DOF STANDARD

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Code of good aquaculture practices for marine shrimp hatchery

DEPARTMENT OF FISHERIES MALAYSIA

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Contents

Foreword

This DOF Standard was developed by the Project Committee on Good Aquaculture Practices for Marine Shrimp Hatchery.

This standard was developed with the following objectives:

a) to provide technical guidance on key aspects of marine shrimp hatchery activities that can be followed voluntarily by farmers;

b) to provide guidance that can be used to produce shrimps that are disease free, safe and of good quality; and

c) to provide guidance to ensure that marine shrimp hatchery activities are carried out in an environmentally sound, socially acceptable and economically viable manner.

This standard will be subjected to review to reflect current needs and conditions. Users and other interested parties may submit comments on the contents of this standard for consideration into future versions.

Compliance with this standard does not by itself grant immunity from legal obligations.

Code of good aquaculture practices for marine shrimp hatchery

0. Introduction

This code of good aquaculture practices for marine shrimp hatchery is aimed to promoting good management practices in the aquaculture industry generally, and in marine shrimp hatcheries specifically, so that the hatcheries that are registered with the Department of Fisheries can implement these practices and successfully obtain MyGAP (Malaysian Good Agricultural Practices) certification. Additionally, this code of good practices will ensure that the monitoring of activities in these hatcheries under the Department of Fisheries official control programmes is carried out in a more consistent and effective manner.

The adoption of these good practices will not only ensure the quality and safety of the shrimps produced for human consumption but will also ensure the shrimp hatchery is operated in a socially responsible manner such that it promotes the sustainability of the industry.

This code of good practices is intended to address the generally recognised key elements in the marine shrimp hatchery in order to ensure food safety and quality requirements along with the processing environment and operation up to the point of delivery, while protecting the health of the consumer and ensure global competitiveness.

1. Scope

This standard prescribes the code of good aquaculture practices for marine shrimp hatcheries that are aimed at ensuring that the fry produced are safe, disease free and of good quality for further farming by taking into account animal health and welfare as well as environmental and social responsibilities.

This standard covers all stages of marine shrimp hatchery from broodstock selection until post-harvesting practices prior to transportation.

Marine shrimp species covered by this standard are shrimps in the Penaeidae family such as black tiger shrimp *(Penaeus monodon*) and white shrimp (*Penaeus vannamei*).

2. Normative references

The following normative references are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the normative reference (including any amendments) applies.

World Organisation for Animal Health (WOAH) Aquatic Animal Health Code

Environmental Quality (Industrial Effluents) Regulations 2009

Occupational Safety and Health Act 1994

3. Terms and definitions

For the purposes of this standard, the following terms and definitions apply.

3.1 animal welfare

How an animal is coping with the conditions in which it lives.

NOTE. An animal is in a good state of welfare if (as indicated by scientific evidence) if it is healthy, comfortable, well nourished, safe, able to express innate behavior, and if it is not suffering from unpleasant states such as pain, fear and distress. Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing. Animal welfare refers to the state of the animal; the treatment that an animal receives is covered by other terms such as animal care, animal husbandry, and humane treatment".

3.2 sustainable

Holistic approach that is efficient in resource management and focuses on the interrelationship of social, economic and environmental processes. This approach ensures efficient production of safe and high quality aquaculture products.

3.3 biosecurity

Set of management and physical measures designed to mitigate the risk of introduction of pathogenic agents into, or spread within, or release from, aquatic animal populations.

3.4 competent authority

Any person or organisation that has the legally delegated or invested authority, capacity and power to perform a designated function.

3.5 copulation

In zoology, copulation is animal sexual behavior in which a male introduces sperm into the female's body, especially directly into her reproductive tract. This is an aspect of mating.

3.6 fry

Marine shrimp larvae and post larvae.

3.6.1 larvae

Marine shrimp fry that are newly hatched from eggs and are within the three larval stages of metamorphosis: nauplius, protozoea (zoea) and mysis.

3.6.2 post larvae (PL)

Marine shrimp fry after mysis stage at which their physical appearance is similar to that of adult.

The post larvae are commonly abbreviated as PL and followed by days after hatching, e.g. "PL 12" means post larvae aged 12 days.

3.7 marine shrimp broodstock

Mature shrimp for breeding purposes that either cultured, wild-caught or imported.

3.8 marine shrimp hatchery

Establishment consisting of relevant facilities where marine shrimp eggs are hatched under controlled conditions.

3.9 Specific Pathogen Free (SPF)

Shrimps that are guaranteed free of particular pathogens as listed by World Organisation for Animal Health (WOAH).

The certified stock claim is accompanied by a list of the absent pathogens.

3.10 Specific Pathogen Resistant (SPR)

Shrimps that are resistant to infection by a specific pathogen as listed by World Organisation for Animal Health (WOAH)(this is a qualitative trait, the shrimps can either be infected or not).

3.11 Specific pathogen tolerant (SPT)

Shrimps that are tolerant to a specific disease caused by a specific pathogen as listed by World Organisation for Animal Health (WOAH) (the shrimps can be infected but may not develop the disease or may develop the disease to a lesser extent).

4. Site selection

4.1 The location of the site for the hatchery shall be approved by the relevant competent authority. Hatchery operators are encouraged to select areas in designated Aquaculture Industrial Zones (AIZ). The hatchery shall be registered with the competent authority.

4.2 The hatchery should be located in area where risk of pollution or contamination can be controlled or mitigated.

4.3 Hatchery site selection and infrastructure construction should take into consideration the conservation of the natural habitat, minimisation of disturbance to the surrounding environment and not to cause adverse impacts on human health.

4.4 There should be sufficient infrastructure and facilities, such as access roads, electricity and transportation systems, to facilitate operations and rapid transport of inputs and outputs. Infrastructure such as for water intake and discharge, access roads etc. should minimise negative impacts on local communities and other resource users.

4.5 The following areas are not encouraged for site selection:

a) flood-prone areas or areas where there is no proper flood prevention measures;

b) wetlands and natural conservation areas; and

c) problematic areas such as polluted areas and areas that are prone to erosion .

4.6 Hatcheries shall not be located inside the grow-out facilities for biosecurity reasons.

Existing hatcheries and larval rearing facilities shall have distinct separation from the grow-out tanks and should integrate biosecurity measures to prevent cross contamination.

4.7 Hatcheries should be far from estuaries and streams where flowing freshwater or brackishwater can abruptly lower salinity.

4.8 Hatchery facilities should be enclosed.

5. Hatchery construction

5.1 General

5.1.1 The hatchery design and layout shall be done in accordance with the requirements as recommended by the relevant competent authority(ies).

5.1.2 The clearing of site shall consider conservation or preservation of the natural habitat. Buffer zones should be maintained to minimise the effect of site operations on the environment.

5.1.3 All materials used in the hatchery construction should be environmentally friendly.

5.1.4 The design of the shrimp hatchery should include facilities for implementation of good hygienic practices such as sanitisation of equipment and machinery to reduce the potential spread of diseases.

5.2 Hatchery design and layout

5.2.1 The hatchery should be designed according to the characteristics of the selected site and the culture system and should integrate safety, hygiene, and bio-security measures to prevent cross contamination.

The design and size of the pond or tank is determined by the target production and financial capability and should facilitate the hatchery management and operations. Examples of hatchery layout as in Annex A.

5.2.2 The hatchery facilities should be separated from the staff quarters and office areas.

5.2.3 The hatchery should be built to withstand adverse weather conditions.

5.2.4 The design of the hatchery should consider the roof and walls (for optimal heat).

5.2.5 The marine shrimp broodstock area should be isolated from sound and other forms of disturbance.

5.2.6 The reservoir pond/tank and treatment pond/tank should be constructed separately.

5.2.7 A sedimentation pond/tank shall be provided.

5.2.8 Pond or tanks used for culturing larvae and postlarvae may be of rubberised canvas, marine plywood, fiberglass, or concrete. These can either be circular, oval, or rectangular, depending on the target production and financial capability. A well-designed pond/tank i.e. one with rounded corners, is preferable due to more effective water circulation such that wastes will be accumulated at the center of the pond/tank.

5.2.9 Culture system

There are two types of culture systems widely practised for shrimp hatcheries i.e. semi-intensive and intensive as in Table 1.

