Sustainable Aquaculture principles and emerging themes

Note: This is a working document designed to aid the development of the working group’s final position. It is not a draft policy position and the wording within is likely to change.

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<th>Overarching</th>
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<td>1. Sustainable aquaculture should be undertaken in a way that is environmentally, ethically, and economically acceptable for consumers, producers, and wider society.</td>
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<td>• The group should consider the point at which whole system change should be encouraged, as well as looking at solutions to individual issues</td>
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<td>• The group must be careful when referring to “aquaculture”, in many respects aquaculture is more diverse than terrestrial farming, with a vast diversity of environments, species, etc. The group will need to be specific about the scope of its position, eg UK, fresh or marine, species etc.</td>
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<th>Global development</th>
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<td>• There has been a culture shift in recent years to eat more farmed fish than wild caught. Around 50% of global fish consumption now comes from farmed fish, and this is increasing. This represents a major culture shift, as in 1975 this was less than 10%, and by 2050 it is expected to reach 70%.</td>
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<td>• A lot of growth is in freshwater fish production, and this is expected to continue. Significant but more modest growth is in molluscs and marine fish</td>
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<td>• 94% of aquaculture happens in LMIC countries, and most of the expansion is expected here. However, they have relatively poor infrastructures for animal health, food safety etc., so many organisations internationally are trying to work with those nations to make it safe and viable.</td>
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<td>• As the human population grows and climate change threatens the stability of seafood sources, we face the key question of how we will meet increasing demand, and do so sustainably. Many of the 20 International Council for the Exploration of the Sea (ICES) member nations have been global leaders in the protection and management of wild fisheries, but to date, most of these nations have not developed robust aquaculture industries. There will potentially be a 7 million tonne deficit by 2050 which needs to be addressed.</td>
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<td>• We culturally accept fisheries as a way of getting food, but are slower to accept aquaculture as a concept. This needs to change to meet demand.</td>
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<td>• Capture fisheries are at their limit, so any increase in fish protein needed to feed the global population will need to come from aquaculture.</td>
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<th>UK aquaculture</th>
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<td>• One of UKs key strategic food production sectors, aquaculture helps to underpin sustainable economic growth, both in rural and coastal communities and in the wider economy</td>
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<td>• Scottish salmon farming dominates UK aquaculture production (95% by value, and 90% by volume)</td>
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• Around 30% of the fish eaten in UK is farmed Salmon
• In 2020 – 52 million smolts were transferred to sea, 192,129 tonnes of salmon produced, and around 17,000 tonnes of Rainbow Trout
• This is a big UK industry - in 2018, the industry added £885 million gross value to the UK economy, supported 11,700 jobs, and paid £94.1 million in taxes.
• This is a significant sector in Scotland, contributing to around 3% of Scotland’s total employment. It is especially important to rural communities
• Main species farmed in England are rainbow trout, sea trout/brown trout; Pacific oysters and mussels (7648 tonnes, £22.8m combined)
• We currently do a lot of land-based farming that contributes to making water unusable for fish farming – this will need addressing to improve our aquaculture industry
• Potential development
  – There is a trend for growth in freshwater species globally, but in the UK the trout sector appears to be remaining fairly static.
  – There is significant interest in tilapia globally, but this doesn't appear to be a fish people in the UK want to eat. It also does not provide the same benefits as some other fish, such as omega 3, so is effectively an alternative for chicken. It useful in other countries as a protein source.
  – Shellfish could be a key growth area if the UK can resolve water quality issues

History of the sector
• The Salmon aquaculture industry is relatively new, the first output being Unilever in 1970. The sector has since grown very rapidly, but has recently plateaued as site development became a key issue.
• In the early 1990s, there were 171 companies with 298 active farms and many small owner operations. By 1995 this had reduced to 106 companies with 268 active farms, but very few large companies. Today there are 7 companies, with 200 farms, all run by large companies (with 20 to 50 farms). 4 of these large companies work internationally
• New entrants to the industry are rare. There had been on recently, but only because the owner already had extensive experience in the sector.
• All companies produce ‘vertically’, meaning they use freshwater and sea water sites
• The total pen area is 168ha, which is smaller than Edinburgh airport. This impacts an estimated 120/125m2 of seabed. The sector is worth around £1billion a year
• This sector is success due to innovation:
  – Feed can now get 1:1 conversion rates or better
  – Sea boats and reverse osmosis
  – Cleaner fish
  – Science led processes
• Some believe that bigger business is bad, but a key benefit is the ability to invest. One major investment is in teams, including a fish health and welfare specialist on every farm. Many have in house vet practices, with a vet and support staff. They also have teams looking at environmental concerns. This provides huge job opportunities which can be based on the needs of the fish.
• Salmon Scotland launched their sustainability charter in 2020, with a commitment for the next 20 to 25 years. Fish Welfare is the first pledge, as good welfare is better for fish, business and the environment

Site development
5 consents required from 4 bodies, Marine Scotland, SEPA, Crown Estate Scotland and local council (planning).

Planning is the most frustrating part as anyone can have a say, no matter where they live or who they are.

Nature Scotland do not issue licenses (though could for seal control), but are useful advisors.

The consenting bodies will look at biology and health of the fish, hydrography of the location, environment, Seabed / water (complex modelling), Natural heritage (NatureScot), Protected areas (MPAs, SACs, SSSIs, PMFs etc), Predator management plans (adaptive management), Visual, Practicality, Neighbours (fish farms / others), Communities, Stakeholder engagement / consultation.

It takes 2 to 3 years and many millions of pounds to get a new site approved, plus many more years and millions to develop it. One big frustration is that fish health and welfare ranks low on the consenting.

The “Griggs” review for Scottish Government effectively concluded that we need a more streamlined approach and to make sure it is science led. It recommended having one licensing body, but keeping all current bodies involved in the process. This would be very positive for the industry.

### One health aquaculture

- How do we start to build a different way of thinking about aquaculture?

