DOF STANDARD

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Code of good aquaculture practices for marine finfish farming

DEPARTMENT OF FISHERIES MALAYSIA

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Foreword

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

This standard was developed with the following objectives:

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

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

c) to provide guidance to ensure that the farming activities are conducted 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 finfish farming

0. Introduction

This code of good aquaculture practices for marine fish farming has been developed with the aim of upgrading the aquaculture industry in Malaysia. It is intended that marine fish farms registered with the Department of Fisheries will be able to implement the good management practices specified in this document and successfully obtain Malaysian Good Agricultural Practices MyGAP certification. Additionally, this code of good practices will ensure that the monitoring of activities in these farms under the official control programmes of the Department of Fisheries is carried out in a more consistent and effective manner.

This code of good aquaculture practices is applicable to marine fish farming either in cage, pen, pond or tank. There are some differences in the requirements for different culture types especially in terms of requirements for site selection and the design of the farm. To facilitate the use of this standard, users should refer to the following table.

Culture type / Aspect	Cage	Pen	Pond	Tank
	Clause to be referred			
Site selection	4.1 4.2	4.1 4.2	4.1 4.3	4.1
Farm layout and design	5.1 5.2 5.6 5.7 5.8	5.1 5.3 5.6 5.7 5.8	5.1 5.4 5.6 5.7 5.8	5.1 5.5 5.6 5.7 5.8
Farm preparation and farm management	6.1 6.5 6.6 6.7 6.8 6.9 6.10 6.11 6.12 6.13 6.14	6.2 6.5 6.6 6.7 6.8 6.9 6.10 6.11 6.12 6.13 6.14	6.3 6.5 6.6 6.7 6.8 6.9 6.10 6.11 6.12 6.13 6.14	6.4 6.5 6.6 6.7 6.8 6.9 6.10 6.11 6.12 6.13 6.14
Animal health and welfare	7	7	7	7
Transboundary	8	8	8	8
Worker's safety, health and welfare	9	9	9	9
Personal hygiene	10	10	10	10
Transportation of marine fish	11	11	11	11
Traceability	12	12	12	12
Record keeping	13	13	13	13
Training	14	14	14	14
Social responsibility	15	15	15	15

The adoption of these good practices will not only ensure the quality and safety of the marine fish produced for human consumption but will also ensure that marine fish farming is conducted in a socially responsible manner and promote the sustainability of the industry. These good practices also take into account the welfare of the farm's workers including their health to ensure that the workers are free from diseases that could potentially affect the safety of the marine fish produced.

These good practices are intended to address the generally recognised key elements in marine fish farming and the subsequent handling processes in order to ensure food safety along the processing environment and operation up to the point of delivery.

1. Scope

This standard prescribes a code of good aquaculture practices for commercial and sustainable marine finfish farming to ensure safe, disease free and good quality fish produce.

This standard covers the stage of grow out farming until post-harvesting practices (delivery point) taking into consideration the aspects of food safety, animal health and welfare, environmental integrity and socioeconomic responsibility.

This standard does not include the hatching and nursing stages as well as activities such as processing, distribution, and retailing.

This standard is applicable to marine finfish farming in cages, pens, ponds and tanks.

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.

Environmental Quality (Industrial Effluents) Regulations 2009

Occupational Safety and Health Act 1994

Food Hygiene Regulations 2009

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) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, 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 antibiotic

Substance produced by a micro-organism or any other product, produced wholly or partially by chemical synthesis and, which in low concentration, inhibits the growth of or kills micro-organisms and that is used for the purpose of growth stimulation and prevention of diseases.

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 cage

Tool hanging or floating in natural water sources used for marine finfish culture. It has a variety of shapes such as rectangle, square, polygon or round with or without frame. It is made from fishing net or wood and may be stationed with poles or buoy.

3.5 competent authority

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

3.6 extensive culture

Extensive aquaculture systems are systems that always supply the output function of harvesting and have at least one of the input functions or the output function of preventing escapes. The other input functions apart from providing light are optional. Extensive aquaculture systems have no treatment functions.

NOTES:

1. Adapted from article entitled ‘A Definition of Aquaculture Intensity Based on Production Functions - The Aquaculture Production Intensity Scale (APIS)’ by Guðmundur Valur Oddsson.

2. Refer Tables A.1 and A.2 (Annex A) for details on the extensive culture system

3.7 fingerling

Juvenile fish of size 10 cm to 15 cm in length or roughly equal the size of a finger.

NOTE. Fingerling is the proper size for stocking in table fish production ponds. It takes about 30 days to 60 days for the fry to grow up to fingerling size.

3.8 intensive culture

Intensive aquaculture systems are systems that use very high densities of culture organism and always supply the input functions of supplying water, stocking and feeding the treatment functions of controlling DO and CO_2, controlling organic matter, controlling nitrogen compounds and controlling solids and the output function of harvesting. All other functions are optional.

NOTES:

1. Adapted from article entitled 'A Definition of Aquaculture Intensity Based on Production Functions - The Aquaculture Production Intensity Scale (APIS)' by Guðmundur Valur Oddsson.

2. Refer Tables A.1 and A.2 (Annex A) for details on the intensive culture system.

3.9 marine finfish

Fish naturally live and grow in seawater, brackish water or adaptation to live in fresh water and be able to culture on farm such under family Chanidae (e.g., Milkfish), Latidae (e.g: Sea bass), Serranidae (e.g: Grouper), Carangidae (e.g: Golden Trevally), Lutjanidae (e.g: Red snaper), Stromatidae (e.g: Silver pomfret) and Polinemidae (e.g: Thredfin), hereinafter referred to as marine fish.

3.10 marine finfish farm

An establishment devoted for raising marine finfish which includes ponds, cages, pens, tanks, feed preparation area, building and other facilities which are necessary for marine finfish culture, hereinafter referred to as farm.

3.11 pen

Confined area used for marine finfish culture located in the sea or coastal area. It is made from wood or tile or fishing net and the lower part of the pen is buried under the ground.

3.12 pond

An inland water-filled pond that is earthen, concrete, coated canvas or plastic layered that is used for raising marine finfish.

3.13 semi-intensive culture

Semi-intensive systems use densities higher than extensive systems and use supplementary feeding. Semi-intensive culture systems are systems that always supply the input function of stocking, and either feeding or fertilising and the output function of harvesting. The other input and output functions are optional. These systems have at least one treatment function.

NOTES:

1. Adapted from article entitled 'A Definition of Aquaculture Intensity Based on Production Functions - The Aquaculture Production Intensity Scale (APIS)' by Guðmundur Valur Oddsson.

2. Refer Tables A.1 and A.2 (Annex A) for details on the semi-intensive culture system.

3.14 sustainable

Holistic farming 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.

4. Site selection

4.1 General

4.1.1 The location of the site for marine aquaculture farming activities shall be approved by the relevant competent authority(ies). Farm operators are encouraged to select areas located in designated Aquaculture Industrial Zones (AIZ) and to conduct basic impact assessment prior to selection of the site for commencement of any project.

4.1.2 The specific criteria to be considered for selection of the area shall depend on the type of culture practice or method to be implemented i.e., cage, pen, pond or tank.

4.1.3 The area selected should be such that the risk of contamination is minimal and shall be without any conflict of land and/or water use.

4.1.4 Farm site selection and infrastructure construction should follow the minimum distance between farm as recommended by competent authorities and should take into consideration the conservation of natural habitat (e.g., mangrove, coral reef, sea grass and peat swamp), minimisation of disturbance to the surrounding environment and the potential to cause adverse impacts on human health.

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

4.2 Site selection for cage and pen farming

4.2.1 The site selected should be at a suitable location with optimum water parameter for the fish culture.

4.2.2 The area selected shall be free from pollution and shall not be affected by polluted sources. There should be preventive measures or corrective action in place to mitigate the risk of pollution.

4.2.3 The area selected should be in an area protected from strong winds and waves. Strong waves may cause the cage to be distorted or damaged and result in injury to the fish or the fish escaping to the water body. Areas that are close to boat, ferry or ship routes should be avoided.

