5. OBSERVATIONS

A survey of 206 hatcheries in India was made during 1992-1995. The technological concepts involved in the hatchery designs and operation that govern the status of shrimp hatcheries in India were studied in depth. This extensive survey and collection of data were possible due to the author's accessibility to (i) an engineering firm, M/s Maritec Consultants (I) Pvt., Ltd., Madras, (ii) hatcheries and other institutions, viz., MPEDA, Cochin, and The Shipping Credit and Investment Company of India Limited (SCICI), Hyderabad branch. In general, entry into the shrimp hatcheries is prohibited for the public. However, shrimp hatcheries were accessible to the author for the benefits rendered in the form of technical audit through the above mentioned agencies to augment their seed production.
5.1. **Technological Concepts Involved In Hatchery Design.**

There are two main types of hatchery technology for rearing shrimp larvae, viz., Japanese and Galveston. These technologies have been appropriately modified to suit to different geographical, climatic conditions and different species of shrimps the world over (Neelakanta Pillai, *et al.*, 1993). Thus, four allied hatchery technologies, viz., Philippines, Taiwan, French and German, which are nothing but the combination of these two main technologies have been witnessed in different parts of the world. It is worth mentioning that apart from these four allied technologies, Indian technology, a combination of Japanese, Galveston, Philippines and Taiwan technologies is also popular in India. Therefore, totally there are seven basic shrimp hatchery technologies. These seven basic technologies (Japanese, Galveston-Hawaii, Philippines, Taiwan, French, German and Indian) were observed during the course of the present survey on 206 hatcheries in India, and the details of these technologies are described below:

1. **Japanese Technology:**
   
a. **Maturation section:**

   Adults of 100-120g are found to survive and grow well at a stocking density of 2-3 animals/sq.m. Breeders prefer darkness and shelter. They prefer low intensity of light. The roof of the hatchery in the maturation section is completely closed by asbestos sheet to prevent sunlight. Artificial fluorescent light with blue translucent cover is provided to simulate sea colour. These lights are used only during cleaning and for a short period in a day.
Temperature between 26 and 28°C is maintained in this section. When temperature falls below 23-25°C, immersion heaters or space heaters are used. During increase in temperature above 32-35°C, shaded clothes over the tanks with ventilation or gunny bags with trickling water filters above the roof of the hatchery are provided to reduce temperature. Adult shrimps especially in the maturation section are provided with black or dark blue colour coating of epoxy paint to simulate dark condition.

b. Spawning and hatching section:

Gravid females of 80-150g at a stocking density of 2-5 spawners/tank (1-5 ton - capacity) are worked out in this technology. Water exchange of 50% is carried out if breeders are kept for more than a day. In the spawning section, lights are not provided since the act of spawning by the female is during darkness. However, in the hatching section, artificial lights are used to hatch the eggs to nauplius. Temperature ranging 26-28°C in controlled condition is provided in this sections. The spawning and hatching tanks are coated with white paint to distinguish and identify the process of spawning.

c. Larval section:

Larvae at Nauplius (N3) stage are stocked at the rate of 50-80 nauplii/litre in Japanese, Taiwan and Philippines technologies. In this technology, water is raised gradually depending on the various larval stages correspondingly with 30-100% water exchange. However, at N₆ and PL₆ stages, water exchange of 30-50% is carried out daily in 8-10 hrs. The larvae of
shrimps are phototactic in nature and they grow well in the presence of light. The roof of the hatchery in the larval and post-larval sections are provided with alternate arrangement of Fibre Reinforced Plastic (FRP) light sheets to facilitate sunlight penetration. These translucent sheets are blue coloured tinted in order to permit light in controlled intensity. Apart from natural light, fluorescent lights are fixed to provide illumination artificially, in the larval section. These lights are fixed from the roof truss at a distance of 0.5-1.2m between the truss and the tank surface in order to allow the required intensity of light to the larvae. Temperature is maintained at 26-28°C. Temperature is regulated as adopted in the broodstock section. The larval tanks are coated with bluish-green or sky blue paint to simulate sea condition.

d. Post-larval section:

In this technology, the larvae are grown in the same tank till they reach PL20 stage. However, at PL5 stage, the post-larvae are distributed equally at the rate of 8-12 PL/litre in the larval rearing tanks. Water exchange, lighting arrangement, temperature and colour of paint used in this section is carried out similar to that of the larval section.

e. Broodstock pond:

These ponds are constructed to rear breeders. The breeders are reared in an area of 4000-10,000 sq.m. A stocking density of 2-5 animals per sq.m. is considered for effective growth and maturation process. Presently, it has been observed that broodstock ponds are not the essential components of the Seven
technologies, viz., Hawaii, Japanese, Philippines, Taiwan, German and Indian. However, they are considered as ‘optionals’ irrespective of the chosen technologies. This observation is based on the following evidences collected during the course of the present investigation.

Out of seven hatchery technologies, only two hatcheries, viz., M/s The Orissa Shrimp Seed Supply, Production and Research Centre (OSSIPARC), Gopalpur, Orissa (French) and M/s Kumta Shrimp hatchery, Kumta, Karnataka (Indian) were found to possess broodstock ponds. Hatcheries, viz., M/s The Andhra Pradesh Shrimp Seed Supply, Production and Research Centre (TASPARC), M/s SSV/Durga, M/s Nagarajuna Construction Company Blue Water Products Ltd. (NCCBPL), Vizag, M/s Veerat Aqua-tech, West Godavari (Hawaii), M/s Nagarajuna Aqua Exports Ltd. (NAEL), Nellore, (Taiwan) Andhra Pradesh and M/s Giridhar Foods, Ramnad, Tamilnadu (Philippines) have proposed to construct broodstock ponds in their project in the near future. However, hatcheries, viz., M/s Kalyan SeaFoods (Hawaii) M/s Lahari SeaFoods (Japanese), Kakinada, Andhra Pradesh, M/s Aurolee Hatchery, Madras, M/s Pioneer Aqua, Tuticorin, (Indian), M/s ITC, Minota Aqua-Tech Tuticorin, Tamilnadu (Japanese), M/s Aqua Plaza, M/s CIBA Hatchery (formerly called NPCL - National Prawn Culture Laboratory) (Indian), M/s Travancore (Taiwan), Trichur, M/s MPEDA Hatchery, Cochin, Kerala (German) and M/s Bluchip, Kumta, Karnataka (Philippines) have no provision for broodstock ponds.
f. Live-feed sections:

In indoor algal culture, water is exchanged only after complete harvest as in all the technologies. Exchange of water is also carried out indirectly when algae are partially harvested and replenished with fresh seawater in 3-4 days interval. Light is the major component for the growth of algae. It aids in photosynthesis activity and multiplication of cells. In Indoor culture, artificial lighting (fluorescent lights) of intensity ranging 5000-8000 lux has been found essential for algal growth (Joshua et al., 1993). Some algae adapt to low light intensity but while adapting, they may exhibit retarded growth. Species like Skeletonema costatum reduces their rate of dark respiration thereby lowering the consumption of light intensity. In S. costatum, the light intensity as against photosynthesis process showed growth condition at 0.05 Ly/min at 20°C of tungsten light. In Chaetoceros affinis, growth was observed at 0.97 Klx at 16°C in fluorescent light (Edward and Akra, 1993). Algae require 24-26°C temperature for growth process. Temperature is controlled by air conditioner in the indoor system. Algal cylinders, flasks are made of glass or translucent FRP sheets to allow light to pass through for effective photosynthetic activity.

g. Artemia section:

Set of tanks are used to hatch Artemia nauplii/day. The tanks are flushed alternatively after harvest since, the nauplii hatch in 24-36 hours. Light helps to hatch Artemia cyst to nauplii. It has been found that light requirement is very much essential for the first three hours after hydration of cyst takes place. Light also play a role in harvesting Artemia nauplii using
the phototactic behaviour of this species. Tungsten bulb of 100W or two, one each fluorescent bulbs, of 40W per tank (400-500 l capacity) are used for the process of hatching. Temperature is maintained at 30-33°C for cyst hatching. *Artemia* tanks are coated with white colour in order to distinguish the red coloured nauplii and also to facilitate maximum absorption of light which facilitates cyst hatching process.

In the Japanese technology, the following concepts are taken into consideration for designing the hatchery components:

a. To stock low number of adults and larvae of shrimps in a given area of tank capacity.

b. To provide more area and volume for all sections so that animals move freely and interturn increase survival rate.

c. Circular tanks are used to provide circular movement of water in the tank and prevent cannibalistic nature and also aid in equal distribution of feed.

d. A common drain pit for 2 or 4 tanks is provided to collectively remove waste materials and sent through drain pipe to the exterior of the hatchery complex.

e. The tank that is used for maintaining broodstock is used to rear larval and post-larval stages of shrimp.

f. Post-larvae are grown in open tanks and subjected to natural environment in order to get acclimatised and thereby result in producing larvae with good survival rate.
g. The animals are maintained in natural condition. Prophylactic drugs or chemicals are not generally used. The hatchery operation are carried out only when all parameters are found conducive for production.

h. Algal feed is cultured in outdoor system and mainly cultured in the natural environment by the presence of sunlight.

i. Seawater intake system comprises of pumping water from sea to a slow sand filter, stored in overhead tanks or reservoirs and pumped to the hatchery system only after the quality of water is assured.

2. Galveston - Hawaii (American) technology :

   a. Maturation section :

      Adults of 100-120 g are stocked in the maturation tanks at the rate of 5-7 animals/sq.m. Water exchange of 200% in 24 hrs. is practiced in this technology. The roof of the maturation section, the provision of lighting and its arrangement, control of temperature and colour of paint used in the maturation tanks are found to be adopted as similar to that of the Japanese technology.

   b. Spawning and hatching section :

      Gravid female of 80-150 g at a stocking density of one spawner per tank (200-300 l capacity) are worked out to be ideal in Hawaii technology. The spawning tanks are flushed every alternate days after spawning and therefore, sets of tanks are provided to operate every day. The requirements of light, temperature and colour preference of adults and larvae of shrimps in
the spawning and hatching sections are found to be similar as in Japanese technology.

c. Larval section:

Larvae at Nauplius (N3) stage are stocked at the rate of 100 Naupliii/litre. Water exchange of 100% is carried out in 4-6 hrs. In this technology, water is filled and maintained at 1 m depth throughout the rearing period. The roof of the hatchery and its arrangement in the larval section is provided as mentioned in the Japanese technology. However, fluorescent lights which provide illumination artificially in this section are fixed from the roof truss at a distance of 0.8-1 m as against 0.5-1.2 m of Japanese technology. Temperature control, lighting arrangement and colour preference by larvae of shrimp in this section are provided as in Japanese technology.

d. Post-larval section:

In the Galveston-Hawaii technology, 20-25 PL5/l are stocked in post-larval tanks, separately. Water exchange is carried out as in the larval section. Likewise, the roof of the hatchery, artificial lighting arrangement and the paints used to coat the PL rearing tanks are designed similar to that of the larval section.

e. Live-feed sections:

The various parameters that govern the production of live-feeds are provided as mentioned in the Japanese technology.
The basic concepts involved in the Galveston-Hawaii technology are described below:

a. To reduce floor area and volume by constructing rectangular tanks against circular tanks.

b. The circular flow of water is aided by designing a semi-circular shape at either ends of the tank.

c. The shape of the tank is further modified by designing parabolic shape in larval and post-larval tanks to facilitate efficient draining of waste water.

d. Prophylactic drugs and chemicals are frequently used.

e. Air is diffused into the larval and post-larval tanks using lead keel tubes.

f. Sophisticated designs are made for indoor algal culture apart from utilising outdoor culture system.

g. The seawater intake system comprises of pumping water from the sea to slow sand filter and mechanical filters, wherein, the water is treated before it is sent to the hatchery complex.

3. Philippines technology:

The Philippines technology follows the Japanese technology in designing the shape of the tanks and various parameters required for the various section of the hatchery. However, it adopts Galveston-Hawaii technology in having separate tanks for maturation and larval sections.
4. **Taiwan technology:**

The Taiwan technology adopts the concepts followed in Philippines technology with exceptions only in (a) the construction of larval and post-larval tanks and (b) water exchange in larval and post-larval sections. In this technology, the larval and post-larval tanks are constructed at different levels (Ladder system) in order to facilitate the transfer of larvae to post-larval tanks through pipes. Further in the larval and post-larval sections, water exchange is carried out as and when degradation of water quality takes place.

5. **French technology:**

The designs and concepts of Galveston are followed in this technology except in (a) the utility of circular FRP tanks for maturation process and (b) in designing separate walls for a set of larval tank with independent exit, which in turn prevents the spread of diseases from one tank to the other.

6. **German technology:**

This technology adopts most of the concepts involved in Galveston-Hawaii technology except from the usage of large FRP cylindroconical tanks for larval, post-larval and Algal culture. It adopts Japanese technology in group spawning and in the artificial lighting arrangement for the larval and post-larval sections. Further, this technology differs from all other technologies only in the water exchange of 100% in 18-24 hrs. in the maturation section.
7. Indian technology:

The Indian technology is a combination of characteristic features of various technologies developed to achieve maximum production. The concepts are site specific and hence variation in stocking density, water exchange and aeration are observed from one hatchery to the other. M/s Aqua-tech and M/s Aroma hatcheries, Trichur, Kerala, use Taiwan technology in larval and post-larval rearing (Ladder system) and Circular tanks as in Japanese technology for rearing breeders. M/s Abad Plaza and M/s Trimarine hatcheries, Trichur, Kerala, use Japanese technology for water exchange in larval and post-larval tanks, but Hawaii technology in aeration system (use of lead keel tubes and in percentage of air distribution in the various sections).

In M/s CIBA hatchery, Narakkal, Kerala, Parabolic tanks, fabricated with FRP material are used for larval and post-larval rearing as in Hawaii technology, whereas, the shape, size, water exchange and aeration system in the maturation tanks are of Japanese technology. Likewise, In M/s Asia Pacific hatchery, Jamnagar, Gujarat, the Japanese technology of rearing breeders and larval stages in the same tank, drainage system as in Philippines and aeration system as in Hawaii technology are utilised to achieve maximum production.
5.2. Engineering Details Involved In Hatchery Design

The engineering design involved in the hatchery is based on the biological concepts. The engineering details of civil structures, mechanical equipments, accessories and electrical installation are described below:

5.3.1. Civil design:

The major designs involved in civil structure for constructing the hatchery can be broadly classified into (A) Seawater intake system (B) Slow sand filter (C) Reservoir (D) Culture tanks (E) Drainage system (F) Wastewater treatment system and (G) other buildings.

A. Seawater intake system:

The seawater intake system is designed based on the (a) volume of water required for the hatchery (b) Nature and topography of the site (c) ocean dynamics (d) bed level of sea and sediment deposition at low tide level. Based on the above features, specific type of intake system is designed to cater to the requirements. Different types of intake system in civil construction are adopted to suit the site conditions. They are (i) jetty system, (ii) pipelines with infiltration gallery (iii) siphon system with pipelines and (iv) earthen canal.

(i). Jetty system:

In this system, piles are laid from the shore to the interior of the sea upto the low tide level (Fig. 1). Pipeline or open canal is laid above the
supporting piles from where water is pumped and sent to the hatchery. The jetty system runs for a distance in the range between 50 and 100m from the suction point at sea by providing a pump house. Pump house may also be constructed at the shore from where suction pipe is extended to the interior of the sea. The jetty system is found common on the east coast especially in Andhra Pradesh and Tamilnadu. They are constructed by entrepreneurs owning hatchery, whose capacity is more than 50 million PL production per annum and with integrated shrimp culture project. The piles laid across the sea are constructed using Reinforced Concrete Cement (R.C.C.), whose strength is determined after analysing the features in ocean dynamics of the specified site, wind action and the action of fouling organisms.

(ii). Pipelines with Infiltration Gallery:

In some places especially in the district of Ramnad, Tamilnadu, pipelines are extended to the interior of the sea whose suction point is connected to an infiltration gallery. Two types of gallery are generally used. (a) Infiltration gallery (Fig.2) made of PVC/HDPE pipelines interconnected with pores to infiltrate fresh seawater without any debris or sand particles as erected in M/s Giridhar Foods, Tamilnadu and M/s Bluchip, Kumta, Karnataka and (b) Gallery made of concrete structure (Fig.3) with central pipeline with strainers are submerged inside the sea as laid in M/s Siris Aqua, Kakinada, Andhra Pradesh at low tide level and anchored. Suction pipeline from the centre of such gallery system are connected to the pumps, wherein filtered seawater is sent to the hatchery.
(iii). Siphon system with pipelines (Fig.4):

In M/s Aurolee hatchery, Madras, Tamilnadu, pipelines are laid below ground level from the hatchery to the sea due to social problems caused by fishermen. The suction end with 'L' shaped pipeline at sea is laid above the low tide sea bed level at a height of 0.5-1 m in the form of a siphon so that water enters the pipeline only during high tide. Likewise, in M/s DCL Maritec, Nellore, Andhra Pradesh, where hatchery is more than 500 m from the shore and having road crossing or bridge, a sump is constructed, wherein water from the sea is pumped to the sump. A sump at the other end is also constructed and concrete pipelines are laid connecting the sump to form a siphon system. During continuous pumping, water is sent to the hatchery complex by siphoning principle in the sump at the cross end which is further sent to the hatchery by PVC or HDPE pipelines. The pipelines laid above the shore or ground level are fixed by using anchor blocks made up of concrete structures. These blocks are extended at specific interval from the shore to low tide level in order to prevent the pipeline being washed away during flood or due to water current.

(iv). Earthen canal:

On the west coast, hatchery with a capacity of less than 20-25 million production utilises a simplified system to draw seawater to the hatchery. In M/s Aqua Plaza, Trichur, Kerala, a canal is dug from the low tide level to the hatchery complex. Water enters the hatchery during high tide through this canal. Water is collected in a sump or a filtering unit which is constructed at
the delivery end of the canal. The water from the sump is further processed and pumped to the hatchery system.

The seawater intake system is designed based on the nature and topography of the site. The water intake point is determined by conducting a bathymetry survey. The coastal and ocean dynamics, the soil bearing capacity, water depth at various levels from the high tide to low tide mark, the nature and quantum of siltation, sedimentation, suspended solids, rainfall and tidal amplitude are considered for designing the intake system.

B. Slow Sand Filter (Fig.5):

The seawater that is pumped from the sea contains debris, suspended particles and silt which when sent to the hatchery hinders the operation. To prevent this entry of silt, a slow sand filter is constructed to filter seawater. The filtered seawater is collected in a sump from where it is pumped to the hatchery complex. The flow rate of water from the sand filter to the sump is calculated and a synchronised schedule is maintained to pump water from the sump to the hatchery in a continuous manner. This type of filter helps in containing suspended silt, eggs of fishes and also prevents bacterial growth to certain extent. The filter medium with fine grain size determines the maximum particle size to pass through the bed. The filter comprises of fine sand, gravel or coarse gravel and pebbles in the descending order respectively. Each layer is designed with an appropriate area based on the requirement and flow rate of water to be filtered.
a. **Design determining the process:**

The particulate material having the smallest grain size in the influent is studied in order to filter it. Using a scale model of the filter and the influent, the value of hydraulic conductivity for the filter medium is found out and substituted its value to determine the area of filter, when the rate of flow and filter depth against pressure head ratio are known. The trial design of the filter unit is provided with necessary allowance for any change in the flow rate expected during operation.

b. **Filter Material:**

The gravity sand filters consist of more than a layer of different materials with effective grain size. The fine particles are layered in the uppermost region of the filter successively followed by larger particles in the lower half. The grain size is generally from 0.25mm to 0.40mm (Fig.5). The rate of flow depends on the top layer having the hydraulic conductivity.

c. **Efficiency of the filter:**

The slow sand filters are efficient to remove suspended particles and siltation. However, it takes a long period to filter water. Filtration is generally carried out in 16-24 hrs. and can extend upto 36 hrs. based on the capacity of the filter area, water quality and design. Every fortnight, the filter is cleaned by backwashing in order to remove the clogged particles between the sand particles. They are further dried and used. In the recent past, the slow sand
filters are replaced by pressurised rapid sand filters which are operated by a motor and thus more efficient in filtering capacity.

C. Reservoirs:

The reservoirs are constructed to store water that is pumped from the sea. In the Hawaii technology oriented hatcheries, the reservoirs aid in storing water and also for disinfection process. Reservoirs are generally constructed by R.C.C. and in those with smaller capacities are built with bricks, above or below ground level depending on the site condition. The average daily flow (ADF) required per day for every section of the hatchery is calculated to determine the capacity of the reservoir. The shape of the reservoir may be circular as observed in M/s SSV Aqua and M/s Durga Aqua, Vizag, Andhra Pradesh or rectangular as in M/s NAEL, Nellore, Andhra Pradesh and M/s S&S Industries, Sirkazhi, Tamilnadu. The reservoirs with large capacities are provided with circular shape in order to enable circulation of water during chlorination and dechlorination process. The circular reservoir is provided with 150mm thick base slab, 100mm thick roof slab with a manhole and 150mm thick concrete cylindrical wall around it. The thickness of concrete structure increases as the diameter of the reservoir is increased.

In rectangular reservoirs, 230-350mm thick walls are designed. The rectangular reservoirs are easier to construct than that of circular type apart from economising space.
In small hatcheries, viz., M/s MPEDA, Vallarpadom, Cochin, M/s Aqua Plaza, Trichur, Kerala and M/s Gajalli Traders Hatcheries, Sindhurg, Maharashtra, with capacities ranging 2-10 million production per annum are found to utilise PVC/HDPE tanks for storing water. The tanks are provided with backwash system to prevent bacterial or any other microbial growth which may contaminate the hatchery system.

The large sized reservoirs are provided with ventilation which are made up of non-return valves to exit the pressurised air from the reservoir to the exterior. Adequate drain pipes and backwash system are also provided to clean the reservoirs. The reservoirs are painted with food grade epoxy paint to prevent seawater action on the walls.

D. Culture tanks:

The culture tanks are constructed by using R.C.C., bricks, ferrocement or FRP material. R.C.C. tanks are found ideal for larger capacity tanks whose volume is more than 5-10 ton. They are highly durable and can withstand water pressure. However, for a small sized or backyard hatchery run by small entrepreneur, R.C.C. constructed tanks become expensive and therefore, tanks made up of bricks or ferrocement has been found economical. The shape of the tanks varies from circular to cylinroconical, semi-circular, oval, rectangular and square types. Circular tanks are generally designed by Japanese, Philippines, Taiwan and German technologists. Maturation tanks of 150mm, 230mm, and 350mm thickness are constructed with R.C.C., bricks and ferrocement respectively. The capacity of tanks varies from 2 to 40 tons. In
Hawaii and French technologies, semicircular-rectangular tanks of 230mm thickness are designed for maturation section. The tank capacity generally does not exceed 10-15 tons. The length, breadth and height range from 2-9m, 0.5-3m, and 1.0-1.5m respectively. The larval and post-larval tanks are of square or semicircular-rectangular as in Philippines and Taiwan, circular in Japanese, parabolic and oval shape in Hawaii technology. The tank capacity ranges from 2 to 30 tons. In German technology, cylindroconical tanks fabricated with FRP material is used to culture larvae. The capacity of these tanks varies from 0.5 to 2 tons. In the Hawaii technology, twin type-parabolic shaped post-larval tanks are constructed using R.C.C. material.

The tanks for indoor algae are made up of FRP material to provide necessary translucency for light penetration which augments photosynthetic activity. Tank sizes vary between 50 and 250 l capacity.

Tanks for Artemia culture are generally made up of FRP material with cylindroconical shape to enable harvesting nauplii through the conical bottom provided in these tanks.

E. Design of drainage system:

Drains inside the hatchery comprises of two types (a) Central or common drainage and (b) Collective drainage system (drain pit).
(a). Central or common drainage:

In this type, the individual drain pipe from each tank is connected to a central drainage channel from where the entire water is flushed to the exterior of the hatchery by providing a slope. This system is observed in Hawaii, French and German technologies.

(b). Collective drainage system (drain pit):

The wastewater from four tanks, each with individual drain pipe is drained into a common pit from where water is collectively sent through concrete or hume pipe, interconnecting each drain pit to the exterior of the hatchery. This type is generally adopted by Philippines, Japanese and Taiwan technologies.

An open drainage system is provided all around the exterior of the hatchery to collect waste water from the hatchery complex as well as rain water which is discharged into the nearest river or sea after proper treatment.

F. Wastewater treatment system:

Wastewater from the hatchery is discharged into the sea after proper treatment. Chemical methods by using chlorination and de-chlorination process can be adopted. Since, the quantity of wastewater from the hatchery is minimal, biological treatment system can also be utilised. This treatment utilises clams or mussels to filter wastes before it is discharged into the sea. A scientific wastewater treatment comprises of water from the hatchery being
sent to an aeration pond for agitation process. This process aids in the breakdown of suspended solids and also liberates the abnoxious gases to the atmosphere. The aerated water is sent to an earthen pond which comprises of clams or mussels. These organisms filter the particulate substances and releases filtered water to the exterior which is drained to the sea.

Effluent treatment system can also be adopted to treat wastewater. It comprises of a collection well, primary, secondary, aeration, tertiary treatment tanks and a sludge bed. Wastewater collected from the collection well is pumped into the primary settlement tank prior to treatment with lime and vigorous agitation by flash mixer. The wastewater is sent to the secondary treatment tank, wherein the sediments are allowed to settle in this tank for a specified retention period. The supernatent water from this tank is flown to the aeration tank, where the water is agitated by aerator or air diffuser or air injector. Bacterial flocculants are added to destroy the harmful bacteria in the system. The supernatent is sent to the tertiary treatment tank from where the water is treated by chlorination and de-chlorination process. The treated water is then sent to the outlet. The waste sludge is collected from the settlement in the sludge bed comprising of filter system. The sludge is allowed to dry in the open sludge bed and the water is filtered and sent to the tertiary treatment tank.

The biological treatment of wastewater is proposed to be carried out in a few hatcheries located in the states of Tamilnadu and Andhra Pradesh, where the production capacity is more than 60 million/annum. The chemical treatment and effluent treatment system have been proposed to be established
in a few hatcheries, viz., M/s NCC BPL, Vizag, Andhra Pradesh; M/s MAC Industries Ltd., Madras and Tuticorin, Tamilnadu. Till date, no hatchery has implemented the treatment process effectively, since the quantum of wastewater discharged into the sea is minimal and no standards have been framed by the Pollution Control Board for shrimp hatchery.

G. Design of hatchery buildings:

The structural design of the main hatchery building is based on the conceptual design and proven technology. The foundation for the hatchery building built near the sea coast is designed based on the soil bearing capacity to withstand landslides, flood, wind action, erosion and other natural calamities. The main hatchery building is built with bricks or laterite or hollow blocks and painted with epoxy to prevent the action of seawater. The walls are provided with 230mm thickness, supported by a frame of running beam above the lintel level, wherein, the roof trusses are fixed. The roof on the larval or post-larval section is provided with translucent sheet alternatively fixed with asbestos sheet covering 30-40% of the total area to permit sunlight to the tanks. These sheets are not provided in the maturation and spawning section.

Separate rooms of the requisite dimensions are built for Algae, Artemia, Quarantine, Office, Generator-Blowers, Pumps-filters, Staff and Manager quarters with all amenities and sanitation.
5.3.2. Mechanical design:

The mechanical design for the hatchery comprises of details for selection of pumps, blowers, filters, plumbing and routing of pipeline to supply seawater, freshwater and air to the various sections and details for equipment like rapid sand filter and cartridge filters.

a. Pump selection:

The total quantity of seawater required for the hatchery is calculated to determine the rating, type and number of pumps involved in the hatchery system. The total requirement of water for the hatchery in terms of litres per second (lps) is calculated and the total horse power (HP) is derived to determine the number of pumps with corresponding ratings as standardised and supplied by the manufacturer. Pumps for seawater intake may be stationed at sea on the jetty system as observed in M/s NCC BPL, Vizag, Andhra Pradesh, M/s Victory, Tuticorin, Tamilnadu, to minimise suction head. This design is applicable in places where no social, political and fishermen interference take place. In some places, viz., M/s Pioneer, Tuticorin, Tamilnadu, M/s SSV Aqua, Vizag, Andhra Pradesh, where social problems exist, pumps are stationed at shore with pipes laid above or below the ground level. In such type, the suction head's length and height tend to increase, which inturn causes friction loss. The loss is compensated by using high rated pumps. This increases the capital investment and also recurring expenditure through power consumption. In M/s Travancore hatchery, Trichur, Kerala, water from the sea is pumped into a collection sump from where it is sent to
the hatchery sections. This method is adopted where heavy siltation occurs, since direct pumping will clog the pumps. Water from the sea is pumped to the reservoirs. Pumps of suitable ratings are used in the hatcheries, where chlorination and de-chlorination process is undertaken. Pumps of 0.5-1 HP capacities are used to pump water to a dozer (Fig.6). Dozer of suitable capacity is used to mix and evenly distribute chlorine in the reservoir. Based on the retention period for chlorine residual settlement in the reservoirs, suitable pumps are selected. Though retention period is site specific, in general, the chlorine settlement period of 8-12, 10-14, 18-24 and 20-24 hrs. were observed as in Hawaii, French, German and Philippines technologies respectively. In the Japanese and Taiwan technologies, chemical treatment is seldom used. In Hawaii, French and German technologies, chlorination and de-chlorination process is carried out in separate reservoirs, whereas in Philippines technology, the chemical treatment is carried out in the same reservoir and hence the number of pumps required in the Hawaii technology is found to be more than the Philippines technology at this stage. However, in the Philippines technology, the overall requirement of pumps is observed to be more than in any other technologies as more number of transfer pumps are used to directly supply seawater from the reservoir to the various hatchery section. In the Hawaii, French and German technologies, seawater from the reservoir is pumped to an overhead tank from where it is supplied to the hatchery sections by gravity flow.

**Design factors** are also taken to provide standby pumps inorder to operate the hatchery system without any interruption and during maintenance
and repairs. Separate pumps of suitable capacity are used for algal section, freshwater and for priming in seawater intake system.

b. Pipeline system:

In Hawaii technology, the various sections in the hatchery are provided with two seawater pipelines, one freshwater and an aeration line as observed in M/s TASPARc and M/s NCC BPL, Vizag, Andhra Pradesh and one line each for seawater, freshwater and aeration in all other technologies. The pipelines are generally routed on the inner walls of the hatchery building above the lintel level and supported by clamps. Branches of pipelines are taken along the truss from where it is routed to the respective tanks.

c. Aeration:

Aeration is supplied by means of air-blowers. Air is required in the hatchery section to supply oxygen, aid in circulation of water and disintegrate waste particles in the culture tank. In Hawaii technology, high rated capacity blowers are used as the stocking density is very high. Twin lobe roots blowers or regenerative blowers are used. In general, air volume ranging 46-1180 Cubic Feet/Minute (CFM) at the rate of discharging 0.1 CFM per air stone can drive 414 - 10,600 stones (Argent Aquaculture products manual, 1994). The number of air blowers and capacity required for efficient oxygen and circulation supply is calculated based on the oxygen requirement of shrimps (Respiratory Quotient) and turbulence factor required to circulate water in a given volume of water column in the tank. The air requirement varies in each section. The
maturation and spawning section requires controlled and lesser aeration than the larval and post-larval sections. The algal and the Artemia sections require vigorous aeration. In the Hawaii technology, aeration is provided to the larval and post-larval tanks using lead keel tubes which diffuse air through minute pores. In all the other technologies, air is sent through air stones.

d. Rapid sand filters and Cartridge filters:

These filters operate by pressure applied through a medium of sand particles and water by using suitable pumps. The pressurised water from the source prevents siltation or sand particles entry into the other hatchery sections. The filter is provided with a backwash which is periodically used to maintain the flow rate by removing and cleaning the waste deposits clogged in between the sand particles. The filter is fabricated using high quality standard ‘seamless fibre glass unibody’, which is free from rust and corrosion. The filter has an air valve for efficient start-up use and have a capacity ranging 40-380 gpm (gallons per minute). In the pressure sand filter, water enters the upper portion of the closed pressure vessel through a baffle. By forced pressure, water is sent through the filterant. The pressurised sand filter is fabricated with FRP material.

