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THE VALUE OF AQUACULTURE TO SCOTLAND

A Report for Highlands and Islands Enterprise and Marine Scotland

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1.1. INTRODUCTION AND BACKGROUND

This impact study was commissioned by Highlands and Islands Enterprise (HIE) and Marine Scotland (MS) to understand the composition of the aquaculture sector in Scotland and consider the opportunities and challenges relating to the potential growth of the sector and its wider value chain through to 2030. The aquaculture sector in Scotland spans finfish, shellfish and seaweed. This study report provides material that will help inform the considerations of the newly formed Aquaculture Industry Leadership Group (AILG) and complements the industry-led strategic plan, "Aquaculture Growth to 2030", published in October 2016, which sets out the industry's objectives and aspirations for growth (broadly to double production by 2030), and recommends steps that should be taken to achieve this. Also, the new strategy, "Ambition 2030", published in March 2017 by the industry body, Scotland Food & Drink, concludes that there is an opportunity to approximately double the turnover in the food & drink sector in Scotland by 2030.

The report has drawn on recent and trend data collated by Marine Scotland, Seafish and others on production, employment, distribution of activity within Scotland, supply chain linkages, etc. Our interpretation of this information was aided through speaking to representative organisations across the aquaculture spectrum, businesses, and public bodies involved in supporting and regulating the industry and granting permissions and leases for new developments. These contacts also provided insights into the perspectives and plans of key businesses, which confirmed the strong growth aspirations up to 2030 that underpin the industry's new strategic plan and their appetite and financial capacity to commit the required investment.

In order to assess the potential growth in economic impacts from aquaculture in Scotland up to 2030, our consultations with organisations and businesses spanned, for each aquaculture sub-sector: market development (UK and overseas); growth capacity at existing sites; potential new production sites; potential growth in productivity in production and processing; supply chain growth as output grows; innovations that would increase productivity; workforce development requirements; and potential constraints – including reduced production in particular years due to disease, sea lice and other biological causes, regulatory controls (including biomass limits and planning consents), the ramifications of the UK leaving the EU, international competition, and sufficient labour supply.

How these and other positive and negative factors will play out will determine the nature and extent of growth across the aquaculture sector in Scotland, and two indicative scenarios are given for employment and GVA (Gross Value Added) impacts that might stem from particular output growth scenarios by 2021, 2025 and 2030.

1.2. CURRENT STATUS OF THE SECTOR & RECENT TRENDS

1.2.1. FINFISH

Atlantic salmon production dominates the Scottish aquaculture sector by volume and value, accounting for 95% of finfish production by volume. According to the annual MS survey, the production of farmed salmon in Scotland increased from 129,588 tonnes in 2005 to 171,722 tonnes in 2015 (plus 32.5%), peaking in 2014 at an all-time high of 179,022 tonnes.

The five largest salmon producers accounted for 92% of production in Scotland in 2015. Site employment in Scotland increased from 915 full time equivalent jobs (FTEs) in 2005 to 1,310 FTEs in 2015 (plus 43.2%), which implies a reduction in productivity in terms of volume produced per hour of labour input at farm sites; although this trend did not adversely affect Scottish producers' profitability as indicated by strong price per tonne produced increases over the period, or the sub-sector's competitiveness due to productivity improvements in the value chain – including transport by well boats of increasing size and mechanisation and scale economies in processing.

Employment in smolt production grew from 231 FTEs in 2005 to 267 FTEs in 2015 (an increase of 12.7%), with smolts produced per FTE increasing by 9.2% over the period – a modest labour productivity increase.

In Scotland, employment identified in Seafish's annual survey of UK processors fell by 12% from 4,007 FTEs to 3,551 FTEs between 2008 and 2014 in units principally processing salmon (though with growth between 2012 and 2014 following the recession), while growing by 62.6% in the rest of the UK over the period to 1,096 FTEs. In 2016, employment in salmon and freshwater fish processing (as now categorised) was shown by the survey to total 3,225 FTEs in Scotland – a reduction of around 4% on 2014 – although the reduction in the UK as a whole was 15%. This reflects the lower output tonnage of Scottish salmon in 2016 discussed in the report and due principally to the impact of increased sea lice.

Export sales of salmon from the UK are difficult to interpret from available statistics, but appear currently to have a value in the region of £400-500 million excluding re-exports and processing of imported salmon, with the USA, France and China the principal overseas markets.

The main other finfish species farmed in Scotland is rainbow trout. Total production was 8,588 tonnes in 2015, mostly for food consumption, though a small proportion of production is for restocking of recreational fishing. This volume is a 46% increase from the previous year, and the trend is towards seawater cages (54.5% of production in 2015) along the salmon production model. The highest previous annual total was 7,670 tonnes in 2008. Site employment in 2015 totalled 118 FTEs, a reduction from 137 FTEs in 2002 when production, at 6,659 tonnes, was 22% lower than in 2015. Producers' expectations for 2016 were for a slightly reduced total of 7,415 tonnes.

Other finfish employment in 2015 totalled 43 FTEs, a significant reduction from 101 FTEs in 2006, which was due in large part to the failure in 2008 of the Shetland organic cod farming operation, No Catch. The other species produced were halibut (90 tonnes) and brown trout/sea trout (58 tonnes). "Cleaner fish", lumpsucker (15 tonnes) and wrasse (7 tonnes), used as a biological control for parasites on Atlantic salmon, are increasingly being farmed, with Marine Harvest planning a new wrasse hatchery in Machrihanish.

1.2.2. SHELLFISH

Mussel and pacific oysters are the main shellfish species produced in Scotland, with mussels for the table accounting for 7,270 tonnes in 2015 and 2.7 million pacific oysters produced according to Marine Scotland's annual survey. There were 144 shellfish businesses operating in Scotland in 2015, with 171 of 335 sites producing in that year. Scottish Shellfish Marketing Group has 16 members and is the leading supplier of rope-grown mussels and cultivated pacific oysters. There were 15 oyster operators across West Scotland supplying two seafood processors. The shellfish sector employed 344 people, 166 of whom were full time. The value of aquaculture shellfish production at first sale

was £10.1m in 2015, but the sector in Scotland increasingly extends beyond production to value added processing and marketing.

Tonnages of mussels produced for the table grew from 4,219 tonnes in 2006 to 7,270 tonnes in 2015 (plus 72.3%), peaking in 2014 at 7,683 tonnes. The 2.7 million pacific oysters produced for the table in 2015 were lower than the 3.1 million produced in both 2006 and 2011 and the 3.4 million produced in 2014, but numbers for on-growing have increased greatly in recent years, averaging 6.3 million over the 2013-15 period compared with 1.4 million in 2011. Other shellfish species farmed are of much lower volumes, comprising native oyster, queen scallop, and king scallop.

1.3. GEOGRAPHICAL SUMMARY OF CURRENT ACTIVITY

Almost all Scottish production of finfish and shellfish is in the Highlands and Islands, with processing and supply chain employment (including feed supply, pharmaceutical services, sea and road transport and equipment suppliers) also important to different parts of the region, as well as to other specific places in the Central Belt and the North East of Scotland.

Salmon production is focused in the North West (32%), Shetland (25%), the South West (21%) and the Western Isles (16%). Orkney (6%) has grown from 3,724 tonnes in 2006 to 11,074 tonnes in 2015, with more new sites planned.

76% of rainbow trout production was in the West of Scotland in 2015, with Dawnfresh the one large scale producer as well as the principal processor.

The greatest contribution in regional mussel production in 2015 was from Shetland, accounting for 77% of Scotland's total. The former Strathclyde region accounted for 79% of Scotland's pacific oysters.