4.2.4 Areas with phytoplankton or microalgae blooms should be avoided. Phytoplankton or microalgae blooms in areas with high light and nutrient level and warm temperature. Phytoplankton or microalgae may lower the level of dissolved oxygen and some algae species may be harmful to the marine fish. List of algae that are harmful to marine fish is in Annex B.

4.2.5 The criteria to be considered for the site selection includes the topographical criteria, physical criteria and chemical or water parameter criteria. Details on these criteria are as per Table 1.

Table 1. Criteria for consideration for site selection of cage and pen fish farming

Criteria to be considered		Ideal value/range
Topography	Height of waves	< 1 m
	Wind speed	< 10 knots
	Water depth	> 4 m
	Seabed	Level and not pebbly
Physical	Water current	Min > 10 cm/sec Maximum < 100 cm/sec
	Total Suspended solid	< 50 mg/L
	Water temperature	27 °C - 31 °C
Chemical	**See Table 2**	

Table 2. Chemical parameter of the water (optimum value)

Parameter	Ideal/optimum value
Dissolved oxygen (mg/L)	> 5
Salinity (ppt)	15 - 34
pH	7.0 - 8.5
Ammonia (µg/L)	< 50
Nitrate (µg/L)	< 60
Nitrite (µg/L)	< 55
Phosphate (µg/L)	< 75
Chemical Oxygen Demand, COD (mg/L)	< 3
Biological Oxygen Demand, BOD (mg/L)	< 5

4.3 Site selection for pond farming

4.3.1 The area selected should have the appropriate type of land with suitable water resources, e.g. coastal and estuarine areas.

4.3.2 The suitable areas for fish culture are those with average natural ground elevations of about 1 m to 3 m above mean sea level or at least 1 m above the highest high tide level to allow drainage and harvesting.

4.3.3 The following area are not encouraged to be selected for pond farming:

a) flood-prone areas or areas without proper flood prevention measures;

b) mangrove forest reserves;

c) natural conservation areas; and

d) problematic areas such as polluted areas or areas prone to erosion.

4.3.4 The ideal or optimum parametesr of the soil for pond farming is as per Table 3.

Table 3. Recommended ideal parameters of soil for marine fish ponds

Parameter	Ideal/optimum value
Organic carbon (%)	1.5 - 2.0
pH	6.5 - 8.5
Phospohorus (mg/100 g)	6 - 12
Nitrogen (mg/100 g)	50 - 75
Ferum (mg/L)	< 0.1
Aluminium (mg/L)	< 0.02
C/N ratio	10 - 15
Soil texture	Clay or loam-based soil containing more than 50 % clay

4.3.5 Sites with sandy or silty soil should be avoided due to their porous nature that may lead to erosion, see page of water and easy infiltration of waste into the soil.

4.3.6 Where sites with suitable soil type is unattainable, appropriate action such as using plastic lining, cementing, or soil top-up may be taken.

5. Farm layout and design

5.1 General

5.1.1 The farm design and layout shall be in accordance with the requirements as recommended by the relevant competent authorities.

5.1.2 The clearing of the site shall consider conservation and preservation of the natural habitat. Buffer zones (at least 50 m to 100 m) should be maintained to minimise the effect of site operations on the environment.

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

5.1.4 The fish farm should be designed according to the characteristics of the selected site and the culture system.

5.1.5 The design and size of the cage or pen or pond should facilitate farm management and operations. Example of the design and layout of a typical farm (fish cage and fishpond) is illustrated in Annex C.

5.1.6 Factors affecting safety and hygiene should be taken into account in the design of the farm. The cage or pen or pond area should be separated from the workers' quarters and office areas.

5.2 Farm layout and design for cage farming

5.2.1 The cage for marine fish farming may be made of wood or High-Density Polyethylene (HDPE) or plastic type with floaters made of styrofoam or plastic drums. The type of cage to be used may depend on its suitability and the preference of the farmer.

5.2.2 The recommended minimum size for the cage is 3 m x 3 m x 3 m with square shape.

5.2.3 Anchors made of steel, concrete block or log may be used to tie and retain the cage at a specified location. The size and weight of the anchors shall depend on the size of the cage.

5.2.4 Fishing net made from polyethylene or nylon is recommended. Mesh size of the fishing net shall be identified and shall be suitable for the size of the cultured fish. Incorrect mesh size can cause entanglement and injury to the fish, or the fish may escape from the cage. Recommended mesh size of the fishing net shall be as in Table 4.

5.2.5 The net of the cage shall be adequately tensioned and shall be of a weight that prevents distortion. Cage-weights should be used to maintain the size and shape of the cage. Distorted cage may cause crowding, entanglement, or injury to the fish and affect its welfare. Cage-weights may be made of tin coils, concrete blocks or clay bricks. Weight of the cage-weight shall be proportional to the size of the cage.

Table 4. Recommended mesh size for the net

Mesh size	Fish size
½ inch	1 inch - 3 inch
1 inch	4 inch - 5 inch
1 ½ inch	200 g
2 inch	700 g - 800 g

5.3 Farm layout and design for pen farming

5.3.1 Pens have the same basic design concept as cage. Pens are designed as a fixed structure of net enclosure supported by a rigid framework. Net bottom of the pen is the seabed.

5.3.2 The net of the pens shall be anchored, by means of bamboo pegs, wood pole, concrete piles or steel piles. Pens can be of rectangular or square shape with nets made of knotless nylon netting material. The net shall be fixed on the seabed such as by using a rope along the seabed, or by using piled heavy rubble or concrete blocks or a net bottom may be provided. Galvanised wire mesh or chain links may also be used as barriers.

5.3.3 Sinkers such as concrete blocks, tin coil or clay brick may be used to maintain adequately tension of the net to prevent distortion.

5.3.4 The netting shall be taken above the surface to prevent the escape of fish by jumping.

5.4 Farm layout and design for pond farming

5.4.1 The fishpond should be designed according to the characteristics of the selected site and the culture system. The recommended size and design is as per Table 5.

Table 5. The recommended minimum size and design for fishpond

Type of pond	Recommended minimum size and design
Culture pond	• Size of pond: 0.07 ha - 0.5 ha • Shape: square or rectangle shape, rounded at each corner • Depth of the pond is in the range of 0.8 m - 1.8 m • Elevation: 1 m - 1.2 m • Pond bottom gradient: 10 degrees inclination towards the water outlet • Width of the bund: 2 m - 4 m • Pond water outlet: shall be higher than the perimeter discharge outlet.
Reservoir pond and treatment pond	• Recommended minimum size is: – 10 % - 15 % of the culture pond size; and – 5 % - 10 % of the sedimentation pond. • Bottom of the reservoir pond should be higher than the water inlet to the culture pond.

5.4.2 The reservoir pond and treatment pond should be constructed separately. A reservoir pond is important for the control of the pond environment and storage of water supply when water quality is inconsistent, or the supply is intermittent.

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

5.4.4 Water used in marine fish aquaculture, including brackish water aquaculture, shall be in the optimum salinity range. The water may be sourced from sea water and/or brackish water.

NOTE. Sea water or salt water is water from the sea or ocean. Normal salinity of the sea water is around 35 ppt. Brackish water is a mixture of sea water and fresh water. The salinity of brackish water is usually in the range of 5 ppt to 20 ppt.

5.4.5 Where pumps are used to get 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 best time for pumping or filling the pond is during high tide.

5.4.6 Fresh water supply shall be available to be used.

5.5 Farm layout and design for tank farming

The recommended minimum size of tank for marine fish culture is 5 m^3 to 10 m^3. Tanks can be made of concrete, fibreglass, marine plywood, metal or other hard substances. Only durable materials that are free from toxic paints or chemicals shall be used. Fibreglass is a popular material for tank construction as it is light, strong and inert to fresh and salt water. Circular tanks are very commonly used for nursery and grow out purposes.

