusions which otherwise would not be possible.

We use geoinformatics for locating the potential fishing zones (PFZ), identifying and monitoring of different marine habitats, mangrove areas, oceanic variables like sea surface temperature (SST), ocean colour (chlorophyll a content), ocean currents etc. which otherwise would not be possible to collect information from such a vast area.

Geographic information system (GIS) is a tool for making and using spatial information and it is mainly concerned with location of the features as well as properties/attributes of those features. It helps us gather, analyse and visualize spatial data for different purposes. A GIS quantifies the locations of features by recording their coordinates which are the numbers that describe the position of these features on Earth. The uniqueness of GIS is its ability to do spatial analysis. GIS helps us analyse the spatial relationships and

interactions. Sometimes, GIS proves to be the only way to solve spatially-related problems and it is one of the most important tools that aid in decision making process. GIS basically helps to answer three questions; How much of what is where? What is the shape and extent of it? Has it changed over time?

Globally, on an average, GIS tools save billions of dollars annually in the delivery of goods and services through proper route planning.GIS regularly help in the day-to-day management of many natural and man-made resources, including sewer, water, power, and transportation networks. GIS help us identify and address environmental problems by providing crucial information on where problems occur and who are affected by them. It also helps us identify the source, location and extent of adverse environmental impacts. GIS enable us to devise practical plans for monitoring, managing, and mitigating environmental damage. Human impacts on the environment, conflicts in resource use, concerns about pollution, and precautions to protect public health have spurred a strong societal push for the adoption of GIS.

GIS is composed of hardware, software, data, humans and a set of organizational protocols. The selection and purchase of hardware and software is often the easiest and quickest step in the development of a GIS. Data collection and organization, personnel development and the establishment of protocols for GIS use are often more difficult and time consuming endeavours. A fast computer, large data storage capacities and a highquality, large display form the hardware foundation of most GIS. GIS software provides the tools to manage, analyse, and effectively display and disseminate spatial information. GIS as a technology is based on geographic information science and is supported by the disciplines like geography, surveying, engineering, space science, computer science, cartography, statistics etc.

In GIS, we handle thespatial and attribute data sets. Spatial data describes the absolute and relative location of geographic features while the attribute data describes characteristics of the spatial features. These characteristics can be quantitative and/or qualitative in nature. Attribute data is also referred to as tabular data. Vector and raster are two different ways of representing spatial data. Raster data is made up of pixels (or cells), and each pixel has an associated value. A digital photograph is a simple example of a raster dataset where each pixel value corresponds to a particular colour. In GIS, the pixel values may represent elevation above/below sea level, or chemical concentrations, or rainfall etc. The key point is that all of this data is represented as a grid of (usually square) cells. Vector data consists of points, lines, and polygons. The individual pointsare stored as pairs of (x, y) co-ordinates. The points may be joined in a particular order to create lines, or joined into closed rings to create polygons, but all vector data fundamentally consists of lists of co-ordinates that define vertices, together with rules to determine whether and how those vertices are joined.

As with many other systems, GIS basically works on the principle of '*GIGO*' that is *garbage in garbage out*. Hence the quality of data that you feed into GIS is very important and it determines the quality of the end products. But, when used wisely, GIS can help us live healthier, wealthier, and safer lives.
Two examples of the applications of geoinformatics on is given below.

I. Potential Fishing Zones (PFZ) Identification

PFZ are the are the possible zones of fish aggregation indicated by satellite-derived sea surfacetemperature (SST) and chlorophyll-a (Chl-a). In 1999, Space Applications Centre (SAC), Indian Space Research Organization, Ahmedabad developed the techniques to generate the PFZ advisoriesusing SST and Chl-a data.The biological

productivity is considered to be higherin regions where strong SST fronts are observed.

A front is a boundary between two distinct water masses. The water masses are defined by moving in different directions, i.e. on one side of the front the water is generally moving in one way, and on the other side of the front, the water is moving in another.The water masses on either side of a front may also have different temperatures, salinities, or densities.

In frontal regions where SST gradients are large and rapidchanges takes place in SST. The high resolution infrareddaily SST data are used to identify such regions.Apart from this, the chlorophyll data which is sensedby the satellite as ocean colour is used as a direct markerof biological productivity. Regions in which SST gradientsoccur along with a higher chlorophyll concentrationare considered to be strong potential for fishing. The figures below show the SST fronts, chlorophyll fronts and sample PFZ map.

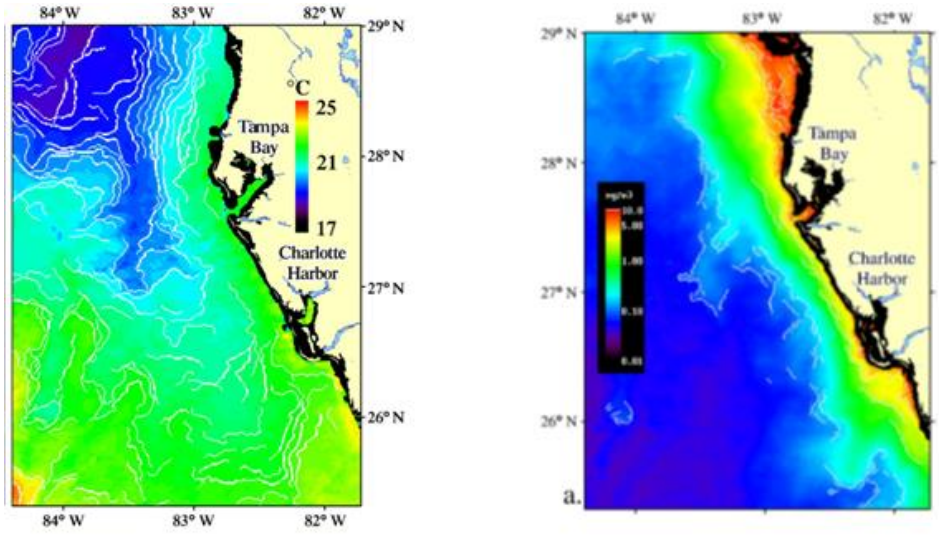


Fig 1. Satellite derived SST map showing the thermal fronts (Left) and Chlorophyll a map showing the chlorophyll fronts (Right) (Wall *et al*., 2008).

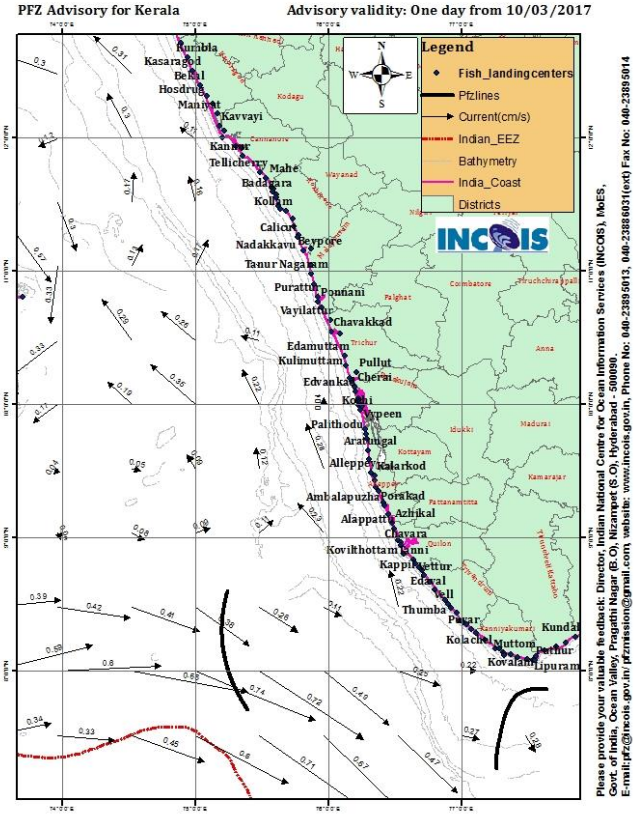


Fig 2. PFZ map of Kerala coast prepared by INCOIS, Hyderabad. The thick black curved line indicates the PFZ.

II. Monitoring the coastal habitats

The most important advantage of Remote Sensing is its synoptic view and repetitively. Due to this advantage we can use it monitor different areas of earth with comparatively less efforts. The below satellite images show how the coastal areas of Ernakulam has changed over time.

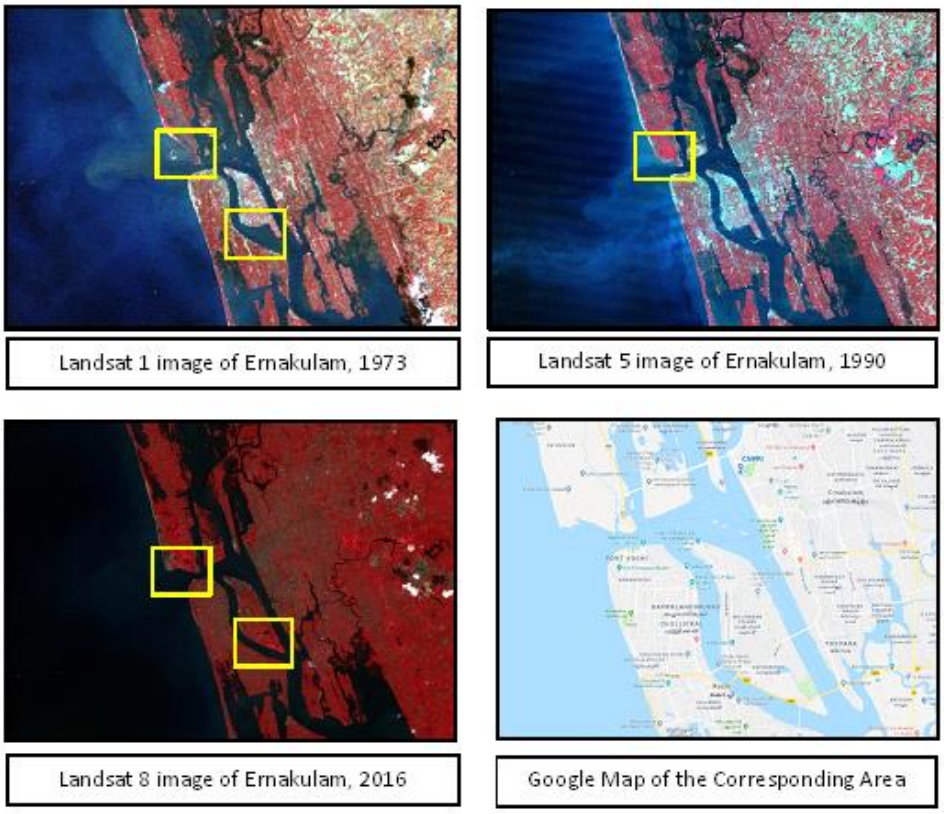


Fig 3. The three images above show the utility of satellite remote sensing in monitoring the earth surface / our environment. The yellow box indicates the areas where drastic changes had taken place.

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A Glimpse of Motivation & Personal Effectiveness for Professional Excellence

19

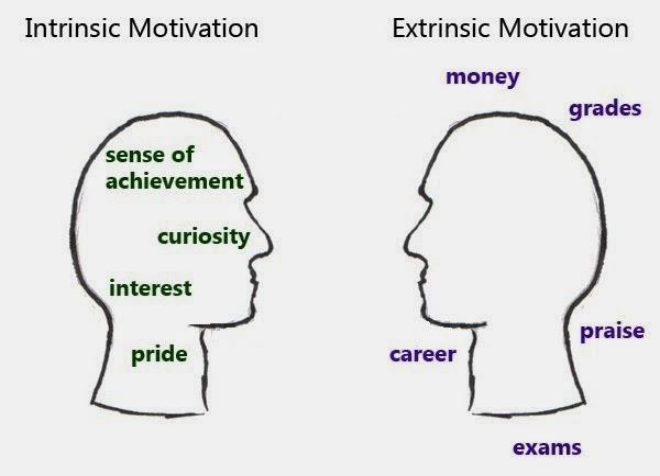
Vipinkumar V P
Socio Economic Evaluation and Technology
Transfer Division, CMFRI

Let's start the topic of behavioural dimension for this Vocational Higher Secondary Education Curriculum with a quotation on motivation. *'A great man is the one who can make a small man feel great, and perform great.* The man greatness is simply determined based on his motivational skills. Motivation is the word derived from the word 'motive' which means needs, desires, wants or drives within the individuals. It is the process of stimulating people to actions to accomplish the goals. In the work goal context the psychological factors stimulating the people's behaviour can be the desire for money, success, recognition, job-satisfaction, team work, etc.

One of the most important functions of management is to create willingness amongst the employees to perform in the best of their abilities. Therefore the role of a leader is to arouse interest in performance of employees in their jobs. The process of motivation consists of three stages. A felt need or drive, a stimulus in which needs have to be aroused and when needs are satisfied, the satisfaction or accomplishment of goals. Therefore, we can say that motivation is a psychological phenomenon which means needs and wants of the individuals have to be tackled by framing an incentive plan. In the general motivational process, there is a need, drive and a particular goal.

There are two types of motivation. Extrinsic motivation from outside, often from rewards and Intrinsic motivation within the

individual based on sense of achievement, curiosity, interest and pride.



Personal Effectiveness

The motivational sills of a person give rise to his effectiveness. Let's look into what effectiveness means? The word 'effectiveness' differs significantly from the word 'efficiency'. Effectiveness means 'doing the right thing' and efficiency refers to 'doing things rightly'. Both are almost appearing to be synonymous, but indeed there are a couple of differences. Any way for human beings, we normally use the terminology of effectiveness. Efficiency is a terminology generally used for machines. Here are some glimpses of personal effectiveness. Have a glance of the following remarks and the corresponding persons who really created a difference and made their presence remarkable due to their personal effectiveness.

