



# › Making Scottish farmed salmon sustainable

## Recommendations for policy-makers

### KEY INFORMATION

#### THE CURRENT PROBLEM

- The Scottish salmon industry currently uses an estimated 460,000 tonnes of wild-caught fish, such as herring, sprat, whiting and anchovy, in feed. This is roughly the same as the amount of seafood purchased by the entire adult population of the UK in one year.
- Existing measures to protect wild fish targeted for feed, such as certification, are insufficient to ensure long-term sustainability of fisheries, equitable distribution of marine resources and ocean health.
- Feeding salmon with human-edible wild fish wastes enormous quantities of essential micro-nutrients as well as protein and calories. Feedback have calculated that by using some of the wild fish fed to salmon for direct human consumption, alongside a significant reduction in farmed salmon production, would provide the same level of omega 3 as is currently delivered by Scottish salmon farming. Crucially, it could do this while leaving an estimated 59% of wild fish – around 273k tonnes – currently caught for feed in the sea.

#### THE SOLUTION FOR SCOTLAND

- There are important opportunities to promote alternative forms of mariculture in Scotland, such as mussels farming, which are less dependent on wild marine resources than farmed salmon. In 2018, Scotland produced around 6,800 tonnes of farmed mussels, as well as 4,000 tonnes of farmed oysters: there is room to considerably scale up this production, with benefits including delivering conservation services.
- Moving beyond salmon allows for the exploration of new economic opportunities for Scottish coastal communities, through moving power from global corporations to local projects, thus ensuring money invested remains in Scotland.
- Job creation can be maximised through a transition from farmed salmon production to more sustainable shellfish production. For every £1 million of industry value, the shellfish industry generates 23 jobs compared to only 2 jobs for the salmon industry.
- Scotland can lead on the transition to aquaculture feed comprising of by-products as opposed to whole wild-caught fish by providing funding for research and development to increase understanding of the fisheries by-product supply chain.



## INTRODUCTION

Seafood is a delicious and important part of our diets: it provides key nutrients, particularly micronutrients such as omega-3 and iodine, which are less readily available from other food sources<sup>1</sup>. Producing and eating seafood also forms a major part of not only Scotland's food culture and economy, but also that of the wider UK. However, wild seafood is a finite resource, and one that must be monitored carefully to ensure long-term sustainability. According to the FAO<sup>2</sup>, the proportion of global overfished marine stocks peaked in 2016 (representing 33% of global fish stocks); this was mirrored by the lowest level of underfished stocks (7%). The remaining 60% were fished at sustainable levels but with no room for any further expansion. In addition, academic modelling shows that the plight of global fisheries may be even worse than initially thought, with catch reconstructions revealing that global fisheries catches are likely to be higher than reported, which would mean that fish populations are in a much stronger decline than previously believed<sup>3</sup>.

Besides overfishing, ocean life is facing a major threat: according to the IPCC, climate change has already impacted fisheries catches and their composition in many regions<sup>4</sup>. In the future, climate change may also make fisheries governance more challenging, as the impacts of warming include the unpredictable changing of habitats and the abundance of different species.

Aquaculture is promoted as a sustainable solution to the increasing pressure on wild seafood, supposedly relieving pressure on overfished species, while providing the public with a healthy source of protein and key nutrients like omega-3. More than half of the seafood we eat globally is farmed, and as the world's fastest growing food production sector, farmed seafood will account for 60% of global fish consumption within the next 10 years<sup>5</sup>. However, certain forms of aquaculture are highly reliant on wild marine resources.

Wild fish, usually small pelagic fish, which are processed into fishmeal and fish oil (FMFO), are a vital ingredient in the production of farmed salmon and other 'fed' aquaculture species (i.e. species that require external feed inputs, rather than species like bivalves, such as mussels, which do not). Fish oil is a vital ingredient in the production of farmed salmon, as it is high in omega-3, ensuring the micronutrient content. Every year, around 15 million tonnes of wild fish from across the globe are used to produce FMFO<sup>6</sup>, with global aquaculture accounting for 70% of FMFO consumption<sup>7</sup>. While the average global proportion of salmon feed made from wild fish has declined from 69% in the 1990s to 31% in 2015<sup>8</sup>, the industry's expansion has contributed to the substantial demands made by global animal agriculture, the petfood industry and other forms of fed aquaculture, on wild fish populations. The ambition to expand the farmed salmon industry in Scotland will further exacerbate this issue.

