Output 8: Learning resources for Fish Health

Introduction

The learning resources in this guide have been designed to support 'short episodes' of focussed learning' on a specific topic within the Fish Health section following the Recognition of Prior Learning (RPL) using the multiple-choice question sets. Each episode has a title and number that relates it to a specific multiple-choice question or questions within the subject area.

The resources cover the measures fish farms can take to prevent and treat fish diseases as well as identify disease symptoms. The aim is to provide experienced husbandry operatives with enough information, insight and understanding of fish health and welfare so as they can do everything within their authority to reduce the risk of fish disease on their farm.

The multiple-choice questions and learning resources have been designed to satisfy the level of knowledge and understanding prescribed by the Scottish Aquaculture MA level 2 (husbandry operative). In addition to the learning episodes there is an interactive fish on power point that has been designed to help learners to relate structure to function as they self-study.

The RPL/APL system is designed for experienced work-based learners with some knowledge, as well as knowledge gaps who wish to 'fast track the assessment and accreditation of their knowledge.

(See spread sheet guide to Scottish Optimal RPL and follow up through guided self-study learning)

Recommended pedagogy for RPL/APL

Step 1- Undertake multiple choice questions for the section

Step 2 Automated RPL to determine which questions have not been answered correctly in full

Step 3 (a) Automated documentation and QA of correct responses for submission for accreditation of specific knowledge

Step 3 (b) Self -study guided by the RPL results and feed back

Step 4 Second Multiple Choice (MC) with alternative question (same topics and level) or complete alternative approved summative assessment leading to accreditation.

(Note: Alternative MC questions will need to be developed by the VET user as only one set is available from the optimal project.)

Using these resources

The multiple-Choice questions can be presented by Rapid Response technology via hand-held devices or presented within a Virtual Learning Environment, which is the recommended method for independent work-based learners.

A well designed VLE with high level assessment functionality and grade book will allow the full automation potential of the system to be gained, as well as supporting communication with tutors, farm supervisors and peers.

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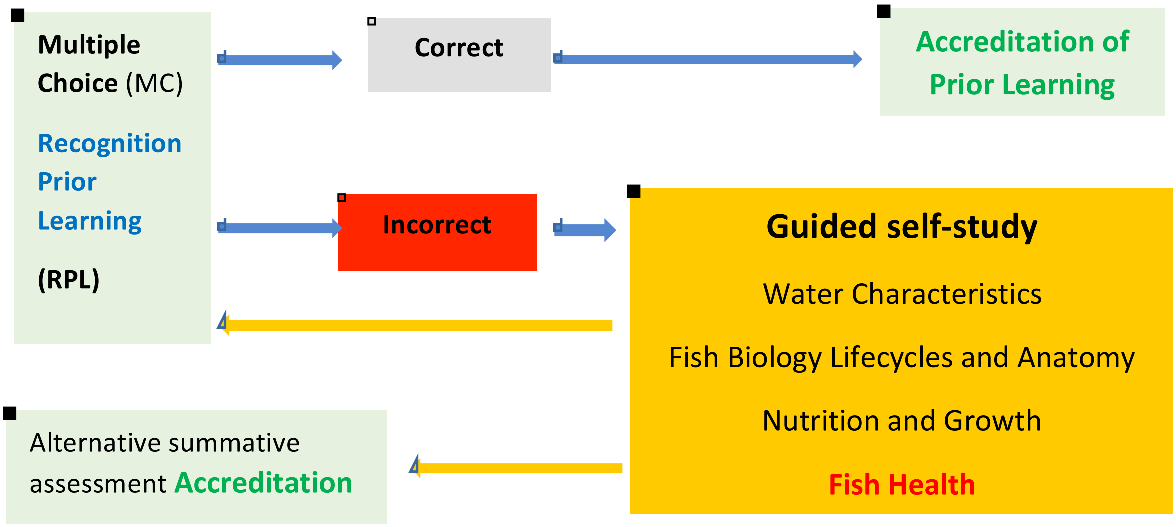
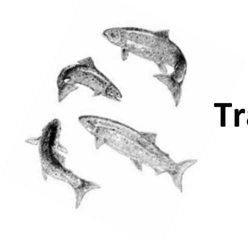


Graphic to illustrate recommended RPL/APL pedagogy for experienced work-based operatives

B1 Fish Health



Transmissible diseases

Fish diseases can be infectious or non-infectious. Infectious diseases are attributed to a range of pathogens (the collective name for the micro-organisms that cause infectious disease) and parasites. Fish are no different to other organisms and are susceptible to infection from a range of sources but do have defences to help them fight off potential infections.

What are the fishes first lines of defence from pathogens and parasites?

The first defence in the fish's armoury is the mucous layer, scales and the skin. These defences are known as 'non-specific', which means they will defend against all potential threats from the external environment.

The skin, scales and mucus produced by this rainbow trout are its first line of defence against pathogens and parasites

What happens if a pathogen finds a weakness in the external defence and enters the body?

The next line of defence is the fish's immune system, which will combat recognised pathogens. This is known as a specific defence and is activated in response to administered vaccines.

A vaccine introduces the body to an inactive sample of the pathogen to which the fish's immune system will respond. If the fish encounters the active pathogen in the future, the immune system will recognise it and produce an immune response that will challenge that specific pathogen.

How threatening are parasites?

Parasites in fish are a common natural occurrence, and most fish will carry parasites that can either be internal (endoparasites) or external (ectoparasites). Any disease outbreaks in fish are rarely attributed to the presence of the parasite alone, but usually come about due to a range of factors that increase the disease risk.

What parts of the fish anatomy are most susceptible to parasite attack?

As fish have gills with gill lamellae, they are particularly susceptible to parasitic infections and damage. In most cases the lamellae are very delicate structures, rich in blood capillaries and therefore protected by a gill cover called the operculum. Infestations or damage to the gills will influence the fish's ability to take in oxygen which will stress the animal. Stress is known to be a major factor in fish health and anything that elevates a fish's stress level will compromise the immune system.

How does stress contribute to fish diseases?

Stress is the result of a combination of chemical and physical factors that trigger a physiological reaction which can compromise a fish's natural defence against pathogens and in some cases lead to mortality. Stress in fish is a major contributory factor influencing their susceptibility to disease pathogens as their immune system and resistance to disease is weakened.

Some pathogens will kill off the infected host as part of their life cycle, but in most cases, it is in the interest of the pathogen to keep the host alive so that the pathogen may continue to thrive. As most fish carry pathogens with no signs or symptoms of disease there will usually be other factors that will interact to compromise the fish's immune system and cause a disease outbreak.

It is therefore important that not only should the disease be treated, but the underlying cause and potential factors causing stress should also be addressed.

It is important to note that prevention is always better than a cure!

What factors could lead to an increased risk of disease?

Below are some of the main potential contributory causes of disease outbreaks in an aquaculture environment:

Overcrowding

This can lead to increased stress through competition for food and space. In addition, there will be an increase in fin and tail damage through fish 'nipping' when in proximity. There will also be an increase in oxygen demand which lead to a further deterioration in conditions as stress levels grow.

Prevention: By the careful planning and monitoring of fish production, overcrowding is avoidable. Fish stocks should be held in holding units at or below the recommended stocking density for that unit. It is advisable to stock a holding unit well below its maximum stocking capacity as this will allow the fish space to grow. When stocks get close to the upper limit they should then be split or graded, reducing the stock density to ensure overcrowding does not become an issue. (Note that care should be taken not to reduce densities below the recommended level of 40-50Kg/M3 for Arctic char, as this can stress the fish due to increased territoriality).

- Poor hygiene/biosecurity

if hygiene and biosecurity are ignored the potential for a serious disease outbreak will increase. A failure to; quarantine of new stocks on site or at times when a disease is suspected, movements within a site, remove and dispose of dead fish routinely and disinfect equipment between holding units including staff PPE can all increase disease risk.

Prevention: To reduce the risk of hygiene and biosecurity causing problems on an aquaculture site a few rules should be observed.

- All new stocks on site should be quarantined and observed before entering the production site. Any problems should be addressed and/or reported to a specialist fish veterinarian.

- All holding units should be checked and any mortalities removed daily and examined to establish the cause of death, recorded in stock records and disposed of according to Standard Operating Procedures to prevent any contamination of other stocks.

- All equipment, including PPE, should be disinfected before and after use in each holding unit Ideally each holding unit will have its own equipment which will further reduce the potential for spreading of disease.

Poor handling

if fish are not handled correctly during grading, moving, netting or transportation they can suffer serious injuries that will make them more susceptible to disease. Once the protective mucous layer of the fish becomes damaged, its effectiveness as a barrier is reduced. Any further damage to the fish's skin and scales, further compromising the integrity of the skin as a physical barrier, allowing pathogen entry. The fish's ability to osmo-regulate is also compromised, leading to further stress the fish.

Prevention: To ensure that poor handling does not contribute to deteriorating fish health, the following simple rules should be followed.

- Only use equipment that is suitable for handling fish, including; nets with knotless mesh, tables and machines with smooth surfaces made of stainless steel or fibreglass.

- Keep handling to a minimum, but when fish must be handled ensure it is done swiftly and gently in a manner that minimises the risk of injury and stress.

- Monitor water quality before, during and after all handling operations and maintain optimum conditions throughout.

Poor water quality

If water quality conditions are not routinely monitored and any deterioration is not dealt with promptly, there is an increased risk of fish becoming infected with a pathogen leading to mortality among stocks. Water quality can deteriorate for several reasons including low dissolved oxygen, water temperatures that are too high or low, pH too high or low or an increase in other parameters such as ammonia and carbon dioxide. The water quality conditions inside a holding unit can deteriorate through something as simple as overstocking.

Prevention: To prevent water quality problems arising the following routines should be applied:

- Monitor all main water quality parameters routinely including; oxygen, pH, water temperature, salinity, ammonia.

