People Development Program: Aquatic Animal Health Training Scheme

Boosting Biosecurity Capability

in Western Australia

Fish Health Management Plan Guide

ACWA

AQUACULTURE COUNCIL OF WESTERN AUSTRALIA

Australian Government
Fisheries Research and Development Corporation

Government of Western Australia
Department of Fisheries

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Project No: 2009/315:16

Contents

Acknowledgements:

The author wishes to acknowledge that this Fish Health Management Plan Guide was adapted from the Template for Development of Facility – Specific Fish Health Management Plans, British Columbia. Last accessed on 19 Oct 2011 at: www.agf.gov.bc.ca/ahc/fish_health/Template_May2006.doc, and materials she developed for workshops and courses.

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04 Nov 2013

Chapter 1 Elements of a Fish Health Management Plan (FHMP)

The development of a good fish health management plan (FHMP) requires three elements to be in place:

- Dedicated facilities;
- Trained personnel; and
- Standard operating procedures.

A good FHMP contains these key elements:

- Specific to farm or site;
- Involves every personnel on farm – from operational to management;
- Knowledge-based & training of personnel; and
- Monitoring process & record keeping.

In order to support the development and execution of a successful fish health management plan, management and all personnel must understand how each element affects fish health and hence production. Policies on management of fish stocks and availability of adequate resources including facilities and equipment can have tremendous impact on fish health. In broad terms, FHMP is about managing activities carried out in the facility or farm and their impact on fish health. The maintenance of appropriate records such as water quality, feed consumption, regular weight checks, mortality rates and laboratory reports from regular monitoring will aid the recognition of health problems and will lead to the improvement of fish health management.

When drafting a Fish Health Management Plan, a risk based approach will help identify activities which may pose a risk to fish health in terms of disease introduction or increased stress levels so that fish are more susceptible to developing disease. The development of baseline knowledge on what is considered optimal production or acceptable losses from mortality at each stage in the culture cycle and understanding why disease outbreaks occurs in a farm are critical to a successful FHMP. Such information is invaluable in making decisions on improving activities to reduce stress and disease, putting in place appropriate prevention measures such as prophylactic treatments or vaccination programs, and preventing the introduction of new disease agents by improving biosecurity.

- Vertical approach addresses risk factors at critical steps of farm practices from stocking to harvest
- Horizontal approach considers an event e.g.

– Managing disease outbreaks;

– improving staff skills and training; and

– Improving standard operating procedures and record keeping.

Reviewing available published information on what is known about the fish species cultured on farm with respect to known or reported diseases, nutrition, and optimal fish stock management will be a useful guide in developing a FHMP. However, available information cannot replace the need for auditing the FHMP by regular monitoring of stock and appropriate record keeping, as each farm has a very different set of production conditions.

Sustainable practices should also be part of a FHMP. Environmental codes of practices have been developed by the Aquaculture Council of Western Australia and can be viewed at: http://www.aquaculturecouncilwa.com/aquaculture-and-the-environment/caring-for-our-country/codes-of-practice.

Deterioration of environmental conditions can lead to deterioration of water quality or increased pathogen loads in the facility or site, and predispose to disease outbreaks. Information on good aquaculture practices (GAPs) are also available from www.bestaquaculturepractices.org. Although GAPs or BAPs (Best aquaculture Practices) address environmental managements, environmental conditions can influence algal blooms, benthic organism population many of which can be intermediate host for fish parasites and indirectly affect dissolved oxygen levels through organic load levels, all of which impact fish health. Net changing or cleaning can affect load of 'sticky' parasite eggs on nets or degree of fouling, which affects dissolved oxygen levels. Overfeeding in ponds or net cages goes beyond loss from cost of feed; it can cause deterioration of the environment and affect fish health. Animal (fish) welfare is another consideration in creating a FHMP. Reports from other domesticated animals has shown that welfare has been proven to affect health and hence production.

One of the few fish health management plans available on line is the 'Template for Development of Facility – Specific Fish Health Management Plans, British Columbia' available at www.agf.gov.bc.ca/ahc/fish_health/Template_May2006.doc.

Whilst documents such as these serve as useful guide as to what aspects should be included in a FHMP, one must always remember that a simple facility specific FHMP put together over time as the farm improves and expands may be more useful than a voluminous document that will not be referred to. A useful way to start an FHMP is to draft a general farm workflow from stocking to harvest, supported by standard operating procedures already in place.

1.1 Objective

The Fish Health Management Plan (FHMP) aims to optimise health of existing stock via good aquaculture practices. The FHMP should address the fact that disease outbreaks in aquaculture are influenced by interactions between the host, the aquatic environment and pathogens. It is specific to the identified facility, and serves to specify the responsibilities and capabilities of management & operation staff. The FHMP puts in place appropriate mitigation measures for specific identified risks, such as disease outbreaks. It seeks to create a more defined mechanism to address gaps in knowledge to improve production by appropriate record keeping, staff training and adopting or carrying out research & development.

In summary, a FHMP hopes to achieve the following:

- Exclusion of pathogens through reliable sources of eggs, juveniles and broodstock, quarantine, eradication programs & long term policies;
- Management of diseases from pathogens present in environment;
- Improve fish health, FCRs and hence economic returns;
- Identify risks posed at various stages of culture cycles; and
- Draft mitigation measures to address risks – short, medium & long term

1.2 Target Audience

The plan is used by management including technical managers who have to make decisions about future planning on fish health management and production targets. However, all staff should be familiar with the overall objectives, and the part they play in contributing towards good fish health management practices.

