Inquiry on salmon farming

Rural Affairs and Islands Committee

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OneKind
Ending cruelty
to Scotland's animals

We ask that this document be considered as part of the Rural Affairs and Islands committee's (RAIC) follow-up inquiry into salmon farming, which aims to assess the level of progress that has been made in implementing the recommendations that were agreed by the Rural Economy and Connectivity committee (RECC) in the previous session of Parliament. Here we provide evidence that little or no progress has been made towards the recommendations relating to fish health and welfare.

We also provide evidence that those recommendations were themselves not enough to fully provide for the welfare of fish in the salmon farming industry. We understand that this goes somewhat further than the stated scope of the current inquiry. However, the REC committee stated that *"[…] the "status quo" in terms of regulation and enforcement is not acceptable. It is of the view that urgent and meaningful action needs to be taken to address regulatory deficiencies as well as fish health […]"*. Six years on, there has not been urgent or meaningful action and the status quo is very much still evident in terms of animal health and welfare. We believe that this justifies a fresh assessment of the changes needed for fish welfare, particularly as the understanding of animal welfare for terrestrial animals is rapidly evolving and the salmon farming industry has not kept up.

In 2018 OneKind published a detailed, fully referenced report on the welfare issues in salmon farming. Although a few specifics, such as references to seal shooting, are outdated, the core issues are still very much relevant. We urge members to consult that report for further information, including on issues not included here. Here we concentrate on the RECC recommendations and more recent evidence.

Key points

- Farmed fish mortality levels have continued to increase and are unacceptably high. Mortality is usually preceded by suffering. The causes of farmed fish mortality are a vicious cycle of competing harms, where treatments do further harm to fish already compromised by planktonic blooms, micro-jellyfish, diseases and parasites. This situation seems very unlikely to improve while the industry continues to expand because increasing farmed fish biomass is one of the two most important risk factors for higher mortality, along with milder winters, according to Scottish Government Marine Directive researchers.[1] Technological solutions, such as physical lice treatments, bring concurrent increased risks to welfare, so promises that innovation will reduce mortality and improve

[1] Modelling temperature and fish biomass data to predict annual Scottish farmed salmon, Salmo salar L., losses: Development of an early warning tool - ScienceDirect

welfare should be viewed with caution. Scrutiny must shift to the root causes and how to achieve acceptable holistic fish welfare.

- As sentient animals protected under the Animal Health and Welfare (Scotland) Act 2006, farmed fish should have statutory welfare standards and official guidance, which they currently do not.
- The RECC stated that regulation was light touch, confusing and poorly coordinated. That remains the case with regards to fish welfare. FHI has no responsibility for enforcing the 2006 Act. Many reports of high mortality sent to FHI are not referred to APHA and the Local Authorities that are responsible. Freedom of Information responses suggest that there are no repercussions, even when APHA does inspect farms that have experienced mass mortality. We urge the committee to invite APHA and COSLA to give evidence, to ascertain why this is. In particular, why any environmental challenges, treatments or practices that occur routinely throughout the industry seem not to be considered to cause unnecessary suffering, regardless of the experience of the fish, and why APHA's inspectors only seem to consider whether unnecessary suffering is occurring *during their visit*, rather than whether it must have preceded the high levels of mortality that resulted in their inspection.
- "Cleaner fish" are also covered by the 2006 Act but they are not being protected from unnecessary suffering.
- The welfare focus in this industry is only on fish health and biological functioning. This is only one aspect of welfare. A modern understanding of welfare focuses on mental state, and opportunities for positive welfare and agency. Welfare provisions and assessment should be expanded accordingly.

Mortality

RECC RECOMMENDATION 9: "However, the Committee considers the current level of mortalities to be too high in general across the sector and it is very concerned to note the extremely high mortality rates at particular sites as highlighted in the data recently produced by the SSPO. It is of the view that no expansion should be permitted at sites which report high or significantly increased levels of mortalities, until these are addressed to the satisfaction of the appropriate regulatory bodies."

This recommendation has not been met. Mortality rates remain persistently high and deaths at sea have increased year on year since the REC report, to over 17 million annually for the last two years.

