NATIONAL CENTRE FOR SUSTAINBALE AQUACULTURE

MPEDA, Ministry of Commerce & Industry,
Govt. of India

Better Management Practices for Sustainable L.Vannamei Culture

NATIONAL CENTRE FOR SUSTAINABLE AQUACULTURE

(MPEDA, Ministry of Commerce and Industry, Govt. of India)

ISO 9001:2008

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Better Management Practices for Sustainable L.vannamei Culture

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NaCSA (MPEDA)- Sustainable Shrimp Farming

Shrimp Aquaculture has provided tremendous opportunity for economic and social upliftment of rural communities in the coastal areas of our country. Over a hundred thousand farmers, of whom about 90% belong to the small and marginal category, are engaged in utilization of the opportunity for their livelihood. However, the sporadic incidences of disease outbreaks, lack of access to technical skills and scientific applications, good quality inputs like seed, limited access to

services, and difficulties in complying with market requirements have compelled the need of adopting every means for conducting shrimp culture in an environmentally, socially and economically sustainable manner. Therefore, adoption of proper shrimp health management practices is the first step towards this direction. In this background, National Centre for Sustainable Aquaculture was established as an outreach organization of MPEDA to build capacity among small-scale shrimp farmers and to address shrimp health and quality management issues. NaCSA is building up a society of shrimp farmers and promoting Best Management Practices among them for sustainable aquaculture which ultimately results in strengthening our nations' economy.

Key Aspects of Sustainable Shrimp Farming:

The objective is to produce shrimp in a responsible and sustainable manner and at the same time minimize the risks and maximize the returns.
This objective will be attained by -

- Organizing a society of aquaculture farmers to implement all farming activities in a disciplined and cooperative manner
- Designing and constructing ponds at appropriate sites
- Developing basic infrastructure facilities
- Developing a crop calendar for coordinating all farming activities in a cluster
- Adopting better management practices

Better Management Practices:

1. After every harvest, sun dry the pond for 20-30 days till the soil cracks, clean the pond bottom by scraping the organic waste and make sure no black soil remains. Plough the soil thoroughly. Apply lime to neutralize soil pH.

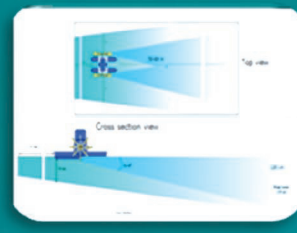
2. Filter intake water using 60 micron mesh at the inlet to prevent entry of disease causing pathogens. Ensure an average water depth of 80cm in the pond with slope inclined towards the outlet. Disinfect the intake water with 20ppm chlorination.

3. Procure high health PL of more than 10mm length from registered hatcheries. Select PL from batches that have high survival rates in salinity and formalin stress tests. Ensure the PL tested negative in PCR and EMS tests.

4. Bio-secure the pond by installing water filters, hand wash, tire wash, foot dip, crab fence, bird net. Clean and disinfect the equipment used between the ponds. Provide disinfection solutions like bleached water or $KMnO_4$ (one table spoon for 10 lit water) in one container and plain water in another container at the entrance of each pond. Workers should dip their hands and legs in $KMnO_4$ solution before moving from one pond to another even during check tray observation.

5. Observe check trays and feed only as per demand. Use boats or floating devices or auto-feeders for feeding. Reduce feeding during periods of low DO, plankton crash, rain fall, molting, extremes of temperature and during disease outbreaks.

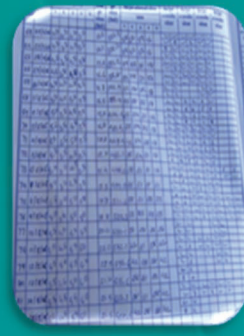
6. Use aerators where stocking density exceeds 30,000/ha. Ensure adequate aeration by placing aerators at appropriate positions in the pond. Aeration increases surface area of water and makes it absorb more oxygen. It also helps in minimizing sludge deposition. Fix aerators 3 m away from the dike. Ensure dissolved oxygen level does not fall below 4ppm.



7. Check shrimp quality, water quality and pond bottom on weekly basis. Remove any benthic algae. Sample the shrimp at least once a week by cast netting and check their growth and health condition.

8. If any disease signs are found, send samples to pathology lab. Remove any sick or dead shrimp and dispose safely to prevent spread of disease to other ponds.

9. Maintain records in hatcheries and farms to keep track of daily monitoring data as it helps in troubleshooting problems at early stages.



10. Complete the harvest in 4 to 5 hours and ensure the shrimp are chill killed. Use ice double the quantity of harvested shrimp to prevent decomposition processing on the way to processing plant.

11. Plant mangroves where ever they can be grown on the river and sea side of shrimp ponds to ensure land conservation and environment protection.
Mangroves are extremely important to our own well-being and to the health of the planet.

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Better Management Practices for Sustainable L.vannamei Culture

1. Pond Preparation

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Better Management Practices in Pond Preparation

The main objective of pond preparation is to provide the shrimp with a clean rearing environment and optimum conditions for their growth and survival. Effective pond preparation is an integral part of successful shrimp farming. Poor preparation can result in deterioration of the soils during the crop, with release of nutrients and toxic compounds to the water column, creating stress for the shrimp and possible environmental problems with the discharge of effluents. Good pond preparation is also a proactive measure for disease control and should be a critical aspect of disease management strategy. Pond sludge that accumulates on the pond bottom may also need to be removed before the next crop; the on-farm disposal of sediments must be done responsibly. Intensive shrimp farming requires a considerable quantity of feed to be added to a pond over the course of a crop (approximately 10 tons for a 5 ton crop). This massive input of organic material has the potential to overload the organic load in sediments and cause deterioration of the pond soils for your next crop. Pond sludge can accumulate in the centre of the pond because of the action of aerators and water currents during the crop and will appear as a mound in the centre of the pond when it is drained.

Key Instructions for Pond Preparation:

1. Completely drain out the water from pond. It helps in removing disease carrying crustaceans and other aquatic animals from previous crops of the pond.

