Humane Slaughter: Atlantic salmon

All animals killed for food should be slaughtered humanely. This means that they must be effectively stunned, rendered instantaneously insensible, and remain unconsciousness until death supervenes.

For Atlantic salmon:

- The use of a single method (i.e. percussive blow or electrocution) that both stuns (instantly) and kills is recommended above other methods where possible.
- Percussive or electrical stunning followed by a separate kill method (see below) is also acceptable, providing fish do not regain consciousness after stunning.
- Acceptable post-stun kill methods are: effectively performed percussion, decapitation, spiking/coring or gill cut (following an effective percussive stun only).
- The use of carbon dioxide systems for Atlantic salmon is unacceptable and must be phased out.

Introduction

Fish are sentient beings capable of feeling pain and suffering[1]. As such, they are entitled under animal welfare law to a humane slaughter that minimises suffering and renders them unconsciousness as quickly as possible, a state that must extend until death. Fish are supposed to be protected under the EU Slaughter Regulation, which requires that they be spared any avoidable pain, distress or suffering during their killing and related operations. According to the European Commission, compliance with this Regulation can be achieved by following the Guidelines of the World Organisation for Animal Health (OIE) on the stunning and killing of farmed fish to which all Member States have signed up[2]. A recent report by the Commission[3] concluded that most Member States surveyed are currently in breach of these guidelines. Many producers are using slaughter methods considered inhumane by the OIE. Subsequently, food companies are increasingly incorporating fish welfare into their corporate social responsibility policies and practices. This document provides information on the humane slaughter of Atlantic salmon, including:

- an overview of the welfare issues associated with pre-slaughter fasting and handling,
- an overview of the main methods of slaughter in use commercially,
- recommendations for corporate animal welfare policies and practices,
- methods to assess welfare at slaughter.

Pre-slaughter procedures

Humane slaughter of fish can only be fully achieved by minimising stress and injury during the pre-slaughter phase as well as during the killing procedure itself. Procedures such as crowding, and moving fish from rearing and holding pens to the place where they will be slaughtered can be very stressful, and can take several hours. Reducing stress and activity prior to slaughter not only improves welfare but has a clear link to improved flesh quality in fish, including salmon[4,5].

Fasting

Farmed salmon are fasted before slaughter in order to reduce their metabolic rate (and therefore lower the oxygen demand) and physical activity before handling and live transport. It also serves to empty the digestive system prior to killing, which reduces water fouling (undigested feed, faeces and microorganisms) during transport, and aids hygienic processing. Fish should never be fasted for presumed flesh quality benefits.

To effectively reduce salmonid metabolic rates, a fasting period of 2-3 days is required[6]. For fish, gut emptying times are temperature dependent (with gut emptying taking longer at lower temperatures) and it has been found that above 10°C it takes less than 48 hours to reduce a salmon's stomach contents to <5%. In Scotland, sea temperatures generally range from 6-14°C throughout the year. In warmer months therefore, it is unnecessary to withhold feed from fish for longer than 48 hours for gut emptying. In any case, salmon should not be fasted for longer than 72 hours[7].

From a fish welfare point of view, little information is available on the effect of the duration of the fasting period. Whilst fish in the wild may not feed for long periods, farmed fish receive feed at regular intervals therefore periods without food are likely to negatively impact welfare. For example, withholding feed can lead to increased aggressive behaviour; when fish are fed less than on-demand, there is an increase in the incidence of dorsal fin erosion[8]. This suggests that the period of feed withdrawal should be kept as short as possible.

Crowding

Salmon are crowded together in their pens so that they can be pumped or netted out and moved to the place of slaughter. However, once salmon are crowded above a threshold density, the risks of injury and stress sharply increase. If not managed well, crowding can lead to a decrease in oxygen levels, exposure to a higher light intensity as fish are moved towards the surface, and abrasion from the net or other fish[9]. Fast swimming, escape attempts (jumping) and burrowing into the net are clear signs that salmon are stressed[10] . There may also be air gasping, lateral rotation, colour change, increased number of tail beats and turns and presence of fish scales in the water[11,12].