In its report the RECC cited monthly mortality rates as high as 7.9% and cumulative mortality for entire cycles as high as 34%, on certain farms. More recent figures far exceed these. In October 2023, Mowi had monthly mortalities of 21.6%, 31.7% and 34.7% on three of its farms. Cumulative mortalities reported in that same month included two Scottish Sea Farms sites with 51.9% and 57.6% respectively. As John Aitchison pointed out in oral evidence, two farms near Gigha had 82% mortality in their most recent production cycles. Subsequently, Freedom of Information requests have shown that those were not reported to Argyll and Bute Council, although the Animal and Plant Health Agency (APHA) say that they refer mass mortality to

local authorities for any enforcement action required (see below for further details on regulatory failures).

RECC RECOMMENDATION 10 "[…] there should be a process in place which allows robust intervention by regulators when serious fish mortality events occur. It considers that this should include appropriate mechanisms to allow for the limiting or closing down of production until causes are addressed."

This recommendation has not been met. There is no such process in place, and little or no formal, recorded intervention when serious mortality events occur. See below for further details on regulatory failures.

Causes of morality, and the interplay between disease, parasites and treatments

RECC: "The Committee does not underestimate the serious challenge which gill health disease presents to the industry. Indeed, it has difficulty in understanding how expansion of the industry can reasonably occur if this issue is not satisfactorily resolved."

This issue has not been satisfactorily resolved; on the contrary is continues to worsen, as the committee heard in oral evidence from several witnesses. Those witnesses also explained that poor gill health can mean that fish cannot cope with lice treatments and weaken or die after them.

The impact of treatments is borne out by published scientific evidence. One study which investigated mortality patterns associated with 4,644 delousing treatment of 1,837 cohorts of farmed salmon found that mortality increased after all of the most common sea lice treatments – thermal, mechanical, hydrogen peroxide, medicinal bath, freshwater bath, and combined treatments – and was highest after mechanical and thermal treatments.[2] Mechanical and thermal delousing are also linked with lowered appetite at a group level and some individuals stop eating altogether due to stress and injury, sometimes for weeks.[3]

The treatments themselves cause suffering, and it seems likely that the subsequent impact on their health does also. Physical lice treatments, including the Thermolicer, are arguably not compliant with the Animal Health and Welfare (Scotland) Act 2006 as they cause suffering, and it is difficult to argue that is "necessary", even within the fairly wide interpretation given to that term. Under the Act suffering is "necessary" if it is for a legitimate purpose, that purpose cannot be achieved with less suffering, and the suffering is proportionate to the aim. As salmon farming is a legal activity the first test is met, but there are alternative methods to treat sea lice, and the suffering the physical treatments causes is, in our informed assessment, disproportionate. Ultimately, farms could also reduce the risk of serious sea lice levels, gill disease and other causes of mortality without causing additional suffering, simply by stocking fewer fish, or by moving to healthier sites.

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[2] Estimating cage-level mortality distributions following different delousing treatments of Atlantic salmon (salmo salar) in Norway (wiley.com)

[3] Fasting and its implications for fish welfare in Atlantic salmon aquaculture - Hvas - 2024 - Reviews in Aquaculture - Wiley Online Library

We also have grave concerns for the welfare of wrasse and lumpfish used as "cleaner fish" and do not see that practice as acceptable, at least as it is currently practised. These species have different needs than salmon, further complicating the already unmet challenge of providing for the needs of all fish in the cage. Farm operators allow many cleaner fish to receive physical and freshwater treatments along with the salmon, causing death. Many other deaths are unaccounted for, and all the surviving and otherwise long-lived cleaner fish are slaughtered alongside the salmon, after only 18 months.

Under the Farmed Fish Health Framework, ten overarching causes of mortality were agreed that should be reported against. Between 2018 and 2020 the highest percentage of mortalities were gill health related, sea lice related (including treatments), or caused by handling, viral disease, or as a result of the transfer to seawater.[4]

Similar findings are reported elsewhere. A study of "baseline" mortality in Norwegian salmon farms found that sea surface temperature, salinity, 'failed' smoltification following transfer to the sea, and location – with some zones being a high disease risk – all contributed to mortality.