- *A small boy-the fifth amongst the seven siblings of a poor father, as selling newspapers in a small village to earn his living. He was not exceptionally smart at school nut was fascinated by religion and rockets. The first rocket he built crashed. A missile built crashed multiple times and he was made a butt of ridicule. He was the person to have scripted the*

space Odyssey of India single –handedly and later who became the honorable Indian President……. He was **Dr. A.P.J Abdul Kalam.**

- *A man failed in business at age 21; was defeated legislative race at 22; failed again in business at 24; Overcame the death of his sweetheart at 26; Met with a nervous breakdown at 27; Lost congressional race at 34; Lost senatorial race at 45; failed in vice-president contestation at 47; Lost senatorial race at 49; finally won to be President of United States at 52 ……..and he was …..*.....**Abraham Lincoln**

- *A candidate for a news broadcasters post was rejected because of his voice. He was also told that with his obnoxiously long name, he would never be famous……He is* **Amitabh Bachan**

- *When a gentleman invented a communications machine in 1876, it did not ring off the hook with calls from potential backers. After making a demonstration call, President Rutherford Hayes said, "That's an amazing invention, but who would ever want to see one of them? He said this to a person who made maximum inventions in the world and was none other than……***Alexander Graham Bell**

- *An ordinary man took up a number of odd jobs including being a carpenter and a coolie. He was later employed as a bus conductor. He then began to take part in stage plays. A famous Tamil film director accidentally noticed him and gave a chance in a Tamil cinema where he played a supporting role. The movie was well received and went on to win three National Awards. Later he became the evergreen superstar in Tamil…….*.**Rajinikanth**

- *A 4 year old girl, the 20th of 22 children, contracted double pneumonia and scarlet fever at a very early age, which paralysed her left leg. Thereafter at 9 years of age she removed her leg braces and started walking without them. At 13, she decided to become a runner but kept failing miserably in all races that she entered in. She kept trying in spite of several detractors and finally started winning every race she entered and*

became the winner of 3 Olympic gold medals. She is ……..**Wilma Rudolph**

- *Born in India. His father was a teacher and his family didn't have money. He travelled with his family to Yemen at the age of 16 where he started his first job. After some time, he returned to India and founded his first company but things didn't go well. He was above thirty when he started his second company. Shortly his new brand became popular and within years he became a billionaire chosen to be among the top business men in Asia and his financial empire today is worth more than 60 billion dollars*……**Dhirubhai Ambani**

- *A school teacher scolded a boy for not paying attention to his mathematics and for not being able to solve simple problems. She told him that he would not become anybody in life. His mother however believed in him and coached him Maths. The boy went on to become* …….....**Albert Einstein**

The above motioned magnificent personalities were the ones who never failed, but who never quitted and proved themselves to be personally effective. The average life span of a human being is 70 years i.e. 26, 500 days and in this period he consumes 60 tons of food and he breaths 23,800 times a day on an average. After finishing every breath we have to realize we are approaching graveyard. So can't we think of something productive to be done by creating a difference to improve our personal effectiveness? The most important prerequisite for improving personal effectiveness is the necessity for a self-change.

Let's quickly have the essence of education. Education is a social process or growth in the sense of producing desirable changes in the behavioral components of human behavior, the behavioral components include knowledge, skill and attitude. There are three things to be changed for a self-change, inevitably and they are our attitude, thinking and behavior. Components of education are

teaching and learning. How we are learning? We know it is by sensory techniques. It has been proved that the comprehension though learning is like this. Reading 10 %, Hearing 20 %, Seeing 30 %, Seeing and Hearing 50 % and Doing 90 %.

Being positive in a tough work environment

We have to be aware of a couple of bullets in the surrounding environment. They are Negative work environment, other people's behavior, Negative world view, changing environment, past experience and Determination theory. Let's look into each of these bullets.

A Totally Negative work environment

In a negative work environment, we can encounter these sorts of experiences.

- Dog eats dog . . . everyone fighting to get ahead
- No one appreciates your contributions
- Too much work . . . not enough help
- Deadlines are unrealistic
- Longer hours . . . additional work
- Budget Constraints
- Competition is eating us alive
- Poor management / direction
- Job insecurity
- Donkey Works

Behaviour of other People

We can observe these types of personalities around us. Bulldozers, Complainers, Gossipers, Patronizes, Whiners, Snipers, Backstabbers, Controllers, Snuffers, Exploders, Hypocrites etc. who make out daily routine miserable.

Changing environment

There is a widely accepted quotation that *"The only person who always likes change is a wet baby"*. This is essentially because of the following aspects concerned with change. The change ***c***hallenges our paradigms. It alters the way we think. It makes life more difficult for a while. It causes Stress. But we have to realize and accept an inevitable truth that Change is an ongoing fact of life.

Past experience

The past experience also might have created a story in our mind. This story will lead to another story and that will lead to another one which in turn makes everything a confusing mesh, which won't make realize the difference between fact and interpretation. Past is only to be refereed for future prospects and never live in the past.

Negative world view

Speaking the context of negative world view, a recent Statistic says crime down 20% in America is being reported up to 600%. Because the trend is to create sensationalisation. Look at what you are looking at! People are bothered on sensational news as the general view of the world itself has become negative. The front page of the newspapers gives the indication that to what extent people are bothered on sensational items.

Determination theory

The determinism theory makes us conclude certain items that it is none of our faults and we find excuses of our own mistakes with justification that those are due to these genetic, psychic or environmental aspects.

- **GENETIC:** My Grandparents did it to me. (Inherited traits)
- **PSYCHIC:** My Parents did it to me. (Upbringing)
- **ENVIRONMENTAL:** My Teacher, My Spouse, My Boss, the Company, the Economy, etc.. is doing this to me. (Surroundings)

A pertinent question arsing concerned to Life:

"Are some people just born positive thinkers……..or is it their CHOICE?" We have two luggage here. Our task is to choose the Choose the Right Luggage: We have to either dodge bullets or wear the bullet proof armor. The problem with dodging bullets is 'You*'re definitely going to get hit!* Choice 2 is wearing a bulletproof armor. Wearing the bulletproof armor comes from 'SELF CHANGE'. So while putting on the armor. We have to change 3 Things! Attitude, Behaviour and Thinking.

How can we change our Attitude?

Now comes the relevance of the major crux of the topic: the 'Attitude.' Attitude is the positive or negative affect towards a psychological object. Attitude change happens personally from the inside out. So we have to accept our responsibility that I am responsible for who I am, for what I have and for what I do. Second step is to take control over our ownerships, values, mission and discipline.

How can we change our Thinking?

Changes in thinking come from observing logically in every situation. For that we have to observe our thinking and manage our self-talk. Henry Ford's quotation is 'If you think you can, or you think you can't…you're right'. When you get up in the morning,

just feed your sub-conscious mind that, this is going to be a wonderful day! Automatically it can be ensured that entire activities will lead to a positive mental stage bringing about a fruitful day. Instead, when you get up and feed your sub-conscious mind that this is going to be a crappy day!, entire activities will become negative leading to a totally embarrassing situation.

How can we change our Behaviour?

This is a million dollar question. Telling how to change is easy, but very difficult to practice. Behaviour changes take true assessment, determination & discipline. For this we have to go for a paradigm shift from the normal reactive behaviour to a proactive/ responsible behavior. Reactive behaviour is just the normal stimulus-response behaviour. But in Proactive behaviour, in between the stimulus and response, there is 'our choice'. Untiring perseverance is required to change our habits and behaviour. Four unique human endowments are Self-Awareness, Imagination, Conscience and Independent Will.

What are the Steps towards Changing Behavior?

This can be explained with an example of learning Car Driving.

1. Unconscious Incompetence: A boy in his childhood doesn't not what a car is and what driving is. He is unconscious and incompetent to drive a car.
2. Conscience Incompetence: As the boy grows, he knows what a car is. But not competent to drive.
3. Conscious Competence: Slowly when he learns driving skill, he is conscious about car driving and is very careful in driving without any distraction as he is consciously competent.
4. Unconscious Competence: In the final stage after expertise in car driving, he drives systematically while he talks or wave as if he is unconsciously competent in car driving. Out entire deeds and

activities should reach to this stage for personal effectiveness to emerge as a new personality.

So influence your environment by adding positive behaviour.

- Replace the bad habits!
- Spread a SMILE around
- Sprinkle some "positive" on the "negatives"
- Focus on the good of each day
- Stay out of the "feeding frenzies"
- Say "please" and "thank you"
- Practice *EMPATHY*
- Evaluate *YOUR* behaviour
- Never miss an opportunity to complement
- Before you say anything to anyone, ask yourself three things: Is it true? 2. Is it harmful? 3. Is it necessary?
- Keep promises
- Have a forgiving view of people
- Keep an open mind with changes
- Count to 100 if necessary
- See criticism as opportunity to improve
- Cultivate your sense of humour

Relationship between Attitude and Behaviour

The effect of attitudes on behavior is a growing research enterprise within Psychology. Icek Ajzen has led research and helped develop two prominent theoretical approaches within this field: the theory of reasoned action and, its theoretical descendant, the theory of planned behavior. Both theories help explain the link between attitude and behavior as a controlled and deliberative process.

Theory of reasoned action

The theory of reasoned action (TRA) is a model for the prediction of behavioral intention, spanning predictions of attitude and

predictions of behavior. The subsequent separation of behavioral intention from behavior allows for explanation of limiting factors on attitudinal influence. The theory derived from previous research that started out as the theory of attitude, which led to the study of attitude and behavior. The theory was "born largely out of frustration with traditional attitude–behavior research, much of which found weak correlations between attitude measures and performance of volitional behaviors".

Theory of planned behavior

The theory of planned behavior was proposed by Icek Ajzen in 1985 through his article "From intentions to actions: A theory of planned behavior." The theory was developed from the theory of reasoned action, which was proposed by Martin Fishbein together with Icek Ajzen in 1975. The theory of reasoned action was in turn grounded in various theories of attitude such as learning theories, expectancy-value theories, consistency theories, and attribution theory. According to the theory of reasoned action, if people evaluate the suggested behavior as positive (attitude), and if they think their significant others want them to perform the behavior (subjective norm), this results in a higher intention (motivation) and they are more likely to do so. A high correlation of attitudes and subjective norms to behavioral intention, and subsequently to behavior, has been confirmed in many studies. The theory of planned behavior contains the same component as the theory of reasoned action, but adds the component of perceived behavioral control to account for barriers outside one's own control.

Have a look at a very interesting quotation *'Watch your definitions……they become thoughts, Watch your thoughts…….. They become words, Watch your words ……. they become actions, Watch your actions……...they become your destiny.'*

The choice is yours, i,e with a bad attitude, we can never have a positive day and with a positive attitude, we can never have a bad day.

Choose POSITIVE Living.

When you have two choices in a natural motivator's case study, the choice you opt will decide your behaviour.
"Each morning I wake up and say to myself, I have two choices today. I can choose to be in a good mood or I can choose to be in a bad mood."
"I always choose to be in a good mood."
"Each time something bad happens, I can choose to be victim or I can choose to learn from it".
"I always choose to learn from it."
'Every time someone comes to me complaining, I can choose to accept their complaining or I can point out the positive side of life'.
'I always choose the positive side of life'.
So 'Life is all about choices. When you cut away all the junk every situation is a choice".

- You choose how you react to situations.
- You choose how people will affect your mood.
- You choose to be in a good mood or bad mood.
- It's your choice how you live your life.

I chose it, because I chose it ... ...Be happy... ... ...

These positive changes in thinking, attitude and behaviour are inevitable for leadership. Leadership is to be observed in a broader perspective compared to management. Because management consists of planning, organizing, leading and controlling and is obvious that leadership is one of the functions of management. It is the degree to which a person can influence other people's behaviour in a desirable way. Inculcating this leadership quality is of paramount significance for personal effectiveness. For that a paradigm shift to a proactive behaviour is mandatory. In the proactive model, our choice is there between the stimulus and

response and this freedom to choose is based on our self-awareness, imagination, conscience and independent will.

Here are some of the habits of highly effective people.

- **Be Proactive**: Proactive people take responsibility for their own lives. They determine the agendas they will follow and choose their response to what happens around them. On the contrary, Reactive people don't take responsibility for their own lives. They feel victimized, a product of circumstances, their past, and other people. They do not see as the creative force of their lives.

- **Begin with the End in Mind**: These people use personal vision, correct principles, and their deep sense of personal meaning to accomplish tasks in a positive and effective way. They live based on self-chosen values and are guided by their personal mission statement. But those beginning with no end in mind, lack personal vision and have not developed a deep sense of personal meaning and purpose. They have not paid the price to develop a mission statement and thus live life based on society's values instead of self-chosen values.

- **Put First Things First**: These people exercise discipline, and they plan and execute according to priorities. They also "walk their talk". On the other hand, those putting second things first are crisis managers who are unable to stay focused on high-leverage tasks because of their preoccupation with circumstances, their past, or other people. They are caught up in the "thick of thin things" and are driven by the urgent.

- **Think Win-Win**: These people have an abundance mentality and the spirit of cooperation. They achieve effective communication and high trust levels in their emotional bank accounts with others, resulting in rewarding relationships and greater power to influence. But those thinking Win-Lose or Lose-Win, have a scarcity

mentality and see life as a zero-sum game. They have ineffective communication skills and low trust levels in their emotional bank accounts with others, resulting in a defensive mentality and adversarial feelings.

- **Seek First to Understand, then to Be Understood**: Through perceptive observation and empathic listening, these non-judgmental people are intent on learning the needs, interests, and concerns of others. They are then able to courageously state their own needs and wants. But those seeking first to be understood, put forth their point of view based solely on their auto-biography and motives, without attempting to understand others first. They blindly prescribe without first diagnosing the problem.

- **Synergize**: Effective people know that the whole is greater than the sum of the parts. They value and benefit from differences in others, which results in creative cooperation and team-work. . Ineffective people believe the whole is less than the sum of the parts which ultimately results in compromise, fight or flight. They try to "clone" other people in their own image. Differences in others are looked upon as threats.

- **Sharpening the Saw**: Effective people are involved in self-renewal and self-improvement in the physical, mental, spiritual, and social-emotional areas, which enhance all areas off their life and nurture the other six habits. Ineffective people fall back, lose their interest, and get disordered and they wear out the saw. They lack a program of self-renewal and self-improvement and eventually lose the cutting edge they once had.

A glimpse on motivational skills and personal effectiveness are given in this article as tips and by inculcating these habits through untiring perseverance, our intrinsic and extrinsic motivational skills and personal effectiveness can be improved to a great extent.

However, it is purely in our hands to make use of our potential to the optimum possible extent.

Relevance of Sub-conscious Mind; Crux of the subject

Now it's time to straightaway proceed to another main crux of the topic i,e the relevance of subconscious mind. It is an unequivocal proposition to proclaim that 'with a bad attitude, we can never have a positive day, and with a positive attitude, we can never have a bad day'. It essentially depends on the mind- set of a human being. There is distinct demarcation between the conscious and sub-conscious mind of a person**.** The conscious mind is the part of our mind that is responsible for logic and reasoning. It also controls all the actions that we do on intention while being conscious. For example, when a person decides to make any voluntary action like moving his hand or leg it is done by the conscious mind. So whenever we are aware of the thing we are doing, we can be confident that we are doing it by our conscious mind. The conscious mind is also known to be the gate keeper for the mind. In the meantime, the subconscious mind is the part of the mind responsible for all involuntary actions. Our breathing rate, heart beats and emotions are controlled by the subconscious mind. It would be pertinent to have a look into the power of subconscious mind and explore its immense potential and possibilities as a character building tool. In the book of Joseph Murphy regarding the 'Power of Subconscious Mind' there are essentially 6 points to memorize and learn.

1. You Receive Answers to Prayer Because Of Mental Acceptance About What You Pray

Joseph Murphy in his famous publication entitled 'The power of sub-conscious mind' proposes that, your religious affiliation is not what makes prayer effective. Rather, it is based on your ability and willingness to accept what you pray. It makes sense that whatever you can accept on a conscious level has to be accepted by your subconscious as well. Another statement that expands on

this idea is this one: "the subconscious mind is subject to the conscious mind." What Murphy is saying is that you can train your subconscious mind to believe what you can accept on a conscious level.

2. Your Subconscious Mind Has the Answer to All Your Problems

This statement makes perfect sense if you don't have any problems with the idea that your subconscious mind = God. Even if not for that, though, it speaks to the power of the subconscious mind. You don't need to go looking outside for the answers you seek – Murphy is saying – you can look inside, and pose questions to your subconscious. The answers may not come immediately, but your mind is always working on problems you submit to it even when you're doing other things, and it will eventually present to you a workable solution.

