DEPARTMENT OF FISHERIES
MINISTRY OF PRIMARY RESOURCES AND TOURISM
BRUNEI DARUSSALAM

MANUAL OF BRUNEI DARUSSALAM ON GOOD AQUACULTURE PRACTICES FOR SHRIMP FARMS

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Preface

Manual of Brunei Darussalam on Good Aquaculture Practice For Shrimp Farms sets out to guide Aquaculture farm operators and authorized Officers in the Department of to ensure the compliance of fishery products for domestic and export market with the health and safety requirements laid down in the national and international requirements where these products are intended for sale. Operators are not obliged to follow the advice in the guide, as other ways of achieving compliance with the law may be equally valid.

The objective of this manual is for marine shrimp culture in Brunei Darussalam where Black tiger shrimp, *Penaeus monodon* and Udang Rostris, *Litopenaeus stylirostris* are among the economically important species in Brunei Darussalam.

Since today's shrimp farming practices are based on the intensive culture system, the danger of major losses due to disease also increases. Marine shrimp farming also has an impact on the coastal environment and mangrove ecology. These problems are considered as barriers towards sustainable development of shrimp farming industry in the region. It is hoped that this manual will partly help solve the problems encountered in shrimp farming and contribute towards better marine shrimp management and a more sustainable farming industry.

The requirement of this manual is reviewed and revised based on the national and international requirements. The guideline can be used by shrimp farm exporters and shall comply with national and international law on export requirements. The manual will be reviewed and amended if necessary.

Regulations/Requirements

The main regulations that govern these aspects and provide detailed guide area as follows:

i. Fisheries Order 2009.

ii. The Fisheries (Fish Culture Farms) Regulations, 2002.

iii. Regulation (EC) 852/2004 of European parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs.

iv. Regulation (EC) 861/2004 of European parliament and of the Council of 29 April 2004 laying down laying down specific hygiene rules for food of animal origin.

v. Regulation (EC) 854/2004 of European parliament and of the Council of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption.

vi. Regulation (EC) 183/2005 of European Parliament and Council of 12 January 2005 laying down Requirements for Feed Hygiene.

vii. Directive 88/2006 Of European Union animal health requirements for aquaculture animals and products.

viii. Regulation (EC) No. 1831/2003 of the European Parliament and of the Council on additives for use in animal nutrition.

ix. Directive 2001/82/EC of the European Parliament and of the Council of 6 November 2001on the Community code relating to veterinary medicinal products.

x. Council Directive 98/83/EC on the quality of water intended for human consumption. Adopted by the Council, on 3 November 1998.

xi. European Parliament and Council Directive No 95/2/EC of 20 February 1995 on food additives other than colours and sweeteners.

1.0 Introduction

Aquaculture has seen rapid growth in Brunei Darussalam and expanding of growth area mainly in shrimp production. Good aquaculture practices (GAqP) are a series of considerations, procedures, and protocols designed to foster efficient and responsible aquaculture production and expansion and to help ensure final product quality, safety, and environmental sustainability. GAqP include considerations for site location, production system design, incoming seed stock, biosecurity facility, feeding management, procurement, storage, production techniques to maximize Shrimp's health, harvest, cleaning and sanitation basics to ensure final product quality and safety.

2.0 Scope

The objective of this manual is to provide practical information on the safe production, handling, storage and transport of aquaculture product.

3.0 Surroundings, Location and Construction

3.1 Location

- Aquaculture farms should be located in areas specifically zoned as suitable for aquaculture development;
- Farms should be located in environmentally suitable areas where risks to food safety from chemical, biological and physical hazards from air, soil and water are minimized;
- Farms should be secured from the entry of wild and domestic animals that may lead to the contamination of aquaculture products.

Selection for a suitable site is a critical activity and must be carefully determined before establishing of a shrimp farm. Proper site selection takes into account environmental resources as well as access to industrial infrastructure such as roads and reliable electrical power. Environmental parameters focus on water resources (typically surface water or groundwater) to supply aquaculture operations as well as water discharge. Surface water and groundwater sources for incoming water should be analyzed for water quality and for chemistry parameters appropriate for the culture species. There are several factors involved:

3.1.1Topography and Climatic Condition

Topographically, the best areas for shrimp culture are those with average natural ground elevations of about 1 - 3 meters above mean sea level or at least 2 meters above the highest high tide level for flood protection and to allow drainage and harvesting. The cost of pumping increases in highly elevated sites. The sites should have minimum vegetative cover, be near the sea or other natural waterways such as rivers and streams, have easy access to roads, a sparse population and be nearly square or rectangular in shape. An irrigated rice field, swamps, existing fish ponds or land outside the mangrove areas are the most likely sites having these features.

Lowland or mangrove swamps are not ideal sites because of the following reasons:

a) The lowland may be made up of potential acid sulfate soils.

b) Deeper ponds cannot be built and complete drainage is impossible.

c) Construction costs in swamp land are always higher.

d) Prone to flooding.

In terms of climatic conditions, areas having short and not as pronounced dry seasons with moderate rainfall distributed throughout the year are the best suited for shrimp farming. A pronounced long dry season may cause an increase in water temperature and salinity that will promote excessive growth of algae and result in oxygen depletion at night.

3.1.2 Soil Conditions

The type of soil is the most critical in site selection, since the shrimp will spend most of their time on the pond bottom during the culture period. Usually, clay or loam-based soil containing more than 90% clay and pH between 6.5 - 8.5 is preferable. Sites with sandy or silt soil should be avoided due to their porous nature that may lead to erosion, seepage of water and easy infiltration of waste into the soil.

Prior to construction of ponds, samples of soil should be taken randomly from 5-10 spots at the surface and at 1 meter deep and sent to a laboratory for the analysis of soil texture and pH. Such data will be useful during pond construction and preparation.

3.2 Farm layout

- Farm is used for aquaculture purposes only (no livestock production);
- Farm activities related to Aquaculture should be registered with the Department of Fisheries
- Farm design and layout should be such that prevents cross contamination
- Septic tanks, toilet facilities and bathrooms/showers should be constructed and placed so drainage does not pose a risk of contamination of farm facilities.

3.3 Farm Design and Construction

A shrimp pond should be designed according to the characteristics of the selected site and the culture system. There is no unique design, but optimum and functional farm layout plan and design should be based on the physical and economic conditions prevailing in the locality.

There are three types of shrimp culture being practiced in ASEAN Member Countries namely:

a) Traditional/Extensive Cultures
The ponds have irregular shapes and sizes, mostly 1.5 ha and bigger with a peripheral ditch or canal of 4-10 m. wide and 40-80 cm. deep. The pond bottom may not be properly leveled, but tree stumps are usually removed, although this is not required. Ponds are normally filled with gravity flow water during the high tide period with natural seeds and left for 60-90 days, without additional fry stocking and feeding. Stocking density in this type of culture is 0.5-5.0 pcs/m^2. These ponds are normally partially harvested.

b) Semi-Intensive Culture
Pond size of 1-1.5 ha in size and are constructed with dikes to hold the water 1-1.5 m. deep. Fry are stocked into the pond at 10-15 fry/m^2 and fed with commercial diets and/or fresh diets. The shrimp are harvested at 90-120 days after stocking.

c) Intensive Culture

The ponds are usually of 0.5-1 ha. in size and are designed to keep the water at 1.5-2.0 m. deep. A reservoir of at least 30 % of the pond area is usually required. High stocking density of 25-60 fry/m^2 with feeding rate of 4-6 times daily and strong aeration is maintained.

3.4 Water Supply System

A shrimp pond is filled with water mostly by pumping. The pumps should be installed at locations where they can obtain water from the middle of the water column with least sedimentation and pollution. The pumps and inlet canal should be large enough to allow the ponds or the reservoir to be filled within 4-6

hours. A screen should be installed at the inlet canal prior to the pumps to prevent clogging at the inlets.

