Improving the welfare of farmed Atlantic salmon at rearing


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Foreword

Salmon are sentient beings that must be provided with a good quality of life in a farmed environment. The salmon welfare policy should address the provision of good housing, good feeding, good health and opportunities to express appropriate behaviour to salmon. Higher stocking densities, poor water quality, sea lice treatments and other procedures that require handling, lead to stress and poor welfare. Any practices that compromise the welfare of other fish, such as cleaner fish, must also be addressed in the salmon welfare policy.

We recommend

✔ Good Environment

- Stocking density per cage shall not exceed 10 kg/m³ in the seawater phase. When the stocking density is calculated, the volume that the fish have the opportunity to move in shall be taken into account. The exact stocking density (though always 10 kg/m³ or lower) should be determined based on water quality, the behavioural and physiological needs of salmon, health status, production system and feeding methods so that welfare is optimised.

- Water quality, such as dissolved oxygen, salinity, turbidity and temperature, should be monitored continuously. Measurements should be taken not only from surface waters but throughout the depth of the cage. This data is crucial to understanding how the fish behave and aggregate within a sea-cage. When changes in the environment occur which lead to sub-optimal conditions within a sea cage or if rapid changes are detected, management steps should immediately be taken to address any welfare impacts upon the fish e.g. by oxygenating the water, reducing biomass within the cage or increasing cage volume. Parameter reference ranges are discussed in more detail in Fishwell welfare indicator handbook[1].

✔ Good Feeding

- Food must be of optimal quality for fish and the feeding method used must minimise competition and hence aggression and ensure that all the fish have access to feed[2]. Fasting periods should only be used when absolutely necessary and when advised by a vet. If used, for instance prior to a disease treatment, 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. Records of the dates and duration of fasting should be kept.

✔ Good Health

- Disease treatments that cause major welfare problems (e.g. treatments for sea lice such as exposing fish to warm water or higher pressures (Thermolicer and Hydrolicer) and bathing fish in chemicals irritants such as hydrogen peroxide) must not be used routinely and only when prescribed by a vet. All treatments should be recorded in a veterinary health and welfare plan which should also assess fish for suitability PRIOR to any disease treatment or management procedure. The veterinary health and welfare plan should outline planned husbandry procedures, risk assessments, disease monitoring and all treatments carried out. If these treatments are used routinely the fallowing period must be extended. Cleaner fish are not recommended as a sea lice treatment and should be phased out.

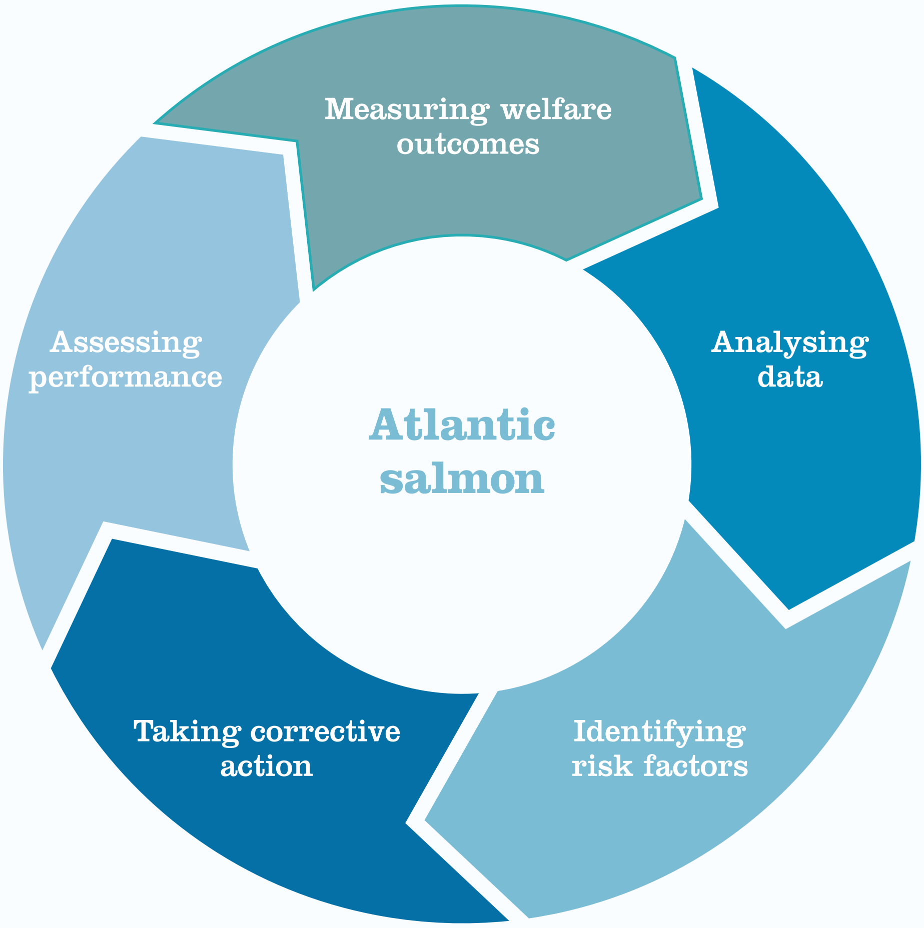
✔ Opportunities to Express Appropriate Behaviour

