Shrimp Health Management Extension Manual

The Marine Products Export Development Authority
and
Network of Aquaculture Centres in Asia-Pacific

Shrimp Health Management
Extension Manual

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The home pages of cooperators are given below:

AAHRI	www.fisheries.go.th/aahri
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Foreword

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 the benefit of the country. However, the sporadic incidences of disease outbreaks and some isolated incidents of social conflicts have reasserted the need for adoption of every means for conducting shrimp culture in an environmentally, socially and economically sustainable manner. Therefore, adoption of proper shrimp health management practices, based on the principles of good aquaculture practice, is the first step towards this direction.

I am pleased to note that the present publication, which is an outcome of the detailed study of the shrimp aquaculture practices in the State of Andhra Pradesh by availing the Technical Assistance from The Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand, contains an illustrative, easy to grasp, guidelines for shrimp health management. I hope this manual will help the shrimp culturists, including the small and marginal farmers, to easily adopt the underlying principles of good aquaculture practices and pave the way for long-term sustainability of shrimp culture in the country.

Cochin
7.7.2003

(K Jose Cyriac)
Chairman
MPEDA

Preface

This manual was prepared as part of the MPEDA/NACA Technical Assistance on Shrimp Disease and Coastal Management. The technical assistance project involved the Marine Products Export Development Authority (MPEDA) and the Network of Aquaculture Centres in Asia-Pacific (NACA). The project started during August 2000 and was completed in December 2002. The scope of the technical assistance included: (a) a study of the horizontal and vertical transmission of diseases in selected shrimp farming areas in India, including investigation of hatcheries and broodstock; (b) development of practical measures for containing/preventing shrimp disease outbreaks; (c) conducting training and demonstration of shrimp disease control measures; and (d) examining opportunities for co-operation and self-help among shrimp farmers in affected areas to control water quality deterioration and shrimp disease control. The technical assistance was conducted over three separate phases: *Phase* 1: Planning of the technical assistance and baseline data collection was carried out between August and December 2000; *Phase* 2: Detailed study of the selected shrimp farming areas through a "Shrimp disease risk factor study", was carried out between January 2001 and December 2001; and *Phase* 3: Support to demonstration and implementation of better shrimp health management practices was undertaken between January and December 2002. The findings were presented to a National Workshop on "Shrimp Disease Control and Coastal Management" during 5-6 March 2003 at Chennai, organized by MPEDA, Cochin, in association with the Ministry of Agriculture, Government of India and NACA. The Workshop recommended that an extension manual based on study findings be widely circulated in the coastal states and Union Territories (UTs) of India.

The extension manual summarises the farm level risk factors identified during the study, and practical management practices that can be used to reduce risks of shrimp disease outbreaks and improve farm production. The recommendations are based on the study conducted in Andhra Pradesh and therefore, more relevant to study area in Andhra Pradesh. However, they can be taken into consideration by farmers from other states, although some of the specific results are time/season bound, and may not be generalized to other geographical areas. There may be changes also on yearly basis depending on the local situation and such changes should be taken into account.

The manual was prepared by NACA and the MPEDA, in association with the Aquatic Animal Health Research Institute (Thailand), Siam Natural Resources Ltd (Bangkok, Thailand) and AusVet Animal Health Services (Australia). Additional technical support to NACA in preparation of the manual was provided by the Australian Centre for International Agricultural Research (ACIAR).

Acknowledgements

The MPEDA and NACA gratefully acknowledge the cooperation of AAHRI, Siam Natural Resources Ltd., Bangkok and AusVet Animal Health Services, Australia in preparing the manual as part of the MPEDA/NACA Technical Assistance on "Shrimp Disease Control and Coastal Management". The NACA is thankful to the Chairman and the Director of MPEDA and local officials of MPEDA in Andhra Pradesh and Tamil Nadu States for their support and excellent co-operation during the field studies and demonstration programmes carried out during the Technical Assistance study. The authors thank the Australian Centre for International Agricultural Research (ACIAR) for their support to NACA in the preparation of this manual. Experts from the College of Fisheries, Mangalore, the Central Institute of Brackish water Aquaculture (CIBA), Chennai and The Andhra Pradesh Shrimp Seed Production, Supply and Research Centre (TASPARC), Visakhapatnam provided valuable suggestions and technical support throughout the study and their assistance is acknowledged.

The authors would like to give special thanks to the survey assistants of the MPEDA/ NACA Technical Assistance for their sincere and dedicated services in conduct of fieldwork. We are especially indebted to the farmers of West Godavari and Nellore districts of Andhra Pradesh and Nagai District of Tamil Nadu for their participation and cooperation. It is hoped that this manual will be useful to farmers and provide useful guidance to support the development of sustainable shrimp aquaculture in Andhra Pradesh and other coastal States of India.

Arun Padiyar P., Mongkhon Primphon, Pornlerd Chanratchakool and Michael Phillips provided the photographs shown in the manual and their contribution is acknowledged.

1. BACKGROUND

Shrimp disease is a major constraint to shrimp aquaculture production around the world. Since 1994, average annual production loss due to diseases in this sector in India amounts to about Rupees 350 – 400 crores. In response to these problems, MPEDA initiated a study on "Shrimp Disease Control and Coastal Management" with Technical Assistance from NACA. The study was conducted in three phases:

1. In *phase 1*, conducted during late 2000, a pilot study was undertaken to survey the major diseases and other disease related problems in estuary-based farms in West Godavari district, creek-based farms around Kandaleru creek in Nellore district of Andhra Pradesh and sea-based farms in Nagai district of Tamil Nadu. The results from the pilot study were used to prepare for subsequent phases of the study.

2. In *phase 2*, a detailed shrimp disease risk factor study was carried out during 2001. Information was collected from 365 randomly selected ponds in Andhra Pradesh during one crop cycle and analysed using science-based epidemiological techniques to identify farm level risk factors for two outcomes: (i) shrimp disease outbreaks; and (ii) low shrimp production. These risk factors provided a basis for designing locally relevant risk management practices for shrimp farmers.

3. In *phase 3*, a demonstration programme was conducted throughout the summer crop of 2002 to demonstrate practical measures to reduce disease risk and improve shrimp production, based on the findings from the phase 2. Demonstrations were conducted with farmers in two villages of West Godavari and in one village of Nellore district. The demonstration phase supported farmers to implement recommended practices in their farms, and evaluated the outcomes, benefits, and constraints in implementation of the recommended shrimp health management practices. In addition, a series of village and district-level workshops and training activities were organized during phase 3 to disseminate the recommendations to farming communities, and develop a set of recommended shrimp health management practices. The outcome of the demonstrations led to better production and better profit in the participating farms.

The outcome from the Technical Assistance is a set of recommendations for reducing risks of shrimp disease outbreaks and improving shrimp production that have been field tested and shown to work on shrimp farms. The recommendations are given here for wider extension to shrimp farmers, extension agents, and others supporting the shrimp aquaculture sector in India.

This manual was drafted initially for use during demonstrations conducted during phase 3 of the study, then subsequently developed from practical on-farm experiences and results of the demonstrations. The manual was prepared through rigorous consultations with farmers who participated in the study, farmer associations, prominent and academic and extension experts from various central and state government agencies. Although the manual is based on experiences with shrimp farming in West Godavari and Nellore districts of Andhra Pradesh, the risk management

principles and practices mentioned here are widely relevant to the other coastal states / UTs in the country and can be adapted to suit a wide range of local circumstances.

The purpose of this extension manual is to extend simple practical recommendations to shrimp farmers and other concerned stakeholders. It is hoped that the manual will be useful for extension personnel from various government organizations including universities, non-governmental organizations, farmers, farmer associations, societies and clubs and private agencies.

