RSPCA APPROVED FARMING SCHEME

INFORMATION NOTES

FARMED ATLANTIC SALMON

JANUARY 2019

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for all creatures **great** & **small**

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INFORMATION NOTES
FARMED ATLANTIC SALMON

Information supporting the RSPCA Approved Farming Scheme Standards — Farmed Atlantic Salmon

The RSPCA Approved Farming Scheme is part of the RSPCA's effort to improve the lives of Australia's farm animals. The RSPCA's animal welfare standards for farmed Atlantic salmon provide the requirements for rearing, handling, transport and slaughter that must be met under the Scheme. The RSPCA encourages producers to exceed these Standards as the opportunity arises and commit to a pathway of continuous improvement in the welfare of their salmon. These notes provide information about a range of aspects relating to the Standards and to the production of farmed Atlantic salmon generally.

Atlantic salmon lifecycle

Atlantic salmon (*Salmo salar)* are a member of the *Salmonidae* family and native to the Atlantic Ocean. They are not native to Australia despite the Atlantic salmon grown in Tasmania often being referred to as Tasmanian salmon. In salmon farming, the lifecycle of the fish starts with laying down of eggs in the hatchery during the early winter months. Eggs are harvested from local broodstock. Eggs and milt are 'stripped' once a year by hand from brood stock that have been anaesthetised.

Eggs are fertilised and then incubated. Depending on water temperature, eggs hatch between 40 and 80 days. The incubation period is measured in 'degree days' (preferred temperature multiplied by the number of days incubated) and is around 450 degree days. This means that if, for example, the water temperature during incubation is 8°C, the incubation period is around 56 days. In salmon farming, water temperature can thus be used to manage hatching time to suit the production requirements. The hatchlings — or 'alevins' — absorb nutrients from a yolk sac attached to their bodies. It is not until a month or more after hatching that the fish — now called 'fry' — are ready to eat a formulated diet. At this stage, fry are transferred to small tanks where they grow into 'parr'. As they grow, they are transferred to larger tanks where they remain for 8 to 12 months. All this time, they are reared in fresh water.

At about 80-150gr live weight or when salmon have lost their characteristic stripy parr marks, the fish — now called 'smolts' — are ready to be transferred to the sea. 'Smoltification' is triggered by increasing day length, so hatcheries use light and light intensity to mimic the day length changes salmon would experience in the wild as winter turns to spring. At this point they are transported in tanks from the land-based hatchery to the marine pens.

Salmon continue to grow in their new saltwater environment where they remain until they are ready for harvest approximately 14-18 months from the time they entered the sea (at which time, the average weight of each fish is around 5kg). Atlantic salmon have a natural life span of 4 to 6 years but some can live up to 10 years. In salmon aquaculture systems, fish spend 10 to 16 months in fresh water (on land) plus 14 to 18 months in the marine pens before they are ready for harvest.

Amoebic gill disease

Amoebic gill disease (AGD) is a parasitic condition common in Atlantic salmon farmed in Tasmania. The parasitic amoebae attach themselves to the gills and the condition affects the fish's ability to breathe. It affects fish growth and requires frequent and repeated bathing in fresh water for two to four hours to kill the amoebae by osmotic shock, flush additional mucous and remove opportunistic bacteria from the fish gills. Bathing subjects fish to multiple handling events and thus stress (particularly over summer when waters are warmer). Because reinfection is common, multiple fresh water treatments may be necessary in a marine production cycle of 15 months. AGD monitoring, particularly at times of increasing water temperature, is required to manage the disease. Vaccine development has not been successful to date. Breeding for AGD resistance is the most promising solution and has the potential to reduce the number of baths. Improved response to disease can be expected with ongoing selection for AGD resistance. However, some fish may also be better able to cope with handling (crowding, pumping, bathing) than others, making handling resilience (to avoid increased mortalities) another important selection trait.

Biofouling

Over time, tanks, pen nets and other associated infrastructure surfaces accumulate algae and microorganisms to the extent that they reduce the water flow across the net or tank which, in turn, can reduce oxygen supply to the fish. This accumulation of marine organisms on wetted surfaces is called biofouling. If oxygen supply to the fish is reduced, this can cause stress levels (and susceptibility to disease) to rise. Antifoulant products form a thin layer on the pen net surface and gradually release 'biocides' that prevent the accumulation of organisms. Antifoulants containing tin and copper, which were traditionally used to counteract biofouling, are not used any more in Tasmania's salmon industry. Regular cleaning of biofouling is important to ensure that the population of stinging, noxious and other potentially harmful fouling organisms doesn't reach a size that fish welfare is likely to be compromised.

