Marine fish hatchery concept, design and construction

R. Jayakumar and A.K. Abdul Nazar
Mandapam Regional Centre of CMFRI
Mandapam Camp - 623520, Tamil Nadu, India

Introduction

A marine fish hatchery is a complex system consisting various units like seawater intake, water treatment and storage, broodstock holding, indoor algal stock culture, intermediary and outdoor algal culture, rotifer culture, artemia hatching and enrichment, larviculture, nursery rearing, laboratory, feed and chemical storage, aeration facility, waste water treatment and disposal, workshop and staff accommodation area. During the production season proper hatchery management requires specialised skills and total dedication by well-trained personnel. Therefore, proper designing of a fish hatchery will give technical solutions to give best results in terms of convenience, ease of use, effective use of the full production capacity, bio-security, hygienic working conditions and cost effectiveness. Improper designing of the hatchery or construction would result in the risk of ineffective utilization of the facilities, uneconomical operation, increased manpower to manage the facility, chances of cross contamination, loss of stock etc.

Size of the hatchery

While designing the hatchery, the entrepreneur should have a clear idea about its annual production target. This helps to design the hatchery facilities in a proper manner. This decision on the size of the hatchery is a fundamental requirement before commencing the search for suitable sites, technical design and investment plan.

The following issues should be addressed while planning to establish a hatchery:

- fish seeds to be produced (either single or multi species),
- availability of broodstock
- yearly targets as number and size of fingerlings to be produced,
- source of technology and availability of trained manpower
- water quality and availability in different seasons,
- availability of power supply, manpower, motorable roads,
- market demand for the fish seeds

If any of the above aspects is not properly considered during the planning phase, it may result in difficulty in operations and sale of seeds.

Site selection

While selecting the site for marine fish hatchery construction the following are important criteria:

- Motorable road up to the site,
- Stable water quality during most of the months of operation
- Stable temperature during the period of hatchery operation
- Uninterrupted electricity supply
- Away from domestic and industrial waste disposal area,
- Elevation from the mean sea level
- Away from flood prone area
- Protected area from cyclones, hurricanes
- Away from the fresh water canals, rivers and drainages
- Availability of copious volume of fresh water (cleaning & disinfection purpose)
- Away from other shrimp/fish hatcheries

Hatchery layout and design

While designing the hatchery, positioning of various units at suitable places plays important role in easy and economic operation of the hatchery. The water pumping stations and aeration systems should be kept away from the broodstock facility to avoid noise and vibration disturbance to the brooders. Similarly, the packing area has to be placed near to the main entrance, so as to avoid the entry of unauthorized persons and visitors into the bio secured area. Elevation of water storage tanks have to be carefully designed for easy and free gravitational flow of water from these tanks to various units of the hatchery. Every section of the hatchery should have separate entry to avoid cross contamination from one section to other.

Quarantine facility

The quarantine facility is one of the important components of the hatchery, which helps in holding of the broodstock entering into the hatchery to undergo proper treatment and conditioning to avoid the entry of pathogens into the hatchery. The quarantine tanks should be of suitable size to match the size of the brooders to be kept. Facilities for continuous supply of seawater, freshwater and aeration should be provided in this facility. The quarantine facility should be placed either near to the entrance of the hatchery or far off from the production area to avoid cross contamination.

Broodstock holding facility

The broodstock holding facility is the vital unit in the hatchery meant to hold adequate stocks of parent fish to assure a timely production and supply of fertilized eggs of the best quality to the larval rearing unit. Broodstock holding facilities can be located both outdoors and indoors depending of the basic requirement of the brood fishes. Certain brood fishes require strict maintenance of photo period and temperature regimes; preferably can be located in the indoor area. Whereas, certain brooders may not require such facilities can be reared in outdoors facilities. Generally, outdoor facilities are mainly used for long term holding of immature fishes. In certain cases the outdoor facilities used for quarantining of wild collected parental stock or spent brooders for proper treatment before inducting into the indoor facility

Indoor broodstock holding facilities

The indoor broodstock facility requires a clean environment, with adequate water supply for flow through or recirculation systems. The elevation of water inlet, outlet, drainage canals have to be properly designed for easy and free flow of water. The tank size, water holding capacity and shape has to be designed according to the requirement of broodstock fishes. The broodstock holding tanks have to be painted with suitable coloured epoxy paints to maintain the brooders in a congenial environment and the smooth surface is needed to avoid injury to the brooders and for easy cleaning.