1.3 Annual Review

The FHMP will be subject to annual review by the farm manager, in consultation with the operation manager and farm veterinarian. SOPs may be reviewed and updated more regularly by designated operational staff. FHMP will be subject to a process of continual improvements, based on information generated from daily observations, fish and water quality monitoring records, and impacts of various events. To aid capture of some of the pertinent issues for improvements as they arise, a Fish Health Management Review Form is attached in Appendix 5.3.

Chapter 2 Organisational Structure

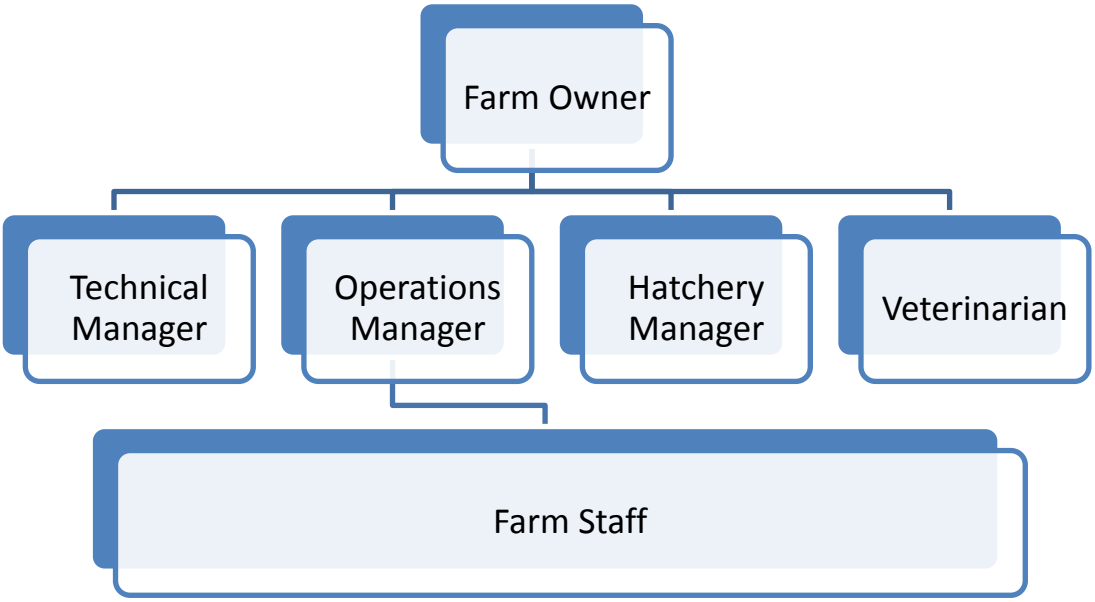

Figure 1: Example of an aquaculture farms organisational structure.

Chapter 3 Personnel

All staff should have adequate knowledge and skills, provided by management, to understand how their role impact fish health. An understanding of disease processes in response to various insults from husbandry practices, environmental conditions including water quality, feed quality and various infectious agents is necessary in order to develop successful preventative measures.

3.1 Responsibilities

3.1.1 [Farm Owner or Director]

The [Farm Owner or Director] is responsible for defining policies regarding fish health management and biosecurity, in consultation with Farm Manager.

3.1.2 [Farm Manager]

The [Farm Manager] is responsible for quarantine and biosecurity on farm. They are responsible for site management with respect to stocking and fish movements. The farm manager should also ensure that workers have the appropriate qualifications and training. The farm manager shall also provide appropriate equipment for optimal farm operation.

3.1.3 [Operations Manager]

The [Operations Manager] is responsible for managing daily operations, ensuring maintenance of equipment and facilities by farm staff, and appropriate record keeping.

3.1.4 Veterinarian

The veterinarian is responsible for disease management (diagnoses, prescriptions) and overall fish health management on the farm. Fish health management refers to advice on decisions by management on major fish health/biosecurity issues such as quarantine, disease outbreaks and disease prevention. They are responsible for identifying risk factors and recommending appropriate mitigation measures to minimise their effect on fish health. The veterinarian will report outbreaks of significant disease to the State authorities.

3.1.5 Operational Staff

Operational staffs are expected to carry out fish health management programs, so that a basic understanding of fish health and good aquaculture practice is necessary. They carry out monitoring and record keeping as designated by the operational manager.

3.2 Job Descriptions

[A detailed job description of each staff is included in his/ her personal file.]

3.3 Training

Based on job descriptions, staff qualifications and experience, appropriate training plans are drafted annually by staff in consultation with supervisor.

The following skills and knowledge will help support a successful FHMP:

- Recognise disease within a fish population;
- The dynamics of disease spread into and within a fish population;
- Understand how a fish response to various disease agents including environmental changes (fish physiology and general disease processes);
- Susceptibility of fish to various disease agents is dependent on age, environmental conditions and the general health of fish (immunology);
- Understand the effects of disease on the fish host and when to deliver supportive therapy such as aeration or increased water changes;
- Carry out basic disease investigations to rule out a few common causes of poor health such as water quality and parasite loads;
- Submit appropriate samples to laboratory for further tests; and
- Understand the basic principles behind quarantine or any disinfection procedures

Relevant farm staff involved in fish health management should possess these knowledge or skills:

- Basic knowledge for conducting fish disease investigations to determine cause of disease and the ability to submit the right samples

to the lab for further analysis. Ability for fish dissection, record gross abnormalities and simple diagnostic methods such as wet mounts microscopic examinations and water quality tests will be useful; and

- How to collect the relevant history during disease outbreak investigations to identifying any predisposing stress factors or sources of disease agents

Chapter 4 Farm Operations

4.1 Overview

This chapter describes the daily operations on site or facility. SOPs on quarantine, waste management, emergency disease response and other biosecurity measures are addressed in their own relevant chapters.