Biosecurity

Biosecurity is the prevention of disease incurrence and transmission as well as the management of endemic diseases. Appropriate and effective biosecurity measures include examination and certification of ova and fish prior to stocking; hygiene and sanitation/disinfection procedures between different working areas and different sites, movements of visitors, vehicles, equipment and staff. In addition, in the marine stage, biosecurity risks related to fish movement can be minimised by, for example, separating year class stocks, appropriate fallowing and site selection.

Broodfish

Farming of Atlantic salmon begins on land at the breeding farm where 'broodstock' (sexually mature fish) are held in large freshwater ponds or tanks. Broodfish are the source of the eggs and 'milt' (sperm) from which, after fertilisation, the salmon will hatch and grow. In Tasmania, salmon farmers use mainly female fish in the grow-out phase because the relatively warm seawater temperatures can result in rapid sexual development in male fish which, in turn, results in greater disease susceptibility and poor meat quality. A common practice in aquaculture, therefore, is sex reversal of some female broodstock resulting in 'neo-males'. This occurs at the hatchery at first feeding when fish are very small. Treated fish are identified by clipping the adipose fin which sits just in front of the tail. This allows for easy external identification of neo-males. Removal of the adipose fin is painful as the fin is innervated (it was previously thought not to be). The fin also appears to act as a 'precaudal flow sensor' and its removal can be detrimental to the fish's ability to swim efficiently in turbulent water. An alternative to fin clipping is tagging, however, tags can attract predators, interfere with locomotion and may also make the fish more susceptible to infection. RSPCA will be monitoring the research looking into alternatives to fin clipping. Until then, the standards require that the procedure is only carried out on anaesthetised fish. By crossing neo-males with females, only female offspring are produced. Once a year, usually in autumn, individual broodstock are anaesthetised by submerging the fish in a water bath containing an anaesthetic. Broodstock should be anaesthetised before undergoing any treatment. While anaesthetised, eggs and milt are removed from female and neo-male fish, respectively (a process referred to as ‘stripping’). While some female fish are allowed to recover from the anaesthetic and are released back into the ponds, the method of milt removal from neo-male fish requires all neo-males to be euthanased prior to stripping. Producers should use all available data of fish performance, survival and deformity rates to only select broodfish that give the highest possibility of good welfare outcomes for their progeny.

Closed Circuit Television (CCTV)

The salmon standards require that CCTV be used to monitor fish behaviour in those areas of the slaughtering facility where the risk to animal welfare is greatest. CCTV should not replace the need to employ people with the right attitude towards animals, comprehensive staff training and good stockpersonship. CCTV, however, is an excellent means by which facility management and auditors can monitor compliance with standards and regulations relating to animal welfare. CCTV allows problem areas to be identified and promptly addressed. It is important that a protocol is in place to determine the use of CCTV. Such protocols should include information about the positioning of the camera to allow a clear view of fish stunning and slaughtering processes; about the period for which the footage should be retained; about the review of the footage and who should be responsible; and how the footage should be kept safe and secure. The salmon standards also require that CCTV be used to monitor fish behaviour during wellboat transport.

Crowding

Crowding is the process of reducing the area available to the fish so that they can be more easily removed from the tank or pen. Crowding may be used to move fish towards a pump or lift that may carry fish onto a wellboat or into another pen for the purpose of carrying out husbandry procedures. Crowding is also required when moving fish onto a wellboat or into a slaughtering plant at harvest. Crowding is stressful and one of the key potential causes of poor welfare during fish handling as it increases the density of fish within a particular volume of water thereby decreasing the amount of oxygen available to them and brings fish into closer physical contact with each other and the pen net which may cause injury. Crowding should be carried out at a speed that does not frighten or unnecessarily distress fish. If fish are attempting to escape, burrowing into the pen net or swimming fast, then fish are stressed and the crowd needs to be slowed. Fish that panic will use up oxygen quicker and will injure themselves on the pen net. Fish that are being crowded should be carefully monitored. Additional oxygen should always be available and be provided to fish as soon as oxygen saturation level falls below 80%. The crowd should be slowed and fish given more room if any signs of stress are observed: fast swimming, burrowing, trying to escape, the dorsal fin and parts of the back of the fish are exposed, fish scales are seen suspended in the water column, or the snout is damaged. A good crowd is when fish are calm, swimming leisurely, not burrowing or trying to escape, and gently turning when they reach an obstruction.