2. RISK FACTORS AND SHRIMP DISEASE CONTROL

The MPEDA/NACA Technical Assistance conducted a detailed shrimp disease risk factor study that identified farm and pond level risk management practices. In West Godavari area the study looked at improved traditional shrimp farms with average stocking density of 3 shrimp/m^2. In Nellore district, farmers were stocking higher densities, with the study farms having an average stocking density of about 8 shrimp/m^2. Although there are some differences in the findings on the two farming systems from the two districts, many of the risk factors, management techniques and principles to address the shrimp disease risks are common.

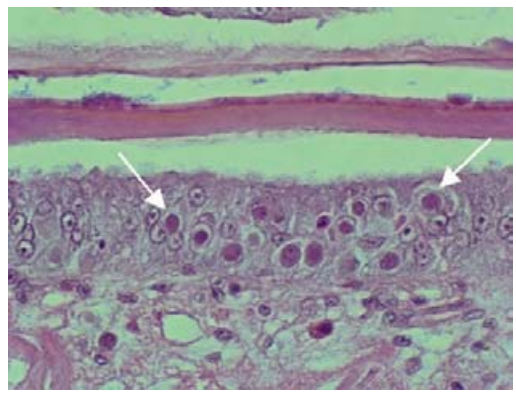
2.1. Major disease problems faced by farmers

The Technical Assistance Project gave particular attention to white spot disease (WSD), vibriosis and loose shell syndrome. The WSD is caused by the white spot syndrome virus (WSSV) and affects shrimps of all age groups. The WSD outbreaks are often characterized by high and rapid mortality of infected populations, shortly after the first appearance of the clinical signs. Diseased shrimps develop anorexia, lethargy, and characteristic white spots on the inside surface of the carapace. Moribund shrimp may also show a pink to red discoloration. There may be drastic reduction in feeding levels.

Vibriosis is a bacterial disease caused by *Vibrio* bacteria. The acute infection usually occurs when shrimps are one month old and therefore some farmers call it one month mortality syndrome. However, chronic *Vibrio* bacterial infections can occur during the later stages of culture till the harvest due to poor water and pond bottom quality conditions. When the problem occurs later in the crop cycle, it is usually associated with loose shell syndrome. In higher salinity the severity is usually greater and is caused by luminous species. In this case the farmers may identify the problem as luminescent vibriosis.

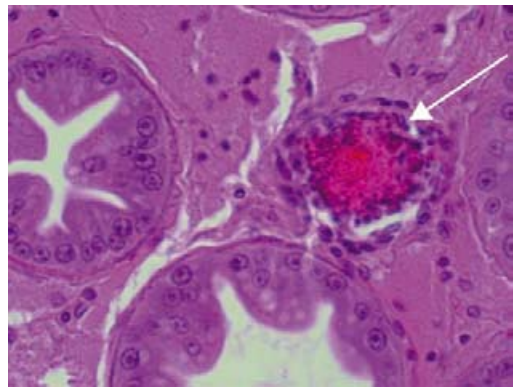
"Loose shell syndrome" reported by farmers in Andhra Pradesh is probably a result of chronic bacterial infection. The affected shrimps usually are bigger in size and have a paper like carapace with a gap in between muscle tissue and carapace. The primary cause of this chronic problem is likely toxic pond bottom conditions.

Shrimp carapace with white spots



Histological section showing the intranuclear white spot virus inclusion bodies in infected cells of the cuticular region

Shrimps with loose shell syndrome



Histological section showing the chronic inflammatory lesions in hepatopancreas indicative of bacterial infection

During the risk factor study conducted in 365 ponds (184 ponds in Nellore and 181 ponds in West Godavari) in 2001, the dominant shrimp disease problem in both the districts was WSD. Eighty percent of the ponds affected by disease outbreaks were affected by WSD. Therefore, this manual mainly addresses management of WSD. However, the management recommendations and principles detailed in the manual are also relevant to reducing risks of most *Penaeus monodon* disease outbreaks, and improving shrimp farm production.

2.2. Shrimp disease risk factors

In aquaculture systems, a risk factor is a crop-related factor, which simply increases or decreases the probability of occurrence of an adverse event happening during a specified time period. For example, WSD is an adverse event during the shrimp cropping period. If a high prevalence of WSSV in seed batches stocked in ponds increases the probability of occurrence of WSD then the high prevalence of WSSV in seed batches is called a risk factor to WSD. Epidemiology investigates the statistical and biological significance of the relationship between the adverse event and the hypothesised risk factor to determine whether the hypothesised risk factor is a risk factor or not. The risk factor study of the MPEDA/NACA Technical Assistance considered shrimp disease outbreak and poor production as adverse crop events for the epidemiological analyses.

The results from the risk factor study of shrimp farms in Nellore and West Godavari districts clearly show that there are a number of significant risk factors that influence shrimp disease outbreaks and shrimp yields at pond level, many of which can be managed by the individual farmers.

The WSSV has been established as the "necessary cause" of WSD. However, presence of the necessary cause alone will not lead to a WSD outbreak in a pond. In a farm situation, a number of "component causes" (risk factors) along with the "necessary cause" might become "sufficient cause" to produce WSD outbreaks. The MPEDA/NACA study clearly shows that WSD is not caused by any one factor. Rather a number of risk factors influence the occurrence of WSD in the farm. These risk factors occur throughout the shrimp cropping cycle and in general terms fall into the following categories during the different stages of the crop cycle:

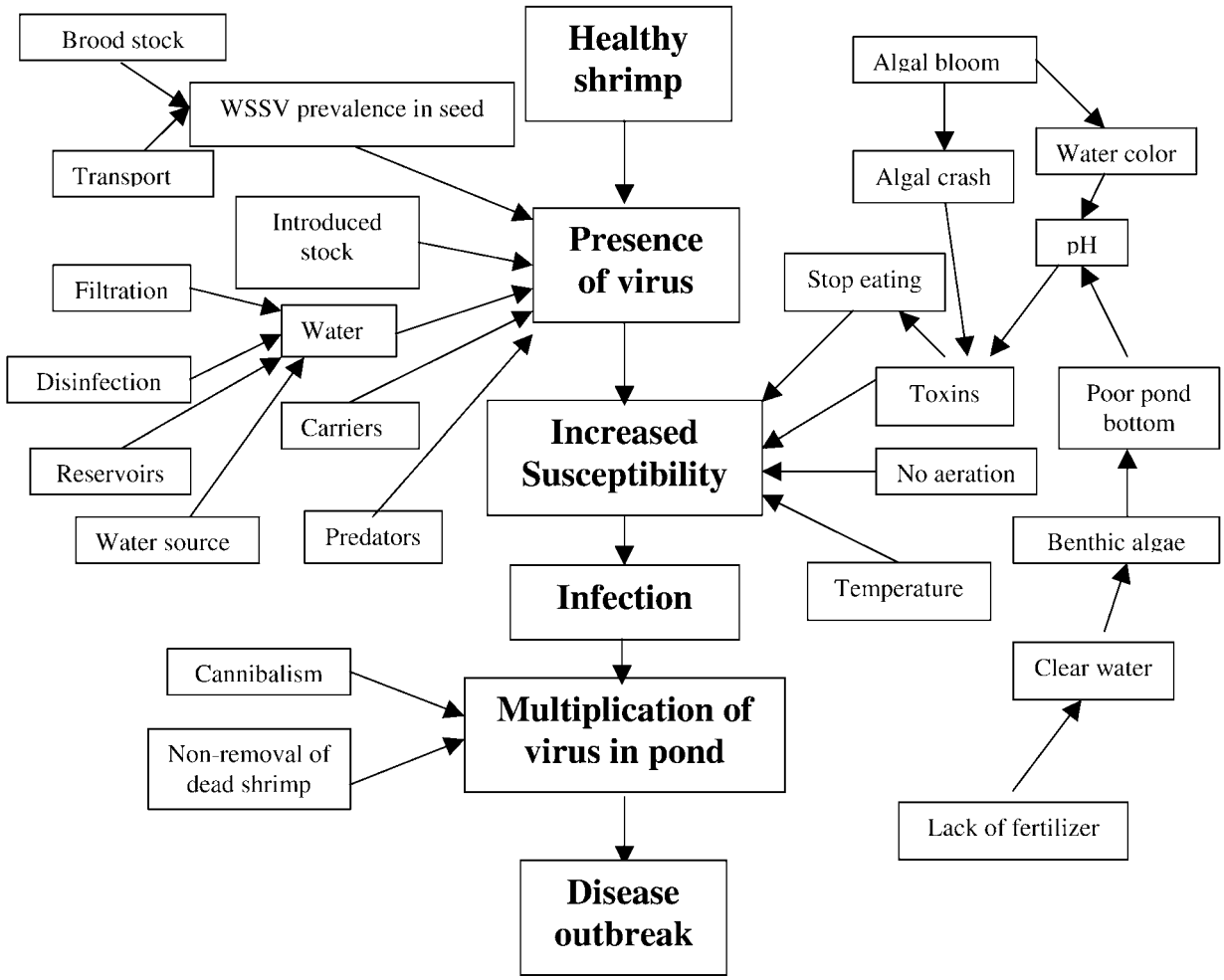
- Season of stocking
- Pond preparation
- Pond filling and water preparation
- Seed quality and screening
- Water management
- Pond bottom management
- Feed management
- Disease treatments