  Cefas hosted the “Sustainable Aquaculture through the One Health Lens” workshop at Defra, London on 1 July 2019. There are lots of people who have a say in the sustainability of the sector, so this brought together all those who acknowledge that aquaculture will be an important part of feeding the population going forward. They discussed which metrics they would like to see being monitored – eg energy use, animal welfare, societal needs (jobs etc). The one health focus helped to keep this democratic.

  “One health aquaculture” is now becoming a phrase that is used.

  The group created a framework for defining, monitoring and averting potential negative impacts of enhanced production — and consider interactions with land-based food systems. These metrics will inform national and international science and policy strategies to support improved aquatic food system design. [https://www.nature.com/articles/s43016-020-0127-5](https://www.nature.com/articles/s43016-020-0127-5).

  A policy evidence makeover is needed – once you have the metrics you can identify where to direct focus.

  - Different parts of the aquaculture sector are all different sectors themselves – need to change how we think about it.
  - Looking at how to build hazard control into the system – any hazard that will mean the animal can’t survive, or won’t be safe to eat.

### Trade

- Nearly half of Salmon produced in the UK is exported, with the largest percentage going to France.

  A significant proportion is also flown across the Atlantic, which has sustainability implications. Norwegian Salmon is often shipped across, but the UK product is aimed at the ‘high end’ niche which requires freshness, and is therefore flown for speed.

- A key issue with EHCs is understanding what is covered.

  - Composite products, even frozen pizza, need an EHC for each animal product used.
  - Isinglass comes from fish swim bladder and can be used to stick yeast together. An EHC is required to trade products containing this.
There are concerns about veterinary capacity for signing off EHCs generally, but this does not appear to be an issue for fin fish exports. It has been established that the on-site vet can sign the veterinary health attestation, which is then used by the person signing the EHC, making the process manageable. There are more significant blockers within the system than EHCs.

Public concerns

- The key issues raised by members of the public needed to be considered, either to provide information and reassurance or recommend improvements.
- The longest standing critical group is the angling lobby, with the belief that Salmon farms have an impact on wild fish. There appears to be little scientific evidence for this, with the decline going on much longer than fish farming. Interactions with wild fish are an important consideration.
- Some groups are against anything happening in the sea since this adds further stress to the marine environment. Others are not against aquaculture in principle, but would like to see marine activities controlled. The main criticism is waste (including fish faeces and uneaten food), and medicines use and discharge (direct from bath treatment and in faeces).
- More recently, animal welfare concerns have been raised. Some groups are against the production of animals in general, and others are concerned specifically with fish welfare. Disease and the possible impact on wild fish are key concerns.
- Key areas of concerns also include control of seals and other predators, and use of treatments, both traditional medicines and more recently physical treatments.
- All of these concerns are due to be discussed by the working group in more detail at later meetings, examining the science base for each of them.
- Some activists had claimed that veterinary professionals working in aquaculture were guilty of professional misconduct for doing so. The group was clear that this is unacceptable behaviour, and unfair on those who are genuinely trying to improve the sector and fish health and welfare.

The main concerns raised related to aquaculture are:

- Mortality levels on farms – across the industry and in the case of extreme events
- Shooting of seals to protect Salmon – this was the top concern until the law changed in Scotland. Use of acoustic devices would also be raised before the law changed
- Inadequate fish welfare – concerns that welfare of fish I universally poor, even on farms under RSPCA standards
- Sea lice levels and treatments – high levels and impact on fish. Concerns about the physical delousing and the pain it may cause. Cleaner fish are also occasionally mentioned, usually in relation to mortality or wild capture
- Disease – view fish farms as incubators of disease, with some occasional queries about antibiotic use
- Environmental impact – concerns that fish farming is seriously damaging the natural environment. Fish feed is a key concern.

To discuss throughout

Sustainable resource management to protect and conserve species, habitats and biodiversity
### Sustainable aquaculture

Sustainable aquaculture must address the use of natural resources, protection and conservation of species, habitats and biodiversity in order to better protect the environment which both humans, domestic and wild animals share and reduce the ecological footprint of aquaculture as a whole.

- Freshwaters are under huge pressures globally for a number of reasons (e.g., pollution), so this is important to consider.
- Natural Salmon populations are under many pressures around the world, including but not solely from fish farming.

### Comparisons with other farmed animals

- ‘Blue food’ compares favourably with agriculture on most sustainability metrics, e.g., Greenhouse gas emissions, Nitrogen, Phosphorus, Fresh water use, and land use per tonne of edible weight.
- Compared with other ways of getting food, aquaculture is arguably more sustainable, but that isn’t always a given. We should be discussing it using the same language as other types of agriculture.
- There is still room for improvement. Aquaculture emissions mainly come from feeds, and fishery emissions mainly come from fuel.
- Specific voices have shone a negative light on aquaculture over the past decade.
- Some areas need to change, e.g., the use of antibiotics, though there is a lot of work already being undertaken in these areas.
- A societal issue – there are a lot of myths about aquaculture which are unfounded.
- The usefulness of comparing aquaculture with poultry farming was questioned, given there are large variations within both sectors.
- There was concern that this messaging could become polarising, and the group should be mindful not to trade them off against each other. A diverse food sector is needed.
- Aquaculture hasn’t been fairly represented as a sector when it comes to sustainability – so comparisons useful to show ‘over amplified’ voices that there is a role for it.
- It’s hard to measure sustainability as there are many metrics, but it’s still important to move in responsible directions. The challenge for each sector is how to compare favourably without showing others in unfairly negative ways.
- For example, the aquaculture sector has high mortality rates of around 25%, which is not where they want to be, and work is underway to improve this, but at least they do publish the figures in order to be transparent – other sectors do not.
- The discussion needs to move from sectors to food in general. There are challenges in each sector and they all need to be worked through.
- BVA can help by enabling pragmatic discussion of these issues.