3. Faith is The Only Universal Healing Principle Operating Through Everybody

I firmly believe the implication here is that, faith is created by accessing and harnessing the power of our subconscious minds. Illness, physical ailments, and even traumatic experiences can be healed by repeatedly submitting thoughts of healing to our subconscious minds. Can we be healed by any other means? According to Murphy, no. Faith is the universal healing principle. Of course, I don't think he would discount the importance of medicine and other orthodox cures, but I have to guess that in this case he is referring to instances of healing that have occurred in so-called "healing services", churches, or religious gatherings.

4. If A Prayer is Answered, it is Answered Scientifically

What Murphy is suggests is that, there is a formula to prayers that are answered. He explains that "science" means knowledge that is coordinated, arranged and systematized1, so the idea here is that we can cooperate with our subconscious minds to see more of our prayers answered. If anything, the entire book sheds light on how

little attention and thought we give to our subconscious minds, and what fantastic tools they are in helping us achieve ends that we desire to see in our lives.

5. Don't Compel Your Subconscious Mind to Accept Your Idea By Willpower

Although Murphy does talk about presenting positive thoughts and images to our subconscious minds, he is also quick to caution us that we can't force things. Our willpower is limited, and it continues to decrease and diminish throughout the day. Can you imagine how tiring it would be to force yourself to think the same things and visualize the same images all day long? The idea is that we can plant seeds and nurture them, but we shouldn't be constantly uncovering the soil to see how our seeds are doing. We have to keep pulling the weeds and watering the seed, and while that may require a daily investment, it shouldn't take more than a couple of minutes.

6. The World You Live in is Determined By What Goes in Your Mind

Whether or not you subscribe to Murphy's theology this is something we can all agree on. What goes into your mind is hugely important**.** If you choose poorly, you'll assimilate bad attitudes, behaviors, and thoughts. If you choose well, you'll begin to see positive changes within yourself. What world do you want to live in? Have you thought about it? If you aren't sure what you want to achieve in your lifetime, it makes it much harder to select input that will assist you on your journey. If you are fully in alignment with your objectives, choosing the right input becomes much easier.

It is a truth that, all of us are born to lead successful lives but our conditioning actually leads us to failure. We are born to win but are conditioned to lose. Most often we hear statements like, that person is just lucky, he touches dirt and it turns to gold or, he is

unlucky, no matter what he touches, it turns to dirt. This is not at all true. If we make a real practical analysis, it can be observed that the successful person is doing something right in each transaction and the person who fails is repeating the same mistake in each transaction. In the real sense, practice does not make perfect. Only perfect practice makes perfect. Practice makes permanent whatever we do repeatedly. Some people keep practicing their mistakes and they become perfect in those mistakes. So their mistakes become perfect and automatic. The real professionals make things look easy because they have mastered the fundamentals of whatever they do. Many people do good work with ulterior motives like promotions in mind. But the person to whom smart work becomes a habit is quite deserving. Cultivating a habit is like plowing the field. It requires time. It has to grow from within. Habits actually generate other habits. Inspiration is what gets a person started, motivation is what keeps him on track and habit is what makes it automatic. The ability to show courage in the face of adversity; show self-restraint in the face of temptation; choose happiness in the face of hurt; show character in the face of despair; see opportunity in the face of obstacles. Strictly speaking, these traits are not coincidences; they are the result of constant and consistent training, both mental and physical. In the face of adversity, our behavior can only be the one we have practiced, regardless of whether it is positive or negative. When we practice negative traits such as hatred, dishonesty or cowardice in small events, hoping to handle the major ones in a positive way, the latter wouldn't happen because that is not what we have practiced. When we permit ourselves to tell a lie once, it is a lot easier to do it a second and a third time until it becomes a habit. Success lies in the philosophy of sustain and abstain. Sustain what needs to be done and abstain from what is detrimental until this becomes habitual. It is a reality that human beings are generally more emotional than rational. Honesty, integrity, probity and uprightness are the results of our belief system and practice. Anything we practice long enough becomes

ingrained into our system and becomes a habit. A person who is honest most often gets caught the first time he tells a lie. Whereas a person who is dishonest most often gets caught the first time he tells the truth. Honesty and dishonesty to self and others both become habits. Our thinking pattern becomes habitual. We form habits and habits form character. Before we realize that we have got the habit, the habit has got us. We need to form the habit of thinking right. There is frequently used quotation in Behavioral sciences that, "Our thoughts lead to actions, actions lead to habits, and habits form character and our Character ultimately leads to our destiny". So thoughts ultimately lead to destiny.

It is a truth that, most of our behavior is habitual. It comes automatically without thinking. The sum total of our habits is our character. If a person has positive habits, he is considered a person possessing positive character. Similarly a person with negative habits is a possessing a negative character. Habits are a lot stronger than logic and reasoning. Habits start by being too weak to be felt, and end up becoming too strong to get out of. Habits can be developed by default or determination. That is the major essence of our parents' advice in our early childhood, to cultivate good habits because habits determine our character.

How do we cultivate our habits?

Whatever we do repeatedly becomes a habit. We learn by doing. By behaving courageously, we learn courage. By practicing honesty and fairness, we learn these traits. By practicing these traits, we master them. Similarly if we practice negative traits such as dishonesty, unjust behavior, or lack of discipline, that is what we become good at. Attitudes are the reflections of habits. They are behavioral patterns. They become a state of mind and dictate our responses. It is interesting to observe that most of our behavior comes as a result of conditioning-it is habitual. If we want to do anything well, it must become automatic. If we have to consciously think about doing the right thing, we will never be

able to do it well. That means we must make it a habit. We are all being conditioned continuously by the environment and the media, and we start behaving like robots. It is our responsibility to condition ourselves in a positive manner. It can also be observed that, the trained classical musicians often practice the basics of '*sa ri ga ma*' and in martial arts even the black belts use to practice the block punch, the basics, because if they needed to use these skills, they should come automatically. Because good habits are hard to come by but easy to live with. Bad habits come easy but are hard to live with.

Conditioning the habits

Regarding conditioning of habit, a simple example of an elephant which is tied up in a weak rope and stake can be explained. Just think of the mighty elephant who can lift in excess of a ton of weight with just its trunk. How do the people condition the elephant to stay in one place with a weak rope and a stake? The elephant, when it is a baby, was tied to a strong chain and a strong tree. The baby was weak but the chain and tree were strong. The baby was not used to being tied. So it kept tugging and pulling the chain, but all were in vain. On a fine day, it realized that all the pulling and tugging will not help. It stopped and stood still. Then it was conditioned. When the baby elephant becomes the mighty giant elephant, he is tied with a weak rope and a small stake. The elephant could, with one tug, walk away free, but it goes nowhere, because it has been conditioned. Human beings are constantly being conditioned, consciously or unconsciously, by exposure to: the kind of organization we keep, the kind of literature we read; the kind of films and TV programs we watch; the kind of music we listen to; etc. Insanity is defined as doing the same thing over and over and expecting different results. If we keep doing what we have been doing, we will keep getting what we have got. The most difficult thing about changing a habit is unlearning what is not working and learning positive habits.

The relevance of 'GIGO' Principle and its effect

If we examine the computer phrase GIGO (garbage in, garbage out) Negativity in; negativity out. Positivity in; positivity out. Good in; good out, it would be interesting to note that, our input equals our output. Our subconscious mind does not discriminate. Whatever we choose to put into our subconscious mind it will accept and our behavior will reflect that accordingly. The television has a considerable impact on influencing our morals, thinking, and culture, for good or bad. TV, while bringing in substantial useful information, has also made an outstanding contribution to degrading our tastes, corrupting our morals, and increasing juvenile delinquency. That is a pretty high price for so-called free speech or free television. Advertisers are good at conditioning their audience. Obviously, advertisements sell products, otherwise why would companies advertise? When we watch TV or listen to a radio advertisement, our conscious mind is not listening, but our subconscious is open and we receive whatever is being dumped in. We can never argue with the TV. When we watch the movies, we laugh and we cry. It is not because they put something in the seats. The emotional input has an immediate emotional output. When we change the input the output automatically changes.

Conscious and Sub-conscious mind: The Relevance

Let's go back to the beginning phase of the article, i,e. looking the true perspectives of the introductory remarks of this article on the conscious and sub-conscious mind, it was already revealed that, our conscious mind possesses the ability to think. It can accept or reject. But the subconscious mind only accepts, it makes no distinction regarding input. If we feed our mind with thoughts of fear, doubt, and hate, the auto-suggestions will activate and translate those things into reality. The subconscious mind is the data bank. Of the two, the subconscious mind is more powerful. The subconscious is like the automobile while the conscious is like the driver. The power is in the automobile but the control is with

the driver. The subconscious mind can work for or against us. It is not rational. When we are not successful we need to reprogram the subconscious. The subconscious mind is like a garden; it doesn't care what you plant. It is neutral; it has no preferences. But if we sow good seeds and grow good plants, we will have a good garden; otherwise we will have a wild growth of weeds. Speaking a step further, even when we sow good seeds and grow good plants, weeds still grow and the weeding process must continue constantly. The human mind is also is exactly like this. The positive and negative thoughts can't occupy the mind simultaneously. Big companies spend millions of rupees for a 30 second advertisement, during a major event. Obviously, they do get results. We see an advertisement, for a particular brand of toothpaste or hair oil and we go to the supermarket and buy that brand. We don't want any tooth paste or hair oil or soft drink but only that brand. Why? Because, we are programmed and becoming liable to act accordingly. In order to succeed, it is inevitable that we need to get programmed in a positive way.

Getting programmed by ourselves…the How part?

How do we get programmed by ourselves? The simple answer for the query is that 'we get programmed by a continuous activity being repeated'. We can think in terms of learning how to drive a car. There are four stages: The first stage is 'unconscious incompetence stage'. This is a stage where we don't know that we don't know. The person doesn't know what it is to drive a car (unconscious) nor can he drive a car (incompetence). This is the stage of unconscious incompetence. The second stage is called 'conscious incompetence stage'. This is the stage where the person grows and becomes conscious of what he is to drive a car but cannot drive one himself, so he is consciously incompetent. But then he starts learning and now comes a third stage which is called 'conscious competence stage'. Now he can drive a car but has to think every time to do it. So with all the conscious thought and effort, the person is competent to drive a car. The fourth stage

is called 'unconscious competence stage.' It comes when the person has practiced consciously driving the car so much that he doesn't have to think. It becomes an automatic process. He can talk to people and wave to others while driving. That means he has reached the stage of unconscious competence. At this level, we don't need the concentration and thinking because the behavioral pattern has become automatic. This is the level that we want all our positive habits to reach. Unfortunately, we have some negative habits too which are at the unconscious competence stage and are detrimental to our progress. Some conspicuous international studies have shown that approximately 90% of all smokers became smokers by the age of 21. If a person has not become a smoker by the age of 21, then there is a very small chance that that person will ever become a smoker. This only proves that smoking is conditioned subconsciously and our conditioning starts at a young age.

How a vacuum gets abhorred by nature?

It is inevitable that, we have to realize the significance of keeping us involved in positive activities. Otherwise they would be attracted to the negative because nature abhors a vacuum. Either, we have a positive or we have a negative; there is no possibility of neutral or passive ground here. Character building becomes a habit. If we want to build a pleasing personality, we have to examine our habits closely. What begin as an occasional indulgence turns into a permanent flaw. We have to examine ourselves with the queries such as 'Do I let the quality of my work deteriorate?', 'Do I indulge in gossip?, 'Are ego and envy the constant companions of me?' and 'Is empathy in short supply?' We are the creatures of habits. It is good that it is that way because if we have to constantly think before doing anything, we would never get anything done. There is just not enough time. We control our habits by exercising control and self discipline over our thoughts. It is high time that we need to harness the power of the subconscious mind. We need to cultivate the habits during

childhood which build character in adulthood. Plant the right things early in life. But it is never too late to start. Every exposure to a positive or negative makes a difference. Learning new habits takes time but positive habits, once mastered, give new meaning to life. Optimism or pessimism is a habit. Habits are a matter of the pain and pleasure principle. We do things either to avoid pain or to gain pleasure. So long as the gain is more than the pain, we continue with the habit. But if the pain exceeds the gain, we drop it. For example, when the doctor tells the smoker to stop, he replies "I can't! It is a habit and I enjoy it!" and he goes on smoking. Here the pleasure is greater than the pain. Until one day, he is faced with a major medical problem, and the doctor says "You better stop smoking immediately if you want to live" and he stops. Here the pain is greater than the pleasure.

What is the reason that, we impose resistance to change?

Change is always something uncertain. Change challenges our paradigms. Even when people recognize or become aware of their negative habits, most probably they don't change. This is essentially because they refuse to accept responsibility. Besides, the pleasure of continuing is greater than the pain. They may lack the desire to change, discipline to change, the belief that they can change and the awareness for the need to change. All these factors prevent us from getting rid of our negative habits. We all have choices. We can ignore negative behavior and hope it will go away-the ostrich approach-or face up to it and overcome it for life. Behavior modification comes from overcoming irrational fears and getting out of the comfort zone. Remember, fear is a learned behavior and can be unlearned. These excuses are generally the most common explanations for not changing negative habits such as: 'I have always done it that way', 'I have never done it that way', 'that is not my job,' 'I don't think it will make any difference' and 'I'm too busy.'

The Positive habit formation, the genuine need of the hour

It is imperative for a paradigm shift for a change right now. It is never too late to change. Regardless of our age or how old the habit has been, this can be done by awareness and using techniques that modify our behavior. Often we hear that, we can't teach an old dog new tricks. We are human beings, not dogs. Neither are we performing tricks. It is possible that we can unlearn self-destructive behaviour and learn positive behaviour. The secret of successful people is that they form the habit of doing things that failures don't like to do and won't do. When we think about the things that failures don't like to do, it can be realized that, they are the same things that successful people don't like to do but they do them anyway. For example, failures don't like discipline, hard work, or keeping commitments. Successful people also dislike discipline, hard work (an athlete doesn't like and want the discipline to get up and train every day but he does it regardless), but they do it anyway because they have formed the habit of doing things that failures don't like to do. All habits start small but end up eventually being very difficult to break. Attitudes are habits and can be changed. It is a question of breaking and replacing old negative habits with new and positive ones. It is easier to prevent bad habits than to overcome them. Good habits come from overcoming temptation. Happiness and unhappiness are habits. Excellence is the result of repeated conscious effort until it becomes a habit. It needs sufficient practice to become a habit. We all have some negative habits that are pulling us down. We have to analyze ourselves by sparing some time alone keeping the mind undisturbed to make a list of all the negative habits those are pulling us down.

The need of Forming positive habits and Peculiarity of Auto-Suggestions

Now we reached the final part of the topic i,e Autosuggestions. The most exquisite part of this article to understand the relevance of what an auto-suggestion is. An auto-suggestion in simple

terms, is a statement made in the present tense, of the kind of person we want to be. Auto-suggestions are like writing a commercial to ourselves about ourselves for ourselves. They influence both your conscious and subconscious mind which in turn influences attitude and behavior. Auto-suggestions are a way to program our subconscious mind. They can be either positive or negative. Examples of negative auto-suggestions are: 'I have a poor memory', 'I get angry easily', 'I am tired', 'I'm not an athlete' 'I'm not good at Maths' etc. When we repeat to ourselves a negative auto-suggestion, our subconscious mind believes it and it becomes a self-fulfilling prophecy and starts reflecting in our behavior. For example, when I am talking to someone and I forget what I had to say, I tell the other person, "See, I forgot what I wanted to say. I have such a poor memory."