Environment

The farming enterprise should be operated with respect for the natural environment and staff should recognise their duty to care for the wider environment. The siting of marine pens should be carefully considered with regard to fish welfare, staff safety and minimising adverse effects upon the environment. All reasonable steps should be taken to minimise the ecological impact of the farming system (e.g. by avoiding feed wastage through overfeeding of fish). These standards are primarily aimed at the welfare of farmed fish. However, the potential for aquaculture to have wider environmental effects should also be considered. Compliance with regulatory requirements in relation to environmental impact management and monitoring is a prerequisite of the Approved Farming Scheme as is ongoing compliance with a recognised certification scheme that promotes best environmental practice. RSPCA will assess the suitability of such schemes on a case-by-case basis and consider whether, among other things, the following elements are suitably covered: management and monitoring of ecological impact, benthic (the sediment surface and the organisms living in close relationship with it) and water quality, pen net biofouling, fallowing practices, escapee prevention, predator control, extraneous species management, and waste and wastewater management and monitoring. In addition to fully complying with all relevant legislation, the farmer should demonstrably and proactively review their environmental protection policies as developments in research and technology allow. It is the responsibility of farm management to ensure that all staff recognise their duty to care for the natural environment and monitor and limit possible impacts on it.

Environmental enrichment

The impact of providing environmental enrichment on the behaviour of farmed fish throughout their lifecycle should always be considered. Enrichment may promote foraging ability and reduce fin injuries as well as behavioural flexibility allowing fish to cope better with disturbances and other stressors in their environment. There is potential to improve the welfare of farmed Atlantic salmon in the freshwater (rearing) stage, for example, by better aligning these systems with the fish's behavioural needs. Areas to consider may include aspects of tank design, tank colour, substrate, overhead cover or hideaways. These could offer opportunities for fish to isolate themselves or escape from aggressive encounters. However, a lack of knowledge on, for example, how fish may perceive such 'enrichments' and what the effects of providing enrichment in the freshwater phase may have on behaviour in the marine phase, means that further research in this area is required.

Escapees

Farmed fish which escape may have an adverse ecological impact and are also likely to experience welfare problems. In Australia, farmed Atlantic salmon are not considered a threat to wild fish when it comes to interbreeding (because there are no salmon species with which it could breed), competition for feed and habitat, or transmission of sea lice (currently not an issue in Australia). Escaped salmon have been found not to feed on native fauna so effectively starve to death. This in itself means it is essential that all reasonable measures are taken to prevent farmed fish escaping.

Euthanasia

Fish which are unlikely to recover from a condition or are likely to be experiencing pain or distress must be humanely killed without delay. It is unacceptable to leave fish to suffer when it is possible to catch and remove them. For example, if a seriously injured fish is noticed during crowding, it should be removed immediately, rather than being subjected to further procedures such as pumping. Similarly, moribund fish that can be easily netted should be removed and euthanased.

Fasting

Salmon may be held off feed (fasted) for varying lengths of time prior to transport, prior to slaughter or handling events. Fasting lowers the fish's metabolic activity thereby reducing their oxygen consumption and ammonia and carbon dioxide build up in the water. Salmon body temperature is dictated by the external environment (referred to as 'poikilothermia') but because in aquaculture systems they are fed high-energy diets (compared to wild stock), their metabolism is higher than it might be in the wild and this faster metabolism increases their oxygen consumption. By evacuating the fish's gut and reducing oxygen demand and waste production prior to handling, fish welfare is improved during the process. Although salmon may not feed for long periods in the wild, e.g. some fish don't feed during winter, holding a farmed fish off feed when it has previously been fed regularly to satiation may have an adverse effect on welfare, particularly if aggression increases. It is unacceptable to deprive salmon of food for perceived meat quality reasons. In farmed Atlantic salmon, the minimum time required to empty the gut, regardless of water temperature, is three days. The longer the period off feed, the lower the available energy reserves that allow fish to cope with the stressors of handling and management procedures that require fasting.