Table 1. Types of culture systems

Culture system	Description
a) Semi-intensive culture	Stocking density: 100 nauplii/L to 150 nauplii/L and fed with commercial diets and/or fresh/natural diets Hatchery tank size: 5 tonne to15 tonne capacity Tank shape: round or square Nursery tank size: 5 tonne to 10 tonne
b) Intensive culture	High stocking density:150 nauplii/L to 200 nauplii/L Hatchery tank size: 3 tonne to 5 tonne capacity Tank shape: round or square Nursery tank size: 5 tonne to 10 tonne

5.3 Drainage system

The hatchery should have separate inlet and outlet water drainage systems. The drainage systems should use gravity force or pumps.

5.4 Water supply

5.4.1 The water may be sourced from sea water and/or and brackish water.

Water used shall be in the salinity range from 28 ppt to 32 ppt.

5.4.1.1 Sea water

Sea water or salt water is water from the sea or ocean. Normal salinity of the sea water is around 30 ppt.

5.4.1.2 Brackish water

The brackish water which is a mixture of sea water and fresh water. The salinity of brackish water usually in the range of 10 ppt to 20 ppt.

5.4.2 Where pumps are used to get the water, 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 type and size of pump depends on the total volume of water required per day and the maximum pumping time. The best time for pumping or filling the tank is when the tide is calm.

5.4.3 Fresh water supply should be available for use if the salinity of the water needs to be reduced to the range as specified in 5.4.1.

5.5 Facilities and equipment

5.5.1 Shrimp hatchery facilities and equipment should be designed and operated in ways that prevent shrimp contamination by workers, sewage/toilets, domestic animals, machinery oil/fuel, and other possible sources. These facilities should include features that ensure biosecurity and sanitary requirements can be met.

5.5.2 List of facilities and equipment are as follow:

a) larval and postlarval tanks;

b) algal tanks;

c) spawning tanks;

d) maturation tanks;

e) mating tanks;

f) quarantine facilities;

g) live feed tanks;

h) reservoir for incoming water;

i) settling tank or treatment facility for effluents;

j) aeration equipment (e.g. blower); and

k) other accessories (e.g. chlorine test kit, weighing scale, basins, pails, etc.).

5.6 Utilities

The hatchery shall have a reliable power source e.g. mains electricity supply. A back-up supply or secondary power source (e.g. generator with power of 60 kVa) shall be available.

5.7 Fuel

Fuel and lubricant should be stored separately and in a safe manner.

Used fuel and lubricants shall be placed in appropriate containers and discarded properly.

6. Hatchery management

6.1 General

6.1.1 A map showing the location of the hatchery and the layout of its facilities should be made available.

6.1.2 Preventive measures against the entry of disease carriers to the hatchery pond/tanks should be implemented at the stages of pond/tank preparation, water preparation and during marine shrimp hatchery operations.

6.1.3 Pond/tanks should be emptied, prepared and cleaned prior to new stocking/crop.

6.1.4 Water quality should be checked and managed appropriately. Water should be treated appropriately and adjusted to the suitable quality for marine shrimp hatchery operations.

6.1.5 Adequate aeration shall be provided in the marine shrimp hatchery operations.

6.1.6 Stocking density of fries in the nursery should be appropriate such that it does not affect the health and survival rate of the fries.

6.1.7 Basic hatchery production processes start from broodstock selection and continue through to transportation of postlarvae or nauplii out of the hatchery facility. The production processes are usually divided into two, the pre-spawning processes and the post-spawning processes.

Pre-spawning processes: broodstock selection and collection, broodstock holding, maturation, disease screening, quarantine, spawning.

Post-spawning processes: hatching, larvae rearing, nursery, disease screening, harvest and transportation.

6.2 Broodstock management

6.2.1 Broodstock source

6.2.1.1 Broodstock shall be obtained from reliable sources. Broodstock may come from any of the following sources: culturing, wild caught or imported. If imported, the source of the broodstock shall be approved by the relevant competent authority.

6.2.1.2 Broodstock collected from the wild should be screened for diseases prior to breeding and spawning.

6.2.1.3 Evidence of the broodstock source shall be available for traceability purposes.

6.2.1.4 Broodstock should be selected according to the maturation, suitable age and size for breeding purposes.

6.2.1.5 Broodstock shall be healthy and SPF or SPR or SPT.

6.2.1.6 The movement of broodstock for fry production and subsequent hatchery processes shall be such that the transmission of pathogens into the growing stocks is minimised.

6.2.1.7 Imported broodstock shall be accompanied by a health certificate issued by the competent authority of the exporting country.

6.2.1.8 Broodstock should not be used for longer period of time which may affect maturation, quality and quantity of fry. (e.g. to be used within a maximum period of three months after eyestalk ablation).

6.2.1.9 Stocking density of broodstock shall be appropriate according to the facilities, production and sale plan.

6.2.1.10 High density of broodstock will cause them to be susceptible to disease. The density of broodstock is recommended as follows:

a) For black tiger shrimp: broodstock density at 2 broodstock/m^3 to 3 broodstock/m^3.

b) For white shrimp: broodstock density at 6 broodstock/m^3 to 8 broodstock/m^3.

Only single species of SPF or SPR or SPT should be stocked at a time in order to avoid the possibility of contagion among species, which may increase the spreading and severity of the disease. For this purpose, a movement document shall be provided with the species of stocking broodstock.

6.2.2 Broodstock packaging

6.2.2.1 The recommended packaging for broodstock is broodstock bag with 0.5 m to 1m length, and 0.5 mm to 1 mm thickness.

6.2.2.2 Before the broodstock is packed into a broodstock bag, a small tube of rubber should be attached to the broodstock rostrum so that the bag is not penetrated and to minimise injury to other broodstocks.

6.2.2.3 A broodstock bag should accommodate about 4 to 5 female broodstock and 8 to 10 male broodstock depending on size and maturity. Temperature should be maintained at 20 °C to 25 °C and oxygen gas is supplied such that 2/3 of the bag is filled with oxygen and the remaining 1/3 with water.

6.2.2.4 For long-distance travel, the plastics bag can be loaded into a styrofoam box or a thick paper box to maintain the temperature.

6.2.3 Broodstock quarantine

6.2.3.1 Upon arrival at the hatchery facility, the broodstock shall be held in isolation for up to 14 days until their health status is ascertained.

6.2.3.2 The broodstock quarantine tank or area shall be physically isolated from the rest of the hatchery facilities. If this is not possible, the hatchery facility should be designed to avoid possibility of contamination from the quarantine tank or area into the other production areas.

6.2.3.3 Care should be taken in disposing waste and treating effluent from the quarantine area. Movement of staff should be controlled and sanitary protocols shall be adhered at all times.

6.2.3.4 Broodstock shall not be released from quarantine until their health status is clearly known in accordance with Clause 7.

6.2.3.5 Laboratory tests shall be conducted by accredited laboratories based on the needs of the hatchery and related Certificates of Analysis (COA) shall be produced.

6.2.4 Acclimatisation

6.2.4.1 During acclimatisation, which can last from 7 days to a few weeks, the broodstock will be adjusted to the environmental conditions of the maturation tank and the types of feed that will be given.

6.2.4.2 During this acclimatisation period, any difference in temperature and salinity between the quarantine area and the maturation facility should be gradually reduced.

6.2.4.3 Feeding protocols should also be adjusted gradually so that the shrimp become accustomed to those utilised in the maturation facility.

6.2.4.4 The moult stage should also be observed and only females in the intermoult stage should be ablated and hence ready to begin production of nauplii.

6.2.5 Selection and stocking of broodstock

6.2.5.1 Black tiger shrimp

The female broodstock starts to mature and lays eggs when it reaches a body weight (BW) of between 80 g to 90 g and a body length (TL) of 25 cm.

The recommended female broodstock selected for hatchery should reach a BW of between 140 g to 250 g and TL of 23 cm to 27 cm, or a BW of between 160 g to 250 g and TL of 25 cm to 27 cm. This will ensure a high number of eggs (between 0.8 million to 1.2 million) produced for one spawning and a rapid development rate of fry in the pond/tank.

The male broodstock selected for hatchery should reach a BW of between 50 g to 60 g and TL of between 17 cm to 20 cm.