Also: *"Several of the mortality determinants were connected to the intensive salmon production system. This included […] practices undertaken to tackle major salmon diseases, especially sea lice treatments. There were considerable effects of applied treatments against sea lice on mortality using baths with H_2O_2 or medicinal compounds as well as non-medicinal delousing, the latter being more detrimental."*[5]

The authors of this study write that: *"Preceding mortality events, important indicators of poor welfare can be observed in fish, including behavioral changes, morphological alterations, emaciation, injuries, and other compromised physical conditions. Mortality is the endpoint of an adverse health condition in the fish. It is caused by a combination of environmental and host factors, and often, one or more pathogens are involved."*

Further contributors to mortality: human decisions, climate change and technology

Not only have overall mortality figures risen dramatically year on year, the frequency and scale of mass mortality events have increased. A report in *Nature* in March of this year analysed these mass mortality events in major salmon farming countries, including Scotland, and described the factors involved, including the prioritisation of expanding production, a reliance on technological fixes, and a lack of regulatory oversight: *"As salmon production increases in scale and more technology is used to grow salmon in contexts otherwise not suited for them, there is a possibility for more frequent and more severe mortality events."*[6]

The wicked problem

The salmon farming industry has invested heavily in trying to reduce disease, parasite and mortality rates, and yet is failing to do so. Many of the treatments are themselves harmful and cause poor welfare and death, as do handling procedures. Several witnesses giving oral evidence

[4] FOI+202300376448+-+Information+Released+-+pdf+1-3.pdf (www.gov.scot)
[5] Factors associated with baseline mortality in Norwegian Atlantic salmon farming | Scientific Reports (nature.com)
[6] Quantitative analysis of mass mortality events in salmon aquaculture shows increasing scale of fish loss events around the world | Scientific Reports (nature.com)

to the RAIC inquiry have spoken about the challenge of having so many salmon with poor gill health, because they cannot survive treatments for sea lice. Climate change is exacerbating these challenges, and the technological fixes bring further risks of mass mortality as they enable production in riskier locations, such as offshore sites, and are vulnerable to human error or technical failings.

Physical health is only one aspect of welfare, as we will detail below, but an industry that cannot even meet the fundamental, legal requirement, to protect animals in their care from suffering, injury and disease, requires urgent, radical reform. The current vicious cycle of failing to balance competing harms within the interplay of environmental conditions, diseases and treatments does not seem likely to be resolved. Scrutiny must shift to the root causes and how to achieve acceptable holistic fish welfare.

Closed containment

RECC RECOMMENDATION 56 "The Committee endorses the ECCLR Committee's recommendation for urgent research on the subject and the consideration of ways to incentivise the industry to explore further use of the [closed containment] technology. However, it is aware that RAS is not the only closed containment option and would encourage wider research on alternative technologies."

In this instance, we disagree with the RECC. Recirculating Aquaculture Systems (RAS) and other closed containment systems, pose substantial risks to welfare due to technological failures or human error. Examples of both are evident in APHA findings reports from on-land systems, where younger fish are raised prior to being put in sea cages. In one, 1.5 million alevins died due to recirculation pump failure, which was possibly caused by an inexperienced staff member mistakenly turning off the pump. In another of these reports, 28,000 fish died due to a blocked filter, which was not corrected quickly enough due to a human mistake when setting up the alarm system. In 2021, a report details two mass mortality reports on the same site within a month. The first caused an unspecified number of fish to suffocate because a staff member forgot to switch the oxygen pump to the correct setting during grading. The second had a less clear cause but was thought to be due to a "*toxic event potentially related to the accumulation and release of Hydrogen Sulphide which is described to have caused similar mass mortality events in RAS units in the past.*"

While discussion of the issues relating to salmon welfare are normally restricted to the sea stage, it is important to recognise these concerns for fish in earlier life stages also, and that they suffer and die in much larger numbers.

Conducting more salmon farming in closed containment (CC) or semi-closed containment (SCC), at the life stage in which fish are currently in open net pens, is seen by some as a solution to many of the problems in the industry. While there may be some benefit to certain aspects of welfare, it would not address most of the welfare concerns and these systems bring their own risks to welfare. Those include but are not limited to the possibility of human error or technical failure already evident in closed containment at early life stages. Other concerns include that sea lice and disease are less frequent but can spread more quickly when they do occur, as CC and SCC farms typically have higher fish stocking densities, to offset their higher operating costs.