The Cartridge filters are made up of polypropylene or nylon. The durability and high porosity of this media allows high flow rate of seawater, high dirt holding capacity and low pressure drops. Different rated filters are used in algal, spawning and hatching sections, where purification is required at 2-5 micron level.
e. Air-conditioners:

Air-conditioners of suitable tonnage are used in the algal section to maintain the temperature between 22 and 25°C in order to stabilise algal growth and prevent them from cellular lysis.

5.3.3. Electrical design:

The total requirement of power for the hatchery is calculated based on the peak load and demand period on a daily basis. Power is obtained from the Electricity Board. A high voltage current being supplied from the board is transferred to the hatchery using a step down transformer. The transformer with double pole structure is stationed adjacent to the power house.

In India, power shortage exists and therefore, to run the hatchery for 24 hours, the required number of Diesel Generators (D.G.) of specific ratings are installed to supply power during demand period.

Light plays an important role in the hatchery. In maturation and spawning section, the intensity of light requirement has been found to be less than 200 lux. In larval and post-larval sections, the requirement of light ranges from 1500 to 2500 lux. In Artemia and algal sections, light intensity of 2500-3500 lux and 6000-8000 lux had been found to be necessary respectively. Fluorescent lights are used in all the section. In Artemia section, incandescent or halogen bulbs are used for effective hatching of cysts.
Power is required for general lighting in the hatchery complex, laboratory equipments, apart from pumps, blowers and air-conditioners. The total requirement of power is calculated based on the total horse power required for various systems and converted to Kilowatts. In general, a peak demand of 75-80% of the total Kilowatt required per day is considered to calculate the power load. A single line diagram is drawn while designing to represent the requirement of power load. The length of the cable, its routing from the power house to the hatchery complex, the necessary accessories for electrical equipments and installation are thoroughly quantified and estimated prior to implementation. Safety measures and other intricate details in the electrical system are considered in the designs based on the specification formulated by the consultant or competent authority in the field.
Fig. 1. Jetty System
Fig. 6. Chlorine dozer.
5.3. **Flaws In Hatchery Design**

5.3.1. Flaws in civil design:

The major problems involved in faulty civil engineering designs are described below:

a. Hatchery complex of each section in different locations will lead to the increase in capital expenditure apart from problems related to monitoring. This has been observed in Taiwanese modified version of hatcheries in India.

b. A change in the design concept to strictly 'Vaasthu Shastra' will render operations difficult, which was noticed in M/s SSV Aqua, Vizag, Andhra Pradesh.

c. The efficiency of technical staff will decrease, when various sections are oriented at random as experienced in M/s Kalyan SeaFoods, Kakinada, Andhra Pradesh.

d. Loss of control over monitoring by managerial personnel will take place, when sections are not interconnected. This condition has been observed in M/s Columbia Seafoods Ltd., Vizag, Andhra Pradesh.

e. Capital cost will increase, if more structures or over designs are provided as observed in M/s Siris Aqua, Kakinada, Andhra Pradesh.

f. Faulty draining facilities will lead to outbreak of disease, when wastewater treatment is not included in the design. It is commonly observed in M/s MPEDA hatchery, Vallarpadom, Cochin, Kerala.
A. Design flaw in seawater intake system:

Civil construction of seawater intake system by jetty system and pile errection have to be designed based on the ocean dynamics of waves, water current and wind action. Any design error in this regard will collapse the jetty system leading to heavy damages. Pipelines laid in proximity with the shoreline are vulnerable to fouling organisms, which in turn reduce the flow rate of water. Civil construction without the consent of government statutory bodies and non-adherence to standard specification in construction will lead to investment loss. Computational errors in length and breadth ratio, break points at specific length as in open canal system will lead to leakages, contamination of water and investment loss in the system as noticed in M/s Sawant Aqua, Raigad, Maharashtra.

B. Design flaws in culture tanks:

Designers, who provide more than 30-40% buffer against volume of tanks may increase the capital cost. Tanks constructed with lesser dimension and tonnage will give constraints to technical personnel who operate it. The design flaws in the various types of tanks in consideration to shape and size are described below:

a. Circular tanks:

Circular tanks are designed to achieve maximum water circulation and to drain waste material through the centrally located drain in the interior of the tank. However, in the light of operation and monitoring, it has been found
problematic in reaching the centre of the tank having a diameter of more than 1.5-2m as observed in M/s ITC Minota Aqua-tech, Tuticorin, Tamilnadu and M/s NAEL, Nellore, Andhra Pradesh. Further, it has also been noted that even when the stocking density of adult shrimps was low, huge volume of water was required to maintain the depth. This in turn, increased the cost of production through power consumption. Moreover, circular tanks occupy large space and thus it has been found inviable to sites having less area, which has been observed in M/s Kavini Ispat, Nellore, Andhra Pradesh.

b. Square and rectangular tanks:

Square and rectangular shaped tanks are generally constructed for spawning, larval, post-larval and outdoor algal tanks as in Japanese and Taiwan technologies. These tanks require simplified construction. However, circulation of water has been found ineffective, when compared to that of circular tanks. In square tanks, the corners of the tank favour microbial growth, which in turn affects production as observed in Philippines, German and Taiwan Technologies. This phenomena of microbial growth has also been noted in rectangular tanks, whose length is more than 6m as observed in M/s SSV Aqua, Vizag, Andhra Pradesh and M/s Claswin, Madras, Tamilnadu (Fig.7). During power failure, the shrimp larvae aggregate at the corners of the tank and exhibit cannibalistic behaviour caused by interruption in aeration system. This has been observed in M/s Balaji Bio-tech, Backyard hatchery, Nellore, Andhra Pradesh.
c. Cylindrical tanks:

These tanks were designed by German technologists. They are made up of mild steel (m.s.) or FRP material. The cylindrical tanks were found effective in circulation and wastewater removal. However, monitoring of such a system has been found difficult due to excess height and water depth in the tank. Tanks designed with m.s. material have been found to be corroded by seawater. Therefore, frequent replacement of tanks which in turn enhanced the expenditure was noted as in M/s MPEDA hatchery, Vallarpadom, Cochin, Kerala.

d. Parabolic tanks:

These tanks are designed based on Hawaii technology. They aid in effective circulation, removal of waste material, supply of oxygen, compact construction and longer durability than other tanks. The parabolic construction utilises more R.C.C. material and hence it has been found more expensive than any other tanks.

C. Design flaws in drainage system:

The drainage system should have necessary slope to flush the wastewater to the exterior. Drainage without provision of slope has been found to favour microbial growth causing disease outbreak. This problem has been frequently observed in M/s MPEDA hatchery, Vallarpadom, Cochin, Kerala. In M/s Mas Aqua Techniks, Nellore, Andhra Pradesh, stagnation of wastewater
in the interior and the exterior of the hatchery building has been noted due to inadequate drainage facilities.

D. Flaws in material selection:

Materials for construction of tanks are generally of R.C.C., bricks or ferrocement. Leakage in tanks occur when poor quality material is used. In some sites, where freshwater is not available and if seawater is used for curing the plastered walls, infiltration of seawater will take place. While painting epoxy, bubbles form on the surface of the tanks and finally leads to peeling of epoxy paint from the tank. The utility of ferrocement has been found economical in constructing tanks with capacity less than 10 tons. Tanks with more than 10 ton capacity have been found to collapse or cause leakage due to its lesser strength and inability to withhold water pressure as experienced in M/s CIBA Hatchery, Cochin, Kerala.

5.3.2. Flaws in mechanical design:

Technical problem arises in plant and machinery when faulty designs are made in orientation or routing of pipelines. A buffer of 40% is generally provided while selecting pumps, motor rating, flow rate and other factors. More than this buffer may increase the capital investment.

A. Pump selection:

High rating pumps will increase capital investment as assessed in M/s Lahari Seafoods, Kakinada, Andhra Pradesh, apart from technical problems in controlling flow rate of seawater to the various sections. Repairs
and maintenance of high rated pumps were found to be difficult and time consuming in remote areas, where no service station was available. Apart from these, technical flaws due to power transient, poor alignment of motors, shafts and pumps, inadequate maintenance and corrosion were noted in many hatcheries.

B. Blowers:

The hatchery adopting indigenous technology uses oil compressors for aeration. Such type of compressors operated by oil were found to contaminate the water in the hatchery as noted in M/s Sharaoa Aqua, Ongole, Andhra Pradesh. Roots blowers are used in most of the commercial hatcheries in India. These blowers lose their efficiency within a period of 1-2 years as noted in M/s S&S Industries, Sirkazi, Tamilnadu and thereby enhanced the depreciation value of the project. Regenerative blowers have been found to be excellent in performance and durability. These blowers are not manufactured in India and hence, they have to be discarded due to the non-availability of spares and service facility.

C. Rapid sand filter, U.V. and cartridge filters:

These are very sensitive filters. The filtration units clog and backwash becomes a regular feature for this equipment installed in areas, where sedimentation and siltation occur frequently. This has been observed in M/s Aditya hatchery, Vizag, Andhra Pradesh. This unit is very delicate in operation, since any operational error is sufficient to cause serious damage to the filter as well as to the operator.
Improper selection of U.V. will lead to reduced flow rate of seawater to the hatchery in the scheduled operation period, as observed in M/s Gajalli Traders, Maharastra. U.V. filters and Cartridge filters were found to clog frequently in areas, where suspended solid was abundant in nature. Mishandling of U.V. or utilising different wave length has been found to cause deleterious effect to the shrimp in its growth.

D. Pipeline routing:

Pipelines for seawater, freshwater and aeration have to be routed properly in the main hatchery building. Pipeline routed from the wall of the building to the tank without support will lead to damages. The drain pipes are susceptible to leakage and contamination in reservoirs constructed below ground level as experienced in M/s SSV Aqua, Vizag, Andhra Pradesh. Pipelines with more bends and valves will lead to friction and pressure loss thereby losing efficiency in the distribution of seawater apart from operational difficulties as noted in M/s NAEL, Nellore, Balaji Bio-tech, Nellore, Andhra Pradesh (Figs.8&9). Pipelines made up of mild steel were found to corrode due to their action against seawater and thereby augmented contamination in the system as in M/s MPEDA hatchery, Vallarpadom, Cochin, Kerala. PVC pipes of light weight when used to draw water from the sea without structural support was found susceptible to water current, wave and wind action as noted in M/s Pioneer Aqua, Tuticorin, Tamilnadu. Pipelines laid across the sea hinder the activities of fisherfolk and will lead to altercations and tensions. This problem was noticed in M/s Carewell investments, Nellore, Andhra Pradesh.
5.3.3. Flaws in electrical design:

Power plays a major role in the operation of the hatchery smoothly and efficiently. Selection of high motor rating for pumps and blowers will increase the recurring expenditure as assessed in M/s Giridhar Foods, Ramnad, Tamilnadu. Excess length of cables provided while routing from pump house, blower room and D.G. room to the hatchery will increase the capital and recurring investment apart from power loss and decreasing efficiency of captive power as noted in M/s Bay Aquatics, Vizag, Andhra Pradesh. Improper routing of cables will lead to short circuit and cause severe damage to the equipments and operators. Designs stationing D.G. room far away from the hatchery will increase the capital cost apart from their inaccessability to the operators as audited in M/s Chowan Exports, Vizag, Andhra Pradesh and M/s Silveira Hatchery, Goa.

The lighting arrangement, its orientation and its intensity on the culture tanks bear an impact on the shrimp growth. Design error or implementation error in lighting system in the hatchery has been found to produce poor results as observed in M/s MPEDA hatchery, Vallarpadom, Cochin, Kerala. Design calculation providing excess buffer on peak load has been found to incur heavy expenditure on power consumption as noticed in M/s TASPARC, Vizag, Andhra Pradesh. An intensity of 6000-8000 lux is found essential for the growth of algae in indoor system. While providing this intensity, the temperature was found to increase. The temperature in the room was reduced by using higher rating air-conditioner, which in turn increased the power consumption.

Designs without lightning arrestors, sub-standard cables, and equipments without ISI standards were found to cause serious damage to the system.
Fig. 7. Square tanks of M/s Claswin, Madras, Tamilnadu.

Fig. 8. Pipeline routing of M/s NAEL, Nellore, Andhra Pradesh.
Fig. 9. Pipeline routing of M/s Balaji Bio-tech, Nellore, Andhra Pradesh.
5.4. Remedial Measures for Faulty Design

The hatchery is constructed prior to approval of conceptual, technological, architectural and other pre-requisites governing civil, mechanical and electrical designs. These parameters are generally specified by the consultant or designers. The major steps involved in rectification/prevention of faulty designs as prescribed by M/s Maritec Consultants (op. cit.), M/s MPEDA (1990) and Treece and Fox (op. cit.) are described below:

5.4.1. Remedial measures for civil design:

(i). All hatchery components should be alligned sequentially and oriented based on the biological concept. They should be constructed in one roof.

(ii). The distance and orientation of various sections should have proximity to each other for effective utility and monitoring purposes.

(iii). Standard materials should be used for construction and specification.

(iv). The pre-requisites for hatchery condition should be on par with effective production.

(v). Seawater intake system should be designed to suit the environmental conditions and should not have social constraints. Structural damages of piles as in jetty system can be prevented by increasing the reinforcement structures and strengthen the supporting system. The intake system with pipelines laid on the ground level should be anchored by cement blocks to prevent the pipelines from erosion, wind, wave action and other natural calamities.

(vi). Slow sand filter should be designed at suitable level to provide uninterrupted flow rate of seawater. Baffle walls in such filters are
designed in order to avoid frictional and water pressure. Frequent monitoring for backwashing process should be carried out to prevent clogging of suspended solids.

(vii). Reservoirs built above or below the ground level should have provision for proper inlet, outlet, ventilation and manholes. It should be built with standard raw material and adhere to construction specification. Proper coating of epoxy should be done to prevent seawater against the wall of reservoir.

(viii). Tanks of various sections should be constructed as specified by the consultant. If the tank height exceeds 1.3-1.5m, a platform should be raised from the floor level in order to facilitate easy operation by the technician. The shape of the tanks should be based on the technological concepts.

(ix). Wastewater treatment and drainage system should be properly designed based on the site condition. Frequent flushing, cleaning and disinfection of the drainage system will prevent contamination of contagious microbes.

(x). Repairs and maintenance should be carried out frequently. Any leakage in tanks, reservoirs and filters should be rectified in the initial stages.

5.4.2. Remedial measures for mechanical design:

(i). A separate technical operator should be recruited for monitoring the operation of pumps, blowers, filters and other equipments.

(ii). Necessary lubricants of standard quality should be frequently used to prevent wear and tear of machinery.

(iii). Blowers should be provided with filters to prevent entry of carbon particles or smoke into the hatchery system.
(iv). Pumps, blowers and D.G. sets should be stationed in specified rooms without causing disturbances like sound and vibration to the hatchery sections.

(v). Pumps and motors stationed near the sea should be periodically checked to prevent fouling organisms, clogging due to suspended materials and corrosive action of seawater. Fouling organisms are removed by the action of chlorine or by thermal shock. Corrosion is prevented by coating epoxy paint frequently.

(vi). Pipelines should be laid linearly. Minimum number of valves and bends are recommended to prevent friction loss. The pipelines should be frequently disinfected to prevent microbial action.

5.4.3. Remedial measures for electrical design:

(i). Electrical equipments and accessories should be designed accurately to provide sufficient power load.

(ii). Standard products of switch gear, transformers, busbars, quality gauge of cables, fuses, plugs, switch boards and panel boards having ISI standards should be used.

(iii) Proper power/switch breaker should be used when transformers tend to burst due to fluctuating high voltage current.

(iv). Lighting load, air-conditioner load, motor ratings should be precisely calculated to provide good results.

(v). Periodical monitoring and inspection with frequent technical audit should be carried out by experts in the field.
5.5. **Hatchery Operation Techniques**

Hatchery operation requires specialised skills to produce the rated target. It involves a systematic schedule of operation on par with the life cycle of shrimp. The major techniques involved in the hatchery operation are classified into seven types. They are:

A. Broodstock rearing and management:

   It involves (a) collection (b) selection of adults, (c) stocking and (d) maintenance.

   a. Collection:

      Adult females are collected from the sea and reared in captivity until they reach spawning stage as adopted in M/s OSSPARC, Gopalpur, Orissa. Most of the hatcheries, viz., M/s TASPARC, M/s NCCBPL, M/s SSV Aqua, in Vizag, Andhra Pradesh; M/s Claswin Aqua, Madras, M/s MAC Industries Ltd., Tuticorin and M/s Giridhar Food, Ramnad, Tamilnadu. Hatcheries in Kerala collect wild spawners because they possess high fecundity than breeders cultured in captivity. Based on the information regarding the peak period of spawning activity of various shrimps in India recorded by Muthu and James (1994), the spawners of *P. monodon* and *P. indicus* on both the east and west coast of India are collected by the hatchery technologists during the spawning season.
b. Selection of adults:

Broodstock comprising males weighing 70-100g, measuring 160-200mm length and females of 100-200g and 200-240mm length or above are selected in general in all hatcheries in India to achieve maximum production.

c. Stocking:

To achieve sustainable production, broodstock ponds of earthen construction are used as observed in M/s OSSPARC, Gopalpur, Orissa. However, only a few hatcheries, viz., M/s NCC BPL, M/s SSV Aqua, Vizag, M/s Veerat Aqua, West Godavari, Andhra Pradesh; M/s MAC Industries Ltd., Madras and Tuticorin, Tamilnadu have proposed to stock breeders in captivity, since most of the small scale and medium scale hatcheries in India prefer to use spawners from the sea or stock those adults which attained maturity in the maturation tanks built in the hatchery complex. Rearing of broodstock in captivity was not favoured by small scale hatcheries due to technical and financial constraints.

In the maturation tank, stocking density, water exchange and other physical parameters are carried out based on the technological concept adopted. In the Hawaii technology, 1 micron cartridge filter is used to filter seawater. Water depth is kept at 60-100cm level in Hawaii and French technologies, 80-150cm in Japanese technology, 100-120cm in Taiwan and Philippines technologies and 180-220cm in German technology based hatcheries.
d. Maintenance:

(i). Antibiotics and Antiprotozoan drugs are administered as prophylactic drugs to larval stages on the 6th, 13th, 20th and 27th day of each month in Hawaii, French, German technology as practiced in M/s TASPARC, Vizag, Andhra Pradesh, M/s OSSPARC, Gopalpur, Orissa and M/s MPEDA hatchery, Vallarpadom, Kerala respectively. In Japanese, Taiwan and Philippines technologies, drugs are rarely used.

(ii). The breeders are checked in the quarantine room for any disease or injury caused while transportation prior to stocking them in the maturation tanks. Only a few hatcheries like M/s Giridhar Foods, Ramnad, M/s S&S Industries, Sirkazi, M/s ITC Minota Aqua-tech, Tuticorin in Tamilnadu; M/s TASPARC, M/s Durga Aqua, Vizag, M/s Veerat Aqua, West Godavari, M/s NAEL, M/s Balaji Bio-tech, M/s Seamen Aqua, M/s The Water Base Ltd., Nellore in Andhra Pradesh; M/s OSSPARC, Gopalpur, Orissa; M/s Bluchip, M/s Skyline, M/s Kumta, Karnataka and M/s Panchem Aqua, Edven, Maharastra have constructed separate quarantine room. Most of the medium scale hatcheries have quarantine tanks in the maturation section itself. Small scale hatcheries are generally devoid of quarantine tanks or rooms.

(iii). The breeders are labelled or tagged to identify them among used and unused spawner in French, Philippines and Taiwan technology based hatcheries. In the Hawaii technology based hatcheries, the spawners are generally used only once for spawning activity, after eyestalk ablation.
Repeated spawning is carried out only when shortage of spawners takes place during which the used spawners are stocked in separate tanks.

B. Spawning and hatching:

In Hawaii technology, only one spawner is stocked in each tank. In the Philippines technology, group spawning is favoured. In the Japanese, German, Philippines and Taiwan technologies, the eggs are hatched in the spawning tanks after the removal of spawners. In Hawaii technology, hatching is facilitated in hatching buckets. In French technology, a flow through system is designed to hatch the eggs. In this system, specially designed bucket is fabricated which has sieve at the mouth of the bucket with strainer nets. Water is forced to flow into these buckets for agitating the eggs enabling hatching.

C. Larval rearing techniques:

The hatched nauplii are transferred to larval tanks at N3 stage and reared till PL5 in Hawaii, French and German technology based hatcheries. But, in Philippines, Japanese and Taiwan technology based hatcheries, the larvae are reared upto PL20 stages in the larval tanks.

a. Preparation of tanks:

Filtered seawater is filled between 60 and 70% of the total capacity of tank in Hawaii, French and German technology based hatcheries. Gradual increase of seawater from 10 to 20% is carried out in Japanese, Taiwan and
Philippines technologies. Algae, viz., Chaetoceros sp. (East coast) and Skeletonema sp. (West coast) are predominantly used prior to larval stocking.

b. Feeding schedule:

The zoeal stages of shrimp are voracious feeders. They are fed with algae at a stocking density of 50,000-60,000 cells/ml. in Philippines, Taiwan and Japanese technologies and 100,000 cell/ml. in Hawaii, French and German technologies. Algal water is pumped from 200 l mass culture tanks to the larval tanks in Hawaii technology. The Philippines and Taiwan technology based hatcheries depend on algal cells from the outdoor culture.

The mysis stages are fed with Artemia nauplii. Quality Artemia cysts are hatched at a stocking density of 2g/l. Around 5-6 nauplii/ml are fed thrice a day to the shrimp larvae in Hawaii and French technologies and 2-3 nauplii/ml fed for 4 times a day in Philippines, Japanese, German and Taiwan technologies.

c. Physical parameters:

In the Hawaii and French technology based hatcheries, a schedule of operation is prepared on the basis of three shifts to maintain physical parameters due to the high technology involved in the hatchery system. In Taiwan technology, physical parameters are generally monitored only once in a week as the hatchery operation is carried out in a simple system and only during conducive seasons. In the Philippines, German and Japanese technologies, physical parameters are generally monitored on alternate days.
d. Harvesting of larvae:

In the Philippines, Japanese and Taiwan technologies, the larvae are grown until they reach PL 20 state and hence harvesting is carried out only in the post-larval stage. In the Hawaii, French and German technologies, the larvae are transferred to the post-larval tanks at PL5 stage.

D. Post-larval rearing techniques:

The parameters and operational methodology used to maintain the larval culture are adopted to rear post-larvae. The stocking density of 25 PL/l (Hawaii), 10PL/l (Philippines), 15PL/l (Japanese) and 12-18 PL/l (French and German technologies) are standardised for stocking in the rearing tanks. In the Hawaii and French technologies, the PL are treated with prophylactic drugs. In other technologies, drugs are rarely used.

The harvesting of PL is co-ordinated with the packing section. The PL are harvested in the drain pit using nets of suitable mesh size in Philippines, Japanese and Taiwan technologies. In the Hawaii, French and German technologies, the PL are harvested in buckets kept in the drain pipe. The post-larvae collected from the nets or buckets are transferred to plastic bins. A plastic strainer (Indigenous device, Fig.10) is used to transfer the post-larvae to the plastic bags. The post-larvae are packed in the traditional method and transported.
E. Feed and feeding:

In the commercial hatchery, where production is pre-determined, sufficient quantity, quality and availability of nutrients specific to various larval stages have been found to be one of the major requisites for successful operation.

a. Algal culture:

Algae form the basic feed for shrimp larvae. The major species of algae cultured in commercial hatcheries are Chaetoceros sp. (East coast) and Skeletonema sp. (West coast) apart from Isochrysis sp. and Tetraselmis sp. Algal culture is predominantly carried out in the indoor system (monoculture) in Hawaii technology, adopting standard procedures (Treece and Fox, op. cit.). The Philippines, Taiwan and Japanese technologies were found to depend mainly on outdoor mixed algal culture and with or without partial indoor culture. In German and French technologies, algal culture is carried out in both indoor and outdoor systems.

i. Culture operation:

The culture at exponential growth is carried out in several methods. They are: (i). algal cells transferred to larger enriched culture volume prior to stationary phase using transferred algae as innoculum. When culture is produced at the maximum density, they are fed to the larvae as employed in Japanese technology, (ii). Continuous culture involving mass culture of algae produced by adding nutrients and filtered water at a flow rate equivalent to
feeding flow rate is executed in Hawaii and French technologies and (iii). Semi-continuous culture involving the use of large culture tank by partial periodic feeding to the larvae. The tank is filled with original volume and supplemented with nutrients to original level of enrichment in German, Taiwan and Philippines technologies.

ii. Culture vessels:

Algal stock culture is done in small screw top pyrex test tubes (20mm x 160mm). This culture is transferred to flask culture through serial dilution techniques. This culture is further transferred to mass culture vessels in the order of 2, 20, and 200-250 l capacities as carried out in M/s TASPAC, Vizag, Andhra Pradesh, Hawaii technology. In M/s S&S Industries, Sirkazi, Tamilnadu, stock culture is prepared in conical flask of 500ml and transferred to 20 l and 500 l tanks for mass culture. In M/s MPEDA Hatchery, Vallarpadom, Cochin, Kerala, FRP tanks of 500 l, 1000 l and 2000 l cylindro-conical tanks are used for mass culture. In M/s Pioneer Aqua, Tuticorin, Tamilnadu, polyethylene bags of 1000 l capacity, are used for mass culture.

Algal cells are susceptible to environmental conditions and the cell density may decline drastically due to slight variation. During shortage of algal density or during non-productive seasons, algal cells are preserved and stored. They are stored in frozen concentrates as freeze dried powder as observed in M/s NCC BPL, Vizag, Andhra Pradesh and by cryopreservation using liquid nitrogen freezing agent to form frozen packages as employed in M/s ITC Minota Aqua-tech, Tuticorin, Tamilnadu. Preservation is also done by
floculation technique as observed in M/s MAC Industries Ltd., Madras and Tuticorin, Tamilnadu.

b. *Artemia* hatching:

Cysts from salt lake or from reputed concern are used to hatch *Artemia* cysts. FRP tanks of 200-500 l are used to hatch nauplius. The nauplius hatch in 18-36 hours. Necessary lighting is used to hatch the nauplius. The hatched out nauplii are harvested utilising their phototactic behaviour and this is done by using nauplius-separator as observed in M/s Aqua Plaza, Trichur, Kerala and also by using sieve of different mesh size in order to separate nauplius from inviable and hatched out cysts as noticed in M/s OSSPARC, Gopalpur, Orissa.

c. Artificial feed:

The nutritional requirement for penaeid species is found to be protein, lipid, carbohydrate, minerals and vitamins for normal growth. The necessity for artificial feed for larval stages of shrimp increased, when shortage in live-feed was observed especially in certain seasons. Studies made on the nutritional aspects on various shrimps according to Yasuhiko et al. (1985) are presented below:

Various studies on the nutritional requirement in *P. japonicus* were made by Kanazawa et al. (1970), Desamaru and Kuroki, (1974a), Teshima and Kanazawa, (1984), Jones et al. (1979a & b), Kanazawa et al. (1982), Teshima et al. (1982a & b), Teshima and Kanazawa (1984), Abdul Rahman et al.
(1979a) and Shigueno (1975); nutritional requirements in *P. japonicus*, *P. monodon* and *P. merguiensis* were made by Kanazawa et al. (1979a, b & c); role of crustacean diet was studied in *P. monodon, P. indicus* and *P. merguiensis* by Hameed Ali (1980,82); role of tissue suspension of juvenile *Metapenaeus dobsoni* in rearing penaeid shrimp larvae was investigated by Alikunhi (1980) and the utility of nutrient binder, Agar for the development of zoeal stages of shrimps was studied by Kanazawa (1980b). Based on these studies on artificial feeds, various techniques in the formulation, manufacture and feeding procedures were carried out by feed manufacturers. Artificial feeds are widely used in Hawaii, French, Philippines and German technology based hatcheries. They are scarcely used in Taiwan and Japanese technologies as the adult and larval stages of shrimp are fed mainly with live-feed.

d. Broodstock diet:

It consists of mashed squid, mantles, chopped raw fish, trash whole shrimp, live marine worms, fresh oyster, clam meat and commercially prepared artificial diet. These are fed at the rate of 10%, 12% and 15% of the total biomass of the shrimp on a daily basis in Philippines, Hawaii and in Japanese and Taiwan technologies respectively. In Philippines technology, as noted in M/s S&S Industries, Sirkazi, Tamilnadu and M/s Bluchip, Kumta, Karnataka, mussel meat at 10-20% of total weight of the shrimp is fed thrice a day. In M/s Giridhar Foods, Ramnad, Tamilnadu, Polychaete worms are found abundantly and hence they are fed at 12-15% of the total weight of the broodstock. Polychaete worms are found to be rich in arachidonic acid, docasahexaenoic acid and PUFA. Further, several recipies comprising fish,
shrimp, squid meal, rice bran, wheat flour, agar, soya bean oil, vitamin mixture and minerals prepared in different proportion are used in M/s Giridhar Foods, Ramnad, Tamilnadu.

F. Water Quality Analysis:

Quality seawater is essential for operating the hatchery successfully. Water quality is daily monitored of its chemical composition, salinity, pH, dissolved oxygen, heavy metals, pesticides and total dissolved substances. Standard methodology by titration or through electronic digital meters are used to determine the various concentration of elements present in the water. In Hawaii, German and French technologies, water quality is daily analysed for any contaminants and also chemically treated. In the Philippines, Japanese and Taiwan technologies, chemical treatment is seldom used as the hatchery is operated only when quality water is available.

G. Shut Down Operation in the Hatchery:

The shut down operation is carried out to prevent microbial growth in the system, to aid in maintenance of machinery and lean period for technician. The shut down period is generally chosen when unfavourable season prevails and when demand for seed is very low. The shut down procedure in hatchery operation is found similar to all technologies. However, the duration of shut down operation is observed to vary in each technology. The hatchery complex is disinfected and shut down once in 45, 30-35 and 90-95 days in Philippines and Taiwan, Japanese and Hawaii technologies respectively.
Fig. 10. Indigenous device to count shrimp seeds.
5.6. **Induced Breeding Techniques**

The physiological activities of Crustacean are controlled by neurohormones. The eyestalk is considered to possess a gonad inhibitory hormone (GIH). This hormone occurs in nature in the non-breeding season. It controls metabolism, moulting, osmoregulation, chromatophore production and reproduction. The ovary also takes part in controlling its own growth. Jhingran (1991) included all the works on the induced breeding of penaeid shrimps of India in his book entitled 'Fish and Fisheries of India'. The principles of eyestalk ablation have been utilised to solve the problems in hatchery, wherein development of ovary and spawning is augmented in shrimps, bred in captivity.

5.6.1. Eyestalk ablation:

Shrimps are ablated when hard shell is exhibited. Four types of techniques are followed for eyestalk ablation. They are: (a) ablation by using a razor blade to cut open the eye and the material being squeezed out from the tip of the eyestalk as practiced in M/s S&S Industries, Sirkazi, Tamilnadu (b) ligation of eyestalk by using a strong twine thread as employed in M/s Giridhar Foods, Ramnad, Tamilnadu, (c) cutting the eyestalk by scissors and sealing with beeswax as done in M/s NCC BPL, Vizag, Andhra Pradesh and (d) cauterisation by electric cauteriser which utilises a hot nitrate bar with an induction of 3 volt current for few seconds as practiced in M/s CIBA hatchery, Narakkal, Kerala.
5.6.2. Repetitive spawning without eyestalk ablation:

Muthu et al. (1986) achieved induced maturation and spawning of *Penaeus indicus* without eyestalk ablation in captivity by merely manipulating the pH of water at 8.1 - 8.2 in the maturation pool. Maheswarudu et al. (1994) achieved repetitive spawning of *P. indicus* without eyestalk ablation by manipulating environmental parameters and feed. This technology not only reduces the number of spawners required/cycle in hatcheries but also prevents over exploitation of spawners and reduces recurring expenditure.