Indoor Broodstock holding tanks with photoperiod control

Broodstock fishes can be retained in the enclosed indoor facilities to avoid exposure to varying environmental fluctuations. Indoor broodstock holding area should have cement/ FRP tanks with proper water supply, aeration lines and lighting to accelerate the gonadal development. When considering installing recirculation systems, enough floor space close to the tanks should be planned in the designing stage to place its various components such as mechanical filters, biological filters, pumps, sterilizers, and heating and photo period control equipments.

Indoor broodstock holding tanks

Outdoor broodstock holding facilities

Outdoor broodstock holding facilities can be located within or nearer to the hatchery premises. Either rectangular earthen ponds or concrete tanks of rectangular/round shape can be constructed between 30 and 100 m3 size, but earthen ponds can be of 500 m3 with proper slope and drainage facilities. These type of facilities are sufficient to hold a good number of fish, but at the same time allows an easy visual control of the captive broodstock. The choice between earthen ponds and concrete tanks is often based on the soil conditions and investment costs and availability of adequate space. While designing the earthen ponds or concrete tanks the space availability, easiness for operation and handling of fishes has to be kept under consideration. In addition, marine fishes can be maintained in the HDPE/ Galvanized Iron Pipe cages in the open sea with proper mooring system. The sea cages can be moored in close vicinity of the hatchery for overall observation, security and safety. While stocking the brood fishes enough care should be taken to feed them with appropriate feed and regular exchange of cage nets of appropriate size.

Spawning and incubation facilities

The tanks where fish are temporarily stocked to obtain fertilised eggs are usually placed in a dedicated area namely spawning facility. These tanks should be located in the quietest location of the hatchery to reduce disturbance to broodstock and adjacent area can be reserved to place tanks for stocking of fertilized eggs for hatching. Dedicated broodstock holding tanks can be constructed adjacent to the spawning tanks to temporarily hold the spent brooders. The spawning tanks should be provided with adequate facilities for altering the photoperiod and temperature regimes, which are essential for faster gonadal maturation. Similarly, the spawning tanks should be provided with adequate water supply and aeration. The spawning area should be maintained clean and bio secured to avoid stress to the brooders.The spawning tanks have to be painted with suitable colour epoxy paints to maintain smooth surface to avoid injury to the brooders and for easy cleaning. Thermal insulated walls and roof are advisable in the areas where temperature fluctuations occur. In such areas additional facilities for controlling the water temperature, heaters with thermostat can be installed. The drains can be placed under the floor and the gutters going to the biological filters should be built well above the floor level to prevent dirt or toxic wastes, such as disinfectants used to wash floors, from entering into the recirculation system.

The spawning tanks are usually round or rectangular (with rounded corners) tanks with water holding capacity ideal for spawning. The spawning tanks can be made of concrete, FRP, or are FRP lined tanks. Tank depth should match the requirement of broodstock fishes and also should be easy to facilitate the work of technicians. Even if automatic egg collectors are used, enough space should be left around the spawning tanks to allow for manual collection of eggs and broodstock handling.

Live feed culture facilities

The live feed culture facility comprises the following units:

- phytoplankton stock culture unit
- rotifer pure strains and small volume culture unit
- phytoplankton starter culture unit
- phytoplankton intermediary culture unit
- phytoplankton outdoor mass culture unit
- rotifer mass culture and enrichment unit
- copepod culture unit
- Artemia nauplii mass production and enrichment unit

Each unit has to be housed as separate bio secured area to avoid cross contamination. The size and area of the unit has to be designed to match the production requirement. Each unit has to be provided with proper aeration supply, treated seawater and fresh water supply lines, lighting, electricity plug points, proper floor slopping and drainage system.

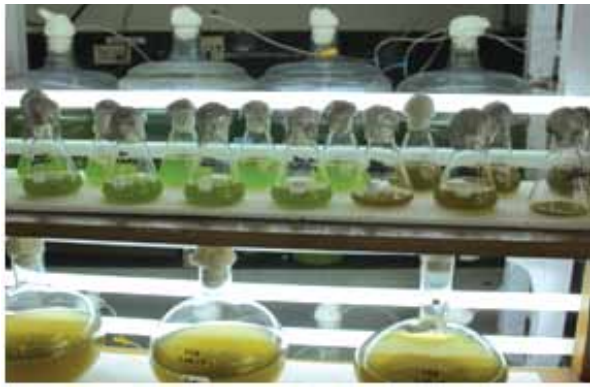
Phytoplankton stock and starter culture unit

Pure strains of algae as well as starter cultures (from small vessels up to 5-20 litre flasks/carboys), should be kept in an air-conditioned room under sterile conditions to avoid possible contamination. Floor and walls in this unit should be tiled for easy washing and disinfection. An adjacent storage room of smaller size can be constructed to store chemicals, glassware and other consumables. The stock and starter culture facility should have the seawater lines fitted with cartridge filters and UV sterilisers to treat the water prior to use.