- Promptly take action to adjust any water quality parameters that are outside prescribed levels, or even borderline for the species being farmed.

- Maintain stocking densities in holding units at a level that will allow fish growth to prevent overstocking and reduce the build-up of metabolic wastes (ammonia, nitrite and carbon-dioxide)

- Ensure mortalities and any organic waste are removed daily to prevent accumulation that would allow an increase in toxic nitrogenous wastes (ammonia and nitrite)

How can you stop transmissible diseases from entering a fish farm?

Any new stocks either brought on site or transferred within a site have the potential to infect other stocks. Despite careful sourcing of suppliers, fish from another site may be infected with a pathogen. There are risks from moving fish within the same site. For example, young stock moving from the hatchery to the main on-growing site could become infected with a pathogen that was not present in the hatchery due to being on a different water supply such as a spring or borehole.

Prevention: To prevent the risk of disease from stock movements the following should be observed:

- Any new incoming fish stocks must be maintained in holding units that do not flow into other stocks on the site.

- All equipment used on incoming stocks must be disinfected before and after use and between holding units. Equipment used for quarantine stocks should not be used elsewhere on the site.

- Stocks brought on site or moved within a site should be monitored and observed for signs of disease and any outbreak dealt with promptly.

These preventative measures can be summarised in one word – **'quarantine'**

Can disease prevention measures be summarised for the fish farm staff room wall?

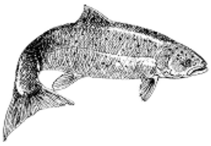
Stress and the presence of a pathogen are not the only factors that can lead to disease outbreaks.

The prevention of disease is easier to implement than managing a disease outbreak and prevention is the best form of disease control.

This can be achieved through good stock management practices which can involve;

- good biosecurity,
- good stock handling,
- correct nutrition,
- monitoring and maintaining water quality,
- quarantine procedures and
- the prevention of overcrowding.

B2 Fish Health



Non transmissible fish diseases

There are some diseases which are not transferred between fish stocks and do not involve disease pathogens. They are classed as non-transmissible and generally categorised as:

- Nutritional
- Genetic
- Water quality (environmental)
- Nutritional

Nutritional diseases

Feeding fish on a nutritionally imbalanced diet that is low or deficient in some essential nutrients can lead to disease problems among fish stocks. Diseases caused by poor nutrition are rare in modern aquaculture as high quality and nutritionally balanced diets are the norm. There may however be occasional nutritional problems caused by poor feeding practices and feed quality deterioration due to poor storage. The diseases attributed to nutritional deficiencies are usually chronic and poor food conversions and growth are often the first signs, which can progress to changes to skeletal structure and outward appearance. If this is not addressed there will be a slow but steady increase in mortality.

Which nutrients are essential to fish health?

Most nutritional diseases can be attributed to a deficiency in one category of dietary components. Each category has been exemplified below:

- **Vitamins** – a deficiency in vitamins such as vitamin C (ascorbic acid) is linked to skeletal deformities, fin ulcers and reduced healing. This is an essential nutrient that is sensitive to temperature changes and easily oxidised in storage.
- **Minerals** - a deficiency in minerals such as Phosphorous (P) can lead to reduced growth, poor feed efficiency and skeletal problems
- **Fats** – a deficiency in Essential Fatty Acids (EFAs) such as linolenic and linoleic acids, which are important for cellular structures, and are linked with fin damage such as erosion and pigmentation problems.
- **Proteins** - a deficiency in Essential Amino Acids (EAAs) such as Methionine can lead to reduced growth rate and the development of eye problems such as cataracts.

Note that vitamins and minerals are needed in fish diets in relatively small quantities and are called 'micro-nutrients'. Proteins and fats are needed in higher quantities and are called macro-nutrients.

What are essential Amino Acids and Essential Fatty Acids?

Amino acids are the building blocks of protein and ten of them are essential in the diet, as they cannot be manufactured by the fish or substituted. If just one of these essential amino acids is low, even if the other nine are at the required level, fish growth will still be restricted.

The same principle applies to the Essential Fatty Acids which make up the fat content of the diet. The Omega 3 and Omega 6 fatty acids are essential to the normal development of cellular membranes

Prevention: To avoid feed and nutrition causing health problems for fish stocks the following should be observed:

- Fish are fed high quality diets which are formulated and balanced to meet the nutritional requirements of the species and life stage.
- Fish are fed according to the manufacturers feed rates for the species, life stage and environmental conditions.
- All food is stored in a dry cool environment that is free from pests and vermin. In addition, any feed showing signs of deterioration and/or mould should be discarded immediately.

Genetic diseases

There are a few genetically induced diseases that can occur in farmed fish stocks that are also found in wild stocks. The prevalence of genetic diseases is higher in farmed stocks due to the increased potential for inbreeding limiting the gene pool. Genetic diseases become more noticeable in farmed stocks as such fish survive longer than they would in the wild.

This angler's sub nosed trout survived (until caught) despite its genetic disease

Examples of genetic diseases in fish include:

- Snub nose – the fishes top jaw is shortened giving the head an unusual shape.
- Spinal deformity – the fishes' spine does not grow properly and results in deformities such as scoliosis.
- Shortened body – fish have a stumpy shape to the body that is much shorter in length than normal.
- Siamese twins – two fish co-joined at the head or tail, most notably observed in juvenile fish at the alevin and fry stages.

Prevention: Most genetic diseases can be prevented or minimised by improving stock management procedures.

- Brood-stock management – selection of brood-stock free of signs of any deformities.
- Outsourcing – in addition to good brood-stock management, new stocks should be routinely introduced to the gene pool to reduce the effects of inbreeding.
- Hatchery procedures - comprehensive hatchery record-keeping and individual brood-fish tagging can assist planning and control of spawning. Controlling the brood-stock used at each egg fertilisation event will reduce the risk of inbreeding.

Water quality related diseases

Water quality is critical when considering fish health and welfare. In an intensive aquaculture environment, it is important that water is supplied by a reliable source of a suitable quality and routinely monitored and maintained at the highest standard. Any deterioration that is not dealt with promptly increases the risk of fish becoming stressed, then infected with an opportunistic disease pathogen.

Water quality can deteriorate for various reasons, including;

- low dissolved oxygen (often the result of respiration by aquatic biomass (fauna and flora),
- water temperature flux (high or low due to climatic changes),
- pH flux - high or low (due to biological activity and/or acidifying land uses) and
- increases in the concentration of naturally produced toxic substances such as ammonia, carbon dioxide.

What non- transmissible water quality diseases can occur on a fish farm?

- Methaemoglobinaemia – caused by increased nitrogenous wastes e.g. nitrite toxicity
- Gas Bubble Disease – caused by supersaturation of gases in the water such as nitrogen gas in pumped water
- Nephrocalcinosis – caused by increased carbon dioxide
- Acidosis/Alkalosis – caused by increased carbon dioxide

The water quality conditions in a holding unit can deteriorate through something as simple as overstocking, including increased levels of toxic ammonia. This can of course be easily rectified by reducing the stocking density.

Poor water quality is particularly problematic if it occurs during the hatchery stage, as the fish are less robust and more susceptible to disease problems. There are specific problems associated with the use of ground water by hatcheries, despite their purity. 'Gas bubble disease' represents a real risk, if not addressed.

The trend towards closed recycled aquaculture systems (RAS) addresses this issue by constant monitoring and control of water quality using mechanical and biological filtration that removes solid and dissolved organic wastes.

Prevention: The following routines prevent water quality related diseases:

- Monitor all main water quality parameters routinely including; oxygen, pH, water temperature, salinity and ammonia.
- Prompt adjustment of any water quality parameters outside prescribed limits, or borderline for the species and life stages being farmed.
- Maintain stocking densities appropriate to the holding units and at a level that will allow for fish growth and prevent overstocking.
- Ensure mortalities are removed daily to prevent accumulation that would allow an increase in nitrogenous wastes such as ammonia and nitrite.
- Feed high quality digestible diets that are carefully rationed to reduce the level of organic wastes from fish feed and excreta.

- Apply water quality control technologies such as degassing equipment and filtration-Recirculation Aquaculture Systems (RAS)

B3 Fish Health

Stress

Stress is a word that can be used to describe many situations and responses experienced by humans and animals. But what does the term stress mean when applied to farmed fish?

The Chambers Dictionary defines stress as 'mental, emotional, or physical strain or tension'. Stress can result from a combination of chemical and physical factors that cause a physiological reaction and compromise an animal's natural defence against disease. Stress in fish has a major influence on their susceptibility to pathogens as their immune system is weakened.

What is happening to a fish when it is stressed?

Under stress, fish will elicit a stress response, known as 'fight or flight', and release stress induced hormones in preparation to react to the stressor.

A series of physiological reactions lead to energy being supplied to the muscles, and include:

- Release of cortisol
- Increased heart rate
- Increased blood pressure

It should be noted that these physiological changes are normal as stress aids survival and is designed to help the fish react to life-threatening dangers. In aquaculture, however, poor husbandry and poor stock management practices tend to be the more common stressors and they are manmade.

Are there different kinds of stress?

There are two types of stress and the reaction of fish to a stressor is normally appropriate to the level of the threat.

These Golden orfe are highly visible, but how easy is it see whether they are stressed?

- Acute stress

Normally the cause is short term, although effects can have long term implications

- Chronic stress

The cause is long term with accompanying effects that last long term

There are many factors that will influence the reaction of fish to a stressor, but ultimately the longer the duration of exposure to the stressor the more severe the stress response. If stress levels continue to increase the well-being of fish stocks will deteriorate further.

The deterioration will include a decrease in the fishes' immune response leading to an increased disease risk, appetite suppression, decreased growth all leading to increased mortality if not addressed.

Can fish husbandry staff notice signs of fish stress immediately?