6.2.5.2 White shrimp

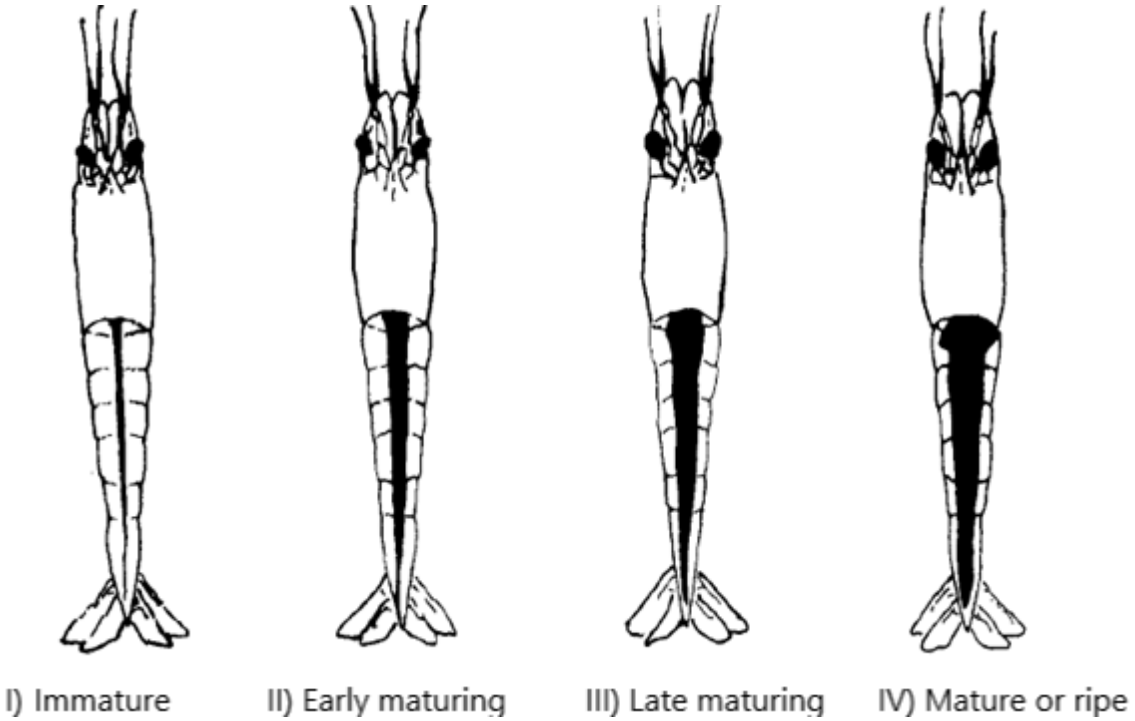
Female broodstock selected for hatchery should reach a BW of between 30 g to 40 g and TL of around15 cm.

Male broodstock selected for hatchery should reaches BW of between 30 g to 35 g and TL of around 15 cm.

Broodstock procured (larva) shall be selected based on the stage of maturity and SPF or SPR or SPT. Female broodstock should be mated to ensure release of sperm cells necessary for fertilisation.

6.2.6 Maturation stage

The maturation stage of the shrimp is based on the outline of the ovary as shown below (see Figure 1):



(Source: Primavera,1983)

Stage 1) **Immature:** No clear egg-fertilisation on the ovaries.

Stage II) **Early maturing:** A thin line of egg formation on the ovaries, vertical along the abdomen.

Stage III) **Late maturing:** The ovaries appear to swell in the section between the carapace and the first segment of the abdomen and extend straight to the abdomen.

Stage IV) **Mature or ripe:** The ovary is thickly elongated along the abdomen. The main feature is the formation of a diamond shape in the part between the carapace and the first segment of the abdomen.

6.2.7 Induced breeding

6.2.7.1 Broodstock selection for induced breeding

6.2.7.1.1 Induced breeding is conducted to ripen/mature the female broodstock.

6.2.7.1.2 The male broodstock is needed to transfer sperm naturally.

6.2.7.1.3 Broodstock selection shall comply with 6.2.1 and the following requirements:

a) Female broodstock's BW and TL:

   i) Black tiger shrimp: BW > 130 g, TL > 23 cm (Broodstock with BW between 160 g to 250 g and TL of 25 cm to 27 cm can give high production of eggs).

   ii) White shrimp (PV): BW between 30 g to 40 g and TL of 15 cm.

b) Newly accepted broodstock needs to be quarantined and acclimitised at the hatchery center for at least 12 h before the induced breeding.

c) Broodstock with soft or injured shells or those with red colour shall be rejected.

d) The thelycum at the underside of the broodstock should be examined. Female broodstock with opaque white and bulging thelyca should be selected as these indicate the presence of deposited sperm. Those with black spots on the thelycum shall be rejected.

e) Those with cut or missing legs shall be rejected.

6.2.7.2 Eye stalk ablation

Induced breeding should be done by eye stalk ablation. Eyestalk ablation is widely practiced in shrimp hatcheries to stimulate female broodstock to develop mature ovaries and spawn.

Hard shelled and healthy female broodstock having spermatophore in the thelycum should be selected for eyestalk ablation.

Eyestalk ablation should be avoided for newly moulted or ready to moult female broodstock.

6.2.7.3 Precautions to be taken during induced breeding

a) the injured or damaged eyes (if available) should be chosen for ablation;

b) the broodstock should be held gently;

c) the wounds and excessive draining of fluid from the eye stalks after ablation should be kept to a minimum; and

d) the broodstock should be transferred quickly into the maturity tank after the ablation.

6.2.7.4 Water requirements for induced breeding

Water quality shall be checked regularly to ensure effectiveness of the induced breeding. Requirements for water quality are in Table 2.

Table 2. Water requirements for induced breeding

Parameter	Reading
Salinity (ppt)	28-32
pH	7.5-8.5
Temperature (° C)	24-27
Dissolved oxygen (mg/L)	> 4

6.2.8 Maturity tank

The maturation tank should be dark coloured or painted in black, smooth sided and covered, with a holding capacity of 10 tonnes to 20 tonnes and a depth of 0.8 m to 1 m.

Light intensity should be low at about 10 % to 20 % of natural daylight and ablated shrimp should not be disturbed by any noise or movement near the tank (movement and other disturbances should be kept to a minimum).

The maturation tanks should be regularly siphoned to remove uneaten food, faeces and shed shell.

6.2.9 Feed for broodstock

Quantity of feed per day should be at 20 % to 30 % of BW for natural feed and 3 % to 4 % of BW for formulated feed.

Feed should be given 2 to 4 times per day.

Natural feeds (e.g. polychaete, squid, cockle) should be chopped to a size suitable for the broodstock.

6.2.10 Spread rate and gender ratio

6.2.10.1 Stocking rate of broodstock depends on:

a) broodstock size;

b) water quality;

c) waterflow rate (inlet and outlet); and

d) water depth level in the tank.

6.2.10.2 The recommended broodstock density for good maturation is as follows:

a) for black tiger shrimp: broodstock density should be at 3 broodstock/m^3 to 5 broodstock/m^3; and

b) for white shrimp: broodstock density should be at 6 broodstock/m^3 to 8 broodstock/m^3.

6.2.10.3 The gender ratio of female and male broodstock should be 3:2.

6.2.10.4 The process of spawning and hatching is affected by the following factors:

a) lack of copulation activity;

b) immature male broodstock;

c) too old or too long broodstock are kept in the maturation tank; and

d) poor quality of feed.

6.2.11 Spawning and hatching process

6.2.11.1 Examination of matured broodstock

6.2.11.1.1 The broodstock should be examined for maturity after 3 to 4 days of inducing. The full maturity of the broodstock by induced breeding method is achieved between the 10th to the 14th day.

6.2.11.1.2 The broodstocks should be removed by using methods that minimise stress and handling disturbance. The broodstock shall meet hygiene requirements and be SPF or SPR or SPT.

6.2.11.1.3 Maturation sourcing requires selection and removal of ripe mated females to separate spawning tanks as follows:

a) Black tiger shrimp

Female spawners indicating maturity of the gonads (at maturity stage IV) should be transferred to the spawning tank for further spawning process in the morning.

The female spawner should be further inspected to see if the thelycum is opaque before transferring to the spawning tank.

b) White shrimp

Female spawners indicating the maturity of the gonads (at maturity stage IV) should be selected.

The female spawner should then be placed in the mating tank for insemination in the morning.

At the late evening or as soon as night falls, the female spawner should be further inspected to see if there is a spermatophore in the thelycum before transferring to the spawning tank.

6.2.11.1.4 After spawning, the spawner should be returned to the maturation tank for further ovarian maturation.

6.2.12 Spawning process

6.2.12.1 A separate spawning tank is recommended in order to keep the spawning area clean and to enable regular washing and disinfection without disturbing the spawners and to reduce the transmission of diseases between the spawners.