The personnel responsible for each activity should have the appropriate training, skills and background knowledge. While it is common to attribute clinical disease to a set of infectious agents whether bacterial, viral or parasitic, there may be other predisposing environmental or management factors. Standard operation procedures should be assessed on their impact on fish health. It may not be directly obvious as to the degree of impact these farm operations have on growth rates or subclinical disease unless careful records were kept or these parameters were assessed.

A good start in putting together this chapter and all supporting SOPs is to map out all the activities from when fish are stocked into a farm until the time the fish is harvested. Critical points when special attention must be paid to improving fish health can be identified. Common activities that can impact fish health are post transportation at time of stocking, transfer of fish from nursery to growth-out, all activities that involve handling during any stage including grading, weight checks or prophylactic treatment bath immersions or tank and net maintenance. If the farm brings in the fish stock as fry or eggs, there is the added requirement on putting in place necessary health checks and quarantine. Then one must consider the daily routine that gets repeated every day such as feeding or tank/net cleaning.

While these activities may sound straightforward, they are golden opportunities to spot any subtle changes in behaviour that may signal disease problems. SOPs serve as a useful guide to how these activities should be carried out and the level of fish health knowledge needed to operate and manage these activities optimally. Remembering that disease outbreaks can be caused by any critical changes in trigger factors whether that involve the fish host, the environment and the pathogens present.

4.2 Standard Operating Procedures (SOP)

A template for SOP is attached as Appendix 2, and list of SOPs outlined in Appendix 3. Specific daily operations are outlined below.

[The detailed SOP is found in the SOP manual.]

4.2.1 General husbandry procedures

This should cover the general management of fish and facility from stocking to harvest. Newly stocked fish are stressed, and may be more prone to disease from breaks in normal barriers in skin and gills. Poor water quality may stimulate increased mucus production and predispose to bacterial infections on the protein rich mucus. Management of sick fish stock may require increased water exchanges and aeration, or temporary withholding of feed. Timing of stocking in areas with clear seasons can impact disease outbreaks as fish cannot maintain body temperature independently of the environmental temperature. Stocking densities in the farmed situation affects the dynamic of spread of disease agents. It also makes fish more prone to cannibalistic behaviour if this is not probably managed through regular grading. Attention should be paid to any build-up of diseased fish in a facility as they can be a source of further spread. Regular removal and proper disposal of dead fish is essential to minimise disease spread. Any unusual fish mortalities should be further investigated to determine the root cause of disease outbreak. The maintenance of tanks or nets during each culture phase for a batch of fish and between batches is critical in minimizing build-up of disease agents.

4.2.2 Feeding SOP000

The fish are generally fed to satiety, unless automatic feeders are used. Newly stocked fish should not be fed on the first day upon arrival, may be fed at reduced rates over several days. Feed may be withheld during disease outbreaks where a compromise of oxygen uptake by fish is suspected.

4.2.3 Fish Handling

Handling should minimise injury and stress to fish, which may predispose to disease. Fish should be monitored both during and after handling for any negative effects, so that mitigative steps can be taken. The time fish are exposed to stressful events such as crowding and out-of-water events (i.e. handling, counting, grading, weight checks, harvesting, vaccinations, and bath treatments) should be minimised by appropriate planning and preparation for such events.

Rough handling during grading of fish may result in breach of the normal skin barrier and provide portals of entry for bacteria. Deterioration of water

quality in baths used for weight checks may cause increase mucus production in skin and gills, and promote bacterial and parasite overgrowth on these surfaces. Any prolonged period of exposure to suboptimal oxygen levels may result in stressed fish that are more susceptible to bacterial or parasite infestations.

List of SOP000

4.2.4 Anaesthesia SOP000

A variety of fish health procedures require that fish be anesthetised. In Australia and New Zealand, the anaesthetic of choice is AquiS™. The anaesthetic level used should be appropriate for procedure and manufacturer's instructions should be followed. Anesthetised fish should be monitored carefully at all times. Water quality of the anaesthetic bath in particular the oxygen level should be monitored, with contingency plans put in place in cases of fish showing signs of hypoxia. Examples of contingency plans would include provision of clean water to recover fish and extra aeration. Food should also be withheld for an appropriate period of time depending on the fish species, and a general appropriate withholding period is 12-24 hours prior to any scheduled handling event. Herbivorous fish such as carp have longer intestinal tracts and need longer withdrawal periods.

4.2.4 Euthanasia SOP000

The method of choice is an overdose of an appropriate anaesthetic.

Chapter 5 Facilities and Equipment

5.1 Overview of Facility

5.2 Layout Plan

The facility or site plan should have dedicated purpose built or designated quarantine, and water source inlet well separated from waste water discharge. Facility design to allow segregation of various activities and accommodate traffic flow with respect to function will be advantageous.

5.3 Management of facility

The use of specific facility or site for fish stock management, and procedures in place to minimise potential disease spread between facilities and fish batches should be outlined in relevant SOPs. Water flow management in tanks or management of nets, and stocking density for optimal operation should be outlined in SOPs.

List of SOP000

5.4 Management of equipment

Equipment should be designated for use in each facility to avoid cross contaminations and minimise disease spread. For shared equipment, appropriate disinfection procedures should be outlined. Any equipment maintenance for optimal function should be indicated in SOP.

