Agriculture, Fisheries and Conservation Department
Aquaculture Fisheries Division

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Good Aquaculture Practices Series 2

Environmental Management of Mariculture

漁農自然護理署
Agriculture, Fisheries and
Conservation Department

Introduction

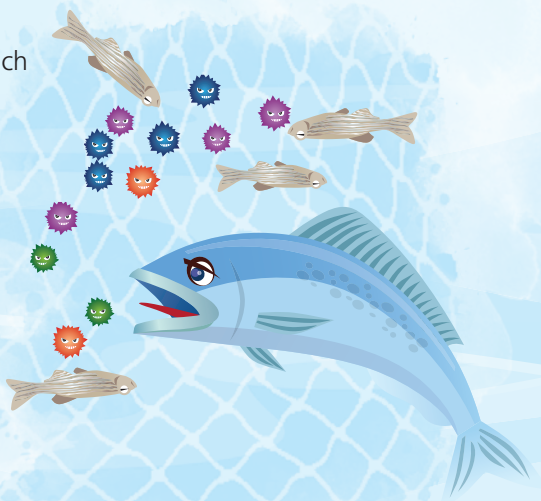
In order to ensure sustainable utilisation of fish culture zones for production of healthy and quality fish, it is necessary to maintain an optimal mariculture environment. Fish farmers must have an in-depth understanding of the impacts of fish farming activities and various natural factors on the culture environment and the cultured fish, and implement appropriate management measures to minimise the risk associated with fish diseases and deaths, as well as the pollution of the culture environment.

Good practices in environmental management of mariculture include adoption of comprehensive and proper preventive, monitoring and emergency response measures, with the primary objective of controlling the impacts of fish culturing activities on the levels of organic matter, dissolved oxygen and microorganisms etc. in the water body.

1 Importance of Maintaining an Optimal Mariculture Environment

An optimal mariculture environment is indispensable to the sustainable utilisation of fish culture zones and the production of healthy and quality fish. Understanding the impacts of fish farming activities and various natural factors on the fish culture environment and the cultured fish will be beneficial to maintaining an optimal mariculture environment.

A healthy seabed serves as an effective buffer zone, and is of crucial importance in maintaining good water quality. Mariculture activities will generate organic wastes, including feed residues, and the faeces and carcasses of cultured fish. Normally, feed remains from the rafts will be consumed by wild fish while feed residues and other organic wastes that reached the seabed will be consumed by various benthic organisms, such as crabs, snails, echinoderms and annelids, or decomposed gradually by bacteria. Besides, there is also a small amount of organic matter that will be carried away from fish culture zones by the ebb and flow of the tides or water currents.



Mismangement of a fish farm, such as overstocking, overfeeding or improper disposal of dead fish, will lead to a gradual increase in organic matter in the water body. Given that excessive organic matter may not be completely consumed by other marine organisms, and the rate of decomposition by microorganisms is limited, organic matter will accumulate on the seabed of the fish culture zone. An increasing load of organic matter on the seabed may give rise to various environmental issues, such as turbid and anoxic water body, death of benthic organisms and proliferation of microorganisms, creating a vicious cycle that increases the risk of disease infection and even mortality of the cultured fish.

Poor environmental management may adversely affect the harvest of fish farmers. If the culture environment continues to deteriorate, the water quality of the fish culture zone which fish farmers rely on for their livelihood may eventually become no longer suitable for rearing fish. Therefore, fish farmers should implement good management measures to reduce the environmental pollution caused by fish culture activities and ensure sustainable utilisation of the fish culture zone. Good management practices should be three-pronged focusing on prevention, monitoring and emergency response, so as to minimise the environmental impact of fish culture activities on the water body, including the avoidance of accumulation of excessive organic matter, reducing the proliferation of bacteria and maintaining the dissolved oxygen at an appropriate level.