5.6.3. Artificial insemination:

One of the problems faced in the hatchery is the release of non-viable eggs due to the absence of sperm in the thelycum. Impregnation in spawned female in the maturation section may become difficult during certain period. To overcome the difficulties of thelycum devoid of spermatophores and unfertilised eggs due to improper mating in broodstock, two techniques namely, artificial insemination and *invitro* fertilisation are carried out. The spermatophores from the mature males (130-140mm in length) are removed by electroejaculation. The spermatophores ooze out and they are implanted into the thelycum of the newly moulted eye-ablated female. For insemination, the spermatophore is quickly inserted into the thelycum of the female. The ablated female matures 4-7 days after implementation. They are introduced into the spawning tank when complete maturity is observed. This technique has been implemented in the laboratory of M/s CIBA hatchery, Narakkal, Kerala. However, no successful achievements were made in the commercial production till date.
5.6.4. *Invitro* fertilisation:

In this technique, the spermatophores from the mature males are removed by electroejaculation and a sperm suspension is made. The sperm suspension is mixed with the eggs obtained from the spawners in order to facilitate fertilisation. The fertilised and unfertilised eggs are transferred into the hatching tanks. Larvae were found to hatch within 12-14 hours after fertilisation. This technique is found useful in solving the problem of non-mating breeders. This technique can also be used to produce quality breeders and aid in hybridisation of penaeid shrimps. This technique is yet to attain perfection in the commercial production of shrimp seeds.
5.7. Technical Flaws In Hatchery Operation

The various technical problems that are observed in different hatcheries of India are described below:

A. Problems in maturation section:

a. The collection of wild broodstock had been on the surge in the recent past due to the increase in the number of hatcheries that are constructed all along the coast line. This has led to over exploitation of broodstock from the sea resulting in the temporary closure of many hatcheries in India.

b. Broodstock with unhealthy and low fecundity caused failure in production in hatcheries as observed in M/s Giridhar foods, Ramnad, Tamilnadu; M/s Neha exports, Calcutta, West Bengal.

c. Pre-mature adult shrimps reared in captivity with considerable length and weight, when used for spawning, released low number of eggs thereby causing failure to achieve the production targets as observed in M/s Seamen Aqua Farm, Nellore, Andhra Pradesh and M/s Rahul SeaFoods, Sindhurg, Maharastra.

d. Physical stress, unfavourable environmental variation in temperature, salinity, pH, light-dark cycle, injury caused during transportation apart from insufficient provision in the hatchery for aeration, sanitation and hygiene have been found to reduce fecundity. These problems are observed in M/s SSV Aqua, Vizag, Andhra Pradesh; M/s Giridhar Foods, Ramnad and M/s ITC Minota Aqua-tech, Tamilnadu.
e. Diseased broodstock lowers fecundity and has been found to produce weak progeny as observed in M/s Rank Aqua, Nellore, Andhra Pradesh and M/s Aquin Quilt, Kumta, Karnataka.

f. Partially matured breeders or those which spawned partially in the sea when used obviously exhibited low fecundity, as experienced in M/s MPEDA hatchery, Vallarpadom, Cochin, Kerala and M/s Tirumala Fujitech, Vizag, Andhra Pradesh.

g. The number of viable eggs spawned was always found to be relatively low in spawners subjected to continuous prophylactic drugs. This is widely observed in M/s TASPARC, Vizag, Andhra Pradesh.

B. Problems in spawning and hatching section:

The various problems that are encountered with spawning and hatching in the various hatcheries of India are described below:

a. Spawners produced in captivity on the east coast are found to release less number of eggs due to unfavourable environmental and physical stress caused through transportation and improper handling.

b. Spawners collected from the east coast especially from Orissa and Andhra Pradesh, when transported and used in hatcheries of the west coast exhibited non-release of eggs, low fecundity and in some breeders spawning inviable eggs. These problems are commonly observed in hatcheries, viz., M/s MPEDA, Vallarpadom, M/s Baby Marine, Calicut and M/s Travancore hatchery, Trichur, Kerala.
c. When light intensity was accidentally supplied with more than 100 lux as noted in M/s NAEL, Nellore, Andhra Pradesh, the spawners were found to delay the spawning activity for more than 48 hours.

d. Vigorous aeration and other disturbances in the spawning section led to non-release of eggs by the spawners as observed in M/s MPEDA hatchery, Vallarpadom, Cochin, Kerala.

e. When salinity is reduced to below 25ppt and raised above 35ppt, delayed spawning and re-absorbption of eggs in the system of spawners are observed in M/s Veerat Aqua tech, West Godavari, Andhra Pradesh.

f. The utility of certain substitutes and chemicals like sodium thiosulphate, sodium sulphate to expedite spawning resulted in mortality of spawners. This has been observed in M/s Rank Aqua, Nellore, Andhra Pradesh.

g. Inadequate lighting in the hatching section has been found to reduce the percentage of hatching of eggs to nauplius as noted in M/s SSV Aqua, Vizag, Andhra Pradesh.

h. Inadequate aeration in the hatching tank resulted in clustering of eggs leading to reduction in survival rate due to oxygen depletion. This problem is faced in M/s MPEDA hatchery, Vallarpadom, Kerala.

C. Problems in larval and post-larval section:

Larval and post-larval growth of shrimps in some hatcheries had been observed to be affected due to the following factors:
Improper sanitation, hygiene and disinfection of the hatchery system causing bacterial, fungal and viral growth in the system have been found to cause mass mortality in the larval section as experienced in M/s MPEDA hatchery, Vallarpadam, Kerala; M/s Tamilnadu Fisheries Development Corporation (TNFDC) hatchery, Madras, Tamilnadu.

Contaminated or adulterated feed when fed to the larvae resulted in the outbreak of various diseases as recorded in M/s Oceanic Aquatics, Balasore, Orissa. Inadequate quantity of feed resulted in cannibalism of the larvae and post-larvae apart from producing unhealthy seeds. Retarded growth was observed, when feeding schedule was frequently manipulated as in M/s Liquors India, West Godavari, Andhra Pradesh.

Wild seed mixed with hatchery seed for scheduling appropriate stocking density/tank/cycle led to the production of uneven sizes and poor quality seed as observed in M/s Sea Jade, Vasai, Maharashtra.

Heavy mortality was observed when larvae were transferred to post-larval tanks during moulting (from mysis III to PL1) caused by injury and stress. Further, the larvae were found susceptible to secondary infection due to their soft body being exposed due to moulting. This has been commonly noted in Hawaii technology based hatcheries.

Differential growth was observed in shrimp larvae due to stocking at different stages in the same tank. This problem is common in most of the hatcheries in India, when low number of larvae are stocked (Batch wise) as against the installed capacity of the tanks.

Inadequate water exchange with high stocking density in larval tanks resulted in the accumulation of waste deposition in the tanks favouring
microbial action thereby reducing the survival rate of the post-larvae. This is commonly observed in the backyard hatchery of M/s Balaji biotech, Nellore, Andhra Pradesh.

g. Inadequate feed in quantity and quality resulted in scanty production of post-larvae as recorded in M/s Durga Aqua, Vizag, Andhra Pradesh.

h. Inadequate aeration, lighting and temperature have led to low production in many hatcheries in India.

i. The continuous utility of prophylactic drugs in the larval tanks resulted in the reduction of resistance of larvae which in turn enabled them to be susceptible to various diseases. Wrong diagnosis and medication were often found to cause depression in growth, secondary infection and mass mortality. This problems was often observed in Hawaii technology based hatcheries.

D. Problems in feed and feeding:

Various problems encountered in the feeding section are described below:

a. Algal section:

i. Algal cells cultured from the seawater without proper techniques have been found to favour unwanted algal bloom causing heavy mortality of shrimp larvae as observed in M/s TNFDC hatchery, Madras, Tamilnadu.

ii. Un-sterilised labware and equipments used for algal culture have been found to contaminate the entire system affecting larval production. This
was commonly observed in M/s MPEDA hatchery, Vallarpadom, Cochin, Kerala.

iii. Growth rate of algal cells are reduced when old stock solutions of culture medium are used as experienced in M/s Giridhar Foods, Ramnad, Tamilnadu.

iv. Light intensity less than 2000 lux in the indoor culture system proved to retard the growth of algal cells, as observed in M/s Aqua Plaza, Trichur, Kerala.

v. Retarded growth was observed in larvae, when algae in the indoor culture room was maintained below 18°C. This problem was noted in M/s NCC BPL, Vizag, Andhra Pradesh. High mortality of larvae was observed when algal cells were subjected to 40°C. as experienced in M/s Oriqua hatchery, Balasore, Orissa.

vi. Seawater containing suspended particles above 5-10 micron caused cellular injury to the algal culture as experienced in M/s Spencer Aquaculture, Mayiladuthurai, Tamilnadu.

vii. Inadequate and interrupted supply of aeration to the culture tanks caused algal cell adherence in the mass culture vessels resulting in mortality as noted in M/s Tisa united, Vizag, Andhra Pradesh.

b. **Artemia** section:

i. Non-availability of **Artemia** cysts at the appropriate period has led to the failure of PL production as observed in M/s Varun hatchery, Bapatla, Andhra Pradesh.
Large-sized nauplii produced by Gujarat strain-Tata cysts are not consumed by the post-larvae as their mouth size was found to be smaller than the *Artemia* nauplii. Likewise, smaller-sized cysts (Tuticorin strain) were not found economical and effectively utilised by these larvae. Therefore, imported brand of cysts, viz., Sanders, Argent, Gold strain, Utah etc. are used very commonly.

Hatched cysts when accidentally let into the system contaminated the culture system affecting production as observed in M/s S&S Industries, Sirkazi, Tamilnadu.

Improper cysts processed by decapsulation technique affected shrimp production due to residual chlorine contamination in the culture system, as observed in M/s Pavithra hatchery, Madras, Tamilnadu.

Artificial feed:

Imported artificial feed when stored for a longer period resulted in denature of the feed composition thereby causing retarded growth.

Feed stored in moist condition has been found to be susceptible to fungal attacks as noted in M/s Giridhar Foods, Ramnad, Tamilnadu.

Excess feed and feed containing hormones when fed to PL to expedite growth occasionally resulted in producing abnormalities, sterility and pre-mature deaths after stocking in culture ponds.

Broodstock diet:

Fresh broodstock diet like clam meat, squilla meat and polychaete worms when fed without cleaning properly contaminated the system. This has further led to the development of secondary infection and
susceptibility to microbial diseases in adult shrimps as observed in M/s Acquaint exports, Vizag, Andhra Pradesh.

ii. Stale feed when fed to the shrimp larvae caused nutritional imbalances, microbial action and contamination of water in the culture system thereby resulting in poor production. This problem was noted in M/s Visaka Aqua, Vizag, Andhra Pradesh.

e. Shut Down Operation:

i. Inadequate disinfection during shut down operation has been found to produce poor results as noted in M/s Geomarine Aqua, Vizag, Andhra Pradesh.

ii. Improper maintenance of machinery, equipments and accessories have been found to reduce the efficiency of the system and increase the work load of man power and recurring expenditure as assessed in M/s Neptune Aqua, Vizag, Andhra Pradesh.

Most of the problems discussed in this chapter are applicable to all hatcheries, where similar conditions exist.
8. Remedial Measures for Hatchery Operation

The technical problems in hatchery operation can be rectified or solved by adopting a systematic procedure laid by the technical staff and the management. The various technical remedial measures that are employed in the hatcheries of India according to MPEDA, 1990, S&S Industries (op. cit.) and Maritec Consultants (op. cit.) are described below:

Remedial measures for maturation section:

1. Non-availability of broodstock from the wild can be solved by (i). culturing broodstock in captivity, (ii). establishing broodstock bank by developmental agencies and distribute broodstock equally to genuine hatcheries at a nominal rate in the stipulated season, (iii). certain percentage of nauplius hatched from such broodstock bank being released into the sea for developing future progeny for sustained shrimp stocks in the wild.

2. Broodstock should be selected on the basis of age, size and weight. Broodstock reared in captivity should not be used before attaining one year and weighing less than 100g.

3. Prophylactic drugs at minimum dose should be used to prevent the larvae from diseases.

4. Breeders with genetical recessive characters, unhealthy species and repeated spawned females should be avoided.

5. Breeders should not be disturbed by sound and vibration of machinery.
Breeders should be checked for any disease in the quarantine section prior to stocking in the maturation tank.

Hygiene and sanitation should be strictly adhered to and precautionary steps should be taken to maintain by providing hand and foot bath with disinfectants and sterile clothes for technical staff and visitors.

Remedial measures for spawning and hatching:

Healthy females reaching the IVth stage of maturity with the characteristic features should be used for spawning. Immature or spent spawners could either be cultured in separate tanks or discarded.

Optimum temperature (28-30°C), light (100-150 lux), quality water, salinity (26-30ppt) and chelating agent (EDTA - 0.5-1ppm) should be provided to achieve efficient hatching.

All the accessories in the spawning and hatching section should be cleaned thoroughly and disinfected prior to operation.

Remedial measures for larval and post-larval section:

All environmental factors that are conducive for culture should be provided to achieve the rated production.

The larvae and post-larvae should be fed with quality feed and should follow a specific feeding schedule to maintain quantity, quality, frequency and distribution of feeding at different stages.

Water exchange should be regularly carried out. The percentage of water exchange is dependent on the technology.
d. Aeration to the larval and post-larval tanks should be given adequately to supply oxygen and circulation of water. Filters should be provided in order to prevent smoke or dust particles by the blowers.

e. Prophylactic drugs in controlled quantity should be supplimented to prevent the onset of microbial or fungal diseases.

f. The tanks suspected for any disease should be isolated by providing separate accessories, buckets, nets and draining facilities.

g. The air lines and water lines should be disinfected regularly to prevent diseases. A dual line system should be recomended for this purpose.

h. Wild seed should not be mixed with hatchery seed in order to prevent differential growth rate and cannibalism.

i. Post-larvae should be immediately transferred when they are between PL20 and PL25 stages, as stocking of post-larvae of more than 25 days in the tanks results in stunted growth and high mortality. Rearing of post-larvae after PL25 stages has been found to increase the recurring expenditure and proves un-economical in the light of commercial production.

D. Remedial measures for feed and feeding :

The various steps taken to achieve quality production through proper feeding methodology are given below :

a. Algal section :

i. Selected species of algae predominantly available near the site from the seawater should be considered for developing algal culture. This
facilitates to culture the species economically not only in quality but also in quantity.

ii. The culture vessels, equipments, flasks, air and water pipelines should be disinfected and cleaned to prevent contamination.

iii. An optimum temperature between 22 and 25°C, lighting of 8000-10,000 lux, salinity ranging 26-28ppt are found suitable for the growth of algae. Excess temperature can be controlled by providing air-conditioners. Space heaters can be used when temperature decreases. Lighting can be regulated by increasing or decreasing the wattage of the bulbs.

iv. Algal cells should be examined under the microscope regularly in order to harvest only the exponential phase cells for the larvae. Cells in the declining phase do not provide sufficient nutrition to the larvae.

v. Cartridge filters of 0.5-5 microns, U.V. filters or ozone treated water enhances sterile and quality algal cultures.

vi. A schedule of algal culture should be prepared to feed the shrimp larvae in the appropriate period of the cycle.

b. **Artemia** section:

i. **Artemia** cysts are expensive and hence they can be cultured in salt pans or in closed tanks to cater to the demand and also to economise the recurring expenditure.

ii. The size of the cysts should be checked in order to effectively feed the shrimp larvae.
iii. The decapsulation technique for the specified brand of cysts should be processed based on the instruction supplemented by the manufacturer to achieve maximum hatching efficiency.

iv. *Artemia* nauplii can be separated by using a nauplii separator or nets of specific mesh size to separate cysts from nauplii. They can also be attracted by utilising the phototactic behaviour near the translucent bottom of the cylindroconical tank.

v. The nauplii should be washed in fresh seawater before feeding to prevent debris or unwanted waste material attached to the nauplii.

c. Artificial feed :

i. The artificial feed should be provided appropriately in terms of size, weight and feeding regime, every day.

ii. Feed should be analysed to detect the presence of any aflotoxin or contaminants prior to feeding the larvae or post-larvae.

iii. The nutritional value and composition should be checked regularly in order to provide a balanced diet to the larvae.

d. Broodstock diet :

i. Broodstock diet should be cleaned thoroughly before feeding.

ii. The fresh feed should be minced at appropriate size in order to aid nibbling by the breeders.

iii. The debris or waste material in the broodstock tank should be cleaned prior to each feeding schedule.
e. Shut down operation:

i. During each shut down operation proper care should be taken to ensure total disinfection of the hatchery system.

ii. Records of inventories and purchase of material should be planned prior to operation of each cycle.

iii. The repairs and servicing of plant and machinery should be undertaken during the shut down period.

iv. The records of manpower turnover should be scrutinised and the necessary technical staff should be recruited before the commencement of the cycle.

v. The shut down period should be synchronised in such a way that the economical status of the hatchery is maintained causing least impact on the demand for seeds.
5.9. **Diseases And their Control Measures In Shrimp Hatchery**

Shrimp diseases are caused by pollution, ecological and stress factors. Non-biological agents through pollution of organic chemicals other than petroleum and heavy metals cause diseases to shrimp resulting in loss of production. The major diseases caused by pollution through organic chemicals, heavy metals and biological factors and their remedial measures are described below:

5.9.1. Organic chemicals:

a. Poly-chlorinated bi-phenyls:

These are industrial pollutants that affect penaeid shrimp ecology. These are accumulated in the system as a result of waste effluent disposal of dielectric fluids and industrial sources. These chemicals cause mortality during pre-moult and moulting stages. These shrimps become lethargic and stop feeding. This has been observed in M/s Neha Exports, Calcutta, West Bengal, wherein polychlorinated phenyl compound is discharged as effluent from phenyl industry in trace amounts.

The entry of these chemicals in the hatchery system can be prevented by providing suitable filtration system, viz., Rapid sand filters, UV and Ozone treatment units.
b. Pesticidal chemicals:

Pesticides like chlordane, DDT dieldrin and endrin bear an impact on the life of shrimps. The effects of pesticides were predominantly observed in hatcheries located near agricultural areas. In M/s Chemmeen hatchery, Tanjore, Tamilnadu, shrimp seed with retarded growth due to the impact of trace DDT compound was observed.

Prevention of pesticidal entry into the hatchery system is only by providing effective water treatment and filtration system.

c. Organophosphates and Carbamates:

These were found more toxic to shrimps than other pesticides. Malathion used for agricultural purpose was found to cause lethal effects in penaeids at 14 micro-gram/litre. Carbamate pesticides (Sevin) have been found lethal to crustaceans. Their action to shrimp larvae is under investigation. The effect of Organophosphates was observed in most of the hatchery sites located in Tanjore, Sirkazi and Nagapattinam in Tamilnadu and Nellore and Kakinada in Andhra Pradesh.

Water treatment system in the hatchery is found to be the major preventive measure against the entry of such Organophoshates and Carbamates.
5.9.2. Heavy metals:

Heavy metals may exist in several oxidative state with different reaction potential. Some metals may act on estuarine microbes to form alkyl-metallic compound that is accumulated by estuarine species. Increasing levels of heavy metal due to weathering and land drainage were reported by Chen et al. (1985). The effect of EDTA on the survival and development of shrimp nauplii was published by Castille and Lawrence (1981). The toxicity levels of copper and manganese in shrimp nauplii were conducted by Lawrence et al. (1981). Studies on the effect of cadmium to shrimp larvae were conducted by Spotte (1970) and Chen (1983). Effect of copper in larval stage of shrimps was published by Couch (1979). Studies on the metal pollution in aquatic environment were conducted by Forstner and Wittman (1979). Management of water quality in shrimp hatcheries was studied by Chen (1983). Chen et al. (op. cit.) reviewed in depth manganese accumulation, blocking the gills and inhibiting respiration in shrimp larvae.

The levels of heavy metals as analysed in the various hatchery sites are found in trace amounts, where industrialisation is predominant. Hatcheries in Gujarat, Mangalore in Karnataka, Cochin in Kerala on the west coast and Orissa and south Tamilnadu on the east coast are anticipated to cause disease outbreak due to heavy metals. Water treatment and filtration system apart from maintenance of the hatchery in hygienic condition have been found to prevent the lethal effects of heavy metals.
5.9.3. Biological Factors:

Studies on various diseases and their impact on hatcheries in India are given below:

Studies on *Lagenidium* sp. causing severe damage to larvae of Penaeid shrimps was reported by Treece and Fox (op. cit.). In *P. subtilis*, Baculovirus penaei disease was reported by Couch (1978) and Bueno et al. (1989). Baculoviral midgut gland necrosis (BMN) was reported in *P. japonicus* by Sano et al. (1981). Monodon bacculo Virus (MBV) was reported in *P. monodon* by Chen and Kou (1989). Infectious hypodermal haematopoetic necrosis virus (IHHNV) was reported in *P. monodon* and Hepatopancreas Parvo-like Virus (HPV) in *P. merguiensis* by Lightner and Redman (1985). Reo-like virus was reported in *P. japonicus* by Tsing and Bonami (1987) and in *P. monodon* by Nash et al. (1988). Plebejus baculovirus was observed in *P. plebejus* by Lestler et al. (1987). Rickettsial infection was studied in shrimp to certain extent by Brock et al. (1986), Brock (1988) and Colorns et al. (1987).

(a). Bacterial Diseases:

(i). Luminous bacteria:

In *P. monodon* hatcheries, larval mortalities are observed due to luminous bacteria. Eggs, larvae and post-larvae are found susceptible to these light emitting bacteria namely *Vibrio harveyi* and *V. splendidus*. Water acts as the main carrier of infectious agent. The use of contaminated water is one of the sources of this bacterial entry into the hatcheries. It proliferates in
faecal material and excess food material in the larval rearing tank. This has been found to affect the various hatcheries in Visakapatnam, Kakinada and Nellore in Andhra pradesh.

Prophylactic measures involving UV treatment prior to water supply into the hatchery system, utility of effective filtration system, siphoning sediments and debris from the bottom of the tank, and disinfection of seawater, freshwater and air pipelines have been adopted.

Drugs like Chloramphenicol, Erythromycin and Perfunran are administered at a dosage of 10ppm, 2-4ppm and 1ppm in the larval and post-larval tanks respectively.

(ii). Brown or black spot or rust disease:

It has been found to destroy shrimp larvae. These are caused by Vibrio spp. and Pseudomonas spp. they destroy exoskeleton of the shrimp larvae leading to osmotic imbalance, problems in moulting and in mechanical injury thereby favouring the entry of pathogens. This has been commonly observed in juvenile shrimps cultured in the nursery ponds of M/s OSSPARC hatchery, Gopalpur, Orissa.

Drugs, viz., Perfunran (1ppm), Furazolidone (2-5ppm), Terramycin (4.5ppm) and Furazone (1.3ppm) are administered in the medium. The onset of this disease is prevented by providing adequate water exchange and stocking low density of larvae in the culture tanks.
(iii). Filamentous bacterial disease:

It is caused by filamentous bacteria, *Leucothrix* sp. in *P. setiferus*, *P. vanamei* and *P. stylirostris*. The filamentous growth can be observed in post-larval stages especially on the setae of uropods, pleopods and gill filaments. Discolouration of gills from yellow to green is noted. It prevents gas diffusion leading to mortality. Rich organic seawater and increased stocking density are the predominant factors for the occurrence of this disease. These bacteria are rarely noted in the hatcheries of Andhra Pradesh and Orissa.

Drugs like Malachite green, Formalin, Potassium permanganate and Cuprous chloride at the rate of 0.5, 10, 8.5 and 1ppm respectively are used to cure gills and pleopods attacked by filamentous bacteria. These drugs are widely used in Andhra Pradesh and Orissa in various hatcheries.

(iv). Bacterial necrosis:

Appendages of zoea, mysis and post-larvae form the affected parts. Drugs like perfuran (1-4ppm), furazolidone (1.1ppm), erythromycin (1.5ppm) and achromycin (1.5ppm) are administered to control this disease. Sufficient feed and preventing over crowding are some of the precautionary steps that are taken in the hatcheries, viz., M/s TASPARC, Vizag, Andhra Pradesh, M/s OSSPARC, Gopalpur, Orissa.
(v). Shell disease:

The exoskeleton muscles of PL are affected by infection caused by chitinivorous bacteria. This disease has been predominantly observed in the hatcheries located in Gujarat.

Malachite green and Formalin at the rate of 0.9ppm and 22ppm are administered respectively to prevent this disease.

(vi). Black gill disease:

This disease is prevalently noted in the PL stages of shrimps. This disease is found to occur during monsoon in hatcheries, where filtration system is found ineffective as observed in M/s Mas Aqua, Ramnad, M/s Mohta hatchery, Tuticorin, Tamilnadu; M/s NAEL, M/s Aquamarine Foods, Nellore, AndhraPradesh and M/s Aquatech, Trichur, Kerala. Malachite green and methylene blue at a dosage of 3 and 8-10ppm are administered to cure this disease respectively.

(b). Bacterial epicommensals:

**Leucothrix mucor** is an estuarine-marine bacterial epi-commensal from Penaeid culture area of the world (Treece and Fox, op. cit.). It attaches to living and non-living substrata. This disease is caused by excess organic load in the culture system, oxygen depletion and stress during moulting. **Thriothrix** sp. (Lightner, 1983) was found to cause bacterial gill disease. This disease is found to occur during monsoon period when water quality is poor as
observed in M/s S&S Industries, Sirkazi, M/s Spencer Aquaculture, Mayiladuthurai and M/s Mas Aqua, Ramnad, Tamilnadu. Adequate water exchange with low stocking density of larvae in the tank has been found to prevent this epicommensal. Drugs, viz., Potassium permanganate (2.5-5ppm), Copper chloride (0.1ppm), Neomycin (10ppm), Formalin (25ppm) and Malachite green (0.0075ppm) are found to cure this disease.

(c). **Protozoan infection:**

Protozoan infection affects gills and eyes of the zoeal, mysis and PL stages of shrimp. The main causative agents are Vorticella sp., Zoothamnium sp., Epistylis sp. and Ephelota sp. Most of the hatcheries in India are observed to be affected by protozoan infection especially during monsoon period. Its prominence is frequently noted in hatcheries, viz., M/s MPEDA, Vallarpadam, Kerala; M/s Pavithra hatchery, Madras, M/s Nalli Aqua, Marakkanam, M/s KMSRS Aqua, Ramnad, Tamilnadu; M/s Skyline, Kumta, Karnataka and M/s Bay Aquatics, Vizag, Andhra Pradesh.

Drugs like quinacrine Hcl, chloramine, methylene blue and saponin 10% at a dosage of 1-2.5, 0.8-5.5, 8.0 and 5ppm are given in the medium respectively to control protozoan infection.

(d). **Fungal disease:**

Lagenidium sp., Sirolpidium sp. and Fusarium solani were found to cause fungal disease in P. semisulcatus in Kuwait (Treece and Fox, op. cit.). Based on histopathological studies (Treece and Fox, op. cit.) and
pathogenesis studies were conducted by Hose et al. (1984), severe infections in Penaeids were found susceptible to *Lagenidium* sp. Secondary infection was also found to change haemolymph content of the host due to *F. solani* in *P. californiensis* (Hose et al., op. cit.). Fungal attacks were observed generally in hatcheries, which failed to maintain hygienic conditions.

Water exchange is mainly adopted to prevent this disease. Drugs like Trelfan and Malachite green at the rate of 0.1ppm and 0.01ppm are used respectively in most hatcheries to prevent fungal infection.

(e). Dinoflagellate poisoning:

Dinoflagellate blooms (red tides) have been found to cause heavy mortalities in cultured shrimps (Treece and Fox, op. cit.). The shrimps developed ‘blunt heads’. These blunt heads were believed to have been developed due to head appendage damages. Ineffective filtration system was found to cause this disease. This has not been predominantly noted in Indian hatcheries.

(f). Red disease:

Red discolouration was noted in *P. monodon* in Taiwan and Philippines (Treece and Fox, op. cit.). It was also observed in pond reared *P. stylirostris* in Hawaii (Lightner and Redman, op. cit.). Treece and Fox, (op. cit.) described the development of red disease in *P. monodon* with a sign of yellow-green discoloration of the shrimp body which becomes reddish in gills and pleopods causing lethargy, anorexic and susceptible to epicommensal organisms. This
disease has been observed seldom in the outdoor post-larval rearing tanks in M/s OSSPARC, Gopalpur, Orissa.

(g) Gas Bubble disease:

Supersaturation of atmospheric gases and oxygen (Lightner, 1983) lead to gas bubble disease in Penaeid shrimps. This disease was observed in penaeid shrimps when oxygen reached 250% of saturation in seawater (Treece and Fox, op. cit.). The shrimp larvae float with the presence of gas bubble in the gills. This has been noted in hatcheries having excess aeration facilities, viz., M/s TASPARC, Vizag, Andhra Pradesh. Prevention of this disease is by regulating diffusion of air in the culture tanks.

(h) Muscle necrosis:

It is characterised by white opaque area in muscle in abdominal segments (Treece and Fox, op. cit.). It is caused by severe stress, increased temperature, low oxygen and salinity changes (Treece and Fox, op. cit.). This has been noted when broodstock is transported from the east to west coast hatcheries as observed in M/s Travancore hatchery, Trichur, M/s MPEDA, Vallarpadam, Cochin, Kerala.

This disease is prevented by reducing the stress to the post-larvae during transportation. Vigorous aeration and water exchange are provided to the larval/post-larval rearing tanks during the onset of this disease.
(i). Monodon Baculo Virus (MBV):

The Monodon Baculo Virus damages tissues of hepatopancreas, lining of digestive tract and destroys the shrimp as virus develops. The causative agent is the Baculovirus species. This has been found prevalent in almost all the hatcheries of India since 1993.

No antibiotics can cure viral disease and hence only water quality and monitoring the system meticulously will prevent such disease to certain extent.

(j). Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV):

Post-larvae of P. monodon and P. indicus are susceptible to IHHNV. It is caused by IHHNV picorna like virus. It cannot be cured in the adult stages. Epizootics attack on 0.005 to 1g shrimp and result in mass mortality. It leads to reduction in feed consumption, white spots on the carapace, bluish abdominal musculature and necrosis of hepatopancreas leading to mortality. This disease has been reported in the hatcheries of Nellore, Andhra Pradesh and Sirkazi, Tamilnadu.

(k). Hypoxia:

Low levels of dissolved oxygen in water leads to hypoxia and asphyxiation to the larvae. Post-larvae are more prone to hypoxia. Symptoms of surface swimming, sudden mass mortalities, prolonged respiration distress and impaired metabolism resulting growth retardation were noted. This is commonly observed in Taiwan, Philippines and Japanese technology based
hatcheries in India due to inadequate supply of aeration in the hatchery system. Adequate supply of aeration with less stocking density of the larvae in the rearing tank is the only remedial measure to prevent hypoxia.

(I). Yellow Head Virus (YHV):

The yellow head virus mainly causes disease in *P. monodon* larvae and adults. It affects the hepatopancreas, lymphoidal organ, cardiac tissues as in sub-adults and haemopoeitic tissues in gills. This was found prevalent in nurseries in Andhra Pradesh during mid 1994. The disease showed its prominence in the hatcheries maintaining post-larvae beyond PL25 stage.

The remedial measures to prevent the onset of this disease are regular water exchange, adequate supply of aeration, effective filtration system and disease-free broodstock in the hatchery system. No chemical treatments or antibiotics are found to be effective to cure this disease.

(m). Hepatopancreatic Parvo-like Virus (HPV):

This virus affects the larvae. No treatment has been found to cure after the onset of this disease.

5.9.4. Indigenous medicines:

In some hatcheries, 'Garlic paste' is found to prevent luminous bacterial disease. Garlic mashed in the form of a paste is treated at the rate of 1-2g/ton of water. Garlic extract in the form of paste has been found to be effective to
cure fungal attacks. Survival rate of 50-60% larval culture had been recorded in hatcheries of Tamilnadu as in M/s ITC Minota Aqua-tech, Tuticorin and M/s MAC Industries Ltd., Madras.

Presently, the combination of turmeric and garlic paste in the ratio of 1:4 at the rate of 1-4g/ton of water is being tried in hatcheries of Andhra Pradesh to prevent fungal growth as employed in M/s NAEL, Nellore and M/s Kalyan Seafoods, Kakinada, Andhra Pradesh.