6.2.12.2 Spawning tanks can be of any size depending on the type of spawning used. Suitable spawning tanks with capacity of 300 L to 500 L is recommended for spawners with BW between 130 g to 200 g, or for those with high eggs production of between 0.5 million to 1 million. The tanks may be flat bottomed, or at least angled to the outlet to allow easier and less damage to the eggs.

6.2.12.3 Eggs and sperm counts should be made to determine good eggs production and fertilisation.

6.2.12.4 During spawning, a moderate rate of aeration should be provided, and this should be increased during the incubation process.

6.2.12.5 Water quality and temperature should be maintained as in the maturation tanks.

6.2.12.6 Spawners should be removed from the spawning tank the morning after spawning has been taken place, which is evidenced by the appearance of pink-orange scum on the water surface and walls of the tank.

6.2.12.7 Spawning is considered complete when all eggs in the ovary, from the anterior to the posterior lobes, have been extruded. Spawning is partial when there are still some eggs left in the lobes.

6.2.12.8 Spawners should be disinfected before they are returned to the maturation tank.

6.2.12.9 Transport and handling stress can cause non-spawning or partial spawning.

6.2.12.10 After spawning, the scum should be removed, and the eggs rinsed to minimise the chances of contamination of eggs with bacteria from the scum.

6.2.13 Egg rinsing

Egg rinsing should be carried out by one of the following two methods:

a) Extensive method

Egg rinsing is done continuously in the spawning tank. The water from the spawning tank is drained through a hose with strainer (mesh net size of approximately 100 µm). This will retain the eggs while new seawater is introduced.

b) Intensive method

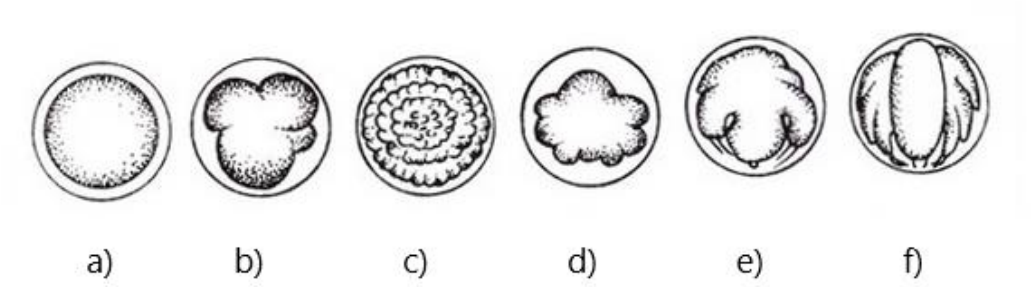
Egg rinsing is done outside the spawning tank.

The eggs are drained out from the spawning tank into a new receptacle to clean/rinse the eggs with treated seawater. The rinsed eggs then transferred to a hatching tank.

The use of disinfectants for egg rinsing shall comply with method(s) as approved by the competent authority.

6.2.14 Fecundation and quality of egg

6.2.14.1 The development stages of fertilised eggs is shown as in Figure 2.



Key

a) newly spawned;
b) 4-celled stage;
c) morula stage;
d) early embryonic nauplius;
e) late embryonic nauplius; and
f) egg about to hatch.

Figure 2. Development stages of fertilised eggs

(Source: Motoh, 1981)

6.2.14.2 Good quality eggs should have the following characteristics:

a) egg shape - sphere;

b) egg colour - yellowish green; and

c) egg diameter - about 0.3 mm.

For production of good quality eggs, the induced broodstock should be given a balanced diet and water quality should be optimal.

6.2.15 Stocking of nauplii

6.2.15.1 The duration for the eggs to hatch after spawning activities is between 12 h to 14 h. Figure 2 can be used as a guide.

6.2.15.2 Nauplii should be transferred to the rearing tank between 32 h to 36 h after hatching. The collection of nauplii is best in the early morning to avoid high temperatures and exposure to strong light.

6.2.15.3 The shrimp shall be given time to gradually adapt to new conditions to avoid stress and mortalities.

6.2.15.4 Procedure for stocking:

a) The aeration in the spawning tank should be turned off.

b) The tank should be completely covered except for only a small portion of the top exposed to light. (The nauplii will concentrate on the area where there is exposure to light.)

c) Nauplii can be collected by using a net (mesh net size of 100 µm) or by siphoning of the nauplii into a container.

d) The nauplii is counted by taking the average of three samples and multiplying it by total volume of water(ml) of the container (e.g. pail). The following formula can be used:

Total number of nauplii = (Number of nauplii in 3 samples/3) x total volume of water (ml) of the container.

6.2.15.5 Before stocking, the rearing tank is cleaned thoroughly by rinsing with seawater or treated with approved chemicals. The equipment and material used to harvest the nauplii shall be washed daily with calcium hypochlorite solution (30 ppm) to prevent contamination of subsequent batches.

6.2.15.6 For delivery (to the nursery tank), nauplli can be loaded at a rate of 60,000 nauplii/L. The temperature should be between 20 °C to 25°C and salinity should be maintained at between 28 ppt to 32 ppt.

6.2.15.7 The packaging should be dark to minimise the penetration of light.

6.2.15.8 Upon arrival at the purchasing hatchery, the nauplii should again be disinfected. If possible, the transport vehicle should first be disinfected before entering the hatchery facilities.

6.2.15.9 After unpacking the nauplii, the packing material shall be disposed.

6.3 Larvae and post larvae management

6.3.1 General

6.3.1.1 Larval rearing should produce the best quality, high-health post larvae possible. In order to achieve this, all areas involved in larval rearing shall be designed for optimal efficiency, cleanliness and productivity.

6.3.1.2 Entrance to the larval rearing areas should be restricted to the personnel that work in this area.

6.3.1.3 All materials and equipment should be for the exclusive use in each room and should not leave the room or be used elsewhere.

6.3.1.4 There are two main stages of larvae after the nauplii stage, namely protozoea and mysis. Mysis will then moult to post larvae (PL). Larvae and postlarvae should be routinely checked for quality. It should be ensured that there is adequate light, aeration and dissolved oxygen (as in Table 2).

6.3.2 Larvae and post larvae rearing

6.3.2.1 Nutrition and feeding

6.3.2.1.1 The quantity, quality and management of feed can have an important impact on larvae health and survival. Failure to provide sufficient feed of the right quality can lead to stress, poor growth, mortality, increase in cannibalistic behaviour, deformity and increased levels of epibiont fouling.

6.3.2.1.2 The recommended feeding practices for larvae and post larvae rearing are as shown in Table 3.

Table 3. Recommended feeding practices for larvae and post larvae rearing

Stages	Numbers of days	Feeds and feeding level (optimum)
Nauplii	1.5	No feeding
Protozoea	5-6	Live feed (i.e. diatom): 10,000 cell/ml to 50,000 cell/ml Formulated feed: 5 g/million protozoea (4 feeds/day to 5 feeds/day)
Mysis	4-5	Live feed (i.e. diatom): 10,000 cell/ml to 25,000 cell/ml Live feed (i.e. artemia): 15 g to 30 g artemia eggs (sista)/million mysis (2 feeds/day) Formulated feed: 10 g/million to 20 g/million (4 feeds/day to5 feeds/day)
Post larvae	PL_1 and above	Live feed: 10,000 cell/ml to25,000 cell/ml Live feed (i.e. artemia): 15 g to30 g artemia eggs (sista)/million PL (2 feeds/day) Formulated feed: PL_1 = 25 g/million PL2 = 30 g/million PL3 =40 g/million PL4 = 50 g/million PL5 = 55 g/million PL6= 60 g/million PL10 = 100 g/million PL15= 150 g/million (below PL 6: 4 feeds/day above PL 6: 4 feeds/day to 6 feeds/day)

6.3.2.1.3 The larvae in each tank shall be inspected regularly (i.e. 2 to 4 times each day). An initial visual inspection of the larvae, the condition of the water in the rearing tank and the feed should be made.

6.3.2.1.4 Observations should be made on the larval stage, health, activity, behaviour and the amount of feed and faeces in the water. Records on the water quality parameters, and the amount of food in the tank shall be taken.

6.3.2.1.5 The same, or a separate sample of larvae, should also be taken to the laboratory for a more detailed microscopic examination. This will provide information on the stage of development, condition, feeding and digestion, and presence of any disease or physical deformity.

6.3.3 Water management for larvae and post larvae rearing

Water quality plays a major impact on the health and performance of larvae. Poor water quality can lead to poor growth, low survival rate, delayed moulting/staging, increased epibiont fouling and deformities. Water management for larvae and post larvae rearing shall be in accordance with 6.5.