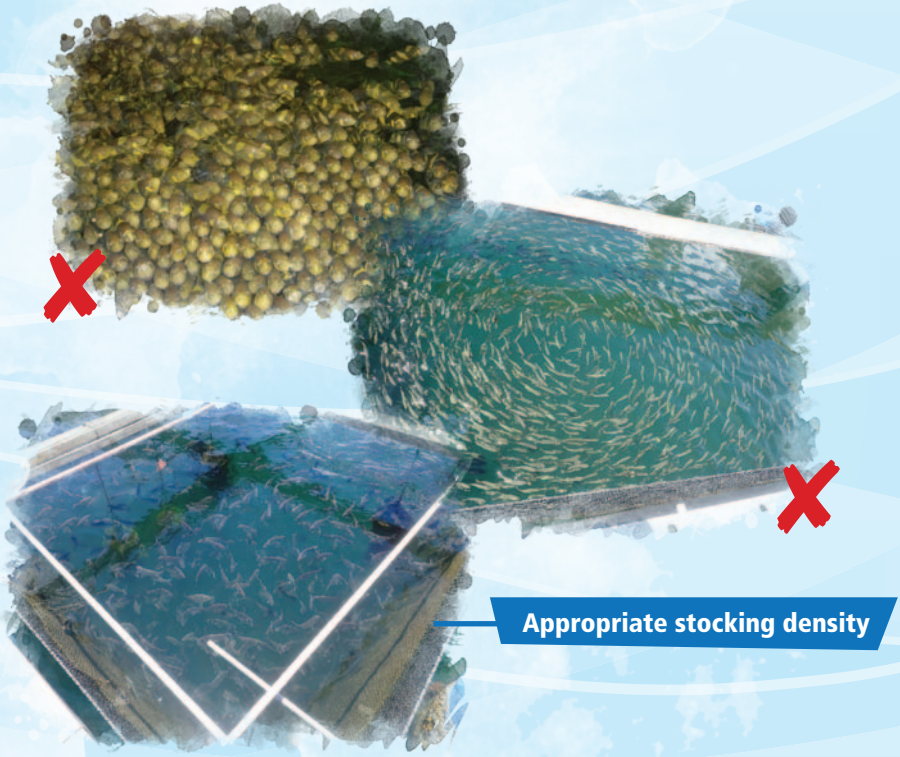
2 Good Practices in Environmental Management of Mariculture

Good practices in environmental management of mariculture should include the following ten key points:

- Maintenance of appropriate stocking density
- Regular removal of fouling organisms from fish cages
- Implementation of proper feeding management practices
- Proper disposal of carcasses of cultured fish and garbage
- Regular disinfection of culture gear
- Health quarantine for newly stocked adult fish or fry
- Isolation/ proper treatment of sick fish
- Proper use of feed additives and drugs as instructed by a veterinary surgeon
- Regular monitoring of water quality and health of cultured fish
- Maintenance of fish culture management records

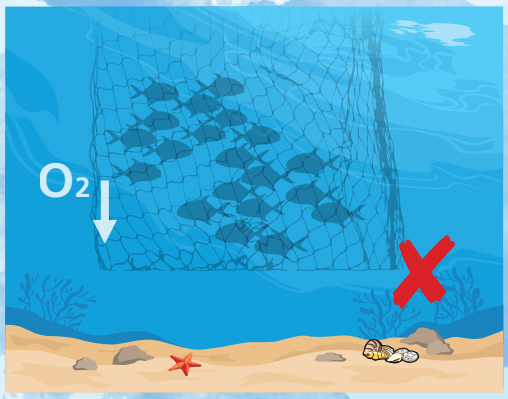
2.1 Maintenance of appropriate stocking density

As the cultured fish gradually grow up, they need more space for movement. Given the limited space in the net cages, it is necessary to adjust the number of cultured fish according to their growth stages and sizes. If the stocking density is too high, the disease resistance of cultured fish will decrease while the risk of injuries from bumping into each other and infections from bacteria, viruses or parasites will increase. Moreover, the level of dissolved oxygen in the water may not be sufficient to support the fish stock and lead to anoxia; and when the water level is too low, the water flow is insufficient or stagnant, the water body is more susceptible to anoxia. Furthermore, the excessive amount of waste produced by the cultured fish may accumulate underwater and result in growth of bacteria.