Coordinate the same with neighboring farmers. Block the inlets and sluice pipes and other sources of water entry into ponds. Use pumps to remove any water logged inside the pond. Remove any snails, barnacles and gastropods manually.

2. Increase the water holding capacity of the pond. Bunds must be compacted well to prevent water seepage. If required, additional soil should be procured from outside to increase the bund height. Pond water depth must be maintained at a minimum water level of 1.2 meter at the middle of the pond Fix a wooden depth scale to monitor the water depth. There should be a free board of 30 cm from water surface to top of the bund.

3. Remove organic waste accumulated by the decay of unfed feed, dead and decaying plankton/algae and fecal matter of shrimp. This waste releases toxic gases like ammonia and hydrogen sulfide into the pond water and causes stress or death to shrimp.

Organic waste forms a black layer on the soil and is mostly accumulated at the feeding area, pond center and corners, and at the trenches. Completely remove it by scraping

when the soil is slightly wet. Dump the waste in the ditch created on the top of the bund and cover it with good soil. Make sure the dumped organic waste does not enter the pond through rain water. If it is difficult to remove the black soil completely, plough when it is wet and wait till it dries.

4. Sun dry the pond bottom till the soil loses its moisture. Sunlight and dryness kill algal spores, benthic algal mats, fish eggs and any predators potentially remaining in the soil. Coordinate to dry the neighbouring ponds simultaneously to prevent water seepage from other ponds. The pond should dry in hot sun for 20 to 30 days or more till its soil cracks.

5. Plough the pond 2 to 3 times with the gap of 2 to 3 days. It will help in oxidizing the organic matter and reducing gastropods. Tilling the pond bottom exposes more surface area of the soil, increases the effect of oxidation, and encourages more aerobic bacteria. The tilling process also generally assists in the breakdown of organic residues and nutrients that are locked up in the soil, making them more biologically available for the next crop. After tilling, compact the pond bottom to reduce the turbidity and seepage.

6. Wet pond preparation can be done when the ponds cannot be dried. Apply tea seed cake or chlorine (20 ppm). Before ploughing, take out all dead animals. Use a tractor with gauge wheels to plough the pond with 15 to 20 cm water. After ploughing, drain out the water from the pond.

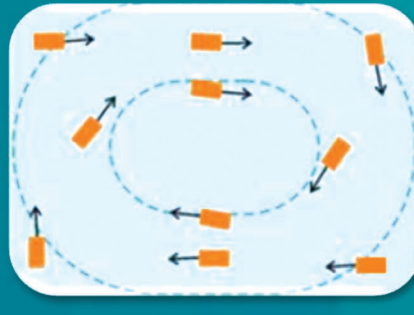
7. Fertilization and liming of the pond bottom will help in improving mineral content of the pond bottom especially in ponds with low soil fertility and ponds which are in culture for more than 10 years. Apply dry vermicompost 250-1000 kg/ha or compost manure. Spread the vermincompost or compost manure all along the pond bottom. Do not use poultry manure or raw cow dung for fertilization.

Apply lime to maintain soil pH. Use a soil pH meter to test the soil pH. Soil should be wet while using the equipment. The levels of lime application during pond preparation depends on the pH of the soil. Follow dosages given in the table below:

Soil pH	Quantity of Burnt lime - CaO (kg/ha)	Quantity of Agri lime - $CaCO_3$ (kg/ha)
5.0	200	400
5.5	150	300
6.0	100	200
6.5	50	100

Spread the lime all along the pond bottom and along the slopes of the pond bund. A large proportion of the lime needs to be applied along the feeding areas and on the wet portions of the pond. When applying lime, farmers and workers should wear face mask. If the soil pH is more than 7, there is no need for lime application.

8. While installing aerators, follow a proper layout to achieve the maximum flow of pond water with the minimal energy input. Poor layout of aerators in the pond can lead to erosion of the pond walls or bottom and significantly increase the amount of sediment in the sludge mound by the end of the crop. This can decrease the life span of ponds and increase maintenance costs.



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2. Water Quality Management

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Better Management Practices for Water Quality

Water quality at the intake point is a vital consideration in successful shrimp farming. The site should have access to an unpolluted estuarine or marine water supply, with an optimum salinity range of 15 to 25 ppt. Seasonal effects of rainfall and evaporation can cause fluctuations, but salinity should not be less than 1 ppt or greater than 35 ppt (average salinity level for seawater). Areas of tropical coasts that experience extended dry seasons will be particularly prone to high salinity in ponds, which can slow growth rates and subsequently increase production costs. The optimum range for pH of the water source is 7.5 to 8.5. The pH of estuarine waters can be affected by acid sulfate soils and other local soil factors. Water sources affected by significant coastal pollution from industry, urban areas, agriculture and water treatment facilities should be avoided. A very important aspect of the intake requirements for a successful shrimp farm is access to sufficient quantities of seawater. Before choosing a location as a pump station site, one may need to determine whether sufficient daily volumes will be available for the design and size of the farm considered. A good water quality monitoring program will give additional tools to manage growth, survival, health and productivity of the crop .The monitoring should be:

Systematic

— it is done at the same place, same time each day or month

— it is conducted repeatedly and consistently

Responsive

— information is available at any time

— it is user-friendly so that others can understand it

Interactive

— it gives feedback on crop progress

— it enables analysis of disease problems caused by previous events

— it can provide ability for rapid response to situations

Predictive
— it can be used for future planning and decision making.

Key instructions for Water Quality Management:

1. Screen the intake water as it is important to keep the disease carriers away. Use water reservoir is in the 3:1 ratio (pond area : reservoir area). Start water pumping not more than 20 days before stocking date. Pond should be filled with water within 4 days. At the time of water pumping, screen the water with 3 levels of twin screens.

