RURAL ECONOMY AND CONNECTIVITY COMMITTEE

SALMON FARMING IN SCOTLAND

SUBMISSION FROM INSTITUTE OF AQUACULUTRE, UNIVERSITY OF STIRLING

The Institute of Aquaculture is a world renowned institute, ranked top 5 in the UK for Agriculture and Veterinary sciences in the 2014 Research Excellence Framework. The Institute of Aquaculture provides high-quality research, teaching, training, technology development and consultancy to the aquaculture sector.

1. General views

The farmed salmon industry is working hard to improve production systems, efficiencies and reduce waste products. Major progress has been achieved over the last 15 years with a wide range of innovative solutions, systems, technologies developed and implemented or in the process of being implemented; all with the aim to improve pest management; reduce mortalities; and ensure optimal wellbeing in farmed stocks. The industry is actively collaborating with research and development institutions independently, as well as collectively through the Scottish Aquaculture Innovation Centre (SAIC) to develop new and innovative technologies to solve the challenges experienced by the salmon production sector in Scotland, and to meet governmental and industry targets. Many of the challenges faced by the industry are being addressed through systematic incremental changes to component parts of the production systems. The Institute of Aquaculture believes that expansion in the salmon sector is possible without impacting negatively on the environment. However, in order to achieve the industry target for a doubling the economic contribution of the sector, a step change is required supported by a more holistic research and development approach to better reflect the complexity and multifactorial nature of the challenges faced. One of the main limitations directly impacting on the pace of developing and implementing new scientific knowledge and translating this knowledge into innovative solutions is capital for infrastructure, revenue and staff investments into research and development programs in Scotland.

2. Actions to help the sector grow

Many of the health and welfare challenges that affect production levels, within the Scottish salmon industry, occur in the latter stages of the salmon life cycle in post-smolt on grown at sea. Transfer of fish from freshwater land based recirculation units to open sea cages is a critical phase during the production cycle, which may lead to increased salmon's susceptibility to infections and diseases. This is a priority research area to develop knowledge and protocols to enhance the robustness of the fish pre and post transfer.

The Institute of Aquaculture is therefore supportive of Scotland Food and Drink's recommendation for innovation sites as part of the Aquaculture Growth to 2030 strategy. Investments in innovative biological and engineering-based solutions that

increase fish robustness during these early growth stages would mitigate some of the production loses experienced at sea.

Additionally the primary concern of the sustainability dialogue surrounding aquaculture production has been the Fish In: Fish Out (FIFO) ratio. An area that has received little attention by the Scottish Salmon industry is the greater utilisation of downstream processing and management of by-products. Research published this month (April 2018[1]) conducted by the Institute of Aquaculture shows that Scotland could increase food production from fish farming more broadly, through the diversification of the range of products that can be produced from salmon farming. Whilst new technologies are developed to create new opportunities for sea cage sites, (a key constraint raised by both the "Scottish Aquaculture: a view towards 2030" and "The value of aquaculture to Scotland" reports) the sector could continue to boost its economic contribution to Scotland through diversification of by-products.

3. How to address fish health and environmental challenges

Fish Health challenges

Many bacterial diseases are now effectively controlled in salmon aquaculture by the use of vaccines, but some bacterial pathogens still present challenges for cleaner fish species (currently being used for biological control of sea lice), and new diseases will emerge. Viral diseases present significant infectious disease challenges with a limited number of effective vaccines commercially available. Sealice (ectoparasites) and gill health issues (involving parasites, viruses and bacterial pathogens) are the main current fish health challenges in Atlantic salmon. No vaccines are available to protect against these diseases and treatments are expensive and can lead to other problems (secondary infections), so there is a need to tackle the route of the problem and develop methods to rethink how to control sealice and gill diseases. New diseases, including new presentations of existing conditions will inevitably emerge. It is vital that there is a rapid respond to diagnose these new threats, then develop and recommend appropriate control strategies.

Close links between industry and academia are vital and although SAIC (industry led) and ARCH UK (an academic led network) have been established, links between industry and academia still need to be strengthened further to tackle fish health challenges.

Through ARCH UK, with discussions led by Stirling, the following approaches to tackle fish health challenges were highlighted:

- Molecular epidemiology of key emerging and established pathogens: Markers and mechanisms of virulence need to be elucidated and knowledge of the

[1] Stevens *et al.* (2018) *The rise of aquaculture by-products: Increasing food production, value, and sustainability through strategic utilisation*, Marine Policy, Volume 90. https://doi.org/10.1016/j.marpol.2017.12.027

diversity of potential pathogens in the environment/ wild species is also important and what may drive their emergence as new causes of disease.