When turmeric powder is mixed along with garlic paste, turbidity has been found causing oxygen depletion in the larval tanks. Hence, vigorous aeration and water exchange have been found to be essential while using this medicine. Likewise, many backyard hatcheries of Kerala have reported the combination of ginger and garlic paste (2 and 4 g/ton of water). However, their utility in commercial scale to achieve consistent production has not yet been proved.
5.10. **Natural Calamities Affecting Hatchery Production**

A. Types of natural calamities:

Natural calamities that led to the loss of production in some of the hatcheries in India are described below:

a. High salinity in seawater due to prolonged summer causing low production in *P. monodon* was noticed in hatcheries located in Andhra Pradesh.

b. The action of wind, causing damage to the structures of the hatchery was witnessed in M/s Anjaneya hatchery, Ongole, M/s Quality Seafoods, Kakinada, Andhra Pradesh and M/s Super Fine hatchery, Cuddalore, Tamilnadu.

c. Low salinity resulting retarded growth of larvae was observed due to heavy rainfall in M/s Kumta hatchery, Kumta, Karnataka.

d. Low production due to outbreak of unwanted and harmful organisms was observed due to pollution in the water and adverse environmental condition during certain season in M/s MPEDA hatchery, Vallarpadom, Kerala.

e. Abnormal tidal action and flutuation causing changes in water quality resulting in poor production were noticed in M/s Bay Aquatics, Vizag, Andhra Pradesh.

f. Siltation process causing reduction in water level at sea resulted in poor supply of intake of water and clogging of pipe lines. This in turn reduced the rate of water flow in M/s MAC Industries Ltd., Tuticorin, Tamilnadu.
g. The coastal belt in Karnataka was found to be subjected to frequent fluctuation in temperature thereby causing retardation in the growth of shrimp larvae. Production loss due to this problem was recorded in M/s Skyline hatchery, Kumta, Karnataka.

h. The impact of flood during monsoon led to low demand for seeds due to temporary suspension in shrimp farming. Due to this impact, hatcheries located especially in Ongole, Andhra Pradesh, Cuddalore, Sirkazi and Nagapattinam in Tamilnadu, were forced to reduce production as against their installed capacity which finally resulted in economical loss in hatchery operation.

i. The absence of sunlight causes retarded production of algae which in turn affects shrimp production. This problem was observed in hatcheries located on the West Coast of India.

B. Remedial measures to prevent natural calamities:

Natural calamities cannot be prevented. However, precautionary measures can be taken to prevent damages to the shrimp hatchery, which are described below:

a. Salinity:

High salinity can be manipulated in the hatchery by adding freshwater to certain extent since a high variation in salinity cannot be altered as large volume of freshwater may be required for dilution. Low salinity may be corrected by adding salts of gypsum as practiced in M/s NCC BPL, Vizag,
Andhra Pradesh. In commercial hatcheries, where water requirement is more than 400-500 ton /day, seawater is stored in reservoirs in order to utilise them during unfavourable period as noted in M/s ITC Minota Aqua-tech, Tuticorin, Tamilnadu. In general, during unfavourable season, the hatchery operations are shut down and only maintenance is undertaken as practiced in M/s TASPARC, Vizag, Andhra Pradesh.

b. Wind:

Wind cannot be prevented by any artificial method. The action of wind to the hatchery is prevented by constructing suitable structure. Designs should include the provision of wind barriers and heavy tubular trusses for the roof of the hatchery building to prevent the action of wind. This design is observed in M/s TASPARC, M/s NCC BPL and M/s Siris Aqua, Kakinada, Andhra Pradesh. The reservoirs and the various components of the hatchery should be built with strong foundation as noted in M/s NCC BPL, Vizag, M/s Rank Aqua, Nellore, Andhra Pradesh; M/s ITC Minota Aqua-tech, M/s MAC Industries Ltd., Tuticorin, Tamilnadu; M/s Bluchip, Kumta, Karnataka.

c. Temperature:

High temperature during summer is reduced by providing vigorous aeration in the tanks. Cooling material like gunny bags or PVC sheets covering the culture tanks or using thermal insulators or airconditioners in the hatchery systems are used in M/s Thirumala fujitech, Vizag, M/s Balaji Bio-tech, Nellore, Andhra Pradesh, (Fig.11). Low temperature can be controlled
by using immersion heaters or space heaters in the system as employed in M/s OSSPARC, Gopalpur Orissa. In some hatcheries, solar panels are used to generate power for heating system as observed in M/s Oriqua aqua, Balasore, Orissa.

d. Disease outbreak:

   The growth of microbes has been found to increase when changes in environmental condition are observed. These can be controlled through monitoring and treating the water by using UV system.

e. Siltation:

   In many coastal areas, erosion occurs due to the action of tides. The eroded materials may form deposition in another area and cause siltation as observed in M/s Kumta hatchery, Kumta, Karnataka. In some regions, the deposits of eroding material may stretch for a considerable distance from the shore thereby reducing the depth of water level in the ocean bed. This is prevented by selecting the site after a bathymetry survey and providing appropriate design to draw sufficient seawater for the hatchery. Siltation can also be removed manually if silt deposition is negligible in quantity. Pipelines can be extended further from the low tide level into the sea in order to draw seawater. Filter screen bags can be used to filter silt from seawater before it is pumped to the hatchery system as noticed in commercial hatcheries in Andhra Pradesh and Tamilnadu.
f. Cyclone:

Cyclone prone area should generally be avoided while selecting the hatchery site. Special structures can be erected in case of cyclone prone areas. Seawall, breakwater barrier, heavy roof trusses, strong foundation and plantation of trees are found to reduce the action of flood into the system. These structures are predominantly observed in the coastal belts of Kumta and Karwar in Karnataka and Nellore, Ongole and Vizag, in Andhra Pradesh.

g. Light:

In the absence of sunlight, artificial lights can be provided by calculating the day-night cycle and the intensity of light requirement by the algal cells and shrimp larvae in order to achieve the rated production.
Fig. 11. PVC sheets covering the larval tanks of M/s Balaji Bio-tech, Nellore, Andhra Pradesh.
5.11. **Management Role In Hatchery Operation**

A successful operation of a shrimp hatchery requires managerial procedure apart from appropriate design, construction facilities and application of scientific techniques. The key aspects of hatchery management are described below:

A. **Organisation chart:**

The organisation chart of a hatchery is based on the capacity and management outlook on delegating the work. The hierarchial order of management staff in a small backyard hatchery is comparatively less than in a corporate sector. In small scale hatchery, the proprietor or some family associate or friends with a few labourers operate the system. A centralised management occurs in this type. In corporate sector, decentralised system is adopted to specialise and monitor the system individually but with complete co-ordination.

B. **Management operation:**

In the management operation, prior to production, three important factors, viz., (i) Project Planning, (ii) Project Implementation and (iii) Technical operation are to be meticulously carried out to achieve successful production.
a. Project planning:

It involves in the certification of site suitability on technical, commercial and socio-economic feasibilities apart from engineering planning of construction work.

b. Project implementation:

The project is implemented within a specified period based on the capacity of the unit, nature of construction and financial support. The nature of construction is based on the technology, design, availability of men, material and conducive environmental parameters. A feasibility report on cost estimates, recurring expenditure and the status for future development is considered to yield good results.

C. Technical operation:

The unit is executed by technically skilled staff in which a trial run is operated with the basic infrastructure available, to determine production as against the rated capacity and the efficiency of the installed equipments and machinery. The management monitors and technically audits the entire cycle for further modification or changes in order to achieve the target production. The hatchery operation involves three major actions which are described below:
(i). Skilled action:

It involves meticulous scrutiny of inventories, viz., broodstock availability and procurement, algal stock preparation, Artemia cyst collection, list of machinery, record maintenance and manpower management.

(ii). Business action:

It involves cost analysis of the project stating the yearly profits or loss, recurring expenditure, balance sheet preparation, internal rate of return and debt service coverage ratio, marketing and sales involving pricing of seeds, customer’s relationship, advertisement strategies, delivery of goods in quantity and quality assurance within the scheduled period to the farmers.

(iii). Social status:

This management practice involves in protecting the welfare of the technical staff, labourers, surrounding villages, agriculturists and fishermen community. It not only aids in technical support but also helps in social upliftment of the industry.

5.11.1. Managerial constraints in hatchery operation:

In the recent past, due to overwhelming demand for seeds and profits from shrimp culture, various entrepreneurs have ventured into this field without taking precautionary steps in operation and administration. Problems in (a) preliminary stage of construction, (b) mobilising materials, equipments
and other accessories from various centres to the site (c) problems by labourers
(d) procurement of raw materials, viz., broodstock, spawners, algal stock
solution, Artemia cysts and feed inputs (e) maintenance problem (f) manpower
management problems, viz., lack of technical/skilled personnel, high manpower
turnover and non-systematic approach in hatchery operation (g) problems in
marketing and sales and (h) social constraints.

a. Problems in construction management:

In a large commercial hatchery, the time taken by inexperienced
engineers in implementing the design factors for construction or labour
problem caused during construction of the hatchery may affect the proposed
schedule of operation as observed in M/s SSV Aqua, Vizag, Andhra Pradesh.
During unfavourable environmental conditions, the construction of hatchery
may be delayed, which in turn increases the capital overheads of the project.
An un-coordinated management due to financial, communication gap or
conflicts between managerial staff will delay the construction process as
experienced by M/s Seamen Aqua, Nellore, Andhra Pradesh. Designs without
standard specifications lead to low production.

b. Problems in mobilising materials:

Many hatcheries are located in remote areas due to which procurement
of essential machinery, viz., blowers, pumps, filters and other accessories are
delayed. Improper planning and delay in commissioning the project by the
management are observed to increase the capital expenditure as observed in M/s Siris Aqua, Kakinada, Andhra Pradesh.

c. Labour problems:

Though labourers are available in large numbers and at a cheaper rates, inexplicable problems arise occasionally due to management conflicts and result in poor production as observed in M/s Sharaoa Aqua, Ongole, M/s Seamen Aqua, Nellore, Andhra Pradesh; M/s Giridhar Foods, Ramnad, Tamilnadu and M/s Golden Shrimp hatchery, Cochin, Kerala.

d. Procurement of raw materials:

Mismanagement in scheduling programme for collection of broodstock causes problem in capacity utilisation during peak demand period. Inadequate knowledge on the breeding ground, over exploitation of broodstock, adverse environmental conditions, nonavailability of Artemia cysts during necessity period due to procedures of import result in production failure.

e. Maintenance problem:

It occurs when proper technical personnel or guidance is not available during crucial situation or when repairs and services are not maintained in a stipulated period as experienced in M/s Neha exports, Calcutta, West Bengal.
f. Manpower management problems:

The demand for hatchery technicians has increased since 1990 due to mushrooming of hatcheries all along the coastal belt of the country. Hatcheries operated by unskilled staff lead to frequent suspension of operation due to lack of knowledge in the maintenance of machinery and handling technical problems during crisis situation as observed in M/s Aroma hatchery, Cochin, Kerala. Unhealthy relationship or harassment imparted by the management leads the skilled technician to seek for better prospects as noted in M/s Giridhar Foods, Ramnad, Tamilnadu. In public sector based hatcheries, lucrative salary is offered due to which a high manpower turnover is observed frequently in small scale hatcheries, viz., M/s Pavithra, Madras, M/s Dee Vee Cee, South Arcot, Tamilnadu; M/s Geomarine, Vizag, Andhra Pradesh and M/s Golden Shrimp, Cochin, Kerala. On the contrary, man power turnover due to absorption by smaller hatchery sector from reputed concerns is also observed, when technicians are lured with short term benefits which are not supplemented by the corporate based hatcheries, viz., M/s The Water Base Ltd., Nellore, Andhra Pradesh; M/s MAC Industries Ltd., M/s ITC Minota Aqua-tech, Tuticorin, Tamilnadu and M/s Chilka Aquatics, Puri, Orissa. Non-systematic approach in hatchery operation caused by non-scheduling of culture techniques, incapability in design implementation and technical faults have been found to tamper the production as experienced in M/s Giridhar Foods, Ramnad, Tamilnadu.
g. **Marketing and sales constraints:**

The demand for seeds in South East Asian countries was found enormous as against actual production. Many farms remained idle and barren due to non-availability of seeds. Similar conditions were observed in India during 1992-1994. A sudden hike in shrimp seed marketed by private entrepreneurs from Re.0.50 to Rs.1.80 and 2.00/seed was observed in 1994. In general, marketing constraints due to inconsistency in quality seed production, supply and survival rate of seed in the culture ponds, improper co-ordination between technicians and marketing staff during peak demand period, lack of customer relationship and non-servicing attitude are observed in hatcheries of India. Marketing constraints started appearing very recently from 1995 onwards because of disease and other related problems. This has caused an enormous impact in the reduction of culture area, which in turn has reduced the demand for shrimp seed on one hand and on the other hand by mushrooming of many hatcheries leading to a situation of ‘glut’ in the seed market, which necessitated reduction in the price of shrimp seed. Thus, a phenomenal fall in the shrimp seed price was witnessed during 1995-96 from Re.0.60-0.25/seed.

h. **Social constraints:**

The increase in hatchery development has created social problems between entrepreneurs and fishermen and local villagers, since a few entrepreneurs have been found to hinder the fishermen's livelihood. The construction of jetty system across the shore to the sea had caused hindrance
to fishing activities as observed in M/s Balaji Bio-tech, Nellore, Andhra Pradesh, M/s Victory Aqua, Tuticorin, Tamilnadu. The various social problems/misconceptions that were raised by the anti-aquaculturists/politicians due to aquaculture developments are listed below:

(i) Salt water seepage causing salinisation of drinking water (The Hindu, 19th May, 1994).

(ii) Fishermen were deprived of the accessibility to sea due to construction of seawater intake systems across the sea (The Hindu, 19th May, 1994).

(iii) Mud walls and floors of houses were reported to peel off, dampen and humid due to aquaculture activity in Allur mandal near Nellore, Andhra Pradesh (The Hindu, 20th July, 1994).

(iv) Pulicat lake, a breeding ground and sanctuary for birds had been reported to be destroyed due to shrimp farming (The Hindu, 20th July, 1994).

(v) Conversion of agricultural activities to aquaculture activities causing unemployment to farmers (The Hindu, 19th October, 1994).

(vi) Salt pan conversion to aquaculture activities caused reduction in salt production and unemployment to labourers of the salt industry (The Hindu, 22nd Feb., 1995).

(vii) The palm trees and casurina plantation near the sea shore were reported to have been destroyed due to aquacultural activities (The Hindu, 22nd Feb., 1995).
5.11.2. Remedial measures for managerial constraints in hatchery operation:

The management problems in a hatchery can be rectified if precautionary steps are taken into consideration. These steps are enumerated below:

a. Proper planning of designs and routine works, delegation of work in a stipulated period, control over labourers and motivating them to produce good results, mobilising material within the budget limits in a given period and maintenance of machinery and equipment periodically would augument good production.

b. Construction of all structures should adhere to specification formulated by the consultant or designers. The management should not neglect any component interms of space, economy and duration of construction.

c. Materials should be mobilised from the vicinity of the site. The management should take necessary action to minimise cost, when materials are imported.

d. A forecast on social calamities should be done by the management to avoid labour problems. It should avoid centralised system of working as the capacity of the hatchery increases.

e. A schedule of operation on broodstock procurement, algal preparation and necessary inputs to the hatchery should be listed out by the management prior to operation of each cycle. The management should assess the inventories and maintain a stock register as practiced in M/s TASPARC, Vizag, Andhra Pradesh.
f. Repairs and maintenance of the hatchery should be taken into consideration by the management. They should allocate separate funds to maintain the hatchery in good condition.

g. Marketing strategies play a role in the success of the hatchery. Consistency in supply of quality seeds, customer's relationship and service oriented management will bring forth success to the industry. Sales force should be given incentives in order to prevent manpower turnover. Service to the farmers during stocking the hatchery seeds, monitoring and harvesting would facilitate popularity as observed in M/s S&S Industries Ltd., Sirkazi, Tamilnadu. Malpractices like mixing ‘threads’ or ‘coconut fibres’ simulating PL to adulterate seed while packing made some hatcheries unpopular. Unhealthy seed or seed with inappropriate age and growth, seed fed with hormones or any growth promoting agents and imported seeds with infection should be avoided. A schedule of marketing operation network area can be demarcated to restrict conflicts related to competition among hatcheries.

Standard pricing of seeds can sustain the industry. An association may be established among hatcheries entrepreneurs to standardise marketing and sales proceedings like other industries. Publicity in the form of advertisement, brochures and exhibitions would boost up the industry to achieve good results.

h. Social constraints can be rectified by implementing rules and regulations or guidelines and manuals to sustain aquaculture and co-exist with other industries. The entrepreneurs should co-operate with local public to derive support in order to operate the hatchery smoothly.
Approach roads to the hatchery should not hinder the pathway of villagers. Agriculture land should be avoided. Legal constraints on land, water, sanctuary and heritage places should be verified prior to the selection of site. Necessary permission should be sought from the Revenue Department, Pollution Control Board, Forest and Shore Development Department and other institutions to prevent social constraints. Facilities like constructing schools as encouraged by M/s Balaji Bio-tech, Nellore, Andhra Pradesh, drinking water supply as provided by M/s VGP Aqua, Madras, Tamilnadu to the villages and work for fisherwomen like establishing mat weaving centres as implemented by M/s S&S Industries, Sirkazi, Tamilnadu can be adopted by other hatcheries keeping in view the local situation to maintain a healthy relationship with the local public and also to increase the economy of the country by augmenting employment in the rural villages. Hatcheries can also form an association with allied industries to achieve maximum benefits while indenting various inputs within and outside the country.
5.12. Exploitation Of Wild Spawners And Shrimp Seeds

Man has been consistently exploiting the ocean wealth for satisfying his requirements. However, over exploitation of some of the commercial species made them to reach endangered level.

5.12.1. Degree of exploitation:

Exploitation of breeders, wild seeds and juveniles increased as the number of hatcheries increased in the country. *P. monodon* is observed to be one of the successful species for commercial production and hence, exploitation of its breeders are in the increasing trend. Likewise, wild seeds of PL 15-20 are being caught near the seashore to meet the growing demand of shrimp seeds due to constant expansion in the shrimp farming activity. The hatchery seed output in India is low. Fishermen with trap nets have been found engaged in catching wild seeds during peak season of seed stocking in shrimp farms. They collect the wild seeds and stock in a small pool of water, artificially made near the shore. The PL are segregated based on the various sizes and are sold to the farmers. This indiscriminate exploitation of wild seeds all along the coastal belt if continued for a few more years may not only result in shortage of seeds but also cause depletion of breeders in the sea in future.

Many agencies, consultancy services and suppliers have emerged in the recent past to distribute and market breeders, wild seeds and other live-feed products without conservation for the future. This inturn would lead to the depletion of the species.
5.12.2. Remedial measures for over exploitation:

Over exploitation of wild spawners can be controlled by taking the following precautionary steps:

a. The resources of shrimp breeders available in the ocean should be informed to deep sea fishing trawler or mechanised boat agencies to restrict the catch of wild shrimp breeders. Restriction should be imposed to curtail the quantum of shrimp catch per vessel (Francis, op. cit.).

b. The commercial hatcheries should be made to indent the required quantity of breeders through proper channel in order to evenly distribute breeders (Fishing Chimes, Oct., 1993).

c. An association has already been established by Shrimp Hatchery Entrepreneurs, Vizag, Andhra Pradesh to release 5-10% of seeds produced from the hatcheries into the sea in order to sustain shrimp production (Fishing Chimes, Oct., 1993).

d. Wild seed collection from the sea or brackishwaters should be restricted (Fishing Chimes, Feb., 1994).

e. Exploitation of shrimps can be avoided by providing rehabilitation/alternate employment opportunities to fisher folks in other industries, viz., mat weaving, handicrafts, tailoring, etc. as adopted in S&S Industries, Sirkazhi, Tamilnadu.

f. Coastal lands deemed to be 'waste lands' should be favoured to develop broodstock ponds in order to rear these breeders in captivity (Maritec Consultants, op. cit.).
g. Over exploitation should be controlled by diversifying culture of different species. In SEAFDEC AQD, the concept of multispecies hatchery by rearing larvae of tiger shrimp, milk fish and seabass had been successfully practiced (Aquafarm News, 1994). Diversification of species from *P. monodon* to *P. indicus* had been found profitable, when culture period of both the species was found to be of similar duration as experienced in S&S Industries, Sirkazhi, Tamilnadu. Profitability in diversification of species can also be observed when culture of one species can be undertaken during the lean period of another species, which is as similar to that of 'crop rotation' in agriculture. The biology of the different species, design and technological inputs, skilled personnel to perfect both the cultures, common raw materials, machinery support, managerial and financial feasibility, transportation process of both species, conducive physical and environmental parameters, marketing and sales potential for both the species and legal procedures should be thoroughly scrutinised to achieve successful results.
5.13. **Technical Designs of Major Shrimp Hatcheries in India**

A thorough survey of 206 hatcheries located both on the East and West Coasts of India was made. The 206 hatcheries are found to adopt seven basic technologies, viz., Japanese, Hawaii, Philippines, Taiwan, French, German and Indian. It is interesting to note that within these seven basic technologies, a few minor variations have been observed. When these minor technological variations are taken into consideration, about eighteen types of hatchery technologies have been observed (five of Hawaii, three of Japanese, two of Philippines, four of Indian, two of Taiwan, one each of German and French) to be adopted by 206 hatcheries in India. Further, a careful scrutiny revealed fine variations within these 18 types of hatchery technologies among 146 hatcheries in India (Table 2). The technical details of each of the eighteen hatchery technologies are described mainly under different aspects, viz., (A) Hatchery set-up, (B) Design and operation involved in the hatchery, (C) Logistic support, (D) Infrastructure (E) Special features, (D) Demerits and (G) Commercial feasibility.
5.13.1. The Orissa Shrimp Seed Production, Supply and Research Centre, Orissa (OSSPARC)

A. Hatchery set-up:

a. Technology : French
b. Year of establishment : 1988
c. Capacity : 65 million/annum
d. Promoter / Sector : MPEDA / Government
e. Location of site : Gopalpur on sea, Orissa
f. Species reared : P. monodon

B. Design and operation:

a. Seawater intake system:

It comprises of a concrete well with an installed pumping capacity of 110 cu.m./hr., dug on the beach at a distance of 350 m away from the hatchery. Seawater is pumped from this well and supplied to the hatchery.

1. Filters:

Four rapid sand filters, each of 140 gpm are used to filter seawater before it is sent to the hatchery.

11. Reservoir/storage tanks:

A rectangular-shaped concrete reservoir of 100 ton capacity is used to store and disinfect seawater by chlorination process. The treated seawater is sent to the hatchery through a concrete overhead tank of 50 ton capacity. The process involved in the seawater intake system is schematically represented below:

Seawater --> Filter --> Reservoir --> Overhead tank --> Hatchery.
b. Hatchery complex (Fig. 12):

i. Broodstock ponds:

It comprises of nine rectangular-shaped earthen ponds. Each pond is of 100 sq.m. area (Fig. 13). The stocking density is maintained at 1-3 breeders/sq.m. Water exchange of 5-10%/day is carried out in these ponds. Aeration is provided by two air diffusers, each with 1HP capacity. The adults are fed with live-feed and reared till they reach maturity.

ii. Maturation section:

It comprises of eight circular FRP tanks (Fig. 14), each of 12 ton capacity. The bottom of the tank is provided with biological filters to maintain water quality. Breeders are stocked at the rate of 3-4 numbers/tank. Water exchange of 200% in 6 hours is carried out daily. Air is diffused through air stones. The tanks are provided with thermostatic control. The breeders are fed with live-feeds and broodstock diet.

iii. Spawning section:

Ten numbers of flat bottom FRP tanks, each of 250 l capacity are used for spawning (Fig. 15). One spawner is stocked in each tank. Water exchange is carried out as and when necessity arises.

iv. Hatching section:

Hatching is facilitated by 'Flow through system' which comprises of two rectangular tanks with 10 egg trays and nauplii collectors (Fig. 16). The eggs in the hatching tray is subjected to a gentle flow of water, which
facilitates hatching. The hatched nauplii are attracted by light and collected in the nauplii collector which are later stocked in the larval tanks.

v. Larval section:
The entire larval rearing section is divided into seven compartments, each having a set of oval-shaped FRP tanks of 10 ton capacity (Fig.17). The larvae are stocked at the rate of 100 nauplii/litre. Water exchange of 100% in 4 hours is carried out per day. Air is diffused through air stones. The larvae are reared upto PL5 stages.

vi. Post-larval section:
It comprises of two types of rearing tanks (a) forty rectangular, brick-wall masonry tanks, each of 10 ton capacity and (b) twenty earthen ponds covered with PVC liner, each of 100 cu.m., capacity. The post-larvae are reared from PL5 to PL15 at a stocking density of 25 Nos./l in the rectangular tanks (Fig.18) and are transferred to earthen ponds (Fig.19) at PL15 stages, wherein they are reared upto PL30 stages at a stocking density of 12 Nos./l. Water exchange and aeration are carried out as similar to that of larval section.

vii. Feed section:
An indoor algal room is provided to culture algae. The stock culture is prepared in conical flasks and 20 l carboyos. The mass culture is carried out in twenty FRP translucent cylinders, each of 200 l capacity. Fourteen FRP cylinders, each of 500 l capacity are used for outdoor
culture (Fig.20). The algae are fed to the larvae at the rate of 50,000 cells/ml.

Twenty FRP tanks, each of 200 l capacity are used for Artemia cyst hatching. The hatched out nauplii are separated by using sieves of different mesh size. The post-larvae are fed with Artemia nauplii at the rate of 2-3 Nos./ml.

viii. Drainage system:

Each section is provided with a central drainage system to collect wastewater.

C. Logistic support:

The hatchery has two pumps, each of 5 HP and 10 HP capacities, four 7.5 HP roots blowers, a 110 KVA generator and a thermostat control (Fig.21).

D. Infrastructure:

The hatchery is provided with an office, laboratory, quarantine, packing shed and other amenities.

E. Special features:

a. The hatchery offers one month training course on shrimp hatchery and management.

b. It offers consultancy services to establish new hatcheries.

c. The hatchery design in the larval rearing section is constructed in order to prevent cross contamination or microbial disease outbreak.
F. Demerits:
   a. Maintenance difficulties are observed in the larval section due to compartmentalisation.
   b. High manpower turnover is observed due to poor remuneration.

G. Commercial feasibility study:
   The OSSPARC hatchery showed promising results since 1989. It raised its production capacity from 25 to 65 million PL20 seed between 1988 and 1995. It is likely to increase its capacity to 80 million capacity. Remarkable results were noted during 1989-1993. An estimated financial projection evaluated in 1995 revealed a sales profit of Rs.101.26 lakhs after repayment of interest, when an average selling price of Re.0.35/seed was taken into consideration. Seed was sold at an escalated price between Re.0.40 and 0.60/seed during 1993-94. However, during the year end of 1994, diseases were observed to spread all over the coastal areas affecting many shrimp farms due to which a ‘crop holiday’ was declared. This resulted in reducing the production level of seed in the hatchery due to low demand. The cost of seed gradually declined from Re.0.35 to 0.30 during 1995.
## ESTIMATED FINANCIAL PROJECTION

A. **Capital Expenditure:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (Rs. in lakhs)</th>
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<tbody>
<tr>
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B. **Recurring Expenditure:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (Rs. in lakhs/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Broodstock</td>
<td>25.27</td>
</tr>
<tr>
<td>2. Artemia cyst</td>
<td>10.80</td>
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<tr>
<td>3. Larval/post-larval feed</td>
<td>5.15</td>
</tr>
<tr>
<td>4. Broodstock diet</td>
<td>0.27</td>
</tr>
<tr>
<td>5. Chemicals</td>
<td>5.00</td>
</tr>
<tr>
<td>6. Power</td>
<td>8.00</td>
</tr>
<tr>
<td>7. Fuel</td>
<td>8.00</td>
</tr>
<tr>
<td>8. Administrative expenses</td>
<td>10.00</td>
</tr>
<tr>
<td>9. Salaries and wages</td>
<td>8.49</td>
</tr>
<tr>
<td>10. Repairs and maintenance</td>
<td>1.28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>82.26</strong></td>
</tr>
</tbody>
</table>

C. **Interest:**

@ 15% per annum A + B (Capital + Recurring expenditure Rs.293.26) = Rs.43.98

D. **Revenue:**

@ Re. 0.35/seed for 65 million seed/annum = Rs.227.50

E. **Cost Benefit Analysis:**

Revenue - (Recurring expenditure + Interest/yr on loan component of Rs. 293.26) = Rs.101.26

F. **Comparative Analysis on Production Cost and Marketing:**

@ Rs. 82.26 lakhs/65 million seed
Production cost/1000 seed (Rs.) = Rs.126.55
@ Rs. 0.35/seed Revenue for 1000 seed (Rs.) = Rs.350.00
5.13.2. The Andhra Pradesh Shrimp Seed Production, Supply and Research Centre (TASPARC), Andhra Pradesh

A. Hatchery set-up:

a. Technology: Hawaii
b. Year of establishment: 1988
c. Capacity: 80 million/annum
d. Promoter/Sector: MPEDA/Government
e. Location of site: Bhemunipattinam, Vizag
f. Species reared: *P. monodon*

B. Design and operation:

a. Seawater intake system:

It consists of dual pipelines laid at a distance of 300m from the hatchery to the sea at the low tide level. Seawater is pumped from offshore through rapid sand filters and sent to the hatchery.

1. Filters:

The hatchery adopts dual filtration process. Seawater is filtered through a set of rapid sand filters, each of 138 gpm capacity and sent to the reservoir. The seawater is disinfected by chemical treatment in the reservoir and sent to the overhead tank through a set of rapid sand filters.

11. Reservoir/storage tanks:

Two concrete tanks, each of 400 MT capacity are used to store water. Two re-circulation pumps, each of 5 HP capacity are used to facilitate re-circulation of seawater during chemical treatment process.
The process involved in the seawater intake system is represented below:

Seawater → Pump → Reservoir I → Rapid Sand Filters → (R.S.F.)
Reservoir I → Reservoir II → OHT → Hatchery.

b. Hatchery complex (Fig.22):

i. Broodstock ponds:

Broodstock ponds have been proposed to be established in the near future. Since inception, the hatchery is dependent on the wild spawners.

ii. Maturation section:

Ten oval concrete tanks, each of 15 sq.m. floor area are provided (Fig.23). Stocking density, water exchange, aeration and operation techniques are similar to that of M/s OSSPARC hatchery.

iii. Spawning section:

Twenty flat bottom FRP tanks, each of 500 l capacity are used for spawning.

iv. Hatching section:

Fifty FRP buckets, each of 50 l capacity are used for hatching. Eggs from the spawning tanks are introduced into the buckets and provided with vigorous aeration. The hatched out nauplii are attracted by light and stocked in the larval tanks.
v. Larval section:
Ten parabolic shaped concrete tanks, each of 10 ton capacity are used to rear larvae. Stocking density and water exchange are carried out similar to that of M/s OSSPARC hatchery. Air is diffused through lead-keel tubes.

vi. Post-larval section:
Ten parabolic concrete twin tanks, each of 10 ton capacity are used to rear post-larvae. PL5 stages are distributed at the rate of 25 Nos./l and reared upto PL20. Water exchange of 100% in 4 hours/day is carried out. Aeration is effected by lead keel tubes.

vii. Feed section:
The mass culture in the indoor algae section comprises of 64 cylindrical FRP translucent tanks, each of 200 l capacity (Fig.24). Culture operation is similar to that of M/s OSSPARC hatchery. The outdoor culture comprises of 20 flat bottom FRP tanks, each of 1 ton capacity. The larvae are fed with 70,000-100,000 algal cells/ml.

*Artemia* cysts are hatched in 18 cylindroconical FRP tanks, each of 400 l capacity. The nauplii are fed from mysis to PL15 stages.

viii. Drainage system:
Each section is provided with a central drainage system to collect wastewater.
C. Logistic support:

The logistic support comprises of four 10 HP pumps, four 7.5 HP blowers and two 62.5 KVA generators.

D. Infrastructure:

The hatchery has infrastructure similar to that of M/s OSSPARC hatchery.

E. Special features:

a. The seawater routed in all the sections of the hatchery are provided with parallel lines. These lines are used alternatively to provide sterile water and prevent outbreak of diseases.

b. The hatchery offers training course and consultancy services similar to that of M/s OSSPARC hatchery.