List of SOP000

5.5 Feed storage

A system of feed management needs to be put in place to ensure feeding of older feed stocks first, to minimise wastage or feeding of expired feeds. Fish feeds generally contain a high percentage of unsaturated fatty acids (up to 40%) which may become rancid (oxidised) with storage or exposure to high temperature. Feed may also become mouldy from storage in high humidity. Rancid fats or mouldy feed can cause disease in fish, and even if not contributing to overt clinical disease, it can affect growth.

List of SOP000

Chapter 6 Biosecurity – Risks, Critical Events and Mitigations Measures

Biosecurity is the prevention of disease outbreaks in an aquaculture facility, usually attributable to an infectious agent. The infectious agents can be viral, bacterial, parasitic or fungal. Although the most common thought that comes to mind is incursion of a new agent, many potentially infectious agents are present in the aquatic environment all the time (ubiquitous), either occurring naturally or were previously introduced and have become endemic in the area.

Disease outbreaks may be precipitated by changes or interactions in environmental conditions, fish host health status and pathogen incursion or potential pathogens present in the environment. An otherwise non-pathogenic infectious agent can cause disease in fish that has been recently handled, transported, subjected to poor water quality, drop in environmental temperature, overcrowded, inadequately graded, or fed a suboptimal diet. Hence, while biosecurity puts in place the measures to avoid the introduction of pathogens into an aquaculture facility, its inadvertent spread within and from the affected fish population, a fish health management plan keeps fish healthy so that overt or subclinical disease will not occur in the facility. Many aquaculture procedures such as handling, transport or grading cannot be avoided. However, they can be managed to reduce harmful effects such damage to skin, duration of the procedure, potential drop in oxygen levels, hottest part of day or water fouling from vomited feed.

Whilst aquatic pathogens may survive for a period of time in the environment, many serious pathogens survive best in the fish host itself. Hence the highest risk of disease introduction is the infected or diseased fish host which will contain relatively higher pathogen loads than elsewhere, because the pathogen has had a chance to multiply in numbers in the infected fish. Additionally, some strict pathogens require the protection of being in the fish host to survive over several hours or days. To add to the complexity of disease control, infected fish may not show signs of disease. In order to mitigate the chance of bringing in carrier or subclinical infected fish into farm, only fish sources with a known health status determined by regular inspection, testing and health certification should be used. With diseases with a slow progression to clinical stages, it is vital that the health status is determined after regular inspection of source facility and testing over a period of at least 1-2 years. The Aquatic Animal Health Code by World Health Organization for Animal Health, downloadable from http://www.oie.int/doc/ged/D7821.PDF (Last accessed on 04 Sept 2013) is

a very comprehensive guide to determining health status for specific diseases as well as health status in general.

In general, fish movements are allowed from a site with a higher health status to a site with lower health status. In addition, quarantine should be instituted to newly arrived fish at a site or facility, as fish stressed from handling and transport are more likely to develop clinical signs from any subclinical infections or any normally ubiquitous pathogens in the first 2 to 3 weeks post-stocking. Quarantining newly arrived stressed fish in facilities also allow better observation for early detection. It is easier to carry out any treatment procedures or control water quality in a quarantine environment than in a sea cage or large pond.

Potential sources of disease agents:

- Fish – carrier or diseased, wild or farmed;
- Effluent water;
- Workflow & Staff movements;
- Equipment – nets, boats, diving gear, feeding gear; and
- Sea birds feeding on dead fish

In summary, pathogens may be spread by sick fish and wild fish, on shared equipment, or by personnel, visitors, suppliers or their gear.

Biosecurity includes three components (Canadian FHMP template):

I Keeping fish healthy;

II Keeping pathogens out; and

III Keeping disease from spreading within the site.

6.1 Site people movement biosecurity

Controlling people movement within or between sites/ facilities contributes to keeping out pathogens and preventing spread of disease. This applies to farm personnel including divers, suppliers or visitors. It involves movement control within and between sites. Procedures must be in place to address the risks that such movements may pose to biosecurity on each aquaculture facility or site. Relevant risk mitigations procedures such as limits of site/ facility access, need for change of footwear and other disinfection procedures must be outlined. There should be suitable signage to indicate access of each site/ facility and any necessary biosecurity mitigation procedures at

the entry and exit to each site/facility. Farm personnel should be familiar with current biosecurity measures. The appropriate disinfectants, protective wear and on-site facilities for decontamination must be maintained in good working order.

SOP000 – Site people movement biosecurity procedures

6.2 Equipment maintenance and disinfection

As equipment or vessels used on farm may potentially be a source of disease introduction or spread, procedures must be in place to ensure they are properly maintained, cleaned and disinfected in between use and between sites/ facilities. Equipment includes fish handling, feeding and water monitoring gear, and vessels which may be used at multiple sites. Equipment not meant for sharing between sites or facilities due to the difficulty in cleaning and disinfection should be clearly labelled with the site/ facility that it is only meant to be used.

Aims of disinfection:

- Prevent disease incursions in biosecurity programs
- Routine hygiene measures to reduce build-up of disease agents on farm
- Eradicate disease agents from outbreaks

Efficacy of disinfection is affected the amount of organic contaminants on surfaces. Pathogens may be protected from disinfectant by solid wastes.

- Established SOPs or workflow to prevent spread
- Adequate cleaning to remove solid wastes
- Appropriate disinfectant concentration & time of exposure
- Not possible to disinfect sea-cage environments
    - Stop movement of live fish into/out
    - Removal of dead fish promptly. Diseased fish can contain high loads of infectious agent
    - Designated staff & equipment to specific sites

Types of disinfection include:

- UV;

- Ozone;
- Chemical disinfectants, e.g. sodium hypochlorite (chlorine); and
- Efficacy is affected by amount of suspended solids in water.