The risk factors at each stage of the cropping cycle and their relationship to WSD outbreaks are illustrated below in a "web of disease causation". The following summarize the main points shown in the "web":

1. A WSD outbreak is the end result of a series of actions or changes, from healthy shrimp through to disease outbreak.
2. At each stage of the cropping cycle, a number of factors influence the development of the disease in individual animals and also in population of shrimp in each pond.
3. The WSSV can enter the shrimp and pond through different routes, including shrimp seed, water, carrier animals and transfer of infected animals and farm equipment from one farm to another.
4. Adverse environmental factors combined with a high incidence of infected shrimp among the pond population are necessary for a mass disease outbreak to occur. Management factors can be used to control environmental factors and reduce risks of WSD occurring in the pond.

To be successful in controlling shrimp disease, one has to manage all potential risks at different stages of cropping cycle. This requires skills and dedicated management by the farmer. This manual provides an outline of recommended management principles and practices for farmers to follow, or adapt to meet their own farming requirements.

Web of White Spot Disease Causation

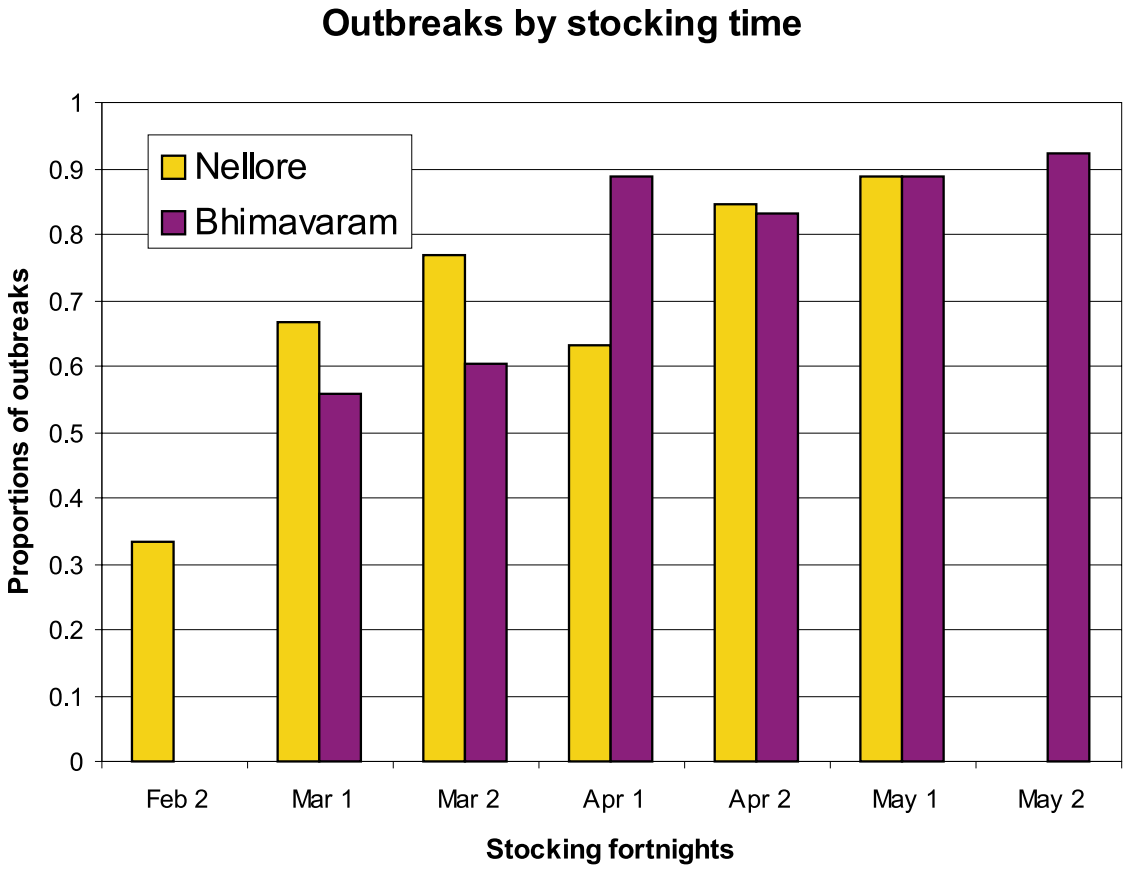


3. SHRIMP HEALTH MANAGEMENT GUIDELINES

3.1. Seasonal factors and crop planning

3.1.1. Risk factors

The study showed that there were seasonal differences in WSSV infection rates in post larvae. In 2001 the prevalence of white spot infection in shrimp post larvae increased from March to June. The results in both Nellore and West Godavari showed that farmers stocking earlier in the year, around February or March, had more chances of a successful harvest (see graph below). The effect was more significant in West Godavari. Temperature also emerged as an important factor, as *Penaeus monodon* is more susceptible to WSSV at lower temperatures.



3.1.2. Management guidelines

Whilst the weather pattern may vary from year to year, it is desirable for farmers to stock shrimp in Andhra Pradesh during the first week of February to the second week of March. Accordingly, pond preparations should start preferably by the second week of January. In other coastal areas, seasonal factors such as temperature and rainfall need to be considered to avoid high-risk periods.

3.2. Pond preparation

3.2.1. Risk factors

Pond preparation is essential to reduce risks of shrimp disease outbreaks. The study has identified the following risk factors that can significantly reduce the risk of disease outbreaks and improve shrimp production

- Removal of bottom sludge, particularly in ponds stocking higher densities (up to 8 numbers per m^2 as in Nellore).
- Ploughing of soil when wet (particularly at higher stocking density farms in Nellore).
- Use of lime in pond preparation.

The study noted that sludge left by the side of the pond (where it may drain back into the pond) may constitute a risk to shrimp health.

Shrimp ponds with a history of disease outbreaks have a greater likelihood of future disease outbreaks, therefore special attention is required during pond preparation in such farms. Farms with poor bottom soil quality, particularly the presence of a black soil layer, will suffer crop failures. These are key factors and pond preparation measures are necessary to improve pond bottom conditions.