5.6 Culture systems

There are three categories of culture systems commonly practiced for marine fish farming, i.e. extensive, semi-intensive, and intensive. The culture systems applied may depend on stocking density, species of the fish cultured and is according to the farmer's requirement of its expected production.

5.7 Facilities and equipment

Marine fish farming facilities should be designed and operated in ways that prevent contamination of the fish by workers, sewage/toilets, domestic animals, machinery oil/fuel, and other possible sources. The facilities should include biosecurity and sanitary facilities.

The farm shall have the suitable equipment for farm management and operation. Cage or pen farm shall have a boat facility for transportation to the mainland.

5.8 Utilities

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

6. Farm preparation and farm management

6.1 Cage preparation

6.1.1 The cage structure shall be ensured to be stable with proper anchor.

6.1.2 The net of the cage shall be clean and disinfected with no torn part. Disinfection should be conducted to a satisfactory level to inactivate pathogens posing significant risk.

6.1.3 Cage-weights shall be positioned at each corner of the cage to maintain the cage shape.

6.1.4 Water parameter shall be ensured to be optimum and free from pollution.

6.1.5 Cage maintenance shall be done regularly. This shall include routine inspection to detect tears in the netting and to remove debris and fouling organism, periodic rotation of floats, repainting of wooden frame, and changing of nets every 2 months or as often as needed to protect from fouling organisms. Nets shall be cleaned, dried and repaired.

6.2 Pen preparation

6.2.1 The structure of the pen shall be of adequate strength and shall be in good condition.

6.2.2 Nets shall be inspected to detect any parts that are torn and to ensure that they are in a good condition with adequate tensioning.

6.2.3 Water parameters shall be monitored to ensure that the water quality is at the optimum level and free from pollution

6.3 Pond preparation

6.3.1 The base of the pond shall be left to dry naturally. This is to ensure that the pond is free from disease or pest. The pond shall be cleaned of any leftover from the previous cycle (e.g. leftover feed, carcass, fish faeces etc).

6.3.2 The pond can be filled either through the use of a pump or by the force of gravity. Where a pump is used, the pump capacity and inlet canal should be large enough to allow the ponds or the reservoir to be filled within 4 h to 6 h.

6.3.3 The time needed to fill the pond or reservoir should be determined to ensure that the process can be conducted efficiently and in a timely manner. The time needed to fill in the pond can be calculated by measuring the flow rate of the water per unit time, l/s.

Example: the pump filled in 100 l of water in 30 s

The flow rate of the water:

100 l/30 s X 60 s/1min = 200 l/min

6.3.4 A filter of 1000 µm mesh size should be installed at the inlet canal before the inlet to the pumps to prevent clogging at the inlets**.**

6.3.5 The volume of water needed per pond shall be determined prior to filing the water into the pond. The volume of the water need shall be in accordance to the area of the pond which can be calculated as follows:

Square or rectangle shaped pond: (length x width x depth) of the pond.

6.3.6 The liming process should be conducted after the pond has been cleaned and drained. Liming is the process carried out to reduce acidity of the pond soil which has the impact of improving fertility and oxygen level.

6.3.7 The lime should be sown after the pond is dry. The type of lime chosen depends on the pH value of the soil. Agricultural lime, $CaCO_3$ should be used if the pH value of soil is neutral or at pH 7. Hydrated lime, Ca $(OH)_2$ should be used when the pH value is less than 5.

6.3.8 The amount of lime used shall be carefully calculated to avoid inducing excessive highwater pH which may increase ammonia toxicity and result in the mortality of the fish. The amount of lime used should be in accordance with Table 6.

Table 6. Recommended amount of lime for liming

pH of the soil	Quantity of the lime (MT/ha)	
	Agricultural lime, $CaCO_3$	Hydrated lime, $Ca(OH)_2$
5.0 - 6.0	2.0 - 3.0	1.0 - 1.5
< 5.0	3.0 - 5.0	1.5 - 2.5

6.3.9 During the process, lime should be sown evenly to cover the entire surface of the pond from the bottom of the pond until the top of the pond bund.

6.3.10 After liming, the pond should be filled to its maximum depth with the water passing through a filter with fine mesh (24 per square inch) to prevent the predators and pest from entering the pond.

6.3.11 The liming process is considered to have been completed when the average pH value of water in the pond is in the range of 7.5 to 8.5 with a daily variation of the pH value not exceeding 0.5. If this reading is not achieved, agricultural lime, dolomite or hydrated lime should be added at 100 kg/ha/day to achieve the required pH value.

6.3.12 Tea seed cake (dried and pressed seeds of *Camellia sp*.) should be added to eliminate unwanted or wild fish and other predators such as loach, snail, tadpoles and some aquatic insects. Tea seed cake is effective at 75 ppm to 100 ppm (5 ppm to 10 ppm saponin content). Before application, the tea seed cake should be soaked overnight and then broadcast over the pond surface.

6.3.13 To ensure that there is adequate aeration to achieve the oxygen requirement and to facilitate the cleaning process paddle wheels should be used. The capacity of the paddle wheels used is based on the fish biomass in the range of 250 kg/hp to 350 kg/hp. The paddle wheels should be arranged in such a way to ensure that the pond sludge settles in the middle of the pond. A typical paddle wheel arrangement to achieve this result is shown in Figure 1.

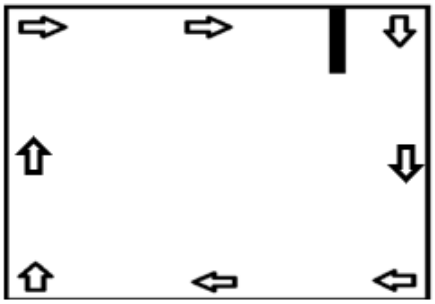

Figure 1. Example of paddle wheel arrangement

6.3.14 Pond productivity should be assessed to ensure that it is at the optimum level. Pond productivity refers to the biological productivity of the pond. Productivity of the pond depends on overall management of the pond and other factors such as good water management, fingerling management, feed management, fish health management, and equipment management. To increase the pond productivity, processes such as fertilisation and water quality conditioning should be carried out.

6.3.15 When necessary for certain species, the pond should be fertilised to stimulate plankton growth. Plankton is needed to shade the bottom of the pond and prevent the growth of algae. Plankton also helps in composting waste such as phosphorus and nitrogen impurities.

6.3.16 Chemical fertiliser of 46 % of Nitrogen (46 % N) or mixed fertiliser such as ammonium phosphate (16:20:0) or N:P:K fertiliser (16:16:16) should be used at the rate of 2 kg/ha to 3 kg/ha.

6.3.17 Chemical fertiliser shall be soaked and dissolved in water before being sown on the surface of the water**.**

6.3.18 Between 3 days to 7 days after the fertilisation process, the water in the pond should turn greenish. If the water does not turn green, the process of fertilisation should be repeated. To maintain plankton growth in the fishponds, more fertiliser should be sown over time at the rate of 5 % to 10 % of the initial rate.

6.3.19 To ensure optimum water quality, water quality conditioning may be done by using permitted probiotics and molasses. The use of probiotics shall follow the supplier’s instructions.

6.4 Tank preparation

6.4.1 The tank shall be disinfected before use by soaking it in minimum of 200 ppm free chlorine for 24 h. The tank then shall be rinsed with clean water until there is no chlorine scent.

6.4.2 The tank shall then be filled with clean sea water or brackish water. The water supply and drainage in the tanks should be organised in such a way as to create a vortex that will sweep most of the detritus and other waste material out of the system.

6.4.3 To ensure that there is adequate aeration to achieve the oxygen requirement, the tank shall be equipped with aeration system.

6.5 Fingerling preparation and culture management

6.5.1 The farm operator should use healthy fingerling of good quality from reliable sources that have been verified by competent authorities.

6.5.2 The stocking of fingerling shall be based on age, size and density according to the production and sales plan.

6.5.3 The recommended size of fingerling, stocking density according to species and culture systems and culture type is as per Table 7.