6.3.4 Nursery tank (optional)

The post larvae (PL_3 to PL_5) should be transferred to the post larvae rearing or nursery tanks to avoid overcrowding of fry and to vacate the larvae nursery tanks for the next run.

Stocking density: 3,000 to 5,000 of PL/tonne of seawater can be stocked in the nursery tank.

Water management for the nursery tank shall be in accordance with 6.5.

6.3.5 Quality evaluation of post larvae

6.3.5.1 Physical evaluation

At stages PL 11 to PL 13, the fry should show the following characteristics:

a) active;

b) uniform size; and

c) brownish white colour.

6.3.5.2 Microscopic evaluation

Microscopic evaluation should show the following characteristics:

a) Rostrum and appendages complete and normal.

b) Healthy fry will have a gut filled with food even if the intestines are not full after eating.

c) Under normal circumstances, in the hepatopancreas section, seed cubs are bright or clear.

d) Fry has a smooth skin, no growth (abnormal) in the skin part and clean of algae.

6.3.5.3 Stress test

Stress test may be conducted as in 6.3.5.3.1 or 6.3.5.3.2 to determine and confirm the quality of the fry. Strong and healthy fry will be able to survive under reasonable pressure while the weak or low-quality fry may die.

6.3.5.3.1 Salinity test

The fry is put in water that has salinity between 15 pt to 20 pt for 2 h. After that, the fry is returned to the original salinity. Healthy fry will survive after the salinity test.

6.3.5.3.2 Water temperature shock

The fry is exposed immediately from normal water temperature of 28 °C to 32 °C to a temperature of 22 °C to 24 °C for a period of 5 min to 10 min. Healthy fry will survive after returning to the normal water temperature.

6.4 Feed management

6.4.1 Feeding should be efficiently managed to provide an appropriate amount of feed as required for the fry. Appropriate feeding will result in healthy fry with low risk of disease.

6.4.2 The feed shall be free from pathogens, prohibited antibiotics, banned substances, porcine and other filthy sources and/or their derivatives.

6.4.3 Production of phytoplankton or algae for feeding has to be synchronised with the hatchery operations so that diatoms or other natural food are available as soon as the larvae molt to the first feeding stage. The most commonly used algal food are skeletonema and chaetoceros.

6.4.4 The feed shall not contain unsafe levels of pesticides, biological, chemical and physical contaminants and/or other adulterated substances in compliance with national regulations or international standards.

6.4.5 Only approved, registered and properly labelled commercial feeds, feed ingredients and additives shall be used in compliance with requirements of the competent authority.

6.4.6 Good quality feeds shall be used. In the of case of hatchery-made feed that is prepared in the hatchery and nursery, the feed ingredients used for the formulation shall be identified and recorded.

6.4.7 Efficient feeding management should be implemented to ensure that the nutritional requirements of the larvae and post larvae are met. The feeding practice should follow the requirements as recommended by the feed manufacturers.

6.4.8 The selection of feed used should consider the feed profile and its stability.

6.4.9 Feed should be stored under clean, dry ventilated conditions within a room with a proper floor and walls such that high humidity and direct sunlight is avoided. Feed should be handled and stored according to manufacturer specification/recommendation in such a way as to prevent spoilage, mould growth and contamination.

6.4.10 Bags containing feeds should be stored on proper pallets and in such a manner so as to facilitate good air circulation between individual bags and should never be allowed to rest directly against the floor or walls.

6.4.11 Specified dosages and withdrawal periods of the feed shall be strictly respected. Veterinary drugs and chemicals that are hazardous should be disposed of in a proper manner.

6.4.12 Feed shall be stored in an area such that the likelihood of contamination is minimised. The first-in, first-out (FIFO) policy should be practised to maintain the quality of feed.

6.5 Water management

6.5.1 The quality of the water shall be monitored and controlled to ensure good growth and health of the fry and that it is safe for human consumption.

6.5.2 The water quality shall be monitored and recorded throughout the culture period. The use of approved probiotics may be employed to improve the water quality. Table 4 specifies the parameters for optimum water quality.

Table 4. Optimum parameter of the water for shrimp hatchery

Parameter	Setting
Dissolved oxygen (mg/L)	> 4.0
Salinity (ppt)	28-32
Temperature (^{o}C)	28 – 32
pH	7.5 – 8.5
Ammonia (unionised) (mg/L)	< 0.1
Nitrit-(Nitrogen) (mg/L)	< 0.02
Alkalinity (mg/L)	> 100
Calcium (mg/L)	> 400
Magnesium (mg/L)	> 1,200

6.5.3 Water used shall be obtained from non-polluting sources and have a water quality parameter (physical, chemical and biological) that are suitable for a shrimp hatchery. It shall not be wastewater from any activity that can affect the health of the fry. In case it is necessary to use such water, suitable treatment shall be carried out and water analysis results should show the suitability of the treated water.

6.5.4 In situations where the water parameter as in Table 4 is not met, chemical treatment by adding molasses, calcium chloride, magnesium chloride and sodium bicarbonate shall be carried out as follows.

a) low level of alkalinity - Add sodium bicarbonate;

b) high pH - Add molasses;

c) low level of magnesium - Add magnesium chloride; and

d) low level of calcium - Add calcium chloride.

6.6 Effluent management

6.6.1 Effluent from the hatchery shall not be discharged into the public or municipal water body without undergoing proper treatment.

6.6.2 Discharges of water, sediment and sludge, from the hatchery shall not cause negative environmental impacts to the surrounding areas.

6.6.3 The hatchery should take appropriate measures to:

a) avoid salinisation of soil and freshwater resources;

b) dispose of solid wastes and garbage in an environmentally sound way;

c) dispose of dead fry in a hygienic and sanitary manner especially after disease outbreak;

d) apply appropriate treatment of effluent using industrial effluent treatment systems (IETS) in accordance with the *Environmental Quality (Industrial Effluents) Regulations 2009*. The parameters for marine water quality index are specified in Annex B; and

e) provide means to collect sludge from the culture tanks and disposal treatment tanks in order to prevent the sludge from contaminating the outside environment.

6.6.4 In case diseases are detected, the wastewater shall be disinfected before discharging, in order to minimise the risk of disease spreading. Disinfection shall be carried out by applying permitted chemicals such as chlorine with a concentration of 30 mg/L and allowing it to dissolve for at least two days.

6.6.5 Treatment technologies for shrimp hatchery effluent can range from the conventional flow-through settlement tank design to recirculation and bioremediation methods that recycle the tank water, and to the use of filtration equipment to reduce particulate matter in the effluent. A suitable method for effluent treatment in accordance with the needs of the hatchery shall be selected.

6.7 Chemical storage

6.7.1 All chemical compounds shall be stored in a secure lockable store and in accordance with the manufacturer’s instructions or as recommended by the competent authority and, where appropriate, be physically separated. Compliance should include a visual assessment of the chemical store.

6.7.2 Manufacturer’s Product Specification and Material Safety Data Sheets (MSDS) shall be made available for all chemical compounds.

6.8 Chemical and biological substances use

6.8.1 Substances requiring prescription should be administered with the supervision of a qualified expert/trained technician authorised by the competent authority.

6.8.2 Prohibited antibiotics, chemicals and banned substances shall not be used for disease treatment.

6.8.3 Approved and registered veterinary drugs, medicated feeds, chemical and biological substances shall only be used according to the manufacturer's instruction or as advised by the competent authority.

6.8.4 Veterinary drugs, chemicals, hazardous substances and probiotics shall be stored appropriately to prevent deterioration and unauthorised use.

6.9 Pest and predator control

6.9.1 The hatchery operator shall control the risk of pest and predator infestation in the shrimp hatchery. The location of all pest and predator control measures shall be identified on a layout plan.

6.9.2 Monitoring records of identified risk locations and preventive measures shall be in place and available.

6.9.3 To prevent pest and predators from entering the tank, the area around the tank shall be clean. Tank inspection should be carried out from time to time.

6.10 Biosecurity and sanitary measures

6.10.1 The buildings and facilities shall be orderly and separately arranged according to sections and regularly cleaned.

6.10.2 Operational areas should be separated. Tools, equipment and facilities should be arranged or located and separated to facilitate hygienic practices according to the technical methods before and after the use for each batch of broodstock.