The recognition of the early signs of stress is one of the most important skills for fish farm staff to acquire and lies at the heart of being a good stockman.

If fish are feeding less vigorously than they were yesterday, something may be stressing them

However, this can be challenging, as the initial responses of fish to the stressors may not be obvious and internalised such as the biochemical and physiological responses. The first indications to the husbandry staff that fish are stressed will normally be physical and behavioural signs, including:

- Increased respiration rate (rapid gill movement)
- Hyper-activity
- Fish rolling at the surface
- Reduced feeding
- Poor growth

Subsequently if the stressor continues unchecked, then this can lead to fish becoming more susceptible to disease (reduced immune response). Eventually, the early stages of a disease in the population may start to become apparent

- Symptoms of a transmissible disease
- Increased mortality

B4 Fish Health

Reducing stress in farmed fish

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What can stress fish in the aquaculture environment?

In any aquaculture production environment fish stocks can be exposed to a range of stressful situations at various stages of the production cycle, including:

- Routine handling - the stress responses increases if the fish are out of the water for too long or overcrowded in nets.
- Grading - which involves fish removal from the water and the potential for physical damage.
- Water quality fluctuations – such as decreased oxygen levels, extreme temperatures, pH flux and increase in dissolved toxic chemicals above the species tolerance limits.
- Predator activity – the presence of predators and/or damage from predators

- Poor husbandry and welfare - failure to remove mortalities, poor hygiene practices.
- Social interactions - fin/tail nipping as a result of overcrowding.
- Resisting disease – combatting pathogen entry (primary and/or secondary infection)
- Harvesting - inappropriate slaughter method and overcrowding for too long.

How can potential stressors be reduced in an aquaculture environment?

It would be virtually impossible to totally prevent all stressors in farmed fish, but there are broad considerations when planning to reduce the impact of stress on farmed fish stocks, including:

- Improving welfare standards
- Improve health management
- Improve stock husbandry and handling protocols
- Improve staff training and awareness

What specific practical on farm measures can minimise fish stress?

Some of the main practices that can reduce stress and improve welfare standards when adopted include:

- Maintaining stocking densities at an acceptable level and never allowing them to exceed holding unit maximum.
- Daily water quality monitoring (including water temperature and dissolved oxygen levels)
- Monitoring and predicting fish stock biomass and densities to maintain them within acceptable limits.
- Careful fish movement and handling, minimising time out of the water.
- Starvation before any fish handling operation

- Feeding a nutritionally balanced at a rate that is suitable for the species and life stage
- Serviceable equipment and well-maintained holding units appropriate to the task and free from abrasive surfaces

In addition to the above measures, disease prevention also assists as it reduces the risk of a disease outbreak leading to further stress and sometimes secondary infections.

This includes:

- Close observation of all incoming stocks before being introduced to the production site followed by quarantining.
- Appropriate biosecurity and disinfection procedures in place throughout the site.
- Routine fish health monitored according to the Veterinary Health Plan.
- Mortality removal and disposal daily.

All the above practices should be documented in the company and site Standard Operating Procedures (SOPs) to ensure that all staff adopt them as routine practices. They can form the basis of staff induction and training to ensure consistent application by all.

B5 **Fish Health**

Fish welfare

The regulations governing fish welfare in Europe are based on the premise that fish are sentient animals. This has come to the fore over the years as research has indicated that fish can experience fear and feel pain as do other farm animals. This has prompted the aquaculture to change its practices over the years to take account of those findings. The management of fish welfare an important consideration within the farming process.

There is more to animal (including fish) welfare than ensuring the animals are killed humanely at harvest

The process starts when fish farmers identify procedures that have a direct impact on fish health and welfare and put in place management protocols to mitigate. All management protocols should be documented within company Standard Operating Procedures (SOPs) to minimise unnecessary stress, damage and any other adverse effects on the health and welfare of fish stocks. This applies from egg up to and including the point of harvest. Consumers have become more aware of where food comes from and have become more concerned with ethical issues surrounding farmed animals. It is also known that poor welfare and handling can lead to much poorer flesh quality at harvest, which provides an additional commercial incentive to high welfare standards.

In Scotland the aquaculture industry adopted the 'Five Freedoms' devised by the Farm Animal Welfare Council and first formulated in the early 1990s. The 'Five Freedoms' have been incorporated into the Scottish Aquaculture Code of Good Practice.

What are the 'Five Freedoms'?

- Freedom from hunger
- Freedom from discomfort
- Freedom from pain, injury or disease
- Freedom to express normal behaviour

- Freedom from fear and distress

It is important that fish farmers take account of the implications of the 'Five Freedoms' as they have a duty of care to the animals they farm.

In Scotland the duty of care is covered by legislation under The Animal Health and Welfare (Scotland) Act 2006, which requires the fish farmer to protect fish under their care from harm and unnecessary suffering. This includes protection from predators, which can have a significant impact on fish welfare not only through damage by the predators but also increased fear and stress.

All of the 'Five Freedoms' can be achieved if fish farmers observe good husbandry practices at all stages of the production cycle.

Does this mean all farmed fish need to be treated in precisely the same way?

The freedom from hunger, discomfort and injury are perhaps the most straightforward and self-explanatory to interpret. However, freedom from fear and distress is more difficult as this parameter can be hard to observe in fish compared to other animals.

These Arctic char in Iceland are held at high densities to discourage territoriality and reduce distress

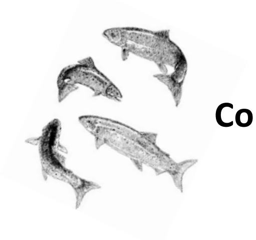
Allowing fish to 'express normal behaviour' can be misinterpreted. It is important that both farmers and the consumer are aware of the differences in the natural behaviour of different fish species.

This can be exemplified by the salmon family.

The Atlantic salmon during its early freshwater phase exhibits territorial behaviour, but during the marine feeding phase it is a shoaling species. Those farms providing the best of conditions for their salmon stocks during the marine phase are limiting stock densities to 10Kg/M3 in order to improve their welfare.

By contrast, if Arctic char were farmed at these low densities, they would start to become territorial resulting in agitation and stress. In the wild they live and feed together in densely packed shoals. Therefore, to reduce stress the fish farmer needs to maintain high densities in the fish tanks and 50Kg/M3 is considered the norm.

B6 Fish Health



Controlling transmissible diseases

Disease treatment in most animals cannot always achieved by administering medication. There are no treatments available for a wide range of disease pathogens or infections. Sometimes the only option available is preventative, which happens to be the best form of diseases control.

Viral diseases

If an infection is caused by a virus this can be the most difficult to treat as viruses are 'obligate' pathogens, which means they require a host to fulfil their life cycle.

A virus depends on the cellular mechanisms of the animal's own body to reproduce and thrive. It is also important to note that they can be spread vertically and horizontally. This means they can be passed from parents to their progeny and amongst individuals in the same population.

There are vaccines available to the aquaculture industry that can prevent outbreaks of certain viruses e.g. IPN, ISA, but they are limited and not available for all viral infections.

The most important way to control any disease pathogen including viral infections is by prevention and eradication of the virus. Eradication can be difficult to achieve as some viruses can survive outside the host for considerable time periods, waiting for a new opportunity to infect a population.

How can a viral infection be prevented?

The prevention of a viral infection is key and can be achieved by following;

- strict bio-security policies,
- stock quarantine,
- routine monitoring and
- general good animal husbandry.

Viruses in fish are the most difficult pathogen to control, and as a result many of them are listed as Notifiable Diseases.

Bacterial diseases

If an infection is caused by bacteria there are medications available for use as disease treatments. Bacteria are single celled organisms that are much larger than viruses, with some being either opportunistic whilst others are obligate pathogens. It is also important to note that some bacterial infections can be spread vertically and horizontally.

The range of medicinal treatments available for use against bacterial infections include vaccines, antibiotics and anti-bacterial flushes.

The most important way to control any disease pathogen including bacterial infections is by prevention and eradication of the disease-causing bacterium. Prevention of a bacterial infection is key and can be achieved by;

- following strict bio-security policies,

- quarantine of stocks,
- routine monitoring and
- general good animal husbandry.

Some bacterial diseases in Atlantic salmon are listed as Notifiable Diseases in Scotland.

Fungal diseases

If an infection is caused by fungi, there are medications available for use as disease treatments. Most fungi obtain energy from dead and decaying plant or animal materials, but some are parasitic and can infest the living tissues of plants and animals. There are very few fungal pathogens of fish but most that infect fish are parasitic fungi made up of tubular filaments called hyphae. Parasitic fungal infections in fish are normally a secondary external infection taking advantage of physical damage to the fish. Fungal infections grow by hyphae spreading through the host animals' tissues creating a mat with a cotton wool appearance.

The range of medicinal treatments available for use against fungal infections in fish are limited and are usually administered as a bath treatment.

The most important way to control any disease pathogen including fungal infections is by prevention and eradication of the fungi. Prevention of a fungal infection is key and can be achieved by;

- following strict bio-security policies,
- quarantine of stocks,
- routine monitoring and
- general good animal husbandry such as the immediate removal of dead and dying stocks to reduce the potential reservoir for fungal growth.

Some fungal infections can be internal and often attributed to a dietary issue. This can be prevented through improved feed management and hygiene.

Parasitic diseases

Parasitic diseases of fish include a diverse range of species from single celled organisms called protozoa, which are similar in size to large bacteria, up to more complex vertebrate species such as lampreys.

Most parasites that infest fish are motile (can swim or move through the water) and are categorised into the groups tabulated (see left).

Parasite group	**Parasite example**
Protozoans	Single celled organisms e.g. Costia
Trematodes	Flukes, flatworms
Cestodes	Tape worms
Nematodes	Round worms
Hirudinae	Leeches
Acanthocephalans	Thorny headed worms
Crustacea	Crustaceans e.g. Sea lice
Molluscs	Larvae of freshwater mussel e.g. Glochidial infestation

Where are parasites found in the fish?