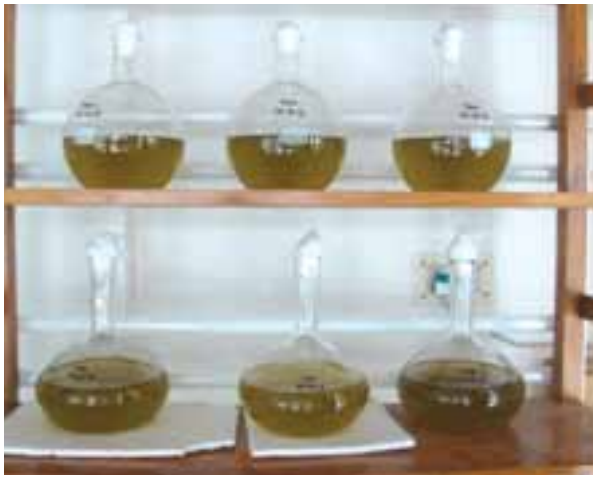
The wooden or concrete slabs/ racks should be provide in this unit for placing the stock cultures in test tubes or glass or plastic vessels with adequate lighting system to accelerate the growth. A CO2 enriched air supply system can be connected to the culture vessels to provide additional source of carbon and to ensure necessary turbulence for uniform mixing of culture media.

Light is very important component in algal culture. The right-size fluorescent tubes have to be conveniently placed to provide light at adequate intensity for pure algal strains and larger starter culture vessels. Aeration is required to create turbulence and to provide oxygen for both pure algae and starter cultures. To avoid the heating effect of the lights installed in the unit, air conditioning is usually necessary to keep the temperature within an optimal range.

Algal Stock Culture



Algal Starter Culture



Algal Starter Culture

Alage cultured in Carboys

Intermediate algae culture unit

In this unit, algae are cultured in large quantities in polyethylene (PE) bags/ Acrylic carboys/ FRP Tanks. They are used directly to as inoculums for culture of larger volumes of algae in outdoor units. The bags/ carboys/FRP tanks have to be housed in a dedicated area adjacent to the stock culture/starter culture unit. The floor of this room should be tiled to facilitate easy cleaning and should have proper slope towards drainage canal. Adequate fluorescent lights should be provided to accelerate the algal growth. The number of bags/ carboys/FRP tanks required has to be calculated according to the time taken for the culture to mature to the harvestable level and daily requirement for use in the outdoor culture units. At least 20% additional volume has to be reared to supplement the loss due to algal crash and slow growth during different climatic conditions. The aeration, water supply, CO_2 supply has to be provided according to the requirement.

Intermediary Culture of Algae

Outdoor algal mass culture unit

In this unit, algae are cultured in large quantities in FRP/ concrete Tanks. The cement tanks of rectangular size with a holding capacity of 5 -7 tones would be ideal for easy handling. These tanks receive inoculums form the intermediary culture tanks. The FRP /concrete tanks have to be placed in a dedicated area adjacent to the intermediary culture unit. Sufficient lighting arrangement has to be provided through transparent roofing. The tanks should be painted with white epoxy paint for improved light reflection. The floor of this unit should be tiled to facilitate easy cleaning and should have proper slope towards drainage canal. The number of FRP /cement tanks required has to be calculated according to the daily requirement of algae for the rotifer culture facility and larviculture unit. Time taken for the culture to mature to the harvestable level also should be taken into consideration while calculating the requirement. At least 20% additional volume has to be reared to supplement the loss due to algal crash and slow growth during different climatic conditions. The aeration, sea water and fresh water supply, has to be provided according to the requirement.

Outdoor algal culture unit

Rotifer stock and starter culture unit

A similar set of facility like phytoplankton stock and starter culture unit except CO2 supply shall be provided for the pure culture and starter culture of rotifers. Care should be taken to avoid cross contamination while maintaining different varieties and sizes of rotifers maintained in this unit.