1.4. BASELINE ECONOMIC IMPACTS

Impacts in Scotland, in terms of FTEs, associated earnings and GVA (Gross Value Added), were estimated using the most recent data in the 2015 Finfish and Shellfish Survey reports (see above). To allow for year to year variations due to production cycles and other factors, the baseline year for the purposes of this report was taken as the average of the 2014 and 2015 calendar years.

The aggregated estimated impacts summarised below for each sub-sector include on-site and off-site employment associated with production and sales, processing, transport and all indirect impacts through the supply chains of these industry components. Also, induced impacts in Scotland through the spending of direct and indirect FTEs were estimated and are included in the table.

TABLE 1: FTES, ASSOCIATED EARNINGS AND GVA FOR EACH SUB-SECTOR (AVERAGE OF 2014 AND 2015)

	FTEs	Earnings (£M)	GVA (£M)
Salmon	10,340	271.0	540
Rainbow Trout	472	12.3	25
Other Finfish	61	1.7	3.5
Shellfish	1,054	25.9	50
Relevant Organisations, Research Institutes, etc	95	3.1	4.5
Totals	**12,022**	**314**	**620**

This estimated employment impact is higher than was estimated in the report by Imani, jointly funded by MS and HIE, that was published by Marine Scotland in 2014 on the Benefits to Scotland of Aquaculture[1] that are quoted in the industry's new strategy due to the more comprehensive coverage of the value chains of the aquaculture sub-sectors undertaken for this new study (with impacts from capital investment included), and increases in output since the Imani report's baseline year of 2012. The Imani report was conservative in its estimates where value chain data were not available.

1.5. SOCIAL & COMMUNITY IMPACTS

Aquaculture provides a range of social and community impacts in remote and rural areas where farms and related activities are located.

The employment that the sector provides in rural areas has helped to compensate for long term declines in agricultural and fishing employment as these sectors have increased their productivity, whilst the year-round employment offered by the sector has contributed towards the sustainability of family livelihoods, with tourism and agricultural employment in rural and remote areas highly seasonal.

Surveys carried out for businesses on their impacts in particular rural and remote areas have identified the following as important in sustaining local areas economically and socially: increased local populations and improved age structures through new employees and their families moving in and people not having to leave their home area for work; additional employment and income (some of which is spent locally); new and enhanced skills with employment that has proved sustainable over time; more families in rural and remote areas which improves the demographic structure and sustainability of communities; the important work carried out locally by partners of aquaculture employees (teaching, nursing, etc); roles that staff and their families play in voluntary activity (including coastguard, fire services, etc); the contribution made by employees' children to the survival of local schools with small rolls; use of company harbour facilities for other commercial and leisure purposes; the survival of small local businesses (hotels, fuel supplies, local maintenance services, etc); and financial support that companies have given to local groups and causes, enabling events and activities to take place and for people to travel to participate in activities elsewhere.

1.6. SUMMARY OF CHALLENGES AND OPPORTUNITIES

Scotland's aquaculture sector has a more certain future in terms of customer demand and scope to grow to meet this than many other sectors of its economy. This confidence relates to:

- The rapidly growing world population, with a large number of people in developing countries each year moving into income brackets where they can afford to buy Scotland's aquaculture produce. Allied to this is limited scope for growth in wild fisheries and the limited number of countries that can farm salmon healthily and cost-effectively.
- The international focus of the companies that farm salmon, which means that Norwegian and Chilean production growth will tend to be focused on supplying world growth in demand (which is expected to be high) rather than competing in the UK or with the export markets targeted by the multinational companies and the smaller Scottish companies for Scottish whole and processed product (which is small in relation to international supply).

- The scope for productivity improvements across Scotland's aquaculture value chains – including efficiencies in feed production costs; new systems for rearing young fish to shorten their time in sea water; increases in permitted biomass through a better understanding of the biomass limits of sites; larger sites for salmon further offshore; increased mechanisation in processing; and production increases and economies of scale in other aquaculture sectors through co-operation and amalgamations.
- The appetite for growth and the financial strength (from their past profits) of the major businesses in the sector.

Specific opportunities include:

- Growing the UK market through messages about the health benefits of eating farmed salmon, trout and shellfish, increasing product diversification (including sauces), strong Scottish branding, and maintaining price competitiveness.
- Growing overseas markets through maintaining a margin for Scottish provenance, collaborating with other Scottish food and drink producers in marketing and establishing new forward linkages with processors and agents.
- Stressing the low carbon footprint of aquaculture compared with typical agriculture to those concerned with the climate change impacts of their consumption – countering, for some people (e.g. councillors making planning decisions), local negative environmental impacts.
- Creating additional relatively skilled and well paid jobs in Scotland through the value chain as the sector grows through a transition from manual work to supervisory and technical roles as mechanisation increases – particularly in processing.
- Increasing R&D employment through collaborations between companies, support organisations and academic institutions across the supply chain, with a combination of public and private funding.
- Success, through R&D, in developing larger sites for salmon in deeper waters that can be developed and operated (without damage to cages, nets or moorings) cost-effectively through producing large volumes – which will be necessary given the higher development and operational costs per site that will be involved.
- Growing employment in Scotland in equipment supply and maintenance, with import substitution and increasing scope for exporting equipment as company scale and expertise grow.
- Identifying innovation sites, as recommended by the industry working group, to permit controlled trials and development of innovative equipment, technologies, disease control measures, and regulation. These sites might be shared by public and private users.
- Continuing to play a role in supporting peripheral and fragile areas that are losing population and have ageing resident profiles through increasing year-round sustainable employment through investments in new sites and other facilities in local areas.

The main challenges in achieving potential growth currently identifiable are:

- The problem of sea lice on salmon that has been increasing and which the sector is attempting to alleviate through a range of measures.
- Achieving environmentally sustainable higher biomass limits on a significant number of sites through the new depositional zone regulation (DZR) that SEPA proposes to introduce, and enabling new sites further offshore to be given higher biomass limits through the scientific

work being undertaken. The potential increases in annual production through the DZR is based on more reliable modelling beyond 2,500 tonnes of biomass than has been possible to-date.

- Maintaining and developing international trade relationships with suppliers and customers after the UK leaves the EU, together with sterling's exchange rate in the short and longer term keeping its exports competitive and competing food imports relatively expensive.
- Attracting and maintaining an adequate labour supply as the regulations on employing overseas nationals change, and encouraging young people in Scotland to take up aquaculture as a career. Interesting young people in outdoor work is an increasing challenge.
- Improved access to loan finance and other private investment by shellfish producers, with production growth constrained if reliant on re-investment of profits.
- Alleviating local concerns around existing sites and new developments – making the case across the value chains that activity is on balance beneficial to livelihoods, with due consideration of the economic, social and environmental impacts.
- Identifying value added product development opportunities for Scottish seaweed producers as this industry expands internationally, with scope for cultivation to supplement harvesting.

1.7. POSSIBLE FUTURE SCENARIOS TO 2030

The industry's Aquaculture Growth to 2030 report states that "sustainably achievable projections for 2030 could be in the range of 300,000 to 400,000 tonnes per annum for finfish production, with "a medium production figure of 350,000 tonnes of salmon". This would be approximately double the average 2014 and 2015 years harvest of 175,372 tonnes. The industry report also suggests that "in shellfish production there is potential to reach 21,000 tonnes of mussels per annum by 2030 and to significantly increase the value of oyster production". Some 21,000 tonnes of mussels would be a 133% increase on the average 2014/2015 production of 9,029 tonnes.