Parasitic pathogens of fish can be found externally (Ectoparasites) or internally (Endoparasites) and can infest a range of tissues and organs leading to a variety of symptoms. Some of the parasites will live and reproduce on a single host species (direct life cycle), whereas others will have a complex life cycle which requires more than one host to complete their life cycle (indirect life cycle).

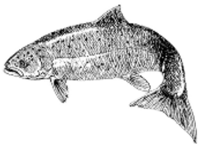
There are a range of medicinal treatments available for use against parasitic infections in fish, which can be administered as chemical bath or flush in the water or as an infeed treatment.

The most important control of any disease pathogen including parasitic infections is by prevention and eradication of the parasite. This can be difficult as most parasites are naturally occurring within aquatic environments. Prevention of any parasitic infection is key and can be achieved by;

- following strict bio-security policies,
- quarantine of stocks,
- routine monitoring and
- general good animal husbandry to reduce stress

Reducing stocking densities and the immediate removal of dead and dying fish will reduce the potential reservoir for parasites.

B7 Fish Health



Bacterial diseases of Atlantic salmon

The treatment of diseases in most animals is not always achieved by administering medication and sometimes, there are no treatments available. If an infection is caused by bacteria there are medications available as effective disease treatments. Bacteria are single celled organisms that are much larger than viruses, with some being opportunistic whilst others are obligate pathogens. It is also important to note that some bacterial infections can be spread vertically (from parents to offspring) and horizontally (from fish to fish within the same population).

Rod shaped non-motile Vibrio

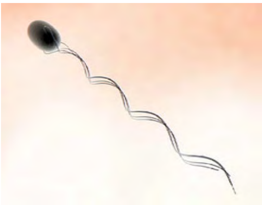
There are a few bacterial fish diseases that can infect farmed Atlantic salmon, in both the freshwater and marine environments, including:

- Furunculosis
- Enteric Redmouth (ERM)
- Bacterial Kidney Disease (BKD)
- Vibriosis

The gross external pathology of bacterial diseases is variable and ranges from a complete lack of clinical signs to visible external and internal symptoms. (See below)

What do the bacteria look like?

Bacteria are a type of biological cell surrounded by a cell membrane made primarily of phospholipids. This encloses the contents of the cell and acts as a barrier to hold nutrients, proteins and other essential components of the cytoplasm within the cell. They reproduce by asexual methods and unlike a virus, do not need a host to survive.



Typically, a few micrometres in length, bacteria have several shapes, ranging from spheres to rods and spirals. Some have flagella and are motile whilst others are immobile. They are part of a large group of prokaryotic microorganisms.

What are the behavioural symptoms of fish infected with a bacterial disease?

The first stage of disease diagnosis is the vitally important initial observations of behavioural changes, which although non-specific, must not go unnoticed and unreported on a fish farm.

Infected fish may separate themselves from others and show signs of nervousness. This may be followed by an increased rate of mortalities, fish swimming near the surface or at the edges of the unit, showing external darkening and a poor feeding response.

Can you tell by looking at an infected fish which bacterial disease it is suffering from?

The next stage is the visible 'gross pathology' that can be seen with the naked eye. This can be problematic as there are many 'shared' symptoms are across a range of bacterial diseases.

Salmon smolt with furuncle clearly indicative of Furunculosis

Some symptoms are termed 'microscopic pathological' signs. For example, one symptom of furunculosis is fusion of the gill lamellae due to necrosis of the epithelium, which can only be revealed through microscopic examination.

It is possible on a well-equipped site for scientists (trained in fish pathology) to undertake microscopic examinations. Some farms will engage a fish veterinary specialist to undertake this work.

A minority of gross pathological symptoms are typical and distinctive and can help to diagnose the disease based on the initial visual inspection.

These have been indicated in the table of symptoms below in large red font.

Unfortunately, some of the most distinctive and confirmatory symptoms are not always so evident as this furuncle above, which is typical of Furunculosis.

Symptom (Note: Y = yes evident, and S = sometimes evident)	Furunculosis	ERM	BKD	Vibriosis
furuncles (or boils) involving skin and/or muscle, progressing to crater lesions	**Y**			
protruding eyes (exophthalmia)	Y	Y	Y	
darkening of the skin	Y	S	Y	Y
haemorrhage at the base of the fins	Y	Y	Y	Y
Haemorrhage on skin or mouth	Y			Y
haemorrhages at vent	Y	Y		Y
gills appear pale and anaemic	Y		S	
fluid accumulation in the abdominal cavity (ascites)		Y	S	
enlargement of the kidney			**S**	
reddening (subcutaneous haemorrhages) of the gill cover, corners of mouth, gums, palate and tongue		**S**		
loss of appetite		Y		

swollen abdomen		Y		
pinpoint haemorrhages on liver, pancreas, pyloric caecae, swim bladder, lateral musculature surfaces	Y	Y		Y
cataracts and cranial haemorrhage (in fry)				Y
enlarged, friable black spleen		Y		
enlarged spleen	Y			Y
focal necrosis of liver	Y			
distended mucoid and necrotic intestine				Y
inflamed lower intestine with thick yellow fluid.		Y		
stomach filled with mucus, blood and sloughed epithelial cells	Y			
Congested intestine	Y			
Bloody discharge (nares or vent)	Y			

How can a specific bacterial disease diagnosis be confirmed when the symptoms are so similar?

Clearly, observations of the gross pathology and even microscopic pathology are not normally enough to confirm a specific diagnosis, as required to prescribe the correct chemical treatment.

Confirmation requires laboratory bacterial cultures from infected tissues to be tested for a specific identification of the pathogen.

Once established, a bacteria culture can be subjected to a series of chemical tests. 'Gram staining', determines whether they are gram positive or gram negative and allows them to be placed in one of these two main groups.

This alone is enough to differentiate the gram positive 'Renibacterium salmoninarum' (BKD) from the gram negative Aeromonous salmonicida (Furunculosis) or Vibrio salmonicida in the table below.

However, a series of additional chemical tests is required to that allow bacteriologists to confirm the identification of the bacterium acting as the causative agent (pathogen).

Bacterial disease	Causative agent (pathogen)
Bacterial Kidney Disease BKD	‘Renibacterium salmoninarum’ a small, non-motile, Gram-positive rod-shaped bacterium that usually occurs in pairs referred to as diplobacilli
Enteric Redmouth ERM	‘Yersinia ruckeri’ - Hagerman strain, serotype O1a which is the most virulent.
Vibriosis	‘Vibrio salmonicida’ - of major importance to salmonid fish culture. It is a Gram negative curved and rod-shaped bacterium with a single polar flagellum
Furunculosis	‘Aeromonous salmonicida’- a non-motlie, Gram-negative bacteria that tests positive for oxidase, lysine decarboxylase, methyl red, gelatin hydrolysis, and catalase.

Table: Bacterial diseases and their causative agents

What role does the fish husbandry person play in bacterial disease identification?

From a fish farmers perspective, their role is to do all they can to prevent disease, but once a fish population has become infected they are relied on to recognise and report any behavioural changes (initial symptoms) and take tissue samples of fish suspected to be infected.

Although bacterial disease identification is a job for a specialist pathologist, the fish farm stockman does have a very important role to play in the process.

- Initial observation and recording of behavioural change, feeding, appetite and general activity
- Removal of mortalities, counting and recording to provide early warning of bacterial disease outbreaks
- Observations of gross pathology (and possibly micro pathology) of infected individual fish
- Tissue sample of a diseased fish to be sent to the veterinary lab

There are guidelines that fish farmers should be familiar with and apply on the farm when taking tissue samples for laboratory analysis.

How can bacterial diseases be combatted?

The range of medicinal treatments available for use against bacterial infections include vaccines, antibiotics and anti-bacterial flushes. The veterinary specialists will prescribe the treatment based on their analysis and identification of the pathogen. (see above)

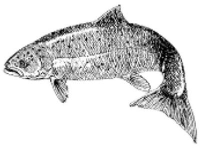
Prevention is always better than cure!

The most important way to control any disease pathogen including bacterial infections is by prevention and eradication of the disease-causing bacterium. Prevention of a bacterial infection is key and can be achieved by;

- following strict bio-security policies,
- quarantine of stocks,
- routine monitoring and
- general good animal husbandry.

Some bacterial diseases in Atlantic salmon are listed as Notifiable Diseases in Scotland.

B8 Fish Health



Tissue sampling for lab analysis

The identification of bacterial diseases is a specialist job normally performed in a laboratory by specialist and highly trained pathologist. However, they rely on suitable samples being brought to them form the fish population on the farm that has a suspected disease problem. This is an important job normally undertaken by the fish farm husbandry operatives or sire manager.

How does the fish farm worker ensure that they take a high-quality sample?

There are some general guidelines:

- Moribund (dying) fish are the preferred sample
- Where possible sample at least 5 fish
- Maintain minimum tissue: fixative ratio of 1:10

Standard sample sites:

When tissue samples are needed from specific organs, the fish must be dissected, and organs recognised

- Internal – heart, liver, anterior and posterior kidney, brain, spleen, pyloric caecae, hind gut.
- External – skin lesions, skin across the lateral line, gills, eye

In order to take samples from the appropriate sites and label them accurately, the farm operatives must have a good knowledge of external and internal fish anatomy.

What precautions must be taken?

The quality of the sample affects the quality of the result.

- Do not use mortalities as post-mortem tissue changes prevent diagnosis
- Do not use scissors to cut tissues when collecting samples
- Do not over fill sample containers with tissues
- Ensure that tissues are well immersed in fixative
- Take care when using buffered formalin; the fixative is toxic by inhalation, ingestion and skin contact

Do the procedures vary when sampling large as opposed to small fish?

For all fish, large or small, the fish should be carefully examined for any obvious abnormalities which are then recorded. Depending on their size the fish are then dissected.