Good oceans governance, and proper regulation of the companies who use key marine resources in their supply chains, is necessary to ensure that our fish suppliers today do not threaten our access to marine nutrients in the future.

This policy brief explores how the aquaculture industry's reliance on wild fish in feed has so far evaded sufficient regulatory review. Greater corporate transparency and regulation are needed to ensure that salmon farming does not distort the market for wild fish, drive extractive fishing practices, and prevent Scotland from realising the benefits of other, more sustainable forms of aquaculture, such as bivalve farming. This brief makes a series of policy recommendations to mitigate inefficient and environmentally damaging production, and to nurture a more diverse aquaculture food economy, which can support human nutrition and local economies.

# ADDRESSING SCOTTISH SALMON'S RELIANCE ON WILD-CAUGHT FISH

The Scottish salmon farming industry uses an estimated 460,000 tonnes of wild fish a year in its feed<sup>9</sup>. The main wild fish species used in Scottish salmon feed are small pelagic fish such as herring, sardines, whiting and anchoveta. Feedback's research suggests that a large proportion of these species are fished from the North Sea and Northern European waters, while Peru and the US also provide major markets for reduction fisheries<sup>10</sup>.

There is expert agreement that heavy fishing of forage fish can have an impact not only on stocks of that fish, but also on the wider ocean ecosystems. The Lenfest Forage Fish Taskforce (a panel of marine experts) has cautioned that pelagic fish are vulnerable to collapse, even at relatively low catch rates<sup>11</sup>. Forage fish are a primary source of food for many ocean predators; their health has major knock-on effects on larger ocean ecosystems. A Scottish Association for Marine Sciences (SAMS) report to the Scottish Parliament in January 2018 stated that 'the global harvest of forage fish is already at its limit' and that further demand may increase pressure for unsustainable harvesting of fish<sup>12</sup>. Moreover, research shows that 90% of the fish used for FMFO could be consumed directly by humans<sup>13</sup>, if markets allowed and encouraged this consumption.

The salmon farming industry argues that, while it accepts the need to reduce its reliance on wild marine ingredients, using forage fish in this way is in fact an effective way to convert marine nutrition from fish not commonly eaten by people, to a highly popular consumer product. However, research demonstrates that, as a mechanism for delivering marine nutrition into human diets, farmed salmon is a poor environmental and nutritional option to

direct consumption of wild seafood: an academic study has shown that for every 100g of protein fed to farmed salmon (both derived from marine ingredients like FMFO and from plant-based feed ingredients like soya), only 28g are made available in the human food supply<sup>14</sup>. Turning from protein to micronutrients, research by Feedback demonstrates that a lower burden is placed on fish stocks by directly eating some wild, oily fish usually fed to salmon, and producing less farmed salmon: modelling showed that, by diverting some of the wild fish currently used by the Scottish salmon industry to human diets, and reducing salmon production by two-thirds, up to 273,000 tonnes of wild fish could remain in the sea and still ensure the same availability of micronutrients for human diets<sup>15</sup>.

By solely using FMFO made from fisheries by-products to produce feed, some farmed salmon production can be undertaken sustainably and make an important contribution to a varied public seafood diet. By-products from fish caught for direct human consumption are already used to some extent in some companies' farmed salmon feed, but on average, only around a third of the fish oil used in Scottish salmon farming is made from by-products, and in some cases far less<sup>16</sup>. Relying solely on fisheries by-products is an effective way to prevent the salmon industry from imposing a disproportionate environmental burden, compared to the nutritional benefit it delivers. Other alternative feed ingredients which replace fish oil, such as algal oil, are in development but not yet available for use at scale<sup>17</sup>: it is vital that careful attention is paid to the lifecycle impact of these alternative feeds, to ensure they do not create negative environmental consequences.