3.2.2. Management guidelines

3.2.2.1. Sludge removal

Cleaning the pond bottom is a very important pond preparation activity. The soil should be checked for the presence of black layer when it is in wet condition. If the soil is completely dried then the black layer will turn to a lighter color due to oxidation, making it difficult to recognize that black layer in the soil. It is easy to remove the sludge when the soil is dry. In farms where stocking densities are usually more than 6 PLs/m^2 (as common in Nellore district) and if a black soil layer is present, it should be removed completely. The sludge must be disposed away from the pond site, so that it does not seep back into waterways, ponds, or cause other environmental problems. In farms with lower stocking densities, such as in West Godavari district, it may not be necessary to remove the sludge, unless there was disease outbreak during the last crop. In such a situation extra precaution should be taken. If the sludge is removed properly then management of the pond becomes easier during high pH periods, a common problem in parts of West Godavari district due to low salinity, and high plankton growth.

Sludge removal should pay attention to areas of the pond where there is a high accumulation of organic matter from previous crops, such as feeding areas, and the side ditches in extensive farms.

Sludge on pond bottom (indicated by arrow)

Arrow showing the thick layer of black soil / sludge on top soil layer of the pond bottom.

Manual removal of sludge

Mechanical sludge removal using bulldozers

3.2.2.2. Ploughing

The main purpose of ploughing is to expose the black soil layer(s) underneath the bottom soil to sunlight and atmospheric oxygen. By this process, the organic waste (sludge) will be oxidised. Presence of moisture in soil (*i.e.*, under wet soil conditions) during ploughing allows bacteria to work better in breaking down the black organic matter, thus making the ploughing process more effective. Ploughing on wet soil is particularly recommended for ponds if the planned stocking density is between 6 and 10 PL/m^2 and when the sludge cannot be removed properly by manual or mechanical methods as explained earlier. After ploughing, dry the pond bottom for 5 to 7 days and repeat the procedure till no more black soil is seen. In case a heavy tractor is used for ploughing, then plough the dry soil first and then fill the pond with water to wet the soil and then again dry. Ploughed pond bottom leads to turbid water conditions during culture period. Therefore, compaction of the bottom using heavy rollers after the whole process of pond preparation, *i.e.*, before water intake, can avoid the turbid water condition.

Dry soil ploughing except in trenches – West Godavari district

Ploughing on dry soil using tractor

Ploughing on wet soil using tiller

Ploughing on dry soil and subsequent wetting of bottom

3.2.2.3. Liming

Liming during pond preparation optimizes pH and alkalinity conditions of soil and water. The type and amount of lime to be added depends mainly on the soil pH and also on pond water pH, which ideally should be checked before lime application. The recommended levels of lime application during pond preparation are given in Table 1. The soil pH can either be measured with a soil pH meter or by air drying some soil and adding it to an equal weight of distilled water. The soil and water should be thoroughly mixed and left overnight before measuring the pH of the water (pH indicator solution or pH papers is sufficient).

Quick lime or hydrated lime should be used only if the soil pH is low *i.e.* pH <5. If it is applied on soils of pH >5, then it may increase the water pH after filling and this high water pH condition may remain for a prolonged period even after stocking, which is not desirable. If the soil pH is more than 5, then shell lime or agricultural lime or dolomite should be applied.

If the soil does not contain acid sulfate (orange color), apply shell lime or agricultural lime evenly on the bottom surface and also on slopes of bunds before water is added to each pond. In case of acid sulfate soil, do not apply lime directly into the soil. The pond should be filled with water and then lime should be applied to increase the pH up to 7. Where a disinfectant like bleach (calcium hypochlorite) is used then apply lime only 3-4 days after the application of disinfectant. If lime is used earlier to disinfect, then the effectiveness of the disinfectant is reduced.

Table 1. Recommended lime application during pond preparation

Soil pH	Quantity of $CaCO_3$ lime (Kg/hectare)	Quantity of $Ca(OH)_2$ lime (Kg/hectare)
> 6	<1,000	<500
5 to 6	<2,000	<1,000
< 5	<3,000	<1,500

Lime application to pond bottom

Liming on water surface

3.3. Pond filling and water preparation

3.3.1. Risk factors

The study showed that there are management practices that can be adopted to reduce risk factors associated with pond filling and preparation of water before stocking. These include:

- Water filtration (mesh of 60 holes/sq inch) reduces the risk of disease outbreak through reduced introduction of carriers to the pond.
- Disinfection of pond water can also reduce the risk of disease outbreaks in farms using higher stocking density (such as Nellore district).
- Fertilization reduces the risk of disease outbreak in lower stocking density farms (such as those found in West Godavari district).

During the study, the use of water reservoir appeared to have no significant benefit to farmers in either reducing risk of disease outbreaks or improving production. As reservoirs are normally good to improve water supply quality in shrimp farming, the findings suggest that reservoirs are not being used properly (probably because farmers are using higher lends of water exchange, and also stocking them with shrimp).

The proper use of reservoirs is therefore strongly recommended as a disease control measure and to make water management more effective during the crop cycle.

3.3.2. Management guidelines

3.3.2.1. Reservoir maintenance and pond filling

For every two grow-out ponds one extra pond should be maintained as a water reservoir (*i.e.*, a ratio of 2:1 with respect to water holding capacity of ponds) to stabilize turbid and unstable water sources. If the farmer has only one pond then one quarter of the pond should be converted in to a reservoir pond with water depth of at least 2 meters. Water should be stocked in the reservoir pond for at least 14 days before pumping to the shrimp culture ponds to facilitate the growth of plankton in the reservoir. This water can even be used to fill grow-out ponds just one to two days before stocking with seeds. If the water reservoir is not maintained then the grow-out pond should be filled directly with source water at least 14 days before stocking.

During water intake to the culture pond, water should be filtered using a net of more than 60 holes/inch or twin bags of 60 holes/inch mesh at the water inlet point to avoid entry of virus carriers such as crabs, wild shrimps and zooplankton and also to avoid entry of fish or crustacean, which may be predator or competitor for shrimp. The suction line should be placed at the deeper side of the reservoir pond and the foot valve of the pump should be kept at least half a foot above the pond bottom to avoid turbidity during the pumping process.

Clean water pumped from the reservoir pond

Water filtration using single bag filter

Water filtration by twin bag filter
(Nellore district)

Water filtration by twin bag filter
(West Godavari district)

3.3.2.2. Fertilization of water

The purpose of fertilization is to ensure green water when the shrimp are stocked, as this reduces stress on the shrimp post-larvae, and reduces the chance of harmful benthic algae developing in the pond by preventing the sunlight touching pond bottom. This is particularly important where ponds are shallow, commonly found in farms in West Godavari district.

Ideal green coloured water after fertilisation

In farms stocking higher densities of shrimp there may be sufficient nutrients in the soil to stimulate a plankton bloom after filling the pond. In farms with low stocking densities such as those in West Godavari district use of organic fertilizer like dry cow dung may be used at the rate of 300 – 500 Kg ha^{-1} in 3-4 split doses over 10 days during pond preparation. Fresh manure should not be used because it may effect the final quality of shrimp produced. Inorganic fertilizers like urea or superphosphate at 30 – 50 Kg ha^{-1} in 3-4 dosages may also be used to boost the plankton production. Fertilizers should be first applied at least 10 days before the planned stocking date so as to obtain a good plankton bloom with green water color for stocking. It the water colour remains unstable, fertilizer application should be continued even after stocking. This would avoid a risk of the plankton bloom collapsing suddenly.