Small fish:

Fish less than 3cm in length can be placed directly in fixative.

For fish between 4-10cm, make a slit along the abdomen, remove the opercula and place directly in fixative

Large fish:

- Cut out several gill arches and place in fixative.
- Carefully open the fish
- Record any internal gross abnormalities noting their position
- Remove the tissues as listed above under standard samples sites; each piece should not exceed 1cm cubed
- Do not crush tissues with forceps or scissors
- Place all tissues in the one sample container, maintaining a sufficient volume of fixative

Submission

Label the samples clearly with fish number, date and serial number

- Check that sample container lids are secure and seal rim with paraffin tape.
- Pack separately from culture plates and surround with absorbent material
- Keep samples cool; refrigeration is not required
- Send to the Veterinary pathologist as soon as possible

B9 Fish Health

Viral diseases of Atlantic salmon

The treatment of diseases in animals cannot always achieved by administering medication following infection and there are no treatments available for a wide range of pathogens. Sometimes the only options available are preventative measures.

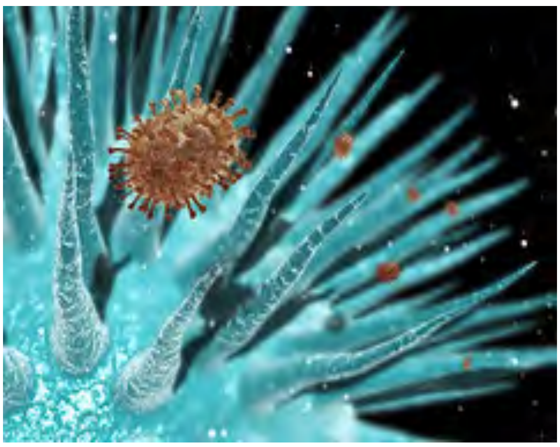
If an infection is caused by a virus this can be the most difficult to treat as viruses are obligate pathogens, which means they require a host to fulfil their life cycle. A virus depends on the cellular mechanisms of the animal's own body to reproduce and thrive.

It is also important to note that viruses can be spread vertically (from parents to offspring) and horizontally (from fish to fish within the same population).

What do viruses look like?

A virus is a small infectious agent, as opposed to being described as a biological cell, 10 to 100 times smaller than bacteria. They can only replicate inside the living cells of an organism and therefore, rely on their host for survival.

The basic structure of virus is a nucleic acid core (either DNA or RNA but not both) surrounded by a protein coat. Central core of nucleic acid of a virus is called the genome and the protein coat surrounding is called as capsid which makes it tough enough to survive between hosts.



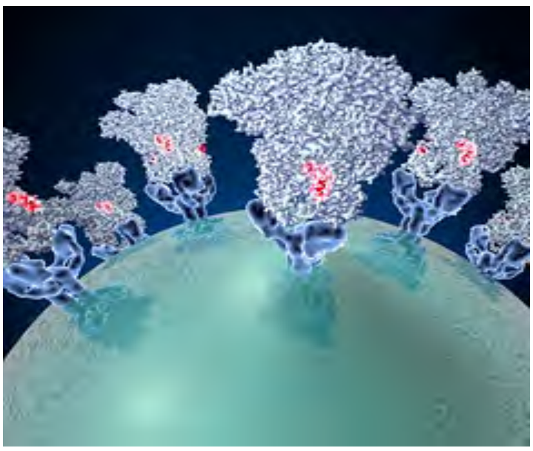


Figure: The protein coat (capsid) can form an elaborate and complex structure

There are a few viral fish diseases that can infect farmed Atlantic salmon, in both the freshwater and marine environments.

What are the behavioural symptoms of fish infected with a viral disease?

The first stage of disease diagnosis is the vitally important initial observations of behavioural changes, which although non-specific, must not go unnoticed and unreported on a fish farm.

Infected fish may separate themselves from others and show signs of nervousness. This may be followed by an increase in mortalities above the normal rate, fish swimming near the surface or at the edges of the unit, showing external darkening and a poor feeding response.

Some of the viral diseases that can infect Atlantic salmon include:

- Viral haemorrhagic septicaemia (VHS)
- Infectious haematopoietic necrosis (IHN)
- Infectious pancreatic necrosis (IPN)
- Infectious salmon anaemia (ISA)
- Cardiomyopathy Syndrome (CMS)

Some behaviours are more disease specific, such as the bursts of spiral swimming during periods of lethargy seen in salmon suffering from IPN. The long periods of low-level mortality are also very typical and a strong indicator of CMS. In both examples the observation, recording and reporting of behaviours and mortalities by the husbandry operative will determine how quickly samples can be sent to the lab for confirmation.

What are the other symptoms of viral diseases?

Some of the other symptoms, such as a 'darkening of the skin' are non-specific and shared with most of the viral and bacterial diseases that salmon can suffer from. Some symptoms are very specific, such as the swollen endocardial cells in the heart of fish suffering from CMS but require a specialist pathologist and microscopic examination to confirm. However, the long-term low-level long-term mortalities referred to above will provide early warning signs.

The indicative symptoms are summarised below with the most distinctive and typical highlighted in red font (**Y**)

Symptom (Note: Y = yes evident, and S = sometimes evident)	VHS	IHN	IPN	ISA	CMS
Behavioural symptoms					
Lethargic fish showing bouts of frenzied activity			**Y**		
Low level mortalities over a prolonged period					**Y**
External and visible physical symptoms					
Protruding eyes (exophthalmia)	Y	Y			
Blood spots in the eyes				Y	
Darkening of the skin	Y	Y	Y		

Lethargic fish showing bouts of frenzied activity		**Y**			
Haemorrhage at the base of the fins		Y			
Gills appear pale and anaemic	Y	Y		Y	
Swollen abdomen		Y	Y		
Internal symptoms					
Severe anaemia				**Y**	
Swollen endocardial cells (heart)					**Y**
Myocardium loss of striations and necrosis (heart)					Y
Empty myocardial "tubes" filled with inflammatory cells (heart					Y
Infiltration of lymphocyte-like cells onto the pericardium					Y
Pancreatic necrosis			**Y**		
Fluid accumulation in the abdominal cavity (ascites)			Y		
Internal haemorrhages - liver, pancreas, pyloric caecae, swim bladder, lateral musculature surfaces			Y	Y	
Darkening of the Liver				Y	

What are the causative agents of these common viruses?

The causative agents of these viral diseases are specific pathogens, as specified below.

Viral disease	Causative agent (pathogen)
VHS	A Rhabdovirus - bullet-shaped and containing a single-stranded RNA genome. the Rabies Virus is a distant relative to VHSV. Confirmed diagnosis can be achieved by virus isolation followed by enzyme linked immuno sorbant assay (ELISA) or indirect fluorescent antibody test (IFAT)
ERM	'Yersinia ruckeri' - Hagerman strain, serotype O1a which is the most virulent.
Vibriosis	'Vibrio salmonicida' - of major importance to salmonid fish culture. It is a Gram negative curved and rod-shaped bacterium with a single polar flagellum
Furunculosis	'Aeromonous salmonicida'- a non-motlie, Gram-negative bacteria that tests

	positive for oxidase, lysine decarboxylase, methyl red, gelatin hydrolysis, and catalase.

How can viral diseases be treated?

There are vaccines available to the aquaculture industry that can prevent outbreaks of certain viruses such as IPN, ISA, but they are limited and not available for all viral infections.

The most important way to control any disease pathogen including viral infections is by prevention and eradication of the virus. Eradication can be difficult to achieve as some viruses can survive outside the host for considerable time periods waiting for an opportunity to infect a population. Prevention of a viral infection is key which can be achieved by following strict bio-security policies, quarantine of stocks, routine monitoring and general good animal husbandry. Viruses in fish are the most difficult pathogen to control, and as a result many of them are listed as Notifiable Diseases.

B10 Fish Health

External parasitic diseases of Atlantic salmon

The treatment of diseases in most animals is not always achieved by administering medication and in some instances, there are no treatments available for a wide range of disease pathogens or infections. Sometimes the only options available are preventative, which is the best form of disease control. If an infection is caused by parasites there are medications available for use as disease treatments.

Parasitic diseases of fish include a diverse range of species from single celled organisms (protozoa, which are similar in size to large bacteria), up to more complex vertebrate species such as lampreys.

Most parasites that infest fish are motile (can swim or move through the water) and are categorised into the following groups:

Parasite group	Parasite example
Protozoans	Single celled organisms e.g. Costia
Trematodes	Flukes, flatworms
Cestodes	Tape worms
Nematodes	Round worms
Hirudinae	Leeches
Acanthocephalans	Thorny headed worms
Crustacea	Crustaceans e.g. Sea lice
Molluscs	Larvae of freshwater mussel e.g. Glochidial infestation

Parasite groups and examples

Parasitic pathogens of fish can be found externally (Ectoparasites) or internally (Endoparasites) and can infest a range of tissues and organs and cause a variety of symptoms.

Some of the parasites will live and reproduce on a single host species (Direct life cycle), whereas others will have a complex life cycle which requires more than one host to complete their life cycle (Indirect life cycle).

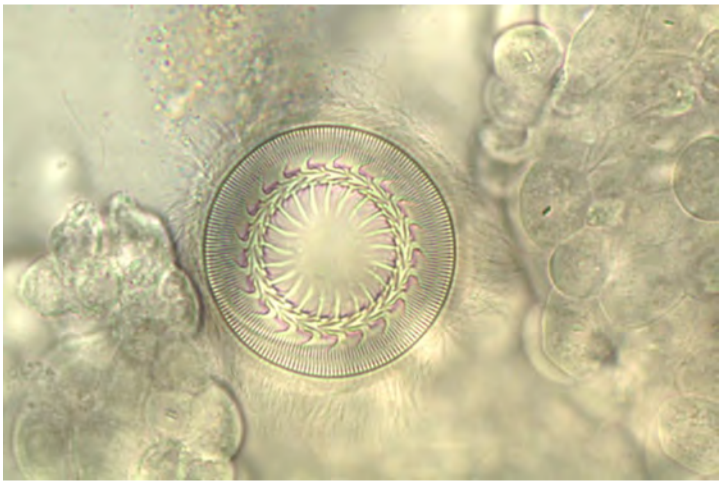
There are a few external parasites that can infest farmed Atlantic salmon, in both the freshwater and marine environments.