## BOX 1: FISH IN, FISH OUT

There is considerable controversy over how the 'fish in, fish out' ratio – that is, the ratio of fish caught and used for feed, and the amount of farmed fish produced – should be calculated. Essentially, fish in fish out seeks to determine whether the quantity of wild fish fed to salmon is higher or lower than the amount of salmon produced.

Feedback's calculations of the wild fish used by the Scottish salmon industry are based on the industry's demand for fish oil, which uses more wild fish than fishmeal. This is because the availability of fish oil is a limiting factor on farmed salmon production: without using a certain quantity of fish oil, the industry is unable to produce farmed salmon with the desired level of omega-3 fatty acids. The industry prefers a 'fish in, fish out' measure, which accounts for fishmeal that is produced in the process of making fish oil, which is then not used for salmon feed but instead sent to other industries, such as petfood or animal agriculture. In Feedback's view, this calculation is misleading, primarily because the most valuable element – omega-3 oils – are concentrated in the fish oil proportion. We therefore propose an approach that compares micronutrients in (in the form of wild fish) to micronutrients out (in the form of salmon). Fish is not a renewable resource in the sense that once a fish has been caught and processed, no further value can be extracted from it. Therefore, if a company requires a certain volume of wild fish to produce the fish oil it requires, it is immaterial that producing fish oil results in some 'leftover' fishmeal which is surplus to its requirements. For this reason, Feedback's calculations of wild fish dependency of salmon production focus on companies' use of fish oil, the types of fish used for this purpose and micronutrient retention.



In 2019, Feedback asked all Scottish salmon companies to provide us with data on where they sourced wild fish for FMFO used in their feed, including the fisheries and locations. Three of the six major companies operating in Scotland at the time – that is, Grieg Seafood, MOWI and Loch Duart – were transparent about their marine ingredient sourcing. However, Cooke Aquaculture, Scottish Sea Farms and The Scottish Salmon Company did not comply. Feedback’s research is based on data provided by Grieg Seafood and MOWI (excluding information provided by Loch Duart, as they represent a very small percentage of the market).

**TABLE 1: SCOTTISH SALMON COMPANIES**

Companies who responded	Companies who did not engage
<b>Grieg seafood</b> 	<b>Cooke Aquaculture</b> 
<b>MOWI</b> 	<b>Scottish sea farms</b> 
<b>Loch Duart</b> 	<b>Scottish salmon company</b> 

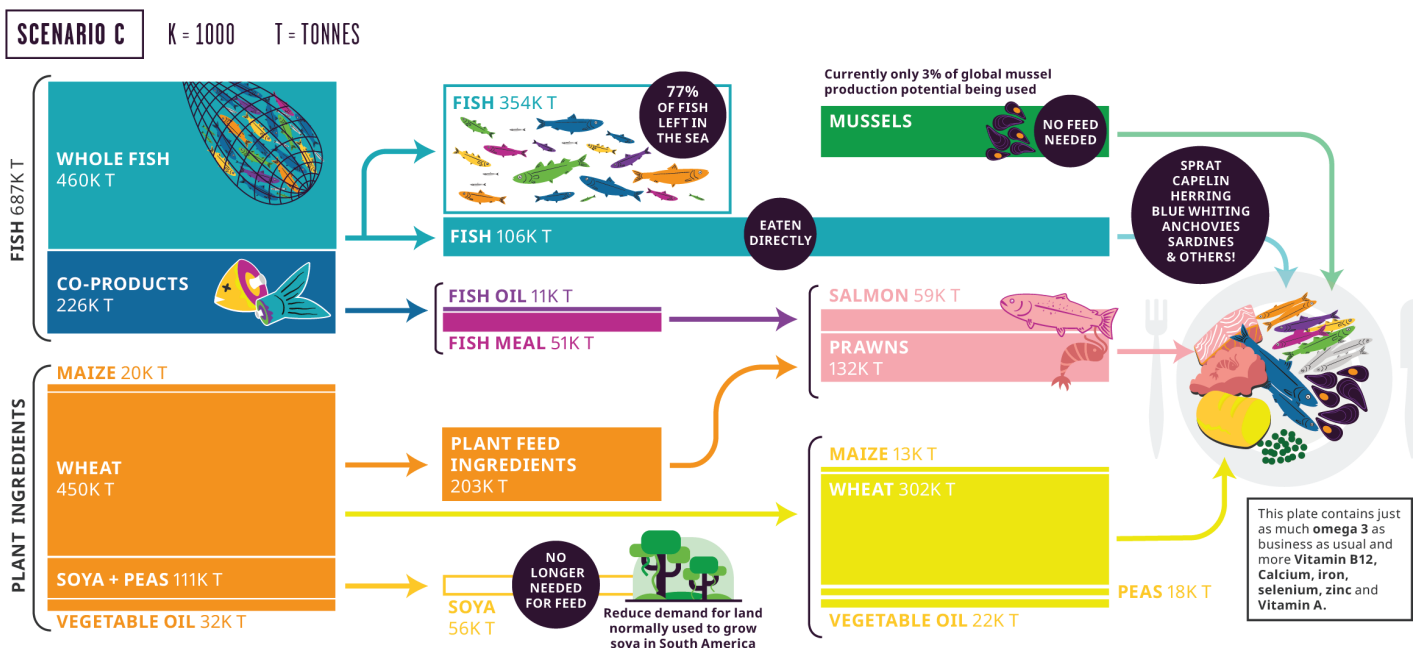
Lack of transparency from Cooke Aquaculture, Scottish Sea Farms and The Scottish Salmon Company means it is not possible to draw conclusions about the sustainability or status of FMFO sourced by these companies.