- Crowding, handling and grading should be performed only when absolutely necessary, be as gentle as possible and salmon must not be out of the water for more than 15 seconds[3]. See our resource about the humane slaughter of Atlantic salmon for more information[4].

- Welfare outcomes should be measured and recorded for salmon and cleaner fish. Although parameters for cleaner fish urgently need development, those for Atlantic salmon include parameters such as swimming behaviour, feeding behaviour, skin and fin damage and skeletal deformities – see Welfare Outcome Measures (below). Further work to develop more behavioural indicators of positive welfare for Atlantic salmon are required.

Welfare outcome measures

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. For the other measures, it is recommended that they are recorded on a representative sample of a minimum of 50 fish. Target setting should be used for all measures, to drive improvement.

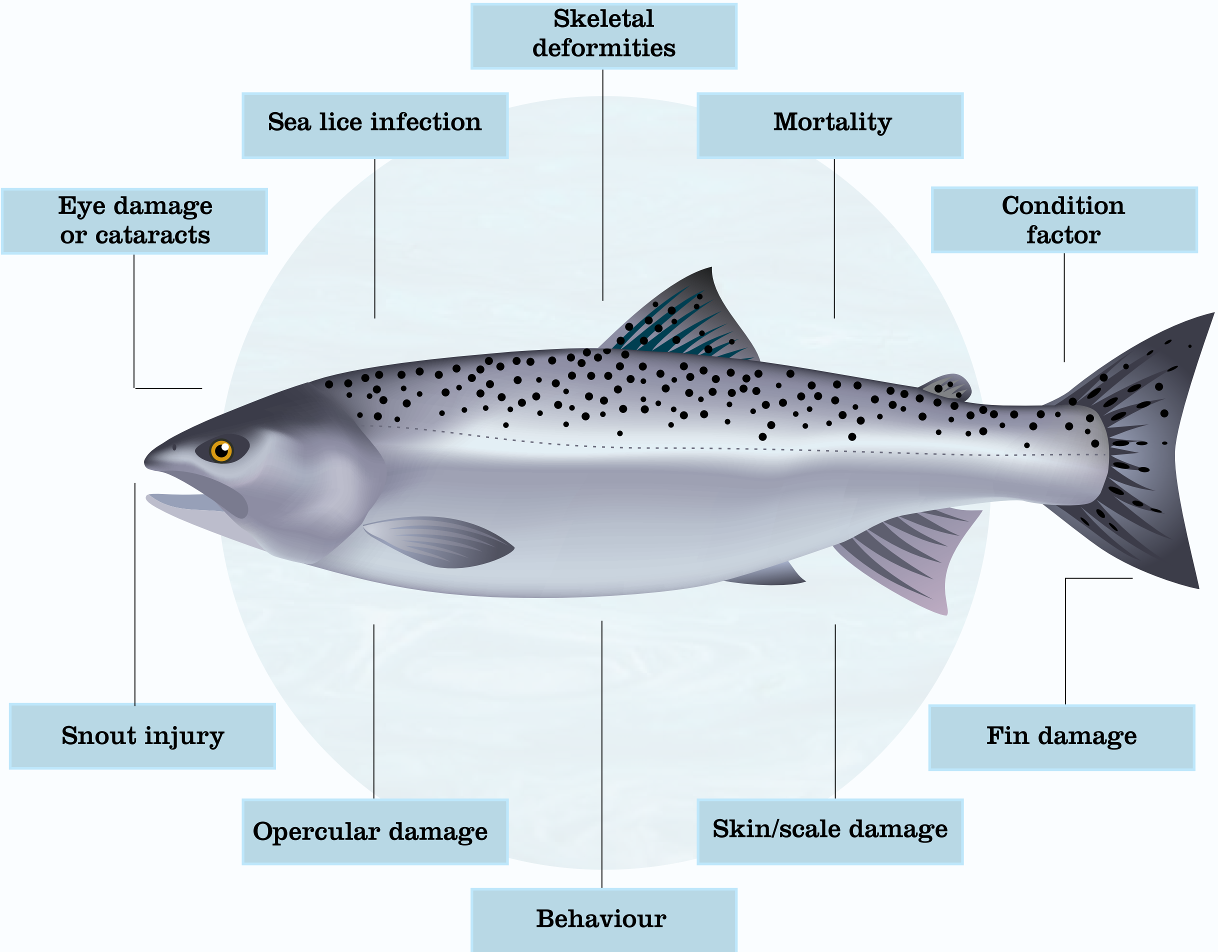
[1] https://nofima.no/wp-content/uploads/2021/05/FISHWELL-Welfare-indicators-for-farmed-Atlantic-salmon-November-2018.pdf