In order to assess the impacts that this scenario might generate in Scotland, indicative estimates for related employment, earnings and GVA growth in Scotland up to 2021, 2025 and 2030 were calculated for our report. Assumptions were made on future labour productivity growth across value chains, and it was assumed that earnings per FTE and the GVA to earnings ratio would both stay as currently – although these impacts could grow proportionately more than employment. The impact estimates, which relate to the complete value chains in Scotland of the aquaculture sub-sectors other than seaweed, showed increases of almost 50% in FTE employment, earnings and GVA by 2030 on an assumed average annual increase in labour productivity of 2%.

Our analysis of the factors that would facilitate this 100% increase in production by 2030, together with our consideration of the challenges that would need to be overcome, however, suggested to us that a 50% increase in production across the aquaculture sector might be more likely. Indeed, relative to past trends during a period of strong market growth, a 50% increase might be considered a good achievement.

This alternative scenario, assuming an average of 1.5% rather than 2% labour productivity growth across the sector's value chains (which is considered more likely if the output increase is smaller), would give the following increased impacts.

TABLE 2: INDICATIVE MEDIUM GROWTH SCENARIO BASED ON 50% GROWTH IN OUTPUT BY 2030 AND 1.5% AVERAGE PRODUCTIVITY GROWTH PER ANNUM

	2014/15 average	2021	2025	2030	2030 Totals
Employment (FTEs)	12,022	+1,173	+1,791	+2,402	14,424
Earnings (£M)	314	+30.8	+46.7	+62.7	377
GVA (£M)	620	+60	+90	+120	740

These would represent increases on the 2014/15 baseline of 9.8% by 2021, 14.9% by 2025, and 20.0% by 2030 in each of employment, earnings and GVA. This assumed productivity growth applies to existing employment as well as increased employment – i.e. should there be a lower output growth, employment impact could fall if productivity rises at a faster rate than output.

As the report emphasises, however, due to the large number of factors that could have significant positive or negative influences on growth across the sector and its value chains by 2030 (the most important of which are highlighted above under Challenges and Opportunities), the outcome in practice could range from little change from current production levels by 2030 to (potentially) greater growth than the industry has projected, depending mainly on how effectively the challenges are overcome and whether the "game changers" in output are achieved.

Indeed, reductions in salmon output in 2015 and 2016 (due principally to sea lice) suggest that the impact scenario above for 2021 might be delayed.

1.8. ACTIONS THAT WOULD HELP TO MAXIMISE IMPACTS BY 2030

The report tabulates the main activities by time period considered to be required if the sector is to be able to capitalise on the opportunities summarised above and overcome the challenges (or minimise their impacts). These suggestions have some read across to those put forward by the industry in its strategic plan, and will involve companies, support organisations, public bodies, research and development institutions, and training providers working together with a focus on achieving the higher end of the sector's sustainable growth potential.

Key actions and outcomes will include:

- Success in ameliorating the effect of sea lice (and gill diseases) on salmon through a range of methods with continuing significant investment by the industry in solutions.
- Obtaining robust site by site information that will enable biomass limits to be increased for certain existing and new sites without adversely affecting the environment.
- Investment in onshore recirculation systems for producing and ongrowing smolts, shortening the time fish are required to spend in sea cages and giving significant annual increases in salmon production and productivity.
- Success in identifying models for salmon production from sites further offshore that are cost-effective, with the trial sites proposed by the industry playing a part in this.
- Securing loan finance for shellfish production growth.
- Workforce development measures that provide the sector's employees across the value chain with the skills they will require to work with new technologies and encourage sufficient numbers of people to enter the industry across the occupational spectrum.

- UK and export market development that successfully capitalises on Scottish provenance, maximises value added in Scotland, and convinces the public of the health benefits of eating salmon and other farmed finfish and shellfish. The industry expects that strong output growth scenarios will entail a high proportion of increased sales being to export markets, with China and other rapidly growing countries offering particular opportunities.

2. BACKGROUND AND METHODOLOGY

Highlands & Islands Enterprise (HIE) and Marine Scotland (MS) commissioned this impact study to understand the composition of the aquaculture sector in Scotland and fully consider the opportunities and challenges facing the growth of the sector and its wider supply chain up to 2021, 2025 and 2030. The study refers to the industry-led strategic plan, "Aquaculture Growth to 2030", published in October 2016, which sets out the industry's objectives and expectations for growth, and what steps should be taken to achieve this, and illustrates the impacts that might be achieved on its growth scenario as well as other, less optimistic, scenarios.

The aquaculture sector is of key economic importance for Scotland and the Highlands and Islands, providing significant direct and indirect employment opportunities in remote and fragile communities. Imani's *An Assessment of the Benefits to Scotland of Aquaculture*[2] report for HIE and MS in 2014 had previously demonstrated the sector's social and economic impacts.

Aquaculture globally plays a significant role in food production, with the United Nations Food and Agricultural Organisation (FAO) estimating that it will provide close to two thirds of global fish consumption by 2030.[3] The Scottish aquaculture sector includes finfish and shellfish (plus cultivated seaweed).

The EU Fish Processor and Traders Association estimated the total turnover of EU aquaculture producers to be €4 billion Euros in 2013. Scotland is the largest salmon producer in the EU, and the third largest globally (after Norway and Chile). With 314 sites[4] producing around 180,000 tonnes of whole wet finfish in 2015[5] [6] plus 9,000 tonnes of mussels, and almost 3 million oysters and scallops produced for the table, the aquaculture industry plays an increasingly significant role in Scotland's economic growth[7]. Farmed salmon is Scotland's number one food export.

Our engagement with finfish and shellfish businesses for this study confirms significant ambitions for growth, as demand for premium Scottish product outstrips supply, and a growing world population seeks additional sources of protein.

2.1. METHODOLOGY

This report captures recent available economic data on production, turnover, employment, and GVA, and presents trends for the sector and its wider supply chain and downstream impacts in Scotland, building on and updating the economic analysis undertaken in the 2014 Imani report. Assessing the baseline upstream and downstream impacts of the sector helps in quantifying the future impacts from the opportunities and challenges facing the industry in relation to production, value added processing, markets and environmental and regulatory constraints.

Our approach identifies impact in three main ways:

1. ***An analysis of data from detailed industry surveys at a national and sub-national level***

This draws on national agency and other surveys – principally annual Marine Scotland surveys, our targeted interviews with industry and support organisation contacts on both economic and social impacts, and related work on opportunities and challenges for the industry (through the Scottish Aquaculture Innovation Centre (SAIC), HIE and MS commissioned studies and follow up consultation within industry, including key producers, suppliers, regulators and planners).

2. ***Impact assessments for particular companies at national and sub-national levels***

In these detailed reports for aquaculture businesses, key supply chain impacts have been identified from actual spend, production and employment based on discussions with both the producers and their suppliers, and information they have provided. For example, information from producers on their supplies and from their suppliers shows that the major input of salmon feed supply creates far less employment impact in Scotland than would be calculated from using the figures for the best fit sector specified in the Scotland Input-Output tables.

Input Output tables for Scotland are a reasonable means of estimating supply chain linkages within some sectors, but whilst aquaculture is a specified sector in the tables, the vertical integration of companies (which can have their own hatcheries, freshwater smolt production sites and processing facilities) means that the indirect impact ratios for the aquaculture sector in the Input Output tables are not meaningful.

Also, Input-Output tables reflect historical sector purchases and sales. When considering future scenarios it is important to consider how impacts might change with investment in new technologies across the value chain.

3. ***Whole value-chain synthesis of the industry, and industry trends which will tend to change future impacts up to 2030***

In this report, the term "value chain" includes the impacts from the processing and distribution in Scotland from aquaculture production in Scotland (forward impacts) as well as from producers' supply chains ("indirect" impacts).