In a study in Norway, published in 2022, 50 % of salmon in a SCC at sea had eye damage, which the authors could not explain. There were also higher levels of snout and fin damage than when transferred to a net pen, and higher cortisol and magnesium levels, indicating stress. Gill health status did not improve during the time in CCS.[7] There are various SCC designs, and these problems may not occur in all of them, but it is a reminder that CC and SCC should not be seen as a panacea.

Regulation and unnecessary suffering

RECC: "From the evidence it has received, the Committee has gained the strong impression that the farmed salmon sector in Scotland has been subjected to what might be described as "light touch" regulation and enforcement to date as the relatively young industry has developed."

RECC RECOMMENDATION 59: "The Committee also notes and shares the concerns expressed in evidence that the current consenting and regulatory framework which is spread across several regulatory bodies is confusing and is poorly coordinated. It is of the view that the co-ordination of and interaction between the various elements of the regulatory regime needs to be significantly improved. The Committee recommends that Marine Scotland should be tasked with taking responsibility in delivering the necessary improvements and in taking on an overarching co-ordinating role."

RECC RECOMMENDATION 60 "The Committee is therefore of the view that maintaining the status quo in terms of the regulatory regime in Scotland is not an option. It considers that there is a need to raise the bar in Scotland by setting enhanced and effective regulatory standards to ensure that that fish health issues are properly managed […]. The Committee therefore recommends that a comprehensively updated package of regulation should be developed by Marine Scotland and other regulatory bodies […]"

These recommendations have not been met. While the complex consenting process for new fish farms has been recognised as flawed and steps taken to change that, regulation and enforcement of fish welfare on salmon farms does not appear to have improved since the RECC report.

There are no regular welfare inspections of fish farms by government agencies. The Fish Health Inspectorate (FHI) carries out health inspections and will report any welfare concern to the Animal and Plant Health Agency (APHA).

A series of recent Freedom of Information requests to APHA and local authorities (LAs) suggests broad agreement about the sequence of events – APHA may carry out an inspection, following a complaint or referral, and then may consult with or refer to the LA – although one LA suggested instead that APHA had requested that the LA should inspect farms, following unexpected levels of mortality. Many communications between the APHA and LAs about inspections are carried out over the phone and there are no records of them. This lack of transparency is unhelpful when trying to establish how decisions are made.

[7] Frontiers | Health and Welfare of Atlantic Salmon in FishGLOBE V5 – a Novel Closed Containment System at Sea (frontiersin.org)

It appears that there is a lack of consistency and that only some welfare concerns or mass mortality events are referred on, at any stage in the chain. When fish farm welfare inspections do occur as a result of reported mass mortality, they often take place after the mortality has ended. APHA's inspectors then report only on what they observe during the inspection.

There is a lack of clarity about which body is ultimately responsible for making the decision to prosecute, with APHA and the LAs each suggesting that the other would be. Perhaps it is not surprising then that there has never been a prosecution recommended to the Prosecutor Fiscal in relation to welfare offences under the Animal Health and Welfare (Scotland) Act 2006 regarding farmed fish, nor has a Care Notice ever been issued in relation to fish farming, by any body.

APHA sometimes issues advice or warning letters, and it seems that they and the LAs feel that this is preferable to prosecution. We have not been able so far to determine if there is ever any follow up to check that changes had been made that resulted in better protection of fish welfare, or what, if anything, happened if not. It is clear though, that some farms consistently have high mortality and that no action is taken to prevent them being repeatedly restocked.

Ten years ago, the UK Farm Animal Welfare Committee, in its Opinion on the Welfare of Farmed Fish, noted a similar lack of prosecutions in England and Wales and wondered whether this was because: "*the official enforcement authorities lack a presence on fish farms or lack confidence in proceeding with actions for welfare (because fish farming presents particular challenges to gathering evidence for welfare enforcement actions).*"

It recommended that: "*Governments should also review compliance with and enforcement of the Animal Welfare Acts by AHVLA [the precursor to APHA] and Local Authorities, including whether inspectors are sufficiently trained and whether welfare inspections of a random sample of farms, as occurs with terrestrial species, should be introduced. If compliance and enforcement are inadequate it may be necessary to consider further strengthening the legislative framework with more detailed requirements. More research will be required to provide the knowledge base for more detailed legislative provisions for the welfare of fish.*"

We suggest that this recommendation is equally applicable now.