Mindful of the depth of water in fish culture zones

The depth of seawater in fish culture zones generally ranges from 10 feet to 50 feet, while the depth of fish rafts normally varies from 8 feet to 15 feet. As such, for fish culture zones located in shallow water regions, the net cages on fish rafts should not be placed too deeply in water to avoid touching the seabed. In addition, the level of dissolved oxygen in the bottom zone of the sea is relatively low. When the cultured fish are reared in a cage too close to the seabed, they may experience anoxia.

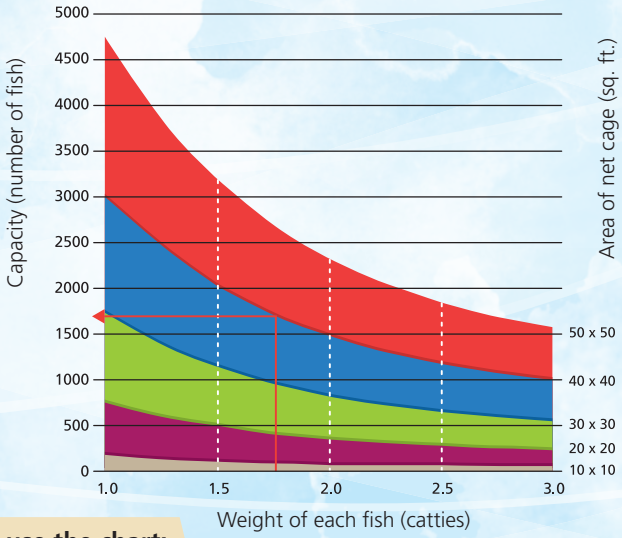


Take note of ebb and flow of tides

The water flow/water body exchange in fish culture zones mainly relies on the natural tidal movements. Tides in Hong Kong are mixed and mainly semi-diurnal, and there are normally two high tides and two low tides a day. The tidal range becomes larger during spring tides when the moon is new or full, during which the seawater exchange rate and the level of dissolved oxygen are higher. On the contrary, the tidal range is the smallest during neap tides when the moon is at its first or last quarter, during which there may be only one high tide and one low tide a day, and the seawater exchange rate and the level of dissolved oxygen are relatively lower.

Management measures

- Pay attention to the growth rate of the cultured fish and separate them into different cages regularly to reduce the stocking density.
- Growth of cultured fish varies, even among the same species. As some of them may grow faster, it is important to regularly sort and separate the fish into different cages according to their growth stage and size, in order to prevent the larger fish from preying on the smaller ones.
- Evaluate and determine the appropriate stocking density according to the "Stocking Density Reference Chart" shown in the figure below.



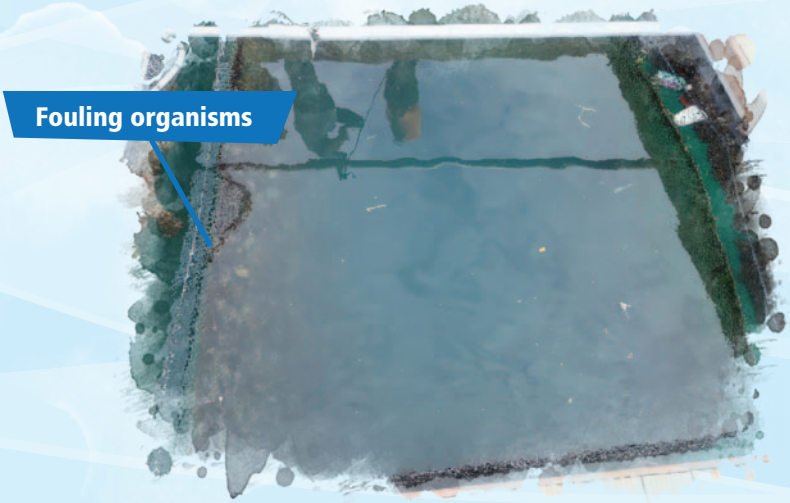
How to use the chart:

1. Estimate the weight of each fish (catties).
2. Measure the area of the net cage (normally ranging from 10 ft x 10 ft to 50 ft x 50 ft).
3. Draw a vertical line with a ruler from the bottom of the chart (x-axis) to the curve that represents the known area of the net cage.
4. Draw a horizontal line from the intersection on the right to the y-axis on the left. This gives the approximate capacity of the net cage.