As crowding is stressful, it should be minimised as much as possible in terms of intensity and time period. RSPCA guidelines stipulate that "fish must not be crowded for more than two hours"; for slaughter "crowding and handling prior to killing must be kept to an absolute minimum" and that "no enclosure must be crowded more than twice in any one week or three times in any month"[7].

Narrow, deep nets are more welfare-friendly than wide shallow nets for crowding fish. When the nets are narrow and deep the fish have more freedom of movement, less of the fish are in contact with the net, and they are not over-exposed to a high light intensity.

Moving fish

Salmon are either slaughtered at the fish farm, or are transported to a centralised slaughter plant. The use of cage side harvest vessels is preferable to offsite slaughterhouses as stressful procedures such as handling and transport are shorter.

For salmon slaughtered on site, they are moved from their rearing pens to a cage side harvest boat. Fish are moved directly from the pen to the slaughter machine, by braille nets (removed from water) or pumped along pipes (transferred in water). Braille nets should not be used as they involve removing fish from the water and also subject them to physical trauma due to pressure from other fish in the net and abrasion on the surface of the net. Pumping fish has a higher welfare potential dependant on the pump design and its operation. Pumping systems should be carefully designed to move the fish as gently and efficiently as possible.

Transport to offsite slaughter plants is typically via well boats, which can take several hours. These must be equipped with water quality monitoring and maintenance equipment to ensure that good conditions are maintained in transit. For example, oxygen levels must be maintained at a minimum of 80% saturation and/or a minimum of 7mg/litre[7]. Well boats must not move too fast or fish will become exhausted when swimming to keep up with the boat.

On arrival at the slaughter plant, salmon may be pumped directly to the slaughter system or maybe kept in net-pens next to the processing plant where the fish are kept for typically 1–6 days (without feeding) before being pumped to the slaughter line[13]. Fish should not be fasted for longer than 72 hours at any one time, and preferably for shorter periods, for welfare reasons (see *Fasting*).

Slaughter methods that can be humane for Atlantic salmon

Percussive and electrical stunning machines are in use commercially and can enable humane slaughter when used correctly. Exposure to carbon dioxide in water (see text box 1) is also used for some salmon but this method is inhumane and must be phased out urgently.

1. **Percussive**

   Percussive stunning is considered to enable humane slaughter for salmonids[2] by the World Organization for Animal Health (OIE), and is the main method used globally for Atlantic salmon.

   An immediate loss of consciousness can be achieved by an effective blow to the head, in order to shake the brain in the skull with sufficient force to damage it and disrupt the brain's electrical activity. An accurately applied blow with sufficient force can prevent recovery of consciousness[14]. Where loss of consciousness from percussive stunning is reversible, a follow-up kill method is required. This must be performed in a timely manner and must result in death before consciousness can recover. Salmon are usually killed by administration of a gill cut to exsanguinate (see text box 2) after the percussive stun. Decapitation can also be used to kill fish that are unconscious following an effective percussion (see text box 3).

   Automated percussive systems are the predominant method used commercially, as they allow a high throughput of fish compared to manual percussive stunning, which will vary with worker fatigue and human error. Both automated and manual methods have the potential to be humane but there are risks to welfare associated with each of these.

   a. **Automated percussive stunning**: A hammer shaped cylinder, moved using air pressure, delivers a blow to the head of each salmon at a specific force, creating a shockwave across the whole brain. For this to be humane, each fish must be stunned immediately by a single blow. Most automated machines also have an automated knife system for gill cutting and exsanguination which usually occurs within 10 seconds of the percussive blow being administered. Several factors need to be taken into account:

      - Size variation between fish can cause percussive blows to be ineffective, as the hammer may hit the wrong part of the fish. Some variation will be due to individual differences in growth rates, deformed individuals, and sexual maturity in males which causes the jaw to elongate. For this reason it is essential that all fish presented to the stunner have been recently graded (sorted into groups of similar sized fish) and the machine is set-up to strike the head in the correct place. The ideal positioning of the percussive blow for salmon is directly above and slightly behind the eyes[9].
      - The force of the percussive blow must be sufficient to cause an instant and prolonged stun. Choosing the force of blow is essentially a trade-off between achieving a high enough force to ensure an immediate and prolonged duration of unconsciousness (ensuring no recovery before fish die from the blow itself or a follow-up kill method) while keeping the force low enough to reduce carcass damage (e.g. broken jaws and eye prolapse). There are no readily available industry guidelines on the forces required, however in a study investigating different percussive pressures, it was found that *at least* 8.1 bars of pressure was needed to stun salmon instantly, and the proportion of salmon effectively stunned increased as the force increased[15]. The improved success rate with increasing force was corroborated in another study, which suggested that over 80N was required to stun the majority of salmon and prevent recovery[14].

- The shape of the hammer affects the effectiveness of the blow. A flat cylinder head is more effective than a cone shape or penetrating spike hammer. This is because it creates a shockwave which shakes the whole brain relative to the skull, rather than targeting a specific area of the brain which would require a very high level of accuracy for each individual fish to be effective[14]. Even with the flat cylinder head hammer, a good level of accuracy is still important, so that the kinetic energy creates the desired shockwave directly into the skull and does not simply push the fish back and upwards[14].
- Method of entry into the stunner can affect stress experienced by fish prior to slaughter. Some automated systems still require an operator to orient the fish as they enter the stunner (i.e. head first and upright). However, there are also 'swim-in' delivery systems (e.g. the BAADER 101 automated Swim-In System[1]) which instead require fish to swim into the entry channels which then feed them into the stunner. Swim-in systems have a higher welfare potential as they minimise handling and keep fish in water until just before they are stunned.

b. **Manual percussive stunning**: This consists of the blow being delivered by a person hitting the fish's head with a 'priest' - a wooden or plastic club. Manual percussive stunning can be a humane method for Atlantic salmon, however is only practical for the slaughter of a limited number of fish, due to worker fatigue. Success rate may also be variable due to uncontrolled movement of the fish, or experience and competency of the worker. This can be used as a backup stunning method but workers must be trained to perform this accurately.

2. Electrical

Electrical stunning is currently used for approximately half of Atlantic salmon in Norway and a small percentage in the UK[16]. When performed correctly, electrical stunning can cause instant insensibility in Atlantic salmon[17]. However this effect is typically reversible so, in order for it to meet requirements for humane slaughter, electrical stunning must be followed by a kill method that prevents recovery of consciousness.

Atlantic salmon killed by gill cutting alone can take several minutes to lose consciousness; in one study loss of consciousness took as long as 7.5 minutes[18]. The time to death by gill cut is likely to be longer than the period of unconsciousness from electric stunning, and there is evidence that salmon can regain consciousness after having their gills cut[16] following an electric stun. Therefore electrical stunning followed by gill cutting does not constitute a humane slaughter.

Electrical stunning is only humane when followed up by one of the following methods (when performed effectively):

- A percussive blow to kill
- A percussive blow to increase the length of the stun, and then gill cut
- Decapitation
- Spiking or coring (see text box 4)

There are variations on the systems used to electrically stun salmon (described below), but more generally, the important factors to be aware of are:

- The specific electrical parameters used are critical in ensuring an effective stun. When the electrical current or voltage is too low, or the application duration too short, there may be ineffective stunning. This can be painful and cause injuries to conscious fish[19]. Alternatively it can mean fish regain consciousness during some stage of the killing or processing procedures, during which they may experience significant pain and suffering. When the electrical current or voltage is too high it can result in carcass damage such as haemorrhages, blood spotting, and spinal fractures [20,21]. It is essential

[1] https://www.baader.com/en/products/fish_processing/salmonides/salmon_and_seatrout/harvesting.html

that electrical stunning machines used are validated by studies carried out by research institutes and users follow verified stun parameters.

- Ineffective electrical stunning can go unnoticed as it can lead to physical immobilisation only, whereby the body is motionless and unresponsive in reflex tests but the fish remains conscious (as shown by brain activity measures) and sensible to pain[20,22–24]. To prevent this it is important that the parameters used in electrical stunning systems are based on recommendations from research that has validated parameters using measurements of brain activity (via electroencephalograph (EEG) measurements) and not just based on behaviour signs.