Feed

Salmon are carnivorous and their formulated feed contains fish meal as a source of protein and fish oil as a main source of lipids and essential fatty acids. Fish meal and fish oil is obtained from wild-caught species of small ocean fish (e.g. anchovies, sardines) and from processing waste (trimmings) from fish caught for human consumption. Efforts to reduce reliance on wild-caught species have seen a significant reduction in fish oil/meal as a feed ingredient. In 2015, the equivalent of 1.7kg of wild-caught fish was used for every 1kg of Atlantic salmon produced and the future aim is to produce more kg of salmon than kg of other fish used in its production. In comparison, it is estimated that salmon in the wild will eat around 10kg of forage fish for every 1kg of bodyweight. Responsible aquaculture companies source their feed from suppliers who source marine ingredients from responsible fisheries, i.e. not from Illegal, Unreported and Unregulated (IUU) fisheries or from species listed as Critically Endangered or Endangered on the International Union for Conservation of Nature (IUCN) Red List. Salmon feed for production fish does not contain added hormones.

Feeding

A fish's willingness to eat can be used to determine feeding levels and should be closely monitored as loss of appetite may be an early indicator of stress, e.g. disease, high stocking density, poor handling or environmental factors that could result in poor welfare.

Five Freedoms

The Five Freedoms were first mentioned in 1965 in a UK report on the Welfare of Animals kept under Intensive Livestock Husbandry Systems which stated that "farm animals should have freedom "to stand up, lie down, turn around, groom themselves and stretch their limbs". Following the establishment of the UK Farm Animal Welfare Council shortly after, the concept was further refined into the Five Freedoms we know today: freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury or disease; freedom to express normal behaviour; and freedom from fear and distress. The RSPCA considers that the welfare of an animal includes its physical and mental state. Good animal welfare implies both fitness and a sense of wellbeing. Criteria for assessing the welfare of farmed Atlantic salmon against the Five Freedoms include:

- Freedom from hunger and thirst — by access to a diet to maintain full health and vigour
- Freedom from discomfort — by providing an appropriate aquatic environment and well-designed enclosures
- Freedom from pain, injury or disease — by prevention, rapid diagnosis and treatment
- Freedom to express normal behaviour — by providing sufficient space, proper facilities and company of the animal's own kind
- Freedom from fear and distress — by ensuring conditions and treatment which avoid suffering.

An overall welfare assessment can be made by looking at the fish's physical environment, its biological functioning and by observing fish behaviour in response to challenges in their environment. The latter, in particular, requires an understanding of normal fish behaviour and being able to identify behaviour indicative of poor welfare.

Flow rate

Flow rate is a basic tool of freshwater husbandry. It is a useful measure, because it sets a water quality standard, which is independent of stocking density. It should be measured as soon as fish are feeding in tanks and continue whilst the fish are in the tanks. The aim of the flow rate principle is to set optimal levels for water flow in freshwater tank systems and therefore prevent sub-optimal rearing conditions, which could impinge upon the welfare of the fish. Optimal flow rates in both freshwater and marine phases, will ensure that harmful levels of carbon dioxide, ammonia, faeces and excess feed etc. do not accumulate.

Grading

Grading is a husbandry practice that sorts a population of fish in one tank/pen and separates them based on their size resulting in several tanks of few, and similarly sized fish. This process requires fish to be moved and handled and can be very stressful. To reduce/remove the need for grading or handling fish, consideration should be given to stocking tanks and pens to planned final biomass from their initial stocking at transfer to sea. Optimising husbandry practices and farming environments can significantly reduce the creation of size hierarchies within populations, and therefore also reduce the requirement to grade. For example, evidence shows that feed distribution and ration size are extremely important, as is knowing how many fish and of what size are present in the population.

It is preferable to grade all populations into new pens in order to promote optimal welfare for the duration of the grade. Pre-grade mortality removal should be undertaken wherever possible. Passive grading is recommended where possible and practical to do so. Lighting strategies can also reduce or eliminate the need to grade maturing populations.