SOP000 – Equipment maintenance, cleaning and disinfection

6.3 Mitigating disease spread from infected or diseased fish

Preventing the introduction of disease via infected or diseased fish on site can be addressed via protocols on fish movements into and between sites, quarantine, removal and disposal of dead or diseased fish, and appropriate site/ facility disinfection or fallowing in between stocking each batch of fish.

There should be clear guidelines on the determination of health status of fish and acceptable health certification procedures before they can be stocked into facility. A list of baseline diseases that may occur in stocked fish on farm, and methods of diagnosis, prevention and treatment should be developed.

The length of quarantine, monitoring of fish, criteria for release from quarantine, disinfection procedures for facility and equipment, staff access and workflow, and record keeping should be outlined. Quarantine should ideally be in self-contained facilities with ability to treat discharge water and segregated from other parts of farm with respect to designated equipment, staff and workflow. Where this is not possible, appropriate disinfection of staff and equipment needs to be put in place. Not all diseases can be detected based on observation of clinical disease during the quarantine period of 2 to 4 weeks. Even if routine samples are taken for on-farm analysis or sent to the laboratory, there is a chance that the disease is present in such a low numbers (prevalence) that they may escape detection. This is the reason that use of reliable fish sources with a known health status determined by a period of monitoring and testing by a fish health laboratory is the method of choice in minimizing disease incursions.

Effluent treatment & disposals should include the management of infectious solid wastes, waste water, dead and diseased fish and chemical or drug wastes.

SOP000 – Fish movement into and between sites/ facilities

SOP000 – Fish quarantine

SOP000- Collection and disposal of dead fish

Chapter 7 Disease Emergencies

In order to successfully manage fish disease outbreaks, a good knowledge of fish health is necessary. Some critical factors to consider include:

- Water with 4-8ppm dissolved O2 (DO) has much less oxygen than atmospheric air at 21% O2, i.e. 30,000x less O2
- Drop in DO or ability of fish to obtain O2 e.g. gill disease can be dramatic
- DO affected by physical factors such as temperature, salinity
    - Increase in temp. or salinity causes drop in DO
    - Less O2 in seawater with 30ppt salt than freshwater
    - Less O2 at 30 ^{o}C than at 25 ^{o}C

Fish living in a freshwater environment experience the need to pass out copious amount of dilute urine in order to balance the tendency of water to move into their tissues. Marine fish need to do the opposite: prevent excessive water loss from the dehydrating effects of living in an environment more salty than its own tissues. In the normal healthy state, the skin and gills form a barrier against excessive water loss or water gain. In the diseased state, these barriers in skin and gills may be lost, so that the ability of fish to adequately osmoregulate is overwhelmed. Excessive water loss or water gain can be fatal, i.e. lead to the death of fish.

Fish cannot maintain their body temperature. Hence environmental temperatures influence their body temperature, and all their metabolic activities including immunity (defence against disease), healing capacity and growth. Hence, the ability to response to stressful events such as handling or transport, and when they are challenge by exposure to potential disease causing agents (pathogens) are influenced by environmental conditions.

As mentioned earlier, the skin and gills form a natural barrier to water loss or gain. Gills also have very important functions besides forming barriers and oxygen uptake. Gills are important for excretion of metabolic waste products including ammonia and carbon dioxide. Hence gill damage can have very severe effects on fish health. One of the reasons why fish may look sleepy may be from build-up of carbon dioxide and resulting acidosis. Ammonia is toxic to cells and hence build up in the body may cause tissue death.

Infectious agents do not always directly cause disease signs or death of the fish. It is the fish tissue's response to the pathogen that may be responsible

for the disease signs we see. For example, excessive build-up of protozoan parasites such as Trichodinids or *Icthybodo* (Costia) may cause a thickening of gills and reduce its ability to uptake oxygen, and excrete carbon dioxide or ammonia. One of the most serious effects of a Streptococcus bacterial infection is the presence of large numbers of circulating bacteria that clogs the blood vessels and result in poor circulation. This can explain why certain species of fish which require more oxygen are more susceptible to fatalities in streptococcosis. This interference with circulation by circulating bacteria also can explain why avoiding handling which increases oxygen demand can reduce mortality. Studies in rainbow trout with bacterial gill disease have demonstrated that withholding feed reduced mortalities due to reduced oxygen demand from need to digest feed (MacPhee *et al.* 1996).

It cannot be overemphasised the need for correct disease diagnosis. This should involve examination of fish, water and other environmental parameters in the light of recent history of affected fish population. Large blood sucking parasites such as *Lernanthropus species* can have devastating effects on fish even when found in small numbers. On the other hand, small numbers of protozoan parasites such as Trichodinids may be relatively harmless. Some parasites such as *Ichthyopthirius multifilis* have very resistant cysts that require fallowing ponds to break the life cycles for successful management. Others as *Neobenedenia* require vigilant net cleaning to prevent build-up of sticky parasite eggs that hatch within days and reinfect fish post treatment with fresh water baths.

Depending on the culture systems, these protozoan parasites can build up to dangerous levels if water quality deteriorates in closed recirculating systems and be fatal in juvenile fish. The presence of skin ulcers with bacteria such as Vibrio species or filamentous bacteria such as *Flavobacterium* may be secondary to recent handling or tank mate aggression from inadequate grading. Fish have a limited ability to demonstrate clinical signs or gross abnormalities so that laboratory examination of fish samples is always useful.