F. Demerits:

a. The hatchery is of High-tech system and hence highly skilled technicians and heavy recurring expenditure are required for successful operation. Thus, the technology has been found inviable to small scale investors.

b. The continuous utility of prophylactic drugs in the hatchery has been observed to reduce the survival rate of shrimp seed in the culture ponds.
Commercial feasibility study:

The total project cost was estimated to be Rs.3.69 crores for 80 million capacity. The TASPARC hatchery raised its capacity from 40 to 80 million seed production capacity during 1987-'92. An estimated financial projection evaluated in 1995 revealed a sales profit of Rs.107.87 lakhs, when an average selling price of Re.0.35/seed was considered. Seed were sold at an escalated price between Re.0.40 and 0.50/seed during 1993-94. During peak demand, seed are reported to have been sold at the rate of Re.0.70-Rs.1.50, illegally. However, during 1994-'95, production level reduced drastically due to diseases outbreak and anti-aquaculture agitation.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure:  
   (Rs. in lakhs)

   1. Civil                      254.66
   2. Plant and Machinery       100.00
   3. Miscellaneous             15.00

   Total                      369.66

B. Recurring Expenditure:  
   (Rs. in lakhs/year)

   1. Broodstock                31.17
   2. Artemia cyst              9.00
   3. Larval/post-larval feed   7.00
   4. Broodstock diet           0.32
   5. Chemicals                 7.50
   6. Power                     13.40
   7. Fuel                      6.50
   8. Administrative Expenses   15.00
   9. Salaries and wages        10.44
   10. Repairs and maintenance  1.14

   Total                      101.47

C. Interest:
   @ 15% per annum A + B (Rs. 471.13)  70.66

D. Revenue:
   @ Re. 0.35/seed (Avg.) for 80 million seed/annum  280.00

E. Cost Benefit Analysis:
   Revenue - (B + C)              107.87

F. Comparative Analysis on Production Cost and Marketing:
   @ Rs. 101.47 lakhs/80 million seed
   Production cost/1000 seed (Rs.)  126.83
   @ Rs. 0.35/seed Revenue for 1000 seed (Rs.)  350.00
5.13.3. **SSV Aqua and Sree Durga Aqua Hatcheries, Andhra Pradesh**

A. **Hatchery set-up** :

   a. Technology : Hawaii  
   b. Year of establishment : 1994  
   c. Capacity : 62.5 million/annum  
   d. Promoter / Sector : Private  
   e. Location of site : Bhemunipattinam, Vizag  
   f. Species reared : **P. monodon**

B. **Design and operation** :

a. **Seawater intake system** :

   The intake system comprises of pipelines supported by piles from the hatchery to sea at a distance of 250m. Seawater is pumped from offshore to the hatchery sections.

i. **Filters** :

   A slow sand filter made of brick wall masonry with a filtration capacity of 500 cu.m./day is used. Filtration is also carried out by using six rapid sand filters, each of 138 gpm capacity.

   The process involved in the seawater intake system is schematically represented below:

   Seawater --> Pump house --> Slow sand filter --> Sump -->  
   Pump house II and rapid sand filters --> Reservoir I --> chlorination  
   Pump house III --> Reservoir II --> Pump house IV --> Hatchery. dechlorination
b. Hatchery complex (Fig.25):

i. Broodstock pond:

A proposal has been made to establish broodstock ponds to rear breeders in captivity.

ii. Maturation section:

Six semi-circular concrete tanks, each of 15 ton capacity are used to rear breeders. Stocking density, water exchange, operation techniques and the various concept in rearing the breeders are carried out similar to M/s TASPARC hatchery.

iii. Spawning section:

Eighteen cylindroconical FRP tanks, each of 200 l capacity are used for individual spawning.

iv. Hatching section:

Thirty plastic buckets, each of 50 l capacity are used to hatch the shrimp eggs. Vigorous aeration and lighting is provided to facilitate hatching.

v. Larval section:

Eight parabolic concrete tanks, each of 16 ton capacity are used to rear larvae. Stocking density, water exchange and aeration are carried out as in M/s TASPARC hatchery.
vi. Post-larval section:
Sixteen parabolic concrete twin tanks, each of 16 ton capacity are used to rear post-larvae. The various parameters and operation techniques are followed as in M/s TASPARC hatchery.

vii. Feed section:
Mass production of algae is carried out in sixty four FRP cylinders, each of 250 l capacity. In the outdoor algal culture, ten rectangular FRP tanks of one ton capacity are used.

*Artemia* cysts are hatched in twenty cylindroconical FRP tanks, each of 400 l capacity.

viii. Drainage system:
A central drain in all the sections is designed as in M/s TASPARC hatchery and the wastewater is sent to the exterior.

C. Logistic support:
Four 10 HP pumps, two 7.5 HP blowers and a generator of 62.5 KVA are used to supply water, air and power respectively.

D. Infrastructure:
The hatchery has no separate buildings for office/quarters other than the main hatchery building.
E. Special features:
   a. The number of tanks in maturation, larval and post-larval sections are reduced, as compared to the number of tanks utilised in a 60 million Hawaii technology based hatchery (M/s NCC BPL, Vizag, Andhra Pradesh), since no buffer in the design has been provided. The tanks are flushed to the wall of the main hatchery building to reduce the total area and capital investment.
   b. The site is accessible to M/s TASPARC hatchery and hence necessary assistance can be availed of.

F. Demerits:
   a. The hatchery design strictly adheres to 'Vaasthu Shastra' and therefore, difficulties in technical operation has been observed.
   b. Many hatcheries are mushrooming in this locality and hence technical and marketing problems may be anticipated in the future.

G. Commercial feasibility study:
   The commercial operation was initiated from the year 1995 and 5 cycles were operated. An estimated financial projection revealed a profit of Rs.101.02 lakhs after repayment of interest. Calculations were based on the average selling price of Re.0.35/seed. Seed was sold at the rate of Re.0.40-0.80/seed during early 1994. However, due to various constraints, viz., disease outbreak, anti-aquaculture agitation and low production of seed were observed by the end of 1995 and this trend has been found to continue till date.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
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<tbody>
<tr>
<td>Civil</td>
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<td>Miscellaneous</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>183.61</strong></td>
</tr>
</tbody>
</table>

B. Recurring Expenditure: (Rs. in lakhs/year)

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Broodstock</td>
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<td>Artemia</td>
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<tr>
<td>Larval/Post-larval feed</td>
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<td>0.25</td>
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<tr>
<td>Chemicals</td>
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<tr>
<td>Power</td>
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<td>Fuel</td>
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<tr>
<td><strong>Total</strong></td>
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</table>

C. Interest:

a. @ 15% per annum A + B (Rs. 262.04) 39.30

D. Revenue:

a. @ Re.0.35/seed (Avg.) for 62.5 million seed/annum 218.75

E. Cost Benefit Analysis:

Revenue - (B + C) 101.02

F. Comparative Analysis on production cost and marketing:

@ Rs.78.43 lakhs/62.5 million seed 125.48

Production cost/1000 seed (Rs.)

@ Re.0.35/seed Revenue for 1000 seed (Rs.) 350.00
5.13.4. Veerat Aqua Tech Ltd., Andhra Pradesh

A. Hatchery set-up:

a. Technology : Hawaii
b. Year of establishment : 1994
c. Capacity : 60 million/annum
d. Promoter / Sector : Private / Public
e. Location of site : Amalapuram, West Godavari
f. Species reared : P. monodon

B. Design and operation:

a. Seawater intake system:
It consists of pipelines laid at a distance of 250m from the hatchery to
the sea. The pipelines are supported by concrete anchor blocks at ground
level.

i. Filters:
A concrete slow sand filter of 500 ton filtration capacity/day, six rapid
sand filters of 140 gpm and a UV filter of 5000 l/hour capacity are used.

ii. Reservoirs/storage tanks:
Two circular concrete reservoirs, each of 500 ton capacity are used to
store seawater.
The process involved in the seawater intake system is similar to that of
M/s SSV and Durga Aqua hatcheries.

b. Hatchery complex (Figs.26 & 27):

i. Broodstock pond:
A proposal has been made to establish broodstock pond in the future.
ii. Maturation section:
Six rectangular (curvature at the ends) concrete tanks, each of 15 ton capacity are used to rear breeders (Fig.28).

iii. Spawning section:
Twenty cylindroconical FRP tanks, each of 250 l capacity are used for spawning.

iv. Hatching section:
Thirty hatching buckets, each of 50 l capacity are used for hatching. The eggs are hatched as practiced in M/s TASPARC hatchery.

v. Larval section:
Eight parabolic concrete tanks, each of 15 ton capacity are used to rear larvae. The larval tanks are not flushed to the wall of the hatchery building.

vi. Post-larval section:
Sixteen parabolic concrete twin tanks, each of 16 ton capacity are used to rear post-larvae (Fig.29).

vii. Feed section:
Fifty six FRP cylinders are used for mass culture of algae in indoor algal room. Likewise, ten flat bottom FRP tanks, each of one ton capacity are utilised for outdoor culture.
**Artemia** cysts are hatched in sixteen numbers of cylindroconical FRP tanks, each of 400 l capacity.

The operation techniques in the various sections are carried out similar to that of M/s SSV and Durga Aqua hatcheries, Andhra Pradesh.

viii. Drainage system:

It comprises of 700 x 700m (width x height) sized drain which is centralised so that water from each tank is led into the system to the exterior of the hatchery building.

C. Logistic support:

The pumps, blowers and generators in terms of numbers and capacities used in this hatchery are the same as of M/s SSV and Durga Aqua hatcheries.

D. Infrastructure:

The hatchery has an administrative building, laboratory, manager's quarters, a canteen and a security shed.

E. Special features:

a. Consistent production has been observed due to the abundant availability of broodstock near the site.

b. The civil designs are made based on the features observed in M/s SSV Aqua, Durga Aqua and M/s NCC BPL hatcheries to facilitate efficient operation and achieve maximum production.
F. Demerits:
   a. A few hatcheries are mushrooming in the surrounding localities and hence pollution and outbreak of diseases may be anticipated in future.

G. Commercial feasibility study:
   The cost benefit analysis of this hatchery revealed a profit of Rs.93.51 lakhs, when an average rate of Re. 0.35/seed was taken into consideration in 1995. The hatchery achieved remarkable results in early 1994 by selling at the rate of Re. 0.60-0.70/seed. However, the demand for seed has been found to decline due to various constraints by mid 1994 and continued till date.
## ESTIMATED FINANCIAL PROJECTION

### A. Capital Expenditure:

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<tr>
<td><strong>Total</strong></td>
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### B. Recurring Expenditure:

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<tbody>
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<td>Broodstock</td>
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<td>Broodstock feed</td>
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<td>Fuel</td>
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<td>Administrative Expenses</td>
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<td>Repairs and maintenance:</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>82.29</strong></td>
</tr>
</tbody>
</table>

### C. Interest:

- a. @ 15% per annum A + B (Rs. 228.02 lakhs) 34.20

### D. Revenue:

- a. @ Re.0.35/seed (Avg.) for 60 million seed/annum 210.00

### E. Cost Benefit Analysis:

Revenue - (B + C) 93.51

### F. Comparative Analysis on production cost and marketing:

- @ Rs.82.29 lakhs/60 million seed
  Production cost/1000 seed (Rs.) 137.15

- @ Re.0.35/seedRevenue for 1000 seed (Rs.) 350.00
5.13.5. **NCC BPL Hatchery, Andhra Pradesh**

A. **Hatchery set-up**:

   a. Technology : Hawaii  
   b. Year of establishment : 1993  
   c. Capacity : 60 million/annum  
   d. Promoter /Sector : Construction group /Public  
   e. Location of site : Nakapalli, Vizag  
   f. Species reared : **P. monodon**

B. **Design and operation**:

   a. **Seawater intake system**:

      The Seawater intake system consists of two types. Pipelines are laid on 
      the platform of the jetty system to the hatchery site at a distance of 
      300m from the low tide level. The jetty system serves mainly to support 
      the open channel which is used to supply seawater to the farm (Figs.30 
      & 31). Another pipeline is laid from the hatchery to the sea at ground 
      level. The dual system is used to facilitate disinfection of one pipeline, 
      when the other is in operation.

   ii. **Filters**:

      Filtration is carried out in four stages as in Veerat Aqua-tech hatchery. 
      Slow sand filter made of brick wall masonry with filtration capacity of 
      1000 cu.m./day is provided. Six rapid sand filters of 138 gpm and UV 
      filters are used.

   iii. **Reservoir/storage tanks**:

      Two circular concrete reservoirs, each with a storing capacity of 
      1100 cu.m./day are utilised (Fig.32).
The process involved in the seawater intake system is similar to that of M/s SSV and Durga Aqua hatcheries.

b. Hatchery complex (Fig.33):

i. Broodstock pond:
The hatchery project has included two broodstock ponds, each of 100 sq.m. water spread area. They are yet to be commissioned.

ii. Maturation section:
Ten rectangular (semi-circular ends) concrete tanks, each of 12 ton capacity are used to rear breeders (Fig.34). Stocking density, water exchange and aeration are carried out as in M/s TASPAREN hatchery.

iii. Spawning section:
Twenty flat bottom FRP tanks, each of 500 l capacity are used for spawning. These tanks are kept on shelves as observed in M/s TASPAREN hatchery.

iv. Hatching section:
Ten FRP buckets, each of 50 l capacity are used for hatching the eggs.

v. Larval section:
It comprises of ten numbers of parabolic concrete tanks, each of 12 ton capacity to rear larvae (Fig.35). Stocking density of 100 Nauplii/l and water exchange of 100% in 4 hours is carried out. Aeration is facilitated by using lead keel tube placed at the bottom of the tank (Fig.36). The lead keel tube has a pore size of 0.01mm diameter through which air is
diffused in the culture tank. The roof of the larval tanks is provided with FRP translucent and asbestos sheet, fixed alternatively (Fig.37).

vi. Post-larval section:
Ten parabolic concrete twin tanks, each of 12 tons capacity are used (Fig.38). The various parameters required for rearing the post-larvae are carried out as similar to that of M/s TASPARC hatchery.

vii. Feed section:
Sixty four FRP translucent cylinders, each of 250 l capacity are used for indoor algal culture. The outdoor algal culture comprises of 10-500 l buckets (Fig.39). The stocking density, feeding procedure, harvesting techniques, water exchange, aeration and lighting were adopted from M/s TASPARC hatchery.

Eighteen cylindroconical FRP tanks, each of 500 l capacity are used to hatch Artemia cysts.

viii. Drainage system:
The central drain system as designed by Hawaii technology is adopted in this hatchery.

C. Logistic support:
It comprises of six 10 HP pumps, four 7.5 HP regenerative blowers and 62.5 KVA generator to supply seawater, aeration and power respectively.
D. **Infrastructure:**

The hatchery has all the necessary infrastructure similar to M/s TASPARC hatchery. In addition, it has staff quarters for all cadres.

E. **Special features:**

a. The entrepreneur is engaged in civil construction activities and hence the design aspects were carried out in perfection.

F. **Demerits:**

a. The dual system of pipelines in the hatchery design has been observed to increase the capital and recurring expenditure.

b. Manpower turnover is observed frequently due to managerial constraints.

G. **Commercial feasibility study:**

Six cycles were operated in the year 1994 as against eight cycles considered in the design factor. An average production of 7 million PL20 per cycle was recorded in 1994 as against 7.5 million PL20 per cycle. The financial analysis revealed a profit of Rs.85.82 lakhs after repayment of interest, when the average cost of Re.0.35/seed was taken into consideration. During peak demand period, seed was sold at the rate of Re.0.70-Rs.1.30/seed. However, by the end of 1994, production declined due to outbreak of diseases and temporary ban on aquaculture.
### ESTIMATED FINANCIAL PROJECTION

**A. Capital Expenditure:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount (Rs. in lakhs)</th>
</tr>
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<tbody>
<tr>
<td>Civil</td>
<td>162.82</td>
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<tr>
<td>Plant and Machinery</td>
<td>55.00</td>
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<tr>
<td>Miscellaneous</td>
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</tr>
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<td><strong>Total</strong></td>
<td><strong>229.82</strong></td>
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**B. Recurring Expenditure:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount (Rs. in lakhs/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broodstock</td>
<td>23.40</td>
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<tr>
<td><strong>Artemia</strong></td>
<td>8.10</td>
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<tr>
<td>Larval/post-larval feed</td>
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</tr>
<tr>
<td>Broodstock feed</td>
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<tr>
<td>Chemicals</td>
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<td>Power</td>
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<tr>
<td>Fuel</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>78.01</strong></td>
</tr>
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</table>

**C. Interest:**

@ 15% per annum A + B (Rs.307.83) 46.17

**D. Revenue:**

@ Re.0.35/seed (Avg.) for 60 million seed/annum 210.00

**E. Cost Benefit Analysis:**

Revenue - (B + C) 85.82

**F. Comparative analysis on production cost and marketing:**

@ Rs.78.01 lakhs/60 million seed production cost/1000 seed (Rs.) 130.01

@ Re. 0.35/seed Revenue from 1000 seed (Rs.) 350.00
5.13.6. **Kalyan Seafoods Pvt. Ltd., Andhra Pradesh**

A. **Hatchery set-up**:

a. Technology : Hawaii  
b. Year of establishment : 1992  
c. Capacity : 30 million/annum  
d. Promoter /Sector : Suryachakra group/Private  
e. Location of site : Bhairavalanka, Kakinada  
f. Species reared : **P. monodon**

B. **Design and operation**:

a. **Seawater intake system**:

Pipelines are laid across the sea at 200m distance from the hatchery below ground level and anchored by cement blocks.

i. **Filters**:

A concrete slow sand filter with baffle arrangement and layered with brick chips at its bottom is used to filter seawater at the rate of 300 cu.m./day. Two rapid sand filters, each of 140 gpm capacity and an UV steriliser of 10,000 cu.m./hour are also used.

ii. **Reservoir/storage tanks**:

Two rectangular concrete reservoirs, each of 120 ton capacity are used to store and disinfect seawater.

The process involved in seawater intake system is represented below:

Seawater --> Slow sand filter --> Rapid sand filter --> Reservoir--> UV --> Hatchery.
b. Hatchery complex (Fig. 40):

i. Broodstock pond:
No provision is allotted to construct broodstock pond in the hatchery.

ii. Maturation section:
The hatchery has two maturation sections in separate building. In each section, two circular concrete tanks, each of 15 ton capacity are used to rear the adults.

iii. Spawning section:
Six FRP tanks, each of 0.5 ton in one section and two numbers, each of 0.35 ton capacity in another section are used for spawning.

iv. Hatching section:
Hatching is carried out in the spawning tanks.

v. Larval section:
It comprises of four parabolic concrete twin tanks, each of 3 ton and five tanks, each of 5 ton capacities are used in the Phase I section. In the Phase II section, two tanks, each of 8.5 ton capacity and two tanks, each of 12.5 ton capacity are designed.

vi. Post-larval section:
It comprises of four parabolic concrete tanks, each of 10 ton capacity in Phase I section and four tanks, each of 12 ton capacity in the Phase II section. Air is diffused through air stones.
vii. Feed section:

A small isolation room is provided to cater to the requirements of both the larval sections. Four carbouys each of 20 l and four FRP tanks, each of 200 l capacities are used. The outdoor algal culture are carried out in 20 rectangular concrete tanks, each of 200 l capacity.

*Artemia* cysts are hatched in six cylindroconical FRP tanks, each of 600 l capacity.

The stocking density, water exchange and operation techniques are carried out based on Hawaii technology.

viii. Drainage system:

It adopts the central drain system as designed by Hawaii technology.

C. Logistic support:

It has six 10 HP pumps, two 7.5 HP blowers and a 62.5 KVA generator set to supply seawater, aeration and power respectively.

D. Infrastructure:

The site has no buildings other than the main hatchery complex.

E. Special features:

a. The site has accessibility to avail raw materials, men and machinery.

F. Demerits:

a. The various sections of the hatchery are not alligned sequentially, due to which difficulties in technical operation are being experienced.
b. The routine operations have been found to delay due to the non-availability of staff quarters in the hatchery complex.

G. Commercial feasibility study:

An estimated financial statement revealed a profit of Rs. 41.18 lakhs, when the cost of seed was considered at Re.0.35/seed. Though the cost for seed escalated during 1992-1994, only marginal profits were achieved due to various problems in this hatchery.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)
   1. Civil 51.93
   2. Plant and Machinery 30.00
   3. Miscellaneous 2.00
   Total 83.93

B. Recurring Expenditure: (Rs. in lakhs/year)
   1. Broodstock 11.70
   2. **Artemia** 2.66
   3. Larval/post-larval feed 8.00
   4. Broodstock feed 0.18
   5. Chemicals 1.90
   6. Power 0.00
   7. Fuel 3.00
   8. Administrative Expenses 6.30
   9. Salaries and wages 10.25
   10. Repairs and maintenance 0.56
   Total 44.55

C. Interest:
   @ 15% per annum A + B (Rs.128.48) 19.27

D. Revenue:
   @ Re.0.35/seed (Avg.) for 30 million seed/annum 105.00

E. Cost Benefit Analysis:
   Revenue - (B + C ) 41.18

F. Comparative analysis on production cost and marketing:
   @ Rs.44.55 lakhs/30 million seed
   production cost/1000 seed (Rs.) 148.50
   @ Re. 0.35/seed Revenue from 1000 seed (Rs.) 350.00
5.13.7. **Lahari Seafoods Ltd., Andhra Pradesh**

A. **Hatchery set-up:**

a. Technology : Japanese  
b. Year of establishment : 1994  
c. Capacity : 60 million/annum  
d. Promoters/ Sector : Suryachakra group/Private  
e. Location of site : Bhiravalanka, Kakinada  
f. Species reared : **P. monodon**

B. **Design and operation:**

a. **Seawater intake system:**

A pipeline that is used for Kalyan Seafoods is extended to cater to the requirements of this hatchery. Separate lines have also been used for individual hatchery.

i. **Filters:**

Water from the sea is drawn by using a concrete infiltration gallery suspended at the suction point. Filtered water is sent to the slow sand filter, which has a filtration capacity of 600 ton/day. The filtered seawater is sent to the reservoir through a sump. Four rapid sand filters, each of 140 gpm and an UV filter of 15000 l/hour capacities are used.

ii. **Reservoir/storage tanks:**

Water is pumped from the sump to a rectangular concrete reservoir, which has a storing capacity of 810 ton/day.

The process involved in the seawater intake system is schematically represented below:

Seawater --> Slow sand filter --> Sump --> Pump house --> Reservoir --> UV --> Hatchery.
b. Hatchery complex (Fig. 41):

i. Broodstock Pond:
The hatchery has no provision for broodstock ponds.

ii. Maturation section:
Ten circular concrete tanks, each of 20 ton capacity are provided in this section. The depth of the tank is 1.5m and hence 0.7m of the tank is constructed below floor level.

iii. Spawning section:
Spawning is carried out in twenty numbers of cylindroconical FRP tanks, each of 250 l capacity.

iv. Hatching section:
The spawning tanks are used for hatching.

v. Larval section:
The larval tanks consist of ten parabolic brick wall masonry tanks, each of 15 ton capacity. The larval tanks are provided with a depth of 1.6m, of which 0.4m depth is below floor level.

vi. Post-larval section:
The post-larval section consists of ten twin parabolic tanks, with five twin tanks in a row. Each tank is of 15 ton capacity. They are outdoor tanks.
vii. Feed section:
The algal section comprises of an indoor and an outdoor culture unit. The mass culture is carried out in sixty numbers of translucent FRP cylinders, each of 250 l capacity. The outdoor algal culture unit comprises of ten numbers of opaque FRP tanks, each of one ton capacity.

A separate section is provided for hatching Artemia cysts. Twenty four FRP tanks, each of 500 l capacity are used for this purpose. The stocking density, water exchange, aeration and operation techniques are carried out as in M/s TASPARC hatchery.

viii. Drainage system:
It follows the central drain system as in M/s TASPARC hatchery.

C. Logistic support:
The hatchery has four pumps each with 10 HP rating, four blowers, each of 7.5 HP and a generator of 62.5 KVA capacities.

D. Infrastructure:
The hatchery has no infrastructure other than the main hatchery building and logistic support rooms.

E. Special features:
a. The hatchery is interlinked with M/s Suryachakra Seafoods and hence purchase of raw material for production is carried out economically.
b. Kakinada port and Visakhapatnam port form the major landing centre for broodstock collection and therefore shortage or demand for broodstock is minimised.

F. Demerits:
   a. Frequent minor changes made in the designs without incorporating the corresponding changes in the related peripheral technological designs resulted in tremendous fall in the production rates and also loss of efficiency of technicians.

G. Commercial feasibility study:
   A financial estimation revealed a profit of Rs.58.58 lakhs, when the cost for seed was fixed at Re.0.35/seed. The cost of seed fluctuated between Re. 0.50 and 0.70/seed in the first quarter of 1994. The cost of seed drastically declined in the mid 1994 and continued till date due to various constraints observed in the aquaculture industry.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)
   1. Civil .................................................. 190.69
   2. Plant and Machinery ................................. 92.00
   3. Miscellaneous ......................................... 10.00
       ------
   Total .................................................. 292.69

B. Recurring Expenditure (Rs. in lakhs/year)
   1. Broodstock ........................................... 23.40
   2. Artemia ............................................... 6.32
   3. Larval/Post-larval feed ............................ 13.00
   4. Broodstock feed .................................... 2.50
   5. Chemicals ............................................. 7.42
   6. Power ................................................ 12.50
   7. Fuel .................................................. 8.00
   8. Administrative Expenses ............................ 12.00
   9. Salaries and wages .................................. 7.56
  10. Repairs and maintenance ........................... 0.80
       ------
   Total .................................................. 93.50

C. Interest :

   @ 15% per annum of A +B (Rs. 386.19 lakhs) ......... 57.92

D. Revenue :

   @ Re.0.35/seed for 60 million seed/annum ............ 210.00

E. Cost Benefit Analysis :

   Revenue - (B + C) ....................................... 58.58

F. Comparative analysis on production cost and marketing :

   @ Rs.93.50 lakhs/60 million seed production cost/1000 seed (Rs.) ..... 155.83

   @ Re.0.35/seed Revenue for 1000 seed (Rs.) ........... 350.00
5.13.8. **Nagarjuna Aqua Exports Ltd., Andhra pradesh**

A. Hatchery set-up:

a. Technology : Taiwan  
b. Year of establishment : 1992  
c. Capacity : 50 million/annum  
d. Promoters/ Sector : NFL group/Public  
e. Location of site : Tupillipalem, Nellore  
f. Species reared : *P. monodon*

B. Design and operation:

a. Seawater intake system:

It comprises of a pipeline laid from the site at a distance of 300m, each of which 60m extends from the high tide line to the sea.

i. Filters:

A slow sand filter made of brick wall masonry with a filtration capacity of 150 ton/ day is used. Two rapid sand filters, each of 138 gpm and an UV filter of 8000 l/hr. capacity are also provided.

ii. Reservoir/storage tanks:

Five rectangular concrete reservoirs, each of 50 ton capacity are constructed in serial arrangement (Figs.42a&b). The reservoir has baffle arrangement in order to flow water from one reservoir to another. Inlet pipelines are connected on top of the reservoir to fill all the tanks in the same period to cater to the demand of water requirement. The water from the reservoir is pumped to an overhead tank referred to as ‘Tower tank I’ (Fig.43) through slow sand filter (Fig.44).
The process involved in the seawater intake system is schematically represented below:

Seawater --> Pumps --> Reservoirs --> Tower tank I --> Slow sand filter --> Tower Tank II --> Rapid sand filter --> UV --> Hatchery.

b. Hatchery complex (Fig.45):

i. Broodstock pond:

A proposal has been made to allocate two broodstock ponds in their existing shrimp farm.

ii. Maturation section:

It comprises of four circular concrete tanks, each of 12 ton capacity (Fig.46). The tanks have a depth of 1.5m and hence for convenient operation, around 0.5m is constructed below floor level. The tanks have a slight cylindroconical shape at the bottom to facilitate draining of water from the centre to a drain pit (Fig.47). The breeders are stocked at the rate of 3-4 Nos./sq.m. Water exchange of 50% is carried out.

iii. Spawning section:

Two rectangular brick wall masonry tanks, each of 10 ton capacity are constructed to facilitate group spawning. Individual spawning is also carried out by using FRP tanks, each of 200 l capacity during peak demand period.

iv. Hatching section:

The eggs are hatched in the spawning tanks.
v. **Larval section:**

The larval section comprises of ten rectangular brick wall masonry tanks, each of 12 ton capacity. The roof in this section has light translucent sheets of FRP material to allow sunlight to pass through the tanks (Fig.48). The stocking density is maintained at the rate of 50-80 nauplii/l. Water exchange is carried out only when necessity arises and the percentage of exchange varies in different periods.

vi. **Post-larval section:**

Post-larvae are reared in the outdoor. Three rows of brick wall masonry tanks with 8 tanks in each row are designed (Fig.49). Each tank has a capacity of 10 tons. The stocking density is maintained at 8-12 PL/l. Water exchange is carried out as mentioned in the larval section.

vii. **Feed section:**

It comprises of an indoor and an outdoor culture sections. The mass culture is carried out in FRP translucent cylinders, each of 200 l capacity. The outdoor algal culture comprises of five rectangular brick wall masonry tanks, each of 10 ton capacity. They are serially arranged (Fig.50).

A separate room adjoining the algal section is provided to hatch *Artemia* cysts. Eighteen cylindroconical FRP tanks, each of 500 l capacity are used for this purpose (Fig.51). Air in all the sections are diffused through air stones. The operation techniques are carried out similar to that of Japanese technology.
viii. Drainage system:
A collective hexagonal and rectangular shaped drain pit is provided to ensure draining wastewater from maturation and larval/post-larval tanks respectively. The drain pit is connected by 0.8m dia hume pipe, which drains the wastewater to the exterior. In the Artemia section, a central drain is provided.

C. Logistic support:
Two pumps (25HP and 10HP) are used to supply seawater to the hatchery sections. Two regenerative blowers, each of 7.5 HP capacity are used for aeration purpose. A 62.5 KVA Diesel generator is provided to supply power.

D. Infrastructure:
The hatchery has a laboratory, an office and stores. It has no dormitory or quarters in the complex. Facilities for staff and labourers are provided near the village adjoining the hatchery site.

E. Special features:
a. The logistic support uses less number of pumps, since the same pumps are utilised for intake system and water supply to the hatchery by valve control.

F. Demerits:
a. The prophylactic drugs are not used. Hence, at times it may lead to outbreak of diseases and mass mortality.
b. The usage of valves to operate the same pumps at times lead to serious damages to the system, when operated by un-skilled labourers.

G. Commercial feasibility study:

The hatchery recorded fluctuating production due to environmental factors. An average of 5-6 cycles were operated per year. The financial estimate for one year revealed a profit of Rs.68.52 lakhs, when the seed price of Re.0.35/seed was taken into consideration. Seed was sold at the rate of Re. 0.50-0.80/seed during peak demand. However, the seed cost declined during 1994-'95 due to various constraints in the aquaculture industry.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)

1. Civil 85.32
2. Plant and Machinery 37.00
3. Miscellaneous 25.00

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Total 147.32
----------

B. Recurring Expenditure: (Rs. in lakhs/year)

1. Broodstock 19.44
2. **Artemia** 5.20
3. Larval/post-larval feed 8.00
4. Broodstock feed 0.50
5. Chemicals 4.00
6. Power 8.50
7. Fuel 5.20
8. Administrative Expenses 10.00
9. Salaries and wages 11.70
10. Repairs and maintenance 0.84

----------
Total 73.38
----------

C. Interest:

@ 15% per annum of A + B (Rs.220.70 lakhs) 33.10

D. Revenue:

@ Re.0.35/seed for 50 million seed/annum 175.00

E. Cost Benefit Analysis:

Revenue - (B + C) 68.52

F. Comparative analysis on production cost and marketing:

@ Rs.73.38 lakhs/50 million seed production cost/1000 seed (Rs.) 146.76

@ Re.0.35/seed Revenue for 1000 seed (Rs.) 350.00
5.13.9. **Aurolee Hatchery Pvt. Ltd., Tamilnadu**

A. **Hatchery set-up**:

a. Technology : Indian  
b. Year of establishment : 1993  
c. Capacity : 10 million/annum  
d. Promoters / sector : Private  
e. Location of site : Sulerkadu, Madras  
f. Species reared : *P. monodon*

B. **Design and operation**:

a. **Seawater intake system**:

A 6 inch borewell beyond the low tide of the beach is used to pump seawater to the hatchery.

i. **Filters**:

A slow sand filter made of brick wall masonry with a filtration capacity of 50 ton/day, two rapid sand filters, each of 138 gpm, two cartridge filters of 5 and 1 micron and an UV steriliser of 5 ton/hour capacities are used.

ii. **Reservoir/storage tanks**:

A rectangular brick wall masonry reservoir of 80 ton capacity is used to store and disinfect seawater.