[2] There is an urgent need to address the high numbers of fish utilised to formulate salmon feed with a focus on sustainability of those fisheries and welfare of the fish species. There is also a need for further research into improvements in reducing the proportion of animal protein in salmon feed without negatively impacting the welfare of farmed Atlantic salmon.

[3] RSPCA welfare standards for FARMED ATLANTIC SALMON (2018), https://view.pagetiger.com/Salmonstandards2018/Salmonstandards2018

[4] https://www.compassioninfoodbusiness.com/resources/fish

Welfare outcomes in sea cages



For photographs of each scoring system outlined below, please see the poster FISHWELL Morphological Operational Welfare Indicators (OWIs) for farmed Atlantic salmon v1.1.

Mortality

WHAT: Record incidence dead and moribund fish in each sea-cage.

WHY: Widely collected data (often required daily) – it is a crude indicator of on-farm welfare issues as it is retrospective however increases in mortality rate can indicate welfare issues that have been overlooked.

HOW: Count the number of dead and culled fish in each cage, ideally on a daily basis, as they are removed and analysed for cause of death and for disposal. Report % and cause of death, if known.

Body condition factor and emaciation state

WHAT: Condition factor assesses and monitors the body fat reserves (condition) of individual fish. It will also identify any thin or emaciated fish however, this is usually picked up beforehand on gross examination using emaciation state. Emaciation state detects salmon that are abnormally weak or thin, combining their physical appearance and behaviour. Common causes for thin or emaciated fish include failed smoltification, disease, sea lice and stress.

WHY: Good nutritional status, measured by condition factor, is required for successful production as well as for good salmon welfare. A drop in condition factor generally indicates a welfare issue. Emaciated fish, being smaller, will quickly be outcompeted for food and will not be able to feed as the pellets increase in size. Early detection of emaciated fish is important as they can experience low welfare for a long time before they die and can also be a vector for transmitting diseases to other healthier fish.

HOW: Condition factor (K) is calculated as: 100 x weight (g) x length (cm). It can be measured automatically. If manually, it should be measured as frequently as possible (such as during sea lice counts), but as a minimum, during risk periods such as smoltification, fasting, stressful periods and feeding deficits. Condition factor will vary with life stage and season but should be between 1 and 1.6 for smolts and fish up to harvest. A K value below 0.9 usually indicates emaciated fish, whilst a very high K value may be an indicator of a vertebral deformity and should be monitored.

Emaciated fish are identified due to their abnormal behaviour (swimming slowly near the net or surface and away from the main school) and can be scored according to their physical appearance on a 0-3 scale. 0 is normal; 1 is potentially emaciated; 2 is emaciated and 3 is extremely emaciated.

TARGET: Condition factor 1-1.6 (smolt to harvest) and 0% emaciated fish at level 3.

Fin damage

WHAT: Fin damage can be measured as an individual OWI where the severity and prevalence of fin damage and lesions are manually scored (see below). If individual fish are not being sampled (e.g. for sea lice counts) then fin damage can be measured more generally from the surface as a group, non-invasive, measure such as looking for dorsal fin damage (seen as grey fins).