3.4.1 Reservoir

A reservoir is important for the control of pond environment and storage of water supply when the water quality is inconsistent or the supply is intermittent. It is recommended that the area of a reservoir within a farm should be about 30% of the total farm area in order to hold a sufficient volume of the water supply. Some farms may use part of the reservoir for sedimentation purpose where biological filter feeding organisms are stocked. The reservoir must have an outlet that can allow total drainage.

3.4.2 Supply Canals

An intensive shrimp farm should have a water supply canal to convey the water from the reservoir to the ponds by gravity or pumping. The size of the supply canal will depend on the size of the culture pond, the efficiency of the pump and the required water exchange rate.

3.4.3 Ponds

A well-designed pond will facilitate the management of water exchange, harvesting of the product, waste collection and elimination, and feeding.

- Shape

  The shapes of pond that are found to be effective for shrimp culture are rectangular, square and circular. A well-designed pond is one that would allow circulation of the water such that wastes will be accumulated at the center of the pond. Some farmers improve the water movement in the square and rectangular ponds by making the corners of the pond rounded through addition of soil.

- Size

  Smaller ponds are easier to manage but the construction and operation can be costly. Ponds, with an area of 0.5-1.0 ha, are commonly used in intensive culture. Meanwhile ponds with area of 1-2 ha commonly used in semi-intensive culture.

- Dikes

  Earthen dikes, with or without lining, are found to be the most economical. Dikes should be designed to impound higher than 1 m.

  Depth of water and must be high enough to prevent flooding during the rainy seasons and the highest high tide. The slope of the dike depends on the nature of the soil. A slope of not less than 1:1.5 is normally used in the sandy soil area to avoid erosion and 1:1 is used for clay soils. One must be aware that shallow slopes will encourage the growth of benthic algae that will impair the quality of the water in the pond. Some dikes in a farm may be wider than the others to provide space for the access road, storage, electricity and aerators.

- Pond Lining

Lining materials are used in pond where the soil contains a high percentage of sand, and organic matter and is acidic in nature. Lining can reduce erosion, water seepage, waste accumulation in the soil and the leaching of ammonia, hydrogen sulfide, acidic compounds, iron and other potentially stressful compounds into the ponds. The lining also allows easy removal of wastes from the feeding areas, reducing the time and costs to clean the ponds between cycles.

Several lining materials are currently available; including the compact laterite, compact clay, bitumen impregnated polypropylene textiles (geotextiles), polyvinylchloride (PVC), polyethylene (PE) and high density polyethylene (HDPE). Farmers may line the pond totally or partially, depending on economic/financial consideration. Another factor will be the rate of waste accumulation in an area on the pond bottom. The economic life of liners varies according to the maintenance and the duration of exposure to sunlight. The following Table 1 shows the economic life of some liners.

Table 1: Economic Life of Some Liners.

Liner type	Thickness (mm.)	Economic life (years)
Compact Laterite	^200	3
PVC, Plastic Sheet	0.2-1.0	<5
Geotextile	0.57	>5

Among the liners, laterite soil is less expensive and commonly used in shrimp farms. However, laterite soil liner may allow the penetration of wastes and requires effective cleaning up. Pond liners with PVC plastic sheeting and geotextiles can reduce the cost for aeration and cleaning up due to the easy movement of wastes and uneaten food on the smooth surface. The disadvantages of PVC plastic and geotextile-lined ponds are difficulties in maintaining plankton bloom within the first month of culture, problem of tears and the floating of the liner if the water and gas accumulate underneath them.

- Gates for Inlet and Outlet

Each shrimp pond should have at least one gate for filling and draining water. However, a typical pond of 0.5 - 1 ha usually consists of two gates having similar structure for the inlet and outlet gates. The size of the gate is dependent on the size of the pond, but must allow the pond to be filled or drained within 4-6 hours. Gates of 0.5-1.0 m. wide are usually constructed, since gates wider than 1 m. will cause difficulty in screening and will allow strong currents which will cause erosion of the soil.

The position of the outlet should be at the lowest point of the pond with a gradual slope of 1:200 from the inlet to allow total drainage of the pond during harvesting. The conventional gates constructed at the side of the pond should have a double screen, with fine a mesh for the initial period of culture and a coarser one for a later period. Some farmers may place both meshes in a single frame and cut out the finer mesh when the sizes of the shrimps are larger than the opening of the coarser mesh.

- Central Drain

This has been employed in some farms and consists of perforated pipes laid horizontally at the center of the pond and connected to a pipe leading to the outlet. A screen of small mesh size is used to cover the drain for the first 48 days of culture and is removed to allow for easy removal of water when the shrimps are larger than the diameter of the pipe.
This method has the advantages in that it can remove the waste and clean the pond bottom any time throughout the culture period.

- Drainage Canal and Sedimentation Pond

  The drainage canal of a shrimp pond should be at least 48 cm. lower than the lowest point of the pond to allow drainage by gravity. The effluent will be drained into a sedimentation pond to settle the particulate wastes before water is pumped into the reservoir or released out of the farm. It is recommended that the sedimentation pond should be approximately 5-10% of the culture area and should be deep enough to prevent mixing and re-suspension of the wastes. Baffles or soft walls made of fine mesh net or plastic sheeting supported by stakes driven into the pond bottom may be constructed in the sedimentation pond to decrease the velocity of water and increase the retention time which will enhance the settlement of the wastes. The wastes in the sedimentation pond should be removed periodically and discharged into the waste dumping area.

3.4.4 Waste Dumping Area

A shrimp farm should provide 5-10% of the area for dumping of the wastes. Wastes from the pond must be collected carefully and dumped into this area without discharging to nearby areas, which will contaminate the natural resources.

3.4.5 Buildings

Accommodation, storage, shop and guard houses may be built in the farm as required. It is advised that accommodation for workers should be set up at various points around the farm for security purposes and to allow the ponds to be adequately monitored.

3.5 Equipment

- Equipment such as containers and vehicles for feed, seed and harvested aquaculture products should be designed and constructed to allow for adequate cleaning and disinfection.

3.6 Infrastructure

3.6.1 Accessibility

The farm must have good accessibility either by road or water, and communication systems throughout the year in order to facilitate supervision and transport of materials and products. It is important that the farm be within 3-6 hrs traveling time from the hatchery to avoid excessively long transportation time of the larvae and should be within 10 hours. From the processing plant to avoid deterioration of the product.

3.6.2 Electricity

Availability of relatively cheap and reliable power source is a major consideration in site selection. In areas where electricity supply exists, it is practical and beneficial to utilize electric power to run the farm, especially for the intensive culture system. It is advisable to have a back-up electricity generator as a secondary power source.

3.6.4 Security

Areas free from security risks result in favorable working conditions, productivity and less extra costs.

3.6.5 Availability of Labor and Other Factors

The availability of labor, equipment and commercial feed and supplies ensure smooth operations and successful crop.

3.7 Source water

- Farm source water should be free from sewage contamination and suitable for aquaculture production.
- There should be sufficient quantity of water suitable for aquaculture throughout the year.
- Farms should have settling ponds or waste water treatment in place to condition the output water prior to discharge.

3.8 Pest Control

- Building construction in combination with a pest control system should be designed to ensure that the risk of contamination of feed, equipment and the farming system is minimized.

3.9 Facilities

- Separate buildings for feed, drugs and disinfection deposits are available and suitable;
- Facilities for hygienic disposal of solid and liquid waste are available and suitable.

3.9.1 Staff Facilities

- Toilets are available and the number of toilets is adequate for the number of staff;
- Toilets are located so that waste does not contaminate the farm;
- Adequate hand washing facilities are available and suitably located for staff to use.

4. General Practices

4.1 Facilities and Equipment Cleanliness

- Farm and surroundings should be maintained clean and in a sanitary condition;
- Measures should be taken to prevent animals and pests from causing contamination;
- Fuel, chemical substances (disinfectant, fertilizer, reagents) feed and veterinary drugs stored in separate and safe conditions;
- Containers, equipment and farm facilities are maintained in a good condition so they are easy to clean and disinfect;
- Adequate procedures for cleaning and disinfection of containers, equipment and farm facilities are in place and implemented.