Example: The estimated weight of each fish is about 1.7 catties, and the area of the net cage is 40 ft x 40 ft. According to the reference chart, the estimated capacity of the net cage is about 1 700-1 800 fishes.

2.2 Regular removal of fouling organisms from fish cages

Mariculture activities introduce additional nutrients into the seawater, attracting fouling organisms such as sea squirts or bryozoans to attach and grow on the fish cages. The excessive amount of fouling organisms not only consumes dissolved oxygen in the seawater, but also covers the meshes of the fish cages, affecting water exchange and hindering effective replenishment of dissolved oxygen inside the fish cages. Fouling organisms also increase the weight of the fish cages, causing damage to them.



Management measures

- Regularly clean the fish cages to prevent excessive growth of fouling organisms which affects water exchange.
- Regularly inspect the fish cages and repair any defective parts.
- Certain cultured species (such as lobsters and gilthead seabreams) can assist in removing fouling organisms attached to the fish cages and thus facilitate water exchange. However, other environmental parameters in the culture zone must be taken into consideration when deciding whether it is suitable to culture such species.

2.3 Implementation of proper feeding management practices

Feeding in moderation can reduce the risk of pathogens and excessive organic matter entering the water body, thereby preventing the decrease in dissolved oxygen and the growth of bacteria. It can also slow down the process of eutrophication in seawater and reduce the risk of red tide.

Management measures

- Stop using trash fish and switch to dry pellet feed to reduce the quantity of organic matter in the water and prevent pathogens from entering the fish culture zone.
- Feed in phases with a suitable amount of feed. If the fish are found to be reducing feed intake, reduce the amount of feed or stop feeding to avoid feeding in excess of the required amount which will result in a waste of feed and pollution in the water body.
- Please refer to the booklet "Good Aquaculture Practices Series 1 – Fish Feed Management" for more information on dry pellet feed management practices.

2.4 Proper disposal of fish carcasses and garbage

Proper disposal of organic waste such as fish carcasses and garbage can reduce accumulation of excessive organic matter and pathogens. It can also help mitigate problems like the decrease in dissolved oxygen level and the growth of bacteria.

Proper disposal of the carcasses of cultured fish

Management measures

- Frequently remove garbage, residual feed and the carcasses of cultured fish from the water, put them inside garbage bags and properly dispose of them in covered garbage bins to prevent deterioration of the water quality and spread of germs. Seek help from the Agriculture, Fisheries and Conservation Department (AFCD) or the Marine Department in case of massive death of the cultured fish.

Proper disposal of garbage

2.5 Regular disinfection of culture gear

Culture gear which has come into contact with sick fish or new fish fry may have pathogens adhering to the surface. Therefore, culture gear should be disinfected thoroughly before and after use to prevent the spread of pathogens or cross-contamination.

Management measures

- Disinfect the culture gear regularly and thoroughly with bleach or steam and dry the gear under strong sunlight.
- Clean and wash the culture gear thoroughly before and after use.
- Please refer to the booklet "Good Aquaculture Practices Series 4 – Prevention and Treatment of Fish Diseases" for more information on the different disinfection and preventive methods for minimising the pathogen level in the water body.

2.6 Health quarantine for newly stocked adult fish or fry

Newly stocked adult fish or fry may introduce foreign pathogens into the water body. Therefore, quarantine should be carried out before stocking to minimise the risk of disease outbreaks.

Management measures

- Newly stocked fish, regardless of their size, should be kept in isolation for several days to observe their health condition. If any abnormalities or symptoms of infections are detected, contact the AFCD or a registered veterinary surgeon for assistance.
- Ensure that the fish fry are issued with valid health certificates.
- Please refer to the booklets "Good Aquaculture Practices Series 4 – Prevention and Treatment of Fish Diseases" and "Good Aquaculture Practices Series 5 – Fry Health Management" for more information on isolation and quarantine of fish fry.

2.7 Isolation/ proper treatment of sick fish

If the cultured fish are suspected of being infected, prompt treatment is required to prevent spread of the fish disease.