3.4. Seed selection and stocking process

3.4.1. Risk factors

The study has shown that there are several important risk factors associated with shrimp seed, which include :

- Stocking of poor quality of seed (less active, more mortality during transportation and size of less than 16mm in case of nursery reared juveniles) increases the risk of shrimp disease outbreak.
- Higher prevalence (>5% of seed population) of WSSV as determined by two-step PCR in stocked post-larvae leads to increased risk of an outbreak and lower pond production.
- Longer transport time (> 6 hours) of the seed from hatchery or nursery to the pond also increases the likelihood of a subsequent disease outbreak.
- On farm nursing of shrimp post-larvae helps to reduce disease outbreak.

3.4.2. Management guidelines

Several management practices can be used to reduce the risk as follows:

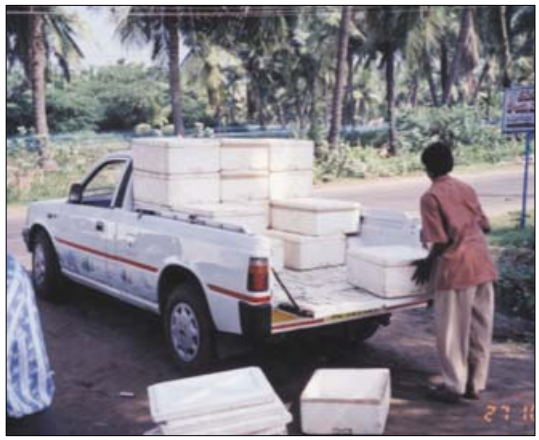
1. Before purchasing, shrimp post larvae should be checked for their general condition at the hatchery. Observations should be made on activity, color, size, *etc*. from the selected tanks in the hatchery. The post larvae should be uniform in size with relatively uniform body color and should be actively swimming against the swirling water current produced in a round tub. If there are any dead and abnormal colored PL in the tank, the entire batch should be rejected.

Healthy and active hatchery post larvae of uniform size and color

Healthy and active nursery juvenile

2. Once the post larvae pass these gross visual examination tests, a PCR test should be conducted on 59 randomly selected post larvae from that tank. Using 59 post larvae will allow detection of WSSV at 5% or more prevalence level. If the sample shows negative result by following 2 step PCR then the seed is ready for transportation to the farm for stocking.
3. The post larvae should be transported to the farm site within the shortest travel time, which should not exceed 6 hours. Bags should be packed with relative low post larvae densities to minimize stress. In West Godavari district, farmers commonly purchase juveniles and transport them in thermocol/polyurethane boxes without special aeration. This is highly stressful to shrimp juveniles. Therefore, transport time should be kept to a minimum. The recommended densities* of seed in transportation bags are as follows :
   - PL 15 = 1000 to 2000 PL/litre
   - PL 20 = 500 to 1000 PL/litre

* Based on recommendations of Chanratchakool, et.al., 1998



Fast transportation of seed using pick up van reduces the risk of disease

Slow transportation of seed leads to more stress and greater risk of disease

4. Weak and dead PL should be removed before stocking at the pond site. A separation method should be employed. To do this, the PL from the transport bags should be carefully transferred into a plastic/fibre-glass tank of around 500 litres water holding capacity. Then, formalin should be mixed at the rate of 100ml/1000litres of water to get a formalin concentration of 100 ppm and the PL should be treated for above 30 minutes. It is essential that water in the tank is well aerated; ideally using oxygen cylinders. After this treatment the water is stirred to concentrate all the dead and weak seeds at the center-bottom of the tank. Thereafter the good/strong PL should be siphoned off using a plastic pipe from the upper portion of the tank, suitably from the sides. This process should be continued till around 3/4th of the water volume gets pumped out so that the bottom settled PL could be seen clearly. The post larvae concentrated in the center should then be siphoned out using a thinner plastic tube. The farmers are also advised to use the following precautions :

    a. Formalin should be used ***only*** when aeration is available. If no aeration is available, then follow the above process but without formalin.

    b. In case molting is observed during transportation or many of the post larvae have died, formalin should not be used.

    c. If the seed comes from a nursery then the juveniles should be treated with 150 ppm formalin (150 ml / ton of water) for 15 minutes. The weak juveniles cannot be separated easily as they are quite big and can withstand the above dosage. Any further increase in formalin concentration may stress healthy shrimp. This treatment is helpful in reducing the external parasites and fouling only.

5. During the above process of weak seed elimination, PLs should also have to be acclimatized to pond water conditions like salinity with gradual addition of pond water to the tank.

The whole process of seed selection (hatchery visit, PCR testing, transportation and screening) should be done at least 2 – 3 days prior to stocking.

Acclimatization of seeds to pond water condition

Transfer of seeds into a fibre glass tub for weak seed separation

Formalin treatment for 20-30 minutes

Releasing healthy seeds to pond using plastic pipe

3.5. Water quality management

3.5.1. Risk factors

The study found a number of risk factors that are significantly related to shrimp disease outbreaks and shrimp production and can be addressed through routine water quality management. These include :

- Water exchange practices – ponds exchanging water to maintain water quality appeared to yield better shrimp production, particularly in low stocking density farms in West Godavari district.
- Water filtration - ponds using water filter nets of fine mesh have better production.
- Aeration – ponds using aeration tend to have higher shrimp production.
- High salinity and pH (>8.5) have an affect on risk of disease outbreaks, but the study found that salinity had less influence on shrimp production. In high saline waters it is difficult to maintain water quality, especially a stable bloom compared with that in low saline waters. Therefore, the stress on shrimp due to changes in bloom conditions may make it more susceptible to viral infection and subsequent disease outbreak. In cases where pH exceeds 8.5, the toxicity of ammonia increases leading to higher stress conditions for shrimps.

The study showed significant relation between shrimp disease outbreaks and algal populations within ponds:

- Ponds with clear water at stocking and during the culture cycle are at risk from lower production and shrimp disease outbreaks.
- Green water (pond colour) ponds have better production and lower risk of disease outbreaks.
- Clear water with benthic and filamentous algae lead to lower production.
- Ponds with dead benthic algae observed during culture are at risk of disease and poor production.

Some farmers used bacterial product (water probiotics) during the study to improve water quality, particularly in Nellore district area. The results did not demonstrate that such products had any significant benefit in reducing shrimp disease risk or improving production. However, there is a need for more research and field trials on the use of probiotics.

The use of Zeolite, Benzal Konium Chloride (BKC) and Iodine was found to provide some benefit in improving shrimp production, although there was no effect on disease outbreak. Zeolite (a soil conditioner), has the potential to reduce the stress on shrimp from toxic gases like ammonia. BKC is usually helpful in treating shrimps for bacterial and external fouling diseases, and is a strong disinfectant and kills bacteria. There is evidence that iodine compounds help in reducing stress due to low oxygen condition (brown/pink gill problem due to low oxygen may be rectified by iodine). All the above health problems were common in the two study areas and the use of the above mentioned three chemicals might have helped to improve production (see 3.8 - Treatments and use of chemicals).

3.5.2. Management guidelines

The management recommendations are directed towards maintaining a healthy algal bloom in the pond. Sufficient water must be kept in the pond to reduce risks of the growth of benthic algae. The water depth in the shallowest part of the pond should be at least 80 cm.

Ideally, water quality should be checked on daily basis for the following parameters and records kept in a recording sheet (see Annex B for a sample).