The process involved in the seawater intake system is schematically represented below:

Seawater --> Rapid sand filter --> Activated carbon filter --> (dozer for chlorination) Cartridge filters --> Overhead tank --> UV --> Hatchery (1&5 micron).
b. Hatchery complex (Fig.52):

i. Broodstock pond:

The hatchery has no provision for broodstock ponds.

ii. Maturation section:

The design comprises of two circular and oval-shaped brick wall masonry tanks, each of 5 ton capacity.

iii. Spawning section:

Five flat bottom FRP tanks, each of 250 l capacity are used.

iv. Hatching section:

Fifty numbers of hatching buckets, each of 50 l capacity are used for hatching the eggs to nauplii.

v. Larval section:

Twelve parabolic brick wall masonry tanks, each of 5 ton capacity are used to rear larvae. Air is diffused through air stones.

vi. Post-larval section:

Twelve square shaped brick wall masonry tanks, each of 10 ton capacity are used. These tanks are kept in the open. A small storage tank is built above each post-larval tank in order to distribute water individually through single pipeline and reduce the cost.
vii. Feed section:

Mixed culture of algae is favoured in this hatchery. The indoor algal culture is carried out in ten FRP tanks, each of 250 l capacity.

*Artemia* nauplii are hatched in ten numbers of FRP tanks, each of 50 l capacity. A small shed outside the main hatchery building is provided to serve this purpose.

The stocking density, water exchange and operation techniques are carried out based on Hawaii technology.

viii. Drainage system:

It follows the central drain system of Hawaii technology.

C. Logistic support:

Two pumps, each of 5 HP, two roots blowers, each of 5 HP and a diesel generator, each of 12.5KVA capacities are used to supply seawater, aeration and power respectively.

D. Infrastructure:

The hatchery has no dormitory or canteen. Facilities for the staff and managerial personnel are provided outside the site.

E. Special features:

a. The hatchery is located near the city and thus facilitates easy purchase of raw materials, plant and machinery and other equipments.
b. The storage tanks in the PL section aid in continuous supply of seawater to the PL.

F. Demerits:
   a. Manpower turnover and lack of acquiring professional personnel was observed due to the low rated capacity of the hatchery.
   b. The storage tanks in PL section contaminated the post-larvae due to microbial growth in the bottom of the storage tanks.
   c. As the site is in rocky area, fouling organisms were found to develop vigorously thus, affecting the flow rate of seawater intake system by clogging the pipes.

G. Commercial feasibility study:
   The cost estimate on the total project on records was Rs.19.165 lakhs, with an operating cost of Rs.3.3 lakhs per cycle. However, on actuals the total project cost escalated to Rs.52.01 lakhs by the time the project was commissioned. A financial estimate worked out for one year revealed a profit of Rs.6.91 lakhs as against the seed cost of Re.0.35/seed. The seed cost escalated from Re.0.70 to Re.1.0 during 1993-'94. However, during 1994-'95, due to constant fluctuation in the market for seed and anti-aquaculture activities, production and cost of shrimp seed declined.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)
   1. Civil                         35.01
   2. Plant and Machinery         15.00
   3. Miscellaneous              2.00
       Total                  52.01

B. Recurring Expenditure: (Rs. in lakhs/year)
   1. Broodstock section          3.96
   2. Artemia                     2.16
   3. Larval/post-larval feed     1.50
   4. Broodstock feed             0.05
   5. Chemicals                   0.01
   6. Power                       1.53
   7. Fuel                        1.00
   8. Administrative Expenses     1.13
   9. Salaries and wages          5.98
  10. Repairs and maintenance    0.33
      Total                   17.65

C. Interest:
   @ 15% Per annum A + B (Rs.69.66 lakhs)   10.44

D. Revenue:
   @ Re. 0.35/seed for 10 million seed/annum   35.00

E. Cost Benefit Analysis:
   Revenue - (B + C)                       6.91

F. Comparative analysis on production cost and marketing:
   @ Rs. 17.65 lakhs/10 million seed
   Production cost/1000 seed (Rs.)        176.50
   @ Re. 0.35/seed Revenue from 1000 seed (Rs.)  350.00
5.13.10. **Pioneer Aqua Farms Pvt. Ltd., Tamilnadu**

A. **Hatchery set-up:**

a. Technology : Japanese  
b. Year of establishment : 1990  
c. Capacity : 20 million/annum  
d. Promoters / sector : Private  
e. Location of site : Tuticorin, Tamilnadu  
f. Species reared : *P. monodon*

B. **Design and operation:**

a. **Seawater intake system:**

The seawater intake system consists of a pipeline laid above the ground level and supported by casurina poles from the hatchery to the sea at a distance of 200m (Fig.53).

i. **Filter :**

Seawater is directly sent to a collection sump of 100 ton capacity with concrete bed.

ii. **Reservoir/storage tanks :**

Filtered seawater is directly pumped to the over head tank which is of 10 ton capacity. Water from the over head tank is sent to the hatchery components.

The process carried out in seawater intake system is represented below:

Seawater --> Pump house --> Slow sand filter --> Overhead tank --> Hatchery.
b. Hatchery complex (Fig.54):

i. Broodstock pond:
   The hatchery has no broodstock ponds.

ii. Maturation section:
   It comprises of two numbers of circular concrete tanks, each of 5 ton capacity.

iii. Spawning section:
   One concrete rectangular tank of 6 tons and five FRP tanks, each of 250 l capacity are used for spawning purposes.

iv. Hatching section:
   Five hatching bins, each of 200 l capacity are used for hatching. These tanks are placed in the maturation section.

v. Larval section:
   Eight numbers of cylindroconical FRP tanks, each of 3 ton capacity are used. The tanks have a slit in the centre on one side fixed with a glass plate to view the larvae and monitor these tanks to avoid frequent handling. A ladder is used to monitor the larval tank while feeding or cleaning.

vi. Post-larval section:
   Post-larvae are reared in three rectangular concrete twin tanks, each of 6 ton capacity.
vii. Feed section:

A small isolation room has been provided to culture algae. The mass culture is carried out in polyethylene bags, each of 5 litre capacity. Outdoor culture is carried out in ten FRP tanks, each of 500 l capacity.

A small room is used to hatch *Artemia* cysts. Six FRP tanks, each of 200 l capacity made up of FRP are used for this purpose. The stocking density, water exchange and aeration is carried out based on Hawaii technology. The operation procedure is carried out as in Japanese technology.

viii. Drainage system:

The central drain system is adopted in this hatchery as in Hawaii technology.

C. Logistic support:

The hatchery has a pump of 10 HP capacity. A blower of 7.5 HP is used to supply air to the hatchery components.

D. Infrastructure:

The hatchery has no provision for staff quarters, since the hatchery works on shift basis and the technical personnel are accommodated near the township.

E. Special features:

a. The hatchery is located near Tuticorin township and therefore transportation of men and materials are made easily available.
b. Tuticorin Fisheries College offers technically skilled personnel and hence no shortage of technicians.

F. Demerits:

a. Monitoring of larval tanks was difficult due to excess height of these tanks.

b. The surge in many hatchery establishment in this area have further reduced the sales value of seed to certain extent.

G. Commercial feasibility study:

Since, the inception of the hatchery, a consistent supply of PL20 seed was recorded with a few fluctuation during unfavourable season. An estimated financial statement revealed a profit of Rs.26.96 lakhs, when seed rate was considered at Re.0.35/seed. During 1992-94, the rate escalated to Re.0.50-Rs.1.20/seed. However, in 1994-'95, decline in production and cost of seed was observed due to anti-aquaculture activities.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)

1. Civil 21.68
2. Plant and Machinery 14.00
3. Miscellaneous 1.00

Total 36.68

B. Recurring Expenditure: (Rs. in lakhs/year)

1. Broodstock section 7.74
2. Artemia 2.16
3. Larval/post-larval feed 4.02
4. Broodstock feed 0.10
5. Chemicals 3.00
6. Power 3.20
7. Fuel 2.20
8. Administrative Expenses 5.00
9. Salaries and wages 5.00
10. Repairs and maintenance 0.23

Total 32.65

C. Interest:

@ 15% Per annum A + B (Rs.69.33 lakhs) 10.39

D. Revenue:

@ Re. 0.35/seed for 20 million seed/annum 70.00

E. Cost Benefit Analysis:

Revenue - (B + C) 26.96

F. Comparative analysis on production cost and marketing:

@ Rs. 32.65 lakhs/20 million seed
Production cost/1000 seed (Rs.) 163.25
@ Re. 0.35/seed Revenue from 1000 seed (Rs.) 350.00
5.13.11. Giridhar Foods Ltd., Tamilnadu

A. Hatchery set-up:
   a. Technology : Philippines
   b. Year of establishment : 1993
   c. Capacity : 70 million
   d. Promoter/sector : Private/Public
   e. Location of site : Sayalkudi, Ramnad
   f. Species reared : P. monodon

B. Design and operation:
   a. Seawater intake system:

   Seawater is pumped through pipelines from sub-sand level offshore using two numbers, each of 10 HP pumps (Fig.55).

   i. Filters:

   An infiltration gallery made of HDPE pipes are anchored to the sub-sand bed. Seawater is filtered through these pipes and sent to the hatchery. Four rapid sand filters (Fig.56) and an UV filter (Fig.57), each of 140gpm and 10,000 l/hr. filtration capacities are used respectively.

   ii. Reservoir/storage tanks:

   A rectangular concrete reservoir of 600 ton capacity is used to store and disinfect seawater. An over head tank of 20 ton capacity is used to supply freshwater.

   The process involved in the seawater intake system is schematically represented below:

   Seawater --> Infiltration gallery --> Reservoir --> Transfer pumps --> UV --> Hatchery.
b. Hatchery complex (Fig.58):

i. Broodstock pond:

A proposal has been made to include broodstock ponds in the near future.

ii. Maturation section:

It comprises of four numbers of oval concrete tanks/module, each of 14 tons capacity. The breeders are stocked at the rate of 2-3 nos./l. Water exchange of 100% is carried out every day. Air is diffused through air stones.

iii. Spawning section:

Ten FRP tanks, each of 500 l capacity per module are used for individual spawning. Group spawning is carried out in two rectangular concrete tanks/module, each of 5 ton capacity.

iv. Hatching section:

Hatching is carried out in spawning tanks.

v. Larval section:

Sixty rectangular concrete tanks, each of 10 ton capacity are used to rear larvae in both the modules (Fig.59). The larvae are stocked at the rate of 50-70 nauplii/litre. Water exchange of 30-50% is carried out/day.

vi. Post-larval section:

The larval tanks are used to rear post-larvae. The larvae at PL3 stages are distributed at the rate of 8-12 PL/l in these tanks.
vii. Feed section:

It comprises of an indoor culture room for each module. In this room only stock culture is prepared. The mass culture of algae is carried out in six concrete tanks/module in the open, each of 5 ton capacity.

The *Artemia* cysts are hatched in twenty five cylindroconical FRP tanks.

The operation techniques are adopted similar to that of Taiwan technology except in the treatment of seawater in this hatchery.

viii. Drainage system:

It adopts the collective drainage system with drain pit as observed in M/s NAEL hatchery.

C. Logistic support:

It has two pumps, each of 10 HP capacity to draw seawater from the intake point and four transfer pumps, (7.5 HP of two nos. and 5 HP of 2 nos. capacities) to pump seawater to the various sections of the hatchery (Fig.60). Four 5 HP and two numbers of 2 HP rated roots blowers are utilised to supply aeration (Fig.61). A generator of 125 KVA is used to supply power (Fig.62).

D. Infrastructure:

The hatchery has a quarantine room (Fig.63), an office, store room, staff quarters, dormitory, security shed, packing section (Fig.64), canteen and basic amenities to cater the welfare of the staff.
E. Special features:
   a. The design criteria in two modules have been found to favour staggered operation to consistently and continuously enhance production.
   b. The hatchery is located in the outskirts of Ramnad and hence, the requirements of raw materials can be purchased economically.

F. Demerits:
   a. The designs provided more than 50% buffer and hence the capital investment has been found to be very high than other hatcheries in India.
   b. The design provides more space between tanks which inturn reduces the efficiency of technicians at work.
   c. Manpower turnover was noted in this hatchery due to lack of facilities for their stay during culture operation.

G. Commercial feasibility study:
   A financial estimate for one year revealed a profit of Rs.92.19 lakhs, when the cost of seed was considered at Re. 0.35/seed.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)
   1. Civil 
   2. Plant and Machinery
   3. Miscellaneous
     Total

   130.10
   60.00
   19.00
     ------
     209.10
     ------

B. Recurring Expenditure: (Rs. in lakhs/year)
   1. Broodstock section
   2. Artemia
   3. Larval/post-larval feed
   4. Broodstock feed
   5. Chemicals
   6. Power
   7. Fuel
   8. Administrative Expenses
   9. Salaries and wages
   10. Repairs and maintenance
     Total

   27.25
   8.40
   11.50
   2.20
   9.00
   13.00
   9.50
   13.00
   10.26
   1.50
     ------
     105.61
     ------

C. Interest:
   @ 15% per annum A + B (Rs.314.71)

   47.20

D. Revenue:
   @ Re.0.35/seed for 70 million seed/annum

   245.00

E. Cost Benefit Analysis
   Revenue - (B + C)

   92.19

F. Comparative analysis on production cost and marketing:
   @ Rs.105.61lakhs/70 million seed
   Production cost/1000 seed (Rs.)
   150.87
   @ Re.0.35/seed Revenue for 1000 seed (Rs.)
   350.00
5.13.12. ITC Minota Aqua-Tech Ltd., Tamilnadu

A. Hatchery set-up:

a. Technology: Japanese
b. Year of establishment: 1992
c. Capacity: 30 million/annum
d. Promoter/sector: ITC group/Public
e. Location of site: Tuticorin, Tamilnadu
f. Species reared: *P. monodon*

B. Design and operation:

a. Seawater intake system:

Seawater is pumped through pipelines laid from the hatchery to the low tide sub-sand bed level. The suction point is provided with a valve and a filter.

i. Filters:

Seawater is filtered through three rectangular concrete slow sand filter arranged in series, each with a filtration capacity of 50 ton/day. Four rapid sand filters, each of 140 gpm are used to filter seawater. An UV filter of 10,000 l/hr., is used to supply filtered seawater to the algal section.

ii. Reservoir/storage tanks:

Three rectangular concrete reservoirs, each of 100 ton capacity and two overhead tanks, each of 10 ton capacity are used.

The process involved in the seawater intake system is represented below:

Seawater --> Pump house --> Slow sand filter --> Reservoirs --> Rapid sand filters --> Overhead tanks --> Hatchery.
b. Hatchery complex (Fig.65):

i. Broodstock pond:

The hatchery has no provision for broodstock ponds.

ii. Maturation section:

The maturation section comprises of ten numbers of circular concrete tanks, each of 40 ton capacity. The stocking density is maintained at the rate of 4-5 Nos./sq.m. Water exchange is carried out gradually from 50-100%. Air is diffused through air stones.

iii. Spawning section:

Spawning is carried out in ten FRP tanks, each of 200 l capacity.

iv. Hatching section:

Hatching is carried out in spawning tanks.

v. Larval section:

The larvae are cultured in the tanks used for maturation process. A stocking density of 60 nauplii/l is maintained in these tanks. Water exchange and aeration is carried out as similar to that of M/s Lahari seafoods, Andhra Pradesh.

vi. Post-larval section:

The larvae at PL3 stages are distributed in the same tanks at the rate of 20 PL/l. Water exchange and aeration is carried out as mentioned in the larval section.
vii. Feed section:

An indoor algal room is provided to develop *Chaetoceros* sp. Mass culture is carried out in five FRP tanks, each of 250 l capacity. The outdoor algal section comprises of four rectangular concrete tanks, each of 20 ton capacity.

viii. Drainage system:

The collective drain system is as in M/s Giridhar Foods, Tamilnadu.

C. Logistic support:

It has 25 HP pumps for pumping seawater to the hatchery. Two pumps, each of 10 HP capacity are used to pump water from the reservoir to the overhead tank. Two blowers, each of 7.5 HP capacity and a generator of 12.5 KVA are used for aeration and power supply respectively.

D. Infrastructure:

The hatchery has similar infrastructure similar to M/s NCC BPL hatchery, Andhra Pradesh.

E. Special features:

a. The hatchery is run by leading corporate sector and hence, financial constraints are not apparently noted.

b. The hatchery roof truss has an air regulatory system to control inlet and outlet air which is a unique feature in this hatchery.

c. The promoters have established training school for shrimp farmers to offer training to use their seeds to achieve maximum production.
F. Demerits:

a. The larval tank with circular shape has problems in operation to reach the centre of the tank for straining water or monitoring since, the diameter of the tank is very large.

b. The outdoor algal tanks are constructed at a distance away from the larval section. Therefore, transportation of algae to the larval section has been observed to be a laborious process.

G. Commercial feasibility study:

An estimated financial projection for one year revealed a profit of Rs. 22.51 lakhs at the rate of Re.0.35/seed. During 1992-94, seed was sold at the rate of Re.0.50-Rs.1.5/seed. However, production constraints similar to that of M/s Giridhar Foods, Tamilnadu were experienced during 1994-'95.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)
   1. Civil  
   2. Plant and Machinery  
   3. Miscellaneous  
       Total  

B. Recurring Expenditure: (Rs in lakhs/year)
   1. Broodstock section  
   2. *Artemia*  
   3. Larval/post-larval feed  
   4. Broodstock feed  
   5. Chemicals  
   6. Power  
   7. Fuel  
   8. Administrative Expenses  
   9. Salaries and wages  
   10. Repairs and maintenance  
       Total  

C. Interest:
   @ 15% per annum A + B (Rs.148.65)  

D. Revenue:
   @ Re.0.35/seed for 30 million seed/annum  

E. Cost Benefit Analysis
   Revenue - (B + C)  

F. Comparative analysis on production cost and marketing:
   @ Rs.60.20 lakhs/30 million seed  
   Production cost/1000 seed (Rs.)  
   @ Re.0.35/seed Revenue for 1000 seed (Rs.)  


5.13.13. **Travancore Hatchery Pvt. Ltd., Kerala**

**A. Hatchery set-up:**

a. **Technology** : Taiwan  
b. **Year of establishment** : 1992  
c. **Capacity** : 30 million/annum  
d. **Promoter/sector** : Private  
e. **Location of site** : Kodungallor, Trichur  
f. **Species reared** : *P. monodon*

**B. Design and operation:**

a. **Seawater intake system:**

It comprises of a simplified system with pipeline laid on the ground. Water is collected in a rectangular concrete collection sump from where water is pumped to the hatchery after settlement of particulate materials.

i. **Filters:**

Seawater is filtered by using an UV filter of 10,000 l/min., capacity.

ii. **Reservoir/storage tanks:**

A HDPE tank of 20 ton capacity is used for storing seawater. The process of seawater intake system is represented below:

Seawater--> Pump house--> Sump--> Overhead tank -->UV--> Hatchery.

b. **Hatchery complex (Fig.66):**

i. **Broodstock pond:**

There is no provision for broodstock ponds.
ii. Maturation section:
The maturation section comprises of four circular brick wall masonry tanks, each of 8 ton capacity. Water exchange at the rate of 60-80% is carried out in this section. Air is diffused through air stones.

iii. Spawning section:
Spawning tanks are placed in the maturation section. Six cylindroconical FRP tanks, each of 200 l capacity are used for this purpose.

iv. Hatching section:
Hatching is carried out in the spawning tanks.

v. Larval section:
Ten square shaped brick wall masonry tanks, each of 6 ton capacity are used. These tanks are constructed in an elevated location to facilitate transfer of larvae to post larval tanks. It adopts the typical ‘ladder’ system of Taiwan technology. Water exchange of 30-40% is carried out. Air is diffused through air stones.

vi. Post-larval section:
Twenty rectangular tanks made of brick wall masonry, each of 6 ton capacity are used for post-larval rearing. These tanks are constructed below the larval tanks to facilitate transfer of larvae. A stocking density of 8-12PL/litre is maintained. Water exchange of 100% is carried out. Aeration is carried out similar to that of larval section.
vii. Feed section:

Mass culture is carried out in fifteen FRP cylinders, each of 200 l capacity in the indoor culture room.

Provision for Artemia cyst hatching is designed in the hatchery within the corridor of the larval section. They are hatched in cylinbroconical tanks of 100 litre capacity.

The operation techniques are similar to that of M/s NAEL hatchery, Nellore, Andhra Pradesh. In this hatchery, shrimp culture is operated only during summer season. During the onset of monsoon, the hatchery involves in freshwater prawn culture.

viii. Drainage system:

It adopts collective drain and central drainage system as in maturation and larval/post-larval sections respectively.

C. Logistic support:

It has two 5 HP blowers, two 10 HP pumps and a generator of 50 HP capacities.

D. Infrastructure:

The hatchery has a laboratory, an office room and a store. It has no quarters for technicians, since it is operated by the inmates of the promoters.
E. Special features:
   a. The hatchery is operational for 4-5 cycles in a year for shrimps. During monsoon, the hatchery uses freshwater prawns in order to operate for 10 months in a year.
   b. The designs for larval transfer to post-larval section through hose using natural elevation and slope of the land have been found to economise the cost, time, space and efficiency of technicians.

F. Demerits:
   a. Hatchery with two different culture operations at times, overlap with each other and thereby affects the economy of the hatchery during peak demand period.
   b. During transfer of larvae to the post-larval tanks, there are possibilities of contamination through hose when they are not properly disinfected.

G. Commercial feasibility study:
   An estimate for one year revealed a profit of Rs.48.68 lakhs after repayment of interest, when the rate of shrimp seed was considered at Re.0.35/seed. During 1992-94, seed was sold at the rate of Re.0.50-Rs.1.70/seed during peak demand period. The cost of seed declined during 1994-'95 due to various constraints in the aquaculture industry. However, the hatchery made consistent profits with freshwater prawn seed production during monsoon season.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)

1. Civil 29.11
2. Plant and Machinery 10.00
3. Miscellaneous 1.00

Total 40.11

B. Recurring Expenditure: (Rs. in lakhs/year)

1. Broodstock section 11.70
2. Artemia 1.50
3. Larval/post-larval feed 8.50
4. Broodstock feed 0.15
5. Chemicals 3.50
6. Power 4.50
7. Fuel 2.72
8. Administrative Expenses 5.50
9. Salaries and wages 5.44
10. Repairs and maintenance 0.24

Total 43.75

C. Interest:

@ 15% per annum A + B (Rs.83.86 lakhs) 12.57

D. Revenue:

@ Re.0.35/seed for 30 million seed/annum 105.00

E. Cost Benefit Analysis:

Revenue - (B + C) 48.68

F. Comparative analysis on production and marketing:

@ Rs. 43.75 lakhs/30 million seed
Production cost/1000 seed (Rs.) 145.83
@ Re.0.35/seed Revenue/1000 seed (Rs.) 350.00

A. Hatchery set-up:

a. Technology : Indian  
b. Year of establishment : 1992  
c. Capacity : 10 million/annum  
d. Promoter/sector : Private  
e. Location of site : Eriyad, Trichur  
f. Species reared : *P. monodon*

B. Design and operation:

a. Seawater intake system:

It comprises of an open channel dug from the sea at a distance of 150m through a sump to the site.

i. Filters:

It has an UV filter of 5000 l/hr. filtration capacity and is used to filter seawater that is sent from the overhead tank to the hatchery.

ii. Reservoir/storage tanks:

Water from the channel gets collected in the sump from where water is pumped to two overhead tanks, each of 20 ton capacity.

The process involved in the seawater intake system is schematically represented below:

Seawater --> Pump house --> Reservoir --> Overhead tank -->UV --> Hatchery.

b. Hatchery complex (Fig.67):

i. Broodstock pond:

There are no broodstock ponds in this hatchery.
ii. Maturation section:
It comprises of four circular tin tanks, each of 10 ton capacity. The tin sheet is protected from rust by using a plastic liner as a cover. The maturation tanks are housed in a thatched roof. The animal are stocked at the rate of 3-4 pieces/sq.m. Water exchange of 60-100% was carried out. Air is diffused through air stones.

iii. Spawning section:
The spawning section comprises of five FRP tanks, each of 200 l capacity.

iv. Hatching section:
Hatching is carried out in the spawning tank.

v. Larval section:
The larvae are reared in the open. Six rectangular brick wall masonry tanks, each of 8 ton capacity and combined by internal walls to form a row are used to rear larvae.

vi. Post-larval section:
Twelve rectangular brick wall masonry tanks with six tanks each, in a row, are used. Each tank has a capacity of 10 ton.

vii. Feed section:
It has a small algal section for mixed culture. Mass culture is carried out in flat bottom FRP tanks, each of 50 l capacity.
A small section is used to hatch Artemia cysts for feeding the PL's. Three cylindroconical FRP tanks, each of 250 l capacity are used.

viii. Drainage system:
The central drainage system of Hawaii technology is adopted in this hatchery.

C. Logistic support:
The hatchery has 2 numbers of 5 HP capacity pumps to supply seawater to the hatchery. Aeration is carried out by using a roots blower of 2 HP and 1 HP capacity. A 30 KVA generator is used as a standby to provide power during electricity failure.

D. Infrastructure:
The hatchery has an administrative section. No other structure other than the main hatchery building is constructed in this hatchery.

E. Special features:
a. The hatchery is of small capacity and hence it can be easily managed.
b. The hatchery is run by the entrepreneur and therefore, necessary care is been taken in monitoring of entire unit.

F. Demerits:
a. The entrepreneurs had to take care and hold responsibilities for the entire administration and hatchery operation.
b. Erosion of shore was noted in this region and therefore, expenditure on developing the shore had to be undertaken, frequently.

G. Commercial feasibility study:

The financial assessment made for one year revealed a profit of Rs.12.95 lakhs, when the seed cost was considered at Re.0.35/seed. Seed was sold at an escalated price of Re.0.50-Re.1.00 during 1993-94. A fluctuation in profit was noted every year due to various factors influencing the shrimp hatchery and farms.
## ESTIMATED FINANCIAL PROJECTION

### A. Capital Expenditure:

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<thead>
<tr>
<th>Description</th>
<th>(Rs. in lakhs)</th>
</tr>
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<tbody>
<tr>
<td>1. Civil</td>
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<tr>
<td>2. Plant and Machinery</td>
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<td>3. Miscellaneous</td>
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<td><strong>Total</strong></td>
<td><strong>28.61</strong></td>
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### B. Recurring Expenditure:

<table>
<thead>
<tr>
<th>Description</th>
<th>(Rs. in lakhs/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Broodstock section</td>
<td>3.90</td>
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<tr>
<td>2. <strong>Artemia</strong></td>
<td>2.25</td>
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<td>3. Larval/post-larval feed</td>
<td>0.50</td>
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<td>4. Broodstock feed</td>
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<td>5. Chemicals</td>
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<td>6. Power</td>
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<td>7. Fuel</td>
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<td>8. Administrative Expenses</td>
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<td>9. Salaries and wages</td>
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<td>10. Repairs and maintenance</td>
<td>0.19</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>15.45</strong></td>
</tr>
</tbody>
</table>

### C. Interest:

@ 15% per annum A + B (Rs.44.06 lakhs) 6.60

### D. Revenue:

@ Re.0.35/seed for 10 million seed/annum 35.00

### E. Cost Benefit Analysis:

Revenue - (B + C) 12.95

### F. Comparative analysis on production and marketing:

- @ Rs. 15.45 lakhs/10 million seed
- Production cost/1000 seed (Rs.) 154.50
- @ Re.0.35/seed Revenue/1000 seed (Rs.) 350.00
5.13.15. The Marine Products Exports Development Authority
Hatchery (MPEDA), Kerala

A. Hatchery set-up :

   a. Technology : German
   b. Year of establishment : 1987
   c. Capacity : 5 million/annum
   d. Promoter/sector : MPEDA/Government
   e. Location of site : Vallarpadom, Cochin
   f. Species reared : Penaeus indicus

B. Design and operation :

   a. Seawater intake system :

      Brackishwater from the island is pumped to the hatchery using a
      pipeline laid on short cemented piles built across the hatchery at 200m
      distance.

   i. Filters :

      It comprises of a rectangular concrete slow sand filter, each of 100 ton
      capacity. Two rapid sand filters, each of 138 gpm are also used in this
      hatchery.

   ii. Reservoir/storage tanks :

      Three rectangular brick wall masonry reservoirs, each of 150 ton
      capacity are used to store and disinfect seawater. Three PVC tanks of
      20 ton capacity are used to distribute seawater to the hatchery.

      The process of seawater intake system is represented below :

      Seawater --> Pump house --> Reservoir I --> Reservoir II -->
      (collection) (chlorination) (dechlorination)
      Reservoir III --> Overhead tank --> Hatchery.
5.13.15. The Marine Products Exports Development Authority
Hatchery (MPEDA), Kerala

A. Hatchery set-up:
   a. Technology : German
   b. Year of establishment : 1987
   c. Capacity : 5 million/annum
   d. Promoter/sector : MPEDA/Government
   e. Location of site : Vallarpadom, Cochin
   f. Species reared : Penaeus indicus

B. Design and operation:
   a. Seawater intake system:

   Brackishwater from the island is pumped to the hatchery using a
   pipeline laid on short cemented piles built across the hatchery at 200m
   distance.

   i. Filters:

   It comprises of a rectangular concrete slow sand filter, each of 100 ton
   capacity. Two rapid sand filters, each of 138 gpm are also used in this
   hatchery.

   ii. Reservoir/storage tanks:

   Three rectangular brick wall masonry reservoirs, each of 150 ton
   capacity are used to store and disinfect seawater. Three PVC tanks of
   20 ton capacity are used to distribute seawater to the hatchery.

   The process of seawater intake system is represented below:

   Seawater --> Pump house --> Reservoir I --> Reservoir II -->
   (collection) (chlorination)
   Reservoir III --> Overhead tank --> Hatchery.
   (dechlorination)
b. Hatchery complex (Fig.68):

i. Broodstock pond:
The hatchery has no broodstock ponds.

ii. Maturation section:
It comprises of four circular concrete tanks, each of 18 ton capacity (Fig.69). Each tank has a height of 1.8m. The tanks are accessible to technicians by mild steel staircase. The maturation tank is attached with a sump (Fig.70) to enable sedimentation of sand particles that is present in the seawater. Breeders are stocked at the rate of 3-4 nos./sq.m. Water exchange of 100% is carried out in 24 hours. Air is diffused through air stones.

iii. Spawning section:
A small room is used for spawning and (Fig.71). Ten circular shaped mild steel tanks, each of 250 l capacity and painted with epoxy are utilised (Fig.72).

iv. Hatching section:
The eggs are hatched in the spawning tanks.

v. Larval section:
It comprises of six cylindroconical FRP tanks, each of 2 ton capacity (Fig.73). It has a height of 2.5m. It uses a ladder to monitor the system. The larvae are stocked as similar to M/s TASPARC hatchery. Water exchange of 50% is carried out in 6 hours. Air is diffused through air stones.
vi. Post-larval section:
Two rectangular brick wall concrete masonry tanks, each of 10 ton capacity are used (Fig. 74). The PL are stocked at the rate of 15-20 nos./l. Water exchange of 30-40% is carried out in 6-8 hours. Aeration lines are laid at the bottom of the tanks using PVC pipes with pinhole perforations. The pipes are anchored by small PVC pipes filled with weights to prevent buoyancy (Fig. 75).

vii. Feed section:
An indoor algal culture shed houses fifty cylindroconical FRP tanks, each of 2 ton capacity apart from stock culture tanks of 250 l, 500 l and 1 ton capacities (Fig. 76). Four fluorescent lights are fixed vertically on the floor at four different corners for each 2 ton capacity tank (Fig. 77).