  There are in-water and dry electrical stunning machines available for salmon. Dry stunning is thought to reduce the amount of carcass damage and injuries sustained by the fish[25] when compared to in-water stunning. However, in-water stunning is preferable to dry stunning in terms of fish welfare as fish need not be singled out, restrained, handled, or removed from the water (all being stressors) before they are stunned[21].

  a. **In-water electrical stunning**: Fish are exposed to an electric current in water, either within a water tank (batch system) or while pumped through a pipe (continuous flow system) which allows for faster processing.

     For in-water electric stunning, the voltage gradient in the water or electric field strength (measured as volts per meter) is the important parameter to consider rather than the total current. The electrical current passes not only through the fish but also through the water surrounding it so the current is dependent on the electrical conductivity of the water and also on the amount of water around the fish. The electrical conductivity of the water changes with its salinity and sea water is typically one hundred times more conductive than river water. The electric field required to stun a fish decreases slightly as the water conductivity increases, however because of the increased conductivity, the current and hence the electrical power increases almost in proportion to the conductivity. Stunning a fish in sea water can therefore require up to 50 times more power than stunning the same fish in fresh water[26].

     It is difficult to provide general recommendations on the best electrical parameters to use in electrical stunning systems as so much depends on the individual set up of the system, the size and number of fish being slaughtered, and the water conductivity amongst other factors.

  b. **Dry electrical stunning**: Fish are removed from water and passed over a conveyor belt which acts as one of the electrodes, with a chain of plate electrodes (steel flaps) hanging above, acting as the other to complete the circuit. In some systems fish are sprayed with water between removing them from water and stunning, and this is referred to as semi-dry stunning.

     It is crucial that the fish enter dry stunning machines correctly - entering head-first and without excessive struggling. Incorrect orientation of fish brings a significant risk of pre-stun shocks and ineffective stunning meaning that the process is inhumane because fish may feel the electricity for a few seconds before the electrodes reach the head[11]. A study of dry electrical stunning in Norway, found that only 25-30 % of fish are oriented head-first when entering the stunner, suggesting ineffective stunning of up to three quarters of the fish through the system. With correct orientation, dry electrical stunning can be humane, providing the follow-up killing method is suitable.

     Using a combined alternating (AC) and direct (DC) current is thought preferable to AC or DC alone, as the combined current can effectively stun without compromising flesh quality[15].

Text box 1.

Carbon dioxide (CO_2) in water – AN UNACCEPTABLE METHOD OF SLAUGHTER

The use of CO_2 (with or without live chilling) is inhumane because it is slow and unreliable in causing unconsciousness, and it is highly aversive to the fish. For example, salmon will show head shaking and vigorous tail shaking for up to two minutes after exposure to CO_2[18], and will become exhausted before losing consciousness.

The gas can also render fish immobile (paralysed) before they lose consciousness and therefore suffering is likely to last longer than it appears based on their activity. For example, in one study Atlantic salmon showed aversion to for CO_2 for up to 2 minutes, but brain activity indicated consciousness persisted on average for 6.1 minutes at 6°C[18]. Therefore fish suffer for several minutes before losing consciousness, or may be bled or eviscerated while conscious.

Carbon dioxide (CO_2) is bubbled into a tank of water (which is sometimes chilled with ice) until the desired levels are obtained. For salmon, the levels of carbon dioxide used are typically between 250 and 460 mg L^{-1} [27]. Fish are transferred to the tank; where the high levels of carbon dioxide disrupt their blood pH, leading to alteration of brain function[28]. After an exposure time of 2-4 minutes they are removed and bled out by gill cut.

This method is used for approx. 7-8% of salmon in Ireland, where it is being phased out. It is already banned in the UK for all but emergency kills[29]. The use of CO_2 is banned for salmon in Norway, however it is permitted when used in combination with live chilling[16], though this variation is also inhumane.