Clinical signs are often a result of fish host response to the inciting disease agent rather than an indication of what infectious agents may be involved. The gross manifestations of disease are also often secondary to other predisposing factors such as drop in temperature, tank mate aggression or recent handling. Not all disease will cause gross abnormalities. If the disease occurred over a short period (acute onset), host response may be less obvious to the naked eye. Laboratory diagnosis of disease in fish often employs histopathological examination of diseased fish tissues, which involve evaluation of diseased tissues at higher magnifications under the microscope. Arriving at an accurate and correct diagnosis has wide

implications on disease management. Parasites have different life cycles, bacteria have different susceptibility to drugs and depending on the impact of these disease agents on the fish tissues, different management strategies may be necessary. Vaccination may be necessary in preventing diseases predisposed by unavoidable management procedures such as transport, handling and grading. Studies have shown that high parasite loads can lead to vaccination failures. Vaccination programs must be carried out with management of other potential pathogens.

In summary:

- Immune incompetency can be age related or in fish after periods of stressful events, e.g. transport, handling, temperature extremes;
- Chronic exposure to seemingly benign environment stress or infectious agents can deplete the fish immune system;
- Culture conditions can cause disease agents to build up, e.g. high stocking density, low water exchange rates, increased total bacterial loads; and
- Feeding regime can cause organic wastes build-up in culture system, e.g. tank/pond bottoms, sea-cage bottoms

While some of the factors that predispose to disease cannot be controlled, the disease may be managed by altering management Disease may be precipitated by stressful events. Understanding effects of disease on fish hosts helps with treatment & control.

7.1 Fish Disease Outbreaks

An outbreak is defined as an unexpected occurrence of mortality or disease. This may be due to significant pathogens or to water quality changes such as plankton blooms or sudden or severe decreases in dissolved oxygen levels. Vigilant monitoring and early detection is the key to good management of emergencies (BC Canadian FHMP).

Emergency disease control requires a coordinated response drawing on significant resources and input from all tiers of government and a range of industry groups. In the event of a disease outbreak, the farm manager initiates quarantine, movement controls and assessments around the initial site which may include the submission of fish and water samples for diagnosis. The farm manager will consult with farm and laboratory veterinarian on control strategy based on available information. Successful control may require determination of where the disease might have come from, and where it might have been spread to.

Depending on whether disease is in the notifiable livestock disease lists, there might be a need to eradicate by culling affected fish. There might follow a period of quarantine and movement control until surveillance clears the farm of the disease.

Chapter 4.4 of the 2011 OIE Aquatic Animal Health Code on 'Contingency Planning' gives a good overview of the areas which must have standard operating procedures developed to address disease incursions. In summary, the areas include movement control, disease diagnosis, handling/culling/disposal of diseased fish, disinfection procedures, fallowing and monitoring after disease outbreaks. It is important that these tasks have been assigned as responsibilities to various farm staff and those responsible personnel have received adequate training.

7.2 Fish Health Emergency Procedures

The farm manager will be *immediately* notified of a serious health problem affecting a significant or higher than expected percentage of fish stocks, and institute a chain of emergency responses. If a water quality problem is suspected, the appropriate emergency response (SOP000) will be carried out. The objective is to minimise the impact of disease or its spread from affected site.

More often than not, disease outbreaks are caused by ubiquitous agents present within the environment. In such cases, the objective will be to reduce losses through fish deaths. It is often not realised that any activities that further draws on the fish ability to osmoregulate or deliver adequate oxygen to its vital tissues can deliver the final fatal blow. Increased aeration, avoiding handling and withholding feed help to conserve oxygen balance in the diseased fish. Gradually reducing salinity in seawater or increasing salinity in freshwater in tolerant species of fish can reduce mortality markedly by helping to reduce the pressure to osmoregulate amidst damaged tissues involved in this function such as skin, gills, intestines or kidney.

7.2.1 Isolation/Quarantine

At the Veterinarian's recommendation the site may be officially isolated/quarantined. Isolation/Quarantine remains in effect until such time as the problem has been diagnosed and/or managed.

SOP000 - Isolation/Quarantine

7.2.2 Stop fish movement and/or handling

The movement of all fish on/off and within the site will cease. Fish will not be further handled. Equipment and personnel will *not* move on or off site unless special arrangements are made, e.g., for staff going on or off shift for the site. No visitors or non-essential staff will be allowed on site unless previously authorised by Management.

7.2.3 Disinfection and Hygiene

Hygiene and disinfection on site, including procedure for personnel and equipment will be strictly enforced.

7.2.4 Suppliers

Suppliers (e.g., feed barge, mort pick up) will be instructed to visit the site last or to make special arrangements (e.g., designated vessel) to pick up and deliver only to the affected site.

7.2.5 Mortality Dives

The frequency of mortality dives will be increased during a disease outbreak. The affected site will be dived last and divers will adhere to disinfection procedures between sites. Separate gear and vessels will be designated for the affected site whenever possible. All equipment, surfaces and clothing that come in contact with infected fish or infected material will be thoroughly disinfected after use. Mortality collection and disposal procedures will be strictly adhered to, and provisions made for increased mortality pick-ups and disposal.

7.2.6 Determining the cause of the outbreak (outbreak investigations)

The Veterinarian may require records and appropriate sampling to determine cause of the outbreak and best course of action. The Veterinarian and/or Fish Health Manager will give instructions for proper sampling. Water and feed samples may be requested. Samples will be properly handled, properly stored and promptly shipped as per the Veterinarian's or Fish Health Manager's instructions.

Parameters that may be useful to maintain records and from part of significant information or history during disease investigations include:

- Source of fish;
- Period on farm e.g. newly arrived;
- Dates of disease onset;
- Age/fish species affected;
- Recent handling, grading, net changes, tank transfer, etc;
- Stocking density;
- Mortality pattern; and
- Water quality/recent weather/tide conditions.