Artemia nauplii are hatched in eight cylindroconical FRP tanks, each of 500 l capacity (Fig. 78). These tanks are kept adjacent to the post-larval tanks.

viii. Drainage system:
The hatchery follows the central drain system as in M/s TASPARC hatchery.

C. Logistic support:
The logistic support comprises of two pumps, each of 10 HP, two blowers, each of 5 HP and a generator of 50 KVA capacities. An oil compressor of 5 HP capacity is rarely used to supply aeration (Fig. 79).
D. **Infrastructure:**

The hatchery has an administrative block, laboratory (Fig.80) and a training centre with hostel and staff quarters.

E. **Special features:**

a. The hatchery serves as a model for entrepreneurs to study the basic concept involved in the various sections through the training programme rendered by MPEDA.

F. **Demerits:**

The civil, mechanical and electrical designs of the technology adopted (German) were not properly implemented. This paved way for technical failure. Further, disease factors also contributed greatly to the downfall of hatchery production rates.

G. **Commercial feasibility study:**

Since the inception of the hatchery complex due to various technical and management problem, the hatchery was not able to achieve the production targets. Estimation revealed a loss of Rs.-13.10 lakhs on revenue. However, in the light of training, the hatchery is still utilised for operation to train entrepreneurs to study the basic concepts of hatchery and its operational procedures.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure : (Rs. in lakhs)

1. Civil 36.03
2. Plant and Machinery 30.00
3. Miscellaneous 2.00

Total 68.03

B. Recurring Expenditure (Rs. in lakhs/year)

1. Broodstock 1.98
2. Artemia 1.12
3. Larval/post-larval feed 0.80
4. Broodstock feed 0.01
5. Chemicals 1.50
6. Power 1.04
7. Fuel 0.76
8. Administrative Expenses 1.23
9. Salaries and wages 4.49
10. Repairs and maintenance 0.46

Total 13.39

C. Interest :

@ 15% per annum A + B (Rs.81.42 lakhs) 12.21

D. Revenue :

@ Re. 0.25/seed for 5 million seed/annum 12.50

E. Cost Benefit Analysis :

Revenue - (B + C) -13.10

F. Comparative analysis on production and marketing :

@ Rs. 13.39 lakhs/5 million seed
Production cost/1000 seed (Rs.) 267.80

@ Rs.0.25/seed Revenue for 1000 seed (Rs.) 250.00
5.13.16. **Central Institute of Brackishwater Aquaculture Hatchery (CIBA), Kerala**

A. Hatchery set-up:

   a. Technology : Indian  
   b. Year of establishment : 1986  
   c. Capacity : 5 million/annum  
   d. Promoter/sector : CIBA/Government  
   e. Location of site : Narakkal  
   f. Species reared : *P. monodon* and *P. indicus*

B. Design and operation:

   a. Seawater intake system:

      It has a simplified seawater intake system. Water from the sea through a creek is pumped to the reservoir.

   i. Filters:

      A rectangular concrete slow sand filter of 15 ton capacity is used to filter the water that is sent from the reservoir. No rapid sand filter is used in this hatchery.

   ii. Reservoir/storage tanks:

      Three rectangular concrete reservoirs, each of 50 ton capacity, are used to store and disinfect seawater.

      The process of seawater intake is represented schematically below:

      Seawater --> Pump house---> Reservoir---> Slow sand filter---> Overhead tank --> Hatchery.
b. Hatchery complex (Fig.81):

i. Broodstock pond:

There is no broodstock pond in this hatchery.

ii. Maturation section:

It comprises of four circular FRP tanks, each of 10 ton capacity. It has an unique filtration-cum-recycling system of water at the bottom of the tank (Fig.82). It comprises of a 3 inch bed of pebbles at the bottom followed by clam shell. Water along with sediments or feed wastes get settled in the filter. An Air Water Lift (AWL) system is provided to lift the suspended particles along with the water to a filter separator kept near the maturation tank. The sediments are collected and settled in the separator. Hence, water is exchanged once in fortnight. The breeders are stocked at the rate of 5 Nos./sq.m. and fed with cooked squilla meat.

iii. Spawning section:

It comprises of six cylindroconical FRP tanks, each of 200 l capacity. These tanks are placed in the maturation section.

iv. Hatching section:

Hatching is carried out in the spawning tanks.

v. Larval section:

Ten parabolic FRP tanks, each of 1.5 ton capacity are used. Stocking density, water exchange and aeration is carried out based on Japanese technology.
vi. Post-larval section:

The larval tanks are used for post-larval rearing. The larvae at PL3 stages are distributed in these tanks at a stocking density of 20PL/l. Water exchange is gradually increased from 50-100% to that of the total volume of water.

vii. Feed section:

A room is provided for indoor algal culutre. Algae are cultured in 1-2 l flasks and 20 l carboys. Outdoor algal culture is not undertaken in this hatchery.

Artemia nauplii are rarely fed to the larvae on experimental basis. They are hatched in ten numbers of plastic buckets (25 l and 50 l). The operation techniques are carried out based on Hawaii technology.

viii. Drainage system:

The central drainage system is as in Hawaii technology.

C. Logistic support:

Two pumps, each of 10 HP capacity are used to pump seawater to the hatchery. Two blowers, each of 5 HP capacity are used for aeration. No rapid sand filters or UV filters are used.

D. Infrastructure:

The hatchery has a laboratory and an office. Separate residential areas are proposed for resident technicians and scientists to carry out their research activities.
E. Special features:
   a. The hatchery is oriented towards research activities than commercial production. Research in the perfection of eyestalk ablation through cauterisation as against conventional practices, *invitro* fertilisation and artificial insemination are being carried out regularly.
   b. The hatchery runs with very low inputs since naturally available resources are utilised.
   c. Technical personnel are being trained in the organisation to develop shrimp hatcheries in the coastal belts of our country.

F. Demerits:
   a. Since it is a Government-run organisation, the hatchery operation is found to be interrupted due to lack of funds.
   b. The site is located in a low lying area and hence, during monsoon, water stagnates inside the hatchery and makes technical operations difficult.
   c. Due to heavy rainfall in this region, only 3-4 cycles of hatchery operations have been found feasible.

G. Commercial Feasibility study:
Consistent commercial production was not recorded since the hatchery operation was mainly involved in research and development activities. The financial projection revealed a profit of Rs.4.52 lakhs, when the seed cost was considered at Re.0.35/seed.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)

1. Civil 12.30
2. Plant and Machinery 10.00
3. Miscellaneous 2.00

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Total 24.30

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B. Recurring Expenditure: (Rs. in lakhs/year)

1. Broodstock 1.98
2. Artemia 0.45
3. Larval/post-larval feed 0.77
4. Broodstock feed 0.01
5. Chemicals 0.01
6. Power 0.50
7. Fuel 0.42
8. Administrative Expenses 0.50
9. Salaries and wages 3.30
10. Repairs and maintenance 0.18

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Total 8.12

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C. Interest:

@ 15% per annum A + B (Rs.32.42 lakhs) 4.86

D. Revenue:

@ Re. 0.35/seed for 5 million seed/annum 17.50

E. Cost Benefit Analysis:

Revenue - (B + C) 4.52

F. Comparative analysis on production and marketing:

@ Rs. 8.12 lakhs/5 million seed
Production cost/1000 seed (Rs.) 162.40

@ Rs.0.35/seed Revenue for 1000 seed (Rs.) 350.00
5.13.17. **Bluchip P. Ltd., Karnataka**

A. Hatchery set-up:

    a. Technology : Philippines
    b. Year of establishment : 1994
    c. Capacity : 30 million/annum
    d. Promoter/sector : Private
    e. Location of site : Kumta
    f. Species reared : **P.monodon**

B. Design and operation:

a. Seawater intake system:

    The seawater intake system comprises of an infiltration gallery at the suction point. The pipeline from the sea to the site is laid below the ground level at a distance of 150m.

i. Filters:

    Four rapid sand filters, each of 138 gpm are used to filter seawater before it is sent to the various sections of the hatchery.

ii. Reservoir/storage tanks:

    Water is pumped to five rectangular concrete reservoirs, each of 100 ton capacity. Water is sent to the rapid sand filters to the respective sections using transfer pumps.

b. Hatchery complex (Fig.83):

i. Broodstock pond:

    There is no provision for broodstock pond.
ii. Maturation section:
It comprises of four rectangular concrete tanks, each of 17 ton capacity. The tanks are flushed to the walls of the hatchery building. Stocking density, water exchange and aeration are carried out similar to that of M/s Giridhar Foods, Ramnad, Tamilnadu.

iii. Spawning section:
Two rectangular hollow block laterite tanks, each of 5 ton capacity are used for group spawning. Five cylindroconical FRP tanks, each of 200 l capacity are used for individual spawning.

iv. Hatching section:
Hatching is carried out in six hatching buckets, each of 50 l capacity.

v. Larval section:
It comprises of two rows of 12 tanks, each of 14 ton capacity. These tanks are made up of brick wall masonry. The tanks are flushed to the walls of the hatchery building. Stocking density, water exchange and aeration are carried out as in M/s Giridhar Foods, Ramnad, Tamilnadu.

vi. Post-larval section:
The larvae at PL3 stages are distributed in the larval tanks at a stocking density of 15-20 PL/litre.

vii. Feed section:
An indoor algal room is provided to culture Skeletonema sp. Mass culture is carried out in three translucent FRP cylinders, each of 200 l
capacity. An outdoor algal section with a raised platform is provided to place five algal tanks, each of 6 ton capacity.

Ten numbers of FRP tanks, each of 500 l capacity are used to hatch *Artemia* cysts.

viii. Drainage system:
The collective drainage system as observed in M/s Giridhar Foods, Ramnad, Tamilnadu is followed in this hatchery.

C. Logistic support:
A 10 HP pump and five numbers, each of 5 HP capacities are used to pump seawater to the hatchery. Two blowers, each of 5 HP and a generator of 62.5 KVA capacities are used to supply aeration and power respectively.

D. Infrastructure:
The hatchery has a laboratory, manager and security quarters. It has no staff quarter or dormitory since the technicians are employed from the surrounding township.

E. Special features:
   a. The tanks are flushed towards the wall of the hatchery building in order to reduce space and provide compactness in operation.
   b. The site is very close to the nearest township and hence mobilisation of raw materials, repairs and maintenance of machinery and transportation of personnel are not problematic.
F. Demerits:
   a. The hatchery does not follow Coastal Regulation Zone rules (CRZ) since the site is located within 200m distance from the sea.
   b. Sea erosion is vigorous in this region and hence, the various structures may be eroded if proper prevention is not undertaken.

G. Commercial feasibility study:

A financial estimate for one year revealed a profit of Rs.35.55 lakhs, when seed cost is considered at Re.0.35/seed. The hatchery has not achieved any remarkable production due to various constraints that have been observed in the recent past.
ESTIMATED FINANCIAL PROJECTION

A. Capital Expenditure: (Rs. in lakhs)

1. Civil 52.00
2. Plant and Machinery 25.00
3. Miscellaneous 10.00

Total 87.00

B. Recurring Expenditure: (Rs. in lakhs/year)

1. Broodstock 11.70
2. Artemia 2.70
3. Larval/post-larval feed 8.25
4. Broodstock feed 0.15
5. Chemicals 3.51
6. Power 4.75
7. Fuel 2.77
8. Administrative Expenses 5.50
9. Salaries and wages 9.11
10. Repairs and maintenance 0.61

Total 49.05

C. Interest:

@ 15% per annum A + B (Rs.136.05 lakhs) 20.40

D. Revenue:

@ Re. 0.35/seed for 30 million seed/annum 105.00

E. Cost Benefit Analysis:

Revenue - (B + C) 35.55

F. Comparative analysis on production and marketing:

@ Rs. 49.05 lakhs/30 million seed production cost/1000 seed (Rs.) 163.50

@ Re. 0.35/seed Revenue for 1000 seed (Rs.) 350.00
5.13.18. **Kumta Shrimp Hatchery, Karnataka**

A. Hatchery set-up:

a. Technology: Indian  
b. Year of establishment: 1993  
c. Capacity: 10 million/annum  
d. Promoter/sector: BFDA/Government  
e. Location of site: Kumta  
f. Species reared: *P. monodon*

B. Design and operation:

a. Seawater intake system:

It has a simple seawater intake system with pipelines supplying 20,000 l of water every day.

i. Filters:

An UV filter of 500 l/hr. capacity is used to filter seawater before it is sent to the various sections.

ii. Reservoir/storage tanks:

Seawater is stored in a storage tank of 40 ton capacity.

The process involved in the seawater intake system is represented below:

Seawater--> Pumps--> Storage tanks--> Overhead tank--> UV--> Hatchery.
b. Hatchery complex (Fig.84):

i. Broodstock pond:

Four ponds, each of 100 ton capacity are provided to develop broodstock in captivity.

ii. Maturation section:

It comprises of two rectangular brick wall masonry tanks, each of 10 ton capacity. The stocking density is maintained at the rate of 5-6 nos./sq.m. Water exchange and aeration is carried out based on Hawaii technology.

iii. Spawning section:

Twenty conical-shaped FRP tanks, each of one ton capacity are used for spawning activities.

iv. Hatching section:

Hatching is carried out in the spawning tank.

v. Larval section:

Twelve rectangular concrete tanks, each of 10 ton capacity are used to rear larvae. The larvae are stocked at a density of 80 nauplii/litre. Water is exchanged at the rate of 50-60%. Aeration is offered through air stones.

vi. Post-larval section:

The larvae at PL3 stages are distributed in the larval tanks at a stocking density of 12-15 PL/l.
v. Feed section:
Diatoms are cultured in ten concrete tanks, each of 250 l capacity. The tanks are kept outdoor. No indoor culture facilities has been provided. Six cylindroconical FRP tanks, each of 50 l capacity are used to hatch *Artemia* cysts to feed the post larvae.
The operation techniques are carried out similar to that of M/s CIBA hatchery, Narakkal, Kerala.

viii. Drainage system:
The hatchery adopts central drainage system.

C. Logistic support:
It has two pumps, each of 2 HP for freshwater, two pumps, each of 5 HP to supply 20,000 l of seawater per day, two air blowers, each of 7.5 HP capacity and 50 KVA-3 Phase generator for standby power supply.

D. Infrastructure:
It has a laboratory, a store and an office. It has three quarters for various staff for different cadre.

E. Special features:
a. Breeders are available near the vicinity of the site and hence shortage does not exists.
b. The site is accessible by road and hence it facilitates easy transportation of men and materials.
F. Demerits:
   a. Since the hatchery is operated by the Government agency to promote research activities, no consistency in the production was observed.
   b. A high manpower turnover is observed due to poor remuneration given to the technicians.

G. Commercial feasibility study:
   Seed have a fluctuating market in this locality ranging from Re.0.35 to Rs.1.20. A financial estimate for one year revealed a profit of Rs.7.41 lakhs, when the cost of seed was fixed at the rate of Re.0.35/seed. Though the state has only a few hatcheries, remarkable achievements through commercial production have been found impossible in this hatchery due to its commitment to research activities.
**ESTIMATED FINANCIAL PROJECTION**

A. Capital Expenditure: (Rs. in lakhs)

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil</td>
<td>30.06</td>
</tr>
<tr>
<td>Plant and Machinery</td>
<td>15.00</td>
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<tr>
<td>Miscellaneous</td>
<td>2.00</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>47.06</strong></td>
</tr>
</tbody>
</table>

B. Recurring Expenditure: (Rs. in lakhs/year)

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broodstock</td>
<td>3.90</td>
</tr>
<tr>
<td>Artemia</td>
<td>1.80</td>
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<tr>
<td>Larval/post-larval feed</td>
<td>3.96</td>
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<tr>
<td>Broodstock feed</td>
<td>2.04</td>
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<tr>
<td>Chemicals</td>
<td>0.01</td>
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<tr>
<td>Power</td>
<td>2.00</td>
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<tr>
<td>Fuel</td>
<td>1.44</td>
</tr>
<tr>
<td>Administrative Expenses</td>
<td>2.31</td>
</tr>
<tr>
<td>Salaries and wages</td>
<td>0.11</td>
</tr>
<tr>
<td>Repairs and maintenance</td>
<td>0.29</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>17.86</strong></td>
</tr>
</tbody>
</table>

C. Interest:

@ 15% per annum A + B (Rs.64.92 lakhs) 9.73

D. Revenue:

@ Re. 0.35/seed for 10 million seed/annum 35.00

E. Cost Benefit Analysis:

Revenue - (B + C) 7.41

F. Comparative analysis on production and marketing:

@ Rs. 17.86 lakhs/10 million seed production cost/1000 seed (Rs.) 178.60

@ Re. 0.35/seed Revenue for 1000 seed (Rs.) 350.00
Table 2. Technological variations observed in the various hatcheries of India.

<table>
<thead>
<tr>
<th>Basic technologies (seven)</th>
<th>Minor variations of basic technologies (18 types)</th>
<th>Fine variation within 18 types of hatchery technologies</th>
<th>Name of the hatchery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minor variation</td>
<td>Fine variation</td>
<td></td>
</tr>
<tr>
<td>1. Dual pipeline in intake system.</td>
<td>TASPARC</td>
<td>i. Single pipeline in intake system. Outdoor algae seldom used.</td>
<td>Siraga, Wyn, Aquaseeds, Nikita, Aquin Quilt, Panchem, R.Sawant, Shyam, Oshodira, Venture, Sripa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Excess buffer in design utilising more area.</td>
<td>Balaji Bio-tech, Photon Simhapuri, Aquin Park, Maheswari</td>
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<td></td>
<td></td>
<td>iii. Building in the shape of ‘H’ to have 2 modules inter-connected.</td>
<td>Surya Chakra</td>
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<td>I Hawaii</td>
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<td></td>
<td>Sections arranged in different locations.</td>
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<td></td>
<td>Circular tanks in maturation section.</td>
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<td></td>
<td>Seawater intake, below ground level.</td>
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<tr>
<th>Basic technologies (seven)</th>
<th>Minor variations of basic technologies (18 types)</th>
<th>Fine variation within 18 types of hatchery technologies</th>
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<tbody>
<tr>
<td>No. technologies</td>
<td>Minor variation</td>
<td>Name of the hatchery</td>
</tr>
<tr>
<td>3.</td>
<td>Emphasises vaasthu shastra. SSV &amp; Durga Less number of tanks designed to reduce buffer. Tanks flushed to wall to save space. Pipe line for seawater intake above ground level and supported on piles.</td>
<td>Pipeline laid above ground level for intake system and anchored by cement blocks.</td>
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<td>4.</td>
<td>Dual pipeline for intake system, but pipeline routing for hatchery reduced unlike M/s TASPARC.</td>
<td>NCC BPL Siris Oceanic Aquacult Auriferous</td>
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<td>5.</td>
<td>Tanks not flushed with wall as in M/s SSV (intermediate between M/s NCCBPL &amp; SSV/Durga in design).</td>
<td>Veerat Aquatech East India Murudheswar Zoro VGP</td>
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<thead>
<tr>
<th>Basic technologies (seven)</th>
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<th>Fine variation within 18 types of hatchery technologies</th>
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</thead>
<tbody>
<tr>
<td>No.</td>
<td>Minor variation</td>
<td>Name of the hatchery</td>
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<tr>
<td>1</td>
<td>Intake pipeline above ground level.</td>
<td>Giridhar Foods</td>
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<td>S&amp;S</td>
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<td>Blue Gold</td>
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<td>II Philippines</td>
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<tr>
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<th>Name of the hatchery</th>
<th>Fine variation within 18 types of hatchery technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Tanks flushed to walls unlike M/s Giridhar.</td>
<td>Bluchip</td>
<td>Tanks not flushed but area reduced unlike M/s Giridhar Foods.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Basic technologies (seven)</th>
<th>Minor variations of basic technologies (18 types)</th>
<th>Fine variation within 18 types of hatchery technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Minor variation</td>
<td>Fine variation</td>
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<tr>
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</tr>
<tr>
<td>1. The hatchery roof truss has air regulatory system to control inlet &amp; outlet air.</td>
<td>ITC Minota Aquatech (TN) ITC (Maharashtra) Southern Hatchery</td>
<td>i. Central Drainage System.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Larvae reared in separate section in concrete tanks.</td>
</tr>
</tbody>
</table>

III Japanese
<table>
<thead>
<tr>
<th>Basic No. technologies (seven)</th>
<th>Minor variations of basic technologies (18 types)</th>
<th>Fine variation within 18 types of hatchery technologies</th>
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<tbody>
<tr>
<td></td>
<td>Minor variation</td>
<td>Name of the hatchery</td>
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<tr>
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<tr>
<td>iii. Larvae reared in brick wall masonry circular tanks.</td>
<td>Bobby</td>
<td>Quality</td>
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<td></td>
<td>Sudarshan</td>
<td>Vijay</td>
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<td></td>
<td>Vasanthi</td>
<td>Geekay</td>
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<tr>
<td></td>
<td>Kavini</td>
<td>Marvel</td>
</tr>
<tr>
<td></td>
<td>Mas Aqua</td>
<td>Star</td>
</tr>
<tr>
<td></td>
<td>Water Base</td>
<td>G.Maijo</td>
</tr>
<tr>
<td></td>
<td>Nalli</td>
<td>Pavithra</td>
</tr>
<tr>
<td></td>
<td>PL Marine</td>
<td>Raj</td>
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<tr>
<td></td>
<td>Trinity</td>
<td>Aditya</td>
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<tr>
<td></td>
<td>Vandayar</td>
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2. Larvae reared in FRP Cylindroconical tanks and PL in Parabolic tanks.
<table>
<thead>
<tr>
<th>No.</th>
<th>Basic technologies (seven)</th>
<th>Minor variations of basic technologies (18 types)</th>
<th>Fine variation within 18 types of hatchery technologies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minor variation</td>
<td>Name of the hatchery</td>
</tr>
<tr>
<td>3.</td>
<td>PL reared in outdoor</td>
<td>Lahari</td>
<td>First Aqua</td>
</tr>
<tr>
<td></td>
<td>parabolic tanks.</td>
<td>Blue Park</td>
<td>TNFDC</td>
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<tr>
<td></td>
<td></td>
<td>Coastal</td>
<td>Chemeen</td>
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<td></td>
<td></td>
<td>DCM</td>
<td>Abad</td>
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<tr>
<td></td>
<td></td>
<td>Baby Marine</td>
<td>Aquahatch</td>
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<tr>
<td></td>
<td></td>
<td>Golden</td>
<td>Aquatech</td>
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<tr>
<td></td>
<td></td>
<td>Southern</td>
<td>Aroma</td>
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<tr>
<td></td>
<td></td>
<td>Ocean Harvest</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Sea Crest</td>
<td></td>
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<td></td>
<td></td>
<td>Sea Jade</td>
<td></td>
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<tr>
<td>IV</td>
<td>Indian</td>
<td>Maturation in circular tanks.</td>
<td>Larvae reared in rectangular tanks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Larvae reared in Parabolic tanks.</td>
<td>Broodstock, larvae and PL fed with artificial feed.</td>
</tr>
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<td></td>
<td></td>
<td>Broodstock fed with squid feed.</td>
<td></td>
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<tr>
<td>1.</td>
<td></td>
<td>CIBA</td>
<td>First Aqua</td>
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<td>Azhikode</td>
<td>TNFDC</td>
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<td></td>
<td>Matsya</td>
<td>Chemeen</td>
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<td></td>
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<td>Govt. Hatchery (Maharashtra)</td>
<td>Abad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Govt. Hatchery (Orissa)</td>
<td>Aquahatch</td>
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<td>Aquatech</td>
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<td></td>
<td></td>
<td></td>
<td>Aroma</td>
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<tr>
<td>2.</td>
<td>Each PL tank with</td>
<td>Aurolee</td>
<td>Kolaventy</td>
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<tr>
<td></td>
<td>additional seawater</td>
<td></td>
<td>Silvera</td>
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<td></td>
<td>storage tank.</td>
<td></td>
<td>Modern</td>
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<td></td>
<td></td>
<td></td>
<td>Gajallli</td>
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<td></td>
<td></td>
<td></td>
<td>Golden</td>
</tr>
<tr>
<td>3.</td>
<td>PL reared in outdoor</td>
<td>Aqua Plaza</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tanks.</td>
<td>Trimarine</td>
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<th>No. technologies (seven)</th>
<th>Basic technologies Minor variations of basic technologies (18 types)</th>
<th>Minor variation</th>
<th>Name of the hatchery</th>
<th>Fine variation within 18 types of hatchery technologies</th>
<th>Fine variation</th>
<th>Name of the hatchery</th>
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</thead>
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<td>4.</td>
<td>Rectangular tanks not parabolic shaped. Larvae &amp; PL reared in the same tank.</td>
<td>Kumta</td>
<td>Asia Pacific Conera Avera AL Hatchery Geomarine Srinivasa</td>
<td>Larvae reared in cylindroconical tank of 2 m height with a glass viewer to inspect larvae.</td>
<td>Hindustan Lever</td>
<td></td>
</tr>
<tr>
<td>V German</td>
<td>Larvae reared in cylindroconical tank of 1.8 m height. PL reared in concrete tanks.</td>
<td>MPEDA</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>VI French</td>
<td>Larval tanks separated by walls. OSSPARC Flow-through-system for hatching.</td>
<td>Travancore D.S. Aqua Tata</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>VII Taiwan</td>
<td>Open &amp; Central drainage system. Ladder system for larval &amp; PL transfer.</td>
<td>NAEL Carewell</td>
<td></td>
<td>Central drainage system. Without ladder system.</td>
<td>Avanti Cocanada Kakinada Samudra Teknomin Aquaint Scanet Claswin</td>
<td></td>
</tr>
</tbody>
</table>
FLOW CHART: SEAWATER → FILTER → RESERVOIR → ONT → HATCHERY

(all measurements are in mm)
Fig. 13. Broodstock ponds of M/s OSSPARC Hatchery, Orissa.

Fig. 14. FRP tank in maturation section of M/s OSSPA Hatchery, Orissa.
Fig. 15. FRP Spawning tanks of M/s OSSPARC Hatchery, Orissa.

Fig. 16. Flow through system in hatching section of M/s OSSPARC Hatchery, Orissa.
Fig. 17. Oval FRP-larval tanks of M/s OSSPARC Hatchery, Orissa.

Fig. 18. Outdoor rectangular concrete post-larval tanks of M/s OSSPARC Hatchery, Orissa.
Fig. 19. Earthen ponds for post-larval rearing in M/s OSSPARC Hatchery, Orissa.

Fig. 20. Outdoor algal cylinders of M/s OSSPARC Hatchery, Orissa.
Fig. 21. Logistic support of M/s OSSPARC Hatchery, Orissa.
Fig. 23. Maturation tanks of M/s TASPARC, Andhra Pradesh.

Fig. 24. Indoor algal culture of M/s TASPARC, Andhra Pradesh.
FLOW CHART: SEAWATER → PUMP HOUSE I → SLOW SAND FILTER → SUMP → PUMP HOUSE II → RESERVOIR I → PUMP HOUSE III → RESERVOIR II → PUMP HOUSE IV / U.V. → HATCHERY

OTHER FACILITIES: BLOWER, D.C. ROOM, QUARANTINE ROOM, BROOD STOCK POND, EFFLUENT TREATMENT SYSTEM.

(all measurements are in mm)

LEGEND
1. MATURATION SECTION
2. SPAWNING HATCHING SECTION
3. LABORATORY
4. ALGAL SECTION
5. LARVAL SECTION
6. POST LARVAL SECTION
7. STORES
8. ARTEMIA SECTION
9. PACKING SECTION

NAME: SSV / DURGA AQUA P. LTD. ANDHRA PRADESH
CAP: 62.5 MILLION
TECH: HAWAII, AMERICAN Fig. 25
Fig. 27. Main Hatchery building of M/s Veerat Aqua-tech Ltd.

Fig. 28. Maturation tanks of M/s Veerat Aqua-tech Ltd.
Fig. 29. Post-larval tanks of M/s Veerat Aqua-tech Ltd.

Fig. 30. Seawater intake Jetty system of M/s NCCBPL, Nakkapalli Andhra Pradesh.
Fig. 31. Seawater intake - Pumping of water in the open channel NCCBPL, Andhra Pradesh.

Fig. 32. Circular reservoir of M/s NCCBPL, Andhra Pradesh.
Fig. 34. Maturation tanks of M/s NCCBPL, Andhra Pradesh.

Fig. 35. Concrete larval tanks of M/s NCCBPL, Andhra Pradesh.
Fig. 36. Aeration by Lead keel tube of M/s NCCBPL, Andhra Pradesh.

Fig. 37. Roof with translucent sheet in the larval section of M/s NCCBPL, Andhra Pradesh.
Fig. 38. Post-larval tanks of M/s NCCBPL, Andhra Pradesh.

Fig. 39. Outdoor algal section of M/s NCCBPL, Andhra Pradesh.
LEGEND
1. MATURATION SECTION
2. SPAWNING/HATCHING SECTION
3. LABORATORY
4. LARVAL SECTION
5. INDOOR ALGAL SECTION
6. ARTEMA SECTION
7. POST LARVAL SECTION
8. OUTDOOR ALGAL SECTION

FLOW CHART: SEAWATER — VIA KALIAN HATCHERY — SLOW SAND FILTER

PUMP HOUSE
RESERVOIR
UV
LAMAR HATCHERY

NAME: LAMAR SEA FOOD LTD, ANDHRAPRADESH
CAP: 60 MILLION
TECH: JAPANESE  Fig. 41
Fig. 42a&b. Reservoirs of M/s NAEL, Nellore, Andhra Pradesh.
Fig. 43. Tower tank for storing seawater of M/s NAEL, Andhra Pradesh.

Fig. 44. Slow sand filter of M/s NAEL, Andhra Pradesh.
Fig. 46. Maturation tank of M/s NAEL, Andhra Pradesh.

Fig. 47. Drain pit of M/s NAEL, Andhra Pradesh.
Fig. 48. Roof with translucent sheet in larval section of M/s NAEL, Andhra Pradesh.

Fig. 49. Outdoor post-larval tanks of M/s NAEL, Andhra Pradesh.
Fig. 50. Outdoor Algal tanks of M/s NAEL, Andhra Pradesh.

Fig. 51. Artemia tanks of M/s NAEL, Andhra Pradesh.
Fig. 53. Seawater intake system - Pipeline supported by Casu Poles in M/s Pioneer Aqua Farms Pvt. Ltd., Tuticorin, Tamilnadu.
Fig. 55. Seawater intake system - Pipelines laid at sub-sand level of M/s Giridhar Foods Ltd., Ramnad, Tamilnadu.

Fig. 56. Rapid sand filters of M/s Giridhar Foods Ltd., Tamilnadu.
Fig. 57. U.V. Filter of M/s Giridhar Foods Ltd., Tamilnadu.
Fig. 59. Larval section of M/s Giridhar Foods Ltd., Tamilnadu.
Fig. 60. Transfer pumps for pumping seawater to hatchery of M/s Giridhar Foods Ltd., Tamilnadu.
Fig. 61. Roots blower for Aeration of M/s Giridhar Foods I Tamilnadu.
Fig. 62. Generator for power supply of M/s Giridhar Foods Ltd, Tamilnadu.
Fig. 63. Guarantine room of M/s Giridhar Foods Ltd., Tamilnadu.