Text box 2

Gill cutting – to be used following an effective stun, not in isolation

Gill cutting (to severe the blood vessels) is a common kill method used for salmon and forms part of the preparation for processing of the fish. Fish must be stunned (or dead) before their gill arches are severed for bleeding and when stunned remain insensible until death supervenes. This may be performed by hand or by automatic gill cutters, i.e. a rotating blade as part of the stunning machine, performing the cut soon after stunning. In most cases, bleeding is done by cutting all the gills arches on one side of the fish.

Text box 3

Decapitation – to be used following an effective stun, not in isolation

The head of the fish is removed rapidly, with a handheld blade or an automated rotating blade. Fish must be stunned (or dead) before they are decapitated, and when stunned should remain insensible until death supervenes. This is because decapitation does not instantly kill and consciousness is not lost immediately. If the stun method does not cause a loss of consciousness for as long as is required for brain death after decapitation, then the brain should be manually destroyed after decapitation, e.g. by spiking or maceration.

Text box 4

Spiking and coring

Spiking (also known as *iki jime*) and coring are used to stun and kill fish by causing severe and irreversible damage to the brain (FAWC, 2014). The brain is damaged either by pushing a solid, pointed metal rod (spiking) into the head which is then moved around to destroy the brain, or a hollow metal rod (coring) which is usually knocked into the brain with a mallet. For both methods, accuracy in positioning and delivery of the device is crucial to avoid injury and suffering (FAWC, 2014). The EFSA (2004) recommend that manual spiking is "slow to achieve and the technique should not be used", but mechanical methods can be humane. For example, pneumatically operated pistols used to insert the spike make the process more effective.

Recommendations for corporate policies on humane slaughter of Atlantic salmon

1. All animals killed for food should be slaughtered humanely. This means that they must be stunned, rendered instantly insensible, and they should not regain consciousness before dying. For Atlantic salmon, the use of *stun-kill* percussive methods are recommended above other methods where possible. Percussive or electrical stunning followed by a separate kill method is also acceptable, providing that fish do not regain consciousness after stunning. The use of carbon dioxide systems for Atlantic salmon is unacceptable and must be phased out (see text box 1).

2. The killing of animals by bleeding without the use of pre-slaughter stunning is not considered a humane method of slaughter. Corporate animal welfare policies should stipulate that all fish products in the supply chain come from fish that have been subject to pre-slaughter stunning.

3. Fish removed from the production line (i.e. sick or injured fish, or those that do not fit market criteria) must be killed humanely.

4. All systems for killing animals should be effectively managed and monitored. This includes:
   - The development and use of Standard Operating Procedures (SOPs) for all live animal operations
   - Effective training of all staff involved in live animal operations.
   - Designating a member of staff responsible for animal welfare in the slaughterhouse, an "Animal Welfare Officer", whose role it is to monitor operations to ensure SOPs are followed and to require remedial action be taken if non-compliance or other issues are found.
   - Use of CCTV in all live animal handling areas, with effective monitoring of the footage.
   - Effective measurement and proactive management of welfare outcomes at slaughter.

5. Pre-slaughter fasting periods should be no longer than is required for fish welfare benefits (i.e. to reduce oxygen requirements and waste accumulation in the water) and should not exceed 72 hours for each fish. Procedures should be in place to ensure that this maximum time is not exceeded for every fish in the pen. For example, where multiple harvests/days are required to slaughter all fish in a pen, the fish should be segregated so that fasting times can be adhered to. Records of the dates and duration of fasting should be kept.

6. Crowding time and intensity should be minimised.

   - Narrow, deep nets should be used as they are more welfare-friendly than wide shallow nets for crowding fish.
   - Crowding should be carefully monitored and managed so that the crowd remains calm, with very few fish showing signs of distress, such as leaping or thrashing. If this occurs it is a sign that the fish are over-crowded.

- The fish should not be crowded for longer than 2 hours and repeated crowding should be avoided. Where unavoidable there should be a period of 24-48 hours between subsequent crowds.
- Oxygen levels in the water should be monitored throughout the crowding process and producers must ensure that oxygen levels stay above 7mg/l. If fish show behavioural signs of stress or oxygen levels fall below 7mg/l then fish should be given more space by releasing the nets. During crowding the water should be aerated and/or supplemented with oxygen. Keeping nets clean also help as fouled nets can reduce the water flow.