Foot valve should be placed in bamboo basket or metal cage and it should be covered with 20 size mesh to prevent large animals getting into inlet mesh. Use double layer of 60 size filter mesh at water inlet point. Tie filter nets properly to the delivery pipe. Provide additional two layers of 80 size mesh hapa below the inlet.

Depending on the pumping capacity increase, the surface area of the filter nets. Every day the meshes should be properly washed away from pond, and the waste should be disposed properly. Meshes should not be washed in the rearing pond . After washing, dry the filter nets and they should be checked thoroughly for any damage, if damages are found, better to replace it with new meshes. Always keep extra filter nets ready at farm. Keep the feeder canal clean. After filling the pond, hold water for 7 to 10 days before stocking the seeds. The filter nets must be maintained throughout the crop.

2. Do not use pesticides to disinfect or kill fish, shrimp and crabs in the pond. Pesticides will enter and remain in the body of shrimps and when consumed cause health problems in humans. Pesticide-contaminated shrimp are BANNED in the international market due to serious health hazards. If necessary use Tea seed cake @ 10 ppm (50 kg/ha at 0.5 m water depth) to kill unwanted fish in the pond.

3. Fertilize the pond water to produce good plankton bloom which is essential for successful shrimp culture. Plankton bloom shades the pond bottom and prevents the growth of benthic algae. It provides the darker environment which is less stressful for shrimp. Make sure pond is filled to minimum 1.2 m water level at the centre prior to stocking of seed. One week after the water is filled, bloom normally develops in vermicompost/compost manure applied ponds.

If the colour of the pond water is clear, carry out chain dragging once a week to stabilize the plankton bloom. Add 200 kg of Dolomite per hectare during sunny period. Apply 2 days fermented mixture of rice bran, jaggery and quality brewers yeast @ 25 kg+10 kg+0.25 kg/ha in doses for three days during the morning period. Spread the fermented mixture across the pond using a floating device.

When the colour of the water is green the pond is ready for stocking. If there are benthic or floating algae in the pond, remove them. The best approach is manual removal.

Do not heavily fertilize the water to get dark green water. It will reduce the oxygen in water during night time thus suffocating the shrimp. It is one of the reasons for lower survival rate of shrimp seed. During the first month of culture, whenever the water colour intensity reduces (Secchi disc reading of more than 50 cm), add fermented mixture of rice bran, jaggery and yeast @ 25kg+10kg+0.25 kg/ha.

Do not carry out chain dragging from the day of seed stocking until 45 DOC. After 45 DOC, follow chain dragging of entire pond phased over 3 to 4 days at least once a week.

4. Water quality parameters that are known to be important in the health of aquatic animals are temperature, dissolved oxygen, pH, salinity, ammonia, nitrate, nitrite, hardness, alkalinity, turbidity and the levels of toxic agents such as heavy metals, herbicides and pesticides. For the maintenance of good health and growth rate of shrimp, the generally accepted ranges of the critical water quality parameters are provided below.

Water Parameter	Optimal Range
Dissolved Oxygen	> 4 mg/L
Temperature	28 - 32 ^{0}C
pH	7.5 - 8.5
Ammonia (Total)	< 0.5 mg/L
Nitrate (NO_3)	1 - 100 mg/L
Nitrite (NO_2)	<0.1 mg/L
Salinity	10 - 25 ppt
Hardness (Total)	>2000 mg/L
Alkalinity	100 - 120 mg/L
Turbidity (Secchi disc)	30 - 40 cm
Calcium/Magnesium	100/200 mg/L
Hydrogen Sulphide	<1.0 mg/L

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Better Management Practices in Seed Selection

A critical stage in shrimp farming cycle is the selection of good quality post larvae (PL) and their subsequent stocking in ponds. Failure to achieve good post-stocking survival of your post larvae can reduce your harvest potential from the start of the crop, thereby reducing profitability. If post-stocking survival is low one may be forced to decide whether to restock (if additional post larvae are in fact available) or continue with a sub-optimal stocking. The decision is made more difficult by the fact that by this time in the year the growing season is usually well advanced, and, as many farmers have found from bitter experience, shorter grow-out time resulting from late season stocking typically results in smaller shrimp at harvest. The first step towards optimizing stocking success is selection of high quality post larvae.

Key Instructions for Seed Selection & Stocking

1. Avoid wild seed and seed from poorly managed commercial nurseries. It has high chances of importing disease. Stock same batch of seed. Avoid different batches of seed from different hatcheries. Stock the shrimp seed only one time per crop. Do not continuously stock with new batches of seed.

2. Select a good registered hatchery to procure specific pathogen-free (SPF) post larvae that. Hatcheries should be designed (or modified, in the case of existing hatcheries) to ensure good bio-security. A well designed shrimp hatchery consists of separate facilities for quarantine, maturation, spawning, hatching, larval and PL rearing, indoor and outdoor algal culture, hatching of Artemia and feed preparation. Hatcheries should have bio-security system to prevent introduction of disease.

Single brooder spawning must be followed. Where only one animal is kept in a spawning tank for spawning. This helps in reducing disease contamination. Hatcheries should maintain management records.

Farmers should check the previous screening records of gravid shrimp for MBV and WSSV. Hatcheries should not use banned chemicals/antibiotics. Each hatchery should have its own set of Standard Operating Procedures. Hatchery should allow access to farmer representatives at any time to observe the tanks. Hatchery should provide proper invoice/certificate for purchase of seed. Farmer should be given a choice to reject the seed (if poor quality) till the time of packing.

3. Test the gravid for disease. Individual brooders must be transported in special brood stock transportation bags filled with oxygen, sealed and placed on ice within insulated foam boxes to maintain temperature of <29^{0}C. Farmers must ensure the same during visit to the hatchery. Brood stock must be screened for MBV before keeping the animal for spawning.

Brood stock must be screened after spawning for WSSV by collecting pleopods along with scum in disposable ampoules for PCR testing in labs that have successfully completed the ring test (Get the latest list of successful PCR labs from NaCSA/MPEDA).

Only the eggs/Nauplii tested negative for WSSV and MBV, must be used for further production of PL. Positives should be discarded after disinfection.