WHY: Fin damage can indicate welfare problems such as increased aggression, strong water currents, recent rough handling or disease.

HOW: Individual fish are scored (ideally at time of sea lice monitoring) by checking dorsal, caudal and pectoral fins. 1: most of fin remaining; 2: only half of fin remaining; 3: very little of fin remaining.

Atlantic salmon sea cage farming.

Snout damage

WHAT: Record incidence and severity of snout damage and lesions via manual scoring system.

WHY: Often occurs in relation to handling procedures such as crowding, pumping or netting.

HOW: Damage (which can be assessed at time of sea lice counts) is scored on a 0-3 scale with 0 being no damage noted; 1 being a minor wound on the snout (either jaw); 2 being a moderate wound and broken skin on snout and 3 showing a large, deep and extensive wound which can cover the whole head.

Gill status

WHAT: Record incidence and severity of gill damage and lesions via a manual scoring system.

WHY: Reduced gill function affects not only the fish's ability to exchange gases but also to excrete waste products and osmoregulate. Bacterial, parasitic, viral and fungal pathogens and poor water quality can all cause gill problems. Chronic gill disease makes the fish more sensitive to stress, reduces growth and can cause high mortalities.

HOW: Severity of gill damage can be assessed on the farm by examining fresh gill smears under the microscope. Once diagnosed by histology, amoebic gill disease (AGD) can be scored by the presence of pale, mucoid lesions on the gills on a 0 (no infection) to 5 (severe infection) scale (Taylor, Muller, Cook, Kube, & Elliott, 2009).

Eye damage or lesions

WHAT: Record the incidence and severity of eye damage and lesions (haemorrhage, cataracts, exophthalmia "pop-eye") via manual scoring system.

WHY: Fish have no eyelids and their eyes protrude so are very vulnerable to damage. Trauma can indicate recent poor handling procedures; exophthalmus is a non-specific sign of disease. Cataracts or loss of transparency are multifactorial (nutritional deficiencies, osmotic imbalances, water temperature or salinity changes), and also linked to exposure to repetitive stress. Development of cataracts eventually leads to blindness and thus poor welfare.

HOW: Damage/protrusion is scored on a 0-3 scale with 0 being no damage noted; 1 being a minor protrusion or haemorrhage; 2 being a moderate eye protrusion or larger haemorrhage/trauma; and 3 being a major eye protrusion or a large haemorrhage/trauma (eye may be ruptured). Cataracts are scored on a 0-4 scale with 0: no cataract; 1: cataract covers <10% lens diameter; 2: cataract covers 10-50%; 3: cataract covers 50-75%; 4: cataract covers >75% lens diameter.

Opercular damage or deformity

WHAT: Shortened, "soft", missing or warped opercula.

WHY: Fish with damaged opercula have less efficient respiration because they cannot pump water effectively over their gills. Deformities are caused by suboptimal rearing conditions, dietary deficiency and pollution.

HOW: Fish are scored on a 0-3 scale with 0 being no evidence of opercular damage; 1: operculum only partly covering gills; 2; operculum absent on one side completely exposing gills; 3: both gills completely exposed and both opercula absent.

Sea lice infection

WHAT: A crustacean parasite of Atlantic salmon that can reach abnormally high numbers under intensive farming conditions. Sea lice feed on the skin, mucus and underlying tissue of the host fish. High numbers cause skin lesions, osmotic problems, secondary infections and, when severe, mortalities. Low numbers can still be an irritant to fish.

WHY: To prevent sea lice reaching levels that will cause injury and welfare issues to fish. Stien *et al.*, (2013) suggests 0.12 lice cm^2 fish as the limit for salmon survival, with levels above this being lethal for farmed salmon. Sea lice numbers on farmed Atlantic salmon are monitored and when they reach a threshold density will trigger the need for treatment on that farm. Lice counts are mandatory in most affected countries.

HOW: Individual fish are removed and anaesthetised and sea lice numbers and life cycle stages noted as they are removed from the fish. Care should be taken to try and get a representative sample of fish. Fish are scored on a 0-3 scale with 0 being no evidence of sea lice; 1: light infection, 2: 0.05-0.08 adults or pre-adults per cm^2 of skin and 3: ≥0.08 adult or pre-adult lice per cm^2 of skin[1].