### Water quality

- A common question is “If we didn’t have aquaculture in the UK, what would water quality be like?”. This debate is focused on the wrong sector, as farms often cause more harm to water than the aquaculture sector. Trying to prevent chemical spill over from aquaculture is important, but a far greater issue is the chemicals we release into our rivers. We need to consider the whole food sector when thinking about water quality.
- Although there is no easy summary data available, there is plenty of evidence on water quality to back this up.
- Our water quality has been highlighted as an issue for exporting shellfish post-Brexit. We need to make improvements in order to trade.
**Medicines in the environment**

- There is growing concern about use of parasiticides in the small animal sector. This impacts on aquaculture as it leads to preconceptions about the use of these drugs for treating sea lice.
- Medicines regulation is different in aquaculture compared with other sectors. This affects how they are used, sometimes with unintended consequences, eg in Norway, lower thresholds have led to lower efficacy.
- Regulating medicine use instead of discharge is easier, but for fish farms it is more important to monitor discharge.
- Medicines regulation needs to be made smarter to enable more products to be readily available. The main drivers for regulation include a very strong wild fish lobby.

- Research at Imperial College is showing a direct overlay between medicines in rivers and farms in the area. It was questioned whether similar data exists for the aquaculture sector. SEPA closely regulate and monitor this, so it would be useful to have a representative present to the group. R. Soutar offered to provide contacts and links to their work.
- Alternatives to medicines include physical treatments for some health issues. These are a step forward from an environmental point of view, but there may be concerns about fish welfare. Some treatments are aversive, but if they are beneficial to their health then they may be useful.
- Moving towards measuring discharge rather than level of treatment is logical as what matters is the chemical ending up in the environment.
- Clean Treat
  - This is a new technology developed by Benchmark with the aim of enabling fish to be treated with medicines. The content of the box is a secret, but is designed to take contaminants out of the water.
  - The idea is that the fish can come onto a well boat, be treated, then released and the water cleaned before going back into the sea. The aim is to release them with no discharge.
  - Benchmark want to bring an imidacloprid treatment to the market, as they have in Norway, to only be used in conjunction with this technology. BVA had received letters of concerns from members regarding this, since imidacloprid can cause significant damage to wildlife populations, especially invertebrates. It is also under trial for other compounds which may have the potential to cause similar negative impacts.
  - Clean Treat claims to achieve 0.3mg/l of discharge, but some research suggests the maximum safe threshold is 0.2mg/l. Benchmark have 0.3mg/l as the maximum as that is on the SPC, though in reality discharge is probably lower, and the aim is to reduce levels until they are non-detectable.
  - Fish are dewatered to help reduce the discharge levels, but fish likely will go back into the environment with some of the product still on them. This will have an impact, and no technology can completely remove the chemicals. Some will also be excreted. Lots of research is being undertaken to better understand the risks.
  - Vets would prefer to move to preventive care, but we also have to accept where we are now and work out how to deal with current issues. If we need to use compounds, how can we do so more safely? If this technology is effective at preventing discharge, it may be a useful tool in the toolbox. However, finding non-biological and preventative measures will remain the preferred option.
  - The group should be mindful not to let discussions become just about imidacloprid, and should seek to understand the wider issues.

- SEPA noted that the ability to decouple fish health and environmental constraints would make a huge difference, as then SEPA regulation would not be a pressure on fish health.
- SEPA is the principal environmental regulator in Scotland, aiming to ensure environment and human health are protected, and feed into sustainable growth. They regulate and
advise on a wide range of environmental activities. They are working towards “One planet prosperity” – to be able to thrive within the resources of our planet.

- The ideal medicines for SEPA is a vaccine with no discharge, and the second best are medicines which quickly break down. Those which take time to break down are a challenge and can have long term cumulative effects, making them difficult to monitor and regulate.
- SEPA have various mechanisms to make sure activities are carried out within the license. When done correctly, sites will have more abundant natural wildlife underneath and close to the nets/cages. At the edges of the designated 100m ‘mixing zone’, SEPA expect to see biological conditions being close to background conditions.
- The majority of poor rating at sites are in relation to effluence
- In addition to monitoring compliance, SEPA are now planning to do more work to influence and encourage improvement. Industry has been leading on this, but SEPA has a role to play in encouraging continued improvement and raising awareness of environmental issues. This involves understanding consumer demands, working with NGOs etc, to take people beyond compliance
- SEPA would also like to improve public reporting to make the information being shared easier to understand.

**Fish feeding**

- Aqua feed comes from fishmeal, by-products, plants and other sources
- It is generally recommended to provide the largest possible feed animals can safely consume – too small risks wasting energy looking for feed, too large isn’t edible and risks choking
- Marine resources are important in fish feed, but the sector has become increasingly reliant on traditional animal feed from terrestrial environments. With depleted stocks, it is important to move away from reliance on marine resources.
- Fish meal and fish oil contain the perfect balance of nutrition for fish, which needs to be taken into account when looking for alternative feed sources. A One Health approach is needed for this issue.
- By 2030, 25% fish feed is expected to be made from by-products of aquaculture
- Current and developing alternatives to fishmeal include:
  - A wider array of different algae
  - Single cell protein – these are limited as legislation requires evidence that it’s safe to use. Quorn is a fungal version proving it can be done. This would enable waste products to be utilised and be very high in protein. Nucleic acids need to be degraded as they could create health risks (cancers).
  - Vegetal sources – the next big thing, including pea protein, chickpea protein etc
  - Insects – now regarded as farmed livestock. This is a growing area, attracting a lot of investment. Chickens naturally eat insects, so highly relevant to poultry sector. In aquaculture, the short-term use is likely to be as a diet additive, with a view to switching feed if further studies checking the animal welfare and nutritional benefits. Insect protein can be considered green and carbon neutral.
  - Insect feed regulations: Live and whole insects are allowed to be given as animal feed if unprocessed. Hydrolyzed proteins and insect oil are also permitted. Not about what can be done, but about what is accepted by legislation and assurance schemes. Aquaculture is a good sector to focus on as insects are part of the natural diet and already permitted. In the future, animal manure may feed the insects.
  - Insects – potentially have added benefits in relation to infection control – insect oil is really useful and can have health benefits. Insects are also so divergent from humans they can’t get same diseases, though the product could still become infected in production. It’s therefore less risky to use insects than other products – we need to keep controls in to ensure no contamination etc.
Predator control