Parameter	Checking time	Recommended values
1. pH	Morning (8 – 10 am) and Evening (3 – 5 pm)	7.5 to 8.5
2.Water transparency	Morning (8 – 10 am)	(30 to 45 cm)
3. Water color	Morning	Green water
4. Water temperature	Morning (8 – 10 am) and Evening (3 – 5 pm)	28 to 32°C
5. Alkalinity	Only once in a week during first month of the crop. Thereafter to be continued based on requirements.	80 to 120 ppm

3.5.2.1. Water reservoir management and water exchange

It is recommended to use water for exchange only from a reservoir. Source water is much more turbid because of drainage from the catchment and the surrounding culture ponds and a reservoir is an essential requirement for management. Water should be left for at least 7 days in reservoir before pumping to the grow-out ponds. This process helps condition the water and allows suspended solids to settle. While pumping the water to grow-out ponds the foot valve of the pump should be placed at least 30 cm above the pond bottom to avoid any turbidity while pumping. The suction line should be placed at the deeper side of the reservoir pond. During water exchange, each time the exchange should not exceed 30% of water in the pond and ideally it should be 10% of the water each time. This prevents sudden changes in the water quality of shrimp ponds, such as changes in blooms, pH, salinity, and therefore, stress on the shrimp during water exchange is minimized.

3.5.2.2. Liming and pH maintenance

During the shrimp production cycle, lime should be applied regularly in order to maintain the water pH. If the water pH falls below 7.5 or fluctuates by more than 0.5 pH units in 24 hours then lime should be applied. If the pH rises above 8.5, water exchange is needed, followed by application of lime. Lime should be used immediately after every water exchange and after periods of rain. In the initial stages of culture (when the bloom is not stabilized) dolomite should be applied. After bloom stabilizes (usually after 30-40 days of culture), agricultural lime should be used.

3.5.2.3. Fertilization and bloom maintenance

A stable bloom in the pond water is an important factor for health management of shrimp. In early stages of culture there may be frequent changes in condition of the bloom. This is mainly due to lack of nutrients and carbon dioxide (CO_2). Therefore, nutrients should be supplied in the form of fertilizers. Organic fertilizers like cow dung or chicken manure are preferred at early stages of culture to develop a stable bloom. If only inorganic fertilizers are applied, there will be a sudden development of bloom and subsequent sudden bloom crash. However, a mixture of organic and inorganic fertilizers gives a better bloom at faster rate, which is likely to be maintained for a longer period. Fertilizers should always be applied in split dosages for bloom maintenance. During later stages of culture (after 30 – 40 days of stocking), the pond gets nutrients mainly from waste feed and shrimp excreta and fertilization is not required. However, if there is a sudden changes in bloom due to changes in climate, such as heavy rain, excessive water exchange and other changes, fertilization may be necessary. If the bloom is very dense, then water exchange should be carried out.

3.5.2.4. Aeration

Aeration should be provided especially in farms (such as those in Nellore district) where the stocking density exceeds 6 shrimp m^2. 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 (such as those in West Godavari district), 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 shrimps start surfacing or the bottom soil quality is bad and water has more turbidity and dark color.

Aeration of water using a paddle wheel aerator

Ideal green colored water during grow-out period

Clear water with benthic algae at bottom

Clear water with floating benthic algae

3.6. Pond bottom management

3.6.1. Risk factors

The study did not find any direct relationship between the condition of pond sediment and risk of disease outbreaks or production. However, in other studies the occurrence of black and toxic bottom sediments has been shown to adversely affect shrimp health and lead to disease outbreak or poor production.

The study showed there is a relationship between ponds with higher stocking densities and feeding rates, and poor pond bottom conditions. Therefore, as farmers stock with higher density, more attention must be given to pond bottom management.

3.6.2. Management guidelines

The pond bottom soil should be checked on weekly basis, especially at the feeding area or trench. The occurrence of black soil, benthic algae and bad smell should be recorded. If the soil is black and smelly, water exchange should be carried out and feed reduced (using a feed tray to monitor requirements). During water exchange, the feeding area and where black soil occurs should be midly and carefully agitated to dislodge the soil from the pond bottom. This will facilitate its drainage from the pond. Special attention has to be given to management of feed to reduce wastage and avoid deterioration of pond bottoms (see 3.7 - feed management).

Good soil without any black layer

Poor quality, black soil with benthic algae at surface

3.7. Feed management

3.7.1. Risk factors

The study found no significant relationship between amount of feed used and feeding patterns and shrimp disease outbreaks. However, good feeding practice is essential to maintain water and soil quality and a healthy environment within the ponds.

3.7.2. Management guidelines

Pellet feed should be given according to a fixed schedule. This schedule will depend on the body weight of the shrimp and the feed tray result during previous meal. On the basis of body weight, the feed amount should be calculated. For this purpose the feed tables given on the feed bag by the manufacturer can be used. If fresh (cooked) feed such as snail or trash fish (but not crustacean based fresh feed) is used during the later stage of the cycle to improve the growth, it should be only under close monitoring of water quality and a careful feeding strategy to avoid wastage.

Feed trays should be introduced after one week of stocking and should be used to check the general condition of the shrimps during the first month. From 30 days of culture (DOC) onwards, feeding results from these trays should be used to decide the meal quantity. To reduce size variations, feed size should be changed according to the actual size of the shrimp. A mix of two feed pellet sizes should be used for at least 7 days if there is any size variation during the regular check-up. Feeding area should be changed at least once in 10 days depending on the bottom condition along feeding area. This allows shrimps to feed in a clean area.

Demand feeding using check trays

Feed distribution using boat

3.8. Treatments and use of chemicals

The study showed that many chemicals were used against shrimp disease without any beneficial effect. Farms with higher stocking density tend to use more chemicals, both in terms of numbers and the quantities applied. The study showed that antibiotics and a range of probiotics had no significant effect on the risk of shrimp disease outbreaks.

Use of lime, fertilizers in low input systems, and disinfectants in farms using higher stocking densities had some protective effect against shrimp disease.

Feed additives including vitamin and mineral premix as well as some bacterial products had some beneficial effect on shrimp production in higher stocking density farms in Nellore district. These products had no effect on shrimp disease occurrence.

There is a concern that in low input farms, pesticides such as Nuvan and Endosulphan may be used as disinfectants. These pesticides should not be used because they lead to residues in harvested shrimps which are hazardous for human health. Only calcium hypochlorite (bleach) should be used as a disinfectant. Other chemicals such as lime compounds, fertilizers, zeolite and related compounds that do not lead to residues in the harvested shrimps can be used to manage the pond condition and shrimp health.

During the demonstration phase of MPEDA/NACA Technical Assistance, it has been clearly shown that shrimps of good quality can be grown with very minimal chemical usage and without the usage of antibiotics. Minimal usage of chemicals and no usage of banned chemicals lead to reduced cost of production and easy marketing of the harvested shrimp in domestic and export markets.

There is a serious concern on the use of antibiotics, and their use in shrimp farming should be avoided. The MPEDA advises that the following antibiotics and pharmacologically active substances, which are banned for use in aquaculture should not be used in any circumstances:

1. Chloramphenicol	11. Dimetridazole
2. Nitrofurans including Furazolidone, Nitrofurazone, Furaltadone, Nitrofurantoin, Furylfuramide, Nifuratel, Nifuroxime, Nifurprazine and all their derivatives	12. Metronidazole
3. Neomycin	13. Ronidazole
4. Nalidixic Acid	14. Ipronidazole
5. Sulphamethoxazole	15. Other nitroimidazoles
6. Aristolochia spp. and preparations thereof	16. Clenbuterol
7. Chloroform	17. Diethylstilbestrol (DES)
8. Chlorpromazine	18. Sulfonamide (except approved sulfadimethoxine, sulfabromomethazine and sulfaethoxypyridazine)
9. Colchicine	19. Fluoroquinolones
10. Dapsone	20. Glycopeptides

4. SHRIMP HEALTH MONITORING

Shrimps should be sampled once in a week by cast netting and should be checked for their general health conditions, like external appearance (body color, missing appendages, external/gill fouling, black gills or gill choking, *etc*), gut condition, and growth in terms of weight or length. Shrimp behaviour and feeding trends should be monitored. These observations should be recorded at regular intervals (an example of a weekly data recording sheet is in Annex B).