Management measures

- If the cultured fish are found to be infected, they must be isolated immediately and the AFCD or a registered veterinary surgeon should be contacted to provide suitable treatment or dispose of them as appropriate.
- Prescription veterinary drugs must be used as instructed by a registered veterinary surgeon and should not be used without authorisation.
- Please refer to the booklets "Good Aquaculture Practices Series 4 – Prevention and Treatment of Fish Diseases" and "Good Aquaculture Practices Series 5 – Fry Health Management" for more information on the handling of sick fish.

Proper treatment

2.8 Proper use of feed additives and drugs as instructed by veterinary surgeon

Casual use of feed additives or drugs will not only result in wastage but also lead to problems such as an increase in organic matter in the water, drug residue in food animals exceeding the permitted level and emergence of drug-resistant bacteria, which will have a detrimental impact on the environment and the health of fish.

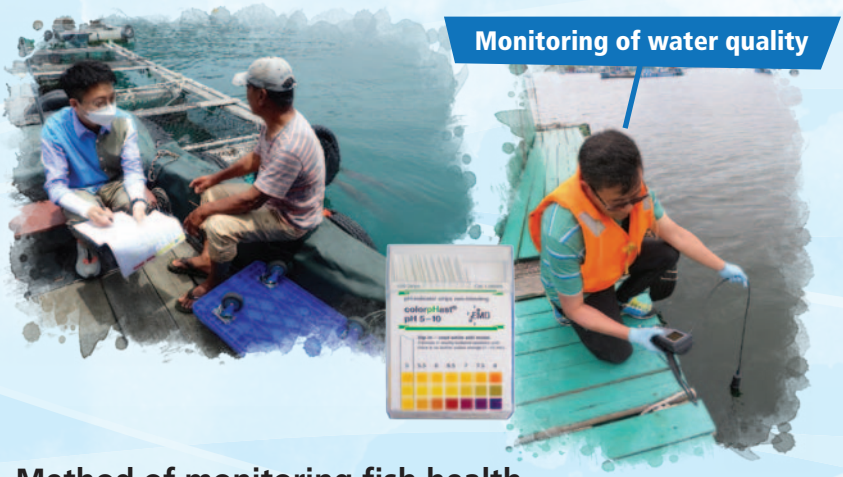
Management measures

- Use feed additives and drugs as instructed by a registered veterinary surgeon.
- Please refer to the booklet "Good Aquaculture Practices Series 4 – Prevention and Treatment of Fish Diseases" for more information on the correct use of fish drugs and additives.

Feed additives and drugs

2.9 Regular monitoring of water quality and health of cultured fish

In addition to preventive measures, fish farmers should also monitor the water quality and the health of the cultured fish on a regular basis for early detection of any abnormalities in order to avoid massive death of cultured fish due to disease outbreaks or abrupt changes in the culture environment.



Method of monitoring fish health

- Perform a simple health check on the cultured fish on a daily basis and take note of their feed intake or any abnormalities, such as the presence of parasites on their body surface, fins, and gills or other symptoms.
- Please refer to the booklet "Good Aquaculture Practices Series 4 – Prevention and Treatment of Fish Diseases" for more information about fish health checks.

Method of monitoring water quality

- Measure water quality parameters at regular intervals each day. The water quality parameters in fish culture zones may vary from seasons to seasons. In general, except under extreme circumstances such as water stagnation or cold surge, the water quality parameters in fish culture zones should fall within the range as follows (the figures are for reference only):

Water quality parameter	Normal range	Measuring instrument
Dissolved oxygen	4-8 mg/L	Dissolved oxygen meter
Water temperature	18-28°C	Thermometer
pH value	7.9 - 8.3	pH meter/ pH paper
Salinity	25-34 ppt	Salinity meter

Water quality monitoring equipment

- The AFCD has set up real time water quality monitoring systems at 16 fish culture zones for continuous monitoring of water quality in the zones. Fish farmers may visit the AFCD website (www.afcd.gov.hk) to view the real time water quality parameters.