- Predators for Salmon include Birds and otters, but main focus is on seals. They pose a serious welfare problem for salmon.
- Scottish seal population is healthy and growing, but is a significant proportion of the total UK population
- Seals cause damage to nets, leading to more escapes. They directly kill salmon, and also cause stress which increases susceptibility to disease.
- 2021 paper demonstrated that the fish were significantly affected presence of predators, even when not visible. They showed a raised heart rate over long term.
- A strong behavioural response is seen in salmon when seal turns up, so it is not unreasonable to assume there would be a long term impact on the fish
- Research into what causes seals to attack specific farms would be a useful next step
- There is a high incidence of seals attacking from beneath the nets – they bite them and suck out insides through the netting.
- In 2021, the licenses to shoot seals were removed due to US trade requirements, no longer trading with countries allowing the lethal control of seals. Previously 60-80 were killed each year, with training and controls in place to ensure this was done correctly.
- Seals can only be shot without a license to alleviate suffering, or with a license for a limited number of other reasons (eg disease control). This poses a challenge for the aquaculture sector on how to deal with a seal if it gets into a pen. It is difficult to encourage a seal to leave the pen.
- Acoustic deterrents had been used to discourage seals from approaching nets, though there was little scientific evidence for their effectiveness. These are no longer allowed in new areas due to their impact on cetaceans.
- Cetacean species of concern include harbour porpoise, minke whale, orca
- Finlay et al 2021 found sonification of west costs was causing issues, although there are some questions over the validity of the modelling. Brandt et al 2012 showed significance disturbance, but other research shows less or no disturbance – more research is needed but the risk to marine mammals can’t be discounted. Some devices that some may be more disturbing than others
- ADDs potentially cause behavioural responses and disturbance to cetaceans. Possible hearing loss. A lot depends on the particular design and use of the ADD
- ADDs could be licensed under habitats regulation, but the challenge would be proving they have “no impact on favourable conservation status”. Four applications so far, but all have been withdrawn.
- Perhaps there could be the potential to use them with AI and cameras, so they are only turned on when seals come near. Research into frequencies etc would also help to take a more targeted approach
- Other options to prevent seal attacks include changes to the net design, to make it harder for them to reach the salmon.
- Industry moving towards HDPE nets – better tensioning arrangements, makes it harder for Seals to attack
- Seal blinds, seal protection nets – to separate seals from fish to make it less interesting
- Huon fortress pen now being used in Tasmania – huge pen, inner pen with conventional netting for fish plus outer netting to keep predators away. Plus raised posts with netting over top
- Larger pens allow fish to move away from seals when they are outside. However these changes will also impact on welfare consideration, so need to be carefully thought through.
- If pens need to become larger, this will require planning to take predation and the impacts on fish welfare into account.
- Also has an impact on use of medicines and other welfare issues
• The Scottish Animal Welfare Commission (SAWC) working group is considering the welfare of farmed fish, wild seals and cetaceans, and has specifically been asked to comment on the extent to which avoiding stress to fish could be a reason for licensing ADDs.

• Seals causing stress is relatively widely accepted by everyone in aquaculture sector, but lacking conclusive scientific evidence

• There is a lot of anecdotal evidence, and growing research, showing the long term impact of predators on fish. This is clearly a significant issue, but currently no clear solution or direction of travel. There is plenty of willingness to make changes to improve this issue, but few answers on how to do so.

• Farmers use every available non-lethal method to deal with seals already. Research is being carried out into use of ADDs as there are a wide range of options and new technology which may enable some to be used under license.

• Seals are now more likely to haul themselves onto walkways – not so scared of humans. New solution needed for this

• Seals getting into cages is a significant welfare issue for the fish and seal. 73% sites record this as a problem every year – shows how significant this is

• The BVZS position is that seals cannot be anesthetised once they are in a pen - this is not safe for the animal or humans.

• Issue of seals in pens and what happens to them is a key issue – this can impact vets on grounds of seal welfare/euthanasia

• There were two different species of seal and their distribution is variable. Studies had suggested than pregnant or lactating females were more likely to predate on fish in pens.

• There is a balance to be struck between fish welfare and the welfare of their predators. As with all wildlife control, the first consideration should be measures to deter and prevent access, before control measures are taken.

Policy, legislation and planning

• Climate change and biodiversity loss are major drivers for policy change globally and in Scotland. Other issues also need to be factored in, such as health and food security. The current crisis in Ukraine is also a good example of the fragility of global markets.

• International agreements, obligations and MOUs impact policy. The EU and its predecessor have shaped much of the framework, eg water framework directive and aquatic animal health regulations. Scottish government aim to keep pace with the EU and adopt EU laws as required.

• Scotland have significant environmental ambitions, including creation of more marine protected areas, and an ambition to achieve net Zero by 2045, with an increase in wind farms to boost green energy and marine economy. The Blue Economy strategy will need to be taken into account

• Scotland’s seas are managed through the marine plan, which is a relatively new concept. There are national policies and regional marine plans. The national planning policy also impacts on aquaculture.

• When planning a site, all impacts should be identified and mitigated where possible. Key environmental interactions considered within planning include:

  • Interactions with wild salmonids; sea lice, fish disease, escapes
  • Organic waste
  • Eutrophication
  • Medicines and chemicals
  • Feed sustainability
  • Predators (birds, seals, other)
  • Wrasse/ lumpsucker fishery
  • Seabed, water quality and cumulative impacts
Wellboat discharge
Visual and landscape fishery
Marine Scotland’s three aquaculture commitment for this parliamentary term are:
- Regulatory review – following on from the Griggs report, working to streamline the consenting system. This is due to be commenced ASAP and delivered within the parliamentary term
- Revised vision for sustainable aquaculture – with an enhanced emphasis on environmental protection and community benefit
- Environment – control of escapes and sea lice, to better protect species in the local environment
- Industry codes etc usually go above and beyond the legal policies – this is a very innovative industry with lots of competition, and therefore lots of potential

Animal health and welfare

3. Animal health and welfare should not be unnecessarily compromised to address human need. Aquaculture systems must work towards the positive health and welfare of all fish raised and used within them.