4. Select healthy shrimp seed. Observe the PL in a bowl by taking samples from different locations in the PL tank. Switch off the aeration briefly in the tank while taking samples. Tanks having dead pieces or showing reddish coloration should be rejected, PL tanks having good survival indicates good health of the stock. Prefer PL 15-16 stage (total body length should be >12 mm). Smaller sizes may not be ready for stocking and may not survive in the pond.

5. Shrimp seed should be uniform in size and dark or light brown in colour. Seed with red, blue or green colour must be rejected. Shrimp seed should be strong and active. Collect about 500 PL from the bottom of the tank and pour in a round tub. Stir the water. Wait for 1-2 minutes. If many seed concentrate in the centre then do not select that seed batch. Shrimp seed should pass a salinity stress test. Collect about 100 PL in a glass with tank water with ambient salinity (28 to 32 ppt) , and pour equal quantity of fresh water. Wait for 30 min. If 100% of the seed survives, then select the seed batch. Shrimp seed should pass a formalin stress test. Collect about 100 PL in a glass containing 100 ppm formalin (0.25 ml of commercial formalin/L). Wait for 1 hour. If more than 90% of the seed survives, then select the seed batch. Select the seed batch which passes the above stress test for PCR test. Also test the PL for presence of antibiotic residues.

6. Test the seed for disease and healthiness. Shrimp seed may have pathogens like WSSV. Viral related disease can cause mass mortality of shrimp in ponds. The unhealthy seed will result in poor survival and growth in ponds. Collect and pack about 500 PL in a seed bag and send to a shrimp diagnostic laboratory which successfully completed ring test for disease testing. The result should be negative for MBV/HPV by wet mount and WSSV by PCR test. Take only batches which test negative for both MBV and WSSV.

Laboratory Standards for PL selection

Parameter	*Standard*	*Method*
WSSV	*Absent*	*2 step Nested PCR*
MBV/HPV	*Absent*	*Wet mount/PCR*
Stress Test	*100%*	*50% Salinity drop for 30 min*
	>90%	*100 ppm formalin for 1 hr*
Muscle to Gut	*4:1*	*Microscopy*
Hepatopancreas	*Full with oil globules*	*Microscopy*
Gut	*Full & without Gregarines*	*Microscopy*
Necrosis	*Absent*	*Microscopy*
Fouling	*Absent*	*Microscopy*
Dorsal Rostral	*>5*	*Microscopic*
Total Length	*>12mm*	*Physical*
Size variation	*<5%*	*Physical*

7. During seed packing and transportation do not mix the seed batches from different PL tanks of a hatchery or from different hatcheries. The salinity of PL tank water and pond water should be the same and should not differ by more than 2 ppt. Prior to packing the seed, adjust the salinity of the PL tank water to the salinity of pond water. Start adjusting the salinity in hatchery at PL-5 stage and complete the process of adjusting at least one day prior to seed packing. Seed bags should have minimum 5 L water and enough oxygen (water : oxygen = 1:3). Do not pack more than 1000 PL per bag. Add Artemia in the seed bag to prevent cannibalism.

Seed bags should be transported in thermo coal box or plastic tubs. Mark the seed bags/boxes from different larval tanks. Transport time from hatchery to ponds should be less than 6 hours. If transportation time is longer, slightly reduce the temperature by placing ice bags in between two polythene layers of seed bag. Transport during cool hours (7 pm - 7 am).

8. Seed should be stocked in pond during cool hours of the day i.e. after 8 pm and before 8 am. Make sure the plankton bloom is good and stable (green colour water). Avoid stocking if pond has transparent water or dark green water. Allow to acclimatize the seed for temperature to pond water for 30 minutes by floating the bags in the confined area in the pond. Take the disinfected 500 L flat bottom, round tank and fill it with pond water up 50%. Oxygenate the water using oxygen cylinder. Open the seed bags & release the seed into the tank. Treat the PL with 100 ppm formalin for 15 minutes. If moulting is observed or the seed transportation period is more than 6 hrs do not treat with formalin. After treatment, stir the water to create a swirl. All the dead and weak PL concentrate at the bottom-centre of the tank. Siphon off dead and weak PL using 1inch flexi hose. Siphon rest of the healthy PL to the grow-out pond using 2 inch flexi hose. Do not release seeds where water is turbid or shallow. Keep 100 PL in two small hapas and check the survival after 48 hrs. If the average survival is less than 70%, one may have to plan for restocking.

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4. Biosecurity & Shrimp

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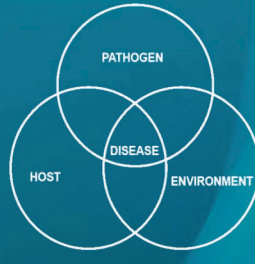
Best Management Practices for Biosecurity & Shrimp Health Management

Biosecurity is preventing the introduction, establishment and spread of unwanted biological organisms or agents. In the context of shrimp farming, biosecurity is about managing dangerous disease risks. Biosecurity programs can be applied at several levels, including pond, farm, locality and so on, up to national levels. Biosecurity measures should be part of every shrimp farm's health management program. Shrimp farm biosecurity involves applying sets of targeted, science-based procedures to eliminate or reduce the risk of a particular pathogen that is, a disease-causing infectious agent such as a virus —

(a) entering the farm, and
(b) spreading within a pond, between ponds, to other farms, or to the wider environment.

Pond factors that can lead to disease:



Because of the costs (in time and money), many farmers generally implement biosecurity programs to reduce the risks associated only with dangerous pathogens. In an ideal world, they might aim for zero risk, but in reality they will need to balance the costs of any biosecurity program against the uncertain costs of future disease outbreaks. Development and implementation of a biosecurity program therefore requires a clear appreciation of the technical issues and involves compromises in which costs and benefits must be carefully considered.