7. Movement of fish to the point of slaughter should be carefully managed to minimize stress.
   - Only healthy fish should be transported so a health check should be carried out before transporting fish.
   - If hand-nets are used (e.g. to remove sick fish from the cage), they should be used to remove small numbers of fish only. Nets should have a smooth surface and should be used carefully, with fish being out of water for a maximum of 15 seconds.
   - Braille nets should not be used to move fish out of water. Instead, pumping systems should be used to move fish in-water, and these must be carefully designed and managed to ensure gentle movement of fish through pipes. The following points are important:
     - An even flow of fish should be achieved, rather than a pump which delivers fish in bursts.
     - Fish must move through the pipes at a suitable speed - fish should not be able to swim against the pumping current as this risks injury and exhaustion of fish and keeps them inside the pipe for longer than necessary. However, if the pumping current is too strong the fish may be at risk of injury either inside the pump or on exit.
     - Pipes should be dimensioned to accommodate the size of the fish and the number of fish being pumped, and should have a smooth surface on the inside, including at the point of any joins between pipes.
     - Pipes should be as short and straight as possible.
     - All fish should be cleared from the pipes/pumps before any break/stop in pumping, and fish should not spend any longer in the pipes than necessary. Oxygen is quickly depleted inside the pipes and fish will die quickly if stuck in the pipes.
     - If injuries occur (e.g. fin damage, scale damage, wounds on the snout, bruised musculature etc.) inside the pipe, measures must be taken to investigate and correct any flaws in the system.
   - Transport of fish over longer distances (e.g. by well boat) must be carefully managed. The water quality must be continually monitored for oxygen (must be 7mg/l or higher) and pH (must be 6.8-8)[7]. Stocking densities during transport are based on the liveweight of the fish and should not exceed 125 kg/m^3 (for 5kg salmon), 110 kg/m^3 (for 4kg salmon), 100 kg/m^3 (for 3.5kg salmon)[7].

8. If fish are dewatered before slaughter this should be well designed so that fish are moved with the least impact and risk of injury. The time that fish are exposed to air should be kept to a minimum; 15 seconds should be the maximum.

9. With percussive systems:
   - Automated percussive machines are preferable over manual percussive blows, especially in larger operations. However, where manual stunning is performed (e.g. as a backup killing method) operators must be trained to deliver a single, effective blow to stun each fish.
   - A kill method (gill cut, decapitation or spiking) must be performed as soon as possible following stunning to reduce the risk of recovery before death occurs.
   - Fish should be graded (if there is significant size variation) before stunning with an automated percussive machine so that the machine set-up will be effective for all fish; the ideal positioning of the percussive blow for salmon is directly above and slightly behind the eyes.
   - All fish must enter the automated percussive machine head-first. Operators should be present to orient fish manually and check that every fish is correctly aligned, even with swim-in systems.

10. With electrical systems:
    - Compromises to the welfare of the fish should not be made for the sake of product quality. Electrical parameters should be chosen that result in an effective stun which lasts until death and that minimises the risk of electro-immobilisation (fish being paralysed but still conscious). The parameters should be appropriate for the size and number of fish being slaughtered, equipment set-up and water conductivity.
    - In dry and semi-dry systems, all fish must enter the machine head-first. Operators should be present to orient fish manually and check that every fish is correctly aligned.
    - In dry and semi-dry systems, the time out of water should be kept to a minimum (the Humane Slaughter Association recommend a maximum of 15 seconds from dewatering to stunning)[9] to minimise stress and prevent aversive movements which may affect their smooth entry into the percussive stunner.
    - Fish should be graded (if there is significant size variation) before stunning as very small or large fish, deformed fish or sexually mature fish will lie outside the stunning machine parameters[32].
    - A kill method (decapitation, percussive blow or spiking) must be performed as soon as possible following stunning to prevent recovery of consciousness before death occurs. A gill cut is not an acceptable kill method unless percussive stunning is performed first.
    - For in-water systems it is important to clean and maintain electrodes daily as corrosion can build up quickly, especially in saltwater systems, which can affect the amount of current delivered to the fish and result in an ineffective stun.