6.10.3 Hatchery operators are encouraged to provide physical bio-security measures (e.g., nets, grills, screens or barriers of the appropriate mesh size on all farm or pond inlets) which are effective to prevent any disease outbreak.

6.10.4 The hatchery shall have a system to prevent the escape of fry to public water bodies because of potential problems such as the transmission of exotic diseases, encroaching on the habitat or feed sources of native shrimps, or causing genetic manipulation.

6.10.5 Pets and domestic animals shall not be allowed in the hatchery area.

6.10.6 Sanitary facilities shall be provided that allows for disinfection at the entry and exit points of the hatchery including the cleaning and sanitisation of vehicles that enter and leave the hatchery.

6.10.7 There shall be only one entrance and exit from the farm. The entrance for both vehicles and people on foot, shall be equipped with a disinfection system in order to prevent the introduction of pathogens.

6.10.8 Measures shall be in place to prevent personnel and visitors from introducing pathogens into the hatchery.

6.10.9 No one shall be allowed to enter the hatchery for at least three days after visiting any marine shrimp hatchery, hatchery, or nursery where there is a risk of infection or where a specified disease outbreak has been declared or after visiting an aquatic disease laboratory.

6.10.10 The bathrooms and toilets shall be kept at a distance from the operational area to prevent contamination of sewage to the marine shrimp hatching and/or nursing system.

6.10.11 Rubbish and waste shall be disposed in a hygienic manner. Good management of waste disposal should be in place to prevent cross-contamination, animal carrying diseases and pets from digging.

6.10.12 All the tanks, equipment and tools shall be regularly cleaned and disinfected. Equipment and tools shall not be moved from hatchery to hatchery.

6.10.13 Personal protective equipment (PPE), wherever applicable, shall be cleaned after every use and stored separately from contaminants. Separate storage areas should be provided for clean and used PPE. Clean PPE shall be stored in manner such that it does not become contaminated and does not cause cross contamination, when used.

6.10.14 All staff entering the production area should wear personal protective clothing that is clean and uncontaminated. Where a foot bath is used, it shall:

a) incorporate a cleaning procedure to remove accumulation of organic material and mud;

b) be sufficiently deep to cover the boots;

c) use disinfectant solution that is not inactivated by organic matter; and

d) be regularly refreshed with new solution.

6.11 Harvesting

6.11.1 Fry shall be hygienically managed and handled to prevent contamination during the harvest and post- harvest stages to ensure the safety, quality and the value of the fry.

6.11.2 Harvesting should be planned and carried out in a timely manner to prevent fry from being exposed beyond the optimal range of temperatures.

6.11.3 Fry shall be harvested at a suitable time (recommended time for harvesting is early in the morning), at the suitable stage and when it is of good quality, i.e. free from any defects or are SPF or SPR or SPT.

6.11.4 The workers shall be trained to ensure that they are capable of selecting the fries for harvesting at the suitable stage, black tiger shrimp (i.e. PL 15-18) and white shrimp (i.e. PL 10-15).

6.11.5 Requirements in Clause 11 shall be followed when transporting/transferring the fry to the nursery or for transport.

6.11.6 During extended periods of transportation, the water temperature shall be reduced to decrease moulting and metabolic rates and the incidence of cannibalism among fry. However, there is no need to lower the water temperature in transport bags when transporting at night or during cool weather.

6.11.7 The hatchery operators shall provide a health certificate for each batch that is to be exported and laboratory test results for produce destined for the domestic market.

6.11.8 Minimising stress of the fry immediately prior to transportation is necessary to prevent welfare problems and to maintain quality of the fry.

7. Shrimp health management

7.1 Hatchery operations should take place in accordance with the relevant provisions of the WOAH Aquatic Animal Health Code for aquatic animal health management to prevent introduction or transfer of disease and infectious agents pathogenic to fry while avoiding unwarranted sanitary measures.

7.2 Shrimp health management programmes should be implemented in compliance with relevant national legislation and regulations and WOAH Aquatic Animal Health Code.

7.3 Management, monitoring, maintaining of environmental setting and checking of marine fry health should be done regularly, and records of health and corrective actions should be maintained.

7.4 In the case of occurrence of an outbreak of any disease of fry, the hatchery shall be prepared with measures to effectively control, prevent and respond to the incidence.

7.5 The responsible persons and procedures shall be clearly determined to prevent spread of the disease within the hatchery and to the outside. For instance, if a disease is detected, the hatchery shall be closed, and production shall be temporarily suspended. The farmers should then notify the competent authority and seek advice from the competent authority or other available experts.

7.6 Inspection reports of random sampling of fry indicating the absence of the target diseases shall be available. The broodstock shall be healthy or SPF or SPR or SPT and free of the diseases listed in Annex C (common diseases listed by the WOAH and the clinical signs or symptoms of the diseases).

7.7 In case of occurrence of abnormal mortality and target diseases are suspected, steps shall be implemented to control the disease transmission. The operator should notify the competent authority and seek advice from the competent authority or other available experts.

7.8 Appropriate methods of dead fry/broodstock disposal and water discharge shall be in place. The disposal of dead fry/broodstock shall be done in a suitable area and in a sanitary manner to avoid cross-contamination.

7.9 The hatchery operators shall disinfect the affected tank prior to release to their effluent/ treatment tank.

7.10 A dry up period should be observed to break the cycle of disease. Each culture tank shall be left vacant for a period after each harvest to reduce the risk of accumulation of disease vectors.

8. Transboundary

8.1 Movement of fry should take place in accordance with relevant provisions in the WOAH Aquatic Animal Health Code to prevent introduction or transfer of diseases and pathogens to aquatic animal while avoiding unwarranted sanitary measures.

8.2 Hatchery operator shall seek approval from competent authorities for the importation and culture of alien species and genetically modified organism (GMO). All alien species and GMO shall be cultured under closed aquaculture systems.

8.3 The method of disposal of alien species and GMO shall comply with the requirements of the competent authorities.

9. Workers safety, health and welfare

9.1 Workers (including foreign and migrant workers) shall be treated responsibly and in accordance with relevant national labour laws and regulations and, where appropriate, relevant International Labour Organization (ILO) conventions.

9.2 Workers shall not be discriminated on the basis of gender.

9.3 Workers of both genders shall be provided with decent working conditions.

9.4 Child labour shall not be used in a manner inconsistent with national regulations or ILO conventions.

9.5 Workers directly involved in production or hatchery activities shall be in good health condition and receive basic training on hygiene requirements.

9.6 Safe hatchery work conditions shall be ensured at all times in line with the *Occupational Safety and Health Act 1994* and ILO conventions to ensure safe and healthy working conditions.

9.7 Workers should not be exposed to hazards which may pose danger to their health and safety. Workers shall be equipped with suitable personal protective equipment (PPE) appropriate to the danger posed to their health and safety.

9.8 First aid boxes shall be available at permanent sites on the hatchery.

9.9 Hazards shall be clearly identified by warning signs where appropriate.

9.10 Accident and emergency procedures with clear instructions shall be made available to all workers. These procedures shall be displayed appropriately.

9.11 Basic amenities for on-site living shall comply with national regulations and local laws.

10. Personal hygiene

10.1 All personnel involved in the production shall have relevant knowledge on practices of SPF or SPR or SPT fry production such as proper cleaning methods, disinfection of tools and working places, methods for waste disposal, methods for primary fry health examination and water quality testing methods.

10.2 The fry shall be handled under hygienic conditions in accordance with Annex D.

11. Transportation

11.1 The selection of a suitable container, packing material and adherence to good packaging practices for transportation is of primary importance in order to protect fry from physical damage, ensure high survival rate of fry and ensure that it will arrive in a good condition.

11.2 The container shall be strong enough to withstand external pressure, be leak-proof, light weight, easy to handle, easy to clean and insulated against both heat and cold.

11.3 Packing material helps to maintain humidity in the container and absorb water when transporting the fry.

11.4 It is also essential for the organisation to check with the cargo carrier for any requirements on size, weight, selection of packing materials, etc.

11.5 The number of fry loaded per bag will depend on the size and age of fry, travel time, distance and means of transportation. Total number of fry can be estimated by using comparison method (count individual fry in a basin) or by volumetric method.

11.6 During transportation of fry, the following should be considered:

a) the temperature (between 20 °C to 23 °C) and adequate oxygen supply;

b) exposure to elevated temperatures during loading and unloading of fry should be avoided;

c) product arrangement when loaded should ensure good air flow taking into consideration the wall, floor and roof panel of the transportation container; and

d) transportation facility should provide adequate protection against contamination from dust, exposure to higher temperatures and the drying effects of the sun or wind.