Table 7. Recommended size and stocking density of fingerling

Family	Recommended culture type [a]	Recommended culture system	Size for fingerling (g)	Initial stocking density[b] (kg/m^3)	Estimation of final harvest (kg/m^3)
Chanidae (e.g: Milkfish)	Cage	Semi-intensive	10	0.2 - 0.5 (≈20 - 50 pcs/m^3)	< 16
		Intensive	10	0.5 - 0.7 (≈50 - 70 pcs/m^3)	> 16
	Pond	Semi-intensive	2	0.025 - 0.04 (≈13 - 20 pcs/m^3)	< 7
		Intensive	2	0.05 - 0.07 (≈25 - 35 pcs/m^3)	> 7
Latidae (e.g: Sea bass)	Cage	Semi-intensive	15	0.4 - 0.5 (≈20 - 30 pcs/m^3)	< 17
		Intensive	15	0.5 - 0.7 (≈30 - 45 pcs/m^3)	> 17
	Pond	Semi-intensive	10	0.03 - 0.05 (≈3 - 5 pcs/m^3)	< 4
		Intensive	10	0.05 - 0.1 (≈5 - 10 pcs/m^3)	> 4

Table 7. Recommended size and stocking density of fingerling *(continued)*

Family	Recommended culture type [a]	Recommended culture system	Size for fingerling (g)	Initial stocking density[b] (kg/m^3)	Estimation of final harvest (kg/m^3)
Serranidae (e.g: Grouper)	Cage	Semi-intensive	25	0.7 - 1.0 (≈28 - 40 pcs/m^3)	< 25
		Intensive	25	1.0 - 1.5 (≈48 - 60 pcs/m^3)	> 25
	Pond	Semi-intensive	10	0.03 - 0.05 (≈3 - 5 pcs/m^3)	< 4
		Intensive	10	0.05 - 0.1 (≈5 - 10 pcs/m^3)	> 4
Carangidae (e.g: Golden Trevally)	Cage	Semi-intensive	25	0.7 - 1.0 (≈28 - 40 pcs/m^3)	< 25
		Intensive	25	1.0 - 1.5 (≈48 - 60 pcs/m^3)	> 25
Lutjanidae (e.g: Red snaper)	Cage	Semi-intensive	25	0.7 - 1.0 (≈28 - 40 pcs/m^3)	< 25
		Intensive	25	1.0 - 1.5 (≈48 - 60 pcs/m^3)	> 25
Stromatidae (e.g: Silver pomfret)	Cage	Semi-intensive	2	0.2 - 0.3 (≈10 - 15 pcs/m^3)	< 48
		Intensive	2	0.3 - 0.4 (≈15 - 20 pcs/m^3)	> 48
Polinemidae (e.g: Thredfin)	Cage	Semi-intensive	25	0.7 - 1.0 (≈28 - 40 pcs/m^3)	< 25
		Intensive	25	1.0 - 1.5 (≈48 - 60 pcs/m^3)	> 25

[a] The initial stocking density is calculated based on cage size 6 m x 6 m x 3 m and pond size 1 ha x 2 m (depth)

6.5.4 Only single species of disease-free fish 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 traceability document shall be provided with the species of stocking marine fish.

6.5.5 The fingerling shall be allowed to acclimatise before stocking, for example by floating the plastic bag in the culture system for 10 min to 20 min for the fish to adjust to the surrounding water temperature. The fish shall be stocked during soft sunlight.

6.5.6 Stress tests may be conducted to determine and confirm on the quality of the fingerling. Strong and healthy fingerling will be able to survive under reasonable pressure while the weak or low-quality fingerling may die.

6.6 Feed management

6.6.1 The feed shall be free from prohibited antibiotics, banned substances, porcine and filthy materials and/or their derivatives. The feed shall not contain unsafe levels of pesticides, biological, chemical and physical contaminants and/or other adulterated substances.

6.6.2 The use of antibiotics, hormone and chemicals in feed, where necessary shall be approved by the competent authorities and their use shall be within permitted levels. Banned or unapproved anti-bacterial, veterinary drugs and/or chemicals shall not be used in any stage of fish production.

6.6.3 Aquaculture operations shall include procedures for avoiding contamination of the feed, in compliance with national regulations and/or international standards.

6.6.4 The farm operator shall use formulated feed or commercial feed that has been registered with the competent authority and properly labelled in compliance with requirements of the competent authority.

6.6.5 The feeding practice should follow the requirements as recommended by the feed manufacturers. The feeding system shall be managed efficiently by ensuring that the amount of feed used takes into account the survival rate of the fish. Appropriate feeding will result in healthy fish with low risk of disease.

6.6.6 The feed used shall be suitable for the species and age of the culture. The selection of feed used should consider the feed profile and its stability.

6.6.7 During the first 2 months, the recommended feeding rate is 10 % from the fish body weight. After the second month and onward the feeding rate is recommended at 5 % of the fish body weight. Recommended feeding rate is as per Table 8.

Table 8. Recommended feed rate and percentage of feed

Average body weight of fish (ABW), (g/*marine fish*)	Percentage of feed weight (from the marine fish' weight) (%)
< 10	10
10 - 13	6
13 - 15	5
> 15	4

6.6.8 To determine the suitable feeding rate and feeding profile. Sampling of the fish may be conducted as follows:

Weight of 20 fish = 20 kg

Weight of a fish, 20/20 = 1 kg

Number of fish in the cage/pen/pond/tank = 400

Total weight of fish = 400 x 1 = 400 kg

Weight of feed required = 5 % x 400 = 20 kg

6.6.9 The recommended feeding frequency is around 1 times to 2 times per day.

6.6.10 The recommended size for palleted feed is as Table 9.

Table 9. Recommended pellet size

Fish weight (g)	Feed pallet diameter (mm)
> 1	1
10 - 50	3
50 - 150	4
150 - 300	6 - 8

6.6.11 Feed should be stored under clean, dry and ventilated conditions within a room with a proper floor and walls avoiding high humidity and direct sunlight. Feeds should be handled and stored in such a way to prevent spoilage, mould growth and contamination.

6.6.12 Bags containing feed should be stored on 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.

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

6.7 Water management

6.7.1 The quality of the water for the culture shall be maintained within specified conditions to ensure good growth and health of the species cultured and that it is safe for human consumption. Optimum water parameter for the fish farm are as per Table 2.

6.7.2 The water quality shall be monitored and recorded throughout the culture period.

6.7.3 Appropriate action shall be determined and taken if the water quality shows a significant drop. For cage or pen culture, such action may include reducing stocking density, use of blower or partial harvest. For pond culture, probiotics may be used to improve the water quality. Molasses can be added at the rate of 10 ppm every day to control plankton growth.

6.7.4 For pond and tank culture, the water quality management shall include requirement as in 6.7.5 to 6.7.7 as below.

6.7.5 Water shall be changed at the rate of 5 cm (water level) per day to ensure the water is always clean and to remove dirt and residual waste.

6.7.6 The water that is used shall be obtained from non-polluting sources and shall be of suitable water quality parameters based on specified chemical and biological parameters for marine fish culture. The water used shall not be wastewater from any activity that may cause contamination affecting marine fish health. In case it is necessary to use such water, suitable treatment shall be carried out and the quality of the water analysed to ensure it meets the specified quality requirements before it is used.

6.7.7 Where Recirculating Aquaculture System (RAS system) is used in tanks such as in cement tanks, fibre glass tanks or polyethylene (PE) tanks, the water shall be drained into a filter system consisting of physical filters e.g., sand filters, chemical filters e.g., protein skimmer and biological filters e.g., biofilter to control the ammonia level produced as a by-product of fish protein catabolism. The water then shall pass through ozone or ultra-violet light before being recirculated into the tank.

6.8 Waste and effluent management

6.8.1 Waste and effluent from the marine fish farm shall not be discharged into the public or municipal water body without undergoing proper treatment.