4.2 Pond Preparation for stocking

- Pond preparation practices should minimize the risk of cross contamination.
- Fertilizers, probiotics, chemicals etc. are used according to manufacture instructions.
- Animal manures used as fertilizers should be adequately composted before use to eliminate the risk of transferring pathogens to the pond water.

Before a pond can be stocked for a new crop, the excessive wastes that accumulate in the pond during the previous crop must be removed and the soil and water conditioned. Growing of shrimp in an improperly prepared pond may lead to difficulty in pond management during the culture period that could result in a decrease in production capacity of the pond.

4.2.1 Soil organic matter

Shrimp farmers are concerned about the excessive accumulation of organic matter in pond soils. Although this problem is probably less severe than often thought, monitoring of bottom soil organic matter concentrations can be useful for management decisions.

The best time to sample pond bottom soils is soon after the pond has been drained, but before any soil treatments have been applied. Soil samples should be collected from several places in the pond bottom. It is adequate to take 10 to 12 random samples of the upper 5-cm layer and combine equal volumes of these samples to provide a composite sample for analysis. The composite sample should be mixed thoroughly, dried in an oven at 60°C, and pulverized to pass a 20-mesh screen. The best procedure for organic carbon determination is the oxidation of organic carbon by potassium dichromate and sulfuric acid (Walkley-Black Method).

Soil organic carbon concentrations in bottom soils of shrimp ponds seldom exceed 1 or 2%, and values up to 3 or 4% are probably acceptable. Some organic matter in bottom soils is good because it favors benthic productivity. Ponds with less than 0.5% organic carbon may not have good benthic productivity. Organic carbon values can be multiplied by a factor of 2 to provide a rough estimate of actual organic matter concentration.

4.2.2 Pond Cleaning

The cleaning of a pond or removal of the wastes, especially the organic and phosphatic wastes that have accumulated in the pond bottom could be, accomplished by drying, liming and ploughing. However, these methods could still leave an adverse effect on the water and soil quality in the pond which could result in a decrease in the production capacity of the pond.

There are two methods for cleaning a pond according to the possibility of the pond to be dried:

a) Dry Method

This method is used when the pond bottom can be dried completely. The pond is drained and left to dry in the sun for a period of 10-30 days. Then the waste is removed, either manually or mechanically, and transported to the waste dumping area. Removal of waste by machines has an advantage that it can compact the bottom soil. However, this cleaning method by drying may lead to development of acidity, lowering the level of the pond bottom and the diffusion of wastes if the workers are inexperienced.

b) Wet Method

- Pressure washing

  In areas where the pond cannot be dried completely, pressure washing can be used to flush out the wastes. This method takes a shorter time and is more efficient than the dry method. Flushing should be continued until the acid and dark anaerobic layer in the soil are removed. This method is suitable in the acid sulfate areas where the oxidation of the soil must be avoided. However, the method requires a sedimentation pond to all settlement of the suspended wastes to avoid contaminating the drainage canal and the natural environment. The remaining pathogens in the ponds can be eliminated during the liming process.

- 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 PL/m^2 or above as explained earlier.

4.2.3 Liming

Once the pond is cleaned, it is then filled with water and left overnight before flushing out to remove debris and elevate the pH. This process should be repeated until the pH of the water remains above 7, and only then the lime is applied. 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 applies lime only 3-4 days after the application of disinfectant. The amount of lime to be used should be carefully calculated to avoid inducing an excessively high water pH which may increase ammonia toxicity and result in the mortality of the shrimps.

The recommended amount of lime that should be applied to a pond is shown in Table 2.

Table 2. Recommended Lime Application Rate in Pond.

Soil pH	Quantity of Agriculture Lime ($CaCO_3$) (MT/ha)	Quantity of Hydrated Lime ($Ca(OH)_2$)(MT/ha)
>6	1.0	0.5
5-6	2.0	1.0
<5	3.0	1.5

During the application, lime should be spread throughout the pond bottom and up to the top of the dike. A large portion of lime should be applied over the feeding areas and to all parts of the pond that have remained wet.

When the pond is properly limed and filled with water, the average water pH should be between 7.5-8.5 with daily fluctuation of less than 0.5. Agricultural lime, dolomite or hydrated lime at 100 kg./ha./day should be added to maintain the required pH.

4.2.4 Eradication of Predators and Competitors

After liming, the pond should be filled to the maximum depth through a screen with fine mesh (24 per square inch) to prevent the predators and competitors from entering the pond. These animals, including fish, crustaceans and some invertebrates, may compete for food, prey on the shrimp or carry diseases and parasites.

They may establish themselves in the pond that is not effectively screened or is left for a long period of time. Some chemicals should be used to eradicate these animals in the pond before stocking. Fish can be killed by the application of tea seed powder at the rate of 20-30 ppm. After the application of tea seed, the pond should be left for 3 days before the post larvae can be stocked. Tea seed may also be used when the shrimp has reached a weight of more than 2 grams. However, it must be remembered that tea seed is more toxic at high salinity and temperature, but less toxic at high pH. Application of tea seed in the evening may reduce pH and result in plankton die-off.

Snails can be eliminated by the application of quick lime (CaO) at 610 kg./ha. and sun dried for 2-3 days. Then the pond should be thoroughly cleaned, filled with water and the other pests eradicated.

Hypochlorite, either calcium or sodium salt, is currently used at 15-20 % (60 % active ingredient) to eliminate both vertebrates and invertebrates. The pond must be cleaned prior to the application of hypochlorite since hypochlorite may react with the organic matters and produces the toxic organochlorine compounds. Hypochlorite should be applied after the pond is filled to the maximum height and left for 3 days to allow the hatching of planktonic organisms. It should be remembered that hypochlorite should be used prior to the liming since the effectiveness of hypochlorite will be lowered in high pH conditions.

After the hypochlorite application, the pond should be aerated and the application of lime and fertilizer should be conducted on Day 3 , while the seed can be stocked on Day 7. During the first month, water must not be added to the pond, unless the water quality is poor, to prevent the introduction of competitors and predators.

4.2.5 Fertilization

The pond must be fertilized with either organic or inorganic fertilizer to stimulate the plankton bloom in order to provide shade to the pond bottom and utilize the nitrogenous and phosphate wastes within the pond. The shade will also prevent the growth of harmful benthic algae.

The sun dried chicken manure is the most common organic fertilizer to be used in the amount of 200-300 kg./ha. The manure must be soaked in water for 24 hours before it is spread over the surface of the water.

Inorganic fertilizers, such as urea (46%N) and compound fertilizers like, ammonium phosphate (16:20:0) or those with N:P:K combination of (16:16:16) can be used at 20-30 kg./ha. The fertilizer must be dissolved in water before it is spread over the water surface to avoid precipitation of the fertilizer onto the pond bottom which will enrich the soil and accelerate the growth of benthic algae.

After fertilization, the plankton should bloom within a few days and the color of the water becomes slightly green. The fertilizer, either the organic or inorganic, should be applied daily in the pond at 5-10 % of the initial amount to maintain the plankton bloom. If the plankton has not bloomed within a few days, additional fertilizer must not be applied, but plankton rich water or green water from the reservoir should be added.

4.2.6 Aeration

A 0.5-1.0 h.a. pond would require, four aerators installed at the corners of the pond, approximately 3-5 m. from the bottom of the dike and positioned at an angle that will encourage the maximum water flow within the pond. The type of aerator to be used depends on the depth of the water. One horse-power paddle wheel aerators should be used in ponds of less than 1.2 m. water depth and the 2 horse-power paddle wheel aerators should be used in ponds deeper than 1.2 m.; while the "Venturi/Aire-O_2" should be employed in a pond deeper than 1.5 m. The most popular type of aerator is the long arm paddle wheel aerator which is driven by a 2-10 horsepower electric or diesel motor mounted on the dike. The aerators should be switched-on 24 hours before the fry are stocked to allow enough time to create the current and clean up the feeding area.

4.2.7 Reservoir maintenance and pond filling

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

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.