11.7 Upon reaching the farm site, the fry should be acclimatised to the water temperature and salinity of the nursery or rearing ponds prior to stocking.

12. Training

12.1 Workers should have knowledge and be trained on the good aquaculture practices.

12.2 Training shall be given to all workers on aquatic animal health and welfare management, and good hygienic practices to ensure they are aware of their roles and responsibilities in protecting aquaculture products from contamination and deterioration.

12.3 General training on safe working practice, accident prevention, emergency procedures, risk reduction and safety should be provided to all hatchery workers. Information relating to this should be made available and displayed appropriately.

13. Traceability

The produce shall be traceable to the hatchery where it was originally produced. All data related to fry produce should be recorded, maintained, and be readily accessible when required by the customer or the relevant competent authority.

14. Record keeping

14.1 All records shall be maintained on the quantities and origin of inputs. Types of records that should be maintained including the following:

a) broodstock origin;

b) feeding and water management;

c) estimated production volume/quantity distributed to hatcheries;

d) disease history of the hatchery and nursery facility;

e) preventive measures against and control of disease outbreak;

f) purchase and use of veterinary drugs, chemicals and hazardous substances;

g) probiotics and other inputs;

h) employment records and wage payments;

i) potential clients;

j) health certificates; and

k) laboratory test results.

14.2 All records shall be kept up to date for a minimum of two years unless stipulated by any specific legislation.

14.3 A record keeping system shall be established in which all records are properly stored, protected from damage or deterioration such that they remain legible and should be readily accessible.

15. Social responsibilities

15.1 Shrimp hatchery activities should be carried out in a socially responsible manner which does not jeopardise the livelihood of farmers and local communities. It should be conducted in accordance with national rules and regulations, and where appropriate, relevant International Labour Organization (ILO) guidelines and conventions on labour rights.

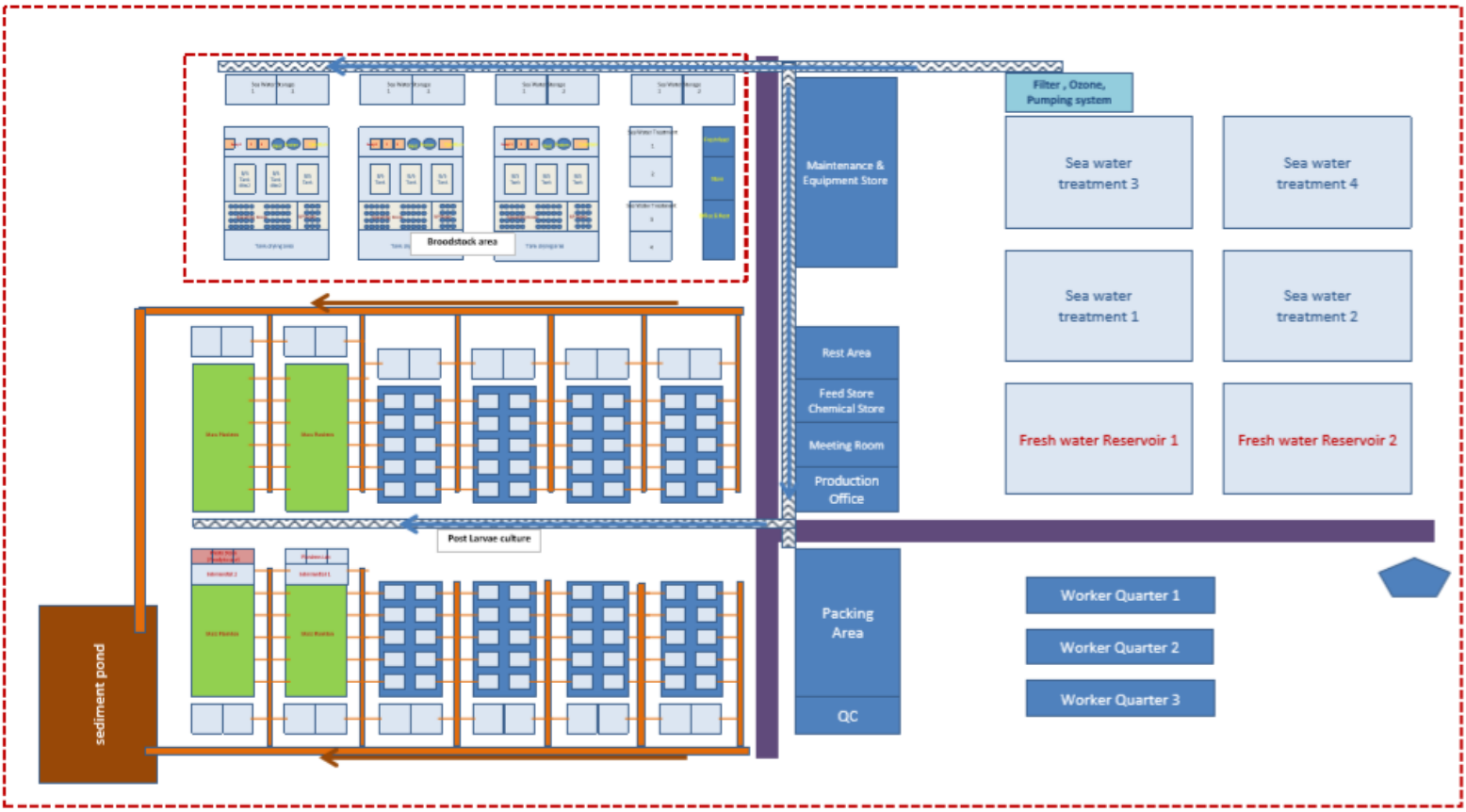
15.2 Socio-economic aspects should be considered at all stages of shrimp hatchery planning and operation with the aim of enhancing benefits and equity in local communities such as alleviating poverty and promoting food security.

15.3 The hatchery operators shall ensure equal rights on public land and water use for local communities in accordance with the requirements of the relevant competent authorities.

15.4 The hatchery operators should have mechanisms for communication and engagement with the local community and to take positive actions in response to their complaints.

Annex A
(informative)

Layout of shrimp hatchery (example)



Annex B
(informative)

Parameters for marine water quality index for marine life, fisheries, coral reefs, recreational and mariculture ports

B.1 The parameters for shrimp hatchery effluent before it is released to the marine water shall be as specified in Table B.1.

Table B.1 Parameters for marine water quality index

Parameter	Value
Dissolved oxygen (mg/L)	> 5
Total suspended solid (mg/L)	50.0
Phosphate (µg/L)	75.0
Nitrate (µg/L)	60.0
Ammonia (µg/L)	50.0
Mercury (µg/L)	0.04
Cadmium (µg/L)	2.0
Chromium (VI) (µg/L)	10.0
Copper (µg/L)	2.9
Cyanide (µg/L)	7.0
Lead (µg/L)	8.5
Zinc (µg/L)	50.0
Arsenic (III) (µg/L)	3.0
Aluminium (µg/L)	27
Tributyltin (TBT) (µg/L)	0.01
Polycyclic Aromatic Hydrocarbon (PAHs) (µg/L)	200
Total Phenol (µg/L)	10
Oil and grease (mg/L)	0.14
Faecal coliform (Cfu/100 ml)	100
Temperature (°C)	≤ 2°C increase over maximum ambient
pH	6.5 - 9.0
Marine litter	Free from marine litter

Source: Malaysian Marine Water Quality Standard (MMWQS), Class 2, 2019.
*IMWQS in parentheses are for coastal and marine water areas where seafood for human consumption is applicable.

Annex C
(informative)

Diseases and pathogens and clinical signs/symptoms

C.1 The diseases and pathogens in this annex have been assessed in accordance with WOAH list of aquatic animal diseases. The following diseases of crustaceans are listed by the WOAH Aquatic Animals Health Code:

a) Acute hepatopancreatic necrosis disease, AHPND

b) Infection with *Aphanomyces astaci* (crayfish plague)

c) Infection with *Hepatobacter penaei* (necrotising hepatopancreatitis), HP

d) Infection with infectious hypodermal and haematopoietic necrosis virus, IHHNV

e) Infection with infectious myonecrosis virus, IMNV

f) Infection with *Macrobrachium rosenbergii* nodavirus, MrNV (white tail disease)

g) Infection with Taura syndrome virus, TSV

h) Infection with white spot syndrome virus, WSSV

i) Infection with yellow head virus genotype 1, YHV

C.2 Clinical signs or symptoms of the diseases are specified in Table C.1 below.