11. All fish must be observed post-stun by a trained operator. If any fish show signs of recovery, such as opercular movement or eye roll, or in the case of stunner equipment failure, a contingency plan must be in place to immediately stun and kill the fish, e.g. with manual percussion and gill cutting, or spiking.

Welfare outcomes at slaughter

In order to proactively monitor and improve animal welfare at slaughter it is necessary to start by identifying appropriate measures of salmon welfare. Whilst it is important (and in many cases mandatory) to record non-animal-based measures, such as electrical stunning parameter data, it is also important to look at the animal. Welfare outcomes are animal-based measures which give a more direct insight into the animal's experience than can be achieved by measuring 'inputs' such as husbandry resources alone. They are influenced by several factors and corrective action may require investigating a range of potential solutions.

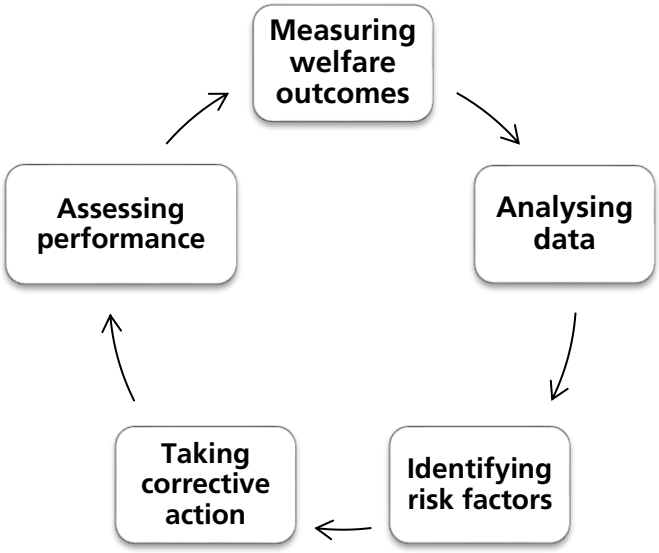
Corporate policies on animal welfare should stipulate that welfare outcome measures are used at slaughter. Recommended welfare outcome measures for Atlantic salmon at slaughter include the following:

Welfare Outcome	Detail
Activity during crowding	**WHAT:** A qualitative assessment of the activity of fish during crowding. **WHY:** The activity of the fish during crowding, as seen at the surface of the water, is an indicator of the stress experienced during this time. **HOW:** This measure should be continuously recorded. Their activity can be scored on a 5 point scale, described here: https://www.hsa.org.uk/downloads/publications/harvestingfishdownload-updated-with-2016-logo.pdf **TARGET:** 100% of the crowding procedures to be scored 1.

