SALMON FARMING IN SCOTLAND

OPTIMISING ITS CONTRIBUTION TO CLIMATE AND ENVIRONMENTAL POLICIES

POLICY BRIEF

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THE POLICY CONTEXT

The Scottish government has ambitions to play a significant role in meeting three of today's biggest international challenges:

- Sustainably feeding a growing global population;
- Minimising our contribution to climate change;
- Halting and reversing biodiversity loss.

Fish farming will be an important contributor to all three areas.

Comparing different protein sources in human diets globally, aquaculture production has significantly lower global warming potential (GWP)[1] per kg of edible product than beef or sheep production.

Beef production globally averages 45kg CO2-eq/kg of product, compared to aquaculture at 5kg CO2-eq/kg. In Scotland, beef and sheep production are already more sustainable than in many other regions of the world and, like aquaculture, have the potential to make further reductions in their GWP.

The focus of this policy brief is on aquaculture, assuming that animal protein will continue to contribute to human diets but will be replaced to varying extents by aquaculture and plant-based protein sources.

Given that most of the world's wild-capture fisheries are either close to, or exceeding, a sustainable exploitation threshold, a large scale shift in human diets to greater consumption of protein from fish and shellfish will need to be met by increases in aquaculture.

In Scotland, salmon farming dominates aquaculture production, producing 200 Ktonnes/year with the ambition to double production by 2030. To be sustainable, in addition to producing high quality nutritious food, this increase will need to be accompanied by further reductions in GWP, improved environmental and biodiversity protection, and high standards of animal welfare.

The sector is already investing heavily in innovations that can increase capacity and at the same time contribute to these important policy objectives.

However, a more strategic, systemic, networked/circular economy approach is needed to deliver the optimal combination of policy/technology initiatives across the full aquaculture value chain.

1 Global Warming Potential (GWP) is expressed as CO2 equivalents (CO2-eq). CO2 is the principal anthropogenic GHG and is the main cause of global increased temperatures, remaining in the atmosphere for hundreds of years. It is the reference gas against which other GHGs are measured and therefore has a global warming potential (GWP) of 1 (IPCC, 2018). Other greenhouse gases are shorter lived and remain for years to decades in the atmosphere and some, for example methane, have a more powerful GWP than CO2.

OPPORTUNITIES FOR POSITIVE CHANGE

The Fish Farming in Scotland Report (see note 1) identified innovation in aqua-feed production as the single most promising route to a sustainable increase in the output of protein for human consumption, reducing both GWP and negative biodiversity impacts.

Aqua-feed accounts for more than 90% of fish to farm-gate GWP and is the most expensive component of aquaculture production. Reliance on fishmeal and omega-3 oils from wild-capture fisheries has been damaging to marine biodiversity in Scotland and in S. America.

In Scotland there has been a shift to plant-based ingredients, such as soya meal and rapeseed oil, so that farmed fish diets now contain roughly 50% plant based ingredients.

Greater reliance on plant-based ingredients has, if anything, increased the GWP of the feed and shifted some of the biodiversity impact from marine to land ecosystems such as the Amazon rainforest. Better solutions are urgently required.

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Single celled protein (SCP) feeds (using micro-algae, yeast, bacteria or fungi) can be produced using a variety of feedstocks, such as waste residues and by-products from other industry sectors. SCP feeds contribute to a circular economy, reduce the GWP, improve biodiversity in marine and land ecosystems, and avoid competition with foods that could be used for human consumption. To give just a few examples:

- Methane gas can be used to develop a product with 71% protein and 9% fat that resulted in increased growth and improved feed efficiency, reducing the land requirement (1692 km2 required to produce 40,000 tonnes of protein from soy compared to 0.04 km2 for SCP), along with 77–98% reduction in water consumption compared to soy and wheat production. Using 100% biogas from waste streams to produce the protein, the GWP could be reduced from 5819 kg CO2eq/tonne of product to 2274 kg CO2eq/tonne of product.