It can be re-iterated that, auto-suggestion is a powerful self-help technique. Long before affirmations and the 'Law of Attraction' became common talk, auto-suggestion was used for many purposes, either consciously or unconsciously. The subconscious mind receives all kinds of information from the conscious mind. These bits of information come through our five senses and are related to how we see and perceive the world around us. When these experiences are repeated continuously, they sink into the subconscious mind and become an intrinsic part of who we are, what we believe and how we behave. We can condition our subconscious mind to hold certain beliefs those enhance our living experience; thus, through repetition, they become the reality we experience on a regular basis. The auto-suggestion technique when learned and applied correctly, has the power to influence the subconscious mind according to our instructions. In other words, auto-suggestion helps the subconscious mind believe a specific affirmation with an intended goal. An interesting fact is that auto-suggestion goes one step beyond positive affirmations. This is because affirmations are broader in structure while the auto-suggestion technique bypasses our thinking mind and

awareness of our material body and goes to affirm our unique human spirit identified with the words: 'I AM.' This fact alone makes it a more powerful statement directed precisely to the subconscious mind.

Shall we look into a comparison? The first statement is a positive affirmation; the second is an auto-suggestion: "I enjoy happiness and wealth" and "I AM happy and wealthy". By reading both statements out loud, we can feel the difference while stating out loud "I AM". Use of "I AM" to state our suggestion in the present moment and in the first person. There is something intrinsic and very powerful in those two words. It centers us right at that precise moment. As stated above, one simple example of this is "I AM happy". When this self-affirmation is stated on a regular basis, it becomes an auto-suggestion which eventually sinks into the subconscious mind where it will be taken at face value. Moreover, this practice will help us to focus on happy moments on a more regular basis versus the sad, anxious driven or depressed moments we may be encountering in our life. An interesting thing to notice is that those sad, anxious moments don't just disappear; however, our subconscious mind is being trained to focus on "happy" moments instead; thus, bringing more of those experiences to our life. Mohamed Ali, the boxing champion always gives auto-suggestions while he practices boxing, that 'I am the Champion and I am the winner'. He doesn't lay idle and give auto-suggestions. The positive affirmations with practice will ultimately make him win in every encounter,
The people who come into contact with crime the first time, hate it. With constant exposure, they get used to it and if the exposure is long enough, they may embrace it. And they become creators of their own misfortune. When a person repeats a belief long enough, it sinks into the subconscious and becomes reality. A lie repeated long enough becomes accepted as the truth. Positive auto-suggestions are being widely used in the field of sports and medicine. Why do we make positive statements? Because we want

to create a picture in our minds of what we want to have rather than what we don't. Any picture that we hold in our mind becomes reality. Auto-suggestions are a process of repetition. A person who repeats a statement long enough lets it sink into the subconscious mind. For example, I am relaxed. I am cool, calm and collected. Auto-suggestions should not be practiced in a negative way 'I am not' tense, I won't be angry etc. Positive statements are made because we think in pictures and not in words. If we say ourselves "don't think of a red elephant," the first picture that comes to our mind is that of a red elephant. If we think of "mother," the thing appearing in our mind is a picture of our mother. We never start spelling m-o-t-h-e-r. That means, when a negative word comes in the auto-suggestion, it forms a negative picture which we want to avoid. There is also a necessity to put it in the present tense. Because, our sub-conscious mind can never tell the difference between a real experience and an imagined one. For example, when the parents are expecting their child to come home at 9 p.m. but the kid is not at home by 1 a.m. then what is going through the parents' mind? They are probably hoping everything's okay. "I hope the kid didn't get into an accident." But it is definite that, their blood pressure level goes up! This is an imagined experience. The reality could be that the kid might be having fun at a party, and is irresponsible, and did not get home when he was supposed to. Let's look into the reverse scenario. Suppose the kid was very responsible and was actually coming home at 9 p.m. but got into an accident, and still didn't get home at 1 a.m. then also the parents' blood pressure naturally goes up! The first scenario was an imagined experience. The second one was a real experience but the body's response in both cases was identical. Our subconscious mind cannot distinctly differentiate between a real and an imagined experience.

Subconscious mind tuning up with Auto-suggestions

We know yesterday if history. Tomorrow is mystery. But today is a gift. Why can't we use this gift in the appropriate way to tune up

out subconscious mind with auto suggestions? It is quite necessary to think how we can use auto-suggestions to eliminate negative habits and develop positive ones. We have all used auto-suggestions unconsciously. For example, when we have to catch an early morning flight, we automatically tell ourselves that we have got to get up. And invariably, we do (sometimes, even without an alarm clock). A prepared subconscious mind has hunches and gut feelings. Auto-suggestion is a way to program and condition our mind to make a statement into a self-fulfilling prophecy. Auto-suggestion is a repetitive process through which we feed our subconscious mind with positive statements which translate into reality. Repetition alone is not enough, unless it is accompanied by emotions and feelings. Auto-suggestions without visualization will not produce results. The first time, when our mind receives auto-suggestion, it rejects it. Because it is an alien thought, contrary to our belief system. Success would depend on our ability to concentrate and repeat the process.

Trainees' Practical Session: Case studies / Develop games / practical exercise

The practical session was focusing attention on systematic Steps to follow on auto-suggestions

The first requisite to follow an auto-suggestion is going to a spot where we won't be disturbed and writing down peacefully our suggestions. The self-discipline to finish what one starts, is imperative. Auto-suggestion is a powerful character building tool. Translating auto-suggestion into reality requires the following steps:

1. Making a list of our auto-suggestions in the present tense.
2. Repeating auto-suggestions at least twice a day: first thing in the morning and at the end of the day. This is because in the morning, the mind is fresh and receptive and at night you deposit the positive picture into your subconscious overnight.
3. Repeating it consecutively for 21 days until it becomes a habit.

Auto-suggestions alone will not work. They need visualization. Let's come to final paradigm of visualization.

The Visualization Process

Visualization is simply the process of creating and seeing a mental picture of the kind of thing we want to have or do, or the kind of person we want to be. Visualization goes hand in hand with auto-suggestion. Auto-suggestion without visualization is mechanical repetition and will be ineffective. In order to see results, auto-suggestion must be accompanied by feelings and emotions (visualization). The important caution regarding the auto-suggestion is that it may not be acceptable to the mind the first time you do it because it is an alien thought. For example, if for the past few decades I have believed that I have a poor memory and now all of a sudden, I tell myself, "I have a good memory!", my mind will throw it out, saying, "You are a liar! You have a bad memory!" Because that is what it has believed up to this point. Behavioural experts through experiences and observations proclaim that it will take 21 days to dispel this notion. Because it takes a minimum of 21 days of conscious, consecutive practice to formulate a habit. The big question which may arise here is: Is 21 days of conscious effort a heavy price to pay to change a lifetime for the better? It all sounds simple but it is not easy.

Immense examples have been observed in many case studies, how auto-suggestions and the subconscious mind have been utilized to the fullest potential as a powerful character building tool. The imaginary craziness imposed through auto-suggestions made in present tense on positive habits made astonishing changes in the character of very many people through conscious efforts and untiring perseverance. It is never too late or better late than never for a positive change by realizing the power of subconscious mind and auto-suggestions. Whether you realize it or not, you have probably been using auto suggestion techniques your whole life. If you have ever told yourself to wake up at a certain time, "relax," "sleep," "concentrate," "smile," "breathe," or whatever -

- you have used auto suggestions. In truth, auto suggestion is the simplest and arguably, the most powerful of mind programming tools. It is one of those simple mind power techniques that is easy, always accessible, can be done anywhere any time (even while driving) and requires no special skill or training. We do it naturally.

The problem is that, most people use autosuggestion UNCONSCIOUSLY– and often in a way that holds them back from accomplishing what they want. For example, people talk about being "sick and tired" of this or that. Then, they wonder why they feel low and lethargic. Or they bitch that, their boss is a pain in the rear, and then they begin to have problems with their lower back. They fail to realize that mind power techniques, used unconsciously also have consequences. Auto suggestion techniques can be used to improve performance at work, to combat anxiety while driving, in sport, in meditation, dance, even in bed. It can boost your confidence, help you relax, improve concentration, energy and help you sleep. Used negatively, or in ignorance, it can do the opposite as well and it does.

Suggested Reading:

Reference: Qualified Learning Systems Inc., USA.Murphy Joseph. 2010. *The Power of Your Subconscious Mind*. Amazone India, p170.

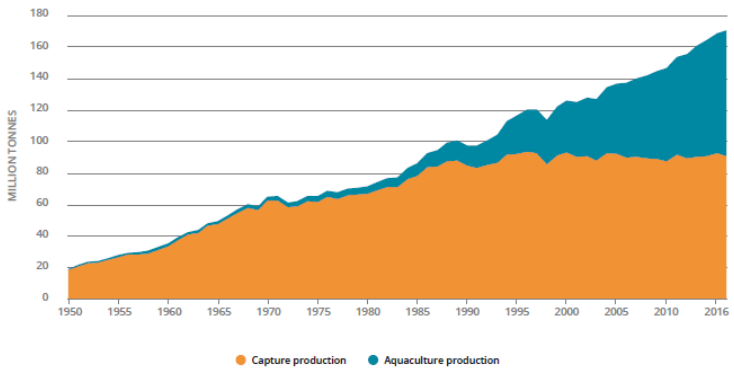
20

Major Cultivable Demersal Fishes and their Biology

Rekha J Nair
Demersal Fisheries Division, CMFRI

Global fish production peaked at about 171 million tonnes in 2016, with aquaculture representing 47 percent of the total (and 53 percent, if non-food uses (including reduction to fishmeal and fish oil are excluded). Since the late 1980s capture fishery production has beenrelatively static and aquaculture has been responsible for the continuing impressive growth in the supply of fish for human consumption. (SOFIA, 2018)

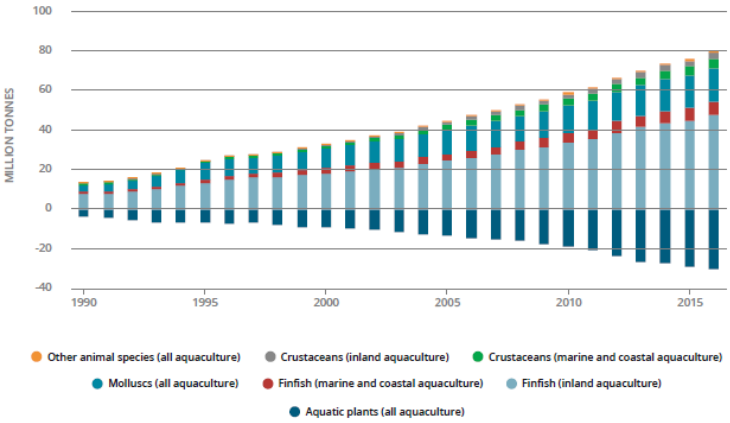
World capture fisheries and aquaculture production



NOTE: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants

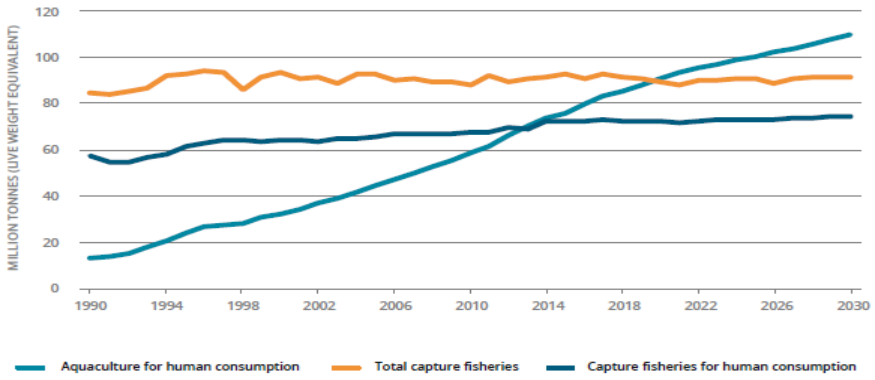
Food and Agriculture Organization of the United Nations
THE STATE OF WORLD FISHERIES AND AQUACULTURE 2018

World aquaculture of food fish and aquatic plants, 1990-2016



With 5.8 percent annual growth rate during the period 2001–2016, aquaculture continues to grow faster than other major food production sectors, but it no longer enjoys the high annual growth rates experienced in the 1980s and 1990s. Also, the disparity in the level of sectoral development and uneven production distribution remain great among the countries within the regions and across the world.

Global capture fisheries and aquaculture production, 1990–2030

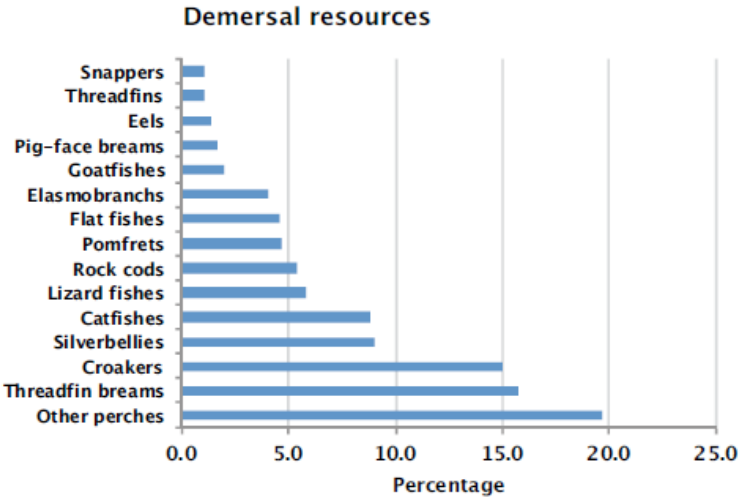


On the export front, frozen fish, the second largest export item, contributed 25.64% in quantity and 10.35% in earnings. However, the unit value realisation decreased to $ 2.08 a kg in 2017-18 from $ 2.27 in 2016-17. (MPEDA, 2019).

Fisheries is an important sector in India. It provides employment to millions of people and contributes to food security of the country. With a coastline of over 8,000 km, an Exclusive Economic Zone (EEZ) of over 2 million sq km, and with extensive freshwater resources, fisheries play a vital role. The gross value addition of the fisheries and aquaculture sector during 2016-17 was Rs. 1,33,492 Crores which is about 0.96% of the National Gross Value Added (GVA) and 5.37% to the agricultural GVA (2016-17). During the year 2017-18, the country has exported 13,77,244 tonnes fish and fisheries products worth Rs. 45106.89 crore (7.08 billion US $). Presently India is the third largest fish producing and second largest aquaculture nation in the world after China. The total fish production during 2017-18 is registered at 10.8 million metric tonnes (MMT). The marine fishery potential in the Indian waters have been estimated at 5.31 MMT constituting about 43.3% demersal, 49.5% pelagic and 4.3% oceanic groups.Marine fisheries contributes to food security and provides direct employment to over 1.5 m fisher people besides others indirectly dependent on the sector. There are 3,432 marine fishing villages and 1,537 notified fish landing centres in 9 maritime states and 2 union territories.
2016.