To give an example, in November 2020, APHA visited a Scottish Sea Farms site in Loch Crenan, following a complaint, and carried out a Veterinary Risk Assessment. The site had had high mortalities due to an algal bloom; 87,263 fish had died in the four weeks prior to the inspection alone. The site also had high sea lice levels and so was using Thermolicer treatments. The report said that the fishes' needs were not being met, as demonstrated by the previous mortality levels and photographic evidence of heavy sea lice burdens and damaged fish, described as "*a large number of fish found with big chunks of flesh missing, fin erosion and scale/skin loss.*" It also said that "*it is clear that gills damaged and the sea lice increased the stress of the salmon.*" During the inspection, some salmon inspected had damaged gills and three had to be culled due to damage by physical trauma.

Despite this, the APHA veterinary inspector wrote to the farm that: "*At the time of my visit I found no evidence of unnecessary suffering (due to the sea lice issue reported) among the animals which I saw and that, as far as could be ascertained at that time, the welfare legislation appeared to be being complied with. […] Regarding the event that occurred during September*

and October 2020 it was clarified during the visit and supported by the records checked on 06/11/2020 that it is now under control as the salmon is responding satisfactory to the treatment. Although the treatment was complicated because following the algae bloom issue, the fish was not in the best condition (due to the gills were damaged) to commence treatment for sea lice, all the decisions made by the veterinary team and the head of Fish Health and welfare for SSF were appropriate according to the circumstances presented."

The farm was only advised to keep following the treatment plan and no further action was taken on the suffering of at least 87,263 fish, that had preceded but was not observed during the inspection.

This case study is a good example of a pernicious problem: anything that is also happening elsewhere in the industry and/or where the protocols agreed by the industry were followed is not viewed as "unnecessary suffering", regardless of the experience of the fish.

Even if the inspection was prompted by welfare concerns or high mortality, APHA inspectors frequently comment that they did not see signs of unnecessary suffering on the day of the visit (in some cases because a different group of fish is now on site), or that steps were being taken to try to address the problem, so no further action is taken.

As the RECC pointed out, this relatively young industry has grown with limited regulatory influence, and that seems to also have shaped how the Animal Health and Welfare (Scotland) Act is interpreted and applied.

RECC RECOMMENDATION 63 "The Committee is of the view that a key part of any improvement in the enforcement of regulation should be the introduction of mechanisms to provide more open and transparent reporting of regulatory breaches. It also strongly recommends that any changes to the enforcement regime should incorporate measures which will ensure that there is a move away from the self-assessment culture that appears to be prevalent at present."

This recommendation has not been met.

The Scottish Science Advisory Council's report on the use of science and evidence in aquaculture noted that only a limited number of disciplines have been involved in contributing knowledge to guide aquaculture regulation. Independent animal welfare expertise is one of the disciplines which is currently left out. This means that the industry has defined what is seen as normal and acceptable when it comes to fish health and welfare, and research funded by the industry and the Scottish Government has accordingly been channelled into this narrow framing, leaving knowledge gaps for salient aspects of fish welfare.

Farmers raising terrestrial animals must comply with species-specific requirements set out in the Welfare of Farmed Animals (Scotland) Regulations 2010. Additional detailed guidance is also published for each species, which describes how farmers can meet their legal responsibilities and recommends how to go beyond the legal minimum to achieve higher welfare. Farmed fish are not included in the 2010 regulations and there is no official government guidance. Instead, the Scottish Government refers to the fish farming industry's voluntary Code of Practice. This seems to be in the same vein as the "self-assessment culture" identified by the RECC.

Data reporting and transparency

RECC RECOMMENDATION 13 "The Committee further recommends that there should be coordination with the data that is to be provided on sea lice infestation levels (see paragraph 216) to ensure that a package of data is available which provides an up-to date and comprehensive overview of all fish health, welfare and treatment issues across the sector."