What are the best fish samples to collect or sent away for testing? Freshly dead fish, preferably alive at time of sampling and submitted alive or chilled on ice but not frozen for laboratory examination within 12-24 hrs are recommended. Fish are cold blooded & have enzymes & microbes that are active even in chilled conditions so that tissue autolyse quickly after death. Floating dead fish are filled with gases produced by bacteria overgrowth and hence unsuitable for testing. 3 to 5 diseased fish are generally sufficient. A range of moderately to severely affected fish should be collected for examination. If fish samples cannot reach the laboratory within 12-24h, they must be fixed in 10% buffered formalin.

Fish less than 4-6cm can be fixed whole in 10% buffered formalin. Make slits in abdomen and behind head to ensure good fixation. Allow 1 part tissue: 10 parts formalin fixative. For fish measuring >4-6cm, dissect out whole organs to fix or take representative samples of all organs. Tissues samples should measure <1cm thick to allow good fixation.

Bacterial culture can be performed on fresh fish samples. For farms located in remote sites, when samples cannot reach diagnostic laboratories within 4-6h, it is best to perform the primary culture onto an agar plate from the spleen or recommended organ for target bacteria to avoid overgrowth of normal bacteria flora during transport. Samples for molecular tests can be collected as fresh tissues or fixed in alcohol. It is always best to consult the diagnostic laboratory as to the best samples to collect and submit.

7.2.7 Monitoring

Continued monitoring will be required after the initial workup to determine the course of the outbreak and to assess whether treatment and/or management measures are being effective. Repeat sampling of fish for laboratory examinations maybe necessary.

7.2.8 Dealing with Large Scale Mortality Events

If it has been agreed to depopulate the site, the procedures will conducted in a manner consistent with the standard operating procedures for disposal of dead fish, appropriate disinfection and other solid, liquid or chemical wastes disposal.

Chapter 4.6 of the 2013 OIE Aquatic Animal Health Code downloadable from: http://www.oie.int/international-standard-setting/aquatic-code/access-online/, which gives a good guide on the various methods for disposal of high risk aquatic animal wastes. The competent authority must be consulted in the event of a significant disease outbreak with respect to the suitability of mitigation procedures to be carried out. Chapter 5 of a document produced by Australian Department of Agriculture, Fisheries and Forestry (2012) is downloadable from: http://www.animalhealthaustralia.com.au/wp-content/uploads/2011/01/CH5-Aquatic-animal-health-AHIA-2012.pdf

The key to managing disease outbreaks is appropriate disease diagnosis and treatment or management. Mortality in disease outbreaks can be minimised by ensure optimal water quality with increased water exchange, adequate aeration and adding salt to freshwater or reducing salinity in seawater.

Reducing stress by avoid handling and reduce stocking density may also be helpful. Antibiotics kill all susceptible microbes on treated fish as well as its environment including filter systems, in addition to targeted organism. Studies have shown that normal microflora help to keep potential pathogens in check. Some antibiotics do not kill but only inhibit the growth of bacteria so that duration of treatment needs to be at least 3 to 5 days to be effective. Withdrawal periods need to be adhered to for food fish, where unknown, 300 to 500 degree days has been recommended. Degree days are the number of days withdrawal necessary multiplied by the ambient temperature during treatment period.

7.2.9 Reporting to authorities

In Western Australia, significant disease incidences should be reported to the Department of Fisheries within 24 hours. The notifiable disease list is available from http://www.agric.wa.gov.au/PC_92820.html. Disease reporting mechanisms in Australia together with a list of reportable aquatic animal disease in Australia is available from http://www.daff.gov.au/animal-plant-health/aquatic/reporting.

The competent authority to which notifiable diseases must be reported to in Western Australia is the Chief Veterinary Officer (CVO), Department of Agriculture and Food of Western Australia (DAFWA). The Department of Fisheries Western Australia will report any notifiable diseases to CVO, DAFWA who then reports to the CVO, Department of Agriculture Forestry and Fisheries (DAFF), Canberra.

The following forms a summary to a disease outbreak response:

- Early detection & prompt action;
- Farm manager to initiate movement control & investigation;
- Rule out water quality problem;
- Decide on sending samples;
- Devise control strategy based on available information;
- Determine where the disease might have come from or spread to;
- Notifiable livestock disease lists, eradicate by culling; and
- Period of quarantine and movement control until surveillance clears the farm of the disease.

Chapter 8 Monitoring and Record Keeping

Objective of monitoring fish

- Surveillance for disease incursions - early detection;
- Check efficacy of treatment or control programs;
- Collate information to develop future risk mitigation measures
    - Information should include environmental & husbandry factors that may influence disease, e.g. stocking age, grading, stocking density, feeding regimes, weight gains

When should you monitor?

- Preferably well before fish are stocked into a facility. Some disease may not present clinically or be present in such low numbers that they escape detection. Sources with a known health status from 1-2 years of active monitoring are recommended.
- During the stressful periods, usually 1-2 weeks post-stocking or any handling or transfers between facilities. If sources with a known health status are used, then monitoring during this period will determine what diseases can occur from opportunistic organisms and aid in future disease prevention programs.
- Benefit in monitoring larger grow-out fish as disease outbreaks can still occur. Reports have been made of streptococcosis in association with muddy runoff during heavy rains. Toxic algae blooms may occur in certain sites in association with certain seasonal conditions. Such monitoring will help the development of future mitigation procedures.