6.8.2 Discharges of water, sediment and/or sludge from the farm should not cause negative environmental impacts to the surrounding area.

6.8.3 The farm shall take appropriate measures as necessary to:

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

b) dispose of dead marine fish in a hygienic manner especially after a disease outbreak.

6.8.4 In cases where diseases are detected, the wastewater shall be disinfected by applying permitted chemicals such as chlorine with a concentration of 30 mg/l and left to dissolve for at least two days before discharging in order to minimise the risk of disease spreading.

6.8.5 Cage farming may cause deposition of bottom sediment, including undesirable build-up of waste material such as uneaten food and/or metabolic waste. The farm should apply appropriate feeding technique or technology to ensure the feed quality and quantity, and feeding method does not lead to build-up of waste material. Farm should take appropriate measure to remove accumulated sediment under the cages, e.g., using a submersible pump.

6.8.6 Disposal of septic waste in cage or pen farm shall be conducted in a hygienic manner according to the requirements of the competent authority. Disposal of septic waste shall be recorded, and the record shall be retained.

6.8.7 Pond and tank farms should take appropriate measure to collect sludge from the culture ponds and disposal treatment ponds in order not to allow the sludge contaminating the outside environment. Farm should take appropriate measure to avoid salinisation of soil and/or freshwater resources.

6.8.8 Effluent from the pond or tank farm shall be treated appropriately in accordance with the *Environmental Quality (Industrial Effluents) Regulations 2009* and comply with the parameter for marine water quality index as in Annex D.

6.8.9 Treatment technologies for marine fishpond effluent can range from the conventional flow-through settlement pond design to recirculation and bioremediation methods that recycle the pond water, and to the use of filtration equipment to reduce particulate matter in the effluent.

6.8.10 A suitable method for effluent treatment in accordance with the needs of the farm shall be selected.

6.9 Chemical storage

6.9.1 All chemical compounds shall be stored in a secure lockable store and supervised by trained and authorised personnel and in accordance with the manufacturer's instructions or as recommended by the competent authority and, where appropriate, be physically separated. Evaluation of compliance shall include a visual assessment of the chemical store.

6.9.2 The manufacturer's product specification and the Material Safety Data Sheet (MSDS) shall be made available for all chemical compounds.

6.10 Disease control

6.10.1 Cultured marine fish shall be regularly monitored, and monitoring results recorded for early detection of health problems. In the case of occurrence of an outbreak, the farm operator shall immediately notify and seek advice from the relevant competent authority.

See Annex E for the common diseases listed by the World Organisation for Animal Health (WOAH) and the clinical signs or symptoms of the common diseases of marine fish species.

6.10.2 Prohibited antibiotics, chemicals and banned substances shall not be used for disease treatment. The farm operator shall only use registered veterinary drugs and chemicals. If necessary, treatment shall follow the prescription or as advised by the competent authority.

6.10.3 Each culture pond and tank shall be left vacant for a period after each harvest (fallowing period) to reduce the risk of accumulation of disease vectors.

6.10.4 If an infection of a specified disease is detected, the disease shall be controlled to prevent the spread from one cage/pond to another or to neighbouring farms or to natural water sources. The relevant competent authorities shall be informed immediately so that nearby farms can be alerted.

6.10.5 Infected and dead marine fish shall be disposed of by burying or burning in a suitable area and shall be carried out in a sanitary manner to avoid cross-contamination.

6.11 Pest and predator control

6.11.1 The farm operator shall control the risk of pest and predator infestation in the marine fish farm. The location of all pest and predator control measures shall be identified on a layout plan.

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

6.11.3 To prevent pest and predators from entering the cage/pond, the area around the cage/pond shall be clean. Cage/pond inspection should be carried out from time to time.

6.12 Biosecurity and sanitary measures

6.12.1 Farm operators are encouraged to provide physical bio-security measures (e.g., traps, fencing, bird nets, etc.) which are effective to prevent any disease outbreak.

6.12.2 The farms shall have systems to prevent the escape of marine fish to public water bodies to prevent the spread of exotic diseases and to prevent the marine fish from encroaching on the habitat or feed sources of native marine fish or causing genetic manipulation.

6.12.3 Pets and domestic animals shall not be allowed in the culture area.

6.12.4 Sanitary facilities shall be provided that allows for disinfection at the entry or exit point of the marine fish farm including the cleaning and sanitisation of vehicles and/or person. The layout of buildings and facilities shall be arranged in an orderly manner and separated based on sections to facilitate regular cleaning and maintaining hygiene.

6.12.5 Measures shall be in place to minimise the risk of the introduction of pathogens into the farm by personnel and visitors. For example, no one shall be allowed to enter the farm for at least three days after visiting any risk area of infection or declared specified disease outbreak area of marine fish farm, hatchery, or nursery or visiting any aquatic disease laboratory.

6.12.6 The bathrooms and toilets shall be located at a suitable distance from the culture ponds to prevent the likelihood of direct contamination. Rubbish and waste shall be disposed of in a hygienic manner. For toilets on cage or pen farms, the disposal of septic waste shall be recorded, and the record shall be retained.

6.12.7 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.

6.12.8 All equipment used in the farm shall be cleaned and disinfected prior to use. Equipment shall not be moved from farm to farm.

6.12.9 Personal protective equipment (PPE), wherever applicable, shall be cleaned after every use and stored separately from contaminants. A separate storage area should be provided for clean and used PPE. Clean PPE shall be stored in such a manner that it will not cause cross contamination when used.

6.12.10 All staff entering the production area should wear personal protective clothing that is clean and uncontaminated. Where 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.

6.13 Grading

6.13.1 Grading of fish is crucial to ensure the appropriate and uniform size of cultured fish in a cage Significant difference of size may induce cannibalism among the fish.

6.13.2 Grading shall be conducted regularly. Grading shall be conducted whenever there is significant size difference in a cage or pond.

6.13.3 Grading may be conducted manually by hand or by using an automatic grading machine.

6.13.4 Minor injury or scratch on the fish body may occur during the grading process. Fish shall be treated with chemical treatment e.g., acriflavine to avoid bacterial infection that may cause disease to the fish. The use of chemical treatment shall be in accordance with instructions by competent authority.

6.14 Harvesting and post-harvest handling

6.14.1 Harvesting results in live marine fish or chilled marine fish. Harvesting may be carried out as a full harvest or a partial harvest. Harvesting and post-harvest handling shall be carried out such that the food safety, quality and the value of the marine fish produce is maintained.

6.14.2 Marine fish shall be transported without undue delay. Refer to Clause 11 for requirements relating to the transportation of marine fish.

6.14.3 Minimising stress to the marine fish produce immediately prior to transportation is necessary to prevent welfare problems and to maintain quality of the marine fish produce.

6.14.4 It is recommended that harvesting should be carried out in the morning or in the evening.

6.14.5 Water and ice used during harvesting should be of quality suitable to ensure that the marine fish produce is safe for human consumption.

6.14.6 Appropriate techniques for harvesting and post-harvest handling should be applied to minimise contamination and physical damage.

6.14.7 Marine fish should be harvested at the right stage of commercial size and should be of good quality, i.e., free from any defects or sign of decomposition. The workers shall be trained on the capability in selecting marine fish that are at the right stage of maturity. The best way of assessing the freshness or spoilage of marine fish is by using organoleptic evaluation techniques.

7. Animal health and welfare

7.1 Marine fish farming should be conducted in a manner that assures the health and welfare of farmed marine fish, by optimising health, minimising stress, reducing marine fish disease risks and maintaining a healthy culture environment at all phases of the production cycle.

7.2 Movement of live marine fish and marine fish products should take place in accordance with the relevant provisions in the WOAH Aquatic Animal Health Code to prevent introduction or transfer of disease and infectious agents pathogenic to marine fish while avoiding unwarranted sanitary measures.

7.3 Good feeding, fertilisation, water management and stocking practices should be performed to create a sound culture environment and minimise stress of cultured marine fish.