Which external parasites can infect Atlantic salmon?

- Amoebic Gill Disease (AGD) (Marine)
- Ichthyobodo
- Trichodina
- Sea lice (Marine)
- Gyrodactylus salaris (Freshwater)

What treatments are effective for external parasites?

There are a range of medicinal treatments available for use against parasitic infections in fish, which can be administered as chemical bath or flush in the water or as an infeed treatment.



The ciliate alveolate, Trichodina has interlocking cytoskeletal denticles used for adhesion to surfaces including fish tissue

The most important way to control any disease pathogen including parasitic infections is by prevention and eradication of the parasite. This can be difficult as most parasites are naturally occurring. Prevention of any parasitic infection is key and can be achieved by following strict bio-security policies, quarantine of stocks, routine monitoring and general good animal husbandry to reduce stress. This includes farming within stocking density limits and removing dead and dying stocks immediately to reduce the potential reservoir for parasites.

B11 Fish Health

Sea Lice

Sea lice are naturally occurring ectoparasite copepods that live in the marine environment and can be found on wild fish including migratory salmonid species during the marine phase of their lifecycle. There are many species of sea lice but the ones most commonly referred to in salmon aquaculture are *Lepeophtheirus salmonis* and *Caligus elongatus*. Sea lice can cause major problems for the aquaculture industry by impacting on fish welfare, and due to their potential for impact on wild fish stocks, the control of sea-lice is a controversial issue

An adult sea lice

There is also a serious economic impact to the aquaculture industry associated with losses and treatment of the sea lice problem. Sea lice do not normally cause significant damage to adult fish, unless infestations are particularly severe. However, they can cause high mortalities among young salmonids, particularly those in the smolt stage if infestations are heavy.

What is the sea lice life cycle?

Sea lice are crustaceans that have a multi-stage life cycle. The larval phase is pelagic with two stages; the nauplii stage are newly hatched larvae that cannot swim and drift with the currents. The copepodids stage larvae have a limited swimming ability and it is at this stage that the sea lice can spread from fish to fish.

Once they find a host they will attach. Once attached, the larvae will feed on the fishes mucous and soft tissues and start to grow. As they feed and grow on the host, they move around the fish to find a mate and reproduce. Female sea lice can produce hundreds of eggs at a time in long strings.

What are the general approaches to sea lice control?

Sea lice infestation is by far the most significant and difficult health issue affecting the farmed Atlantic salmon industry. It is in the interest of aquaculture companies to ensure that lice burdens on contained fish stocks are kept to a minimum.

This can be achieved using a range of approaches, including;

- site fallowing (within farm area management plans),
- stock management practices (e.g. avoid mixing year classes on a site),
- using only licensed veterinary medicines under prescription and
- using cleaner fish where appropriate.

Many salmon farming companies cooperate using Farm Management Area Plans to co-ordinate the control of sea lice. This involves companies and farms in the same area coordinating their sea lice treatment operations to synchronise the treatments at each site to not only treat the lice problem on that site but also reduce the risk of re-infestation locally.

Sea Lice are much more damaging to young fish such as this Pacific salmon (Coho) smolt

How do the salmon farmers know when to treat for sea lice?

Site technicians as part of their routine monitoring will carry out visual lice counts at least once weekly. They will have agreed minimum standards on the numbers of lice per fish that are acceptable and sampling regimes (how many fish should be checked) for their Farm Management Area.

Company standards may exceed must cannot fall below these standards.

The site technicians will look for all life stages of the sea lice when recording their counts, for assessment by the site managers and veterinary specialists. This information will be used to plan the timing of the next sea lice treatment. The life stages that will be counted vary for each lice species

Lepeophtheirus salmonis

- Juveniles
- Pre-adults
- Adult males
- Adult females
- Gravid females

Caligus spp.

- All life stages

What are the symptoms of sea lice infestation?

The most obvious symptom of a sea lice infestation is the presence of the parasite. This will be observed during the routine sea lice checks carried out on each site. There are however other symptoms, as the parasite irritates the fish this leads to behavioural change, such as an increase in jumping, flashing and scraping on the sides of the cage net.

When *Lepeophtheirus.salmonis* have been feeding on a salmon whitish spots will be visible around the dorsal, head and gill area. When infestations are high there may be evidence of skin lesions and open wounds.

As the fish's defensive mucous layer, scales and skin have been compromised this will place further stress on the fish, including secondary infection from bacterial and fungal pathogens and a deterioration in the fishes' ability to osmo-regulate efficiently. If left untreated all this combination of factors will result in the death of the fish.

How can salmon farmers treat sea lice?

There are a range of treatment options employed to combat and control sea lice. The most widely used methods available include chemical (bath and infeed), and cleaner fish (wrasse and lumpfish).

Bath treatments involve reducing the holding unit size by enclosing the fish in a tarpaulin and adding a chemical such as azamethiphos or hydrogen peroxide to the enclosed area (bath) for a defined period. Using this method any attached sea lice will fall from the fish and die, but there are risks. The fish being treated may be overexposed to the chemical and as they are already in a weakened state, deoxygenation of the enclosed space during treatment will stress them further. All of which can be prevented through good management and monitoring practices. There is also a danger of non-target species in the aquatic environment being exposed to the chemicals introduced, unless the site has good flushing to dissipate and dilute the chemical once the treatment has been completed. Although the effects of the chemical bath treatment are instant, there is always the risk of reinfection soon after, hence the need for a coordinated 'Farm Management Area' approach.

The infeed treatment involves including a prescribed dose of a medicine such as 'SLICE' in the fish feed. Unlike the bath treatment, an infeed treatment has a more gradual effect that may be longer lasting than the bath treatments. This treatment makes it difficult for the lice to remain attached to the fish and they will fall off and die. As for the bath treatment there is always a risk that some of the treated feed may fall through the cage and be consumed by non-target species. This has the potential to affect non-target crustaceans.

Lump fish are effective cleaner fish at low water temperatures and are produced as 'cleaners

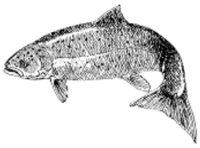
To avoid chemical treatments impacting on 'non-target crustaceans' in the marine environment the prescription and administration of all chemicals used in aquaculture is closely regulated.

Are there any alternatives to chemical treatment?

Cleaner fish are being used as a biological control to combat the sea lice problems faced by the salmon aquaculture industry. There are two species commonly used Wrasse species and Lumpfish. In both cases the cleaner fish are stocked with the salmon in the cages and feed by picking sea lice off the skin of the salmon.

This is a method that is becoming increasingly common and could be used effectively when combined with other methods to reduce chemical usage and provide whenever the chemical resistance of sea-lice appears to be a problem. Lumpfish tend to be used in low temperature conditions and wrasse at higher temperatures. It helps if the nets are kept clean as this deters the cleaners from grazing algae to keep them foraging lice more actively.

B12 Fish Health



Internal parasitic diseases of Atlantic salmon

Diseases treatment in most animals is not always achieved by administering medication and in some instances, there are no treatments available for a wide range of pathogens or infections. Sometimes the only option available is prevention, which is the best form of disease control. If an infection is caused by parasites there are medications available for use as disease treatments.

Parasitic diseases of fish include a diverse range of species from single celled organisms (protozoa, which are similar in size to large bacteria), up to more complex vertebrate species such as lampreys.

Most parasites that infest fish are motile (can swim or move through the water) and are categorised into the following groups:

Parasite group	**Parasite example**
Protozoans	Single celled organisms e.g. Costia
Trematodes	Flukes, flatworms
Cestodes	Tape worms
Nematodes	Round worms
Hirudinae	Leeches
Acanthocephalans	Thorny headed worms
Crustacea	Crustaceans e.g. Sea lice
Molluscs	Larvae of freshwater mussel e.g. Glochidial infestation

Parasite groups and examples

Parasitic pathogens of fish can be found externally (Ectoparasites) or internally (Endoparasites) and can infest a range of tissues and organs causing a variety of symptoms.

Some of the parasites will live and reproduce on a single host species (Direct life cycle), whereas others will have a complex life cycle which requires more than one host to complete their life cycle (Indirect life cycle).

There are a few internal parasites that can infest farmed Atlantic salmon, in both the freshwater and marine environments.

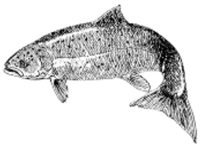
Some of the **internal parasites** that can infest Atlantic salmon include:

- Hexamita (flagellated protozoan)
- Cestodes (Tapeworm)
- Nematodes (Anisakis cause of Red Vent Syndrome)

There are a range of medicinal treatments available for use against internal parasitic infections in fish, normally administered as infeed treatments.

The most important way to control any disease pathogen including parasitic infections is by prevention and eradication of the parasite. This can be difficult as most parasites are naturally occurring. Prevention of any parasitic infection is key which can be achieved by following strict bio-security policies, quarantine of stocks, routine monitoring and general good animal husbandry including reducing stress, maintain stocking densities within limits appropriate to the holding unit and immediate removal of dead and dying stocks to reduce the potential reservoir for parasites.

B13 Fish Health



Fungal diseases of Atlantic salmon

The treatment of diseases in most animals is not always achieved by administering medication and in some instances, there are no treatments available for a wide range of disease pathogens or infections. Sometimes the only options available are preventative, which is the best form of disease control. If an infection is caused by fungi there are medications available for use as disease treatments.