Cage culture systems employed by farmers are currently as diverse as the number of species currently being raised, varying from traditional family-owned and operated cage farming operations (typical of most Asian countries) to modern commercial large-scale salmon and trout cage farming operations in northern Europe and the America. Commercial cage culture has been mainly restricted to the culture of higher-value (in marketing terms) compound-feed-fed finfish species, including salmon (Atlantic salmon, coho salmon

and Chinook salmon), most major marine and freshwater carnivorous fish species (including Japanese amberjack, red seabream, yellow croaker, European seabass, gilthead seabream, cobia, Rainbow trout, Mandarin fish, snakehead)and an ever increasing proportion of omnivorous freshwater fish species (including Chinese carps, tilapia, Colossoma, and catfish). However in southeast Asian countries, marine species being cultured are groupers and snappers. Looking at the demersal fish landings of India during 2018-19, we can see that perches form the dominant group; of this rockcods form over 5 percent, snappers 2 percent.



Groupers

This group is abundant in the rocky grounds off the South west coast and south east coast of India and is exploited by, hooks and lines, traps and gill nets. All India landings of perches is 4.27 lakh tonnes. Around 42 species of groupers have been reported from different parts of India. Family Serranidae includes *Epinephelus malabaricus* (Malabar grouper), *E.tauvina* (Greasy grouper), *E.bleekeri* (Dusky-tail grouper),*E. areolatus* (Areolate grouper),*E .diacanthus* (Spring cheek grouper/ six-bandedreef cod), *E. epistictus* (Broken-line grouper), *E.fasciatus* (Red banded

grouper),*E.flavocaeruleus* (Blue and yellow reef cod), *E.latifasciatus* (Banded grouper),*E.morrhua* (Banded cheek reef cod), *E.undulosus* (Brown- lined reef cod), *E.merra* (Wire netting reef cod), *E.fuscoguttatus* (Brown marbled grouper), *E.chlorostigma* (Brown spotted grouper), *Cephalopholis sonnerati* (Red coral cod) and *C.boenack* (Blue-lined seabass).

a. Species cultured

A diversity of grouper species are cultured, but only a few are produced in hatcheries to any significant extent. *Cromileptes altivelis, Epinephelus fuscoguttatus, E. coioides, E. malabaricus, E. akaara, E. lanceolatus, E. tukula, E. areolatus, E. tauvina and E. polyphekadion are reported (Rimmer, Williams and Phillips, 2000; Rimmer, Mc Bride and Williams, 2004)* from hatcheries around the region and are expected to form the mainstay of grouper production in the future. Orange spotted grouper *(E. coioides),* greasy grouper *(E. tauvina),* Malabar grouper *(E. malabaricus)* and duskytail grouper *(E. bleekeri)* are cultured in cages in Myannmar using using fry and juveniles caught from the wild. Most grouper grow out is conducted in cages located in marine estuaries or sheltered coastal areas. Groupers are generally sold alive at a size range of 0.5–1.2 kg per fish, with the average weight for table-size fish being 850 g, requiring ready access to markets. In Thailand, six species of groupers *(Epinephelus coioides, E. malabaricus, E. areolatus, E. lanceolatus, E. fuscoguttatus and Plectropomus maculatus* are cultured. In Malaysia, interest in grouper culture has led to atleast six species being introduced.

Biology: Groupers are protogynous hermaphrodites. The gonad lies ventral and slightly posterior to the swim bladder. The ovary is in the form of a bilobed sac that unites posteriorly to form a common oviduct In a mature female, numerous oocytes are arrayed in lamellae surrounding a central lumen,with spermatogenic tissue in small dormant cryptson the periphery of the lamellae. After spawning asa female for one or more years, the grouper changes

sex and thereafter functions as a male. Atsexual transition, the oocytes degenerate, the spermatogonia proliferate, and the ovary is transformed into a functional testis. Evidence of the ovarian origin of the testes are the remnants of oocytes andthe ovarian lumen, which can be seen in cross-sections of the testes. This protogynous mode of reproduction is complicated in certain species bythe 'occurrence of some large females that do not change sex and some small males that are mature atthe same size as the smallest females. (Heemstra and Randall, 1993) Most fishes are gonochorists (Wootton 1991; Helfman et al. 1997), which means they are either born as males or females and reproduce only as one sex throughout life. But many species, including many serranids, exhibit several sexual patterns such as hermaphroditism (Sadovy de Mitcheson and Liu 2008). Hermaphroditism includes simultaneous and sequential hermaphroditism and the latter is further divided into protogyny and protandry (Sadovy and Shapiro 1987). *Epinephelus malabaricus* change sex between 97 and 113 cm TL with the length at 50% sexual maturity of female *Epinephelus malabaricus* reported to be 79 cm (7.5 kg) (Lydia and Ian 2013). *E. tauvina*, is a protogynous hermaphrodite and sexual transition is found to occur in individuals 5575 cm in length, and is related to spawning activity. Fecundity estimates for *E. tauvina*, of length 35.142.3 cm ranged from 850 186 to 2 904 921. In the case of *E. tauvina*, lunar cycle has been shown to affect the reproductive cycle. The fish matures at 52 cm total length ie 4- 5 years old whereas *E. chlorostigma* attains sexual maturity at 28 cm TL. Giant grouper (*E. lanceolatus*) is popular with farmers for its hardiness and rapid growth and is reported to grow to around 3 kg in its first year. The Serranidae exhibit both synchronous and protogynous hermaphroditism (Lavenda, 1949; Reinboth, 1962,1970; Smith, 1965; Yamamoto, 1969; Atz, 1964;Bortone, 1977; Bouain, 1981) as well as the gonochoristic pattern. Van Oordt(1933) made the first observations on hermaphroditism in *Epinephelus* from the Java Sea. and since that time there have been several reports on sex transformation in this

genus (Smith, 1965; Reinboth, 1968; Moe, 1969; Tan & Tan, 1974; Brusle & Brusle, 1975a,b; Chen et al., 1977, 1980).

Stages of the ovary (Nair et al., 2018)
Stage I –immature I - relatively small, translucent and white pinkish in colour.
Stage II - Mature resting female / maturing female stage II of larger than Stage I and white brownish in colour.
Stage III - is defined as the ovarian stage in which active vitellogenesis taking place in preparation for spawning in the mature active female/ripe female. The ovary occupies 2/3rd of the body cavity and is light yellowish in colour
Stage IV –Ovary occupies the gonad cavity –is pinkish in colour and is ready for spawning. Gonad weight is also increased.
Stage V –Spent –Gonads are flaccid –loose and shrunken –covered with blood shots and veins

Snappers:
The snapper is a demersal fish occurring on the continental shelf down to a depth of about 200 m, but most abundant in depths of less than 70 m. It lives on all kinds of bottom-sand, mud, rocks- There are several species of seabream cultured in Asia, mainly in more temperate parts of the region. These include squirefish (*Chrysophrys auratus*), goldlined seabream Rhabdosargus sarba), blackporgy (*Acanthopagrus schelgelii*) and redseabream (*Pagrus major*). In Thailand, *Lutjanus argentimaculatus* is the major species cultured. In Malaysia, Snappers (Lutjanidae) are next in importance; these include the yellow streakedsnapper (*Lutjanus lemniscatus*), the mangrove red snapper (*L. argentimaculatus*), John's snapper (*L. johnii*) and the crimson snapper (*L. erythropterus*). Adult red snappers were primarily piscivorous, although in certain seasons, they fed heavily on tunicates. Juvenile red snappers fed primarily on crustaceans, but periodically took fish Biology: They are solitary and wary fish, rarely found in groups or schools except during spawning aggregations (Domeier et al., 1996). Snapper is a

serial spawner and releases many batches of eggs over a period of several months Water temperature is the most important factor influencing the timing of the breeding period. Eggs are spherical, with a diameter of 0.85- 0.97 mm and a single oil droplet 0,1H,25 mm in diameter. The yolk is non-segmented, Snapper eggs are planktonic and after fertilisation float freely in the sea until hatching, which takes from 36 to 54 hours, depending on temperature. The snapper's capacity to spawn many times during a season enables it to produce a very large number of eggs and is one of the reasons for its great success as a culture species. Snapper is a predatory fish and its food is extremely varied. Its ability to feed on almost any animal food available enables it to penetrate different habitats and is another reason for its great success as a species.

Commonly Cultivable species of Snappers: The family Lutjanidae collectively known as snappers, contains 17 genera and105 species, which are mainly confined to tropical and subtropical marine waters, with fewoccurring in estuaries. In India, Rekha (2017) recorded 35 species under 8 genera of snappers. The majorspecies observed in the all Indialandings of snappers were *Pristipomoidestypus, L.argentimaculatus, Lutjanus gibbus,L. rivulatus, L. bohar*, and *L. lutjanus.*

Flatfishes:

Halibut:The name flounder is used for several only distantly related species, though all are in the suborder Pleuronectoidei (families Achiropsettidae, Bothidae, Pleuronectidae, Paralichthyidae and Samaridae).

Species in Indian waters: *Psettodes erumei* or the Indian halibut: *P. erumei* is highly predacious benthic fish which lives on muddy and sandy bottomsof the continental shelf down to about 100 meters depthand is predominantly piscivorous in habit. Body is oval and flat, but thicker than in most other flatfishes. Mouth large with strong teeth; maxillary extends well beyond hind edge of lower eye; both eyes are on left or right side; upper eye lying immediately below dorsal edge. Gillrakers are not developed. Dorsal fin origin is well posterior to eyes; anterior fin rays isspinous. Lateral line is almost straight. Body colour is usually brownish grey, sometimes with 4 broad, dark crossbars. Dorsal, analand caudal fin tips black. Blind side is white to partially coloured. Diet is mainly fish with Molluscs and arthropods supplemented to some extent.

Rabbitfish: Rabbit fishes belong to the genus *Siganus* of the family Siganidae. Siganus species are all remarkably similar to each other in most of the features. All species possess thirteen dorsal fin spines, and seven anal fin spines. The genus *Siganus* is also unique among marine fish having two pectoral spines on each side which are separated by three soft rays. Along with these twenty-four spines, one procumbent spine is found in front of the first dorsal spine which is part of the proximal pterygiophore. It is completely embedded or sometime protrudes from a small groove and collectively makes up the main defense of fish. The spines are poisonous. The teeth are also remarkably similar to each other. The number of teeth and the overall shape are "identical." with a single row on top and the bottom jaw. They are very compressed and incisiform in shape. The teeth also overlap and are individually spadelike and pointed.

Species in Indian waters: *Siganus canaliculatus* (Park, 1797)
Distinctive Characters: Body compressed, fairly slender, with a headwith a concave slope above eye. Snout is blunt, anterior nostril is with a long flap in juveniles (shortening with age, absent in old

fish);tip of flap reaching less than halfway to posterior nostril in specimens larger than 12 cm standard length. A forward-directed spine is present in front of dorsal fin; last dorsal spine the shortest, contained 0.5 to 0.6 times of the longest dorsal spine; last anal spine contained 1.2 to 1.5 times of the longest anal spine (usually the third). Caudal fin is almost emarginate in specimens under 10 cm SL, forked in larger fish. Scales minute with naked cheeks or with few to many very fine scales; 21 to 27 scale rows between lateral line and bases of leading dorsal spines. Colour in live fish is highly variable from greenish grey on dorsal side to silver on ventral side; numerous pearly blue matchhead size spots covering nape and sides, arranged more or less in horizontal rows. Caudal fin grey or with pale and dark grey bars; pectoral fins hyaline; dorsal, anal and pelvic spines and rays have same colour as adjacent areas of sides; fin membranes greyish in colour; after death fins usually with pale and dark grey, dorsal fin rays banded.

Biology: Common rabbit fish reported from India are *Siganus javus, S. canaliculatus, S.lineatus , S.stellatus, S. vermiculatus. S. canliculatus* is generally found and its sizes vary from 20-25 cm, with a maximum of 45 cm TL. They are found in coral reef areas, mangrove swamps and shallow lagoons (Saoud et al., 2008) and are able to tolerate a wide range of salinity (17-37 ppt), low dissolved oxygen upto 2 ppm and pH upto 9 and high stocking densities andgrow well in temperatures between 23 and 30°C. All these characters make this species suitable for culture.

Further reading

Nair, Rekha J and Mahesh, V and Ambarish, Gop P (2018) *Biology of some important Demersal Fishery Resources In: ICAR Sponsored Winter School on Recent Advances in Fishery Biology Techniques for Biodiversity Evaluation and Conservation, 1-21 December 2018, Kochi.*

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Broodstock Management of Fresh Water Ornamental Fishes

Nisha Raj
GRFTHS & VHSS Arthunkal, Alappuzha

Broodstock management is an important prerequisite in ornamental fish farming in order to ensure the qualitative production of ornamental fishes. Selection of broodstock of ornamental fish is an arduous task, as most of the fishes used in trade are the result of selective breeding done at innumerable centres spread all over the world. Keen observation of traits passed on to succeeding generations, selection based on desirable and heritable characters is of prime importance in choosing the broodstock. As inbreeding can lead to the production of individuals with undesirable traits, stock improvement by choosing broodstock from other farms (raised in different areas with different lineages) is a managerial measure that has to be applied discerningly.

Brood stock selection

In general, while selection of broodstock, the following things have to be kept in mind.

Young adults with great vigour and vitality having larger sizes are always desirable. Therefore it becomes necessary to choose sufficient number of males and females from among a large number of individuals in a brood.

Shape of the body, its colouration, nature of fins, occurrence of desirable variations, etc. are other attributes which are to be considered. New introductions are always integral part of

ornamental fish hobby hence it is necessary to produce variants which can be done successfully by selective breeding.

Maintenance of Broodstock

It is always advisable to keep broodstock in different tanks or ponds as outbreak of diseases is unlikely to occur simultaneously in all the systems. This reduces the risk of complete loss of valuable broodstock .

Ideally, in many cases it is necessary to keep males and females of the same species separately. They are conditioned for spawning and the introduced together into breeding tanks, at appropriate times.

High quality nutritious diet should be provided for the brood stock as maturation is an energy consuming process.

Optimum stocking is advised in the broodstock tanks for maintenance of health of the stock. Daily monitoring of the broodstock and water quality of the broodstock tanks is essential.

Water quality management is of utmost importance in brood stock tanks. Care should be taken to provide optimum physic-chemical conditions of the water that is typically needed with respect to each species. Good nourishment coupled with ideal water conditions is the key for proper maturation of gonads and successful spawning. Any change in the behaviour of the broodstock or quality of the water is noted, corrective measures have to be adopted at an early time.

In order to ensure spawning success, specific spawning conditions has to be provided for those fishes which require them. Undue delay in spawning can lead to inability of the fish to spawn at all.