4.3 Stocking

4.3.1 Fry selection

Selection of good quality fry for stocking into a pond is the first important step of the shrimp grow-out management. The farmer must ensure that he or she gets healthy fry by purchasing them from reliable hatchery or hatcheries and preferably that can provide health certificate validated by competent authority of the country of origin to avoid transmission of diseases if have any. It may not always be possible to obtain the desired shrimp fry due to limitations in availability and quantity.

The following parameters should be taken into consideration in purchasing shrimp fry for stocking.

4.3.1.1 Size

Fry of PL15-20, indicated by the appearance of 4-6 spines on the rostrum, are recommended for stocking in a pond. The healthy fry should have the muscle-to-gut ratio in the sixth abdominal segment of about 4:1 or the thickness of the gut should be about the thickness of the muscle. Practically, fry from the first and second spawning of a broodstock with uniform size can be used.

4.3.1.2 Morphology

The fry should have normal appearance of trunk, appendages and rostrum. The abdominal muscle must be clear, no discoloration or erosion on any parts of the body, the gut should be full of food, and the muscle should fill the carapace.

4.3.1.3 Color

Fry with the presence of pigment cells in the uropod should be used since this indicates the stage of development. Fry that will have high survival and growth rates will be light grey, brown to dark brown and black in colour. Signs of red or pink coloration are normally related to stress.

4.3.1.4 Behavior

Healthy fry swim straight, respond rapidly to external stimuli such as a tap on the side of the basin, actively swim against the current when the water is stirred, and cling to the sides rather than aggregate or be swept down into the center of the container when the current has subsided.

4.3.1.5 External Fouling

Fry should be free from external parasites, bacteria and other fouling organisms. The presence of these organisms indicates unhealthy conditions which will affect growth and survival of the fry. It is recommended that before purchasing, the farmer should visit the hatchery to check the fry once or twice either in the early morning or late afternoon, especially one day prior to stocking. However, healthy fry with some fouling may be used when the animals are in good condition after treatment.

4.3.1.6 Pathogen Free

Fry should be checked for the presence of viral occlusion bodies. 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

Once the post larvae pass these gross visual examination tests, a PCR test should be conducted on 60 numbers randomly selected post larvae from that tank. Using 60 post larvae will allow detection of WSSV (White Spot Syndrome Virus) at 5% or more prevalence level. If the sample shows negative result then the seed is ready for transportation to the farm for stocking.

4.4 Stocking Density

When a farm is ready for operation, the optimum stocking density of fry in a pond should be determined in accordance with the production capacity of the farm and the culture system, which include the soil and water quality, food availability, seasonal variations, target production, and farmer's experience. It is recommended that farmers should start a new crop with a low stocking density to access the production capacity of the pond. If production is successful, then the stocking density could be increased for subsequent crops. Overstocking should be avoided since it may result in management problems and loss of entire production.

The stocking density between 10-20 fry/m.^{2} is usually practiced in a semi-intensive culture. In an intensive culture, a well-managed pond with consistent good water quality can stock up to 25-30 fry/m.^{2} at 1.2 m water depth and up to 40-48 fry/m.^{2} at 1.5 m water depth or deeper. However, it must be emphasized that intensive cultures involve high densities and can only be sustained in well-managed farms under an experienced farmer.

4.5 Technique of Stocking

Proper stocking techniques will prevent unnecessary mortality of fry. The following methods have shown excellent results.

4.5.1 Transportation

Fry are normally transported in plastic bags. The bags are usually filled up to 1/3 with water, oxygenated and then placed inside styrofoam boxes. If the transportation is longer than 6 hours, small bags of ice should be added into the boxes to reduce the water temperature and maintain it at 20-22 ^{o}C. The densities of fry in a bag are 1,000-2,000 fry/Litre for PL15 and 480-1,000 fry/Litre for PL20. The ideal time for transportation is in the early morning or evening to avoid excessively high temperatures during the day, unless a covered vehicle is used.

4.5.2 Acclimation

To eliminate stress, the fry should be maintained in water of constant salinity for at least 1 week prior to transfer. The adjustment of salinity by about 3 ppt. daily is advisable. Acclimation of fry to the water pH and temperature of the pond must be rendered upon arrival. Two common techniques are used for gradual acclimation of fry to the water conditions in the pond. The first method is accomplished by placing the fry and water from the transported bag into a tank at the side of a pond containing an equal volume of well-aerated pond water. The fry will be kept for 0.5-1 hour before being siphoned into the pond. The second method, the most favorable one, is to float the plastic bag in the pond until it has reached equilibrium. The bags are opened one by one and pond water is added gradually to an equal volume. After a further 30 minutes of acclimatization, the fry are released directly into the pond by distributing them throughout the area of the pond or into a nursing system. The actual numbers of fry at stocking can be estimated by counting the fry individually in 3-5 bags with a spoon or small net to attain the average number in each bag and multiplied by the total number of bags.

4.5.3 Nursing of Shrimp Post Larvae (PL)

To ensure high survival and adequate feeding of fry during the first 2-3 weeks, some farms may stock the fry in a separate nursing pond or a small impoundment, usually 5-10 % of the total pond area, within the culture pond. The nursing system will help in concentrating the fry in a limited area until they reach PL30-40 and in more accurate monitoring for survival and feeding of the fry. However, it appears that the separate nursing pond system may lead to some unfavorable results in that the size of the fry varies widely, ('broken sizes'), and the fry difficult to harvest and would experience stress during harvest and transport to the culture pond. As a result, a farmer prefers to nurse the fry in an impoundment installed inside the pond, rather than in a separate pond. Recently, some farmers employ a system in which high densities of fry (100-200 fry/m.^{2}) are stocked into a pond for 1-2 months, and then approximately half of the juveniles are transferred to another pond by large lift nets. The same acclimation process should be performed during fry and juvenile stocking.

In a very intensive pond (>30 fry/m.^{2}) where the nursing impoundment is not available, a survival pen may be installed to estimate the survival of the fry during the first 2 weeks after stocking to allow accurate feeding management. The survival pen may be a small net pen or hapa of approximately 1 m^2 containing 100 fry or a large net pen of usually 10 m^2 at 100 fry/m^2 stocking density. In the small pen, the fry can be counted accurately while the fry in the large pen may be counted by using a 1 m^2. lift net placed with 10% of the feed. In this method, fry should appear in the lift net at 3-4 days after stocking and the number of shrimp in the net should be counted at 2 hours after feeding once daily. The survival number of shrimp can then be estimated.

If the survival rate during the nursing period is less than 48%, the problems that cause this initial mortality must be identified and rectified and the addition of more fry should be considered. Fry can be added up to 30 days post-stocking without causing a variation in size at harvest. If the survival is less than 30%, the pond should be drained and prepared for a new crop.

Some farmers release fry directly into the pond. In this direct stocking method, the survival number of fry during the first 2 weeks post stocking may not be accurately estimated, since the shrimp will not approach the feeding trays during this period.

4.6 Feed and Feeding

Cost of feed constitutes a major part of the production cost and accounts for 48% to 70% of the total variable cost. The use of feeds will improve shrimp production and increase profits. The availability of nutrients from feeds depends on the type and quality of the raw material used, the formulation, the feed processing, feed storage conditions and the feeding management. Therefore, feed and feeding practices for semi-intensive or intensive shrimp farming require a basic understanding of nutrition and feed requirements.

4.6.1 Nutrient Requirements

Approximately 40 essential nutrients are required by shrimp. These nutrients are provided in various amounts by natural food and supplemental feeds. Although the nutrition principles are similar for all animals, the quality and quantity of nutrient requirements vary from species to species. The recommended levels of nutrients and dietary components for black tiger shrimp are listed in Table 3.

Table 3. Recommended Nutrient Levels for Shrimp Feed (% as fed basis)

Shrimp size (g)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Moisture (%)	Calcium (%)	Phosphorus (%)
0.0-0.5	45	7.5	Max.4	Max.15	Max.12	Max.2.3	Min. 1.5
0.5-3.0	40	6.7	Max.4	Max.15	Max.12	Max.2.3	Min. 1.5
3.0-15.0	38	6.3	Max.4	Max.15	Max.12	Max.2.3	Min. 1.5
15.0-40.0	36	6.0	Max.4	Max.15	Max.12	Max.2.3	Min. 1.5

Source: Lin, 1994.