A grading plan should include: the reason for the need to grade, a pre-grade risk assessment, the number of fish to be graded per day, the location of fish populations both pre- and post- grade, the pre-grade fasting period, the health status of the fish, the equipment to be used, including the type of grader, expected timetable for completion of the grade, the required number of staff and duties to be performed, the physical characteristics of the site such as water temperature, tides and weather conditions, the training records of the grading team, the requirement for a post grading health check, post grading mortality records, any relevant contingency plans, and the agreement and signatures of the site manager and the person in charge of the grading equipment.

Handling

Removing fish from the water, crowding, pumping, grading, bathing, and transport are stressful events for fish that may result in reduced appetite, reduced growth, disease outbreak and mortalities in the days following the procedure. Fish must be handled in a considerate and skilled manner. Caring and responsible planning and management should be employed to safeguard welfare during essential procedures.

Health

Fish must be protected from pain, injury and disease, through good management and husbandry practice, and by rapid detection and treatment of disease. All producers must develop a veterinary health plan in consultation with a designated veterinarian. Disease is a major cause of poor welfare and mortality in farmed salmon. Therefore it is essential to take all reasonable steps to minimise the likelihood of disease outbreaks in the farmed stock.

Incubation/hatching

Eggs and milt from selected broodstock are mixed together to produce fertilised eggs. The fertilised eggs are then placed in purpose-built incubators at specialised hatcheries where their environment aims to mimic egg incubation in the wild, for example, by providing clean water flow with plenty of oxygen for the eggs to grow and, later on, substrate in which hatchlings can nestle. As the small pea-sized eggs develop, the eyes of the salmon can be seen as a black dot on the orange egg. The hatchlings (called 'alevins') absorb nutrients from a yolk sac attached to their bodies and they remain in the hatching environment until they are able to feed independently.

Injury

Damage to fins could be a sign of aggression or chronic infection and may be related to high stocking density, poor handling, underfeeding, poor water quality, poor body condition and high stress levels. Skin conditions can be caused by mechanical damage or bacterial/viral/fungal infections. Damage to fins or skin is likely to cause pain and discomfort particularly where tissue loss and depth/size of the wound is severe. Skin damage may also cause osmoregulatory problems resulting in the fish being unable to maintain fluid balance and electrolyte concentration. Observations of recurring similar physical damage in a significant proportion of the fish population should be investigated, as it is likely to suggest a common cause. Examples are poor tank or pen design and/or methods of handling or a husbandry procedure.

Lighting

Inadequate light in the freshwater phase can lead to spinal deformities, suppressed growth and reduced smolt quality. Exposure to high levels of UV light may result in cataracts so protecting fish by using shade cloth over outdoor tanks in the freshwater phase or by providing sufficient depth in marine pens is important. Sudden changes in lighting levels may cause distress and providing gradual dawn/dusk periods in indoor hatcheries as part of the lighting program will help prevent this. Farmed salmon swim deeper during the day while rising at dusk to swim nearer to the surface at a reduced swimming speed. Use of submersible artificial lighting at night sees salmon maintaining their daytime rhythm of circular schooling, vertical distribution through the water column as well as daytime swimming speed. Providing submersible lighting in marine pens will avoid salmon schooling at high densities near the surface at night and potentially becoming frustrated in an effort to obtain light. Manipulating photoperiod should not result in fish competing for resources such as access to preferred temperature, light or salinity zones within the water column.

Mortality

High mortality levels can be an indicator of poor welfare. During the marine stage, mortality may be a result of disease, injury, problems with the quality of smolts, handling, and other production- or environment-related factors. In addition, losses from predator (e.g. seals and cormorants) attacks also occur. During the fresh water stage, disease and removal of small or poor performing fish make up a large part of the mortality rate.

Oxygen

Fish extract oxygen from the water through their gills in exchange for carbon dioxide. In aquaculture, oxygen saturation is a measure of the amount of oxygen dissolved (or carried) in water and is used as a parameter in water quality monitoring. The ability of oxygen to dissolve in water (and be available for uptake by fish) is greatest in cooler, less saline water. Fish will tend to avoid areas in the water column with low oxygen saturation. If oxygen saturation drops below 50%, salmon are no longer able to regulate their metabolism to cope with hypoxia. Generally, ambient oxygen saturation levels above 80% are associated with positive performance, reduced illness and increased survival of Atlantic salmon in the marine phase. In the freshwater phase, reduced growth, reduced efficiency of yolk conversion, premature hatching, reduced size at hatching, increased mortality and changes in salmon morphology can result if the incubation environment is oxygen deficient and less than optimal. Optimal oxygen saturation is not always achieved in the marine farming environment, e.g. in times of extreme weather events or high algal mass in the water. Mitigation strategies such as injection of oxygen into the water must then be employed. There are many factors that play a role in the amount of oxygen available to fish including water flow through pens, biofouling, husbandry procedures, stocking density, and feed management. These should all be considered when dealing with low oxygen saturation levels in the water column.