- To have a ‘good life’, and at least a ‘life worth living’, animals must have the opportunity to have positive experiences. Over time, positive experiences should outweigh negative experiences. This should encompass the whole of an animal’s life. Animal health and welfare should not be unnecessarily compromised to address human want or need.
- There is a lot of research being undertaken to determine what a life worth living looks like for a fish, but so far there is little evidence of which factors have a positive or negative impact. This will make it difficult to produce an evidence-based position, so the group is likely to need to recommend further research
- The RSPCA welfare standards are generally considered to be the gold standard, which have been copied by organisations around the world. In the UK, nearly all Salmon and a majority of trout are covered by these standards, driven largely by demand from retail and consumers.
- The SAWG position should make it clear that fish do feel pain and are sentient beings.
- It is important to remember that companies can’t profit easily from fish with poor health and welfare, and there are legal limits on the number of lice found on a fish at the point of slaughter, so it is in everyone’s interests to ensure higher welfare standards.
- RSPCA and RSPCA Assured can, and do, investigate welfare concerns on accredited farms and have the ability to remove accreditation if there are significant welfare concerns
- We need to be conscious that water quality in the sea can’t be controlled, and this has an impact on fish welfare. This may be an issue that cannot be solved in some cases.

Common health issues - Freshwater

- A wide range of protozoan parasites affect gills, skin and fins, causing irritation and general morbidity. Diagnosed via wet scrapes direct to microscope slide, jumping in freshwater fish is a sign of itchiness. Incidence decreases in more contained systems.
- Saprolegnia is a fungus like mould, and Saprolegnia spp. are considered a principal freshwater problem. This often affects maturing broodstock, their eggs and alevin, and is associated with handling, especially vaccination. Control is generally by good hygiene, water management and careful husbandry. Transfer to sea-water can help for salmon, but it may be too early for the fish.
Parasites
There are many parasites which affect salmon, trout and some Cleanerfish

- Saprolegnia (oomycete) is a fungus, and most significant for freshwater salmon.
  - Handling and stressful events are risk factors
  - There is no available licensed treatment for this – the only product licensed in not effective on its own and has not been available for four years
- The three most significant parasites for marine aquaculture systems are *Lepeophtheirus salmonis* (salmon louse), *Caligus elongatus* (sea lice) and *Neoparamoeba* (Amoebic gill disease)
- Sea lice are the top health issue for aquaculture and will remain a major challenge going forward
  - The damage caused comes at significant cost to industry, so there is a financial incentive to control sea lice as well as the moral one.
  - There are regulations around sea lice recording and reporting, including the requirement to conduct weekly lice counts.
  - Historically bath treatments have been used, but their use is decline as lice are developing resistance.
  - New treatments are being trialled. Introducing Cleanerfish has had very good results on some farms, though these come with their own welfare and sustainability issues
  - Thermal and mechanical treatments can also be successful but also come with the drawbacks, eg some can strip off the protective mucus on fish skin. More research is needed on these alternative treatments.
  - Fish can cope with a few sea lice as they would naturally be present, but in a farm they can spread and build up quickly
  - Sea lice cause extensive skin damage and stress, and increased susceptibility to other diseases.
  - How sea lice are treated is a significant sustainability issue going forwards
  - As more sea lice treatments are developed, it would be helpful for vets to be involved from the start to ensure controls are in place. There are often high levels of mortality when new systems are being developed.
  - Work in Norway has shown that moving farms offshore or into deeper water has the potential to reduce problems with sea lice. Moving out to sea and away from other farms helps and moving deeper reduces infection pressures. However, this brings rougher conditions and other challenges to consider, such as the technology and cages needing to withstand the conditions.
  - Limited choices of medicinal therapy – a few POM-Vs can be administered by bath treatment (deltamethrin, azamethiphos, hydrogen peroxide) or in-feed medication (emamectin).
  - Integrated sea lice-management includes a fallow period to break lice lifecycle, lice shields to prevent early settlement, in-feed medication to target juvenile lice, bath treatment to target mobile lice on small salmon, Cleaner Fish to target adult lice, Physical treatments to target mobile lice on larger salmon, in-feed or bath treatment to target seasonal Caligus
  - International obligations come into play with Sea lice – goals of 100% sea lice control and 100% containment of fish
  - There was a very significant increase in number of cleaner fish being used for sea lice control in 2020, which shows commitment to control of sea lice. Wrasse fishery voluntary regulations have now been made mandatory, including open and closed
seasons, min/max size of fish etc. There has also been an increasing interest in the welfare of Cleaner Fish, and better understanding of how to handle them.

- In October 2021, SEPA received direction from Scottish Government to manage wild fish and farmed fish interaction in relation to Sea lice. They also manage emissions from marine pen farms into water and the environment.

- Amoebic gill disease (AGD)
  - This is ubiquitous on Scottish farms, and infected farms can have up to 50% mortality rates.
  - This also affects Cleanerfish
  - Treatments include hydrogen peroxide baths or freshwater bathing
  - Research is being undertaken to look at how risk of disease can be increased by environmental factors, such as sediment under the pens
  - The work in Norway has shown that even in deep cages, fish can still get AGD.
  - Main cause is (Neo)Paramoeba perurans
  - A seasonal disease, with main issues in autumn and early winter. This is related to water temperature. Amoebae may proliferate following environmental change, so climate change may increase the risks.
  - Causes plaque-like lesions on the gill filaments, which can affect respiration and the removal of metabolic waste etc, and damage to gill tissue frequently causes haemorrhage. This is a big issue for fish, and in severe cases may result in anaemia or death.
  - It rarely occurs alone, so other gill pathogens such as Branchiomonas cisticola, Paranucleospora theridion / Desmozoon lepeophtherii and the Salmon Gill pox virus may also be involved.
  - To monitor and diagnose, farmers take a sample of fish from pens each week, anesthetise them, check number of lice on them, score the gills, score for AGD, and take gill swabs.
  - There are no medicines authorised specifically for use against AGD. Only treatment is via baths, using freshwater or hydrogen peroxide (at lower doses than lice treatments). There are no available “supportive therapeutants”
  - Gill disease may be intercurrent with other health threats – especially lice infestation and viral cardiac myopathies. This can make control and treatment challenging.
  - Regulations can further complicate it. For example, farmers may only be able to treat one pen at a time due to discharge consents, but with mobile parasites which can travel to another pen, this would not be the preferred timeline for treatment.