Broodstock management of live bearers

Live bearers include the guppy *(Poeciliareticulata*) , the swordtail (*Xiphophorushelleri*, the platy (*X. maculatus,* and themolly*(P.sphenops).* Adult males and females (4-8 months old) in 1:4 ratio with attractive colouration and fancy fins are selected and kept in breeding tanks at a stocking density of 100- 125 fish /m3 of water. A fry trap of some sort is provided to offer shelter for the fry. Each female can produce a brood of fry every 4-6 weeks. Each day, fries are collected from the breeding tanks and introduced into nursery tanks. A batch of brooders is used to produce 4-6 broods before they are replaced by a fresh batch of breeders.

Broodstock management of Angel Fish *(PterophyllumScalare*)

Sexing angelfish is difficult. In nature, male and female angel fish pair up and swim close together to establish their territory. Each singlemating pair is placed in a 40 litre breeding aquarium. The colour patter of each pair must be well matched and both parents must have either short or long fins. They are fed profusely with mosquito larvae or the fry of guppy. A piece of slate with an area of 100 cm^2 is placed at an angle of 45^o against the wall of the aquarium for adhesion of eggs.

8-10 months old fish are selected as broodstock and are used to produce 6-10 broods before they are replaced. By this time they are about 2 years old. The spawning interval of a batch is 3-6 weeks. Although both parents guard and nurse the eggs, it is advisable to remove the parents into another hatching tank.

Brood stock management of gold fish *(Carassiusauratus)*

Carefully selected broodstock are used for each variety of gold fish. Each variety has its own unique characteristics. The breeders have to be selected on the basis of the characteristics which are important for each variety, 7-9 month old male female fishes are selected.

Males and females are reared separately and conditioned for spawning. They are fed with mosquito larvae and other live food like daphnia.

Males and females in the ratio of 2:1 are introduced into breeding tanks. The concrete breeding tank – size can vary, they may be 1m X1m and with water depth of 20 cm. For each of these tanks, a set of breeders are used. One or two water hyacinth plants (Eichornia sp.) are placed in the tank for the eggs to adhere.

After introduction of breeders, the roots of the water hyacinth plants are checked for attached eggs in the following morning. Spawning normally takes place very early in the morning. If eggs are present on the roots of the water hyacinth, the parent fishes are removed. If eggs are absent, parents are left for another day. The breeding tanks are used as nursery for the newly hatched fry. The parents are returned to the broodstock tanks where they are conditioned and can be used after 3 to 4 weeks. The same broodstock can be used for spawning for about 1 $^{1/2}$ to 2 years.

Brood stock management of gouramies

Three spot gourami *(Trichogastertrichopterus*) and the Pearl Gourami (*T. Leeri*)

Single pairs are set up in small containers which hold 40 litres of water. Mature fish are about 6-8 months old. Pieces of dried banana leaf are put to float on the surface of water in the breeding container, for the males to build a bubble nest under the leaf. It takes about 2-5 days for mating and spawning. The male picks up the eggs with its mouth and places them in bubble nest and looks after the bubble nest and eggs. After spawning, female can be removed from the breeding container. The eggs hatch in 24 hours after fertilisation and fry become free swimming after 3 days. The parent is removed and the fry are reared.

Conclusion

Feed and feeding is the most critical component in broodstockmanagement and larval rearing of ornamental fishes which has to be dealt in detail. Generally protein rich nutritious feed has to be provided for all the varieties twice a day.

Water quality management is another criterion to be discussed in detail. Sword tails and mollies thrive well in moderately hard water with a pH of 6. Gouramies too flourish in such conditions. Apart from these, all other varieties discussed thrive well in soft and neutral water conditions. Aeration has to be done when stocking densities are high and partial change of water daily up to about 10% of the volume is done in such conditions. Above all, keen observation and gentle care are of prime importance in broodstock management of ornamental fishes.

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Probiotics in Aquaculture

Raghunath Ravi

The FAO estimates that half of the world's seafood demand will be met by aquaculture alone by 2020 as capture fisheries is overexploited and are on decline. During the past 20 years, aquaculture industry has been growing tremendously, especially that of marine fish, shrimps and bivalves. This boon has certainly brought with it the problem of environmental pollution. Currently the shrimp industry accounts about 4% of the world's cultured aquatic species and nets about US$ 10 billion per annum. Unfortunately this multi-billion industry has been facing serious threats recently. Coastal waters all around the globe have been seriously damaged and this ultimately led to serious disease outbreaks that plunged the industry. The main causative organism was found to be bacteria, especially the luminous *Vibrio harveyi.* High stocking density, low quality seeds and bad management practices are the reasons for the situation. Disease outbreaks can be controlled to a limit by adopting good hatchery and culture practices, as a last resort, antibiotics are depended. But the continuous and copious use of antibiotics led to the development of antibiotic- resistant strains of bacteria. In reply to this and also due to the need for more responsible sustainable aquaculture many researchers are actively seeking alternatives for the control and treatment of diseases. The key causative organisms implicated in outbreaks are viruses, bacteria, rickettsia, mycoplasma, algae, fungi and protozoan parasites. To control these diseases a host of antibiotics, pesticides and other chemicals were used finally creating antibiotic resistant bacteria, persistence of pesticides and other

toxic chemicals in aquatic environment leading to human health hazards. When antibiotics or disinfectants are used to kill bacteria, some bacteria will survive, either strains of pathogenic ones or others, as they carry the genes of resistance. These pathogens will then multiply rapidly as their competitors are removed. Any virulent pathogens that re-enter the pond or hatchery tank form biofilms in water pipes or in the guts of animals. It can then exchange genes with the resistant bacteria and survives further doses of antibiotics. Thus antibiotic-resistant strains evolve fast. Despite the obvious success of various vaccination strategies in aquaculture, there are many situations in fin/shell fish culture where vaccines are ineffective, or cannot be employed. These situations include, but are certainly not limited to impaired or under-developed immune systems, lack of knowledge involving antigens of the pathogens, the lack of a specific immune response, physical problems associated with vaccine administration etc. In these situations, alternatives to antibiotic therapy must be sought. Investigators worldwide are trying to solve these problems through the effective use of probiotic bacteria. Commendable progress has been made by many countries in this field and their success has paved way for huge investments and participation in probiotic research and utilization.

Probiotic bacteria are a group of beneficial bacteria which when introduced to the culture media or administrated would improve overall production. Probiotic technique is the use of these bacteria instead of antibiotics or other chemicals to improve the growth and survival of the cultured organisms. 'Probiotics', 'Probiont', Probiotic bacteria or 'Beneficial bacteria' are synonymously used for probiotic bacteria. A recent addition to these is 'EM' - effective microorganisms. The definition of "Probioticum" was formulated in 1974 simultaneously with the use of living cultures in feed for various animals in order to substitute the application of nutritive antibiotics or

chemotherapeutics. In the meantime probiotics are applied not only as feed supplements or pharmaceuticals but increasingly in suitable food specimens such as dairy products, fruit juices, chocolates, and even meat products. The most commonly used probiotic agents in aquaculture are Photosynthetic bacteria, Lacobacillus, Actimomycetes, Nitrobacteria, Denitrifying bacteria, Bifidonbacterium, yeast etc. Micro algae are seldom included in this list. Eventhough, microalgae is not a common probioic agent the species *Tetraselmis suecica* was found to inhibit *Aeromonos hydrophila, A. salmonicida, Serratia liquefaciens, Vibrio anguillaram, V. salmonicida* and *Yersinis ruckeri* type 1. Fluorescent pseudomonad is found capable of limiting the growth of *A. salmonicida* through competition for free ion. The probiotic strain of *V. alginolyticus* is used against pathogenic bacteria like *V. ordalii, V. anguillarum, A. salonicida* and *Y. reckeri.* 'It has been reported that the use of *V. alginolyticus* and *Lactobacillus* sp. will increase the growth and survival in *Penaeus vannamei* and P. *monodon* postlarvae respectively by competitive exclusion and can effectively reduce or eliminate antibiotic prophylaxis is intensive culture systems. *V.alginolyticus* is reported to be effective against 'Zoea syndrome' in *Penaeus oannamei* caused by *V.harveyi* type E22.

Mixtures of many kinds of photosynthetic bacteria *C Rhodomonas* sp. are used in hatcheries and culture ponds as water cleaners and auxiliary food. Certain other strains used in the industry are *Aspergillus niger* ATCC 9642, *A. oryzae* ATCC 11866, *Trichoderma reesei* ATCC *74252, Bacillus cereus* ATCC 14579, *B. megaterium* ATCC 55405, *Pseudomonas aeruginosa* ATCC *31580, Pseudomonas fluorescens* ATCC 13525, *Nitrosomonas* sp., *Nitrobacter* sp., *Rhabdococcus* sp., *Rhodobacter* sp., '*I*'*hiobacillus* sp., *Saccharomyces* sp. etc.

The following benefits can be ascribed to the proper use of probiotics in aquaculture-

- Regulation of harmful micro flora in the culture media by bio-killing.
- Enhanced decomposition of undesirable organic substances.
- Increased population of food organisms.
- Augmented feed digestion of animalsEnhanced immunity.
- Organic/eco- friendly.
- Increased moulting rate.
- Deactivation of toxins produced by other microbes.
- Increased survival and growth.
- Higher low salinity tolerance.
- Improved water quality.
- Maintenance of desired pH.
- Steady maintenance of primary productivity.
- Prevention of eutrophication.
- Improved time of recovery from injury and/or infection.
- Increased efficiency in nutrient absorption by the body.
- Removal of water column turbidity.
- Reduction of sludge builds up in pond bottoms.
- Reduction of time required to oxidize the pond bottom between culture cycles.
- Increased pond life.
- Low algal blooms.
- Prevention of black soil formation.

Several bacteria isolated from the intestine of fishes with antibacterial and/or antiviral abilities are being widely used now. The selection of a suitable strain of a microorganism can be regarded as the primary requirement for the use of it as a probiotic. These cultures must be able to pass the stomach-duodenum barrier in a viable state and multiply at the site of destination in the intestine. Assemblages of microorganisms-are produced by adding several nutrients, urea, glucose and potassium phosphate to natural seawater with gentle aeration

in which bacteria and yeast were prevailing. These microbes are added to culture systems where it will multiply rapidly manipulating the microbial population to a favourable state. The probiotic bacteria are offered in various forms, liquid 'ready-to-use' products, dry powder and spores are the most frequent among these. There is no report of any harmful effects for probiotics, but it is found that the BOD level (biological oxygen demand) may temporarily be increased on its application; therefore it is advisable to provide sub surface aeration to expedite the establishment of probiotic organism. A minimum dissolved oxygen level of 3% is recommended during probiotic treatment.

Probiotics could be used in shrimp/fish farms, hatcheries, ornamental fish ponds, tropical lakes with high pollution, ponds and lakes near agricultural or industrial run-off, waste water/ effluent treatment plants etc. The special efficacy of probiotic must be strictly verified in animal nutrition due to rest-fictive USFDA and EU regulations, in pharmacy due to legal restraints, and in food applications-hi accordance with food law regulations. Safety aspects are considered very restrictively in feed applications, in the food and pharmaceutical sector they should be in accordance with the intended purpose of "fulfilling health claims".

The mechanism of action of probiotic agents has not been studied systematically. The following are some of the modes that elicit useful effects when applied-

- Competitive exclusion of harmful bacteria(for food oxygen and space/adhesion site)
- Produce substance that inhibit the growth and multiplication of pathogenic bacteria(antagonistic metabolites)
- Provide essential nutrients to enhance the nutrition of cultured animals when ingested
- Probiotic bacteria directly uptake or decompose the organic matter or toxic material in water improving the quality of

water

- Produce digestive enzyme(amylase,protease,lipase etc) that increases the digestibility of animals
- Serve as a supplementary food for cultured species
- Improve the nutritional level of water (several vitamins are released)
- Produce inhibitory compounds towards pathogens or toxins
- Improvement of the nutritional quality of the feed when added as an ingredient
- Breakdown of complex substances to simpler ones which could be absorbed through the body of cultured animal easily
- Uses the nutrients of the eutrophic media for their growth and thus reduce the chance for multiplication of harmful microorganism
- Control of algal bloom is through biological nutrient removal (BNR) this in turn will improve the oxygen level in the culture media.
- Convert toxic gases and other toxic compoubds into less toxic or harmless chemicals which help in maintaining a balance in the biochemical cycling of various organic and inorganic constituents in water keeping them in safe limits for high survival ,growth and better health of stocked species

At present probiotics are widely applied in US, Japan, Europe, Indonesia and Thailand with laudable results. Probiotics in China, the largest aquaculture contributor is scanty. In India even though major investors have taken up probiotic techniques it is yet to reach the masses. With their setined benefits and added advantages, probiotic certainly will earn an imperative place in the development of aquaculture in future

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ജലകൃഷിയിലെ തീറ്റ

വിജയഗോപാൽ.പി
സി എം എഫ് ആർ ഐ കൊച്ചി

ജലകൃഷി എന്ന ഭക്ഷ്യോല്പാദന മേഖല കഴിഞ്ഞ പത്ത് വർഷമായി ഏകദേശം പത്ത് ശതമാനം വളർച്ച കൈവരിച്ച് വരുന്നു. ഇത്രയും ഉയർന്ന വളർച്ച നിരക്കുള്ള മറ്റൊരു ഭക്ഷ്യോല്പാദന മേഖല ഇല്ല എന്ന് വേണം പറയാൻ. അതുകൊണ്ട് ജലകൃഷി നല്ലൊരു തൊഴിൽ മേഘലയും, ഉയർന്ന വരുമാനം നേടുവാൻ സാദ്ധ്യത കൂടുതൽ ഉള്ള ഒരു മേഘലകൂടിയാണ്.

നമ്മുടെ നാട്ടിൽ ജലകൃഷി ചെയ്യപ്പെടുന്നത് പ്രധാനമായും ഓരു ജലം ഉള്ള മേഘലകളിൽ ചെമ്മീനും, കല്ലുമെകായും ശുദ്ധജല സമ്പത്ത് ഉള്ള സ്ഥലങ്ങളിൽ കാർപ്പ്, തിലാപ്പിയ മത്സ്യങ്ങളേയുമാണ്. അലങ്കാര മത്സ്യങ്ങളുടെ ഉല്പാദനവും, വിപണനവുമാണ് മറ്റൊരു സാദ്ധ്യതയുള്ള മത്സ്യകൃഷി.

ഇതിലെല്ലാം കൃഷിയിൽ വിത്തും വളവും എന്നപോലെ, വിത്തു മത്സ്യവും അവയുടെ തീറ്റയുമാണ് പ്രധാനപ്പെട്ട മുതൽമുടക്ക്. ഗുണമേന്മയുള്ളതും, രോഗവിമുക്തവുമായ മത്സ്യവിത്തിന്റെ ലഭ്യതയും കൃഷി പുരോഗമിക്കുമ്പോൾ കൊടുക്കേണ്ട തീറ്റയുടെ തരം, തോത് എന്നിവ വളരെ പ്രാധാന്യമർഹിക്കുന്ന വിഷയമാണ്.