Effective will implementation requires long-term commitment from the farmer as well as discipline from the farm workers. Effective biosecurity relies on a secure farm design, hygiene and quarantine, regular health testing, record keeping, and control of disease vectors. Using specific pathogen free (SPF) seed is the first important step in reducing risk.

Key Instructions for Biosecurity Implementation and Shrimp Health Management:

1. Stock only post larvae that have acceptable test results in terms of pathogen absence. Do not exceed optimal stocking densities. Eliminate or reduce risk from potential vectors (infection carrying agents) on the farm. Use water management practices that prevent or reduce contamination by the pathogen. Reduce the risk of spreading infection between ponds by restricting movements of people, equipment and other possible agents. Implement a health management program that

2. Install Physical barriers to prevent crabs, birds and other animals. To protect from crabs, pond should be covered with crab fence (gill nets with mesh size of less than 1 cm) of more than 0.5 meter height. To avoid the contamination from birds, bird net should be provided at the height of 2 m from the dyke. Red coloured plastic wire with 0.5 mm thickness is preferred. The gap between bird lines should not be more than 10 cm. There should not be any gap between crab fence and bird fence. It is preferable to provide the fence around all the farms in the neighbourhood to avoid the animals, which may lead to cross contamination. Care should be taken not to obstruct access to pathways for local community.

3. Follow farm sanitation and hygiene. Area surrounding the farm should be kept clean. Garbage and other farm waste need to be managed through recycling and biodegradation. Each Society should have a toilet in good sanitary condition, and toilet should be located 20 to 30 m away from farm area. Farm must avoid contamination of domestic sewage into grow-out pond, reservoir and canal. Do not use any animal manure. Provide the disinfect solutions like bleached water or $KMnO_4$ (one table spoon for 10 L water) in one container and plain water in another container at the entrance of each pond. Workers should dip their hands and legs in $KMnO_4$

solution before moving from one pond to another even during the check tray observation. Use separate, marked equipment for each pond (nets, feed buckets, water sampling jars, feeding float etc.) to eliminate the risk of contamination between ponds. In case separate equipment are not available disinfect them with bleached water or KMnO4 solution (one table spoon for 10 L water) before using in another pond. Each pond should have a separate water sampling container. Maintaining a healthy pond bottom is essential. Check the pond bottom on weekly basis and remove any black soil or benthic algae accumulated at pond corners. Do chain dragging to get organic matter oxidized.

4. Assess the health of shrimp by checking feed trays on daily basis. If there is poor feed consumption for consecutive three to four days, it indicates health problem of shrimp. Check the general health and growth of shrimp collected by cast net on weekly basis. Carry out sampling during early morning or late evening at different places. The shrimp should be clean with normal colour, have a full gut and without any infection of legs or antennae. Gut content of >80% of the shrimp sampled from a healthy, recently fed pond should be full of food. If not, it could be an indication of onset of disease. If there is antennae cut with out black tip, check under feeding. If the antennae tip is black it could be bacterial infection due to poor pond bottom. If the gills of shrimp are black it means that the pond bottom is not clean. Check shrimp for external fouling i.e. is growth of organisms and accumulation of debris on the surface of the shrimp. Improve water quality to encourage shrimp to moult regularly. Check if the shrimp have black spots. The causes could be localized bacterial infections like Vibriosis, fungal infections (e.g. Fusarium species), high nitrite levels, acidic water.

Shrimp coming to the side or surface of the pond, lethargy, lack of appetite, discoloration-either red or blue are all symptoms of potential disease. Improve pond water quality. If shrimp have dirty or black gills, reduce feeding and exchange 10 cm of water. Check the pond daily during early morning hours for sick or dead shrimp or other signs (oxygen problems or any other unusual observations).

If there is antenna cut, fouling or gill problem, corrective measures to improve general pond condition should be carried out. If the shrimp have white spots do not let water out and inform all neighbouring farmers immediately. Do not panic in emergency situation, co-ordinate with other farmers. Farmers should implement agreed emergency action plan in case of white spot disease outbreak. Immediately isolate the affected pond.

If the size of the shrimp is small, do not abandon or drain the pond. Disinfect the affected pond with 20 ppm chlorine. Keep the water for one week without discharge. If the size of the shrimp is harvestable, harvest all the shrimp without draining the water. Disinfect the affected pond with 20 ppm chlorine. Keep the water for one week with out discharge. When the disinfected water is discharged after a week, inform neighbouring farmers and ensure that water is not pumped in at least for two days. Put up bird net to prevent birds picking up dead shrimp and carrying it to other ponds.

Care should be taken to collect all the shrimp in the pond to prevent spread of disease. Dead and moribund shrimp should be buried under soil away from the pond area. Necessary precautions should be taken to avoid transfer of shrimp or equipments or anything used in the disease-affected pond to other ponds. Do not stop feeding the normal ponds during disease outbreak. Without feeding, shrimp get weak and susceptible to disease. Cooperation and communication with neighbouring shrimp farmers and farm workers should be practiced with regular meetings on disease problem to prevent the spread of disease.

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5. Feed Management

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Better Feed Management Practices

Feed management is one of the most important aspects of successful shrimp production as the feed accounts for 50 to 60% of operating cost.

Key Instructions for Feed Management:

1. Check the date of manufacture on feed bag upon its arrival. Feed should not be more than 90 days old form date of manufacture. Start feeding from the day of seed stocking. The starter feed (crumble) should be mixed with little water to distribute easily and to ensure that it sinks rapidly. Determine the pellet size based on the size of shrimp. A mix of two feed sizes should be used for at least 4 days-while switching from one feed size to the next. Feed quantity on daily basis should not exceed the quantity that is indicated in the feed chart given along with the feed bag. Weigh and record the feed quantity to be given accurately in the pond record book.

2. Reduce feeding during periods of low DO, plankton crash, rainfall, molting, extremes of temperature and during disease outbreaks. Active swimming of shrimp around the edge of the pond during day light hours (but not at the water surface) could indicate under feeding. If you observe this consistently, check the feeding rate and increase accordingly. Install feed trays after 10 days of stocking and monitor the feeding from 20 days. Do regular sampling of shrimps once a week

after 45 days to determine growth rate and to calculate FCR. Never overfeed. Never mix any antibiotics with the feed. No need to mix any additives to the feed as long as feed is fresh and of good quality.