- Multiscale modelling approaches. It is necessary to collate environmental, physiological, behavioural, pathogen prevalence/ diversity data to predict new/ existing pathogens causing disease outbreaks. This includes remote sensing/ collection of data on farms, collection/ curating/ integration and interpretation of these complex datasets, and better background data on 'normal' versus perturbed systems.

- Alternative Treatments: Replacement treatments/ management approaches are required for existing treatments (removed from market/ reduced efficacy: resistance).

- Vaccines and optimal vaccination strategies to current and emerging pathogens: Vaccines are recognised as important tools for the prevention and control of diseases in fish, but there are still numerous diseases where no vaccines are available or cases where existing vaccines do not perform well. Effective mucosal vaccine delivery vehicles and associated adjuvants are lacking.

- Improvement in fish welfare standards: Changes in culture systems will present new welfare challenges e.g. growing fish in large off shore systems, or indoors on land; triploids/ new strains may have differing welfare requirements; increasing use of cohabitation strategies (e.g. cleaner fish) present new welfare problems; changes in disease management/ treatments present welfare challenges (*e.g.* use of thermocyclers)

- Elucidation of underlying basic host protective mechanisms: This is essential to enable more targeted approaches to disease management.

- Improving/developing new tools and technologies: e.g. rapid diagnostics

Environmental challenges:

Escapees from fish farms and potential effects on wild populations

The impact of escapees on introgression and competition with wild stocks was a key environmental challenge raised in the Scottish Parliament's Review of the Environmental Impacts of Salmon Farming in Scotland. A key issue regarding introgression is how and when this happens. The Institute of Aquaculture would like to note one of the most developed strategies to mitigate the negative impacts of escapees as well as providing further evidence on the actual likelihood of introgression within Scottish waters.

One of the most developed strategies to mitigate the negative impacts of escapees is through the use of sterile salmon induced by triploidy. This practice is routinely used in large-scale rainbow trout and brown trout production for restocking and

oysters across Europe. This work started in 2008 by researchers at the Institute of Aquaculture, in collaboration with salmon farmers and Norwegian colleagues. Work done up to now has showed that triploid salmon can perform as well or even better than normal diploid stocks and while it does not prevent escapees, it removes the risk of farmed fish returning to rivers and breeding. However, further research is required to fully assess the robustness of triploid stocks especially with regard to their environmental sensitivity and coping to challenging conditions. This has been identified as a priority research area by the ARCH UK "Stock improvement" working group. New alternative strategies are also being researched in Scotland by the Institute of Aquaculture and Roslin Institute, Norway and USA to sterilise fish using gene editing techniques but it is still early days and only used for research purpose.

Regarding the likelihood of introgression within Scotland, the literature cited in the Scottish Parliament report was predominantly from Norwegian based research. The situation in Norway is clearly different to that in Scotland, as well as being different between areas in Norway. As the authors point out, much more research has been conducted on escapees and their impacts in Norway, so it is logical to examine this. However, key studies from Scotland were omitted, which allow comparison between the two countries. This research indicates that the impact of introgression within Scottish waters is much lower than our Norwegian counterparts, as the incidence level of encountering escapees in Scottish waterways is much reduced. That said, the above does not justify or make escapees acceptable.

The East-West split in salmon farming location in Scotland is of importance (and very unlike the situation in Norway, where the salmon farming is along the same coastline as the major salmon rivers) – the vast majority of wild salmon return to rivers on the East coast of Scotland, where there is little or no salmon farming activity. The parliamentary report estimated that the recorded numbers of escapees equated to approximately half of the total number of adult salmon in Scottish rivers. However, analysis of the Marine Scotland data conducted by the Institute of Aquaculture in 2012 showed a steeply declining presence of escapees from the total reported numbers to coastal fixed engine and net and coble catches (24.8% of catch in west-coast salmon farming regions[1]) and to much lower proportions in rivers[2].