Most fungi obtain energy from dead and decaying plant or animal materials, but some are parasitic and can infest the living tissues of plants and animals. There are very few fungal pathogens of fish but most of the ones that will infect fish are parasitic fungi made up of tubular filaments called hyphae. Parasitic fungal infections in fish are normally a secondary external infection following physical damage to the fish which weakens external defences (mucus, scales and skin). Fungal infections in fish grow as the hyphae spread through the host animals' tissues creating a mat with a cotton wool appearance. There will be a host of fungal infections that can affect farmed Atlantic salmon and their ova, but two can cause problems for farmed fish. One is commonly found in freshwater and the other can survive both the marine and freshwater environments.

The most common fungal infections that can affect farmed Atlantic salmon and their ova are:

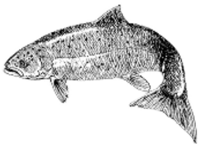
- Saprolegnia sp (Freshwater)
- Exophiala sp (Freshwater and Marine)

The range of medicinal treatments available for use against fungal infections in fish are limited and are usually administered as bath treatment.

The most important way to control any disease pathogen including fungal infections is by prevention and eradication of the fungi. Prevention of a fungal infection is key which can be achieved by following strict bio-security policies, quarantine of stocks, routine monitoring and general good animal husbandry including the immediate removal of dead and dying stocks to reduce the potential reservoir for fungal growth.

Some fungal infections can be internal and usually be attributed to a dietary issue. This can be prevented through improved feed management and hygiene.

B14 Fish Health



Disease prevention and treatment

All living organisms, including humans and other animals, will experience ill health during their life. This can normally be attributed a range of pathogens, which is a collective name for the micro-organisms and parasites causing transmissible (and infectious) diseases. Fish are no different from other organisms and are susceptible to infection from a range of pathogens, but they do have defences to help them fight off potential infections.

The first defence in the fishes' armoury is the mucous layer, scales and the skin. These defences are known as non – specific, which means they will defend against all potential threats from the external environment.

The next line of defence is the fishes' immune system, which will defend against recognised pathogens, this is known as a specific defence. It is the specific defence that is activated when administering vaccines. Vaccination introduces the fishes' body to an inactive sample of the pathogen to which the fishes' immune system will respond. If the fish encounters the pathogen in the future the immune system will recognise it and produce an immune response that will combat the pathogen.

It is therefore important that not only should the disease be treated, but the underlying cause and potential factors causing stress to fish stocks should also be addressed.

Prevention is always better than cure!

Disease prevention

The prevention of disease is always easier to implement than managing a disease outbreak as disease prevention is the most cost effective and form of disease control and maximises fish welfare.

This can be achieved through good stock management practices which can involve; good biosecurity, good stock handling, correct nutrition, monitoring and maintaining water quality, quarantine procedures and the prevention of overcrowding.

If prevention has failed, there are a range of treatment methods the fish farmer can use. The medicine or chemical treatment of fish stocks can either be administered internally or externally.

External treatments

External treatments can include the addition of liquid chemicals, chemicals in powder form which must be added to water, or liquid medicines such as immersion antibiotics. The following steps describe how to calculate the correct amount of chemical/medicine to be administered:

- Follow the manufacturer and veterinary instructions for the treatment
- Calculate the water volume of the holding unit being treated
- Calculate the chemical quantity required for that treatment

The most common forms of external treatments are:

Bath – during a bath treatment a chemical is added to the holding unit for a prescribed time and dose rate e.g. Formalin bath to treat a Costia infestation at a dose rate of 200ppm for 30 minutes.

Flush – during a flush treatment a chemical is added to the holding unit near the inlet and allowed to flow through the unit at a prescribed dose rate e.g. Chloramine T flush to treat Bacterial gill disease at a dose rate of 2 ppm

It is important to take measures to ensure good even mixing of the chemical throughout the water body, otherwise a hotspot of highly concentrated chemical will enter and leave the holding unit, leaving some of the stock relatively untouched by the treatment.

Internal treatments (addition of chemicals to the feed)

Orally (medicated feed) – a prescribed medicine is added to the fish feed and fed to the fish stocks over a prescribed time. For example, an antibiotic treatment for a bacterial infection at a dose rate of 80mg/kg of fish/day for a total of 10 days

Internal treatments can include the addition of antibiotics, sea lice treatments and booster supplements to fish feed. For large quantities this is normally carried out by the feed production companies, however small batches can be mixed on fish farm sites by suitably qualified and trained staff.

The following steps describe how to calculate the correct amount of chemical/medicine to be administered:

- Calculate the total biomass (kg) of the stock in the holding unit being treated
- Follow the manufacturer and veterinary instructions to select the appropriate dose rate
- Calculate the total quantity of medicine required for the recommended treatment period
- A reduced feed rate should be calculated for the recommended time period to ensure the stocks consume all the treated feed
- Medicine should be added to the feed and mixed thoroughly
- Feed should be stored appropriately and whole treatment administered to the appropriate stocks over the recommended time period.

Vaccination (injection and immersion) – a prescribed medicine is administered to the fish using either a direct injection or immersion in a bath containing dilute vaccine. The latter technique is commonly used as a preventative treatment (prophylactic) administered to the fish before a disease becomes a problem.

What records of disease treatments does the fish farmer need to keep?

It is important to note that all treatments administered to any fish stocks should be accurately recorded as part of good management practices and as a legal requirement. This is important as some chemicals or medicines used will have withdrawal periods that must be observed before fish can be harvested for human consumption.

What is a withdrawal period?

If fish have been fed a diet containing a medicine such as antibiotics there is a prescribed time that has to pass before any fish destined for human consumption can enter the food chain.

Withdrawal periods in fish are normally described using the term ‘degree-days’.

When a treatment has finished there will be a minimum number of degree days that must pass before the fish stocks can be considered safe for human consumption.

How are degree days calculated?

Example: An infeed medicine (antibiotic) has a withdrawal period of 600-degree days **after** the treatment has finished.

The water temperature currently averages 10^{0}C.

How many days will it be before these fish can safely be considered fit for human consumption?

600 degree days / 10^{0}C = 60 days (**after** the treatment is finished)

To ensure accuracy - the water temperature should be taken and recorded daily and degree days calculated as a cumulative total.

How is the impact of chemical treatments on the aquatic environment regulated?

As with all other types of farming the use of chemicals and medicines is regulated not only from an animal welfare perspective but also to ensure human health is not adversely affected. The relevant water or environmental monitoring authorities in any country will be required to authorise aquaculture enterprises to use certain medicines and chemicals. This will be detailed in the consent to abstract and/or discharge into the aquatic environment.

B15 Fish Health

Chemical treatments added to water (raceways)

Calculating chemical treatment quantities is straight forward but does require a series of calculations to be conducted accurately. In most aquaculture facilities the calculations will be completed by farm control software or specialists fish vets. However, it is useful for all fish farmers to understand how the chemical quantities are calculated.

External treatments will require either the addition of a liquid or powder to a holding unit for a bath or flush treatment. The first calculation we require is the volume of the water in the holding unit being treated.

It is important that it is the volume of the water and not the volume of the holding unit that needs to be calculated! Rarely will the holding unit be filled to the top and so to a calculation of the holding unit volume would give an incorrect answer. In most cases prior to treatment the water level will be dropped to reduce the volume of water in the holding unit which consequently reduces the amount of chemical required.

Treating a stock of fish held in a raceway

To calculate the volume of water in a rectangular raceway unit you must first measure the length, breadth and the depth of water. All measurements should be made and recorded in metres.

The volume of the unit can then be calculated using the formulae: -

Volume (m^3) = Length (L) x Breadth (B) x Water Depth (D)

The volume calculated in this way will be expressed in cubic meters (m^3)

It is important to note:

$1m^3$ = 1 000 litres or 1 000 000 millilitres

Example 1

The rectangular raceway to be treated has the following dimensions:

Length = 6 metres

Breadth = 1.2 metres

Depth = 1.5 metres

Raceway volume = 6 metres x 1.2 metres x 1.5 metre raceway depth

= 10.8 m^3 x 1000

= 10 800 litres x 1000

= 10 800 000 ml

Remember this is the tank volume and not necessarily the water volume.

Example 2

To demonstrate how an error could be made we will look at the following example.

Length = 6 metres

Breadth = 1.2 metres

Water Depth = 0.8 metres

Raceway volume = 6 metres x 1.2 metres x 0.8 metre water depth

= 5.76 m^3 x 1000

= 5 760 litres x 1000

= 5 760 000 ml

In both examples 1 and 2 above you will notice the raceway unit is 6 metres long but in example 2 we have used the actual water depth in the calculation. This gives a very different water volume of 5.76 M3 as opposed to 10.8 M3. This type of error can result in the wrong chemical dose being administered.

How do we calculate the actual quantity of chemical required?

Once you have the volume of water in the holding unit to be treated you next need to know the dose rate of the chemical being administered. This will either be on the manufacturers label or in the written veterinary advice provided with the chemical.

If we use both calculations in the above examples you will notice the difference in chemical quantity between them is significant. If the calculations are incorrect there is a danger of over/under dosing the chemical, which can cause damage to the fish, cause mortalities, be ineffective against the pathogen and pollute the environment unnecessarily with the excess chemicals.

The chemical we are using in this example is Chloramine T which has a prescribed dose rate of 2 parts per million (ppm).

Example 1 has a tank volume of 10.8 m^3.

To calculate the total quantity of Chloramine T required for example 1:

10.8 m^3 x 2ppm = 21.6 = **21.6 grams of Chloramine T required**

Example 2 has a water volume of 5.76 m^3

To calculate the total quantity of Chloramine T required for example 2:

5.76 m^3 x 2ppm = 11.52 = **11.52 grams of Chloramine T required**

It is obvious to see that getting the volume calculation wrong at the start can make a significant difference to the amount of chemical required, which in this case made a difference of **10.08 grams of Chloramine T**.