Predators

Farmed Atlantic salmon may be vulnerable to attack by sea birds and fur seals. Protecting the welfare of the fish is as important as control methods that consider the welfare of the predator. Salmon farms may be subject to hundreds of seal interactions each year with seals capable of biting fish through the pen nets, jumping into pens, ripping holes in the netting and sometimes threatening staff. Cormorants and common seagulls are the main aerial predators that are attracted to salmon in the marine pens. Although the marine pens are completely covered by bird netting, some birds find their way in through holes or may become ensnared in the netting. Once inside, birds that are able to perch within the enclosure will generally survive but those that cannot, may die. Exclusion measures, both above and below the water, should be the primary method of deterring predators. Safeguarding the welfare of seals and other predators is important. The use of seal deterrent devices must meet the requirements set out by the Tasmanian Government. However, the RSPCA Standards prohibit the use of devices such as bean bags, scare caps, electronic seal scarers and acoustic pingers.

Sentience

Scientific evidence shows that fish have a nervous system that responds to noxious stimuli, in other words, fish can exhibit an unconscious response to pain. If fish are consciously aware of this pain, then they have the capacity to suffer. There is sufficient and growing evidence to suggest that fish can experience pain, fear and distress and should be given the benefit of the doubt when it comes to their capacity to suffer. At the very least, the potential for fish to experience pain or distress should be taken into account. Fish must be treated humanely and practices that have the potential to cause pain, injury or suffering avoided. It is essential that persons responsible for managing farmed fish aim to ensure that fish welfare is an integral part of every aspect of production every day.

Shocking

Shocking is the process that allows unviable eggs to be sorted from the viable ones and is usually done when eggs reach the eyed stage and are more robust. The process involves pouring or siphoning eggs into a bucket of water, and then returning the eggs to the incubator. Infertile or poor eggs will turn white after this process as a result of the delicate yolk membrane rupturing. The unviable eggs can then be carefully removed and the viable eggs laid down for hatching.

Smoltification

Salmon undergo a series of physiological changes as they adapt from living in freshwater to being able to live in seawater. This process is called smoltification and the salmon at this stage in their lifecycle are referred to as ‘smolts’. At this stage, they are transferred from the freshwater hatchery to the marine pens. The transfer of smolts to the marine pens is a peak stress period in the lifecycle of salmon. In order to avoid high mortalities, fish should not be transferred to seawater until they are confirmed to be capable of smolting.

Stocking density

While stocking density on its own is not an adequate predictor of fish welfare, at higher stocking densities, fish are more likely to become injured (either through contact with each other or the pen), and are more susceptible to infections and disease. Stocking density also affects the amount of space that fish have available to express their behavioural needs. In marine pens, fish tend to school (swim in the same direction in a coordinated manner) during the day but at night, they rise to the surface, swim slower and gradually move away from each other. Stocking density affects the way fish are able to respond to changes in water temperature and available oxygen at different depths within the water column. Fish should be able to avoid higher water temperatures and areas of low oxygen without resulting in overcrowding in parts of the water column they do prefer. Stocking density calculation should take into account the actual depth and different levels of the water column that the fish use rather than the total volume of water they may have available – particularly in summer, fish will seek out cooler water temperatures. The relationship between stocking density and welfare needs to be considered in conjunction with water quality (including oxygen saturation and flow rate). In other words, welfare needs to reflect the behavioural need for space as well as the biological need for a suitable living environment.

Stockpersonship

The attitudes and competence of staff are a vital factor determining whether high standards of fish welfare can be achieved. It is the responsibility of management to ensure there is a welfare ethos among staff. It is essential that stockpersons are suitably trained and experienced, and are able to recognise indicators of poor welfare at an early stage. They must have a good working knowledge of the husbandry system used and the animals under their care. High standards of husbandry must be maintained at all times with the welfare of stock being considered as a priority. The stockperson is responsible for optimising the environment that farmed fish rely on for survival and must maintain the highest environmental quality at all times. It is widely acknowledged that good stockpersonship and reduced stress are key factors in meat quality.