Although there has been some progress on reporting, this recommendation has not been met. The sea lice data is on a different website and presented in a different format than mortality data. A comprehensive overview of fish health and welfare issues across the sector would require much more than mortality and sea lice data. Health is an important component of welfare but is only one aspect of it. A comprehensive overview of fish welfare in the salmon farming industry should account for all five domains of animal welfare (see below).

Five domains, behavioural interactions and mental state

Welfare in relation to the salmon farming industry is focussed on physical health and biological functioning. As the evidence above shows, even these are not being protected adequately, but these are only one aspect of welfare. The Five Domains is a widely accepted model of welfare, including by the Scottish Animal Welfare Commission. In it, health sits alongside nutrition, physical environment, and behavioural interactions, all of which contribute to the fifth domain of mental state which is the key determinant of welfare. There is also emphasis in the Five Domains on giving animals opportunities for positive mental states, not only the alleviation of negative states, and on the importance of agency. Viewed through this lens, many welfare concerns for salmon become apparent, beyond the frequently discussed issues of sea lice, disease and mortality.

Domestication in salmon is still in its early stages and that, along with differing physiology and behaviour, make comparisons with terrestrial farmed animals difficult. Additionally, no other farmed animals in the UK are carnivorous or migratory. The implications of this for farmed salmon welfare have not been adequately considered.

The rapid growth of this industry has prematurely created husbandry systems without the necessary knowledge to protect welfare. The industry and Scottish Government have invested heavily in aquaculture research but, due to the narrow focus mentioned above, there is limited knowledge of behavioural needs, mental state and positive welfare, and relevant indicators, in salmon. Animal welfare scientists have pointed out that very little is known about the post-smolt phase of their lives that wild salmon spend at sea, so we cannot determine their needs or preferences. Also, nobody has ever tried to assess the impact of being unable to migrate on salmon welfare.[8]

The British Veterinary Association (BVA) has acknowledged this knowledge gap and that the suitability of farming salmon, a migratory species, has been questioned. In its position paper on aquaculture, it says that: "*Given the lack of clear evidence, this position takes a pragmatic*

[8] Animals | Free Full-Text | From Land to Water: Taking Fish Welfare Seriously (mdpi.com)

approach, focusing on recommendations for improvement rather than questioning the choice of species."

A related point is that schooling may not be the natural behaviour for salmon for much of their time at sea and is thought be a behavioural adaptation to avoid collisions and make the necessary trade-offs[9], and reduce the stress[10], imposed by the cage environment and densities.

Farmed fish do not experience some of the challenges that wild fish do, such as searching for food, but different challenges are introduced by the captive environment. For example, aggression is more likely due both to confinement at high densities and because conditions in cages favour selection for risk-taking/aggressive fish, due to competition for food and selection for fast growth, which is linked to these traits. It has been noted that: "*This creates an obvious welfare problem that can only be solved by a deep understanding of the biology of the species as well as through the design of appropriate and diverse farming environments, which can accommodate different coping styles, even at the expense of lower production outputs.*"[11]

The individuality of salmon and differences in coping are important. A significant number of farmed salmon exhibit behaviour and serotonin levels that can be considered a depressed state.[12]

Despite the knowledge gaps, there has been some research in the more neglected areas. For example, it has been suggested that some ways positive welfare could be promoted in fishes are opportunities for control and cognitive engagement, as well as species appropriate environments and social conditions.[13]

Compared to their wild counterparts, farmed fish live in extremely standardised and barren conditions with a lack of relevance to their behavioural needs.[14] Ethologically relevant enrichment could go some way to addressing that[15]. Evidence shows that structures such as plastic tubes or shredding, and other environmental complexity, can improve swimming ability, cognitive abilities, brain plasticity, physiological stress response, infection resistance, growth and survival, and decrease fin damage and parasite occurrence in Atlantic salmon.

Shelters, kelp curtains and feeding blocks can go some way to mitigating the welfare risks for wrasse and lumpfish used as "cleaner fish". During incubation, adding hatching mats to the tanks brings a range of benefits.