B16 Fish Health

Chemical treatments added to water (circular tanks)

Calculating chemical treatment quantities is straight forward but does require a few calculations to be accurately conducted. In most aquaculture facilities the calculations will be completed by farm control software or specialists fish vets. It is useful for all fish farmers however to understand how the chemical quantities are calculated.

External treatments will require either the addition of a liquid or powder to a holding unit for a bath or flush treatment. The first calculation we require is the volume of the water in the holding unit being treated.

Note, it is the volume of the water and not the volume of the holding unit that is being calculated! This is important because very rarely will the holding unit be filled to the top and to calculate the holding unit volume would give an incorrect answer. Normally the water level is dropped to reduce the volume of water in the holding unit which will reduce the amount of chemical required.

How do you calculate the volume of a circular tank?

To calculate the volume of water in a circular unit you must first measure the Diameter (or radius) and the depth of water. The diameter is then halved to give the radius e.g. a diameter of 4 metres = a radius of 2 metres. All measurements should be made and recorded in metres.

The volume of the unit can then be calculated using the formula:-

Volume (m^3) = $\pi R^2 \times D$

Where	π	=3.14
	R	= the radius (in meters)
	D	= the depth (in meters)

The volume calculated in this way will be expressed in cubic meters (m^3)

It is important to note:

$1m^3$ = 1 000 litres or 1 000 000 millilitres

Example 1

The circular tank to be treated has the following dimensions:

Diameter = 5 metres

Depth = 1.5 metres

To calculate the tank volume we half the diameter to give the radius; 5 metres /2 = 2.5 metres

Tank volume = 3.14 x 2.5 x 2.5 x 1.5 metre tank depth

= 29.44 m³ x 1000

= 29 440 litres x 1000

= 29 440 000 ml

Remember this is the tank volume and not necessarily the water volume.

Example 2

To demonstrate how an error could be made we will look at the following example.

Diameter = 5 metres

Water depth = 1 metre

To calculate the water volume in the tank we half the diameter to give the radius; 5 metres /2 = 2.5 metres

Tank volume = 3.14 x 2.5 x 2.5 x 1 metre water depth

= 19.63 m^3 x 1000

= 19 625 litres x 1000

= 19 625 000 ml

In both examples above you will notice we used the same 5 metre circular tank but changed the tank depth for the actual water depth. This gives a very different volume, 19.63 m^3 as opposed to 29.44 m^3, which can result in the wrong chemical dose being administered if not calculated correctly.

How do we calculate the actual quantity of chemical required?

Once you have the volume of water in the holding unit to be treated you next need to know the dose rate of the chemical being administered. This will either be on the manufacturers label or in the written veterinary advice provided with the chemical.

If we use both calculations in the above examples you will notice the difference in chemical quantity between them is significant. If the calculations are incorrect there is a danger of over/under dosing the chemical, which can cause damage to the fish, cause mortalities, be ineffective against the pathogen and pollute the environment unnecessarily with the excess chemicals.

The chemical we are using in this example is formalin which has a prescribed dose rate of 200 parts per million (ppm).

Example 1 has a tank volume of 29.44 m^3.

To calculate the total quantity of formalin required for example 1:

29.44m^3 x 200ppm = 5888 ml/1000 = **5.888 litres of formalin required**

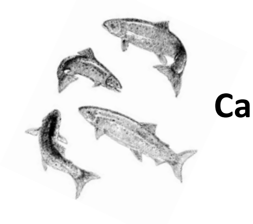
Example 2 has a water volume of 19.63m^3

To calculate the total quantity of formalin required for example 2:

19.63m^3 x 200ppm = 3926 ml/1000 = **3.926 litres of formalin required**

It is obvious to see that getting the volume calculation wrong at the start can make a significant difference to the amount of chemical required, which in this case was **1.962 litres of formalin**.

B17 Fish Health



Calculating bacterial disease treatments

Calculating treatment chemical quantities is straight forward but does require a few calculations to be performed accurately. In most aquaculture facilities the calculations will be completed by farm control software or specialists fish vets. It is useful for all fish farmers however to understand how the chemical quantities are calculated.

When the treatment to be administered is an infeed treatment the volume of the holding unit is not required to calculate the quantity of chemical required, unlike external treatments. The information that is necessary however is the total biomass (weight in kg) of the stock being treated, the daily dose rate of the chemical being added to the feed. It is important to use the correct units of measurements when calculating any infeed treatments. If the calculations are incorrect there is a risk of either overdosing the treatment, treatments being ineffective through underdosing and an increased risk of bacteria building a resistance to the antibiotic treatment.

Step 1

How do we calculate the biomass of the holding unit to be treated with antibiotics for a bacterial infection?

Biomass = Total number of fish in holding unit x Average weight in grams/1000 = Biomass (Stock Wt) Kg

20 000 fish x 60 grams average weight/1000 = **1200 kg biomass**

How do we calculate the actual quantity of antibiotic required?

- Infeed antibiotic quantity required = Biomass (kg) x Daily dose rate of antibiotic/kg of fish/day
- 1200 kg x 80 mg = 96000 mg/1000 = **96 grams of antibiotic/day**
- The treatment is administered daily for 10 days so the total amount of infeed chemical required for this example = 96-gram x 10 days = **960 grams total antibiotic over 10 days**

The quantity of antibiotic required would normally be added to the feed as a batch that would be fed to the stocks being treated. To ensure that all the treated feed is consumed the daily feed rate for the treated stock will normally be reduced e.g. by 50% for the whole 10-day treatment period.

Step 2

The stocks being treated should be fed at a daily feed rate of 2% of the biomass/day.

- Biomass - 1200 kg x 2% = 24 kg of feed/day for the treatment period of 10 days = **240 kg of feed**
- The treatment daily feed rate should be reduced, in this case by 50% to ensure all the food (and therefore antibiotic dose) is consumed.

- Biomass – 1200 kg x 1% = 12 kg of feed/day for the treatment period of 10 days = **120 kg of feed**

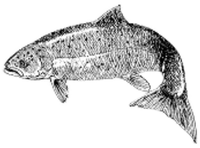
For this example, **960 grams of antibiotic** would be premixed with **120 kg of feed** for the **whole 10day treatment.**

It is standard practice to order the feed pre-treated by the feed manufacturers, especially when dealing with large quantities of feed as is the case on Atlantic salmon on growing sites.

Can medicated feed be produced by fish farmers themselves?

On site mixing of treated feed would only be considered when dealing with a small batch as in the example shown here. When applying antibiotics to feed on the farm dry gelatine can be mixed to the medication before mixing it with a feed. The gelatine acts as an adhesive agent to stick the medication to the external surface of the feed particles. This is a less precise process than having the antibiotic added during the feed manufacture process and is only used on small farms lacking access to a commercial supplier to make up the medicated feed.

B18 Fish Health



Notifiable diseases of salmon

What is a notifiable disease?

Notifiable' diseases are diseases that you are legally obliged to report to the relevant government authorities, even if you only suspect that a human, animal or plant may be affected.

Notifiable diseases can be:

- Endemic – this means it is already present in a country
- Exotic – not normally present, but poses a significant risk

It is important to note that some diseases can be passed between animals and humans, which means they are zoonotic. This can make them a danger to human health if not dealt with promptly and appropriately.

Fish, molluscs and crustaceans are protected by various pieces of legislation within the jurisdiction of each country. In Scotland this protection is provided by the Aquatic Animal Health (Scotland) Regulations 2009. This Regulation places a responsibility on the owner of aquatic animals, including others who may be involved with the animals to report the symptoms of certain diseases to the Fish Health Inspectorate in Scotland.

The reason some diseases in aquaculture are classed as notifiable diseases, is they are generally those are considered to have the potential for significant economic consequences to aquaculture or could cause detrimental environmental effects to wild species and the wider environment.

Diseases are caused by pathogens, but what are they?

A definition of a pathogen is:

"An agent causing disease or illness to its host, such as an organism or infectious particle capable of producing a disease in another organism."

http://www.biology-online.org/dictionary/Pathogens

Pathogen is a broad term to describe a group of agents that cause disease. The disease-causing agents that most people will know of, are as follows:

- Viruses
- Bacteria
- Fungi
- Parasites (internal and external)

Now we know what a pathogen is and that they cause disease, what is a disease?

A definition of a disease is:

"A pathological condition of a part, organ, or system of an organism resulting from various causes, such as infection, genetic defect, or environmental stress, and characterized by an identifiable group of signs or symptoms."

(http://www.thefreedictionary.com/disease)

A **disease is a condition caused by a pathogen**, so which diseases are commercially important to aquaculture?

There are many diseases important to aquaculture, particularly when the diversity of species being farmed globally is taken into consideration.

Gyrodactylus salaris a gill fluke has wiped out wild salmon stocks in entire river systems in Norway and is not found in the UK. if ever found it is 'notifiable'

Some of the diseases of importance to salmon aquaculture in Scotland, for example, include;

- Amoebic Gill Disease (AGD)
- Bacterial Kidney Disease (BKD) - Notifiable
- Enteric Redmouth (ERM)
- Furunculosis
- Infectious Pancreatic Necrosis (IPN)
- Pancreas Disease (PD)
- Saprolegnia
- Sea Lice Lepeophtheirus salmonis
- Viral Haemorrhagic Septicaemia (VHS) – Notifiable

There are also other diseases which are of concern but have not been observed in Scotland to date, and include;

- the external parasite Gyrodactylus salaris and
- the viral disease Infectious Haematopoeitic Necrosis (IHN)

both of which are notifiable diseases.

The viral disease Infectious Salmon Anaemia (ISA), has been observed in Scotland in the past but has been successfully eradicated and this is also a notifiable disease.