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

7.5 Routine monitoring of marine fish health should be performed, and records of health and corrective actions should be maintained.

7.6 In the case of occurrence of an outbreak of any disease of marine fish, the farm shall be prepared with measures to effectively control, prevent and respond to the incident. The responsible persons and procedures shall be clearly determined to prevent spread of the disease within the farm and to the outside. For instance, if a disease is detected, the farm 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.

8. Transboundary

8.1 Aquatic animal health management programmes and movement of aquatic animal 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 animals while avoiding unwarranted sanitary measures.

8.2 Farm operators shall seek an approval from competent authorities to import and culture any alien species and genetically modified organism (GMO). All alien species and GMO shall be cultured under closed aquaculture systems.

8.3 Disposal of any alien and GMO species, shall be approved by the relevant competent authorities.

9. Worker’s safety, health and welfare

9.1 Workers (including foreign migrant workers) shall be treated responsibly and in accordance with 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 at the farm level shall be in good health condition and receive basic training in hygiene requirements.

9.6 Safe farm work conditions shall be ensured at all times in line with the *Occupational Safety and Health Act 1994* and relevant ILO conventions.

9.7 Marine fish farm 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 farm.

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

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

9.11 Farm operators shall be provided with basic amenities for on-site living in compliance with national regulations and local laws.

10. Personal hygiene

10.1 All personnel involved in the production activities shall have relevant knowledge on practices for a disease-free marine fish production such as proper cleaning methods, disinfection of tools and working places, methods for waste disposal, methods for primary marine fish health examination and water quality testing methods.

10.2 The marine fish shall be handled under hygienic conditions in accordance with the *Food Hygiene Regulations 2009*.

10.3 The minimum personal hygiene and health requirements are as specified below.

a) Footwear shall be changed before entering the workplace.

b) Hands and feet shall be cleaned before and after work.

c) The workers shall not have any contagious diseases or infected wounds that may infect or contaminate the marine fish.

10.4 Details on personal hygiene and health requirements are described in Annex F.

11. Transportation of marine fish

11.1 Transportation of marine fish from cage to land shall be carried out using boats practising hygiene on board and that are registered with the relevant competent authority.

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

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

11.4 It is also essential for the farm operator to check with the cargo carrier for any requirements such as size, weight, selection of packing materials, etc.

11.5 During transportation of marine fish, the following should be considered:

a) the temperature of the product before loading and during transportation should comply with the specific product standard;

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

c) product arrangement during loading should ensure good air flow between product, wall, floor and roof panel; and

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

11.6 In the case of live marine fish, the important factors of cold temperature and aeration to ensure adequate dissolved oxygen supply shall be considered.

12. Traceability

The harvested fish shall be traceable to the farm where it was originally produced. All data related to marine fish produce should be recorded, maintained, and made accessible to the relevant authorities, if required.

13. Record keeping

13.1 Records shall be maintained on the quantities and origin of inputs. Types of records that should be maintained include the following:

a) records of pond preparation and treatment;

b) records of water management;

c) records of fry management;

d) records of marine fish management;

e) records of feed management;

f) records of pond performance;

g) records of employee;

h) record of use of drugs and chemicals; and

i) record of harvesting.

13.2 All records shall be kept up to date for a minimum of two years unless stipulated by any specific legislation. Record keeping system shall be established in which all the essential elements are captured. The records shall be accessible and monitored.

13.3 Example of farm management records and feeding records is specified in Annex G.

14. Training

14.1 Training shall be given to all workers on good aquaculture practices including aquatic animal health and welfare management as well as sustainable aquaculture.

14.2 Workers should be trained in good hygienic practices to ensure that they are aware of their roles and responsibilities in protecting aquaculture products from contamination and deterioration.

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

15. Social responsibility

15.1 Marine fish farming should be conducted in a socially responsible manner which does not jeopardise the livelihood of marine fish 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. Socio-economic aspects which can enhance benefits and equity in local communities and alleviate poverty and promote food security should be considered at all stages of marine fish farming planning and operation.

15.2 Farm operators shall ensure rights on public land and water use for local communities in accordance with the requirements of the competent authorities.

15.3 Marine fish farming should have mechanisms in place for communication and to build engagement with the local community and to take positive actions to respond to complaints.

Annex A
(informative)

Details of culture system according to Aquaculture Production Intensity Scale (APIS)

A.1 The culture system is defined based on the production functions of the aquaculture systems as in Tables A.1 and A.2.

Table A.1 Aquaculture Production Intensity Scale (APIS) and its levels.

APIS		Functions involved	Descriptions
0	**Extensive**	Only the output functions harvest and at least one design solution (placement or structural) of a production function.	Extensive system can use structural or environmental (including placement) designs to solve one or more of treatment functions
1		The output function harvest and at least one of the input functions or output function of preventing escapes. No treatment functions.	
2		At least stocking, and either feeding or fertilising and harvest, other inputs than providing light are optional along with output function of preventing escapes. No treatment functions.	
3	**Semi-intensive**	The input function of stocking, and either feeding or fertilising and the output function of harvesting. The other input and output functions are optional. These systems have at least one treatment function.	Semi-intensive system can use structural or environmental (including placement) designs to solve one or more of treatment functions
4		The input function of stocking, and either feeding or fertilising and the output function of harvesting. These systems have at least one of the treatment functions of controlling DO and CO_2, controlling organic matter, controlling nitrogen compounds, and controlling solids. The other functions are optional.	
5	**Intensive**	The input functions of supplying water, stocking and feeding, the treatment functions of controlling DO and CO_2, controlling organic matter, ‘controlling nitrogen compounds and controlling solids and the output function of harvesting. All other functions are optional.	Intensive systems mostly solve treatment functions explicitly, not through design only.
6		The input functions of supplying water, stocking and feeding, the treatment functions of controlling DO and CO_2, controlling organic matter, controlling nitrogen compounds and controlling solids and the output function of harvesting. At least one of the other output functions is used. All other functions are optional.	
7		The input functions of supplying water, stocking and feeding, use all of the treatment functions and the output function of harvesting. At least one of the other output functions is used. All other functions are optional.	

Table A.2 Mapping of functions to the APIS level

APIS	INPUT FUNCTIONS					TREATMENT FUNCTIONS										OUTPUT FUNCTIONS				
	Supplying water	Stocking	Feeding	Fertilising	Providing light	Controlling temperature	Controlling solid	Controlling DO and CO_2	Controlling pH	Controlling N compound	Controlling matter	Controlling P compound	Controlling metal	Preventing disease	Controlling disease outbreak	Harvesting	Process effluent	Process solid waste	Controlling GHG emission	Preventing escapees
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-
1	①	①	①	①	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	①
2	O	✓	①	①	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	O
3	O	✓	①	①	O	②	②	②	②	②	②	②	②	②	②	✓	O	O	O	O
4	O	✓	①	①	O	O	②	②	O	②	②	O	O	O	O	✓	O	O	O	O
5	✓	✓	✓	O	O	O	✓	✓	O	✓	✓	O	O	O	O	✓	O	O	O	O
6	✓	✓	✓	O	O	O	✓	✓	O	✓	✓	O	O	O	O	✓	①	①	①	①
7	✓	✓	✓	O	O	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	①	①	①	①

LEGEND:

"-" → Not practiced

"✓ " → Required

"①" → To have at least one from the input functions or the output function

"②" → To have at least one from the treatment functions

"O" → Optional

Source of Table A.1 and A.2: Article A Definition of Aquaculture Intensity Based on Production Functions - The Aquaculture Production Intensity Scale (APIS); Guðmundur Valur Oddsson

Annex B
(informative)

List of algae that are harmful to marine fish

B.1 Standard references of harmful algae or phytoplankton species known or suspected of causing fish losses in mariculture and recommended action concentrations as per Table B.1

Table B.1 List of algae or phytoplankton that are harmful to marine fish and recommended action concentrations