- Carbon dioxide (a power station by-product) and hydrogen are being used to produce SCP with a comparable nutritional profile to fishmeal and a claimed reduction in GWP of 25%.

- Micro-algae are being used to produce omega-3 oil and protein meal ingredients for aqua-feed. One tonne of algal oil could save up to 60 tonnes of wild fish, depending on the feedstock used to grow the algae.

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Insect meal from black soldier fly (BSF) larvae could meet all the protein requirements in Atlantic salmon diets, but not the oil-based component (as is also the case for the first two examples in the above list). In the EU, non-domestic food waste has been approved for use as a food source for the larvae. Redirecting 10% of available by-product streams to BSF production could produce 2.7 Ktonnes of insect meal for Scotland's salmon farming industry along with an additional 10% of carbon savings, compared to anaerobic digestion of the food waste, saving 69 kg CO2eq/ tonne of input. Using low-grade waste heat to fuel the process, the carbon savings from BSF farming could be increased to 153kg CO2eq/tonne of input.

Innovation beyond feed production is coming from additional initiatives, with the potential to increase production capacity, reduce environmental impacts, and increase overall control of production systems. However, some will also have an increased energy demand and potentially higher GWP, which could be addressed by using renewable energy sources.

- Offshore high-energy systems currently face technical challenges and risks to workforce health and safety, but could benefit fish health and reduce localised environmental impacts from fish-farm waste.
- Closed containment aquaculture systems, mainly for hatcheries and smolt-growing, are not new but recent innovations have improved waste treatment and disease control (reducing fish mortality), increasing feed conversion and reducing energy consumption by up to75%.
- Food processing innovations include improvements in the GWP of transport such as reusable bulk bins for domestic supply chains, which have already led to an estimated saving of 4.1 Ktonnes CO2-eq., and biodegradable packaging based on chitin, a by-product from crustacean production.
- Waste elimination, by-product utilisation and non-renewable input minimisation are important as core elements of a circular economy approach. For example (i) where the production system allows capture of un-eaten food and faeces, they can be used as biofuel or fertiliser; (ii) fish mortalities can be processed to produce fuel to replace diesel oil for fishery service vehicles, producing a small local circular economy; and (iii) food processing by-products can be used for terrestrial livestock feed, pet food and pharmaceuticals, further reducing the reliance on fish meal and fish oil from wild capture fisheries.

Across all production-related elements, the figure below illustrates how the core fish farming value chain is becoming part of a circular economy, based on innovative technologies, and could also contribute to, and benefit from, links with other value chains, creating what could be more accurately called a 'networked economy' rather than a circular economy.