4.6.1.1 Protein

Shrimp consume dietary protein to obtain a continuous supply of amino acids for normal growth. About 20 major amino acids make up most of the proteins and 10 are essential including methionine, arginine, threonine, tryptophan, histidine, isoleucine, leucine, lysine, valine and phenylalanine. Thus, essential amino acids must be provided in adequate quantities and qualities (well-balanced) in the diet. On the other hand, the recommended dietary protein levels for shrimp vary from 30 % to 55 % depending on the shrimp size and species. It is believed that postlarval shrimp require a higher protein level than larger shrimp.

4.6.1.2 Lipid

The lipid requirement of shrimp depends on their essential fatty acids and phospholipid content. There are four fatty acids which are considered essential for shrimp, namely linoleic (18:2n6), linolenic (18:3n3), eicosapentaenoic (20:5n3) and decosahexaenoic (22:6n3). In general, plant oils are high in 18.2n6 and 18.3n3, while the marine animal oils are high in 20:5n3 and 22:6n3. The phospholipid requirement is 2 %; however if lecithin is used this level can be reduced to 1 %. The requirement for cholesterol ranges from 0.25 % to 0.4 %. In addition, the recommended lipid level ranges from 6.0 % to 7.5 % and the level should not exceed 10 %.

4.6.1.3 Carbohydrates

The utilization and metabolism of carbohydrates by shrimp are limited. Their type and level in the diet have been shown to affect shrimp growth. Starch as the carbohydrate source is utilized better than dextrin or glucose for *Penaeus monodon*

4.6.1.4 Vitamins

Little is known about vitamin requirements in shrimp. In intensive farming, vitamins must be supplied in the diet for normal growth. Commercial shrimp feeds are usually over-fortified with vitamins to overcome shortfalls due to processing loss and feed storage. The minimum requirement for vitamin C, which is easily lost, is about 48-148 ppm for *Penaeus monodon.*

4.6.1.4 Minerals

Shrimp can absorb or excrete minerals directly from the aquatic environment via gills and body surfaces. The dietary requirement for minerals is largely dependent on the mineral concentration of the environment in which the shrimp are being cultured. Among the other minerals, phosphorus is the most important, and is recommended at 0.9 % as available phosphorus in the diet. Calcium is not considered to be a dietary essential. However, its level in feed needs to be monitored because it is important to maintain calcium to phosphorus ratio of 1:1 to 1:1.5. Calcium should not exceed
2.3 % in the diet.

4.7 Water Quality Management

Water conditions in the rearing pond deteriorate through the production cycle due to uneaten food, animal's excretion, etc. Generally, shrimp farmers use dissolved oxygen (DO), pH, ammonia, water color and water odor as indicators to judge the water quality of the pond.

These parameters are observed regularly by using either scientific equipment or the farmer's experience in order to control them within the optimum range (Table. 5).

Table 5. Optimum Water Quality Conditions and the monitoring time for Cultured Shrimp.

Parameter	Checking time	Recommended values
1. DO	Morning (2-6 am) Afternoon (3 pm) Evening (11 pm)	> 4 (mg/L)
2. pH	Morning (8-10 am) and Evening (3-5 pm)	7.5 to 8.5
3. Water transparency	Morning (8 – 10 am)	(30 to 45 cm)
4. Water color	Morning	Green water
5. Water temperature	Morning (8 – 10 am) and Evening (3 – 5 pm)	28 to 32°C
6. Alkalinity	Only once in a week during first month of the crop. Thereafter to be continued based on requirements.	80 to 120 ppm

4.7.1 Dissolve Oxygen

The amount of oxygen dissolved in the pond water is vital to the shrimp's health. However, in the rearing pond, dissolved oxygen is mainly consumed by pond sediment (48-70 %) and plankton (20-45 %). Only a small portion of dissolved oxygen is consumed by the shrimp (5%).

The level of dissolved oxygen can be controlled in three ways:-

a) By increasing the water surface area by means of placing paddle wheels in the right position. This is not only causes proper water circulation, but also adds oxygen to the pond water.

b) By controlling plankton density to an optimum level

c) By minimizing excess organic substances, such as uneaten food.

4.7.2 PH Adjustment

Shrimp farmers control water pH within the optimum range of 7.5-8.5, and limit diurnal pH fluctuation to less than 0.5 by applying lime. The application of lime is as follows:

a) At the beginning of a crop cycle, when water pH ranges between 7.5-7.8 about 4.8-8.0 kg./ha. of dolomite should be used every 2-3 days.

b) When pH is in the range of 7.5-7.8 and there is less than 0.5 unit difference between the pH in the morning and the pH in the afternoon, 4.8-8.0 kg./ha. of dolomite should be used every 2-3 days.

c) If the pH in the morning is less than 7.5, 4.8 kg./ha. dolomite should be used every day until the morning pH is increased to above 7.5.

d) If the pH in the morning is higher than 8.0 and the pH in the afternoon is higher than 9.0, 4.8-8.0 kg./ha. of dolomite should be used every day until the day's pH

e) In the second half of a crop cycle, 8.0 kg./ha. of dolomite should be used every day or at least every 2 days, depending on water color.

f) Every time before exchanging water, 4.8-8.0 kg./ha. of dolomite should be used.

4.7.3 Water Color Control and Adjustment

The color of pond water mainly results from suspended particles of phytoplankton. Plankton density and species are two management aspects that require attention of shrimp farmers.

In the first 2 months of shrimp culture, an additional fertilizer either organic (10-30 kg./ha.) or inorganic (1-3 kg./ha.) is added to the pond in order to ensure that there are enough nutrients for plankton bloom. After this period, nutrients derived from uneaten food normally are at adequate levels. Too many nutrients in some cases may lead to excessive plankton bloom, followed by plankton crash. In an open shrimp culture system the farmers exchange pond water with natural clean seawater to reduce excess plankton density. But in a closed system, where exchanging water is not needed, shrimp farmers use algaecides such as calcium hypochloride or benzalkonium chloride (BKC) 0.1-1 ppm to reduce plankton density.

In cases where undesirable water color appears like the 'redtide' caused by certain types of plankton such as dinoflagellates, the plankton can be controlled by switching-off the aerators for a period of time and applying BKC (0.1-1 ppm).

4.7.4 Aeration

Aeration should be provided especially in farms where the stocking density exceeds 6 shrimps /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, 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.

4.7.5 Water Exchange for traditional ponds operation without probiotics

Mass shrimp mortality in a pond associated with deteriorating environmental conditions has occurred frequently during the last 5 years. Shrimp farmers have tried to solve this problem by changing the culture system to a low water exchange system, including partial water re-circulation, full water re-circulation and a closed system.

Partial water re-circulation shrimp farming system is practiced where a supply of good quality water may only be available for short periods of time. Normally, the farm area is divided into 4 portions: culture area (60-70 %), effluent settlement (10 %), mixing reservoir (5-10%) and inlet reservoir (15-20%).

In the full water re-circulation shrimp farming system, where seawater can be treated and re-circulated, the farm area is divided into the culture area (40-48 %), inlet water treatment (15 %), seawater storage reservoir (20-25 %) and effluent settlement pond (15-20 %).

In the close shrimp culture system or zero-water discharge system, no pond water exchange is needed. However, the aeration in the pond must be adequate for shrimp respiration and oxidation of organic waste. Additional seawater may be required to make up for losses in the system. The technique provides disease-free seawater with no effluent being discharged. Shrimp may grow slowly and furnish lower production than those of an open or water circulation system.

4.7.6 Probiotics and other treatments

In Asia, a large number of chemical, physical, and biological treatments have been used for the purpose of enhancing water quality in ponds. These products include formalin, chlorine, benzylchromium chloride, provodone iodine, zeolite, peroxides, bacterial inocula, enzyme preparations, etc. Most of these products are not appropriate for use in large, semi-intensive ponds. Also, formalin, chlorine, and other strong chemicals have not been effective, and they could cause negative environmental impacts.