From the data made available, it is apparent that the Scottish industry uses a higher percentage of marine ingredients in feed than other comparable locations such as Norway, due to its market positioning as a provider of high omega-3 products. The industry argues that the trade-off between high marine ingredient use – and thus greater reliance on wild fish to produce its salmon – is justified by the greater health benefits provided by farmed fish with high levels of protein and omega-3.

**“Our salmon are fed a higher Fish Meal and Fish Oil content diet than farmed salmon from Norway, Canada or Chile.”**  
 The Scottish Salmon Company<sup>18</sup>

A more environmentally efficient way to introduce higher levels of omega-3 and other key micronutrients into our diets, without imposing a greater burden on wild fish, is to increase our production and consumption of unfed aquaculture species, such as mussels and oysters. Feedback’s modelling showed that by introducing a weekly portion of mussels into our diets, as well as eating a greater variety of wild fish, we could access the same level of omega-3, and other micronutrients, as is supplied by the current Scottish farmed salmon production, while leaving 75% of wild fish caught to feed Scottish salmon in the sea<sup>19</sup>. In 2018, Scotland produced around 6,800 tonnes of farmed mussels, as well as 4,000 tonnes of farmed oysters: there is room to considerably scale up this production, with benefits including delivering conservation services<sup>20</sup>.

**FIGURE 2: A MORE SUSTAINABLE FARMED SALMON INDUSTRY**



Source: Off the menu: The Scottish salmon industry’s failure to deliver sustainable nutrition (2020), Feedback. London

Another problem impacting the environmental credibility of salmon farming is the high rate of mortalities. Feedback's analysis of the data from 2016 to 2019 (the latest years with full data available) showed a significant increase in mortalities in these years, rising from just under one million fish in 2016, to 5.8 million fish in 2019. Part of this increase is likely to reflect improvements in reporting over this period, alongside the growth in

**TABLE 2: FARMED SALMON MORTALITY RATES IN SCOTLAND**

2016	
Total number of produced fish	35,680,674
Number of fish mortalities	986,032
Total number of attempted produced	36,666,706
<b>% MORTALITIES OF TOTAL</b>	<b>3%</b>
2017	
Total number of produced fish	36,716,695
Number of fish mortalities	4,842,501
Total number of attempted produced	41,559,196
<b>% MORTALITIES OF TOTAL</b>	<b>12%</b>
2018	
Total number of produced fish	28,636,991
Number of fish mortalities	3,500,390
Total number of attempted produced	32,137,381
<b>% MORTALITIES OF TOTAL</b>	<b>11%</b>
2019	
Total number of produced fish	34,964,385
Number of fish mortalities	5,846,848
Total number of attempted produced	40,811,233
<b>% MORTALITIES OF TOTAL</b>	<b>14%</b>