By maintaining recording sheets, it is easy to review the sequence of changes in water and soil conditions, feeding and shrimp health and the management practices followed. A first sign of disease is when diseased or weak shrimps swim at the water surface or come to the edges of the pond. If many shrimps are affected by the disease, then feeding may be reduced. During this period, looking back at the farm records for sharp changes in water quality, bottom soil conditions or shrimp appearance in net sampling and feeding trays will give an idea on the possible causes of disease. With regular monitoring and review of important parameters it is easier to understand and rectify the environmental conditions at an early stage and prevent the spread of disease to other shrimps.

Cast net sampling for health check up

Healthy shrimp samples

5. HANDLING A SHRIMP DISEASE OUTBREAK

Despite all the precautions, farmers may still suffer some shrimp disease problems. Prompt action is essential in such circumstances to rectify the problems, reduce the losses and minimise the impacts on neighboring farms.

Particular times of concern:

- If any sick shrimp has been found in any of the surrounding farms, this is an indication of stressful conditions in the area.
- Weather changes, particularly cloudy and rainy weather for prolonged periods.
- Changes in the colour of pond water.
- Sudden blackening of pond bottom.
- Shrimp coming to pond edges and increasing number of dead or weak shrimps.

Under such circumstances, the following actions should be taken :

- Check any abnormalities in water and soil condition and take immediate action to correct the problem. (See 3.1.2. water management and 4.1.1 soil management)
- Remove dead animals and bury them away from the ponds.


Removal of dead shrimp from pond margins

- If the mortality rate is increasing rapidly, and shrimp are not feeding, an emergency harvest can be carried out preferably using cast netting to avoid discharge of infected water into the main water source.
- Before releasing the water to the drainage, treat the pond water with bleaching powder (calcium hypochlorite) and leave for 5-7 days before discharging.
- To avoid spread of disease to other ponds in the area, the neighbouring farmers should be kept well informed about shrimp disease problems, emergency harvest and the time and date of water discharge.

- The pond water should be treated in an effluent treatment system (ETS) (as per the guidelines given by Aquaculture Authority, Government of India) before discharging to a common water source. This system must be followed in shrimp farms of 5 hectares water spread area (WSA) and above located within the CRZ and 10 hectares WSA and above located outside the CRZ. In the case of smaller farms farmers should form a group and construct a common ETS to manage disease problems and ensure sustainability of the environment.
- During periods of disease outbreak, surrounding farmers should try to avoid water exchange and should not use any equipment (nets, tanks, pumps, boat, *etc*) from affected farms. The aim of this practice is to avoid any risk of cross contamination of the virus or other disease causing agents.
- To maintain water quality in the pond during such periods, feeding may be reduced. This practice reduces the necessity for water exchange. Liming may be necessary to maintain the pH above 7.5.

Finally, farmer groups are encouraged to discuss common actions that can be taken during disease outbreaks on a priority basis, to avoid spreading of disease from one farm to another.

6. FARM RECORD MAINTENANCE

It is a good practice to maintain farm management records. Records are necessary to identify problems in the pond environment and shrimp health and to rectify these problems at the earliest during the production cycle. Record keeping also helps the farmer to learn from past mistakes, thus reducing risk and costs of production in subsequent crops. Records are useful to plan the entire crop cycle including stocking densities for each pond, well ahead of its start.

Farm records ideally should contain details on pond preparation, seed and its stocking, feed management, water quality parameters and its management, pond bottom management, shrimp health and harvest. The farm data maintenance sheet (see Annex B) should be used for the purpose.

7. FARMER ORGANIZATION

It is very important for farmers to discuss the farming situation of the village at regular intervals to maintain a close vigil on the disease outbreaks in the surrounding areas. Presently, such meetings take place in an unorganized manner. Organizing farmers under a village level farmer club/ association/society would lead to many benefits, such as common stocking dates and seed sources to minimize seed selection and transport cost. Similarly, they can purchase feed, lime, fertilizers and other commonly used crop inputs under the group (as maintained by paddy farmers). This minimizes the cost of inputs and assures farmers on the quality of the product. The farmers' clubs can also procure basic instruments for soil and water quality parameter analysis (like pH meter, DO meter, kits for ammonia, alkalinity, etc.) and even some simple health management kits. During harvesting time, farmers' groups can negotiate with buyers, bargain reasonably good prices for shrimps and also get a premium price for high quality, chemical residue free shrimp which gives an added advantage to the farmer in marketing its product. Thus, the farmer groups can play a very important role in managing the source water quality and the local environment.

Farmer group in Mogalthur village, West Godavari district, Andhra Pradesh

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Annex A: Some frequently asked questions

The following list of questions and answers was prepared during the workshops organized towards the end of Phase 2 and 3. They are reproduced here to help in dealing with some frequently asked questions.

My pond suffered a disease outbreak 30 days after stocking the last crop. Please advise me how to prepare the pond for the next crop?

Ans. Prepare the pond normally by removing the black soil (sludge), which has a bad smell. Dispose this removed sludge away from the pond site. Maintain the water reservoir and culture the plankton in reservoir first and then transfer the water to grow-out ponds. Avoid clear water at stocking by adding more fertilizer to get a green color. Maintain pH and alkalinity by applying the required quantity of lime. This entire process may require 30 days before stocking. So plan the pond preparation accordingly.

What should be the optimum soil pH for shrimp culture?

Ans. It should be above 6. However, farmers should check the water pH and try to maintain it in the range of 7.5-8.5 by using lime, because it is difficult to completely rectify the soil pH problems.

It is very difficult for us to discard the sludge away from the pond site as in our village all the area is filled with ponds, with out leaving much free space. Where to discard the sludge and is there any other option to reduce the sludge in the pond?

Ans. Most preferred practice is to discard the sludge away from the pond site. If the black soil is disposed off on the bunds of the pond then it may seep back to the pond during rain and again create a bad pond bottom condition. Sludge may be disposed off in a trench dug along the bund so that it does not seep back in to the pond, which is better than not removing it at all. In case it cannot be removed, ploughing several times on wet soil can reduce the organic matter, which will be a more time consuming activity.

What are the disinfectants found useful in reducing disease outbreaks from your study observation? Why are they effective in Nellore district only?

Ans. Iodine compounds were found to be commonly used as disinfectant in Nellore district. The compounds were found to be more effective if used during pond preparation. They were not commonly used in West Godavari district since it may not be a cost effective practice to use such compounds in low input farms.

Is the use of pesticide good or bad? If bad, do you suggest any alternative to disinfect the pond?

Ans. The use of pesticides is bad because they can accumulate in the environment as well as in the shrimps. Screening the water using water filters to prevent the carriers and storing the water for at least 7 days before pumping to grow-out ponds is a better option.

What is the required water depth in culture ponds?

Ans. The optimum depth should be 1.2 meter. There should be a minimum depth of 0.8m in the shallowest part of the pond.

Measuring pH using liquid pH indicators is not showing any minor fluctuations in pH. So how can this type of pH measurement be useful for the farmers?

Ans. The purpose of using liquid pH indicators is to look only at the pattern or trend on how pH changes. Greater fluctuations of pH can be easily noted by farmers during critical periods using simple kits. Farmers can afford to have a simple liquid pH indicator, as its price is below Rs 100 and 200 tests can be carried out.

How to reduce pH in saline waters when there is no color/bloom in the water?

Ans. Exchanging the water by 10-20 % may introduce phytoplankton before applying fertilizer and some agricultural lime. This approach will lead to the bloom. Also one can try using 10 to 15 Kgs of rice bran or wheat bran in one ton of water (pond), stirred frequently at an interval of 2 to 3 hrs and fermented for seven days to develop acidic bacteria. The supernatant acidic water should be applied to the pond water every 7 days till the pH gets reduced to normal level.