3. During the first 10 days of culture, feed should be spread within 2 to 4 m from the edge of the pond. Use scoop for wide distribution of the feed. After the first ten days the shrimp move in to the main part of the pond. Spread the feed all over the pond by using boat/floating device; not just spread on the sides and shallow parts of the pond. Check the pond bottom soil on a regular basis and avoid feeding in areas with black and badly smelling soil and in corners.

4. Feed should be supplied to clean areas in the pond. In the ponds with the aerators, feed in the areas cleaned by the water movement. It is preferable to switch off the aerators just before feeding until 2 hrs after feeding, based on stocking density. If Auto Feed transmission had been arranged, feed need to be verified in storage and timing needs to be adjusted according to check tray observation.

5. Use feed trays to monitor feeding. Use 4 to 6 preferably stainless steel feed trays (round shape with 80 cm diameter) per ha pond to monitor the feed consumption by shrimp from 30 days onwards. Feed trays should be placed on the pond bottom 2 m away from the slope of the pond bund, aerators, sluice gates and pond corners. Provide feed in feed trays and check as per the feed chart given below. Record the feed quantity, brand and batch no in the pond record book. Release the check tray slowly in to the water to prevent the feed from scattering. Ensure check tray settles on the pond bottom. If greater than 25% of feed remains on the tray suspended the next feed; if 10-25% feed remains on the tray, decrease feed by 50% for the next feeding; if less than 10% of the feed remains on the tray, continue feeding as scheduled; and if no feed is found on remaining on the trays increase feeding approximately 5% for the next feeding.

6. There are several factors, other than survival which affect feed consumption in trays. When the reduction in feed consumption is noticed check for
-Deteriorating water quality and pond bottom
-Competitors in the pond
-Quality of the feed
-Moult cycle
-Temperature, salinity and rainfall
-Diseases

If consumption drops drastically and does not improve within two to three days then check for any health problems. After feed tray observation, keep the check trays clean and dry. Ensure the net in the feed tray is not damaged. Examine the gut content colour and take corrective actions as given below.

Gut content colour	Probable food item	Probable cause	Corrective action
Black	Benthic detritus, sediment	Under feeding; inadequate feeding frequency	Increase feeding and frequency
Dark Brown			
Red	Cannibalized body parts from dead shrimp	Disease event in pond	Check for dead shrimp in the pond
Pink			
Green	Benthic algae	Under feeding	Increase feeding
Pale	Manufactured feed or natural feed	Gut infection	Reduce feeding
White			
Light Brown	Manufactured feed	Normal	None
Golden Brown			

7. Store feed in clean, cool and ventilated area well protected from sunlight. Keep bags stacked neatly on pallets (no more than 10 bags per stack) 30 cm away from walls and prevent them from being in direct contact with damp floor. Avoid excessive handling of feed bags, and always handle with care. Pelleted feeds are durable but not indestructible. Excessive or rough handling increases incidence of fines, thereby increasing feed losses. Maintain different types of feeds separate and clearly marked. Rotate stock using older feed first (feed that has been stored the longest). Follow the "first in, first out" principle. Feed should ideally be used within the first 2-4 weeks after manufacturing, and should not be stored for more than 2-3months. Keep the store and outside premises clean and use traps to prevent rodents. Do not keep any fuel or liquid items in the feed store. It is important to protect feed bags from sunlight and rain, by storing them off the ground in simple, pond side storage sheds. During the rain proper care should be taken to prevent feed bags getting moist. Store the empty feed bags properly and recycle them by selling to traders.

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6. Aeration

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Best Management Practices in Aeration

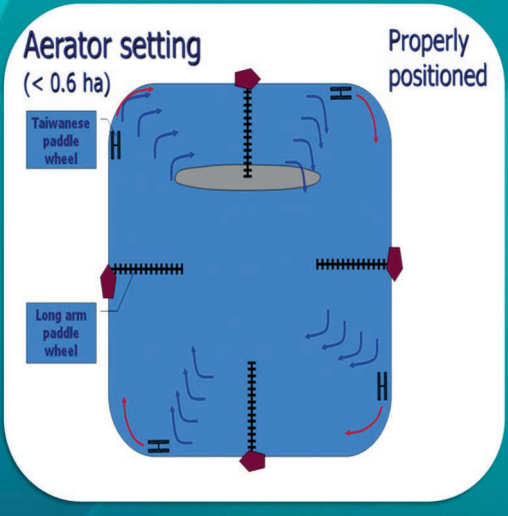
Pond aerators and water movers play a critical role in setting up a desirable culture environment for prawns in large ponds. They are primarily used to maintain adequate oxygen levels and gaseous exchange. They also keep the pond water column well mixed and prevent stratification so that the water quality is consistent throughout the pond. The circular flows that are generated by aerators will also concentrate slow-settling wastes (such as silt, algae and feces) towards the centre of the pond, creating a mound of sludge that will be visible when you eventually drain the pond at harvest time. This mound should ideally be less than 40 m in diameter (1200 m^2) in a 1 hectare pond. The faster currents around the periphery of the pond sweep the pond bottom and keep this

feeding area free of excessive organic debris. Aerators can be installed in position with tall stakes hammered into the mud, or with long ropes to the bank. The layout of pond aerators should be designed to achieve the maximum flow of pond water with the minimal energy input. In square ponds, the use of at least four aerators, each positioned 15–18 m from the sides at each corner, allows sufficient water supply to the aerator and minimizes bank scouring. One of the most common mistakes is placing paddlewheel aerators too close to the banks or corners where it is

perceived that currents are tracking past in the generally circular pattern that develops. Directing flows across the path of another aerator should be avoided because this creates eddies and deposits wastes in places other than in the centre. Positioning in odd-shaped ponds needs to be undertaken on an individual basis, possibly by trial and error.