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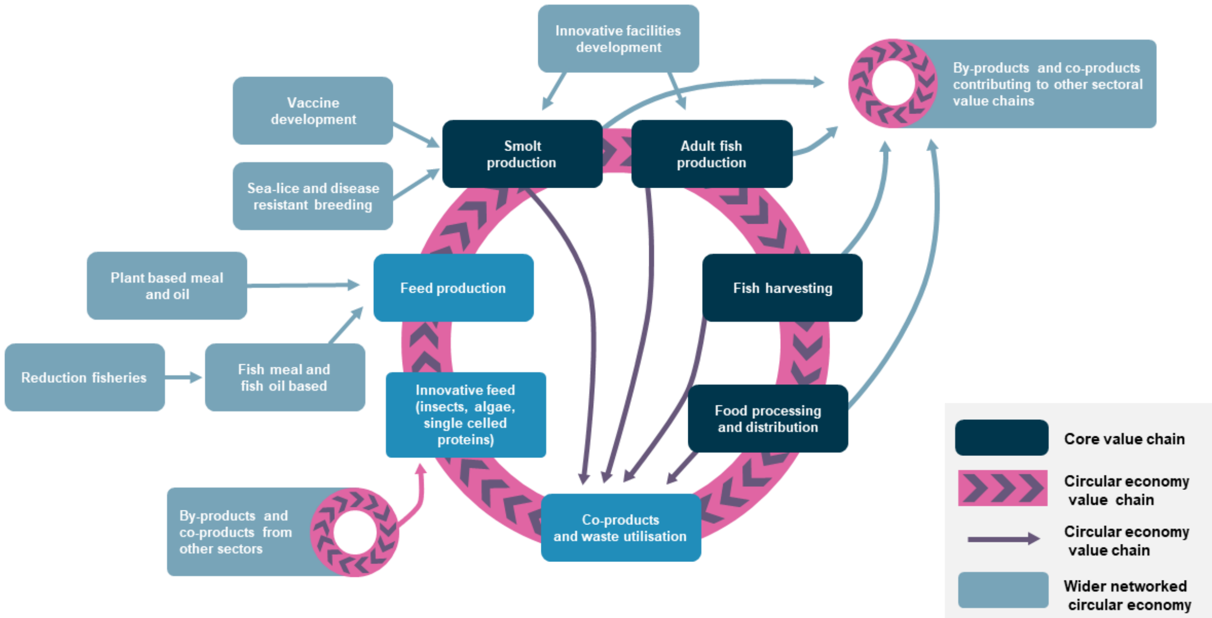

FIGURE 1: The circular economy value network and the role of innovative technologies for Scottish salmon farming

A SUPPORTIVE INNOVATION POLICY ECOSYSTEM

The Fish Farming in Scotland Report suggests that the impact of aquaculture on climate change and biodiversity could be reduced by incorporating the use of innovative technologies, in addition to other policy initiatives and incentives. This could be achieved while potentially improving on today's safety, quality and efficacy standards.

To achieve these objectives and meet Scotland's Net Zero emissions target by 2045, we will need to rely on quick wins, technologies that are already in the early stages of development, and to design favourable circular economy and policy environments that encourage rapid identification and adoption of the technologies that can deliver optimal outcomes across the entire network included in the figure.

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1. **Policy and economic incentives for aqua-feed innovation** (both protein and omega-3 oils) will have the greatest impact over the shortest timescale. The biggest challenges in this area are supporting scale-up of feed production processes to meet future market needs, and providing policy and economic incentives for feed producers to incorporate these new ingredients in their feed formulations, while they are in competition with less sustainable ingredients that will initially be cheaper and more familiar to feed producers, their customers, retailers and consumers.

2. **All policies, including those relevant to non-feed innovations** should take account of the whole innovation landscape and interactions between technologies, policies and markets when considering priorities relevant to innovation management.

3. **Considering the nature, extent and direction of policy and economic support**, life cycle analysis or an equivalent approach should be used to prioritise support for single innovations or combinations of innovations that will have the greatest impact on both climate change and biodiversity objectives.

4. **A future-oriented approach** to policy development should be adopted across all areas, scanning for future innovation opportunities and emerging commercial, regulatory, or consumer-related incentives or barriers to adoption of innovations.

5. **A strategic, systemic approach**, taking account of the entire value network (see figure) and the interactions among businesses and policies, will be needed to deliver outcomes that maximise Scotland's contribution to improving the sustainability and environmental impact of fish farming and are internationally competitive.

6. **A public communication strategy** should be in place to support stakeholder understanding of the value of innovative technologies in meeting widely agreed societal objectives – Net Zero, a circular economy and preventing biodiversity loss.

7. **In the immediate future, in the context of the UN COP 26 meeting in November 2021**, there is an important story to be told about the improvements in sustainability that have already been made by Scottish aquaculture and the further improvements that could be made, based on innovative technologies. The policy approach proposed here could contribute to international discussions on aquaculture-related initiatives and is relevant to other sectors in which technological innovations can enable delivery of climate change and biodiversity objectives.

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