Rotifer culture and enrichment unit

In this unit rotifers are cultured in large quantities in tanks of 1 to 5 tone capacity. This unit has to be little away from the algal culture units to avoid cross contamination. The tanks can be rectangular in shape made of FRP material or cement tanks with Epoxy painting. The epoxy paint colour has to assist in light penetration and easy for observation and cleaning. The rotifer culture unit has to be divided into multiple sub sections according to type and size of the rotifers cultured. To avoid cross contaminations separate water lines, aeration supply and impediments should be provided. Floor and walls should be covered with tiles for frequent washing and disinfection to maintain hygienic conditions. As harvesting has to be done in the same room, involving large quantities of culture water, an efficient drainage system is required. The volume and number of tanks has to be designed according to the daily requirement of rotifers and its and multiplication rate.

The space occupied by rotifer culture unit is determined by the expected maximum daily consumption of rotifers by the larval fish rearing unit. The calculation should therefore take into account:

- the peak daily amount and type of rotifers to be fed to fish larvae,
- the peak daily amount and type of rotifers to be re-used to inoculate new tanks,
- the individual volume and number of the particular type of rotifer mass culture tanks,
- the average density of enriched rotifer at harvest,
- the average number of days to get a mature rotifer culture.

Mass culture of rotifers

Artemia nauplii production and enrichment unit

The production of Artemia larval stages (nauplii and metanauplii) has to be carried out in a separate area, usually adjacent to the rotifer culture unit. Separate seawater and freshwater lines, aeration lines should be provided. The tanks should be made of FRP material with conical bottom for easy harvest of nauplii. As in the other units, the floor and walls should be tiled to help maintain good hygienic conditions. As harvesting takes place in the same room with tons of culture water being filtered daily, an adequate drainage system is necessary. The daily requirement of nauplii and metanauplii for the larviculture has to be calculated and accordingly the number and size of the tanks have to be calculated. This also shall match with the hatching percentage of the Artemia cysts and incubation time.

Fish larviculture unit

Rearing of various stages of fish larvae in the hatchery is one of the important activity. All other sections like algal culture, rotifer culture are ancillary units to this activity. The fish larvae are very fragile, sensitive and prone for outbreak of diseases. Utmost care should be taken while designing the larviculture unit. This unit shall be separate from all other units and have proper bio security to avoid cross contamination from outside and tanks within the facility. Adequate lighting has to be provided for this unit. The tanks can be of either FRP or concrete materials. Ideally the tanks should be rectangular with epoxy painting. The epoxy colour should assist the larvae for easy prey catching and feeding. Floor and walls should be tiled to secure proper hygienic conditions and to facilitate frequent cleaning. Since at harvest the tanks are emptied, an adequate drainage system is required.

When a recirculation aquaculture system is used, enough floor space close to the larval rearing tanks should be provided to place components such as mechanical and biological filters, pumps, sterilizers and heating/cooling devices.

The basic considerations for the tanks in larviculture unit includes:-

- the larvae should be easily visible throughout the whole water volume;
- the tank bottom should be easily accessible for daily cleaning; white/ yellow/ pale blue colour facilitates for better detection of dirt;
- absence of dead zones to avoid anoxia, ammonia build-up, etc.;
- optimization of the aeration pattern;
- low cost and local availability of building material;
- optimal use of space;
- Simplified design of support systems (water circulation, air supply, power supply, illumination);
- Minimal manpower requirements for their management;
- A large number of smaller tanks offers better protection against disease outbreaks than few large tanks.

Each tank should be provided with an independent inlet and angle at which water enters the tank will depend on tank design and on the age of the fish population. To prevent excessive turbulence, the aeration in fish larval rearing tanks should be very gentle, with a low air flow. Aeration has to be provided by means of one or more fine diffusers placed on the tank bottom. Freshwater with a few delivery points and a wash-basin for cleaning purposes has to be provided.

The larviculture tanks have to be designed according to the water volume necessary for larval rearing based on:

- number of fish larvae to be reared in each tank,
- amount of fingerlings required per production cycle,
- final larval density and average survival in the larval rearing sector,
- final larval density and average survival in the fingerling rearing sector.

Fish Larviculture Tanks

Nursery rearing unit

The nursery rearing unit is essentially to hold the fish larvae which have attained to the weaning stage to inert larval diets. These larvae are expected to metamorphose within a short span of time similar to the shape of adults. Nursery rearing unit requires larger size rearing tanks. Nursery tanks are usually constructed adjacent to the larval rearing unit to facilitate the easy transfer of fish larvae. Either rectangular or circular tanks can be used as nursery rearing tanks. These tanks shall be made of either FRP/ cement with smooth finishing to avoid bacterial and algal growth on the walls.