The Code of Good Practice for Scottish Finfish Aquaculture suggests thresholds for the treatment of sea lice on individual farm sites are:

- An average of 0.5 adult female L. salmonis per fish during the period 1st February to 30th June.
- An average of 1.0 adult female L. salmonis per fish during the period 1st July to 31st January.

However, it should be noted that where lice levels are low, frequent handling and treatment associated with delousing may be a more serious welfare issue to Atlantic salmon than the effects of sea lice themselves[2]. It is critical to regularly assess the welfare impacts of sea lice infection versus treatments and thresholds re-adjusted as information on newer sea lice treatments becomes available (see "Improving the welfare of farmed Atlantic salmon" for further details).

Skeletal/vertebral deformities

WHAT: Vertebral and skeletal deformities may be due to many factors but links to malnutrition, elevated temperatures and altered photoperiod to speed up growth (Fjelldal *et al.* 2012) are clear.

WHY: Impacts morphology and swimming behaviour and therefore welfare. In addition deformities also affect automated processing methods post slaughter.

HOW: Visual scoring (at time of sea lice counts) on a 0-3 scale with 0 being no evidence of deformitiy; 1: mild signs of deformed spine; 2: a marked spinal deformity that is visibly obvious; 3: extreme deformity.

Behaviour

WHAT: Extremely feasible and useful welfare indicator as it is non-invasive and doesn't require handling of the fish or removing them from the water. Observations can usually be made by mobile feed cameras and fish aggregations can also be detected and assessed by echosounder. See Table 1 for detail of behaviours.

WHY: Gives us a subjective idea of the experience of the fish, for example, exploratory behaviour and feed anticipatory behaviour can all be signs of good welfare. On the other hand, abnormal behaviour can indicate poor management of the sea cage or suboptimal environmental conditions.

HOW: Use underwater/mobile feed cameras to look at body language. i.e. different swimming modes, fin displays, gill ventilation rate, skin pigment patterns and colouration, response to feeding, position in water column, swimming densities. The downside is that many behaviours are difficult to quantify and also rely on skills of the observer and knowing what normal is for each life stage/production system/water environment.

[1] 0.05 lice per cm^2 equates to about 7 lice per 100g animal and 35 lice per 1000g animal.

[2] Noble *et al* 2018 - Welfare Indicators for farmed Atlantic salmon – Part A. Knowledge and theoretical background. https://www.researchgate.net/profile/Stine_Gismervik/publication/329782245_Welfare_Indicators_for_farmed_Atlantic_Salmon_tools_for_assessing_fish_welfare/links/5c1a4e2d299bf12be38b26f7/Welfare-Indicators-for-farmed-Atlantic-Salmon-tools-for-assessing-fish-welfare.pdf#page=239

Table 1: Atlantic salmon sea-cage behaviour signals (can be assessed during routine observations)

Behaviour	Positive/good welfare	Sign of stress and/or poor welfare
Depth distribution (natural lighting conditions	Distribute near surface at night and then deeper depth during the day[3]	Escape behaviour such as hiding, burrowing, seeking shelter, increased group clumping.
Ventilation rate	Normal or baseline rates can be very variable, for example, 56 beats/min; 108 beat/min; 56-64 beats/min	% increases are useful to monitor during husbandry procedures i.e. low water oxygen, gill disease such or stress (NB increases due to increase in activity are normal).
Swimming behaviour	Circular schooling behaviour at daytime avoiding innermost part of cage and cage corners – breaks down upon feeding	Stereotypic or slow swimming. Unstructured swimming at bottom of cage – acute stress. Congregating at the surface – gill disease. Freezing behaviour: individual does not move (fear response or avoiding predation.
Aggressive behaviour		Chasing, nips, attacks.
Exploratory behaviour		Poor or absent response to novel objects.
Feeding behaviour	Increase in swimming speed and turning angle; approaching the feed delivery area and rising to surface prior to feeding. Fish swim towards the food pellets – usually delivered centrally. Swimming speed can also change within a meal in relation to appetite and hunger status.	Hungry fish remain at the feeding area after feeding has ceased rather than descending to deeper waters when satiated. Reduced feed intake – can be due to poor water quality; anaesthetisation and vaccination.
Pain/nociceptive behaviour		Body rocking or rubbing against surfaces.

[3] exception is newly transferred smolts which prefer to accumulate at the halocline (where salinity changes most rapidly) for the first 2 months after transfer to seawater.