Calculated on the basis of data available on:  
<https://www.gov.scot/publications/fish-health-inspectorate-mortality-information>

the size of the industry, but it is still a startlingly high percentage<sup>21</sup>. In one event in 2018/19, 50% of a farm's salmon died, over 1.5 million fish. One salmon company, MOWI, have stated, 'While our fish currently average better than 80 per cent survival, we expect 90 per cent to be commonplace'<sup>22</sup>. It is alarming that a 10% mortality rate is deemed to be an acceptable target, and an indication of how wasteful salmon farming is in its current form. Salmon mortalities also represent a waste of feed ingredients, including wild fish: Feedback have calculated that in 2019, the farmed salmon that died before being harvested led to a waste of around 25,000 tonnes of wild fish in the form of feed, enough to feed 2 million people their weekly portion of oily fish for a year<sup>23</sup>.

Farmed salmon is the most purchased seafood in UK supermarkets<sup>24</sup>; this was not always the case. Data from Defra shows that since 1974, purchases of salmon have risen by 550%<sup>25</sup>. Farmed salmon has grown to become the UK's biggest food export<sup>26</sup> by value, with the industry increasing in production volume by 90% between 1997 and 2017<sup>27</sup>. Considering possible changes to fisheries regulation post-Brexit, a focus has been placed on consuming fish from UK waters. By prioritising the nutrients in wild fish from Scottish waters for direct human consumption and diverting subsequent by-products to aquaculture such as salmon farming, we can ensure the best use of a finite and vital environmental and nutritional resource.

Reliance on wild-caught fish in feed ingredients is undermining the Scottish salmon industry's claims to sustainability. Wild forage fish populations are a finite resource, one that plays a key role in maintaining the health of ocean food webs. By normalising high demand for feed ingredients made from wild fish, the Scottish salmon industry provides a veneer of respectability to a fundamentally unsustainable approach to food production. Feedback recommends that the Scottish salmon industry uses its market-leading position to establish a full-scale transition away from any purpose-caught wild fish in feed by setting targets to solely use marine by-products in its feed, and that policy-makers facilitate this process<sup>a</sup>.

a Feedback recommends that there should be a differentiation between human-edible fishery by-products, regardless of current market demand, and unavoidable by-products where human consumption is not possible. In doing this, the human edible products are considered 'coproducts' as opposed to 'by-products'. For more information, see Box 4: The By-Product Pitfall in Feedback's report 'Off the menu: The Scottish salmon industry's failure to deliver sustainable nutrition'.



## RECOMMENDATIONS FOR POLICY-MAKERS:

- Require salmon farming companies operating in Scotland to adopt targets to source 100% of marine ingredients from unavoidable fishery by-products by 2025.
- Support this transition by providing research and development funding to increase understanding of the fisheries by-product supply chain, including the possibility of rainbow trout farming to use salmon oil and vice versa (as salmon oil cannot be used to produce salmon), and by developing regulation to restrict the disposal of by-products, to drive industry innovation in maximising the use of fishery by-products in human consumption.
- Implement a moratorium on the further expansion of the Scottish farming industry until the industry demonstrates how it will operate without reliance on wild-caught fish in feed. This is in line with findings of the Scottish Rural Economic and Connectivity committee in 2018, which highlighted that the industry's regulatory regime and production methods were untenable:

*The Committee strongly agrees with the view of the Environment, Climate Change and Land Reform Committee (ECCLR) Committee that if the industry is to grow, 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 and environmental issues before the industry can expand<sup>28</sup>.*

- Commission an investigation by the Fish Health Inspectorate into the high rate of mortalities in the industry, developing a strict monitoring system for mortalities and mechanisms to revoke the licences of farms with mortalities above 10%.
- Expand and enforce the use of marine protected areas (MPAs). Scotland has a strong network of MPAs, but the expansion of salmon farms, particularly 'supersized' farms, pose a threat to vital ocean ecosystems. The recently published 'Future Fisheries Management Strategy' recognises the importance of MPAs, and it is vital that these are not lost to salmon farming<sup>52</sup>.