Bacterial disease and AMR

- Principal bacterial syndromes involve ulcerative skin diseases and septicaemias
- Pathogens involved include Aeromonas salmonicida, Pasteurella skyensis, Listonella/Vibrio anguillarum, Vibrio salmonicida and Moritella viscosa. There are no zoonotic bacterial (or viral) diseases of farmed salmonids.
- Flavobacteria psychrophilum is the main challenge for Rainbow Trout in the UK
- Vaccination is used wherever possible to prevent disease - available to prevent disease caused by many common pathogens
- Treatment is limited to 2 authorised medicines: Aquatet (oxytetracycline) and Florocol (florfenicol). Vetremox (amoxicillin) was previously authorized but is no longer permitted for use. These are most commonly added to feed, though some injections are used on high value individuals. Bath treatment for small numbers in contained systems is possible, but rarely used.
• Rapid diagnosis is crucial to provide effective treatment
• Oxytetracycline and florfenicol are the most commonly prescribed treatments, but the delivery method may drive resistance. An effective response may mean that treatment is required before sensitivity testing can take place.
• Although the amount of antibiotics used has increased, in response to emerging occurrences, the percentage of farms treated remains very low.
• Oxolinic Acid is the first choice treatment for Enteric Redmouth in Trout sector, and is now Category B – “Restrict”
• A range of medical baths, including bronopol, formaldehyde, benzalkonium chloride, Chloramine T and common salt
• It is difficult to define what constitutes a medicine in aquaculture. Traditionally it is “anything that has a medicinal effect”, which in aquaculture could include salt and seawater.
• Antibiotics can also be used to treat for pathogens.
  – Antibiotics use is much lower in aquaculture than in most terrestrial systems, but their use has started to increase due to more bacterial outbreaks at sea.
  – They are still used infrequently, with 90% freshwater and marine salmon farms not using any. In Scotland, no critically important antibiotics have been used for several years
  – Some critically important antibiotics have been needed for Trout production in England.
  – In the 1980’s, a lack of vaccines meant antibiotics were used much more frequently, so many people believe that farmed fish are ‘full of antibiotics’

Vaccination
• Parr are vaccinated, before smoltification and sea transfer
• Almost all will be vaccinated against Furunculosis (Aeromonas salmonicida), most against Infectious Pancreatic Necrosis (IPN) and Pancreas Disease (PD), and some against other bacterial diseases
• Fish are anesthetised for the vaccination process. The majority are now machine vaccinated.
• Some smaller farms are now choosing not to vaccinate because it is too costly to be viable, and they find it is cheaper to treat for diseases. A lack of available options means there is no competition to keep vaccine prices low, but farmers have no other options.
• Fish cannot be vaccinated for notifiable diseases (if they are being exported), but this appears to be a political issue rather than scientific. These vaccines could be useful if we could safely determine between a vaccinated and unvaccinated fish.

Biosecurity
• In many ways management will be different in the sea to traditional agriculture, eg it is not possible to double fence fish in the sea, but there will be lessons to be shared.
• Fish farms have largely been consolidated geographically, so that all farms in one sea loch are usually owned by one company – some companies swapped farms in order to make this happen. This helps to synchronise production cycles, and allows for a more holistic approach to disease challenges. It is much more effective now than in the past.
• Management areas have been created, meaning individual sea lochs, by legislation have to be farmed at the same time. This possibly needs revamping now we have a better understanding of water flow and dynamics. A review of these areas may help to control lice etc.
• There is good communication between companies working in each area. Big businesses being involved also means more impact can be made through investment.
Gill health
- Gills are highly adapted, but easily damaged. They are involved in gas exchange, osmoregulation, acid-base balance, excretion of nitrogenous wastes, immune function
- Water chemistry tolerance ‘thresholds’ will be different for fish with compromised gills, especially O2 and CO2
- When gills are affected by enough change, fish can really struggle. Handling fish with compromised gills can result in significant mortality
- Gills can recover if fish are moved into a better system – this is sometimes seen in fish moving out of hatcheries
- Once in the sea, AGD is a big challenges, especially for fish transferred in the Autumn. Fish with AGD will often also be anemic, which makes it harder to assess. PCR testing is useful for spotting this.
- Gill health can affect treatment efficacy. Certain treatments are contraindicated in the presence of specific gill pathology (eg hydrogen peroxide and acute HAB damage).
- Thermal treatments can be damaging to gills. These treatments can be effective when done well, but can be overused. They do not require any veterinary involvement or prescriptions, so there are currently no controls on their use. As they can cause harm, there should be some controls in place. All treatments should be brough into some form of welfare assessment structure

Skin and fins
- Fish skin is important, and has living cells on the outer layer, making it delicate.
- Skin is the barrier to the environment and against infections and pathogens, so any disruption is significant.
- Fish in order to actively maintain the balance of water and salts within their cells compared with the external environment. There are different pressures acting on a fish depending on whether it is living in freshwater or seawater. Damage to skin and gills makes osmoregulation more difficult.
- Fin damage can be from many sources, including inter-fish aggression, handling, seals, feed withdrawal. The impacts depend on age and level of damage, but can be significant

Water quality
- There are many chemical and physical parameters to consider in relation to water quality, including oxygen, nitrogen and CO2 levels, pH, salinity, temperature and water flow.
- Changes in one parameter can affect the toxicity of others, which can have consequences for fish health.
- The requirements are different depending on system, location and species.
- Significant knowledge and expertise are needed to understand how all parameters interact, but not enough people are available to help everyone avoid issues. Vets need training in water quality, recirculation systems etc.