In many Norwegian rivers, the proportions of farmed salmon caught (generally identified on morphological characteristics, comparable to the Marine Scotland data) has been higher on average than in Scotland, exceeding 50% in some rivers[3][4]. In an

[1] Green DM, Penman DJ, Migaud H, Bron JE, Taggart JB, McAndrew BJ (2012). The impact of escaped farmed salmon *Salmo salar* L. on catch statistics in Scotland. PLOS ONE **7**:e43560.
[2] 0.30% of the overall rod catch in Scottish rivers was identified as being of farmed origin over 2001-09, with a higher proportion (2.8%) within the intensively farmed regions (West, North West, Clyde Coast and Outer Hebrides). The highest was in the West region (5.8%) and the lowest in the East region (0.0045%), where there was no farming activity at all.
[3] Fiske et al., 2006.

analysis of 20 Norwegian rivers, genetic changes were detected compared to historical samples (from stored scales), with the amount of change being in proportion to the mean number of escapees observed in the rivers over a 20 year period (using a set of DNA markers distinguishing between farmed and wild fish[4]). In five out of these twenty populations, statistically significant temporal genetic changes were detected, in the direction of farmed fish pool.

One of the few studies comparing deliberate release of farmed salmon involved parallel release of tagged large fish (510-870 mm fork length) in Scotland and in Norway[5]. Of 597 such fish released in Norway, 7.0% were recaptured, mostly within 150 km of the release site and 64% of these were caught by anglers in freshwater. Of 678 fish released in Scotland, 0.6% (five fish) were recaptured. None were recaptured in rivers in Scotland; two detached tags were found on beaches in Scotland north of the release site and three live fish were recaptured in Scandinavia (two in Norway and one in Sweden). While this was a single study, with only one release site in each case, this does appear to agree with the overall data on escapes in Scotland and Norway in suggesting that escapees from Scottish salmon farms are much less likely to enter Scottish rivers.

Modelling and empirical data by Glover et al., 2013 suggest that high proportions of farmed fish need to regularly enter rivers and spawn successfully to cause significant introgression and impact on fitness of wild fish. Recent research conducted by the Scottish Association for Marine Science (SAMS) have found that there is almost no direct evidence for this in Scotland[6].

4. Adequacy of data on salmon operations and fish health and related matters

The SSPO manage a Fish Health Management System designed to assist the industry in managing fish health, allowing real time exchange of information across Scotland between companies and individual farms. Local meetings are also held where health issues are discussed and exchanged between farming neighbours.

There is also comprehensive national data collection but access to data is currently restricted. This is in contrast to the situation in Norway where detailed annual reports are readily available. Greater access to these data sets would enable better epidemiological modelling to be conducted on the spread and/or emergence of disease/health related matters, which could help identify hitherto unidentified systematic industrial challenges.

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[4] Glover KA, Pertoldi C, Besnier F, Wennevik V, Kent M, Skaala Ø. (2013). Atlantic salmon populations invaded by farmed escapees: Quantifying genetic introgression with a Bayesian approach and SNPs. BMC Genetics **14**:74.

[5] Hansen LP, Youngson AF (2010). Dispersal of large farmed Atlantic salmon, Salmo salar, from simulated escapes at fish farms in Norway and Scotland. Fisheries Management and Ecology 7:28-32.

[6] Verspoor E, Knox D., Marshall S (2016). Assessment of interbreeding and introgression of farm genes into a small Scottish Atlantic salmon Salmo salar stock: Ad hoc samples–ad hoc results? Journal of Fish Biology 89:2680–2696.

5. Regulatory regime

As a research institution the Institute of Aquaculture feel it more appropriate for those working within the regulatory requirements to address issues pertaining to this question.

6. Impact of Brexit on the farmed salmon industry

As an institution supplying research and education services to the sector, the outcome of Brexit could have significant impacts on the growth of the Scottish salmon sector. Much of the pioneering collaborative research (such as cleaner fish) that has taken place over the last 10-20years has been the product of a team of international academics and industry investments. The uncertainty over access to research and development funding for continuing fundamental research into the biological and engineering-based technologies is having an effect on the willingness of investor and collaborator involvement in research and development projects.

In addition to pushing the envelope for developing innovative solutions to intractable challenges, the Institute is involved in the training and development of a large proportion of industry practitioners. Reports such as SAIC's "Scottish Aquaculture: a view towards 2030" highlight a key area of constraint for the industry is the ability to find and retain skilled staff. Any reduction or restriction to the funding landscape at a Scottish or UK level (both revenue and capital investment) may influence the ability of key educational institutions in supporting the development of postdoctoral training programmes. This at best will hamper the industry's ability to fill the skills gap currently identified, and at worse accentuate the long-term effects of a skills deficit.

It is imperative that clarity on the position of the UK's future involvement in European research and development funding is reached as soon as possible.

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