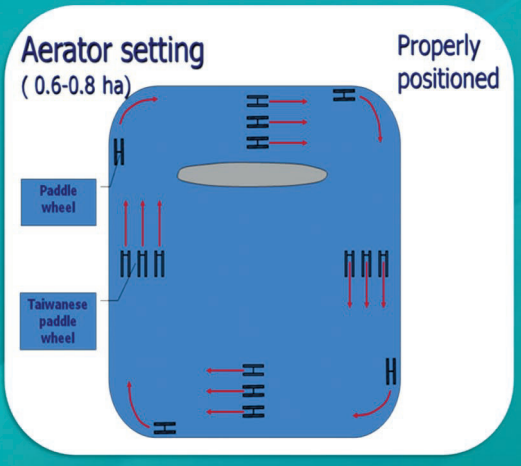
Key Instruction for Better Aeration Management:

1. Use aerators where stocking density exceeds 30,000/ha. The use of aerators in pond has a strong influence on the maximum yield that can be achieved from the pond. Dissolved oxygen (DO) concentration should be more than 4 ppm. If concentration falls below 4 ppm during night and early morning, use aerators. If oxygen levels deplete in the pond, shrimp will start swimming near the water surface especially during early morning.



2. Use 1 hp aerator for every increase in 400 kg of shrimp biomass in the pond. For biomass less than 500 kg in extensive ponds there is no need for aerators. Fix aerators at least 3 m away from the dike. Maintain the aerators RPM 80 to 100. Aerator should be positioned correctly and operated efficiently to minimize pond dike erosion and suspension of pond bottom sediments.

3. The position and orientation (clockwise direction) of the aerators should encourage maximum water flow within the pond. It should be adequate enough to concentrate waste in the centre of the pond. Aeration can be used while application of lime and fermented juice into the water. Stop aeration during



feeding and chain dragging. If for any reason of mismanagement or equipment failure, the dissolved oxygen levels falls below 3 ppm, first increase mechanical aeration, and as the last choice perform water exchange. Aeration is required usually after 30 days of culture and during late evening to early morning period. Regular aeration is a better practice. In farms with lower stocking density, low dissolved oxygen is mainly the result of organic wastes at the pond bottom, especially from un-removed sludge, dead benthic algae and excessive feeding. In such conditions, aeration should be provided when shrimp start surfacing or the bottom soil quality is bad and water has more turbidity and dark colour.

4. Suggested operation of aerators in shrimp ponds:

Days after stocking	Aeration Requirement	Running Time
1 to 30	During cloudy days/during rain/ when less bloom	
30 to 60	During cloudy days/during rain	4 to 6 hrs at night every 2 to 3 days
60 to 90	As above	Every night for 8 hrs
90 to harvest (For biomass of <1.5 ton/ha)	As above with additional aerators	Every night for 8 to 12 hrs, 1 to 2 hrs before feeding
90 to harvest (For biomass of >1.5 ton/ha)	All day every day except around feeding	

5. Poor layout of aerators in the pond can lead to erosion of the pond walls or bottom and significantly increase the amount of sediment in the sludge mound by the end of the crop. This can decrease the life span of ponds and increase maintenance costs.

6. The oxygen transfer efficiencies of the aerators in kilograms of oxygen transferred per kilowatt-hour of power applied to aerator shafts is presented below for the basic types of aerators:

Type of aerator	Average oxygen transfer efficiency (kg O_2/kWh)
Paddle Wheels	2.13
Propeller-aspirator-pumps	1.58
Vertical pumps	1.28
Pump sprayers	1.28
Diffused air systems	0.97

The purchase prices of different types of aerators do not differ greatly per kilowatt of motor size. Therefore, paddle wheel aerators will transfer oxygen to pond water at a lower cost than other types of aerators. However, all types of aerators have been used successfully in aquaculture.

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8. Harvest Management

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Better Harvest Management Practices

Maintaining the freshness and edible quality of harvested shrimp is very important for the export market. Simple planning and preparation for a harvest can make the work much easier and prevent costly mistakes that may result in wastage or deterioration of the product that you have worked so hard to produce. Make sure you have all the equipment on hand and make sure you have coordinated the harvest with the contract processor.

Essential items that must be ready for a drain harvest include:

- drag nets or bag nets
- bins for storing chilled prawns pond-side — more than enough to hold the estimated quantity of shrimp
- bins for storing ice pond-side — more than enough required to chill the estimated quantity of shrimp
- ice delivered or made on site in an ice-making machine
- scoops, hoist or lifting arrangement

Key Instructions for Harvest Management:

1. Exchange 20% of the water one week before the planned harvest date. Immediately after water exchange apply agricultural lime (100-200 kg/ha) to the pond and pond bottom where it is more black, specially in the corners.

2. Avoid harvest during the molting period (full moon or new moon). Two days before harvest check if there are any newly molted shrimp, if newly molted shrimp are>10%, delay the harvest by a day or two. Do not exchange water or reduce water level 2 to 3 days before harvest.

3. Do not feed the shrimp 6 hours prior to harvesting to keep the gut empty and improve the shelf life.

4. Complete the harvesting process (draining and harvesting) within 6-8 hrs. between 6 PM to 6 AM. Avoid harvesting and packing shrimp during hot time of the day. Use the Drag net to harvest. Avoid using cast nets.

6. If normal draining of the pond water is difficult, use artificial gates (made up of bamboo sticks or fish nets) in a corner at deeper side of pond for fixing the bag net. Use more pumps if necessary to complete the harvesting in time and to catch most of the shrimp with the bag net.

7. Thoroughly wash the handpicked shrimps in clean water and pack them separately from bag net harvested shrimp.

8. Do not use any chemicals while washing the shrimp or chill killing without the knowledge of the processor.

9. Make sure good quality ice is used (preferably from the processor) during harvesting and packing.

10. Workers with wounds, open sores or skin infections should not handle harvested shrimps. Do not smoke or spit at packing area.