Stress

The mechanism that allows animals (including fish) to cope with challenges in their environment is called a stress response and it allows the animal to overcome or avoid such challenges (referred to as 'stressors'). However, where the animal is not able to escape the stressor or where stressors persist beyond the short term, chronic stress results. Chronic stress compromises animal welfare and can usually be observed through physical and behavioural changes in the animal (e.g. loss of appetite and weight, compromised immune and reproductive system, impaired mental function and coping ability).

Substrate

In the wild, as salmon eggs hatch and become alevins, their natural surroundings would be gravel which provides them with solid support. Without this substrate, alevins in a hatchery environment may crowd into corners to seek this support. Providing substrate will prevent alevins bunching while at the same time reducing activity levels which means energy (from the yolk sac) is directed at growth. In addition to improved utilisation of the yolk sac, the use of substrate has also been associated with improved fry weight and stable respiration rate and heartbeat frequency. Suitable substrates may include plastic grids, rubber spikes on mats, modified artificial turf, or gravel.

Temperature

Ideal water temperature for salmon at the marine stage is around 10-15ºC in terms of salmon preference and positive growth rate. However, water temperature may increase in warmer months. Salmon are able to adapt to higher water temperatures, at least in the short term, as long as sufficient oxygen is provided. As water temperatures rise, oxygen levels decrease and, particularly at higher stocking densities, fish may become stressed as they struggle to obtain sufficient oxygen from the water. As a result, they are more susceptible to disease, growth performance is reduced and mortality may increase.

Triploid salmon

Triploid salmon are produced by applying thermal or pressure shocks to the egg and sperm mix at fertilisation. As a result, rather than having two sets of chromosomes (one inherited from each parent) the fertilised egg now has three (one from the father and two from the mother). Triploids are sterile and used in salmon aquaculture for their lack of sexual maturation. However, triploids may be more susceptible to deformities. Triploids are more easily stressed (e.g. during handling events), are more sensitive to warmer sea temperatures and low oxygen concentrations and have generally higher mortalities than normal diploids throughout their lifecycle. At slaughter, mature fish with jaw abnormalities may become stuck in the stunning equipment and may not be adequately stunned prior to bleeding out. Skeletal problems in triploids may be addressed by modifying their diet, e.g. providing extra phosphorous. Superior breeding techniques, careful handling, close monitoring and timely intervention are required if the welfare of triploid salmon is not to be compromised. The RSPCA Standards do not permit the triploidisation process nor the farming of triploid salmon.

Vaccination

A number of infectious diseases are able to be prevented through vaccination and the introduction of vaccination procedures in hatcheries has seen antibiotic use reduced dramatically. However, some fish suffer adverse reactions to intraperitoneal vaccines including adhesions between internal organs or between internal organs and the wall of the peritoneum. If effective oral vaccines are developed these should be the preferred method of vaccination. Adverse reactions to vaccines may also include reduced growth rate, poor carcass quality, behavioural restrictions, spinal deformities, eye infections and autoimmune reactions. Care should be taken when returning fish to the recovery tank following vaccination. For example, lowering the pipe going into the return tank can make it a much gentler experience for the fish. Abdominal adhesions should be monitored to allow vaccination procedures to be improved where necessary. Where possible, vaccination should coincide with grading operations to minimise handling of fish.

Water quality

Water quality and water flow, serving the supply of oxygen and the disposal of wastes, are critical to fish health and welfare. Water quality is affected by stocking density, feed and other waste, oxygen and ammonia levels among other things. Poor water quality may result in stress, reduced growth, disease, fin erosion, gill damage and mortality in fish. Water that is super-saturated with oxygen can also compromise fish welfare. Levels of oxygen, carbon dioxide, ammonia and nitrogen should be regularly monitored in order to avoid this. As our knowledge of the water quality needs of the fish improves, it may be necessary to change and/or add to the parameters needing to be monitored. For example, the inclusion of parameters associated with the mineral content of the water may be appropriate as more information becomes available about their effect on the welfare of the fish.

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