# THE FAILURE OF CERTIFICATION TO PROTECT FORAGE FISHERIES

When it comes to the use of wild fish in feed, certification of wild-caught marine ingredients (FMFO), and of the fisheries from which they are taken, is the primary means by which the salmon industry and feed companies seek to establish and maintain their sustainability credentials.

However, the market for FMFO from reduction fisheries is distorting certification schemes and reducing the value of certification<sup>29</sup>. By certifying fish intended for feed ingredients, as well as for direct human consumption, certification legitimises an approach to food production that is fundamentally inefficient and has severe equity impacts in terms of availability of key micronutrients to communities around the world. This is because wild-caught fish intended for FMFO in the Scottish salmon industry are often sourced in countries like Namibia and Peru, which means these wild fish, which are a vital source of micronutrients for populations facing food insecurity, are instead used for fisheries markets in Scotland. Essentially the farmed salmon industry is removing a food source, wild fish, to feed to salmon and in certain areas this could exacerbate food security issues. For example, recent research published in Nature found that, in several countries in which nutrient intakes are inadequate, a fraction of local and regional fisheries catches could meet or exceed the dietary requirements of populations living within 100km of the coast<sup>30</sup>. For example, the risk of iron deficiency in Namibia is severe (47%); however, only 9% of the fish caught in the exclusive economic zone of Namibia is equivalent to the dietary iron requirements for the entire coastal population. By certifying 'reduction fisheries', wild fish populations are reclassified as a commodity for global supply chains, rather than a local food resource.

While Scottish companies who provided data on their sourcing generally avoid sourcing from the most vulnerable reduction fisheries markets, such as those in West Africa and Turkey, FMFO from these markets is used in the wider supply chains of multinational companies such as MOWI and BioMar (a major aquafeed supplier for several Scottish salmon companies). In other words, with a growing demand for a finite source of FMFO, sourcing decisions are made within companies which ensure supply will continue to meet demand by reserving FMFO from more credible markets for Scottish operations and using less credible sources for production elsewhere (for example, operations in Norway or Chile). This approach does not lessen demand for fish from fragile fisheries.

- Feedback recommends that certification schemes, such as the MSC, solely certify fish intended for direct human consumption. This will ensure that certification does not become a way of incentivising and legitimising greater use of FMFO in supply chains, rather than prioritising the nutrients in wild forage fish for human consumption. Policy-makers in Scotland can facilitate this transition by making it clear that FMFO from certified and uncertified fisheries should not be used in Scottish salmon farming supply chains.
- Feedback recommends that the UK government suspends recognition of the IFFO RS/MarinTrust certification as a certification scheme by Defra (or relevant devolved authority in line with the Fisheries Bill) in the case of farmed Scottish salmon. For other fed aquaculture species, a suspension would apply until such time as there is clear and independent evidence that fed aquaculture delivers more protein and essential micronutrients in the edible portions than is inputted as aquafeed (from both plant and animal sources).

## BOX 2: INTERNATIONAL FISHERIES AND GOOD GOVERNANCE APPROACHES TO PROTECTING MARINE ECOSYSTEMS

With the advent of the Fisheries Bill, Scottish policy-makers will have greater control over fisheries governance in Scottish waters. However, fisheries supplying FMFO to Scottish salmon feed are generally located further afield, including in Norway, the Faroe Islands, Iceland, the USA and Peru. Feedback recommends that governments and inter-governmental fisheries authorities, rather than rely on certification to provide sufficient protection, focus on global, legally enforceable fish population rebuilding programmes, including:

- The abolishment of all fishery capacity-enhancing subsidies (i.e. any subsidy that facilitates overfishing of fragile fish stocks).
- An expanded use and enforcement of MPAs, including a global ban on fishing in the high seas.
- A halving of fishery capacity alongside a fair transition for those currently dependent on fisheries for their livelihood; there is evidence that this will result in fish stock increases and overall economic gains across the board.

For further analysis of wider fisheries measures, please see Feedback's report 'On the hook: Certification's failure to protect wild fish populations from the appetite of the Scottish salmon industry'.