Salmon farming production and value added processing have grown strongly in Scotland, and it is important to model the extent to which productivity improvements might be achieved in the three time periods to 2030 (up to 2021, 2025 and 2030) assuming that continuing production and market growth is achievable. Scenarios are considered in Section 7 of this report. The nature of aquaculture – the consenting stages required to start using a new site, the need for capital investment, and the production cycle – mean that there is relatively limited scope for output and impacts by 2021 to exceed growth that is currently identifiable from companies' recent investments, planning applications, and stated plans. Longer term, scenarios are much more variable.

In assessing the future, the study considers how opportunities might best be capitalised upon – including the potential role of research and development carried out by institutions with public and other funding as well as the R&D that individual businesses will be carrying out. Also, the roles that public sector and other organisations could play in helping the industry to achieve increased impacts are considered.

The wider economic context facing the sector is considered, including the uncertain economic landscape resulting from the UK's vote to leave the EU in the European referendum on 23rd June 2016, using the best available information and industry views obtained through consultation for this study on future production potential and trends in market demand.

An overview of the types of social impacts generated by activities in the aquaculture sector is provided, demonstrating the wider benefits to many remote and fragile communities. Examples are presented in case study format, utilising findings from social impact studies undertaken and anecdotal evidence gleaned from the consultation process. Some social impacts for local case study

areas are evidenced from primary research for impact studies carried out in recent years for major salmon farming companies.

2.1.1. QUANTITATIVE ANALYSIS

Our statistical analysis is based on output and employment data from Marine Scotland's Scottish Fish Farm Production Survey and its Scottish Shellfish Farm Production Survey – the most recent data from these surveys relating to 2015.

Direct, indirect and induced employment (FTEs), earnings and Gross Value Added (GVA) figures have been produced for this study for the average of the 2014 and 2015 calendar years (as a baseline) for each of the farmed fish and shellfish sectors, their supply chains and their forward linkages through to processing, and other downstream impacts – with all figures estimates other than the MS survey data. These estimates have been made as accurately as available information has allowed, although we would emphasise that detailed value chain information across the sector in terms of turnover and employment attributable to aquaculture is lacking and our impact figures should be regarded as indicative. The figures are for Scotland as a whole, although indications of where impacts are concentrated within Scotland are given.

Indicative impacts from expenditures in Scotland on capital investments and annual equipment supplies have been captured alongside operational impacts, and available information on exports from the UK has been collated (principally from HMRC data).

Interpretation of this statistical information has been informed by discussions with sector representatives who have provided additional relevant data to us for 2015 (and 2016/17).

Data sources have included:

- *Scottish Finfish Farm Production Survey 2015*
- *Scottish Shellfish Farm Production Survey 2015*
- *UK Seafood Processing Industry Reports, Seafish (2014 and 2016)*
- *Scottish Salmon Producers Organisation (SSPO) data*
- *Scottish Annual Business Statistics*
- *Company accounts*
- *Data provided by particular businesses – both for this study and for previous impact studies completed for the companies*

2.1.2. CONSULTATION

Our consultees included:

- Representatives from each of the major aquaculture producers, and the key supply chain businesses and processors in Scotland;
- HIE, Marine Scotland, Local Authority representatives, Scottish Aquaculture Innovation Centre (SAIC), Scottish Environmental Protection Agency (SEPA), The Crown Estate and Skills Development Scotland;

- Industry bodies – Scotland Food & Drink, SSPO, British Trout Association, Association of Scottish Shellfish Growers, Scottish Shellfish Marketing Group, Shetland Aquaculture, and other representative groups;
- Research & Development organisations, including universities and research units (including the Marine Alliance for Science and Technology programme).

2.1.3. FUTURE SCENARIOS

The key impact figures for the average of the 2014 and 2015 calendar years collated and estimated through this study have been used as a baseline for projections of employment and GVA impacts in 2021, 2025 and 2030 on different scenarios based on:

- Known plans of the key businesses in the sector.
- The foresighting and roadmapping of challenges, constraints and opportunities drawn from the consultation process, supplemented with material from the concurrent SAIC Innovation roadmap and sector needs study that was carried out by Imani Development in 2016.
- Supplementary information obtained from key organisations and businesses, including research and public policy relating to industry productivity.
- Potential changes in productivity across value chains.
- Potential new developments of significance (e.g. larger salmon cages further offshore).

Positive and negative factors are considered for future scenarios for salmon farming, other finfish farming, and shellfish (with separate analysis for mussels and oysters).

2.2. BACKGROUND

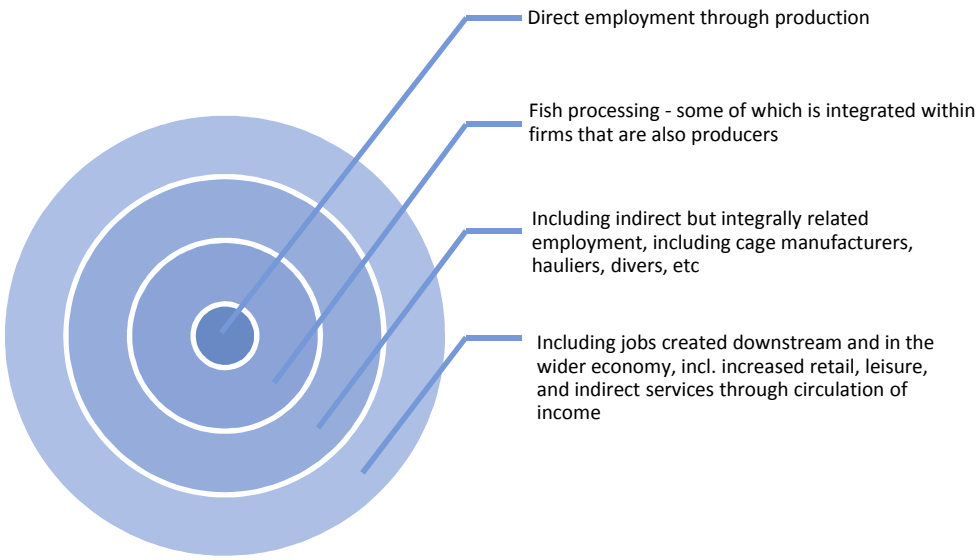
2.2.1. AQUACULTURE'S ECONOMIC IMPACT

Within Scottish aquaculture, Atlantic salmon remains by far the largest species by volume and value of production, and its predominance in impact over other aquaculture products is important to appreciate – it can fluctuate in one year by the total annual volume of mussels or trout.

Total salmon farming employment has been growing: in 2005 the total number of staff in salmon production was 915 full time equivalent jobs (FTEs) and in 2015 it was 1,310 FTEs (see Table 8 in Section 0). However, farm production is only one part of the value chain – for full economic impact in Scotland one must consider all of the people benefiting from or servicing that production, including:

- **Direct production jobs on fish farms, plus support staff in management and administration**
- **Suppliers of equipment, transport, feed and husbandry** inputs (including bio-tech vaccine and de-licing supply) – the "supply chain"
- **Organisations involved in research & innovation**
- **Downstream processing jobs** where attributable to Scottish supply
- **Retail and catering** sales in Scotland of finfish and shellfish produced in Scotland, in as far as the employment involved can be attributed to the Scottish produce
- **"Induced Impacts"** – i.e. a grocer, garden centre or electrician may not supply the sector directly, but will benefit from additional income and employment where industry income is spent and re-spent in their local area.

FIGURE 1: THE ECONOMIC MULTIPLIER IN SCOTLAND OF SALMON PRODUCTION



Direct, indirect, downstream and induced impacts of the aquaculture industry vary in a complex way by area and by magnitude – for example, there may be an intense impact from production on a Shetland island, but with feed supply from the Scottish mainland and downstream benefits generated through employment in a processing company in mainland Scotland. The predominantly overseas ownership of Scotland's salmon producers illustrated in this report provides inward investment in the sector through international profits that has been valuable in capacity growth and related employment growth in Scotland, although subsequent profits do not generally accrue to Scotland residents.