Why does pH change suddenly on daily basis?

Ans. Excessive algal blooms or low alkalinity.

Why does pH rise suddenly when poultry manure is applied to get a bloom? How to control pH in such a situation?

Ans. Too much manure in a single dose can raise the pH suddenly. Reduced quantity of manure applied in 2-4 split dosages and subsequent addition of some water into the pond can control this situation.

How to reduce ammonia and what level kills shrimps at high pH values?

Ans. Again, the most cost effective way to dilute any toxic condition, especially ammonia in the pond is to exchange some water. This will also reduce the water pH at the same time by diluting the bloom. The level of total ammonia nitrogen should not be higher than 1 ppm at pH value of 8.5.

During rains the water temperature reduces and shrimps come to the sides. Why? And how to avoid it?

Ans. The problem is caused by the cloudy sky that leads to reduced oxygen levels in the pond water. The feed consumption by shrimp gets reduced due to lower temperature. Therefore, feed quantity should be reduced and water exchange should be done if the water is too green in color.

Is it good to use some fishes in shrimp ponds? If yes why? Which species and how many numbers should be introduced?

Ans. Fish can be used in later stages of culture (after 60 days) for feeding on the plankton and benthic algae. In Thailand, 3,000-5,000 fry (1-2 cm.) of Tilapia are stocked in 1 ha. If the fish are big, then they can be stocked in cages. Some species like sea bass can eat the dead shrimp in the

pond, which may help in reducing the transmission of virus from dead to live shrimp by avoiding cannibalism.

For water exchange, which time of the day is suitable?

Ans. Time does not make much difference. It can be done at any time as convenient to the farmer.

Why is there a sudden collapse of bloom after 30 days of culture?

Ans. For a healthy bloom to be maintained, it requires nutrients, carbon dioxide and sunlight. After around 30 days of culture the bloom develops heavily due to the availability of all three components. Due to heavy bloom the sunlight is prevented from penetrating the lower column of water thus leading to oxygen deficiency and death of plankton present in the lower column of water. This condition leads to collapse of the bloom.

How to control blue-green algae (filamentous/slime forming species) in low saline waters?

Ans. Water exchange is the most cost effective method. In cases where water exchange is not possible, aeration should be stopped during the strong sunlight period. This will allow the plankton to float on the surface where it will get pushed to the pond corner by the wind. The algae can be removed, or an algicide may be used in that corner of the pond to kill the algae. This is a low cost treatment method and safe for the shrimp since the chemical will be applied only to a small area. Repetition of this treatment may be necessary if the algae persists.

How to control filamentous algae?

Ans. In reservoirs, the phytoplankton bloom should be developed initially before shifting it to the grow-out ponds. Avoid using disinfecting agents in both reservoir and grow-out ponds.

How to control benthic algae?

Ans. Initially culture the plankton in a reservoir and then shift the bloomed water to grow-out ponds. Avoid clear water at stocking by adding fertilizer as required. Even after these measures if the benthic algae develops then drag a heavy iron chain along pond bottom to dislodge the algae from the soil surface and then remove the floating benthic algae using a hand net.

What is the reason for excessive algal bloom in the pond?

Ans. Mainly because of higher nutrient levels in the pond and less water exchange.

Since 1994, farmers have observed good crop in lower salinity area compared with higher salinity area. Why?

Ans. In ponds with lower salinity water, it is easier to control the water quality leading to less stress to the shrimp.

PL from the same hatchery tank were stocked in the same nursery pond and then distributed to 5 grow-out ponds. At the end of the crop, 3 ponds faced disease outbreaks and 2 ponds were harvested without disease problems. Why?

Ans. Disease outbreak not only depends on the seed quality but also on the individual pond

management practices. Infected shrimp may not die at the same time in all the ponds. There may be a possibility that the 2 ponds with good harvests might have been managed better, leading to reduced stressed conditions in the pond.

What are the symptoms of HPV? In which area has it been observed during the MPEDA/NACA study?

Ans. HPV stands for "Hepatopancreatic Parvo-like virus" which can damage the hepatopancreas of shrimp, causing slow growth or stunting (similar to MBV). The study found the virus in both areas but at a very low prevalence when compared with white spot disease. HPV should not cause any serious problem in grow-out, if the ponds are well managed.

What is LSS ? How can it be prevented from the beginning?

Ans. This is "loose shell syndrome" and is usually caused by chronic bacterial infection. The primary causes of this infection are toxic conditions at the pond bottom. This is mainly related to clear water with benthic or filamentous algae. Over feeding and high organic matter in the soil can also cause bad pond conditions and lead to the infection. To reduce the risk of this problem, pond bottom sludge should be removed during pond preparation. Maintaining green color water as well as better feed management to prevent benthic algae and pond bottom deterioration can also reduce the risk.

What is vibriosis? What are the clinical signs? How to prevent the disease?

Ans. Vibriosis is an infectious disease caused by Vibrio *bacteria. The acute infection usually occurs when shrimps are one month old. Therefore, sometimes the farmers call it as one-month mortality syndrome. In higher salinity areas, the severity of this problem is usually greater and is caused by luminous species of bacteria. In this case the farmer may call the problem luminescent vibriosis. The clinical sign is not obvious. The sick shrimp is usually pale or darker color, with no feed in the gut. Sometime the problem is associated with soft shell. In later stages of the production cycle, the infection seems to be a chronic type. This is usually associated with loose shell syndrome. To prevent the infection, the pond should be prepared well and the green color must be maintained to prevent benthic algae. The pond bottom condition must be kept clean to prevent high organic matter accumulation.*

Can antibiotics control the white spot disease outbreaks?

Ans. Viral diseases in shrimps cannot be treated by antibiotics.

In shrimp nurseries, cutting insects (*Notonecta* sp ?) are present and kill the PL. How to control them?

Ans. Spread palm oil over the water surface at the rate of 15- 20 litres/ha in the evening hours.

Annex B: Crop detail and pond management record

Farm name: ……..
Pond number: ……..
Pond water spread area: …….

Pond preparation details:

Dried:	☐ Yes	☐ No
Sludge removed	☐ Yes	☐ No
Sludge disposal place	☐ Inside the pond	☐ Outside the pond
Ploughed:	☐ Yes	☐ No
Soil condition while ploughing	☐ Wet	☐ Dry

Soil treatment:

Name of substance	Number of application	Total Quantity

Water treatment / fertilization/ disinfection :

Name of substance	Number of application	Total Quantity

Seed stocking details:

Stocking date: ……
Name and place of hatchery/nursery: ……
Number of seed stocked: …….
PCR status
Overall quality of seed: ☐ Good
☐ Average
☐ Bad

Daily recording sheet:

Day of culture	Date	Feed details									Feed supplement		Water quality							Water exchange		Aeration (Y/N)	Water / soil Treatment		Diseased shrimps		Other observations
		6 AM	9 AM	12 PM	3 PM	6 PM	9 PM	12 PM	Total feed	Feed brand & Number	Name	Quantity	Color	Transparency (cm)	pH		Temperature		Salinity	Out (cm)	In (cm)		Name	Quantity	Numbers /day	Appearance / behaviour	
															8-10 AM	3-5 PM	8-10 AM	3-5 PM									

Weekly monitoring sheet:

		Pond bottom condition			Shrimp health	
Days of culture	Date	Benthic algae (Y/N)	Black soil layer (Y/N)	Bad smell from soil (Y/N)	Avg. body weight (g)	Appearance

Harvest details:

Date of harvest: ……..

Count	Kgs

FCR = Total feed used (kg) / Total harvest (kg) = ……..