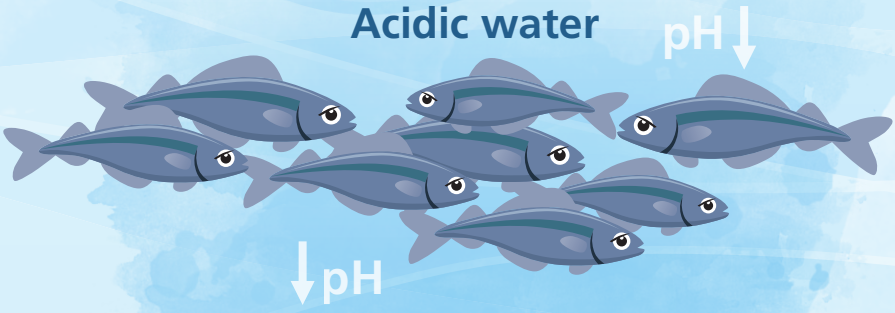
Below are the items covered by water quality monitoring and the corresponding management measures:

pH value

Decomposition of organic matter will make the water more acidic. Acidic water will reduce the oxygen-carrying capacity of the blood of cultured fish, causing inhibited growth as a result of lethargy, decreased feed intake and slower metabolic rate.

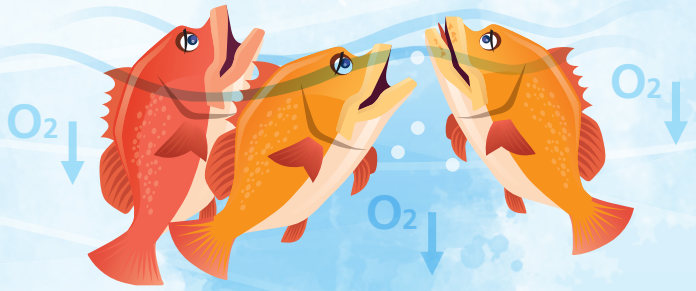
Management measures

- Feed in moderation to prevent excessive feed from making the water acidic during the decomposition process.
- Cease feeding and seek help from the AFCD or a registered veterinary surgeon if the pH value of the seawater is either too low or too high.



Dissolved oxygen level

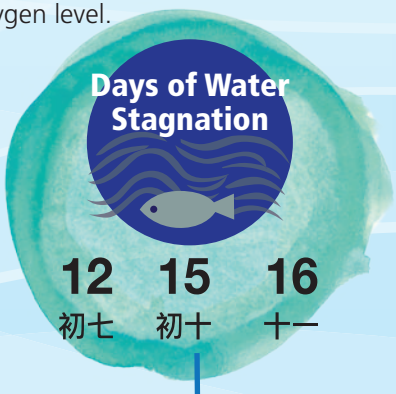
The level of dissolved oxygen in seawater is affected by various factors. Natural phenomena such as a rise in water temperature and water stagnation will result in a drop in the dissolved oxygen level in water. When a red tide occurs, the algae in water proliferate drastically. They consume a significant amount of oxygen in the water at night. In the latter stage of a red tide, a substantial amount of algae die. The decomposition of dead algae by bacteria consumes a large amount of oxygen in the water, resulting in depletion of dissolved oxygen in the water body. Nevertheless, human factors should never be overlooked. Overstocking and overfeeding will lead to the continuous increase of organic matter in seawater, easily resulting in proliferation of microorganisms and subsequently reducing dissolved oxygen in the seawater. Fish staying in an environment with low dissolved oxygen level for a prolonged period of time may become more vulnerable to infection due to low appetite, slower growth rate and reduced resistance to diseases. In severe cases of seawater anoxia, fish will surface to breathe through their mouths and may even die suddenly within a short period of time.



Dissolved oxygen level in seawater may decrease due to the following natural phenomena:	
Water stagnation	With a small tidal range between high and low tides and slow water flow, effective water exchange cannot take place and the dissolved oxygen content cannot be replenished to the appropriate level.
Upwelling current	Seawater with low dissolved oxygen level at the bottom of the fish culture zones will rise up to the surface due to coastal winds, current speed or the ebb and flow of tides.
Water temperature	In hot weather, the water temperature is relatively higher. The higher the water temperature, the lower the dissolved oxygen level of the water.
Red tide	Red tide algae respire at night and consume the dissolved oxygen in the water. After death, they will be decomposed by bacteria and a significant amount of oxygen will be consumed during the process.