തീറ്റ എന്തിന്, എന്ന ചോദ്യമാണ് ഇതിൽ ഏറ്റവും ആദ്യം ചോദിക്കേണ്ടത്. കൃഷി എന്ന രീതിയിൽ മീനോ, ചെമ്മീനോ, നാം വളർത്തുമ്പോൾ, ജലാശയത്തിൽ നമ്മൾ പ്രകൃതിയിൽ കാണുന്നതിനെക്കാൾ കൂടുതൽ മത്സ്യങ്ങളെ വളർത്താനാണ് ശ്രമിക്കുന്നത്. ഇങ്ങിനെയാവുമ്പോൾ ജലാശയത്തിൽ നിന്ന് പ്രകൃതിദത്തമായി ലഭ്യമാവുന്ന ഭക്ഷണം ഇവയുടെ വളർച്ചയ്ക്ക്

അപര്യാപ്തമാവുന്നു. അപ്പോൾ നാം അവയ്ക്ക് തീറ്റ നൽകേണ്ടതായി വരുന്നു. ഇത് ജലാശയത്തിന്റെ ഉല്പാദനക്ഷമതയനുസരിച്ച് പലരീതിയിൽ ആവാം.

1. വളപ്രയോഗം – **Fertilization**

ജൈവവളങ്ങളും, രാസവളങ്ങളും ഒരു പ്രത്യേക തോതിൽ കുളമൊരുക്കൽ മുതൽ ചെയ്തുതുടങ്ങുന്നു. ജലപരിപാലനത്തിനും സസ്യപ്ലവക വളർച്ചയ്ക്കും വേണ്ടിയാണ് ഇത് ചെയ്യുന്നത്.

2. പൂരക തീറ്റകൾ – **Supplementary/Complementary feeding**

ഒരു പരിധിവരെ മത്സ്യങ്ങളുടെ പോഷണത്തിനാവശ്യമായത് ജലത്തിൽ നിന്ന് ലഭ്യമാവുമ്പോൾ, ഒരു പൂരകം എന്ന നിലയ്ക്കാണ് ഈ തീറ്റകൾ കൊടുക്കുന്നത്. ഉദാ: കപ്പലണ്ടി, പിണ്ണാക്ക്, അരി/ഗോതമ്പ് തവിട് മുതലായവ.

3. തീറ്റകൾ – **Compounded feeds**

മത്സ്യകൃഷിയിൽ പലതരം തീറ്റകൾ ഉപയോഗിക്കാവുന്നതാണ്. അവയേതൊക്കെയാണ് എന്ന് പരിശോധിക്കാം.

A. Wet feeds പച്ച തീറ്റകൾ

B. Formulated feeds – സംയോജിത തീറ്റകൾ

പച്ചതീറ്റയായി ഉപയോഗിക്കുന്നത് മത്സ്യവും, കക്കയിറച്ചി മുതലായവയാണ്. മൃഗശാല/കശാപ്പ്ശാലയിലെ അവശിഷ്ടങ്ങളും ഒരു പരിധിവരെ ഉപയോഗിച്ചിട്ടുണ്ട്.

സംയോജിത തീറ്റയായി പലതരത്തിലുള്ള തീറ്റകൾ ഉപയോഗിച്ച് വരുന്നു.

A. Crumble നുറുങ്ങ് / തരി

B. Pellet – തിരി

മത്സ്യകൃഷിയുടെ പ്രാരംഭദിശയിലാണ് തരി/നുറുങ്ങ് തീറ്റകൾ ഉപയോഗിക്കുന്നത്. മത്സ്യങ്ങളുടെ വളർച്ച പുരോഗമിക്കുന്നതനു സരിച്ച് തരിവലിപ്പം കൂടിയ തീറ്റകൾ പ്രയോഗിക്കേണ്ടി വരുന്നു. പിന്നീടാണ് 'തിരി' (Pellet) തീറ്റകൾ ഉപയോഗിക്കേണ്ടി വരുന്നത്. നുറുങ്ങ്/ തരി തീറ്റകൾ 0.25 mm തരി വലിപ്പം ഉള്ളവയാണ്. ഈ തീറ്റകളെ പൊതുവെ (Micro Feeds) സൂക്ഷ്മ തീറ്റകൾ എന്നും 1.5 mm മുതൽ 10–12 mm വ്യാസം(Diameter) ഉള്ള തിരി/ Pellet തീറ്റകളെ Macro feeds/Growout feeds എന്നും പറയുന്നു.

ഇനി ചെമ്മീൻ കൃഷിക്കാവശ്യമായ തീറ്റയും, മത്സ്യകൃഷി ക്കാവശ്യമായ തീറ്റയും തമ്മിലുള്ള വ്യത്യാസം മനസ്സിലാക്കാം. ചെമ്മീൻ കൃഷിയിൽ ഉപയോഗിക്കുന്നത് 'മുങ്ങുന്ന' തരിയും തിരിയുമാണ് (Sinking Pellet). കാരണം ചെമ്മീൻ ജലാശയത്തിന്റെ അടിതട്ടിൽ നിന്ന് തീറ്റ പെറുക്കിയെടുത്താണ് ഭക്ഷിക്കുന്നത്. മാത്രമല്ല ചെമ്മീൻ തീറ്റ കഴിക്കുന്നത് മെല്ലെയായതിനാൽ തീറ്റയുടെ 'ജലസുസ്ഥിരത' (Water stability) കൂടുതലാണ്. ചുരുങ്ങിയത് മൂന്ന് മണിക്കൂറെങ്കിലും തീറ്റ വെള്ളത്തിൽ പൊടിഞ്ഞ് പോകാതിരിക്കണം. അതുകൊണ്ട് ചെമ്മീൻ തീറ്റ നീരാവിയുടെ സഹായത്തോടെ നിർമ്മിക്കപ്പെട്ട ഒരു Steamed Pellet ആണ്. ചെമ്മീൻ തീറ്റ ഒരു പരിധിവരെ അവനവന്റെ ആവശ്യത്തിന് കൃഷിയിടങ്ങളിലോ അടുക്കളയിലോ നിർമ്മിക്കാവുന്നതുമാണ്.

മത്സ്യങ്ങൾക്കുള്ള ഭക്ഷണം, പലപ്രയോഗം പൂരകതീറ്റകൾ, പച്ചതീറ്റകൾ എന്നിവയ്ക്കു ഉപയോഗത്തിലൂടെ പൂർത്തീകരിക്കാൻ സാദ്ധ്യമാവാതെ വരുമ്പോൾ തിരി തീറ്റകൾ ആവശ്യമായി വരുന്നു. മാത്രമല്ല, മിക്ക മത്സ്യങ്ങൾക്കും ജലോപരിതലത്തിൽ പൊങ്ങിക്കിടക്കുന്ന floating feeds ആണ് ആവശ്യം. ഈ തീറ്റകൾ

Extrusion എന്ന സാങ്കേതിക വിദ്യ ഉപയോഗിച്ചാണ് നിർമ്മിക്കുന്നത്. കൂട് മത്സ്യകൃഷിയിലും പച്ച തീറ്റകളെക്കാൾ അഭികാമ്യം മേൽപ്പറഞ്ഞ floating Pellet തന്നെയാണ്.

ഇനി ചെമ്മീൻ കൃഷികൾ അവനവന്റെ കൃഷിയിടത്തിനോ സമീപമോ അടുക്കളയിലോ തീറ്റ നിർമ്മിക്കുന്ന രീതി വിവരിക്കാം.

ചേരുവകൾ

1. മീൻപൊടി	–	20–30%
2. കപ്പലണ്ടി പിണ്ണാക്ക്/സോയ	–	20–30%
3. കപ്പപൊടി/ഗോതമ്പ്	–	20–30%
4. മീനെണ്ണ/സസ്യഎണ്ണ	–	3 – 5%
5. ജീവക/ധാതുലവണമിശ്രിതം	–	3 – 5%

മേൽപ്പറഞ്ഞ ചേരുവകകളിൽ കപ്പപൊടി/ഗോതമ്പ് മാവ് ഒഴികെ ബാക്കിയുള്ള ചേരുവകൾ നല്ലപോലെ യോജിപ്പിക്കു. കപ്പ പൊടിയോ/ ഗോതമ്പ്മാവോ വെള്ളം ചേർത്ത് കുറുക്കുക ഈ 'കുറുക്ക്' തണുത്തശേഷം ഇതിൽ യോജിപ്പിച്ചുവച്ച ചേരുവകളും, ആവശ്യാനുസരണം വെള്ളവും ചേർത്ത് ഒരു സേവനാഴിയിൽ /നൂലപ്പം നിർമ്മിക്കുന്ന പരുവത്തിൽ കുഴച്ച് പിഴിഞ്ഞെടുത്ത് ആവിയിൽ വേവിച്ച് ഉണക്കുക. ഇത് ആവശ്യമുള്ള തരി വലിപ്പത്തിൽ ഉടച്ച് ഉപയോഗിക്കാവുന്നതാണ്.

ഇനി, തീറ്റ കൊടുക്കേണ്ട തോത് എങ്ങിനെയാണെന്ന് മനസ്സിലാക്കാം. ജലകൃഷിയിൽ കൊടുക്കുന്നതീറ്റ മത്സ്യം കഴിക്കുന്നുണ്ടോ അതോ വെള്ളത്തിൽ ലയിച്ച് നഷ്ടപ്പെട്ട് പോവുകയാണോ എന്ന് മനസ്സിലാക്കുന്നതാണ് ഇതിലെ പ്രായോഗിക ബുദ്ധി പൊതുവെ എല്ലാ മൃഗങ്ങളും മത്സ്യമുൾപ്പെടെ ശരീരഭാരത്തിന്റെ 2.5–3 ശതമാനമാണ് ഭക്ഷിക്കുന്നത്. ഈ തോത്

ജലാംശം ഇല്ലാതെയാണ് എന്ന് മനസ്സിലാക്കണം. എന്നാൽ മീനും ചെമ്മീനും കുഞ്ഞായിരിക്കുമ്പോൾ ഇത് 12–15% ഭക്ഷിക്കുന്നു. പക്ഷേ ഈയളവിലുള്ള തീറ്റ 24 മണിക്കൂറിൽ ഭക്ഷിക്കുന്ന അളവാണ്. അതുകൊണ്ട്, ചെമ്മീൻ കൃഷിയിൽ തീറ്റ തട്ടങ്ങൾ (ളലലറശിഴ ൃമ്യെ) ഉപയോഗിച്ച് തീറ്റ നൽകുമ്പോൾ, മൊത്തം തീറ്റയുടെ 1/3 ഭാഗമോ 1/4 ഭാഗമോ നൽകി അവ കഴിക്കുന്നുന്നോ എന്ന് ശ്രദ്ധിച്ച് വേണം തീറ്റ കൊടുക്കുന്നത് ക്രമീകരിക്കാന്. feeding frequency അല്ലെങ്കിൽ 'ആവൃത്തി' പ്രധാനമാണ്. ചെമ്മീനുകളെപ്പോലെയുള്ള ജീവികൾക്ക് മൂന്നോ നാലോ തവണകളായി തീറ്റ കൊടുക്കേണ്ടത് അവയുടെ പരിപാലനം മെച്ചപ്പെടുത്തുന്നു.

മത്സ്യങ്ങളുടെ കാര്യത്തിൽ ജലോപരിതലത്തിൽ പൊങ്ങിക്കിടക്കുന്ന തീറ്റകൾ ഉപയോഗിക്കുന്നതിന്റെ 'യുക്തി' തീറ്റയുടെ ദുർവ്യയം ഒഴിവാക്കുകയും തന്മൂലം പാഴ്ച്ചെലവ് കുറയ്ക്കലുമാണ്. മത്സ്യം കൊടുക്കുന്ന തീറ്റ മുഴുവൻ കഴിക്കുന്നുണ്ടോ എന്ന് കാണുവാൻ സാധിക്കുന്നതിനാൽ, മീനുകൾ തീറ്റയെടുക്കുന്നത് നിർത്തുമ്പോൾ തീറ്റ കൊടുക്കുന്നതും നിർത്താം.

മത്സ്യപോഷണം എന്ന സങ്കീർണമായ വിഷയം അവതരിപ്പിക്കുമ്പൾ അവയുടെ തീറ്റയിൽ മീനും, മീനെണ്ണയും ചേർക്കുന്നത് കുറയ്ക്കാനുള്ള ശ്രമം ഇന്ന് ആഗോളാടിസ്ഥാനത്തിൽ നടക്കുണ്ട് എന്ന് കൂടി അറിഞ്ഞിരിക്കണം. കാരണം മീനും മീനെണ്ണയും മത്സ്യത്തിനെ തീറ്റാനുള്ളതല്ല. അവയുടെ ആവശ്യം മനുഷ്യനാണ്. പ്രത്യക്ഷമായിതന്നെ ഈ വസ്തുക്കൾ മനുഷ്യനുള്ള ആഹാരമായതിനാൽ ഇന്ന് മത്സ്യങ്ങൾക്കുള്ള തീറ്റയിൽ ഇവ ഇല്ലാതെ തന്നെ മത്സ്യകൃഷി സുസ്ഥിരമായി മുന്നോട്ട് കൊണ്ടുപോകുവാൻ കഴിയും എന്ന് തെളിയിക്കപ്പെട്ടിട്ടുണ്ട്.

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കരിമീൻ വിത്തുത്പാദനം

വികാസ് പി എ, ഷിനോജ് സുബ്രഹ്മണ്യൻ
ഐ സി എ ആർ, കെ വി കെ എറണാകുളം

ശുദ്ധ ജലാശയങ്ങളിലും ഓർ ജലാശയങ്ങളിലും ഒരുമിച്ച് വളരാൻ കഴിവുള്ളവയാണെങ്കിലും വാണിജ്യാടിസ്ഥാനത്തിൽ കരിമീൻ വിത്തുൽപാദനം നടത്തുന്നതിന് ഓർജലാശയങ്ങളാണ് അനുയോജ്യം. വർഷം മുഴുവനും മുട്ടയിട്ട് കുഞ്ഞുങ്ങളെ ഉദ്പാദിപ്പിക്കുമെങ്കിലും ഫെബ്രുവരി മുതൽ മെയ് വരെയും ഒക്ടോബർ മുതൽ ഡിസംബർ വരെയുമാണ് കരിമീനിന്റെ പ്രധാന പ്രജനന കാലം. വളർച്ചയെത്തി പ്രജനനത്തിന് തയ്യാറാകുന്ന മത്സ്യങ്ങളിൽ മാത്രമാണ് ആൺ–പെൺ വ്യത്യാസം ബാഹ്യമായി പ്രകടമാകുന്നത്. വളർന്ന് വരുമ്പോൾ കൂട്ടമായി നടക്കുന്ന കരിമീനുകൾ പ്രജനന കാലം സമീപിക്കുമ്പോൾ കൂട്ടം തിരിഞ്ഞ് ഇണകൾ മാത്രമായി നടക്കുന്നതായി കാണാം.