Stocking density
- Ideal density depends on many factors – system, lifestage, water source, species
- If other factors are poor, lowering the stocking density will not always mean better welfare

Handling
- Handling can cause significant stress, which needs to be controlled
• Avoiding overfilling nets and making sure fish are corralled slowly can help to reduce stress.
• Vaccination requires handling, and must be done carefully especially if using injections. Automated machines remove some operator errors but still have their risks

Other
• Scottish Shellfish policy – statutory designated areas have been established by Scot gov. Shellfish monitoring and classification programmes are focused on protecting public health, rather than animal welfare
• Stress reduces resilience. If there is an infection in the background, then a stressful events occurs (eg a treatment), this may lead to a sudden increase in mortality a few weeks later
• Cleaner fish – the optimal conditions for salmon are not necessarily ideal for cleaner fish. Treatment and handling events for salmon can lead to issues for the cleaner fish, and lots of work is needed to optimise conditions for them
• An increase in biomass has led to increase in mortality. This includes some from environmental sources, such as jelly fish and algae blooms, but also from mechanical treatments and diseases.
• Medicinal treatments and vaccine are not widely available for fish, and products get pulled from the market due to small markets. This is a welfare issue and there needs to be more corporate social responsibility amongst pharmaceutical companies to continue production.

4. Slaughter processes should result in a humane death for fish, minimising avoidable pain, distress, fear, and suffering

• Slaughter processes should be designed to minimise avoidable pain, distress, fear, and suffering.
• Species-specific needs should be considered at all stages of the slaughter process, and all animals, including farmed finfish, should be effectively stunned before slaughter.
• We support the Farm Animal Welfare Council’s (FAWC) principles of humane slaughter as set out in the FAWC opinion and reports on the welfare of farmed animals at slaughter or killing.
• Slaughter […] is the final event in a farm animal’s life. The following principles must be observed if slaughter […] is to be humane with minimal pain, suffering and distress:
  – All personnel involved with slaughter […] must be trained, competent and caring
  – Only those animals that are fit should be caught [or penned], loaded and transported to the slaughter site
  – Any handling of animals prior to slaughter must be done with consideration for the animal’s welfare
  – In the slaughter facility only equipment that is fit for the purpose must be used
  – Prior to slaughter of an animal, either it must be rendered unconscious and insensible to pain instantaneously or unconsciousness must be induced without pain or distress
  – Animals must not recover consciousness [before] death ensues

• Fish may be slaughtered on site, but the majority are transferred by wellboat and pumped into dedicated facilities (“harvest stations”)
• At a harvest station, they will pass over a dewaterer, stunned by automatic percussive systems, then killed by gill cutting (exsanguination). This is an automatic process, but they are manually checked and action taken if any issues arise.
- Some systems use electrostunning before or instead of percussive stunning
  - Industry has driven real innovation around stunning and slaughter techniques and has put a huge amount of work into this. Electrical stunning without damaging fish is difficult.
  - Wild caught fish not usually stunned at all

- Slaughter process have improved dramatically in the last 20 years to the benefit of fish welfare, but there are still improvements to be made across the sector.
- As well as a moral obligation to consider fish welfare, health and safety and commercial reasons also drive improvements.
- SSF have invested heavily in new technology, and their latest system provides the highest levels of welfare at slaughter to date.
- Fish are taken (alive) on wellboats to a harvesting facility, with conditions including temperature carefully controlled to keep the fish calm.
- At the harvesting facility, much of the process is automated with staff members checking at every stage. Adequate time is allowed for inspection to reduce the risks of something going wrong. Processes are in place to ensure any fish that are still moving are stunned and harvested as humanely as possible. This affects around 1 in 100 fish, and any increase in this rate results in inspection of the machine for mechanical faults.
  - Fish are first electro-stunned, then stunned again using a percussive blow. This renders them unconscious and avoids pain when the blade comes to bleed the fish. Electro-stunning has been difficult to get right, and many other processing facilities stopped trying to develop it, but it is beneficial to fish welfare and will hopefully become more widespread.
  - Electro-stunning is especially useful for stunning larger fish, as percussive stunning is not always as effective if fish are larger than expected.
  - Cameras and apps are used throughout the process to continually check everything is working correctly and the number of fish being processed is at a safe level.
  - Blood is captured and contained so it does not contaminate the environment
  - Moving fish from the sea to the wellboat and from the wellboat to the harvesting facility are critical points to manage carefully.
  - Better regulation is needed to ensure welfare at slaughter continues to improve across the sector.
  - The automated process is also used during vaccination, so progress on this technology is helpful at several important stages.

The group were in support of electro-stunning continuing to be developed and rolled out. RSPCA also support its use.

### Role of the veterinary profession

**5. Veterinary professionals should play an active role in aquaculture, as part of a vet-inclusive team.**

- For historical reasons, including fish not being covered by the veterinary surgeons act, vets have not been as closely involved in the aquaculture sector as they are with terrestrial farming systems. There are a shortage of vets with the correct expertise for this sector.
- The veterinary profession could potentially be a helpful voice in the regulatory bodies, but currently has very little influence on regulation.
- It is important to recognise the different role of the vet in aquaculture and what they can influence. Vets will often get a request for a prescription for a specific medicine, rather than for a diagnosis.
### Stakeholders

- The sector will engage with anyone who is willing to have an informed discussion and can find some common ground to start with. Major stakeholders include:
  - Statutory bodies (UK/EU)
  - UK/Scottish trade groups
  - Accreditation - this is a major driver to improving welfare, more important than legislation, as producers cannot sell fish without it.
  - Research funders
  - Retailers
  - NGO/Lobby groups
  - Pharmaceutical companies
  - Universities - try to have good engagement from research point of view, and from a teaching perspective. It would be good to see more coverage of fish within veterinary schools, as there is a huge opportunity within business, but currently a post-doctorate degree or on-the-job training is required to gain sufficient knowledge
  - UK & Scottish media outlets
  - Other trade bodies (EU/global)

- **Medicines**
  - RUMA are frequently consulted, especially around AMR
  - Salmon Scotland have an advisory group to look at responsible use of medicines. Aim is to bring stakeholders together to improve survival rates across the sector

- Other stakeholders of interest to the veterinary profession include FVE, the Fishmed+ coalition, and fish pathologists

- There is a shortage of vets in general, but experienced vets who want to work in aquaculture are extremely rare
- Challenges include attracting vets, making sure they are supported and changing attitudes within the industry so vets feel valued and want to stay. There is a need to tackle view that vets are only there to write prescription, to make sure they are listened to and their views acknowledged
- This is especially worrying with increase in requirement for vet certification

### 6. The veterinary profession as a whole should work to improve its understanding of aquaculture

- Fish vets need to do more to communicate with others to avoid misrepresentation. The sustainable aquaculture position may help to share some of that necessary information.