Fig. 64. Packing section of M/s Giridhar Foods Ltd., Tamilnadu.
FLOW CHART:  ← SEA ← PUMP HOUSE ← RESERVOIR ← RAPID SAND FILTER ← O.H.T ← HATCHERY SECTION

OTHER FACILITIES: BLOWER, GENERATOR, DORMITORY, SECURITY SHED

(all measurements are in mm)
FLOW CHART:
SEAWATER → PUMP HOUSE → SUMP → OHT → UV → HATCHERY

LEGEND
1. PUMP HOUSE / BLOWER
2. MATURATION SECTION
3. SPAWNING SECTION
4. HATCHING SECTION
5. LARVAL SECTION
6. POST LARVAL SECTION
7. OUTDOOR ALGAL SECTION
8. OFFICE
9. FRESH WATER PRAWN CULTURE

NAME: TRAVANCORE HATCHERY, KERALA
CAP: 30 MILLION
TECH: INDIGENOUS TAIWAN

(all measurements are in mm)
FLOW CHARTS: SEAWATER -> PUMP HOUSE -> RESERVOIR

OTHER FACILITIES: BLOWER, D.G. ROOM

LEGEND
1. MATURATION SECTION
2. SPANNING SECTION
3. LARVAL SECTION
4. POST LARVAL SECTION
5. OFFICE
6. BLOWER ROOM
7. PUMP HOUSE
8. RESERVOIR

NAME: AQUA PLAZA (P) LTD. KERALA.
CAP: 10 MILLION
TECH: INDIAN, Fig. 67

(all measurements are in mm)
Fig. 69. Circular maturation tanks of M/s MPEDA, Kerala.

Fig. 70. Sump in the maturation tank of M/s MPEDA, Kerala.
Fig. 71. Spawning section of M/s MPEDA, Kerala.

Fig. 72. Spawning room of M/s MPEDA, Kerala.
Fig. 73. Cylindrical FRP larval tanks of M/s MPEDA, Kerala.

Fig. 74. Rectangular post-larval tank (Brick wall) of M/s MPEDA, Kerala.
Fig. 75. Aeration through PVC pipes in PL tank of MPEDA, Kerala.

Fig. 76. Indoor algal section of M/s MPEDA, Kerala.
Fig. 77. Fluorescent lights and its arrangement for indoor algal culture in M/s MPEDA, Kerala.

Fig. 78. FRP Artemia tanks of M/s MPEDA, Kerala.
Fig. 79. Oil compressor used during power failure in M/s MPEDA, Kerala.
Laboratory of M/s MPEDA, Kerala.
FLOW CHART: SEAWATER → PUMP HOUSE → RESERVOIR → SLOW SAND FILTER → O.H.T → HATCHERY

LEGEND
1. OFFICE
2. LABORATORY
3. INDOOR ALGAL SECTION
4. MATURATION SECTION
5. SPAWNING SECTION
6. LARVAL & POST LARVAL SECTION
7. BORE WELL

NAME: CIBA HATCHERY, KERALA.
CAP: 5 MILLION
TECH: INDIAN

(all measurements are in mm)
Fig. 82. Maturation tank with filtration-cum-recycling system of M/s CIBA, Kerala.
LEGEND

1. QUARANTINE ROOM
2. FEED ROOM
3. MATURATION SECTION
4. SPawning SECTION
5. LARVAL SECTION
6. PACKING
7. ARTEMIA SECTION
8. INDOOR ALGAL SECTION
9. LABORATORY
10. STORE
11. OUTDOOR ALGAL SECTION
12. ISOLATION ROOM

FLOW CHART: SEAWATER → INFILTRATION GALLERY → RESERVOIR → TRANSFER PUMPS → UV → HATCHERY

PLAN

All measurements are in mm.
5.14. Role Of Vaasthu Shastra In Hatcheries:

The vaasthu shastra deals with the selection of sites, configuration of plans and dimensions, placement of rooms and selection of material for use. Standards were formulated for materials, workmanship and sizes of rooms with necessary heights of building to achieve conducive and efficient working atmosphere utilising the latest development in designs and construction techniques. Performance oriented codes relating to design, safety, structural sufficiency, health aspects and fire hazards. Many guidelines available in selection of sites on astrological consideration tally with engineering aspects in construction of buildings.

The colour, taste and smell of the soil, effect of topography of land indicating sickness, evil effects or retardation in prosperity, the shape and levels of land, presence/absence of space at site, the various positions of rooms/sections in the building, various aspects considered in fixing the data and time of construction, action of wind and its effect in the design of drainage system were reviewed (Reddy, 1994).

In the hatchery, the above principles were considered to orient broodstock ponds, maturation, larval and post-larval tanks, algal, *Artemia* sections, pumps, filters, blowers and generator rooms.

In general, vaasthu can function to certain extent to enable smooth operation of the hatchery. It is very difficult to possess all the characteristic features mentioned in the vaasthu shastra. The principle behind vaasthu
shastra cannot be compromised with that of the sequential arrangement of tanks in the hatchery system. Many hatcheries in India have failed to achieve good production due to emphasis and importance given only to vaasthu shastra without considering the technicalities in operation. This problem has been predominantly noted in M/s.SSV Aqua, Vizag, Andhra Pradesh and M/s.Giridhar Foods, Ramnad, Tamilnadu etc. Therefore, vaasthu shastra has to be judiciously followed while designing, implementing and executing construction work in order to suit both scientific and vaasthu principles to augment production.
5.15. **The Shrimp Hatcheries and their Status in Different Maritime States of India:**

In the recent past, several shrimp hatcheries with different production capacities have been established all along the coast line of India. About 206 hatcheries have been recorded in the present study (Table 3). The growth of shrimp hatcheries and their status in different maritime states of India are described below:

1. **West Bengal:**

There are Four hatcheries in the state (Table 3). Of these four, three hatcheries are in operation and one is under construction. Of the three hatcheries, two are inconsistent in production (Table 4) due to non-availability of broodstock and non-conducive environmental parameters. Out of 405,000 hectares of potential area in the state, only 34,050 ha., are utilised for shrimp culture (Table 1). The present production capacity of state hatcheries is only 65 million seed per annum. With the commission of hatchery under construction, it may be increased to 75 million seed per annum (Table 5) as against the demand of 3405 million seeds per annum, when the stocking density is considered at the rate of 5 PL/sq.m. There are two hatcheries of 30 million capacity (Table 5). The Philippines technology based hatcheries are found to be more than the hatcheries based on other technologies in the state (Table 6). The fluctuation in the cost of seeds as per the Government and private entrepreneurs are presented in Tables 7a & b.
2. Orissa:

The state has ten hatcheries. Of which eight hatcheries are in operation (Table 3). Of these eight hatcheries, three are inconsistent in production due to technical constraints and two hatcheries are under construction (Table 4). Only 7760 ha. are utilised for shrimp culture as against the total area of 31,600 ha. (Table 1). The existing production capacity of the hatcheries in the state is 425 million seed per annum. With the commmission of the two hatcheries under construction, it may be increased to 925 million seed per annum (Table 5) as against the requirement of 776 million seeds per annum, when stocking density is considered at the rate of 5PL/sq.m. Thus, the estimate reveals that the number of hatcheries in Orissa is sufficient, if 90-95% of the hatcheries are utilised as against the rated capacity. The hatcheries with production capacity of 50 million seed/annum are found to be more in the state (Tables 5). The Hawaii technology based hatcheries are found to be more than the hatcheries based on other technologies (Table 6). The fluctuation in the cost of seed was found to be similar to that of West Bengal.

3. Andhra Pradesh:

Eighty nine hatcheries are listed in the state of Andhra Pradesh (Table 3), of which 69 are in operation and 20 are under construction. Of the 69 hatcheries, 20 are inconsistent in production (Table 4). It is interesting to note that most of the hatcheries of the state are situated in three main regions, viz., Vizag, Kakinada and Nellore. There are 25 hatcheries in Vizag, 15 in Kakinada and 41 in Nellore. Eight hatcheries are distributed in different
regions of the state. The total extent of potential area available in the state is 150,000 ha., of which about 9500 ha. are utilised for shrimp culture (Table 1). The present status of production capacity of hatcheries in the state is 4760 million seed/annum. It may be increased to 6135 million seed/annum, if all the hatcheries under construction are commissioned (Table 5). Estimates reveal that 2850 million seed/annum are sufficient to stock in the potential area of 9500 ha. at the rate of 15 PL/sq.m. The surplus seed can be utilised by shrimp farmers of other states of the country. The hatcheries with production capacity of 50, 30 and 50 million seed/annum are found to be more in Vizag, Kakinada and Nellore of Andhra Pradesh respectively. Many hatcheries are found to adopt Hawaii technology followed by Philippines and Taiwan technologies (Table 6). The fluctuation in the cost of seed was found to be similar to that of West Bengal.

4. Tamilnadu:

There are 55 hatcheries in Tamilnadu (Table 3). Of the 55 hatcheries, 43 are in operation and 12 are under construction. Twenty hatcheries are considered sick units due to technical and financial constraints (Table 4). Most of the hatcheries in the state are located in three main regions, viz., Madras, Marakanam and Tuticorin. There are 29 hatcheries in Madras and its suburban region, 6 in Marakanam and 7 in Tuticorin. Further, 13 hatcheries are distributed in different regions of the state. The state has brackishwater area of 56,000 ha., of which only 530 ha. are utilised for shrimp culture (Table 1). The hatchery capacity in the state is 2497 million seed/annum and it may raise to 2792 million, when all the hatcheries under construction are
commissioned (Table 5). Estimates reveal that 53 million seed/annum are sufficient to stock in 530 ha. area, if the stocking density is considered at the rate of 5 PL/Sq.m. However, in reality, production has not been achieved due to technical constraints. The hatcheries with production capacity of 20, 30 and 20 million seed/annum are found to be more in Madras, Marakanam and Tuticorin of Tamilnadu, respectively. Hatcheries based on Japanese technology were found to be more than the hatcheries based on other technologies in the state (Table 6). The fluctuation in the cost of seed was found to be similar to that of other states.

5. Kerala:

Fifteen hatcheries have been recorded in Kerala (Table 3). Of the 15 hatcheries, 13 are in operation and two hatcheries are at the verge of completion (Table 4). Of the 13 hatcheries, 6 are inconsistent in production due to technical constraints and non-conducive environmental parameters. The state has brackishwater area of 65,000 ha. for shrimp culture, of which 13,400 ha. are utilised (Table 1). The existing production capacity of hatcheries in the state is 160 million seeds per annum and the production may be increased further upto 175 million seed/annum, when all the hatcheries under construction are commissioned (Table 5). The total requirement of seed/annum is 1340 million as against the existing production target of 175 million seed/annum. Heavy rain during monsoon, high labour cost, non-availability of broodstock and delay in the procurement of materials have led to the decline in shrimp seed production. Most of the hatcheries have production capacity of not more than 5-10 million seed/annum adopting Indian technology due to the
above mentioned constraints in the state (Tables 5 & 6). The fluctuation in the
cost of seed was observed to be similar to that of other states.

6. Karnataka:

There are 11 hatcheries in this state (Table 3). Nine are in operation
and 2 are under construction (Table 4). Of the nine hatcheries, five are
inconsistent in production due to non-availability of broodstock and
environmental constraints. It is interesting to note that most of the hatcheries
have been found to be established in Kumta region than in other regions of the
state due to the availability of technical personnel and entrepreneurs. The
state has a potential area of 8000 ha. for shrimp culture, of which 2570 ha. are
only utilised (Table 1). The production capacity of hatcheries in the state is 385
million seed/annum and it may be increased to 505 million seed/annum if all
the hatcheries are commissioned (Table 5). Estimates reveal that 257 million
seeds per annum are sufficient to stock in 2570 ha. as against the total
production capacities of 505 million seeds. Philippines and Hawaii technology
based hatcheries were found to be more than the hatcheries based on other
technologies in the state (Table 6). The fluctuation in the cost of seed was
found to be similar to that of other states.

7. Maharashtra:

The state has 16 hatcheries (Table 3). Ten hatcheries have been
commissioned in the year 1995. Six hatcheries are under construction. Of the
10 hatcheries, six are inconsistent in production due to non-conducive
environmental parameters (Table 4). The state has a potential area of 80,000 ha. for shrimp culture. Of which, 1980 ha. are under culture (Table 1). The existing production capacity in the state is 499 million seed/annum and it may be increased to 879 million seed if all the hatcheries are commissioned (Table 5). The total requirement of seeds to stock in 1980 ha. area is only 198 million/annum. The hatcheries with production capacity of 50 million seed/annum are found to be more in the state (Table 5). The Japanese and Hawaii technology based hatcheries are found to be more than the hatcheries based on other technologies in Maharashtra (Table 6). The fluctuation in the cost of seed is presented in Tables 7a & b.

8. Gujarat:

Five hatcheries have been recorded in the state (Table 3). Four hatcheries are in operation and one is under construction. Of the 4 hatcheries, 3 are inconsistent in production due to environmental and technical constraints (Table 4). The state has 376,000 ha. of brackishwater area for culture. However, only 360 ha. are used for shrimp culture. The existing hatchery capacity in the state is 195 million seeds/annum and it may be increased to 395 million seed/annum, when the hatcheries under construction are commissioned (Table 5). Estimates reveal that 36 million seed/annum are sufficient to stock in 360 ha. area. However, in reality production has not been achieved due to technical constraints. There are two hatcheries of 50 million seed/annum in the state (Table 5). Two hatcheries of Japanese technology and one each of Philippines, Hawaii and Indian technologies are present in the
state (Table 6). The fluctuation in the cost of seed was found to be similar to that of West Bengal.

9. Goa:

Only one hatchery is present and it is in the final stage of construction in this state (Table 3). The state has 18,500 ha. of brackishwater area, of which only 550 ha. are under cultivation (Table 1). The state lifts seed from Karwar, Kumta, Karnataka and other states for farming. Lack of technical personnel, non-availability of hatchery materials, heavy monsoon and non-conducive environmental parameters have led to the decline of hatchery establishment in the state.

From the present investigation, it has been found that there is an immense potential for shrimp seed production and shrimp culture. Growth of hatcheries in India was found to be dependent on (a) environmental site specific conditions, (b) availability of raw materials, broodstock at the appropriate season, (c) skilled manpower with proven technology, (d) financial and (e) political constraints.
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>State</th>
<th>Name of the Hatchery</th>
<th>Capacity (in Million)</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>WEST BENGAL</td>
<td>Ghosh Spawn Culture Enterprises Ltd.</td>
<td>10</td>
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<tr>
<td></td>
<td>Calcutta</td>
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<tr>
<td>2.</td>
<td>- do -</td>
<td>Larica Hatchery &amp; Fishery P.Ltd.</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>- do -</td>
<td>Multiwyn Aqua Farms P.Ltd.</td>
<td>30</td>
</tr>
<tr>
<td>4.</td>
<td>- do -</td>
<td>Neha Exports</td>
<td>30</td>
</tr>
<tr>
<td>5.</td>
<td>ORISSA, Puri</td>
<td>Chilka Aquatic Farms Ltd.</td>
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Table 4. Status of shrimp hatchery development in India.

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<th>Hatchery Under Construction (B)</th>
<th>Inconsistency in Production/sick Unit</th>
<th>Total No. of Hatcheries (A+B)</th>
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## Table 5. State-wise details of the various capacities of hatcheries of India.

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<th>500</th>
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<th>Total (in million) Capacity/annum</th>
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Table 6.  State-wise details of the various technologies adopted by the hatcheries of India.

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Table 7a. Standardised Government rates of shrimp seed during 1987-95.

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Sources: MPEDA Office at Tanjore, Kumta, Cochin and Vijayawada.
Table 7b. Standardised private entrepreneurs rates of shrimp seeds during 1992-95.

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Sources: NCC BPL, Veerat Aqua-Tech, A.P.; Giridhar Foods, T.N; Aqua Plaza, Kerala.
5.16. **Present Trend In Blue Revolution**:

The present trend in blue revolution with reference to shrimp hatcheries and farming in India are described below:

A. **Code of conduct for Responsible Fisheries**:

International conference on responsible fishing held in 1992 in Mexico with the collaboration of FAO prepared the International code of conduct relating to conservation, management development of all fisheries activity.

The codes for Aquaculture (FAO, 1995) are presented below:

1. States should consider aquaculture to promote diversification of income and diet with minimal adverse impacts on the environment and on local communities.

2. To maintain legal and administrative framework.

3. To develop genetic diversity and ecosystem integrity based on latest scientific information.

4. To ensure livelihood of local communities and their access to fishing grounds.

5. To undertake environment assessment to minimise adverse ecological changes and related economic and social consequences.

6. Efforts to be taken to minimise harmful effects of non-native species or genetically altered stocks used for aquaculture.
B. Transportation of shrimp nauplii:

Tiger shrimp nauplii were successfully air lifted from TASPARC and OSSPARC to Cochin, Kerala, in 1990 and 1991 respectively in oxygenated chilled (6°C) water in polythene bags. The survival rate was 95.4% as against 63.91% by surface transportation at the time of reaching destination. Further, the survival rate of airlifted nauplii in terms of production of PL20 was 28% as against 15-20% by surface transportation (Fishing Chimes, July, 1993).

C. Production of breeders/shrimp seeds:

M/s. Aquastride Bio-tech Ltd., Products and Marketing Division, Madras has embarked on a strategy to raise Indian Aquatic Biotechnology at global markets in 1992. They have established broodstock development bank at Visakapatnam, Andhra Pradesh. The company proposes to develop a special vaccine in collaboration with International Aquaculture Biotechnologies Ltd., Canada. The vaccine will be used to develop immune-resistance in breeders in order to prevent various diseases and thereby produce quality seeds (Fishing Chimes, Feb., 1995).

At Visakhapatnam, Andhra Pradesh, farmers have been facing problems in spawners paucity and migration of technical personnel. The hatchery owners have come forward to have segregated production so that some entrepreneurs will concentrate on any one section like spawner, nauplii or post-larval culture exclusively. Technical personnel use larger hatcheries to gain experience in hatchery operation techniques and disappear at crucial period. Therefore, necessary steps have been focussed to retain such
technicians by providing adequate facilities. Farmers have been focussed to create seed bank at co-operative levels, to establish nauplii rearing centre and reduce the load of rearing facilities in hatcheries (Aqua International, 1994).

D. Marketing:

The State Fisheries Department of Andhra Pradesh had proposed to establish sales centre at various locations of its coastal belt for which a consortium was arranged. The hatchery owners were invited to become partners in the shrimp seed sales network. This would enable them to book seeds from any centre of the state.

The Fishermen Association of Andhra Pradesh had agreed to supply shrimp breeders to hatchery owners at the rate of Rs.800/Kg as against the standard government rate for breeders at the rate of Rs.450/Kg. Representatives also stipulated that 25% of seed produced from each breeder should be released into the sea to compensate shrimp population (Fishing Chimes, Oct., 1993).
5.17. Recent Research And Development In Shrimp Hatcheries:

The research and development that took place in the recent past are presented below:

A. Aquaculture Research Foundation:

In Visakhapatnam, Andhra Pradesh, an Aquaculture Research Foundation has been established involving scientists working on shrimps and crustaceans. The foundation involves Government, Private entrepreneurs engaged in shrimp and aqua farmers along with MPEDA. The foundation is in collaboration with Zoology Department of Andhra University and Institute for Zoophysiology, University of bonn, Germany. It has also proposed to conduct research on the technological aspects on shrimp hatcheries and development in aquaculture. (Fishing Chimes, June, 1995).

B. Dietary cholesterol requirements:

At the National Symposium on Aquacrops, held from 16 to 18th November, 1994, Bombay, Chandge and Paulraj mentioned the dietary cholesterol requirements of larvae and post larvae (PL 1-10) of *Penaeus indicus*. The authors stated the optimum cholesterol requirement for larvae appeared to be 0.5% of the diet but higher for post-larvae. Artificial feed comprising 0.5% cholesterol was found to enhance the growth rate of larvae as compared to that of larvae fed with low/without cholesterol (Fishing Chimes, Feb., 1995).
C. Carotenoid aiding vigour in broodstock:

Researchers at Oceanic Institute in Hawaii have noticed that when broodstock is stocked in maturation section for several months, the ovaries bleach from red colour, producing high quality larvae to white colour with 10-20% lower survival rate. In shrimps, a blue colour was noted due to carotenoid deficiency in broodstock diet. Carotenoid was introduced into the broodstock diet with the addition of 'paprika', the highest resource of carotenoid astaxanthin, before feeding. This resulted in deriving healthy larvae, high survival rate along with improvised colour and shell hardness in broodstock ovary (Treece and Fox, op. cit.).

D. Enteromorpha to broodstock diet:

It has been recommended by some hatchery technicians to add enteromorpha (green algae) in the feeding regime which can be collected fresh from rocks below the tide level. Microwaving is suggested to pasteurize the algae before feeding to the broodstock. This algae is rich in carotenoids and hence, its utility has been found to achieve high survival rate (Treece and Fox, op. cit.).

E. Formulated feed for larviculture:

Scientists at the aqua feed quality control and development division, Department of Fisheries, Thailand, conducted experiments to determine the possibilities of using dry formulated feed with HUFA contents for larviculture of P. monodon. Six dry feeds were prepared and tried as against live-feed
supply to the larvae. The scientists also conducted experiments to investigate and determine the nutritional values of dry formulated feeds for *P. monodon* larvae in comparison with commercial feeds. Remarkable survival rate was noted in shrimp seeds fed with dry feeds (Fishing Chimes, Feb., 1996).

F. Alternative technology for shrimp larviculture:

Over the last few years the IFREMER and COFREPECHE/France Aquaculture, developed larval rearing technique based on exclusive use of micro-particulate feed as replacement of algae coupled with management procedures based on the absence of water exchange upto PL 1 (open system) or the use of biological filter to rear upto PL 5 (closed system). This has been applied on a commercial scale in new Caledonia and Madagascar. The micro-diets are used to ensure constant nutritional content supply as against microalgae which are found to deteriorate the quality of the culture medium. The investment is also reduced due to the absence of algal culture room, low production cost, simplicity of techniques and free from bacterial contamination (Info Fish International, 1995).

G. Immune enhancer for vibriosis prevention:

Shrimps are reported to have defence mechanism which enabled the scientists to develop vaccine and induce non-specific immunity. Immune enhancer is found to prevent bacterial establishment in the host and agglutinate them to increase the ability of phagolytic cells. The results stated that immune enhancer may work like bacteriostatic agent inorder to prevent
bacterial growth and also enhance phagocytosis or encapsulation of shrimp defence mechanism (Fisheries World, 1995).

H. 'Pen stim'- The Immunostimulator:

Dr. Newman, president for International Aquaculture Biotech, Canada, developed a product called ‘Pen stim’ which is an immunostimulator for larval stages of shrimps to increase survival rate, growth of shrimps and prevent diseases. ‘Pen stim’ is used in the ratio of 1:1000 parts dilution. The larvae are treated for 90 minutes with maximum aeration (Fishing Chimes, March, 1995).

I. Specific Pathogen Free Broodstock (SPF):

Dr. James A. Wyban, High Health Aquaculture Inc., Hawaii (Asian Shrimp News, 1993) involved with commercialisation of SPF stocks and transferring the technology to farms on world wide basis.

The SPF broodstock in US is free of readily diagnosible obligate pathogen viruses, viz., IHHNV, BP, HPV and protozoans (microsporidians, gregararians and haplosporidians) and metazoans. The broodstock programme involves rigorous procedures of quarantine and diagnostic screening based on one way flow production pyramid to confirm the absence of specific pathogen from the stock. Such SPF broodstock gives healthy nauplii or PL. The coefficient of variation for size is significantly reduced in high healthy shrimp when compared with IHHNV infected shrimps (Asian Shrimp News, op. cit.).
J. Gene probes:

Highly specific gene probes for IHHNV, HPV, BP and MBV were developed by Dr. Lightner (Asian Shrimp News, op. cit.) to detect sub-clinical and latent carriers broodstock or PL. It aids in the study of (i) transmission of diseases (vertical/horizontal) and (ii) pathogenic infection. The probes also determine the dissimilarities of virus with or without inclusion bodies in penaeids and non-penaeids respectively.

Dr. Joan E. Vickers and her group at University of Queensland (Asian Shrimp News, op. cit.) have developed a sensitive probe for MBV. A gene probe for YHV which has wide utility in the control of penaeid shrimp diseases is in the progress of development.

K. Cryopreservation techniques for shrimp culture:

The Madras University, Department of Zoology has developed cryogenic storage of gametes, embryos and larvae of crustacean. The cell components are frozen using liquid nitrogen or helium. To survive in this condition, cryoprotectants like ethyl alcohol, glycol, dimethyl sulphoxide are used. Crustacean sperm is cryopreserved at -196°C. For embryos and larvae, liquid nitrogen has been used at -40°C (Fishing Chimes, Aug., 1994).
The world wide demand for penaeid shrimp has increased over the past few decades. In India, most of the potential area is observed to be under utilised due to lack of proven technology, non-availability of broodstock, raw materials and skilled manpower, which inturn has observed to reflect on the hatchery development. Shrimp seed production increased from 0.08 to 1.5 billion between 1989 and 1994 respectively (MPEDA, 1995). However, in 1995, the trend has been observed to be in the declining phase due to various problems.

The technological concepts involved in various hatchery technologies were observed to follow two major aspects (i) in the utility of area and (ii) stocking density. The Japanese/Taiwan/Philippines technologies differed from that of the Hawaii technology in utilising more area with low stocking density of breeders/larvae in the tanks in order to produce healthy seeds and achieve high survival rate than the latter, which aimed at increasing the number of seed by increasing the stocking density in less area with high-tech system to consistently and continuously supply seed to the farmers. Thus, the preference in Hawaii technology based hatchery over other technologies was imminent. The Hawaii technology based hatcheries were found to be 44 on the east coast as against 8 on the west coast. The probable reason for the establishment of Hawaii technology based hatchery can be attributed due to the flexibilities in Government policies, conducive environmental factors and entrepreneurs. On
the West coast, small scale hatcheries with Indian technology were observed to be more prevalent than the Hawaii technology based hatcheries due to the absence of the above mentioned features on the East coast.

The engineering details on civil, mechanical, and electrical designs adopted by various technologies were observed to vary in the light of two main factors, viz., (a) maintenance and (b) economy. These factors are discussed below:

Various types of seawater intake system were designed based on the site condition. The intake system comprising pipelines with infiltration gallery laid by M/s. Giridhar Foods, Ramnad, Tamilnadu was found conducive for operation and maintenance apart from economy as compared to that of the jetty system constructed by M/s. NAEL, Nellore, Andhra Pradesh. However, it is to be noted that sites without social calamities and hatcheries with production capacity of 60 million, viz., M/s NCCBPL, M/s Chowan Exports, Vizag, Andhra Pradesh were operated efficiently with jetty system than infiltration gallery.

The rapid sand filter is preferred in modern hatcheries over slow sand filters because they are found to be efficient in filtration and automatic in backwashing process. On the contrary, the slow sand filters are found to take longer duration in filtration and involve laborious manual backwash.

The circular shaped reservoirs facilitate effective circulation of water and also evenly distribute chlorine (used for disinfection) in the reservoirs. Hence, circular tanks were preferred over rectangular tanks in large scale
hatcheries, viz., M/s NCCBPL, M/s SSV and Durga Hatcheries, Vizag, Andhra Pradesh. In small scale hatcheries, viz., M/s Travancore Hatchery, M/s Aqua Plaza, Trichur, Kerala, M/s Pioneer Aqua, Tuticorin, Tamilnadu, FRP/PVC (Sintex) tanks are generally used instead of concrete tanks, since they were found to be economical than the later.

The shape of the tanks varied with technological concepts. The present study revealed maximum production with high stocking density of larvae in parabolic tanks as against rectangular or square shaped tanks, since the former has been observed to be effective in circulation of water and augment waste material deposition at the bottom of the tank. Hatcheries, viz., M/s TASPARC, M/s SSV and Durga Aqua, Vizag, Andhra Pradesh achieved maximum production by constructing parabolic tanks. However, remarkable production can be achieved in rectangular or square shaped tanks if larvae are stocked at low density as experienced by M/s NAEL, Nellore, Andhra Pradesh.

The central drainage system of Hawaii technology has been found to be simple in design and operation than the collective drainage system of Japanese technology. The Japanese technology aims at draining wastewater as well as harvest post-larvae from four tanks in a common drain pit. However, in such a system, contamination was found to occur due to stagnation of water in the pit. Cross contamination was also noted when infected larval tank was harvested along with that of the healthy ones.

From the present investigation, it is evident that the wastewater treatment through biological filtration was found to be economical and also
found to cause no reaction to the environment as compared to the chemical treatment methods. It is also worth mentioning that till date, no hatcheries in India have implemented a proper treatment system.

In the light of mechanical and electrical designs, it has been observed that the selection of pumps, filters, blowers and other machinery were based on technological concepts and site specific condition. Thus, a standardised design irrespective of technological factors was not found possible to be implemented for a given hatchery.

The remedial measures for engineering design flaws were implemented in a few hatcheries, which audit technical aspects once in a cycle or when necessity arises. However, in most of the medium and small scale hatcheries, the technical flaws were un-noticed and remedial measures were not implemented causing serious damages.

The basic concept in hatchery operation techniques has been found to be similar in all technologies in broodstock, larval and post-larval sections. Variation in these sections were observed in the utility and quantity of materials required for operation. A major variation was observed in the spawning process. The Hawaii/French/German technologies adopting individual spawning process was found to be more successful in producing maximum number of eggs than group spawning carried out by Philippines, Taiwan and Japanese technologies, which occasionally failed to spawn due to cannibalism or disease outbreak in the spawning tanks.
Another major difference met with Hawaii and Philippines technologies is the utility of drugs. The Hawaii technology aims at preventing diseases in the hatchery by using prophylactic drugs, whereas the Philippines/Taiwan technologies aim at operating the hatchery only during 'disease-free' condition. A few hatcheries in India, viz., M/s Mac Industries Ltd., ITC-Minota Aquatech, Tuticorin, Tamilnadu and Kalyan Sea Foods, Kakinada, Andhra Pradesh were observed to use indigenous medicines comprising extracts of vegetable sources, viz., garlic and ginger. However, their utility in the scientific lines need to be substantiated.

The natural calamities, viz., salinity and temperature fluctuations during peak monsoon, winter and summer seasons were observed to be effectively solved through suitable measures in small scale hatcheries. It was found impossible in large scale hatcheries owing to their enormous size.

Although the designs and technology adopted are suitable for the successful hatchery operation, sometimes due to managerial problems, viz., poor monitoring and control of men and materials, lack of record maintenance, and performance appraisal, financial budget, projection/cycle, updated technology, marketing strategies and social harmony, hatcheries have been found to fail miserably with heavy losses.

Out of the seven basic hatchery technologies, the Hawaii technology was observed to achieve maximum production consistently with even sized seeds. A comparative statement on the cost benefit analysis of 18 types of hatchery technologies revealed 2.69-2.78 folds of increase in revenue as against
production cost/1000 seed in Hawaii technology than any other technology (Table 8). It is interesting to note that the hatcheries which utilised a combination of both Hawaii and Japanese technologies showed less folds of increase in profit than hatcheries based only on Hawaii technology due to the inadequate exposure of technicians to adapt and to execute the new technology, which is the combination of both these two technologies. The evaluation of suitability of technologies for Indian condition revealed that system-linked failure on par with unfavourable environmental condition do exist.

The role of vaasthu shastra was found to forecast the positive and negative aspects of the hatchery site and thus facilitate in taking precautionary steps to prevent any constraints in the hatchery operation/production. However, in India, many hatcheries, viz., M/s SSV and Durga Hatcheries, Vizag, Andhra Pradesh, M/s Giridhar Foods, Ramnad, Tamilnadu and M/s Skyline, Kumta, Karnataka were found to produce negative results due to the over emphasise given to vaasthu shastra principles without considering the technological aspects.

The growth of shrimp hatcheries in different maritime states revealed the status of maximum hatchery establishment with successful operation in Andhra Pradesh than any other states in India due to the availability of conducive parameters, transfer of viable technology and flexibility in Government policies adopting modified and semi-intensive shrimp farming practices.
In the recent past, the role of research and development and blue revolution have been found to play a major role in the growth of shrimp hatchery. Various research activities and guidelines were framed by the Government, statutory bodies and private entrepreneurs to enhance production of shrimp seeds in the hatcheries. However, due to lack of encouragement and financial support from the Government, demotivation from the anti-aquaculturists and political constraints have led to the decline in shrimp seed production.
Table 8. Comparative statement of the cost benefit analysis of 18 hatcheries.

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<th>Capacity (in million/annum)</th>
<th>Cost benefit Analysis (Rs. in Lakh)</th>
<th>Production cost/1000 Seeds (before interest) (Rs.)</th>
<th>Revenue/1000 Seeds (Rs.)</th>
<th>Profit in folds of increase/year</th>
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