In the past few years, a class of products known as probiotics and consisting of bacterial inocula, enzyme preparations, and plant extracts have received increasing use in semi-intensive shrimp culture. To date, there is little evidence that these substances can significantly enhance soil and water quality in ponds or improve natural productivity (Boyd and Goss 1998). However, there is evidence that bacterial inocula and grapefruit seed extracts can improve survival of culture species (Queiroz and Boyd 1998b; Boyd and Gross 1998).

Much additional research is needed to elucidate the modes of action of these products and to determine how and when they can be used for the most benefit to shrimp production. Fortunately, there is no reason to suspect that probiotic use could result in negative environmental impacts.

In summary, there is not enough documentation of successful use of bactericides, oxidizing agents, zeolite, probiotics and other related products for us to recommend use of these substances. In particular, we do not recommend the use of strong chemical treatments such as chlorine, formalin, and insecticides that may cause negative environmental impacts.

5.0 Water Drainage and Treatment

5.1 Water Quality, Effluent Criteria and Regulations

In an intensive shrimp farming system, a large uneaten portion of feed tends to accumulate at the bottom of the pond. If this is discharged into the natural water body it may cause a negative impact on the environmental, such as eutrophication. Sludge accumulation in the pond bottom also causes severe problems if it is discharged directly into a public canal. In some areas, problems also occur from the discharge of saltwater into freshwater resources. In view of this, some ASEAN Member Countries have established regulations governing shrimp farm operations. These rules and regulations may include:

- Prohibition of shrimp farming in mangrove areas.
- Water released from the shrimp pond area must be of a specified quality. For example, it must not contain a BOD of above a specified maximum limit such as < 10 mg/liter.
- Shrimp farms over a certain hectarage (≥ 8 ha) must be equipped with a waste water treatment pond or sedimentation pond of not less than a certain portion (10%) of the total pond area.
- Sediment from a shrimp farm must not be released into public areas.
- Salt water must not be drained into public freshwater resources or other farming areas.

5.2 Technology for Effluent Treatment

Shrimp farm effluents contain 2 major by-products, namely nutrient -loads and suspended solids that contribute to the degradation of a natural water body and coastal environment. Shrimp farmers normally use physical, chemical and biological techniques to improve the quality of the discharged water. Suspended solids, which usually contain high level of organic carbon, are removed by passing an effluent through the settling pond/canal.

Chlorine, either in powder or aqurous form, is used as a disinfectant to treat discharge water from a shrimp pond in order to minimize the risk of disease outbreak. The concentration used for this purpose is 25-30 ppm. About 98% of chlorine usually used in shrimp ponds are hypochlorite compounds such as NaOCl, Ca $(OCl)_2$, etc.

Biological treatment, including integrated shrimp farming where shrimp are cultured with seaweed, mollusks, fish, artemia and sea cucumber, have been studied and practiced in Thailand. Seaweeds are used as a primary producer that can biologically remove soluble nutrients, such as nitrogen and phosphorus. *Gracilaria* spp., is the most suitable seaweed to integrate with shrimp culture due to its ability to thrive in a wide range of pond conditions. Mollusks, such as oysters, mussels, scallops, cockles and clams, have already been used in commercial scale shrimp farms to remove algae and other suspended solids from the water. Three herbivorous fish species, namely milkfish (*Chanos chanos*), mullet (*Mugil* spp.) and tilapia (*Oreocromis* spp.) have been stocked in shrimp ponds and/or reservoirs to reduce plankton density.

6.0 Management of Feed

6.1 Origin of feed and feed substances

- Aquaculture feed (fish / shrimp), both domestic and imported, should come from a company registered with the national competent authority;
- Additives, premixes and compound feeding material is from a company approved by the national competent authority;

6.2 Storage of feed

Feed should be properly stored according to manufacturing instructions and should not be allowed to be contaminated by vermin. Feed quality will rapidly deteriorate if feed is not packed well and properly stored. Feed should be stored in a dry, cool and well-ventilated place to maintain consistent moisture and temperature. Feed should not be stored in direct sunlight and should not be kept longer than 3 months from the time of processing. The spoiled or old feed should not be used.

6.3 Feed Quality

The use of good quality feed will improve shrimp production and profits, and minimize the environmental pollution from shrimp farming. The practical indicators of good quality feed are:

a) Feed Conversion Ratio (FCR)
FCR is an indicator that commonly used in all types of farming and provides a good indicator of how efficient a feed or a feeding strategy can be. In other words, FCR is the mathematical relationship between the input of the feed that has been fed and the weight gain of a population. An ideal FCR always results in model growth rate, healthy shrimp and clean pond bottom conditions. Only the superior quality of feed can achieve an FCR of 1.2. According to recent data, an FCR as low as 1.2 has been achieved, but many farmers are still obtaining FCRs of higher than 2.2. Therefore, besides the feeding management, the FCR is also closely related to the quality of feed.

b) Ideal Attractant Ability & Pleasant Odor
The model quality shrimp feed must be highly palatable.

c) Good Water Stability
Since shrimp are a slow feeder animal, the water stability of suitable feed should be over 2 hours for *Penaeus monodon*.

e) The levels of additives and veterinary drugs should comply with national regulations.

f) Packages of feed should be properly labelled with a description of composition, proper storage conditions, expiry date, feeding rate and other necessary guidance.

6.4 Feeding

Feeding practices shall minimize the risk for biological, chemical and physical contamination of feed and animals. It must ensure the maintenance of water and sediment quality.

A high FCR or high amount of feed required to produce unit weight gain indicates overfeeding, and consequently, a poor FCR is usually associated with poor growth rate, low weight gain, stressed shrimp, mediocre water quality and adverse pond bottom conditions. Therefore, the proper amount of feed is the most critical factor of feeding management.

The guidelines for feeding adjustment to be made according to the mean body weight of the shrimp are shown in Table 4. Since many factors are involved in shrimp feed consumption, careful and frequent observation of shrimp is the most reliable approach for determining the optimal feeding amount.

There are many major key factors for successful intensive shrimp culture. Use of good quality feed with better feeding management by low feed conversion ratios and improved farm management are the important goals to farmers, not only for gaining greater profit, but also for minimizing the pollution of shrimp farming area.

Table 4. Recommended Feeding Rate for Shrimp Based on Body Weight

Shrimp Live Body Weight (gram)	Recommended Feeding Rate (% body weight/day)
2 – 3	8.0 - 7.0
3 – 5	7.0 - 5.5
5 – 10	5.5 - 4.5
10 – 15	4.5 - 3.8
15 – 20	3.8 - 3.2
20 – 25	3.2 - 2.9
25 – 30	2.9 - 2.5
30 – 35	2.5 - 2.3
35 – 40	2.3 - 2.1

Source : Lin, 1991.

6.5 Feed Production on Farm

- Ingredients, additives and veterinary drugs used in feed must be approved for aquaculture species.
- Good hygiene practices are applied on the farm production of feed to minimize hazards with potential to compromise feed and food safety.

7.0 Management of Veterinary Drugs and Chemicals

7.1 Veterinary Drugs and Chemicals Used

- Veterinary drugs, medicated feed, chemical and biological substances are obtained from registered / authorized manufactures and supplier only;
- Veterinary drugs, medicated feed, chemical and biological substances are permitted / registered according to EU/ national regulations.
- Substances requiring prescription are used under adequate supervision by qualified expert.
- Veterinary drugs, medicated feeds, chemical and biological substances are labelled with clear information on the name, active substance, target species of animals, storage conditions, dosage, route of administration, expiry date and withdrawal period.

7.2 Storage and use of veterinary drugs and chemicals

- Veterinary drugs, medicated feeds, chemicals and biological substances are adequately stored according to the label.
- Veterinary drugs, medicated feeds, chemical and biological substances are used according to manufactures instruction and as specified on label.
- Withdrawal periods and residues are verified by adequate testing.