The industry is of particular importance to rural and fragile communities that rely on it for the employment and income that it generates. In some areas there can be a strong local community benefit, i.e. where a community may have a school, ferry provision or other resource that would not otherwise be viable without the local population employed in aquaculture and its associated income generation (as identified in the 2014 Benefits report). However, it is important to take into account competing claims on resource use by other sectors (for example, tourism, fisheries) in assessing planning applications for aquacultural sites and business development – although there can be synergies between activities, e.g. through improved access roads or enhanced berthing facilities in harbours.

2.2.2. POLICY AND STRATEGY

A Fresh Start: The Renewed Strategic Framework for Scottish Aquaculture 2009[8]*,* produced by Marine Scotland set out the Scottish Government's five then strategic objectives for the industry based on the main challenges it faced: healthier finfish and shellfish, improved systems for licencing, improved containment, better marketing and improved image, and improved access to finance[9]. The Ministerial Group for Aquaculture (MGA) was established in 2009 to oversee implementation of the Strategic Framework: it is now the Ministerial Group for Sustainable Aquaculture (MGSA). In the *Aquaculture Science and Research Strategy* report by Marine Scotland in 2014 these were identified as still relevant areas for improvement,[10] with some priorities differing between aquaculture sectors. Effective management of sea lice was seen as the main priority for marine salmon producers, whereas better access to finance was considered essential for shellfish producers.[11] The Framework's targets included increasing marine finfish production to 210,000 tonnes by 2020 (from 165,256 tonnes in 2013) and shellfish production (especially mussels) to 13,000 tonnes (from 7,980 tonnes in 2014). Also, through MGSA, a technical standard for fish farm equipment was developed and published, which, along with statutory training requirements, will help to address containment concerns.

Scotland's National Marine Plan: A Single Framework for Managing Our Seas, adopted in 2015, set out the objectives and marine planning policies for aquaculture with the aim of supporting the sustainable economic growth of the industry with due regard to its environmental impact. The NMP (and the *UK Multiannual Plan for the Development of Sustainable Aquaculture*[12]) include the 2020 production targets.

Within the areas identified by the Strategic Framework, and latterly the Aquaculture Science and Research Strategy, peer-reviewed literature includes studies on: sea lice, including management strategies and effects of lice on farmed and wild fish health[13]; fish nutrition (specifically a reduction in the use of marine-sourced ingredients)[14]; the viability of offshore farming (including co-location)[15]; bio-economic modelling (including the role of genetic improvements such as super-smolts)[16]; and

cross-cutting and complex issues such as space[17], planning and regulation[18], social licence[19], market regulation[20] and competition[21]. These remain priority areas impacting on the future viability and sustainability of the industry.

In 2014, the Scientific, Technical and Economic Committee for Fisheries (STECF) produced a report outlining the economic performance of the aquaculture sector in the EU to 2018. The report identified regulation and space and their associated complexities as a major barrier for future development.[22] Given the industry's contribution to the Scottish economy, particularly to rural communities, it is in the interest of the industry to address the more complex issues of regulation.[23]

The Independent Review of Scottish Aquaculture Consenting prepared for the Scottish Government in 2016 identified inefficiencies, duplication and unnecessary complexities across the current consenting regimes. It recommended a number of ways to improve current arrangements to streamline the consenting process: consolidate Marine Licencing in Planning Permission; review definitions in the Town and Country Planning Act and consider a long term future Aquaculture Act; align CAR and Planning Permission; re-assess one-stop shop; and improve consideration of farmed and wild fish interactions.[24]

The principal EU policy for aquaculture development is the Common Fisheries Policy, supported by the Common Organisation of the Markets for Fisheries and Aquaculture products and the financial instrument, the European Maritime and Fisheries Fund (EMFF). For the EU as a whole, there has been limited growth in output (aquaculture production in EU28 has increased by 25% from 1992, but since 2002 production has decreased by 1% [25]), and a number of challenges facing the industry have been identified: competitiveness issues, including access to suitable sites; monitoring progress and obtaining accurate and up-to-date statistics; clarification of aquaculture within the existing environmental legislation; and the need for better understanding of market interaction to guide future investment and support policies. [26] The UK and other Member States, as required by the EU, have published national, multi-annual plans for aquaculture development.[27] In the European Commission's Blue Growth strategy to 2020 aquaculture has been identified as a sector with high potential for sustainable jobs and growth.

In October 2016, the aquaculture industry's Vision 2030 group set out ambitions to double production to around 350,000t of finfish, and 21,000t of mussels by 2030. The positive and negative factors underlying the extent to which these targets might be achieved are a major consideration in this report.

The aquaculture industry is increasingly important in terms of employment and company income generated in Scotland as its scale has grown compared with sea fisheries (and other primary sector activities where productivity has reduced production employment in rural areas). It has a low carbon footprint compared to other 'meat' proteins[28]; it has proved suitable through providing sustainable employment for remote and fragile areas (i.e. those areas 'characterised by declining population; under-representation of young people within the population; lack of economic opportunities; below average income levels; problems with transport, and other issues reflecting their geographic location'[29]); it is going through 'process upgrading' whereby the jobs available are increasingly requiring skills, training, and/or degree-level education; and it provides opportunities for innovation and growth in Scotland's Research and Development (R&D) sectors.

The conclusions and recommendations in the report recently produced for the Scottish Aquaculture Innovation Centre by Imani Development on innovation priorities to 2030 are taken into account in this economic impact report and summarised.

2.2.3. ENVIRONMENTAL AND CONSENTING REGULATIONS

It is important for the Scottish aquaculture industry to have a reputation for quality products produced under robust regulation, which can translate into a price premium; whilst consenting (including planning) procedures need to manage competing claims on marine space, and balance the growth of aquaculture with other social and economic objectives. The aim is to achieve sustainable economic development which allows people to meet 'basic needs and enjoy a better quality of life without compromising the quality of life of future generations'[30], and, to that end, the recommendations of the Independent Consenting Review are progressing through the Capacity Working Group. The Group contributed to the work of the Independent Review of Scottish Aquaculture Consenting by Poseidon Aquatic Resource Management Ltd, which was published in March 2016.

The Scottish Government's response to this review was published in January 2017, and this is taken into account in our future scenarios in Section 6 below.

Beyond this, the development of Scotland's National Marine Plan in accordance with EU Directive 2014/89/EU (Marine Spatial Planning Directive) will seek to manage more clearly the inshore waters and to promote the sustainable development of marine areas and the sustainable use of marine resources.[31]

The current requirements (ICR summary) for Scottish aquaculture, including finfish (FF), shellfish (SF) and seaweed (SW) are as shown overleaf in Table 3.