Indicators of consciousness	**WHAT:** An assessment of consciousness performed during the time interval between stunning and death. **WHY:** For slaughter to be considered humane, fish must be effectively stunned (rendered unconscious) so that they do not experience pain or stress during the process. **HOW:** This measure should be continuously recorded. Assess indicators of consciousness during bleeding (see later table for a full list of potential indicators that can be used) and record the number and percentage of fish that show signs of recovering consciousness. Also record the action taken when fish showing signs of consciousness are detected. **TARGET:** 0% of fish to show signs of returning to consciousness[33]. *If signs of consciousness are seen, fish must be immediately re-stunned or stunned with an alternative, back-up method.*
Pre-stun shocks	**WHAT:** Fish may receive electric shocks upon entry to a dry electrical stunner, which are not sufficient to cause unconsciousness but which cause pain. These can be caused, for example, when a fish is moving vigorously and makes contact with one but not both of the electrodes, or due to tail-first entry to the stunner. **WHY:** The fish are still conscious and therefore these pre-stun shocks cause pain. Pre-stun shocks indicate that the stunning machine is poorly designed and/or operated. **HOW:** This measure should be continuously recorded. The incidence of fish entering the stunner head-first and calm (not thrashing) can be recorded. **TARGET:** 100% of fish to enter the stunner head-first and without thrashing movements.
Post-mortem flesh quality	**WHAT:** Time to rigor mortis and gaping of the muscle tissue. **WHY:** Post-mortem flesh quality can give a valuable insight into pre-slaughter treatment of the fish. When fish are stressed before (i.e. when crowded) and during slaughter they can become very active and use up their energy reserves, causing an increase in lactic acid. This has a negative impact on flesh quality, i.e. time to rigor decreases (decreasing yield and shelf life) and flesh gaping increases (reducing yield and making it less appealing to consumers). **HOW:** Record time to rigor and gaping from a sample of carcasses.
Post-mortem haemorrhages	**WHAT:** Haemorrhages on the flesh of the fish. **WHY:** Physical damage post-mortem can give a valuable insight into pre-slaughter treatment of the fish. Haemorrhages are areas of flesh that have been damaged causing blood to leak into the area. Haemorrhages can occur if fish fall or are dropped from the dewaterer or braille, or if poorly maintained and operated pumps and pipes are used. They are also typically seen in the tail region if a fish has been lifted or held tightly by its tail prior to slaughter. Haemorrhages can also be caused by poorly-positioned manual percussive stunning and by electrical stunning if the correct parameters have not been used. **HOW:** Record incidence of haemorrhages from a sample of carcasses.
Post-mortem scale loss	**WHAT:** Scale loss or damage. **WHY:** Physical damage post-mortem can give a valuable insight into pre-slaughter treatment of the fish. Fish that are crowded and stressed can damage their scales due to rubbing against nets or each other. **HOW:** Record incidence of scale damage from a sample of carcasses.

Post-mortem eye damage	**WHAT:** Eye damage. **WHY:** Physical damage post-mortem can give a valuable insight into pre-slaughter treatment of the fish. Eye damage occurs during percussive stunning when the blow is position incorrectly and either hits the eye directly or close enough for the eye to rupture. Eyes can also be affected by poorly maintained nets. **HOW:** Record incidence of eye damage from a sample of carcasses.
Post-mortem snout damage	**WHAT:** Snout damage such as bleeding and/sore areas. **WHY:** Physical damage post-mortem can give a valuable insight into pre-slaughter treatment of the fish. Snout damage occurs when pre-slaughter crowding is not well managed and fish are swimming into the nets and each other. **HOW:** Record incidence and level of snout damage from a sample of carcasses.

Welfare outcome measures should be used as part of a proactive programme of measurement and continuous improvement, including target setting. A programme should involve a continuous cycle of:



Regular monitoring of welfare outcomes enables swift detection of problems, implementation of corrective action and continuous improvement to be achieved. Some measures should be continuously recorded (as indicated in the table above). For the other measures, it is recommended that they are recorded on a representative sample of a minimum of 50 fish per harvest. Target setting should be used for all measures, to drive improvement.

Indicators of consciousness

It is difficult to reliably determine *unconsciousness* of fish (and therefore that stunning is effective) at the slaughterhouse (EEG measurements are required and this can only be measured in the lab) but it is important to ensure that there are no signs of consciousness after stunning. If any of the following signs of consciousness are observed then stunning is likely to have been ineffective. If in any doubt as to whether a fish is unconscious, do not hesitate to repeat the stun or use an alternative, back-up method.

Signs of an ineffective stun	Comment	Stunning methods applicable to
Breathing	Regular opercular movements indicate the fish is likely to be conscious	All
Eye roll	The vestibulo-ocular reflex (VOR), known as "eye roll", refers to the movement of the eyes in the head as the fish moves. In a conscious fish, the eye rotates dorso-ventrally when the fish is rocked from side to side.	All
Coordinated behaviour	Coordinated behaviour such as swimming or attempts to escape is a sign that fish is conscious.	All
Behavioural response to tail pinch	Behavioural response such as movement away from the stimulus indicates the fish is likely to be conscious.	All
Ability to achieve equilibrium	If a fish is able to achieve equilibrium after being inverted in water, then it is likely to be conscious.	All

Disclaimer

We will incorporate new scientific information regarding humane slaughter for fish into subsequent versions of these resources. Some of this research may alter our understanding of current established practice. Last update: November 2018

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