കാർപ്പ് മത്സ്യങ്ങളുമായി താരതമ്യം ചെയ്യുമ്പോൾ കരിമീനിന്റെ മുട്ടയുടെ എണ്ണം വളരെ കുറവാണ്. കാർപ്പ് മത്സ്യങ്ങൾ ലക്ഷകണക്കിന് മുട്ട ഇടുമ്പോൾ, കരിമീൻ ഏറിയാൽ 3000 ൽ താഴെ മുട്ട മാത്രമാണ് ഇടുന്നത്. കാർപ്പ് മത്സ്യങ്ങളിൽ ചെയ്യുന്നതുപോലെ ഹോർമോൺ കുത്തിവെച്ച് മുട്ടയിടിയിക്കുന്ന രീതി കരിമീനിൽ പ്രായോഗികമല്ല. ആയതിനാൽ കുളങ്ങളിൽ സൗകര്യങ്ങൾ ഒരുക്കി പ്രകൃത്യാ മുട്ടയിടിച്ച് കുഞ്ഞുങ്ങളെ വേണ്ട വിധത്തിൽ പരിപാലിച്ച് അതിജീവനതോത് വർദ്ധിപ്പിക്കുക മാത്രമാണ് നമുക്ക് ചെയ്യാൻ കഴിയുക.

കുളങ്ങൾ ഒരുക്കുമ്പോൾ ശ്രദ്ധിക്കേണ്ടികാര്യങ്ങൾ

40 മുതൽ 60 സെന്റ് വരെയുള്ള ചെറിയ കുളങ്ങൾ ആണ് കരിമീൻ വിത്തുൽപാദനത്തിന് അഭികാമ്യം. വിത്തുത്പാദനം നടത്തുന്നതിന് മുമ്പ് ശ

രിയായ രീതിയിൽ കുളങ്ങൾ ഒരുക്കേണ്ടതുണ്ട്. ആദ്യമായ കുളങ്ങളിലെ കള മത്സ്യങ്ങളെയും സസ്യങ്ങളെയും പരിപൂർണ്ണമായി മാറ്റണം. കള മത്സ്യങ്ങൾ മുട്ടകളും വിരിഞ്ഞു വരുന്ന കുഞ്ഞുങ്ങളെയും ഭക്ഷണമാക്കുമെന്നതി നാലാണിത്.

കള നിർമ്മാർജ്ജനത്തിന് ഏറ്റവും അനുയോജ്യമായ മാർഗ്ഗം കുളങ്ങൾ പരി പൂർണ്ണമായും വറ്റിച്ച് ഉണക്കുക എന്നതാണ്. ഇതുവഴി കുളത്തിലെ എല്ലാ ക ളമത്സ്യങ്ങളും ഇവയുടെ മുട്ടകളും പൂർണ്ണമായും നശിച്ച് പോകുന്നതാണ്. എ ന്നാൽ എല്ലാ കുളങ്ങളിലും ഇത്തരത്തിൽ ഉണക്കി കള മത്സ്യങ്ങളെ നശിപ്പിക്കു ന്ന രീതി അവലംബിക്കാൻ സാധിക്കുന്നതല്ല. ഇത്തരം സാഹചര്യങ്ങളിൽ കഴിയാവുന്നത്ര വറ്റിച്ചശേഷം ജൈവ / രാസ സംയുക്തങ്ങൾ ഉപയോഗിച്ച് ഇവയെ നശിപ്പിക്കേണ്ടതായും വരും.

ജൈവരീതിയിൽ കള മത്സ്യ നിർമാർജ്ജനത്തിനായി നീർവാളക്കുരു, മഹുവ പിണ്ണാക്ക്, ടീ സീഡ് കേക്ക് എന്നിവയാണ് ഉപയോഗിച്ചു വരുന്നത്. ഒരു സെന്റ് കുളത്തിൽ 200 ഗ്രാം തോതിലാണ് ടീസീഡ് ഉപയോഗിക്കേണ്ടത്. കുള ത്തിലെ ജലത്തിന്റെ അളവ് പരമാവധി കുറച്ച് 10 സെന്റിമീറ്ററിൽ താഴെ കൊ ണ്ടു വന്നതിനുശേഷം വേണം ഇത് പ്രയോഗിക്കുവാൻ. ഉപയോഗിക്കുന്നതിന് 12 മണിക്കൂർ മുമ്പ് 1:10 അളവിൽ കല്ലുപ്പ് ചേർത്ത് വെള്ളത്തിൽ കുതിർത്ത് വെയ്ക്കണം. വെയിലുള്ള ദിവസത്തിൽ കുളത്തിൽ രാവിലെ 11.00 മണിയോട ടുപ്പിച്ച് ഈ മിശ്രിതം തുണിയിൽ പിഴിഞ്ഞെടുത്ത് കുളത്തിന്റെ എല്ലാ വശങ്ങ ളിലും എത്തിച്ചേരത്തക്ക രീതിയിൽ ഒഴിക്കുക. ഒഴിച്ച് കഴിഞ്ഞ് 10 മുതൽ 30 മി നിറ്റുകൾക്കുള്ളിൽ തന്നെ കള മത്സ്യങ്ങളെല്ലാം ചത്ത് പൊന്തി വരുന്നത് കാ ണാം. ഇവയെ കോരിവല ഉപയോഗിച്ച് പുറത്ത് കളയണം. കള മത്സ്യങ്ങളെ നിർമ്മാർജ്ജനം ചെയ്തതിനുശേഷം 24 മണിക്കൂർ കഴിഞ്ഞ് കുളത്തിൽ സെന്റിന് 2 കിലോ എന്ന തോതിൽ കുമ്മായമുപയോഗിക്കണം. കള നിർമ്മാർജ്ജനത്തിനുശേഷം പുറത്തു നിന്നും വെള്ളം കയറ്റേണ്ടി വന്നാൽ ചെറിയ കണ്ണി വലിപ്പമുള്ള അരിപ്പവല ഉപയോഗിച്ച് വെള്ളം അരിക്കുന്നു

എന്ന് ഉറപ്പുവരുത്തണം. കള നിർമ്മാർജ്ജനത്തിനുശേഷം സെന്റ് ഒന്നിന് ഉ ണങ്ങിയ ചാണകം (5 കിലോ), കപ്പലണ്ടി പിണ്ണാക്ക് (300ഗ്രാം), യൂറിയ (50 ഗ്രാം) എന്നിവ ഇടണം. ഇത് കുളത്തിൽ പ്ലവകങ്ങൾ വളരാൻ സഹായിക്കും. കരിമീനുകൾക്ക് കുളങ്ങളിൽ മൂട്ട ഒട്ടിച്ചു വയ്ക്കുന്നതിനുള്ള സൗകര്യം ഒരു ക്കേണ്ടത് അത്യാവശ്യമാണ്. ഇതിനായി മുള, മരക്കൂറ്റികൾ, ഓട്, മണ്ണിന്റെ ച ട്ടികൾ എന്നിവ ഉപയോഗിക്കാവുന്നതാണ്. ഇവ കുളത്തിന്റെ അരിക് വശങ്ങ ളിലായി പരമാവധി ഒന്നരമീറ്റർ അകലം വരത്തക്ക രീതിയിൽ കരയിൽ നിന്നും അരമീറ്റർ അകലത്തിനുള്ളിൽ ചൂറ്റും വെയ്ക്കണം.

തള്ള മത്സ്യങ്ങളെ നിക്ഷേപിക്കൽ

ശരിയായ രീതിയിൽ തയ്യാറാക്കിയ കുളങ്ങളിൽ 7–ാം ദിവസം തന്നെ തള്ള മ ത്സ്യങ്ങളെ നിക്ഷേപിക്കാവുന്നതാണ്. ആൺ പെൺ മത്സ്യങ്ങളെ തരംതിരിച്ച് മനസിലാക്കുന്നത് എളുപ്പമല്ലാത്തതിനാൽ കൂട്ടമായി നടക്കുന്ന മത്സ്യങ്ങളെ മൊത്തത്തിൽ പിടിച്ചെടുത്താണ് കുളങ്ങളിൽ നിക്ഷേപിക്കുന്നത്. 12 മുതൽ 14 സെ.മീ നീളവും 80 മുതൽ 160 ഗ്രാം വരെ വലുപ്പവുമുള്ള മത്സ്യങ്ങളെ വേ ണം തള്ള മത്സ്യമായി ഉപയോഗിക്കുവാൻ. പ്രജനന സമയമായാൽ ആൺ മ ത്സ്യങ്ങുടെ ശരീരത്തിൽ കാണുന്ന വരകളും വെള്ളപ്പൊട്ടലുകളും കൂടുതൽ തിളങ്ങുന്നതായി കാണാം. ഒരു സെന്റ് സ്ഥലത്ത് ആരോഗ്യമുള്ള 4 മുതൽ 8 എണ്ണം വരെ തള്ള മത്സ്യങ്ങളെ ഉപയോഗിക്കാവുന്നതാണ്.

തള്ള മത്സ്യങ്ങളെ കുളങ്ങളിൽ നിക്ഷേപിച്ച് കഴിഞ്ഞ് 24 മണിക്കൂറിന് ശേഷം ദിവസത്തിൽ 2 നേരം എന്ന ക്രമത്തിൽ തിരി തീറ്റ നൽകണം. ഇത്തരത്തിൽ ഒ രു മാസത്തെ പരിപാലനത്തിനുള്ളിൽ തന്നെ ഇവ മുട്ടയിടുന്നതിന് ആരംഭി ക്കും. മഞ്ഞ നിറത്തിലുള്ള മുട്ടകൾ മൂന്ന് മുതൽ നാല് ദിവസത്തിനുള്ളിൽ ക റുത്ത നിറമാകുകയും തുടർന്ന് വിരിയുന്നതിന് ആരംഭിക്കുകയും ചെയ്യുന്നതാ യി കാണാം. വിരിഞ്ഞു വരുന്ന കുഞ്ഞുങ്ങളെ തള്ള മീനുകൾ മണലിൽ / ചെ ളിയിൽ ചെറിയ കുഴികൾ ഉണ്ടാക്കി പരിപാലിക്കും. ഇവ സ്വന്തമായി തീറ്റയെ

ടുത്ത് തുടങ്ങുന്നത് മൂന്ന് മുതൽ നാല് ദിവസങ്ങൾക്ക് ശേഷം മാത്രമാണ്. ഈ സമയത്ത് ഇവ കുഞ്ഞു പ്ലവകങ്ങളെയാണ് തീറ്റയായി കഴിക്കുന്നത്. പക്ഷികളും മറ്റും കുഞ്ഞുങ്ങളെ ഭക്ഷണമാക്കുന്നത് തടയേണ്ടതാണ്. കുളത്തിന്റെ മുകളിൽ പക്ഷികളെ പ്രതിരോധിക്കുവാൻ വല കെട്ടേണ്ടതാണ്. നീർനായയുടെ ശല്യമുള്ള സ്ഥലങ്ങളിൽ ഇവയെ പ്രതിരോധിക്കുന്നതിനായി കുളത്തിന്റെ വശങ്ങളിൽ പ്രത്യേകം വല കെട്ടി സംരക്ഷണം ഒരുക്കണം.

കുഞ്ഞുങ്ങളെ എങ്ങനെയെല്ലാം പിടിച്ചെടുക്കാം.

കരിമീൻ കുഞ്ഞുങ്ങൾ ആദ്യത്തെ ഒരു മാസത്തോളം കൂട്ടമായാണ് നടക്കുന്നത്. രാത്രി സമയത്ത് ചെറിയ കോരി വല ഉപയോഗിച്ച് ഇവയെ ചെറിയ കണ്ണിവലുപ്പമുള്ള ഹാപ്പനെറ്റുകളിലേക്ക് മാറ്റണം. വലുപ്പം കൂടിയ കുഞ്ഞുങ്ങളെ 12മി.മീ കണ്ണി വലുപ്പമുള്ള HDPE വലകൊണ്ട് നിർമ്മിക്കുന്ന ചതുരാകൃതിയിലുള്ള (2മി x 2മി x 1.5മി) കൂട് വലകളിൽ ആണ് ഇടേണ്ടത്. കുറഞ്ഞത് 6 സെ.മി വലിപ്പമെത്തിയ കുഞ്ഞുങ്ങളെയാണ് വിപണനം നടത്തേണ്ടത്. കുഞ്ഞുങ്ങളെ പിടിച്ചെടുക്കുന്നതിനായി കെ.വി.കെ. ചിത്രത്തിൽ കൊടുത്തിരിക്കുന്ന വല വികസിപ്പിച്ചെടുത്തിട്ടുണ്ട്.

കുഞ്ഞുങ്ങളെ പിടിക്കുന്നതിനായി ഈ വല കുളത്തിൽ താഴ്ത്തി താഴ്ന്നുപോകുന്ന തിരി തീറ്റ ഇട്ട് വെയ്ക്കണം. ഒരു മണിക്കൂറിന് ശേഷം വല പൊക്കിയെടുത്താൽ കുഞ്ഞുങ്ങളെ ലഭിക്കുന്നതാണ്.

എന്നാൽ ഈ രീതിയിൽ മാത്രം മുഴുൻ കുഞ്ഞുങ്ങളെ പിടിച്ചെടുക്കാവൻ സാധിക്കുന്നതല്ല. ഈ സാഹചര്യത്തിൽ മറ്റ് പല രീതികളും അവലംബിക്കേണ്ടതാണ്. ഇതിനായി കുളങ്ങളുടെ വശങ്ങളിൽ ഉറപ്പിച്ച് വെയ്ക്കാവുന്ന ചെറിയ ചീനവലകൾ, കുളങ്ങളിൽ താഴ്ത്തി വയ്ക്കാവുന്ന കൂട് വലകൾ, വീശുവല എന്നിവ ഉപയോഗിക്കാവുന്നതാണ്.

കുഞ്ഞുങ്ങളെ ദൂരസ്ഥലങ്ങളിലേക്ക് കൊണ്ടുപോകുന്ന സാഹചര്യങ്ങളിൽ ഓക്സിജൻ നിറച്ച പോളിത്തീൻ കവറുകളിൽ പാക്ക് ചെയ്ത് വേണം കൊണ്ടുപോകുവാൻ. മത്സ്യകുഞ്ഞുങ്ങടങ്ങിയ പോളിത്തീൻ ബാഗുകൾ

കുളത്തിൽ നിക്ഷേപിക്കാൻ 6 മണിക്കൂറിലധികം സമയം എടുക്കുന്നുവെങ്കിൽ ഇവയെ 20 ഡിഗ്രി താപനിലയിൽ താഴെ സൂക്ഷിക്കേണ്ടതാണ്.

മത്സ്യക്കുഞ്ഞുങ്ങളടങ്ങിയ ബാഗുകൾ തുറക്കുന്നതിന് മുൻപ് താപനില ക്രമീകരിക്കുന്നതിന് അവ കുറഞ്ഞത് അരമണിക്കൂറെങ്കിലും നിക്ഷേപിക്കാനുദ്ദേശിക്കുന്ന ജലാശയത്തിലെ വെള്ളത്തിൽ തന്നെ ഇട്ടുവയ്ക്കുക. തുടർന്ന് ബാഗുകൾ തുറന്ന് കുളത്തിലെ വെള്ളം സാവധാനം (20 മിനിറ്റെങ്കിലും എടുത്ത്) നിറച്ചശേഷം മാത്രം കുഞ്ഞുങ്ങളെ തുറന്ന് വിടുക. ഇങ്ങനെ ചെയ്തില്ലെങ്കിൽ താപനിലയിലുള്ള വ്യത്യാസം കുഞ്ഞുങ്ങൾ ചത്തുപോകാൻ ഇടയാക്കും എന്ന് പ്രത്യേകം ശ്രദ്ധിക്കുക.