# TRANSITIONING TO A TRULY SUSTAINABLE AQUACULTURE INDUSTRY FOR SCOTLAND: EXPLORING ALTERNATIVE SPECIES AND BUSINESS MODELS

As the Scottish Environmental Protection Agency's 'One Planet Prosperity' regulatory strategy points out, 'According to the ecological footprint measure, Scotland needs approximately three planets to sustain its current living. There is however, only one planet and most nations around the world face the dilemma of significantly over-using the planet's capacity to support human activity'<sup>31</sup>.

Overuse of wild marine resources to fuel the expansion of salmon farming is one aspect of Scotland's global ecological footprint. To meet this challenge innovatively, Scotland can lead a global movement towards high nutritional value, low environmental impact forms of aquaculture production. Unfed aquaculture – the cultivation of marine and aquatic species such as mussels and seaweed that do not require external feed inputs – must form a key part of this transition.

## CURRENT CONTRIBUTION OF THE FARMED SALMON INDUSTRY IN SCOTLAND

The farmed salmon industry promotes itself as a cornerstone of the Scottish economy, particularly in terms of the employment it brings to the remote areas where salmon farms are located. However, a recent report estimates that the industry's 'Gross Value Added' is potentially exaggerated by 124%, while employment could be overestimated by 251%<sup>32</sup>. Even the direct economic benefits that this globally owned industry does provide to Scotland will be short-lived if the sustainability concerns outlined in this brief are not addressed. Research from the New Economics Foundation argues that national policy must follow scientific advice to set sustainable global fishing limits to preserve future fishing opportunities<sup>33</sup>. Sustainable development involves meeting 'the needs of the present without compromising the ability of future generations to meet their own needs'<sup>34</sup>. Government should look to alternative species and business models to develop a truly sustainable industry for Scotland.





## UNFED AQUACULTURE AND ALTERNATIVES

Sustainably expanding 'unfed' aquaculture species – those that do not depend on external feed inputs for nutrition, such as bivalves (for example, mussels and oysters) and seaweed, can substantially increase nutritious food and feed with a lower impact on the marine environment<sup>35</sup>. Unfed aquaculture is also less reliant on chemical inputs (such as sea lice treatments) than the production of fed species, like salmon, which also means a reduced impact on the immediate aquatic environment; filter feeders such as mussels can even have a positive impact through improving water quality<sup>36</sup>. However, unfed aquaculture in the sea should be constrained by the limitations of the ecological carrying capacity of local environments, particularly under the ongoing impact of global heating; farm scale, density, design and production methods are all important to ensure sustainable outcomes.

### Mussels

Mussels have been described as a 'future food' for their potential to deliver high levels of micronutrients and thus replace some forms of animal-source products currently common in diets<sup>37</sup>. A recent Stirling University study of mussel consumption found that eating only mussels for seafood (and no oily fish) six times over two weeks can improve omega-3 status to a degree that is associated with at least a 20% reduction in sudden cardiac death risk<sup>38</sup>. Overall, the study concluded moderate improvement in omega-3 status but noted that some other sources of long-chain fatty acids should be included to also improve status of a third micronutrient called DPA (docosapentaenoic acid). In contrast to oily fish, where there are maximum recommended weekly portions because pollutants found in oily fish may build up in the body, there is no upper limit for the safe consumption of shellfish<sup>39</sup>. As a result, mussels may be an effective approach to safely increasing omega-3. Other bivalves, such as oysters and clams, also contribute plenty of omega-3, with oysters even capable of offering a higher omega-3 content compared to wild salmon or anchovies<sup>40</sup>. Comparing the job production potential of the farmed salmon and farmed shellfish industries yields interesting results. The Scottish salmon industry is worth £878 million and employs approximately 1700, dwarfing the shellfish industry at £9.5 million<sup>41</sup>, employing approximately 217 people. A simple calculation shows us that for every £1 million of industry value, the shellfish industry generates 23 jobs compared to only 2 jobs for the salmon industry. In other words, not much growth is needed in the shellfish sector to create significantly more jobs relative to the salmon sector.