TABLE 3: SUMMARY OF LICENCES, CONSENTS AND ASSESSMENTS REQUIRED FOR SCOTTISH AQUACULTURE INCLUDING FINFISH (FF), SHELLFISH (SF) AND SEAWEED (SW)[32]

Application	Authorising regulator	Legislation	Aquaculture type		
			FF	SF	SW
Planning Permission	Local Authority (LA)	Town and Country Planning (Scotland) Act 1997	✓	✓	
Environmental Impact Assessment (if necessary, mainly relevant to FF, but can be required for SF)	Local Authority (LA)	The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2011	✓	✓	
Marine Licence	Marine Scotland Licensing Operations Team (MS-LOT)	Marine Scotland Act 2010	✓	✓	✓
Seabed Lease	The Crown Estate	The Crown Estate Act 1961	✓	✓	✓
Authorisation to operate an Aquaculture Production Business (APB)	Marine Scotland Science Fish Health Inspectorate (MSS-FHI)	The Aquatic Animal Health (Scotland) Regulations 2009	✓	✓	
Controlled Activity Regulations (CAR) licence	Scottish Environment Protection Agency (SEPA)	The Water Environment (Controlled Activities) (Scotland) Regulations 2011	✓		
Habitats Regulations Appraisal (if necessary)	All of the above	The Conservation (Natural Habitats, &c.) Regulations 1994 and its amendments	✓	✓	✓
Works Licence	Shetland Islands Council	Zetland County Council Act 1974			✓

3. THE CURRENT STATUS OF THE SECTOR AND RECENT TRENDS

FINFISH

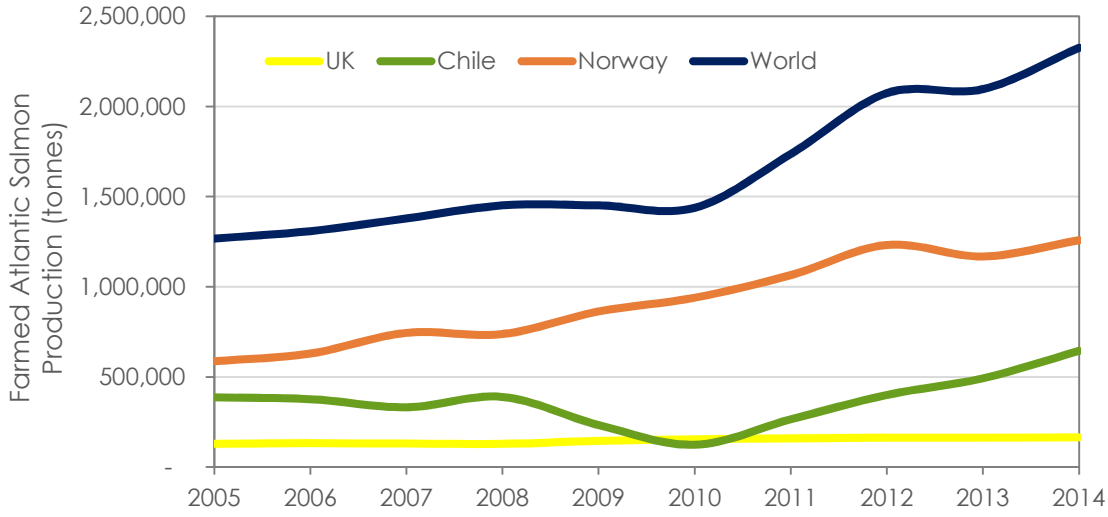
3.1. SALMON

Atlantic salmon production dominates the Scottish aquaculture sector, accounting for 95.5% of finfish production tonnage in 2015.

3.1.1. INTERNATIONAL PRODUCTION

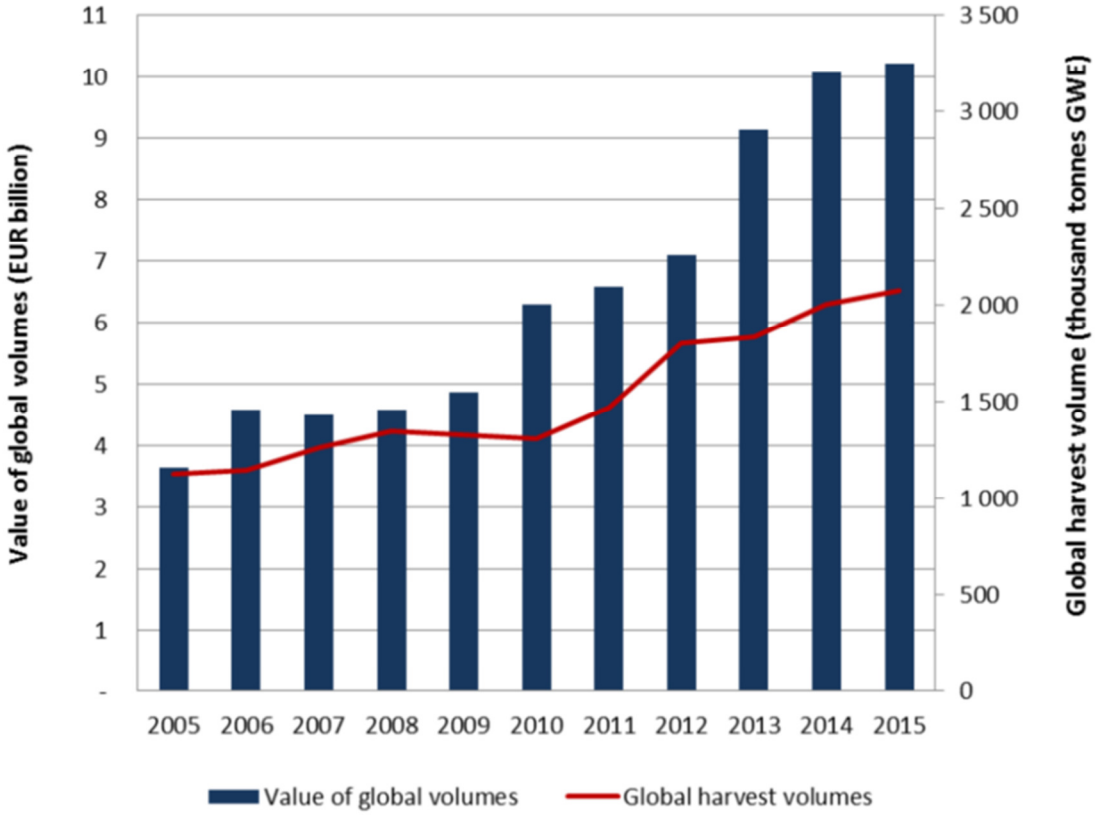
Production in the UK increased by some 27.1% from almost 130,000 Gutted Weight Equivalent (GWE) tonnes in 2005 to over 165,000 tonnes in 2014. This was smaller than the increase in Chile (+66.9%), although Chilean production was more volatile over the period due to disease outbreaks in 2009, which brought the industry to the brink of collapse. Production in Norway increased by almost 115% over the period, with fairly constant year-on-year increases.

FIGURE 2: FARMED ATLANTIC SALMON PRODUCTION (GWE TONNES), 2005-2014, WORLD, NORWAY, CHILE AND THE UK[33]



As shown overleaf from data collated by Kontali Analyse (2016)[34], the value of farmed Atlantic salmon sold across the world tripled between 2005 and 2015, whilst volume grew by 84%. Strong demand and increasing market price has driven increasing international supply since 2010.

FIGURE 3: DEVELOPMENT OF SALMON VALUE VS VOLUME[35]



According to Marine Harvest's Annual Report for 2016, published in April 2017, world production volume fell in 2016 by 6.6%, but with world prices at an all-time high due to strong demand and reduced supply giving substantially increased profitability for producers. The market reference price for salmon in Norway rose by 46% between 2015 and 2016 (with increases of 42% in Chile and 41% in North America). As a consequence, Marine Harvest's worldwide profit doubled despite output tonnage falling by 9%. Prices can oscillate quickly both up and down – one producer quoting recent experience of salmon prices in the UK falling from £7 per kilo in December 2016 to £6 in April 2017.

According to the report, production tonnage by country in 2016 was as follows:

TABLE 4: SALMON PRODUCTION BY COUNTRY

	Tonnes GWE	**%**
Norway	1,054,000	54.1
Chile	454,000	23.3
North America (mainly Canada)	148,100	7.6
Scotland	144,100	7.4
Faroe Islands	69,600	3.6
Other Countries	78,900	4.0
Total	**1,948,700**	

The following ratios from Marine Harvest's 2016 report illustrate the differences in labour productivity between the main producing countries. Employees include permanent, temporary and third party.