Harmful algae category and species	Action level to intensify management	Action level to initiate mitigation
Diatoms and mixtures		
Chaetoceros concavicornis, C. *convolutus and other subgenus Phaeoceros, possibly* C. *danicus*	> 2 - 5 cells ml^{-1}	> 5 cells ml^{-1}
Leptocylindrus minimus	1,000 - 10,000 cells ml^{-1}	> 10,000 cells ml^{-1}
Other harmful diatoms including *Chaetoceros* subgenus Hyalochaete, and in some cases *Corethron criophilum, Skeletonema costatum, Thalassiosira spp*	> 50,000 - 100,000 cells ml^{-1}, depending on sensitivity of fish and life stage	> 100,000 cells ml^{-1}, especially if juvenile fish reared
Other diatom and dinoflagellate mixtures	> 40,000 - 80,000 cells ml^{-1}, if > 50 % dinoflaqellates	> 80,000 cells ml^{-1}, if > 50 % dinoflagellates
Alexandrium tamarense	Unknown; acute mortality to farmed fish not well documented and may not occur; mortality and potential food web toxin accumulation for wild fish	
Ceratium fusus	Unknown; gill irritation, poorly understood, affects oyster larvae and shrimp	
Cochlodinium spp. *C. polykrikoides*	300 - 1,000 cells ml^{-1}, aeration induces lethality	1,000 cells ml^{-1}
Gymnodinium breve (*Karenia brevis) [Ptychodiscus brevis*]	5 - 10 cells ml^{-1}, sometimes co-occurs with G. *mikimotoi*	> 10 - 25 cells ml^{-1}

Table B.1 List of algae or phytoplankton that are harmful to marine fish and recommended action concentrations *(continued)*

Harmful algae category and species	Action level to intensify management	Action level to initiate mitigation
Diatoms and mixtures		
Karenia digitata	Unknown, order of magnitude estimates possible	
Gymnodinium mikimotoi (Karenia mikimotoi)	1,000 - 3,000 cells ml^{-1}	> 3 000 cells ml^{1}
Gyrodinium aureolum (Karenia mikimotoi	500 - 2,000 cells ml^{-1}	> 2 000 cells ml^{-1}
Noctiluca scintillans	Un-ionised ammonia depending on pH and temperature	
Prymnesiophyte flagellates		
Chrysochromulina polylepis, C. leadbeateri	Unknown; causes gill damage and osmoregulatory problems, threshold of damage not defined	
Phaeocystis pouchetii	Unknown; irritant substances and the alga's mucus can clog gills	
Prymnesium parvum, P. pate/fiferum	Unknown; toxins cause tissue, blood cell and neurological damage	
Raphidophyte flagellate		
*Chattonella antiqua (*possibly *C. marina)*	1 - 50 cells ml^{-1}	Conflicting data: 50 - 500,000 cells ml^{-1}, may be dependent on fish species, size, etc.
Heterosigma akashiwo [Heterosigma carterae]	> 50 cells ml^{-1}, less if very calm and warm weather	Variable to nontoxic, some cases, in others > 750 - 1,000 cells ml^{-1}
Silicoflagellates		
Dictyocha speculum [Oistephanus speculum]	Unknown; siliceous skeleton or naked stage may irritate gills causing mucus production, oedema and hyperplasia and probable reduced oxygen and carbon dioxide exchange	

Source: Analysis report by Fisheries Biosecurity Centre Kuantan, Department of Fisheries Malaysia

Annex C
(informative)

Typical design and layout of a marine fish farm (cage and pond)

Figure C.1 Layout plan of marine fish farm (pond)

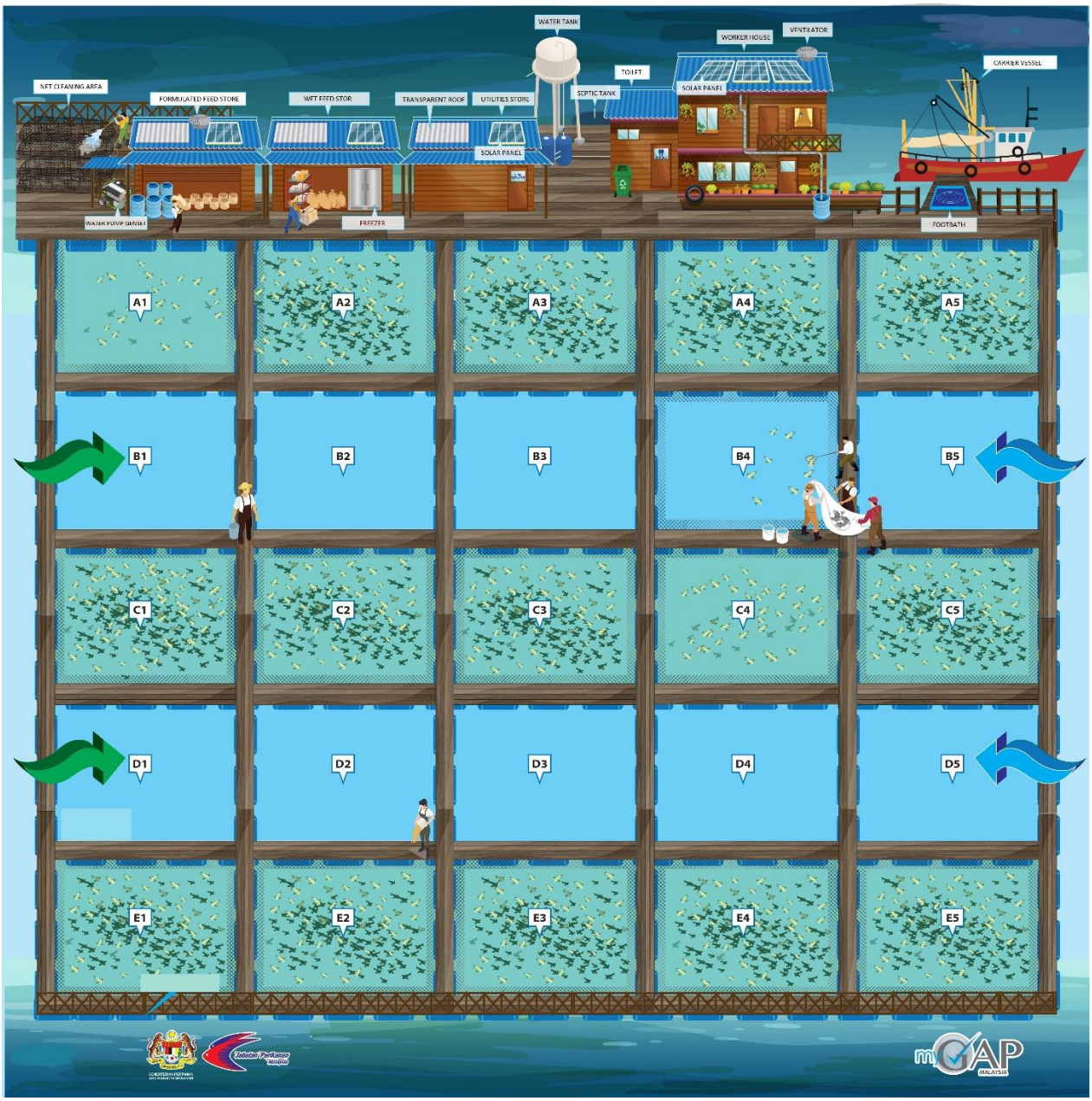

Figure C.2 Layout plan of marine fish farm (cage)

Annex D
(informative)

Parameters for marine water quality index

D.1 The parameter for marine fish farm effluent before releasing to the marine water is as specified in Table D.1.

Table D.1 Parameters for marine 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.

Annex E
(normative)

Common diseases of marine fish as listed by WOAH Aquatic Animals Health Code

E.1 The diseases in this annex have been assessed in accordance with WOAH list of aquatic animal diseases. The following diseases of fish are listed by the WOAH:

a) Epizootic Haematopoietic Necrosis Virus, EHNV.

b) Gyrodactylosis (*Gyrodactylus salaris*).

c) Viral Haemorrhagic septicaemia.

d) Infectious Haematopoietic Necrosis Virus, IHNV.

e) Red Sea Bream Iridoviral Disease.

f) Salmonid alphavirus.

g) HRP-deleted or HPR0 infectious salmon anaemia virus.