Table C.1 Clinical signs or symptoms of the disease listed by WOAH

Diseases	Symptoms/Clinical signs
Acute hepatopancreatic necrosis disease, AHPND	The onset of clinical signs and mortality can start as early as 10 days post-stocking. Clinical signs include a pale-to-white hepatopancreas (HP), significant atrophy of the HP, soft shells, guts with discontinuous, or no contents, black spots or streaks visible within the HP (due to melanised tubules).
Infection with *Aphanomyces astaci* (crayfish plague)	Clinical signs of infection with *A. astaci* include behavioural changes and a range of visible external lesions.
Infection with *Hepatobacter penaei* (necrotising hepatopancreatitis), HP.	A wide range of gross signs can be used to indicate the possible presence of infection with H. *penaei.* These include lethargy, reduced food intake, atrophied hepatopancreas, anorexia and empty guts, noticeably reduced growth and poor length weight ratios (‘thin tails’); soft shells and flaccid bodies; black or darkened gills; heavy surface fouling by epicommensal organisms; bacterial shell disease, including ulcerative cuticle lesions or melanised appendage erosion; and expanded chromatophores resulting in the appearance of darkened edges in uropods and pleopods. None of these signs are pathognomonic.

Diseases	Symptoms/Clinical signs
Infection with infectious hypodermal and haematopoietic necrosis virus, IHHNV	Certain cuticular deformities, specifically a deformed rostrum bent to the left or right, which may be presented by *P. vannamei* and *P. stylirostris* with RDS, are pathognomonic for infection with IHHNV However, this clinical sign is not always apparent in shrimp populations chronically infected with IHHNV. As *P. vannamei, P. stylirostris,* and *P. monodon* can be infected by IHHNV and not present obvious signs of infection (e.g. they may show markedly reduced growth rates or 'runting'), molecular tests are recommended when evidence of freedom from infection with IHHNV is required. In acute disease, *P. stylirostris* may present behavioural changes but with RDS, no consistent behavioural changes have been reported for affected shrimp.
Infection with infectious myonecrosis virus, IMNV	In early juvenile, juvenile, or adult *P. vannamei* in regions where infection with IMNV is enzootic, outbreaks of infection with IMNV associated with sudden high mortalities may follow stressful events such as capture by cast-netting, feeding, and sudden changes in water salinity or temperature. Shrimp in the acute phase of infection with IMNV will present focal to extensive white necrotic areas in striated (skeletal) muscles, especially in the distal abdominal segments and tail fan, which can become necrotic and reddened in some shrimp. Severely affected shrimp become moribund and mortalities can be high immediately following a "stress" event and continue for several days. Affected shrimp present with visibly white tails. Such severely affected shrimp may have been feeding just before the onset of stress and may have a full gut.
Infection with *Macrobrachium rosenbergii* nodavirus (white tail disease), MrNV	Infected PL become opaque and develop a whitish appearance, particularly in the abdominal region. The whitish discolouration appears first in the second or third abdominal segment and gradually diffuses both anteriorly and posteriorly. In severe cases, degeneration of telson and uropods may occur. Mortality may reach a maximum in about 5 days after the appearance of the first gross signs. PLs are highly susceptible to infection with MrNV and mortality reaches a maximum in about 5 days after the appearance of whitish discolouration. Floating exuviae (moults) in the tanks appear abnormal and resemble 'mica flakes'. The infected PL show progressive weakening of their feeding and swimming ability.
Infection with Taura syndrome virus, TSV	Infection with TSV is best known as a disease of nursery- or grow-out-phase *P. vannamei* that occurs within ~14–40 days of stocking PLs into grow-out tanks or tanks, hence, shrimp with infection with TSV are typically small juveniles of from ~0.05 g to <5 g. Larger shrimp may also be affected, especially if they are not exposed to the virus until they are larger juveniles or adults. Only shrimp with acute-phase clinical infection with TSV present behavioural changes. Typically, severely affected shrimp apparently become hypoxic and move to the tank edges or tank surface where dissolved oxygen levels are higher. Such shrimp may attract seabirds in large numbers. In many disease outbreaks, it is the large numbers of seabirds attracted to the

Diseases	Symptoms/Clinical signs
	moribund shrimp that first indicates the presence of a serious disease outbreak (which is often either infection with TSV or white spot syndrome virus) to the hatchery manager.
Infection with white spot syndrome virus, WSSV	White spots embedded within the exoskeleton are the most commonly observed clinical sign. In most shrimp, these spots range from barely visible to 3 mm in diameter, and they sometimes coalesce into larger plates. However, it should be noted that environmental stress factors, such as high alkalinity, or bacterial disease can also cause white spots on the carapace of shrimp, and that moribund shrimp with infection with WSSV may have few, if any, white spots. Therefore, the appearance of white spots is not a reliable diagnostic sign of infection with WSSV infection. High degrees of colour variation with a predominance of reddish or pinkish discoloured shrimp are seen in diseased populations. WSSV infections can be subclinical or manifest as clinical disease. The penaeid shrimp in aquaculture will generally show clinical signs associated with high morbidity and mortality. Some animals may die without showing any clinical signs. The affected animals can show lethargy, decreased or absent feed consumption and abnormal swimming behaviour – slow swimming, swimming on side, swimming near water surface and gathering around edges of rearing units. A very high mortality rate in the shrimp population can be expected within a few days of the onset of behavioural signs.
Infection with yellow head virus genotype 1, YHV	Shrimp from late postlarvae stages onwards can be infected experimentally with YHV1. In cultured shrimp, infection can result in mass mortality occurring, usually in early to late juvenile stages. Moribund shrimp may exhibit a bleached overall appearance and a yellowish discoloration of the cephalothorax caused by the underlying yellow hepatopancreas, which may be exceptionally soft when compared with the brown hepatopancreas of a healthy shrimp. In many cases, the total loss of a tank crop occurs within a few days of the first appearance of shrimp showing gross signs of YHV1. However, these disease features are not particularly distinctive, and in the absence of other more pathognomonic gross signs are not reliable even for preliminary diagnosis of YHV1. Exceptionally high feeding activity followed by an abrupt cessation of feeding may occur within 2–4 days of the appearance of gross clinical signs of disease and mortality. Moribund shrimp may congregate at tank edges near the surface.

Annex D
(normative)

Personnel hygiene and health requirements

D.1 General

An appropriate degree of personal hygiene shall be maintained in order to avoid contamination.

D.2 Medical examination

Top management shall ensure that persons who involved in harvesting and post-harvest handling of marine shrimp should have a medical examination prior to their employment.

D.3 Communicable diseases

Top management shall ensure that no person, while known or suspected to be suffering from, or to be a carrier of, a disease or while afflicted with infected wounds, skin infections, sores or with diarrhoea, is permitted to work in any hatchery area in any capacity in which there is any likelihood of such a person directly or indirectly contaminating with pathogenic microorganisms. Any person so affected should immediately report to the management that he is ill.

D.4 Hygiene training

Top management shall arrange for adequate and continuous training to all personnel on matters pertaining to personal hygiene so that they understand the precautions necessary to prevent contamination.

D.5 Injuries

Any person who has a cut or wound shall not continue to work in any hatchery related activities until the injury is completely protected by a waterproof covering which is firmly secured, and which is conspicuous in colour. Adequate first-aid facilities should be provided for this purpose.

D.6 Washing of hands

Every person, while on duty in a facility/hatchery area, shall wash his hands frequently and thoroughly with a suitable hand-cleaning preparation under running water. Hands should always be washed before commencing work, immediately after using the toilet, after handling contaminated material and whenever necessary.

After handling any material which might be capable of transmitting disease, hands shall be washed and disinfected immediately. Notices requiring hand washing shall be displayed. There should be adequate supervision to ensure compliance with this requirement.

D.7 Personal cleanliness

Every person engaged in the hatchery area shall maintain a high degree of personal cleanliness while on duty, and shall at all times wear suitable protective clothing including footwear, all of which articles shall be cleanable and shall be maintained in a clean condition consistent with the nature of the work in which the person is engaged. Gloves, if used in the handling of food products, shall be maintained in a sound, clean and sanitary condition. The wearing of gloves does not exempt the operator from having to thoroughly wash hands.

D.8 Visitors

Precautions shall be taken to prevent visitors to the processing and handling areas from contaminating the product. These may include the use of protective clothing and other provisions deemed necessary.

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