### Basic overview of aquaculture systems

- **Ponds**
  - Most of aquaculture globally happens in ponds, and this has been happening for thousands of years
  - In the most basic systems, fish are unfed, only eating plants which grow naturally in the pond, which may sometimes be enhanced with fertiliser. Around 10% of global finfish aquaculture is unfed
In other pond systems, feeding may be enhanced or supplemented, or only introduced feed may be used. In more advanced systems, concentrated feed may be used (pellets)

Other than feeding, the only other intervention may be harvesting, by netting or draining the pond

Vast majority of aquaculture globally by volume happens in ponds, especially in Asia. These can be very basic systems, but can also be very advanced.

Pangasius farming in Vietnam is pond based, but equal to Norwegian Salmon industry in economic output

Much of UK trout farming remains pond-based

### Tanks and raceways

- On-land artificial structures, which are fully contained
- All fish needs are artificially met, including the introduction and removal of water, feeding by hand or machine, and oxygen and temperature control
- Recirculating Aquaculture Systems (RAS), in which used water is treated and reintroduced to the tanks, greatly reduce the need for fresh water supplies. This is biosecure, but expensive and component failure could lead to welfare issues for the fish.

### Pens and cages

- Net pens are hung in a water body.
- Juveniles may be grown elsewhere and moved into the cage. Feed is almost certainly added
- Cage systems vary from very basic (small wooden structures) to highly advanced (eg off shore semi-submersibles)

### Production processes and equipment

- The production cycle follows natural lifecycle:
  - **Broodstock** are stripped of eggs and milt
  - fertilised eggs hatch in freshwater nurseries
  - **alevins**, with yolk sac attached, become **fry** and then grow into **parr** (in tanks, raceways or net pens in freshwater lochs)
  - parr undergo a major metabolic change to cope with sea water, becoming **smolts**
  - smolts are transferred to sea for on-growing, traditionally in spring or autumn, but the sector now produces smolts all year around in order to meet demand throughout the year
- Fish are ectothermic, so everything is measured in time and temperature – “degree days”
- **On-growing of Salmon**
  - Smolts being sent to sea are larger than they were previously, as genetics and feeding has improved significantly
  - Smolts are on-grown in sea pens until they reach around 4 to 6kg in size. This usually takes 12 to 18 months
  - Marine farming pens may hold over 40,000 fish, though some pens are now able to hold 500,000 fish. Pens were traditionally squares of 24x24 m, arranged in rafts, but industry has moved mainly towards circular pens of increasing circumference
- All UK marine salmon farming is on the west coast of Scotland and the Western and Northern Isles, where conditions are suitable. There is a moratorium on marine farms on the East coast
- On modern farms, fish are monitored remotely by cameras and mechanically fed, all from a barge in the centre of the pens
- Ideally once at sea, the fish will be left to feed and grow. They may be handled to maintain stocking density of around 15kg/m$^3$ (1 tonne of water), but main reason handling is necessary is to treat for ectoparasites – Sea lice and Amoebic Gill Disease (AGD)

### Knowledge
- There is a deficit in aquatic animal health specialists, including vets
- Aquaculture is a food sector, and the debate and expertise need to broaden out to recognise this. You don’t get ‘agriculture’ experts as it’s recognised this is too broad
- A One health approach with different specialists is needed
  - Vets understand the concept well, but others do not
  - Important to make One Health a policy priority rather than a reactive tool
  - The Salmon industry is advanced in thinking about One Health, but other parts of aquaculture are not. There are concerns around food safety in many areas
  - OIE and FAO are international designations to consider
  - AMR is an international issue

### Welfare outcome assessment

7. **Animal health and welfare outcome assessments should form part of production system key performance indicators.**

### Non-disease welfare outcomes
- There is lots of innovation happening around non-disease welfare outcomes
- Moving sites to larger units is beneficial. Although stocking density doesn’t change, each fish then has a bigger area to move in. It also helps with predators, as fish can school in the middle to get away from them, which reduces risks and stress levels.
- The FishWel manual includes scoring indices for welfare. A poster with various negative welfare indices has been produced, and this is making a positive impact. Checks can be done at weekly lice counts. Welfare condition scoring will be included in the next RSPCA standards, though most of Salmon industry is already doing this. They are used slightly less in Freshwater, so there is scope for improvement.
- Groups are working on positive welfare indicators, but this is very new and difficult. AI and cameras will make a big difference in this area.
- Lifetime assurance should be possible, but the sector is behind some of the other industries on this. The work on welfare indices will probably mean the industry moves towards that in due course.
- Lots of innovation comes from the sector itself – not just because of retail/consumer demand. There is general recognition of the benefits of good health and welfare.
- J. Shotton noted they had tried AWAG scoring at Marwell Zoo, but it has been challenging due to the reliance on human behaviour and needing to make decisions on what data to put in.
Salmon do not show many inquisitive behaviours which can be measured. Cleaner fish are more inquisitive and show a greater range of behaviours which could be assessed.

Emerging trends: breeding, technology and innovation

8. New technologies and innovative models used to improve the contribution of animals, be that in terms of the production of food, animal feed or environmental goods, must not compromise the welfare needs of the animals in question.

- Future possibilities
  - Closed floating systems – removing the net means you can collect all waste, but then water needs to be pumped in and out
  - Stronger systems which can operate in more open oceans

To discuss in meeting #5

Themes last updated: June 2022