TABLE 5: SALMON FARM LABOUR PRODUCTIVITY BY COUNTRY

	Production Tonnes	Farm Employment (FTEs)	Tonnes per FTE
Norway	1,054,000	1,561	675
Chile	484,000	843	574
North America	148,100	501	296
Scotland	144,100	657	219

3.1.2. SMOLT AND SALMON PRODUCTION FIGURES AND RECENT TRENDS

The figures below are taken from the 2015 Marine Scotland Finfish Farm Production Survey.

TABLE 6: SMOLT PRODUCTION, EMPLOYMENT, PRODUCTIVITY AND SITES FROM 2005 TO 2015

	Number of Smolts Produced (000s)	Employment (FTEs)	Smolts (000s) per FTE	Number of Sites	Number of Producing Companies
2005	36,326	237	153	148	41
2007	38,125	248	154	135	37
2009	36,868	243	152	105	30
2011	43,626	259	168	98	28
2013	40,457	261	155	102	27
2015	**44,571**	**267**	**167**	**87**	**25**

There has been a 22.7% increase in smolts produced in Scotland since 2005, although there have been fluctuations from year to year. As the increase in the total smolts produced (22.7%) between 2005 and 2015 was greater than the increase in FTE employment (12.4%) there has been an increase in labour productivity of 9.2%. There has been a move towards larger sites, with the average number of smolts per site increasing from 245,000 in 2005 to 512,000 in 2015, and the number of producing companies decreasing from 41 to 25.

TABLE 7: SMOLT PRODUCTION BY REGION (SEE MAP IN FIGURE 10)

	FTEs	Smolt Production (000s)	Smolt Production (000s) per FTE
North West	144	24,788	172
Orkney	1.5	142	95
Shetland	29	3,372	116
West	58	9,625	166
Outer Hebrides	25	4,823	193
East and South	9	1,821	202
Scotland	**267**	**44,571**	**167**

The breakdown of smolt production by area shows that the vast majority of smolts are produced in the Highlands and Islands, with production in the North West accounting for over half (56%) of total production in Scotland. Although production was low, labour productivity was highest in the East and South area, with the Outer Hebrides and North West areas also having productivity higher than the Scotland average.

TABLE 8: SALMON PRODUCTION, EMPLOYMENT, PRODUCTIVITY AND SITES, 2005-2015

	Tonnage	Employment (FTEs)	Tonnes per FTE	Number of Sites	Tonnes per Site	Number of Producing Companies
2005	129,588	915	142	278	466	40
2007	129,930	857	152	247	526	28
2009	144,247	919	157	254	568	25
2011	158,018	968	163	254	622	21
2013	163,234	1,131	144	257	635	15
2015	**171,722**	**1,310**	**131**	**254**	**676**	**10**

The volume of salmon produced has increased by 32.5% between 2005 and 2015. FTE employment increased by 43.1% over the same period, with a resulting productivity decrease of 7.4% in terms of employment per tonne of output. As illustrated in Figure Figure 3 at 3.1.1, however, the increase over the period in the market value per tonne produced has more than compensated for this. Despite the large increase in volume, the number of sites decreased from 278 to 254 over the period, with a move to larger sites. The number of producing companies decreased from 40 in 2005 to 10 in 2015, as a result of mergers and acquisitions, with companies seeking to benefit from economies of scale through purchasing, use of larger sea vessels, management and marketing, etc, as well as growth through acquisitions being a characteristic of expanding companies in an increasingly globalised economy.

Table 9 below highlights the main Scotland salmon producers from Marine Harvest's 2016 Salmon Farming Industry Handbook and illustrates that their combined production levels represented 92% of the production of the industry as a whole in 2015. The production figures are given in tonnes GWE ('gutted weight equivalent': starved, bled and gutted) and are therefore lower than the live tonnages for the year in Table 8 above.

TABLE 9: THE TOP 5 UK SALMON PRODUCERS[36]

	Tonnes (GWE)
Marine Harvest	50,100
Scottish Sea Farms	27,000
The Scottish Salmon Co.	25,600
Cooke Aquaculture	19,000
Grieg Seafood	16,400
Top 5 Producers	***138,100***
Scotland Total	***149,700***

Scottish salmon production is concentrated in these five largest producers and two other companies (Wester Ross Fisheries Ltd and Loch Duart).[37] Three of the five large firms (Marine Harvest, Scottish Sea Farms and Grieg Seafood) are Norwegian owned, the Scottish Salmon Company Ltd is registered in Scotland (with its parent company listed on the Norwegian Stock Exchange), and Cooke Aquaculture is North American. A small degree of outsourcing of production occurs under contract. Marine Harvest (MH), which now constitutes around 35% of the Scottish industry, has an increasingly vertically integrated supply chain. Wester Ross and Loch Duart focus on high-value markets where small-scale provenance and labour intensive production can be more important than relative price. This has implications for their production model and market strategies.

There is some strategic focus for producers in particular areas (Grieg and Cooke in Shetland, WRF and Loch Duart in the North Highlands, SSF and Cooke in Orkney, Marine Harvest and Scottish Salmon Company in the West of Scotland and the Western Isles). Companies have demonstrated a willingness to 'shuffle' sites (within the terms of consenting) between them if it gives more coherent or improved management control of a loch. Competition policy has also led to divestments of sites, with Marine Harvest limited to 40% of UK production.

The table below is taken from the 2015 MS Finfish Production survey report and gives approximate valuations using an estimated average value per tonne across all wet harvested fish (for which there is no market price).

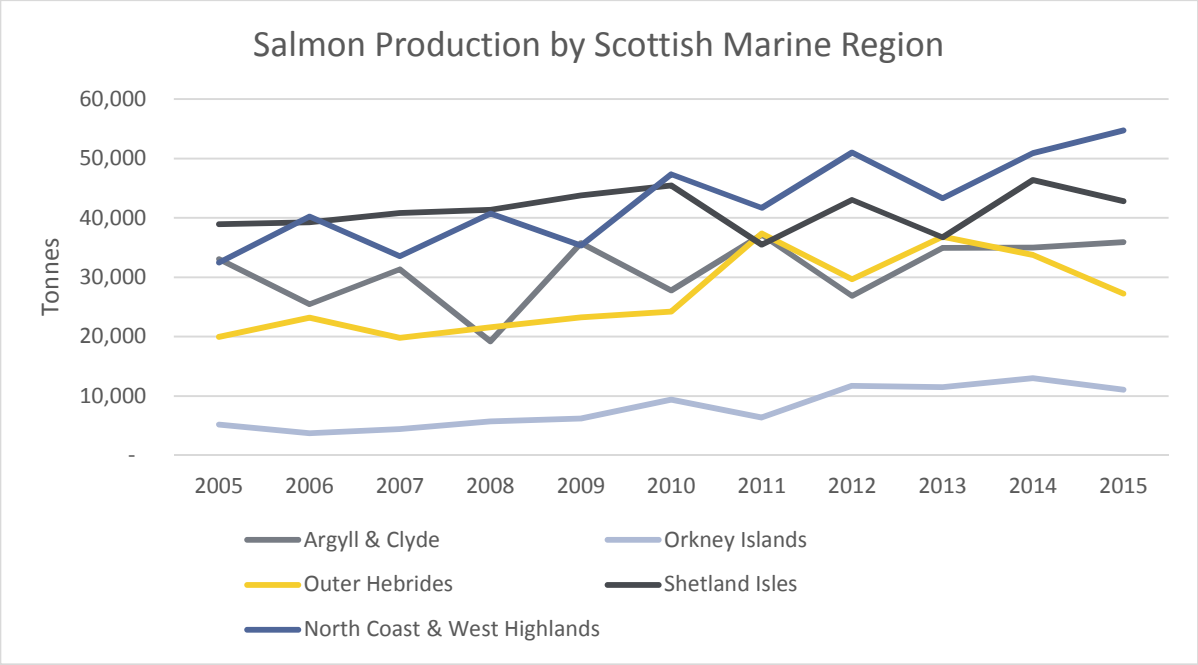
TABLE 10: PRODUCTION VOLUME AND VALUE, 2009-2015

	Tonnage	Value (£m)	Value per Tonne (£) 2015 prices
2009	144,247	459,716	3,187
2011	158,018	622,274	3,938
2013	163,234	691,949	4,239
2015	**171,722**	**637,089**	**3,710**

Value per tonne rose by 33% between 2009 and 2013, together with an increase in volume of 13%, but value fell between 2013 and 2015 due to falling prices – although, as noted at 3.1.1 above, there was a large price rise in 2016 due to unexpected reduced supply. Total salmon (primary) production was valued in the Marine Scotland Finfish report at £637 million in 2015 through their applying an approximate average value to all salmon produced over the year.