Record keeping is essential for long term planning and comprehensive evaluation of fish health and production. It generates data which can indicate trends, and aids traceability of events and their impacts. Such information are necessary to have a data based approach to improving fish health management, recognition of health or production issues and ensuring quality assurance of farm product particularly with respect to food safety.

8.1 Fish Health Records

Fish will be monitored at least once daily for any unusual behaviour, visible lesions or other signs of disease. Changes in behaviour and physical condition will be reported to farm manager on duty. Changes can be physical such as scale loss, parasites, and external injury or behavioural such as abnormal swimming or schooling behaviour or increased respiration. Any unusual behavioural changes or physical signs of disease affecting a significant percentage of fish stock in a unit, facility or site should be further investigated.

Flow chart 1 & 2 gives a broad overview on disease investigations on-site, and sampling of fish for further laboratory examinations. Regular monitoring of fish stocks to establish normal baseline information of growth rates and disease present on a particular site or facility is useful in fish health management, developing future preventative measures such as vaccinations, improving techniques that involve handling, scheduling the timing (seasons) and age of fish stocked on site.

8.1.1 Feeding

This activity is one of the most valuable to spot any potential problems in fish well before overt clinical signs or mortality occurs. Any tank or pen where poor feeding behaviour continues warrants further investigations.

8.1.2 Mort Dives

Mort dives is a useful indicator for any unusual mortalities or disease. Farm manager should be informed, and samples may be taken for further examination by designated farm staff or submitted to the fish health laboratory for analysis.

8.1.3 Monitoring fish

Weight checks and grading are good opportunities for spotting any abnormalities in fish, and samples can be taken for further examination. Less than expected optimal growth rates may be an indication of subclinical disease. Such trends may not be obvious at a point in time until sufficient data has been collected over a period of time.

Simple diagnostic techniques such as examination of tissue smears or wet mounts of skin scrapings or gills are surprisingly useful in demonstrating

disease agents. There is only 55% success of isolation of *Nocardia* from fish with clear clinical signs and when filamentous bacteria were demonstrated in gram stained tissue imprints (Labrie *et al.* 2008). External parasites may drop off in tissue samples taken for histology, and are best viewed in wet mounts. Wet mounts examinations also give the essence of speed in obtaining results, so that treatment can be instituted quickly.

The limitations of test methods to detect various diseased agents must be recognised in submitting samples for laboratory testing. PCR detects DNA whether the disease agents are viable or not, so that environmental DNA contaminants can come out positive after an outbreak, eradication and disinfection exercise. Laboratory diagnostic methods do not tell the difference between opportunistic organisms or the primary causal agent – these require careful analysis of relevant history and corresponding diseased tissues via histology.

The choice of fish tissues to sample for laboratory analysis is important in generating useful results. By the time fish show obvious clinical signs, the disease agents may no longer be present. Sampling fish with mild to severe clinical signs may increase success of diagnosis. Disease agents tend to have a primary target organ or site, and these organs tend to have the most obvious gross lesions but may no longer contain the pathogen. ALL organs should be sampled for histology. Organs such as brain or eye, although without grossly visible lesions should be included in sampling to increase success rates with detection.

8.1.4 Water Quality Monitoring

Maintaining good water quality is vital to good fish health. The operator maintains a regular program for monitoring and recording water quality at net pen sites or hatchery tanks. Monitoring will vary between sites depending on location and specifics of the aquatic environment, and hence it is important to establish baseline parameters for water quality.

SOP00 - Water quality monitoring - temperature, dissolved oxygen, plankton, equipment calibration and maintenance

8.2 Fish Production Records

Fish health records include information on each batch of fish on site, fish movement records, daily feed consumption, growth rate and feeding behaviour, mortality records, water quality records and medicated feed records.

List of records and associated form in Appendix 4

8.3 Handling drugs and chemicals

Medicated feed should be properly stored in clearly marked bags separately from non-medicated feed. The label on the medicated feedbag should include details about the type and percentage of drug in feed, name of veterinarian who prescribed the drug, and date of manufacture. Medicated feed should be fed out in accordance with the veterinarian's instructions, handled according to Material Safety Data Sheet (MSDS) of incorporated drug and the appropriate withdrawal period carried out.

Biologicals include vaccines. Where applicable, these products will be kept refrigerated and handled as per manufacturer's instructions.

Disinfectants will be stored in clearly marked containers, and handled according to the MSDS.

SOP000 - Administering medicated feed, storage of biological and chemicals including disinfectants

8.4 Treatment records

Useful information includes mode/type/rate/duration of drug used, name of the prescribing veterinarian, and specific batch of fish treated and response/outcome. The date of last treatment is important for honouring withdrawal periods or declaration purposes at time of slaughter.

Chapter 9 Gaps and Research & Development

This is an important chapter with respect to a culture of continual improvement on the management and operation of the farm. Fish health and production records are only valuable as far as this leads to future research and development to address some of the health issues that may be encountered on the farm.

Examples include improving the management of the effects of endemic pathogens on fish, reducing stress by introducing better farm practices such as more regular grading, or reducing cannibalism during any procedure that requires handling of fish by improving conditions during anaesthesia for grading or weight checks.

Establishing an algae monitoring program to establish patterns of algae bloom may be beneficial to fish health in some sites where this information is not readily available, and ensuring safe food fish product to the consumer chains.

Overall, this chapter address the short to medium term farm activities that seeks to improve overall health and hence production levels on farm. Perhaps the drafting of a form to aid the putting together of potential research ideas may be useful to help shape the direction of useful research by putting thoughts to paper. It will give management and operational staff the power to drive change.