It is also important to recognise the aspects of fish physiology and sensing that are less familiar to us, as mammals. For example, chemical sensing is a fundamental method of communication for fish, both within and between species. A build-up of chemical cues can occur in the high density of sea cages, having been released during agnostic encounters and stressful handling

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[9] Environmental drivers of Atlantic salmon behaviour in sea-cages: A review - ScienceDirect
[10] Rapport+05-2006+Welfare+in+farmed+fish.pdf (unit.no)
[11] Domestication and Welfare in Farmed Fish | IntechOpen
[12] Brain serotonergic activation in growth-stunted farmed salmon: adaption versus pathology | Royal Society Open Science (royalsocietypublishing.org)
[13] Fishes | Free Full-Text | Positive Welfare for Fishes: Rationale and Areas for Future Study (mdpi.com)
[14] (PDF) Behavioural Indicators of farmed fish welfare (researchgate.net)
[15] Environmental enrichment in fish aquaculture: A review of fundamental and practical aspects (ualg.pt)

events, that can create high stress conditions and undesirable physiological and behavioural responses.

Salmon farmers must of course address, with urgency, the harms caused to fish welfare by physical health problems, but that alone will not ensure acceptable welfare. It is for the industry to demonstrate if it can adapt its systems and practices to provide for net positive welfare in all five domains.

How to assess the welfare of farmed salmon

Heather Browning, a philosopher of animal welfare science, has warned that farmed fish welfare thresholds "*should definitely not be set by industry alone, relative only to the conditions regularly seen on-farm – in this case, it could end up that if all farms are not good, then even the highest welfare scores would not actually represent good welfare*." Unfortunately, this is likely to be the case currently in Scotland.

She concludes: "*Ideally, standards for minimum acceptability should be mildly positive, such that the animals are not suffering at all and experience at least some of the positive welfare states that most would consider necessary for a good life. There could also be use of "aspirational" tiers of higher welfare, where animals have a higher positive score*."

She also emphasises the importance of mental state and positive welfare in any assessment protocol. Positive welfare in fishes is understudied, but some possible behavioural indicators are feed anticipation, play, and opportunities for exploration.

Ideally there would be both input and animal-based outcome indicators. Also, partial indicators, that assess only one aspect of welfare, and whole-animal indicators each have their benefits and drawbacks, so a well-chosen set of partial indicators alongside some complete indicators is ideal. A good example of a complete indicator is Qualitative Behavioural Assessment, which uses animals' dynamic whole-body expression to gain insight into their mental state.

The use of underwater cameras, infrared and solar, alongside individual recognition technology and coding are already used in aquaculture and could help identify health and behaviour indictors that cannot be seen from the surface.

It is encouraging that the industry recognises the importance of non-invasive animal-based measures, and the potential of behavioural indicators[16]. It will be important that the cautionary points above are heeded, and that behavioural indicators are co-designed by industry and independent fish welfare experts.

There is an existing, recently developed, suite of salmon welfare indicators, across all life stages, under the Five Domains model. Animal welfare scientists at Scotland's Rural College (SRUC) were tasked by DEFRA to determine welfare indicators that should be used, in general and for specific types of genome edits to farmed animals, following legislation that pave the way for that being a possibility in England.[17] They chose several species to focus on including salmon.

[16] Concerns and research priorities for Scottish farmed salmon welfare – An industry perspective - ScienceDirect
[17] 16020_AW0521SRUCPrecisionBreedingAnimalWelfareFINALREPORT.pdf

The indicators include some already used by the industry and additional indicators that meet some of the recommendations above. This provides an example of how a welfare assessment protocol under the Five Domains model can be developed, and it could be used as a template to adapt and build on to create a modern assessment protocol for farmed salmon.

Conclusion

We hope that this information is useful to the committee in its inquiry. We urge that the committee considers the increasingly complex, and seemingly intractable, interplay of factors negatively impacting fish health and leading to mortality, and the aspects of welfare which are less examined and equally important.

Regulation and enforcement are not functioning in a way that protects fish welfare, including "cleaner fish" as well as farmed salmon; we suggest that it would be very beneficial for the committee to take oral evidence from APHA and COSLA, or individual local authorities, to try to understand where the gaps and weak points are, and make recommendations accordingly.

We recognise the immense amount of time, money and effort, both within the industry and in supporting fields, that are being invested in trying to reduce salmon death and disease. The fact that, despite this, these problems persist, is indicative of deeper systemic problems that must be addressed. Such a re-evaluation should also include an assessment of the holistic needs of salmon and how those could be met.