11. Pack the shrimp in transport tubs (insulated boxes) with crushed ice:shrimp @ 2:1 ratio for better preservation. Load the packed crates quickly to the truck and send to the processing plant immediately without any delay.

2. The quality of a shrimp starts to deteriorate immediately after it dies. The digestive organ, or hepatopanceas, contains a range of enzymes that cause changes to the shrimp's appearance and texture because they remain active after death. While not feeding the prawns for 24 hours before harvest may reduce the amount of digestive

enzymes (mainly proteases) present in the stomach, the hepatopancreas still retains plenty of activity. Any longer than 24 hours may make them hungry

enough to eat the bottom detritus and spoil the quality of the cooked product. These enzymes digest through the surrounding tissue and attack the ligaments that connect the head (cephalothorax) to the tail meat (abdomen). These weakened tissues will then result in a significant amount of weight loss and head loss during storage and cooking. Initially the only visible defect will be a discolouration of the organ, but this will spread through the head and into the tail meat. As all enzymes operate faster in warmer conditions it is imperative that shrimp be chilled immediately after capture. This can be in an ice slurry, in refrigerated seawater (RSW) or under ice. Another enzyme, polyphenol oxidase, will cause the dark pigment known as black spot to develop on the gills, shell of the head and shell of the tail. Unfortunately, unless the shrimp are frozen immediately, a chemical treatment will be required to prevent black spot.

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9. Environment Protection

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Better Management Practices for Environment Protection

Shrimp farming has notable environmental impacts. Once released, the shrimp pond effluent water adds acid and salt to soil, often making the affected land unsuitable for plants. The released waste can also lead to eutrophication of nearby marine environments. This means that the nutrient dense shrimp waste can cause plant and algal blooms in marine environments, leading to a lack of oxygen that kills other marine species.

Mangroves are an important part of any coastline and help in maintaining the biodiversity of the area in addition to adding to physical protection by acting as a bio-shield to fragile coastal areas. Attracted by the demand for shrimp in the developed countries, shrimp aquaculture has expanded rapidly, mainly in the subtropical and tropical lowlands of America and Asia. To date, approximately 1-1.5 million ha of coastal lowlands have been converted into shrimp ponds, comprising mainly salt flats, mangrove areas, marshes, and agricultural lands. The impact of shrimp farming of most concern is the destruction of mangroves and salt marshes for pond construction. Compatibility with other users, the presence of buffer zones, maintaining an acceptable balance between mangroves and shrimp pond area, improved pond design, reduction of water exchange, and an improved residence time of water, size and capacity to assimilate effluents of the water body, are examples of ways to mitigate the adverse effects. The use of mangroves and halophytes as biofilters of shrimp pond effluents offers an attractive tool for reducing the impact in those regions where mangrove wetlands and appropriate conditions for halophyte plantations exist. Healthy seed supply, good feed with the use of prophylactic agents (including probiotics), good water quality, and lower stocking

densities are examples of actions suggested to control disease in shrimp farming.

Key Instructions for Eco-friendly Shrimp Culture:

1. Ensure that the discharge of shrimp farm waste water does not result in long-term increase in nutrients of suspended solids in the open waters. The integration of effluent treatment system as a part of the shrimp farm will assist to improve waste water quality and provide long-term strategies for sustainable shrimp farming.

2. Do not clear mangroves for shrimp pond construction. Conserve the existing mangroves; deforestation not only affect the mangrove ecosystem but also it reflects negatively on shrimp farming both in India and globally. Presence of mangroves near shrimp ponds cause no harm, rather they are beneficial in many ways. Mangrove trees are the best buffers against winds and waves. Mangrove trees (root, leaf and stem extracts of *Rhizophora apiculata*) have many medicinal properties. They are found to inhibit human pathogenic organisms.

3. Mangroves provide a good environment for the reproduction and growth of other commercially important fishery resources, therefore providing livelihoods for local communities. *Avicennia marina* and *Rhizophora apiculata* are the most common mangrove plants found in most of the coastal states which can be grown in varying salinities. The fruiting season of *Avicennia marina* is from October to November. The ideal season for planting the seedlings is July to November.

4. Mangrove seedlings could be easily grown in the nurseries with the locally available seeds/wildlings. Necessary help for raising seedlings could be secured from the local forest department or organizations like M.S.Swaminathan Research Foundation, Coastal Community Development Agency. Develop mangrove plantations near the existing shrimp farms and near by mangrove areas through planting of mangrove seedlings.

5. Plant mangroves where ever they can be grown on the river and sea side of shrimp ponds in the inter-tidal zone. Planting of mangroves in drain canals and effluent treatment ponds could improve the water quality by absorbing nutrients and other organic pollutants. The mangrove plantations along the bunds help in stabilization of banks and prevent soil erosion during floods and reduce sedimentation of ponds during flood.

6. Protect the newly planted mangroves with fencing to prevent grazing by animals. Encourage near by farmers to plant mangroves along their bunds. When contemplating mangrove rehabilitation, special attention must be paid to seed availability, site elevation, spacing of planting, salinity and fresh water runoff, flooding, wave and tidal actions, weed eradication, nursery techniques, monitoring, community participation and total cost of restoration measures.

Mangrove afforestation is being taken up at a large scale in Bangladesh, India and Vietnam principally to provide protection in cyclone-prone areas as well as to generate economic benefits to the poor coastal communities. Restoration of mangroves has received a lot of attention worldwide for several reasons. Firstly, the long ignored ecological and environmental values of mangrove forests have been documented for many mangrove areas. Secondly, there is a subsistence dependence on natural resources from mangrove forests. In addition, large losses of mangroves have occurred throughout the world leading to coastal erosion, decline of fishery resources and other environmental consequences, some of which is in need of urgent attention. Restoration provides an opportunity to improve or enhance the landscape and increase environmental quality. As responsible aquaculture practices become important, protecting mangroves is a core issue.