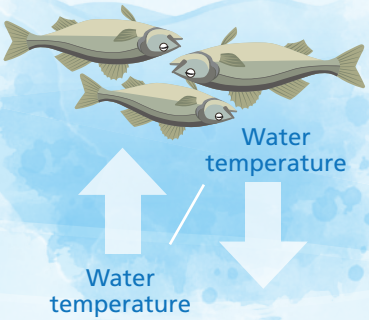
Management measures

- Strengthen monitoring of the change in dissolved oxygen level in case of suspected change in water quality, abrupt change in weather or prolonged cloudy conditions.
- Refer to the reminders in the fish farmer's calendar and closely monitor the conditions of the cultured fish. When necessary, stop feeding, reduce the stocking density, turn on an aerator or spray water along the outside of the rafts with a pressure washer to increase the dissolved oxygen level.



Water temperature

The change in water temperature is mainly affected by the weather. If the water temperature is too high or too low, the cultured fish will be more vulnerable to diseases and even die due to a loss of appetite, slower metabolism and reduced resistance to infection.



Management measures

- Select cultured fish species that are adapted to the local climate.
- Feed in moderation and install shading nets to reduce exposure to direct sunlight.
- Be aware of the SMS messages sent by the AFCD which remind fish farmers that the water temperature may drop continuously during the cold weather.
- Avoid moving the cultured fish when the water temperature is too low.
- Take note of the optimal temperature range for the cultured species and closely monitor the water temperature. Harvest the stock when the water temperature increases or decreases beyond the optimal range.
- Prior to overwintering, it is necessary to provide cultured fish with nutritious feed and appropriate amounts of Vitamins C and E supplements to increase their abilities in resisting diseases and tolerating the cold weather.

2.10 Maintenance of fish culture management records

Fish farmers should develop a good habit of keeping fish culture management records, which should include information such as weather condition, feed quantity, water temperature, dissolved oxygen level and condition of the cultured fish. The information can help analyse the culture results and is very useful for selecting a suitable management method to enhance culture effectiveness.

Fish farmers may consider registering as an "Accredited Fish Farm" to provide the public with premium fisheries products that meet the relevant food safety standards. Fish farmers may visit the website of the "Accredited Fish Farm Scheme" (www.hkaffs.org) for more details.

3 Conclusion

Fish farmers should adopt the following measures for carrying out proper mariculture activities to mitigate the impacts on the environment and ensure healthy growth of the cultured fish:

- Avoid overstocking by monitoring the growth rate of fish and separating them into different cages as appropriate.
- Switch to dry pellet feed and avoid frequent and excessive feeding. Observe the response of the cultured fish to feed intake and stop feeding as appropriate.
- Regularly clean and repair fish cages.
- Promptly remove dead fish and garbage from the water and place them in plastic bags for proper disposal.
- Use feed additives and drugs as instructed by a registered veterinary surgeon.
- Regularly disinfect culture gear and let them dry under sunlight.
- Keep newly stocked adult fish and fry in quarantine and isolation for observation.
- Isolate sick fish and provide appropriate treatment, such as drug bath, as instructed by a veterinary surgeon.
- Monitor and record the dissolved oxygen level, pH value and temperature of the water in the fish rafts as well as the weather changes on a daily basis.
- Turn on the aerator if the dissolved oxygen level is too low.
- Be aware of the red tide alerts issued by the AFCD and take appropriate mitigation measures.
- Take note of the conditions of the cultured fish. If any abnormalities or suspected symptoms of the fish are detected, promptly isolate them and provide appropriate treatment as instructed by a registered veterinary surgeon.
- Seek assistance from the Mariculture Development Section of the AFCD (Tel: 2150 7088) or a registered veterinary surgeon as early as possible when all general treatment measures fail.

Technical Support

Fish farmers are welcome to contact the AFCD for free information and technical support services:

Aquaculture Technology :
2471 9142 (pond fish) / 2150 7083 (marine fish)

Fish Health and Disease Prevention :
2471 9142 (pond fish) / 2150 7088 (marine fish)

Red Tide and Water Quality Environment :
2150 7124

Antimicrobial Resistance :
3426 2284