### Seaweed

One frequently overlooked source of micronutrients, in particular iodine, is seaweed: researchers have identified

a possible relationship between high iodine intake, high seaweed consumption public health statistics in Japan, with one of the world's highest life expectancies and an extraordinarily low rate of certain types of cancer<sup>42</sup>. Observational studies in South East Asia have found that the wide presence of seaweed in diets can bring possible benefits against chronic diseases such as cardiovascular disease, cancer and diabetes<sup>43</sup>. Closer to home, a collaboration between the Scottish Association of Marine Science and the James Hutton Institute has researched the basis of the peppery flavour of the seaweed pepper dulse<sup>44</sup>. Pepper dulse is included in the Slow Food Arc of Taste<sup>45</sup>, which catalogues small-scale quality products which have significant historical and cultural value. Scottish salt herring<sup>46</sup> is also included in the Ark of Taste, and consumption of local small oily fish like this should be encouraged.

### Integrated multi-trophic aquaculture

Integrated multi-trophic aquaculture (IMTA) is acknowledged as a promising solution for the sustainable development of aquaculture. IMTA farmers combine species that need supplemental feed, such as finfish, with algae and filter feeders, such as shellfish, which use the organic and inorganic materials and by-products from the other fed species for their own growth. Deposit feeders, such as worms, sea urchins and sea cucumbers, that feed on organic material on or within the sediment can also be part of the system. The natural ability of seaweed, shellfish and deposit feeders to recycle the nutrients (or wastes) that are present in and around fish farms can help growers improve the environmental performance of their sites. At a local scale, IMTA can be an adaptive strategy for ocean acidification, where seaweed or seagrass are key components that reduce the effects of acidification by absorbing and assimilating dissolved CO<sub>2</sub> from surrounding water<sup>47</sup>. IMTA is being encouraged by EU policies, such as the Blue Growth Strategy and the Atlantic Action Plan, but there still are socio-economic, administrative and legal bottlenecks hampering its development to its full potential. British researchers, including from the Scottish Association for Marine Science, are involved in two large EU-funded projects<sup>48,49</sup> focused on developing IMTA systems so they can become viable options for aquaculture in Europe. In the future, IMTA may be a highly sustainable approach to producing high quality marine foods of various kinds, while keeping both local and global environmental impacts to a minimum.

So far, the development of these alternative aquaculture industries has been neglected in favour of the more impactful salmon farming industry. Feedback encourages the Scottish government to support the development of a sustainable Scottish seafood sector, which would include a diverse production of different fed and unfed aquaculture species, including salmon fed on by-products, unfed species like mussels and seaweed, and wild fisheries.

## FEEDBACK RECOMMENDS:

- The Shellfish Water Protected Areas designation order identifies 84 Scottish waters as 'shellfish water protected areas', and the Scottish Government has introduced a package of measures to ensure the continued protection and improvement of shellfish growing waters by integrating these within the river basin management planning process. In the case of conflicted interests over sea areas, policy-makers should prioritise the ongoing protection of sea areas for shellfish production over salmon farming.
- Crown Estate should consider supporting trials of new bivalve farms in appropriate sites, providing opportunities for new business models, possibly including community-owned cooperatives in remote areas, to develop local and sustainable food production.
- The Scottish government should ensure that funding is made available to support the development of Scottish shellfish production. For example, 'Scottish Shellfish' has received significant funding from the EU<sup>50</sup>, which may leave a funding gap post-Brexit.
- Policy-makers should support IMTA pilot schemes, where the environmental impact of salmon farming is further managed through co-cultivation with seaweed and bivalves such as mussels.
- Local and national devolved public procurement schemes should provide a diverse range of locally produced seafood options in public institutions such as government buildings, schools and hospitals. The Committee on Climate Change has identified public procurement as a mechanism to stimulate new forms of food production and to lead to dietary change<sup>51</sup>.

For more detail on any of the findings or recommendations in this brief, please see our full reports:

*Off the Menu: The Scottish salmon industry's failure to deliver sustainable nutrition*

*On the Hook: Certification's failure to protect wild fish populations from the appetite of the Scottish salmon industry*

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