The drainage system should be larger than in the larval rearing unit as many times huge volume of water will be used for flow through. The capacity of the tanks can range from 5 to 10 m3. Bigger size tanks will limit the flexibility required for frequent grading of fish fingerlings. Seawater, freshwater, aeration lines should be provided to this facility with adequate lighting. Space requirement has to be calculated according to the production aimed in each cycle. The tank colour should assist the easy cleaning, visibility etc

Ancillary units

1. Pumping station and Air Blower room

The size and capacity of the pumps have to be calculated according to the water requirement. The number of pumps have to be decided according to the yield of water from each bore well. Drawing water from the open sea should be avoided as it carries lots of dirt, organic matter, eggs and larval forms of different organisms, disease causing organisms, parasites ect., For the hatchery operations drawing water from the sub soil through bore wells will help to get pure filtered sea water. The location of pumping station should be easily accessible, to simplify transport of pumps and other equipments. Further, the pumping station should be located as close as possible to the hatchery to facilitate constant surveillance. The seawater bores should be installed in the deepest part of the sea during the low tide, so as to get continuous supply of sea water during the entire operational period. The pumps should be housed in a room to protect the motors and electrical installations from heat, dust and rain

Seawater Intake point

Seawater Pumps

water. Proper fresh water lines should be provided in the pump room for priming of the pumps.

Air blowers have to be paced nearer to the pump house or nearby area. The blower capacity has to be calculated according to the aeration requirement in each section. A stand by blower has to be installed for use in the event of failure of the main blower. The blower room shall be covered completely to reduce the entry of dirt into the blowers. Similar covering blower room would provide sufficient proof to avoid sound pollution.

Air Blowers

Stand by Air Blower

2. Seawater filtration and water storage

The sea water pumped should be filtered through various types of filtration systems like slow sand filters and rapid sand filters and can be stored in large sumps designed according o the daily requirement of water in the hatchery. This would help to avoid the entry of unwanted micro organisms, disease causing pathogens into the hatchery. Sea water and fresh water sumps have to be constructed to store sufficient quantity of water required for the hatchery use. The seawater sumps should have provision for chlorination and dechlorination of water. The dechlorinated water can be passed through rapid sand filters and cartridge filters. Over head tanks have to be constructed within the hatchery premises to store copious amount of sea water and fresh water for the storage of water for day to day use. These tanks should be placed in an elevated area with proper gravitational flow it can supply water to all sections of the hatchery. The water requirement should be calculated for the daily operations and accordingly

3. Electrical Generator Room

An electrical generator of suitable capacity has to be installed in the hatchery premises after calculating the load requirement for the blowers, pumps, general lighting and heating equipments. The generators have to be installed in a sound proof casing to avoid sound pollution and preferably, they have to be placed far off from the broodstock holding area. In event of failure of electricity supply from the local authorities for a longer period, the captive generators shall have the capacity to support the entire hatchery operations. A stand by generator is needed for pumps and blowers and general lighting in the event of the failure of the main generators.

4. Workshop and Storage Room

A full-fledged workshop is required in the hatchery to meet the day to day maintenance activities like pump repair, electrical maintenance works, blower repair etc., This unit has to be provide with electrical supply, welding machines, cutting tools, pump and blower repair equipments and accessories. This facility should have a storage room for stocking of aeration & water pipes, other utilities of the hatchery.

5. Fish Feed Store

This storage facility should have air conditioning unit to store the larval feeds, inert diets, Artemia cysts, hormones, antibiotics, health management chemicals etc. This store room should be kept away from the area where water is extensively used. Deep freezers can be installed outside this room to store feeds for the broodstock like, squids, crabs, shrimps, fish etc.

6. Laboratory Room

The hatchery laboratory room has to be located close to the phyto/zooplankton unit or larviculture unit. This laboratory will house microscopes, auto claves, Hot air ovens, etc. Its size depends on the type and number of staff working in the laboratory.. The laboratory should be large enough to allow working together in a comfortable way while performing their routine analyses or carrying out tests. Furniture in the laboratory should be similar to that of a research laboratory, including, anti-corrosion benches for scientific instruments, cupboards with transparent doors for storing glassware and chemical products, and large desks with shelves. Cement floored open areas for drying of glassware, utensils, tanks etc., should be provided in the hatchery premises.

7. Office and seed packing area

Office and seed packing area should be located near the entrance of the hatchery to avoid entry of visitors into the production facilities. A residential accommodation area for the technical staff and kitchen also should be located near the entrance. A parking area for the vehicles should be provided near the entrance of the hatchery to avoid moving of vehicles within the production area. The whole hatchery area should have proper fencing/compound wall to avoid entry of animals and unauthorized persons.