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

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

Disease	Clinical sign
Epizootic Haematopoietic Necrosis	The clinical signs are nonspecific. In perch, sudden death is the most common sign. Darkening of the body surface, ataxia, lethargy and erythema around the nostrils and brain region have also been seen. Haemorrhages may occur in the gills and at the base of the fins.
Gyrodactylosis (*Gyrodactylus salaris*)	Usually there are no clinical signs in fish with one or up to a few tens of parasite specimens. In the early disease phase, increased flashing (fish scratch their skin on the substrate) is typical. Later, fish may become greyish because of increased mucus production and the fins may be eroded. Diseased fish are lethargic and are usually found in slower-moving water.
Infectious Haematopoietic Necrosis	Clinical signs of infection with IHNV include abdominal distension, bulging of the eyes, skin darkening, abnormal behavior, anemia, and fading of the gills. Infected fish commonly hemorrhage in several areas - the mouth and behind the head, the pectoral fins, muscles near the anus, and (in fry) the yolk sac. Diseased fish weaken eventually floating “belly-up” on the surface of the water.

Table E.1 Clinical signs or symptoms of the disease listed by WOAH *(continued)*

Disease	Clinical sign
Red Sea Bream Iridoviral Disease	Affected fish become lethargic, exhibit severe anaemia, petechiae in the gills, and enlargement of the spleen. Diseased fish swim inactively and show abnormal and conspicuous respiratory exercises caused by anaemia.
Salmonid alphavirus	A sudden drop in appetite may be observed 1 to 2 weeks before the detection of elevated mortality. Clinically diseased fish may be observed swimming slowly at the water surface. In some cases, extremely weak («sleeping») fish can be found at the bottom of tanks or in net-cages. An increased number of faecal casts may also be observed. However, it is important to note that clinical signs are not pathognomonic. Careful investigation of any dead, moribund or abnormally behaving fish is necessary to determine involvement of SAV and rule out other pathogenic agents. Initially, nutritional status is usually normal, but in the months after an outbreak or in the later stages of disease, long slender fish with poor body condition are typically observed.
HRP-deleted or HPR0 infectious salmon anaemia virus	The most prominent external signs of infection with HPR-deleted ISAV are pale gills (except in the case of blood stasis in the gills), exophthalmia, distended abdomen, blood in the anterior eye chamber, and sometimes skin haemorrhages especially of the abdomen, as well as scale pocket oedema. Generally, Atlantic salmon naturally infected with HPR-deleted ISAV appear lethargic and may keep close to the wall of the net pen. Affected fish are generally in good condition, but diseased fish have no feed in the digestive tract.
Viral Haemorrhagic	The occurrence of the following signs should lead to extended clinical examination for VHS: rapid onset of mortality, lethargy, darkening of the skin, exophthalmia, anaemia (pale gills), haemorrhages at the base of the fins, gills, eyes and skin, abnormal swimming such as flashing and spiralling, and a distended abdomen due to oedema in the peritoneal cavity. The nervous form of the disease is characterised by severe abnormal swimming behaviour, such as constant flashing and spiralling, because of the tropism of the virus for the brain. Unlike fish with bacterial septicaemia, VHS-infected fish will tend not to escape when being netted.

Annex F
(normative)

Personnel hygiene and health requirements

F.1 General

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

F.2 Medical examination

Top management shall ensure that persons involved in harvesting and post-harvest handling of marine finfish should have a medical examination prior to their employment. Medical examination of these workers should be carried out at other times when clinically or epidemiologically indicated. Person involved in harvesting and post-harvest handling of marine finfish are considered as food handlers and shall be vaccinated by a registered medical practitioner.

F.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 likely to be transmitted through the harvested fish or while afflicted with infected wounds, skin infections, sores or with diarrhoea, is permitted to work in any post-harvest handling area in any capacity in which there is any likelihood of such a person directly or indirectly contaminating the harvested fish with pathogenic microorganisms. Any person so affected should immediately report to the management that he is ill.

F.4 Hygiene training

Top management shall arrange for adequate and continuous training to all personnel involved in harvesting and post-harvest handling of marine finfish on the hygienic handling and in personal hygiene so that they understand the precautions necessary to prevent contamination of food.

F.5 Injuries

Any person who has a cut or wound shall not continue to handle harvesting and post-harvest of fish or be in contact with harvested fish 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.

F.6 Washing of hands

Every person, while on duty in the harvesting and post-harvest handling 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 should be displayed. There should be adequate supervision to ensure compliance with this requirement.

F.7 Personal cleanliness

Every person engaged in the harvesting and post-harvest handling area shall maintain a high degree of personal cleanliness while on duty, and shall at all times wear suitable protective clothing, all of which articles shall be cleanable unless designed to be disposed-off and shall be maintained in a clean condition consistent with the nature of the work in which the person is engaged. Aprons and similar items shall not be washed on the floor. Personnel shall not wear any jewellery or watches when engaged in post-harvest handling.

F.8 Personal behaviour

Any behaviour which could result in contamination of the harvested fish such as, use of tobacco, chewing gum etc. or unhygienic practices such as spitting shall be prohibited in the post-harvest handling areas.

F.9 Gloves

Gloves, if used in the post-harvest handling, 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.

F.10 Visitors

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

Annex G
(informative)

Example of fish culture management record to be kept

G.1 The following items should be recorded as part of the marine fish culture management records:

a) farming month;

b) number of cage/ponds;

c) the area of cage/pond;

d) species of culture;

e) date of stocking;

f) number of fingerling; and

g) source of fingerling.

G.2 Example of record keeping and maintenance for marine fish culture is as specified in Table F.1.

Table G.1 Example of record keeping and maintenance for marine fish culture management record

Date	Age of the culture	Feed (Type and weight in kg)				Maintenance		Average Body Weight (ABW)	Survival rate, %	Biomass	Remarks
		0600	1000	1400	1800	change	clean				

G.3 The following data should be recorded in the report

G.3.1 The date of stocking into the cage/pond. This needs to be recorded to plan for the harvesting date and to determine the actual duration of the culture until harvesting date. This could also help in planning the time for next batch of stocking into the pond.

G.3.2 The pond's number is important for the purpose traceability and to determine the cycle period of the culture for the purpose of overall operation planning of the farm.

G.3.3 The area of the pond is important in determining the rate of fry release, type of treatment needed and number of equipment that will be used.

G.3.4 Stocking date is important to determine the actual culture start date. This is important to analyse the growth rate of the culture.

G.3.5 Species of the culture need to be recorded to ensure that the management, growth monitoring, treatment and disease control is suitable with the species cultured.

G.3.6 Number of fry released into the pond needs to be recorded to analyse the rate of fry release, survival rate, feeding rate and harvesting rate.

G.3.7 The source of fry cultured is an important record as it is needed for traceability and to analyse the quality of source.

G.3.8 Date of culture start until harvesting date is important to analyse culture period, to determine the growth rate, feeding rate and to plan for treatment or harvesting.

G.3.9 The feed used should be recorded to analyse feeding rate and type of suitable feed. It is also important to plan for the feeding rate and to analyse feed conversion ratio (FCR) after harvesting.

G.3.10 Average Body Weight (ABW) should be recorded to analyse growth rate of the culture, to plan for feeding rate, culture period and date of harvesting.

G.3.11 Mortality rate should be recorded to analyse cause of mortality and to plan for treatment of the culture.

G.3.12 Survival rate is important to be recorded to determine the number of healthy culture and to plan the number of harvests.

G.3.13 Biomass is the overall weight of the culture in the pond.

G.3.14 Remarks column in the table is to record any physical observation at the pond such as the colour of the water, any symptom of the culture, treatment planned for the culture, etc.

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