8. Disease Risk Management

8.1 Control Spread of Disease

- Farm is registered/ authorized by Competent Authority;
- Processing establishments slaughtering aquaculture animals for disease control purposes are authorized by the Competent Authority;
- Traceability record for movement of animals in place;
- Good Hygienic practices / Good Aquaculture Practices in place;
- Risk-based animal health surveillance scheme in place;
- Aquaculture animal intended for farming and restocking are clinically health;
- Aquaculture animals and product placed on the market for further processing before human consumption are disease free;
- Measures for the notification and control of disease of aquatic animal origin are in place;
- Surveillance programme in place for disease of animal origin;
- Disease free status of aquaculture premises.

8.2 Disease Prevention and Treatment

Treatment cannot be carried out effectively when shrimp diseases occur in a pond. The best way to get rid of diseases is by practising good farm management or prevention. In this regard, information on various kinds of diseases and their prevention procedures are useful. List of diseases can be referred in Annex 1.

However, in case Shrimp diseases outbreak occur, the method of disposal for should be disposed properly in a designated area either by burying in limed pits and/or incineration.

9. Post-Harvest Management

9.1 Ice and Water Supply

- Potable or clean water is available and used in sufficient amount for harvest, handling and cleaning operations.
- Ice supplied from approved establishment should be manufactured using potable water and produced under sanitary conditions.
- Ice received / arrived in good sanitary conditions
- Ice should be handled and stored under good sanitary conditions which precludes the risk for contamination.

9.2 Harvesting

- Harvesting equipment and utensils easy to clean disinfected and kept in clean condition.
- Harvesting is planned in advance to avoid time/temperature abuse.
- Practices ensure rapid killing of harvested fish / shrimp (if applicable).
- Practices ensure that viability live fish / shrimps are not affected by extreme temperatures, physical damage or undue stress (if applicable).
- Aquaculture products should be hygienically handled using practices which does not cause physical damage to edible part of product.
- Records on harvesting are maintained for traceability.

9.3 Post Harvesting Handling

- Utensils and equipment for handling and holding of aquaculture products is maintained in a clean condition.
- Live fish / shrimp is handles and kept under physical conditions which do not affect adversely their viability.
- Aquaculture products (fish / shrimp) are cooled down quickly and maintained at temperatures approaching that of melting ice.
- Operations such as sorting, weighing, washing, drainage, etc., is carried out quickly and hygienically and without damage to the edible part of product.
- Food additives and chemicals (disinfectants, cleaning agents, etc) used in contact with products only in compliance with prevailing legal requirement.
- Harvesting wastes are collected in designated equipments and disposed to preclude risk of cross contamination.

9.3.1 Transport of Aquaculture products from farm

- Transport is carried out in easy to clean and clean facilities (boxes, containers, etc.).
- Conditions of transport should not allow contamination from surroundings (e.g. dust, soil, water, oil, chemicals, etc.).
- Live fish / shrimp transported under physical conditions which do not affect adversely their viability.
- Aquaculture products (dead fish / shrimp) are transported in containers with ice or with ice + water, in sufficient amounts to ensure temperature around 0 oC (approaching that of melting ice) in all products and during the whole period of transport.
- Containers for ice and product allow melt water to drain away from product
- Based on the prevailing requirement, prohibited additives and chemicals are not used in contact with product / live animals.
- Records for transport of fish and shrimp maintained to ensure product traceability.

10. Record Keeping

Adequate records shall be kept on:

- type, origin and use of feed and feed ingredients;
- veterinary drugs, chemicals, or other treatments administered;
- Animal's Health Analysis Record;
- occurrences of diseases which may affect food safety;
- pond management activities (e.g. preparations and water quality controls);
- origin and type of seed used;
- harvest, transport and customer records are maintained to allow traceability.

11. Staff Training

➢ Staff is trained and has knowledge on food safety issues related to handling of feed, veterinary medicines, chemicals, live animals and harvested products, adequate to the nature of duty.

➢ Staff is adequately trained to recognize clinical manifestations of exotic and non- exotic disease listed in EU.

Annex 1

List of Shrimp Diseases

- Parasitic Infestation

  - Fusarium Disease, Black Gill Disease

Etiological agent: *Fusarium* spp.

Clinical signs:

Brownish to blackish discoloration on the gills of juvenile shrimp.

Diagnosis Procedures:

Microscopic examination of wet mount of the gills of the shrimp shows the fungus showing the conidial spores. Histological examination demonstrates the characteristic lesions with hyphae and diagnostic condinia.

Treatment:

No treatment is available for fungal infestation without harming the shrimp.

Prevention and Control:

No information on prevention and control. However, good management of the pond bottom and prevention of the entry of wild crustaceans into the pond, which may carry pathogen, can be effective control practices.

- Surface Fouling Diseases

Etiological Agent:

Many species of bacteria, algae and protozoa such as filamentous bacteria, *Leucouthrix* sp., *Flavobacterium* sp. and *Zoothamnium* sp.

Clinical Signs:

Infected shrimps show black/ brown gills or appendage discoloration or fuzzy/cottony appearance due to a heavy colony of the organisms. In some cases, the severely affected shrimp die during the molting period.

Diagnosis Procedure:

Wet mount preparations of biopsied gills, manidibular palp and appendage examination by bright field, phase contrast microscophy or routine H&E stained paraffin sections.

Treatment:

Chlorine and formalin are often used to treat those commensally organisms if shrimp display heavy infection. Changing water is the most preferable management which stimulates molting of the shrimp in order to reduce the infestation.

Prevention and Control:

Prevention and control of the occurrence of surface fouling are usually done through maintenance of good sanitary conditions at the pond bottom and the overall pond area. Organic matters and suspended solids in the pond should be reduced to prevent the attachment of those fouling organisms. This is achieved by changing the water or applying lime.

- Bacterial Infection

- Surface Fouling Diseases

<u>Luminous Vibriosis</u>

Etiological Agent :

Vibrio harveyi, Vibrio vulnificus

Clinical Signs:

High mortality rate in young juvenile shrimp (one month syndrome). Moribund shrimp hypoxic often come to the pond surface and edges of pond. Vertical swimming behavior immediately before onset of acute mortality. Presence of luminescent shrimp in ponds

Diagnostic Procedure:

- Presumptive Diagnosis

Observation of occurance of typical clinical signs- (Presence of large number of rod-shaped bacteria in the hemolymph (wet mounts).

- Histological Diagnosis

Observation of occurances of multifocal melanized and/or non-melanized hemocytic nodules with septic centers are the principal diagnositic feature of systemic vibriosis. These lesions are most common in the lymphoid organ, heart gills and hepatopancrease (proximal tubules).

- Isolation, identification and antibiotic sensitivity of the organism.

Treatment:

Disinfection of intake water (i.e. Formalin 100-200 ppm) Anti-microbial preparation application through feeds

- Oxolinic acid 0.6 ppm.

- Sarafloxacin 5mg./kg. of feeds for 5 days

Prevention and Control:

Proper pond and water managementand utilization of reservoir for intake water.

- Vibriosis

Etological Agent:

Vibrio vulnificus, V. parahemolyticus,V. alginolyticus, Vibrio sp.

Clinical Signs:

High mortality rates, particularly in young juvenile shrimp. Moribund shrimp with corkscrew swimming behavior appear at edge of pond. Reddish discoloration of juvenile shrimp

External Fouling:

Black spots, chronic soft shelling

Diagnostic Procedure:

- Presumptive diagnosis

  Observation of occurances of typical gross clinical signs. Presence of large number of rod-shaped bacteria in the hemolymph (wet mounts)

- Histological Examination :

  Observation of occurances of different disease manifestation as follows:

  a) Localized vibriosis (wounds, shell disease) well circumscribed by hemocytes forming capsules or plugs and melanized. Bacteria visible within and/or adjacent to such lesions.

  b) Systemic vibriosis multifocal melanized and/or non-melanized hemocytic nodules with septic centers seen in lymphoid organ, heart, gills, hemocoel and connective tissues.

  c) Septic Hepatopancreatitis Syndrome (SHPS) generalized atrophy of the hepatopancreas with generalized to multifocal necrosis and hemocytic inflammation of the HP, the proximal tubules. Isolation, identification and antibiotic sensitivity of the organism.

Treatment:

- Disinfection of intake water i.e.formalin100-200 ppm.

- Anti-microbial preparation application through feeds

  - Oxolinic acid 0.6 ppm.

  - Sarafloxacin 5 mg./kg. of feed days

Prevention and Control:

Proper pond and water management and utilization of reservoir for intake water.

- Virus infection

- Monodon Baculovirus Disease

Etiological Agent:

MBV-type or PmSNPV is a type A occluded baculovirus, 75+4 by 324+33 mm. in diameter and length. It contains ds DNA.

Clinical Signs:

Normally, a low mortality rate or insignificant losses are achieved from the grow-out pond. However, the severity may be increased if shrimp are reared in high density culture.

Diagnosis Procedure:

The demonstration of single or multiple MBV occlusion bodies in squash preparations of biopsied hepatopancreas, midgut and feces stained with 0.05 % aqueous malachite green. In routine histology, the MBV infection is demonstrated by the presence of prominent, single or multiple, eosinophilic speherical occlusion bodies within the hypertrophied nuclei of hepatopancreatic tubule and midgut epithelial cells stained with H&E stains.

Treatment:

No treatment available for BMV infection

Prevention and Control:

There is little information on prevention and control of the MBV infection in shrimp pond culture. The prevention method for the MBV infection is possibly through avoidance by screening the Pls before stocking shrimp in the pond.

- Hepatopancreatic Parvo-like Virus (HPV) Disease

Etiological Agent:

HPV is caused by a small parvo-like virus, 22-24 nm in diameter.

Clinical Signs:

No specific gross signs for HPV infection are reported, but severe infections may include a whitish and atrophied hepatopancrease, poor growth rate, anorexia and reduced preening activity. Losses may be occurring due to the increased occurance of surface and gill fouling organisms and secondary infections by the opportunistic *Vibrio* spp

Diagnosis Procedure:

Diagnosis of HPV is based on the histological demonstration or the Giemso-stained HP impression smear of prominent basophilic intranuclear inclusion bodies mostly within the distal portions of hepatopancreatic tubules in E- or F-type epithelial cells.

Treatment:

No treatment available for HPV infection.

Prevention and Control:

No information is available on the prevention and control procedures for HPV infection. However, screening the Pls before stocking shrimp by routine histology or the Giemsa-impression smear method is recommended.

- Yellow Head Disease (YHD)

Etiological Agent:

Yellow-headed virus (YHV) is a ssRNA, rod shaped, enveloped virus 40-48 nm by 148-200 nm with two rounded ends.

Clinical Signs:

The affected shrimp shows a marked reduction in food consumption. Following this, a few moribund shrimp will appear swimming slowly near the surface of the pond dike and remain motionless. The animals have pale bodies, a swollen cephalothorax with a light yellow to yellowish hepatopancreas and gills. A high mortality rate may reach 100% of affected populations within 3-5 days from the onset of disease.

Diagnosis Procedure:

Diagnosis procedure is based on histological demonstration of massive necrosis in the tissue originating from octoderm and mesoderm and/or observation of prominent nuclear pyknosis and karyuorrhexis and spherical, basophilic cytoplasmic inclusion in a fresh hemocyte smear stained with Wright-Giemsa staining.

Treatment:

No treatment is available for YHV infection

Prevention and Control:

The reliable method to prevent the occurrence of YHD is possibly through avoidance, such as careful selection of postlarvae, reduction or elimination of horizontal transmission including carriers, disinfection of contaminated ponds or equipment with 30 ppm; and chlorine, providing shrimp with good water quality and proper nutrition.

- White Spot Disease

Etiological Agent:

The disease is caused by the dsDNA virus, Systemic Ectodermal and Mesodernal Baculovirus (SEMBV), 120 by 275+22 nm in diameter and length. It is a non-occluded, rod-shaped to elliptical culovirus surrounded by a trilaminar envelope.

Clinical Signs:

Clinically affected shrimp were first seen to swim to the water surface and congregate at the pond dikes. Typical clinical signs include white spots or patches, 1-2 mm in diameter, on the inside of the shell and carapace, accompanied by reddish discoloration of the body. SEMBV is able to cause acute epizootics of 5-10 days duration with mortality rate from 40% to 100%.

Diagnosis Procedure:

The diagnosis procedure of SEMBV infection is based on the appearance of the intranuclear hypertrophy in stained histological sections and the presence of virus particles in the nucleus of the infected cells observed under the electron microscope. Rapid Davidson's fixation method of SEMBV infection in gills and subcuticular body shell epithelium. PCR technique is recently used to detect SEMBV in shrimp larval and other stages, including broodstock and subclinical virus carriers.

Treatment:

No treatment is available for SAMBA infection.

Prevention and Control:

Prevention practices through avoidance are strongly recommended for the farmers, involving the combinations of efficient pond management, use of proper feed, selection of good quality of PL, reduction of possible carriers, avoidance of introduction of contaminated water into the pond, and disinfection of all equipment and utensils.

- Acute hepatopancreatic necrosis disease (EMS)

AHPND is not listed by the OIE. However the disease does meet the definition of an emerging disease in the OIE *Aquatic Animal Health Code* (*Aquatic Code*). Member countries should consider their obligation to report any occurrence of the disease in accordance with Chapter 1.1 of the *Aquatic Code*.

Etiological agent:

AHPND has a bacterial aetiology. A bacterial isolate identified as a member of the *Vibrio harveyi* clade, most closely related to *Vibrio parahaemolyticus*, has been found to cause AHPND experimentally. Further studies to characterise the causative agent, including genetic characterisation, are continuing.

Clinical sign:

Typical signs of AHPND begin within 10–30 days after stocking of post larvae into a newly prepared pond. The following signs may be observed:

- Hepatopancreas (HP) often pale to white due to pigment loss in the connective tissue capsule
- Significant atrophy (shrinkage) of HP
- Often soft shells and guts with discontinuous contents or no content
- Black spots or streaks sometimes visible within the HP
- HP does not squash easily between thumb and finger
- Onset of clinical signs and mortality starting as early as 10 days post-stocking
- Moribund shrimp sink to the bottom

Diagnosis procedure:

1. Samples

   For culture of bacteria:

   - Live shrimp

   For histopathology:

   - Whole juvenile shrimp fixed in Davidsons fixative

2. *For molecular tests:*

   - Whole juvenile shrimp fixed in 100% ethanol or frozen

Procedures

Identification of the agent

- Bacterial culture
- Biochemical methods
- PCR and sequencing

Histopathology

- Demonstration of characteristic histopathology

Prevention and control:

Commodity	Relevant knowledge	Likelihood of transmission to farmed or wild shrimp populations
Live shrimp for aquaculture	AHPND has been transmitted experimentally by immersion. Transmission by cohabitation is expected. *Penaeus monodon*, *P. chinensis* and *Penaeus vannamei* are known to be susceptible.	High
Fresh dead shrimp for human consumption	AHPND has been transmitted experimentally by immersion and reverse gavage, and transmission by the oral route is likely. *Vibrio parahaemolyticus* is sensitive to refrigeration but will remain viable for several weeks in chilled aquatic animal products.	Low Transmission would require the existence of pathways for exposure of susceptible populations.
Frozen shrimp for human consumption	Attempts to experimentally transmit AHPND from frozen shrimp tissues have failed. Freezing has been shown to reduce the number of culturable *V. parahaemolyticus* but may not eliminate bacteria entirely. Time to total inactivation depends on the initial number of bacteria and temperature.	Negligible Transmission would require the existence of pathways for exposure of susceptible populations.

Commodity	Relevant knowledge	Likelihood of transmission to farmed or wild shrimp populations
Manufactured shrimp feeds – extruded	AHPND has been transmitted experimentally by immersion and reverse gavage, and transmission by the oral route is likely. *Vibrio parahaemolyticus* does not tolerate heating and is not expected to survive commercial feed manufacturing processes where temperatures reach 100°C for at least 1 minute.	Negligible