The trend in production by region within Scotland is shown below in Figure 4 from the 2015 MS Finfish survey report.

FIGURE 4: TRENDS IN SALMON PRODUCTION BY REGION, 2005-2015



Scottish salmon is produced predominantly in inshore sea lochs across the West and North Highlands and in the Islands, though with an increasing recent focus on 'more exposed' sites (albeit close-to-shore), for example Marine Harvest's new site off the island of Muck. Site location and scale impact on a number of variables, from planning, to disease control, to equipment design. Year to year variations characterise the sector and can be due to sites ceasing to be used, new sites being brought into production, the production cycle, and other supply and demand factors.

The regional distribution of salmon farms is shown below in Table 11. In 2015, Shetland had significantly higher labour productivity (189 tonnes per FTE) than the Scottish average (131 tonnes per FTE).

TABLE 11: REGIONAL DISTRIBUTION OF SALMON FARMS, 2015[38]

	Production		Employment		Tonnes per FTE
	Tonnes	**%**	**FTEs**	**%**	
North West	54,741	32%	415	32%	132
Orkney	11,074	6%	94	7%	118
Shetland	42,786	25%	238	18%	180
South West	35,911	21%	308	24%	117
Western Isles	27,210	16%	256	20%	106
Scotland Total	**171,722**	**100%**	**1,310**	**100%**	**131**

3.1.3. SALMON PROCESSING

Salmon is an increasingly large part of the UK fish processing industry, and the majority of salmon produced in Scotland is processed in Scotland. While large-scale Grimsby processors need (largely through constrained supply of Scottish salmon volumes) to use Norwegian and Chilean salmon to ensure continuity of supply to their customers, Scottish processors tend to source salmon produced in Scotland. Table 12 and Table 13 below were taken from the 2014 UK Seafood Processing Industry Report by Seafish. Data relate to premises whose main processing is of salmon; and, taking into

account that other fish might be processed in some units and that some salmon processed might be imported, the total direct FTEs will to an extent exceed employment impact attributable to salmon production in Scotland. The Highlands and Islands excludes Argyll and Bute, and Moray's included in Grampian.

TABLE 12: FTE JOBS IN OPERATIONS PRIMARILY PROCESSING SALMON BETWEEN 2008 AND 2014[39]

Region	2008	2010	2012	2014
Grampian & Highlands and Islands	2,168	1,591	1,078	1,555
Other Scotland	1,839	2,155	1,921	1,996
Rest of the UK	674	476	628	1,096
Total	**4,681**	**4,222**	**3,627**	**4,648**

Although the total number of FTEs in salmon processing was similar in 2014 to 2008, processing FTEs have tended to move away from Grampian and the Highlands and Islands (-28.3%) to the rest of Scotland (+8.6%) and the rest of the UK (+62.6%). The net change across all of Scotland was a drop of 12%: 3,551 FTEs in 2014, down from 4,007 FTEs in 2008. There were 878 FTEs in salmon processing in its Highlands and Islands area in 2014 from unpublished figures provided to us by Seafish.

TABLE 13: FTES IN THE UK BY TYPE OF PROCESSING[40]

Type	2008	2010	2012	2014
Primary	387	404	466	536
Secondary	258	515	352	336
Mixed (primary & secondary)	4,022	3,212	2,747	3,776
Unknown (by Seafish)	15	91	63	
Total	**4,681**	**4,222**	**3,627**	**4,648**

As shown in Table 13, the total number of FTEs in salmon processing in the UK was relatively unchanged between 2008 and 2014. However, the number of FTEs employed in operations where the processing type is mixed decreased by 6.1%, compared to increases of 38.6% and 30.3% in primary and secondary processors respectively – although most processing jobs are still in mixed processing.

The recently released 2016 report gives less detail on salmon processing than the 2014 report; and the category specified is now "salmon and freshwater fish processing". On this basis, employment in salmon and freshwater fish processing in the UK fell from 5,201 FTEs to 4,445 FTEs (a reduction of 15%). Of the 4,445 FTEs, 2,445 FTEs were in areas of Scotland other than in the Highlands and Islands and these jobs were 4% higher than in 2014, whereas in the Highlands and Islands, there were 800 FTEs – a reduction of 20% from 2014 (when they will have been around 1,000 FTEs). It should be noted that comparisons between years are not precise as survey responses vary.

Processors in Scotland have tended to employ a significant proportion of migrants from other EU countries. This source of labour has been important to Scottish processors and has helped them in remaining competitive – although there are more limited induced multiplier effects to the extent that migrant workers repatriate their income or save it before going home (i.e. their annual spending

from their income will tend to be lower than the spending of permanently resident workers and their families, some of whom will invest in their homes, which can generate substantial local impacts).

Primary processing is often carried out by salmon producers, with secondary processing including products for sale in supermarkets and restaurants. Often, exports are whole fish, for secondary processing in the destination country or bought for cooking at home or in a hotel or restaurant. Secondary processing may be by smokeries, or seafood processors preparing with value-added sauces or as full meals.

TABLE 14: SALMON PROCESSING UNITS IN THE HIGHLANDS AND ISLANDS BY PROCESSING TYPE [41]

	2008	2010	2012	2014
Primary	6	2	2	3
Secondary	3	5	5	5
Mixed	9	7	7	6
Highlands and Islands Total	18	14	14	14

The total number of salmon processors in the Highlands and Islands included in the Seafish survey decreased between 2008 and 2014, with decreases in primary processors and mixed processors – although there appear to be more small scale processors in the region than identified in the Seafood reports. However, individual businesses have grown over the period, for example, Aquascot in Alness, whose turnover grew by almost 40% between 2013 and 2015.

A good example of a scale processor is John Ross Jr. in Aberdeen, which has consumer-facing own-brand products in UK supermarkets.

Marine Harvest now supplies all of Sainsbury's fresh and smoked salmon; with processing for this contract having recently moved from Fraserburgh (Young's) to Marine Harvest's own processing plant at Rosyth. While the geographic shift is a relevant factor, this also importantly demonstrates the vertical integration of processing to service with full control a large contract within the producer company.

Processors such as JCS Ltd in Grimsby process salmon with sauces for retail customers. They make up a proportion of the 1,096 UK jobs principally relating to Scottish salmon processing that are external to Scotland. UK processors have reported that need to maintain supply means they must sometimes be able to substitute Norwegian or Chilean supplies in lieu of Scottish. This both supports their use of Scottish salmon when possible and their market development, but demonstrates that irregularity of supply necessarily affects Scotland's ability to differentiate its product in some market segments – i.e. some processors cannot buy Scottish at particular times (at a reasonable price) even if they would like to.

Markets

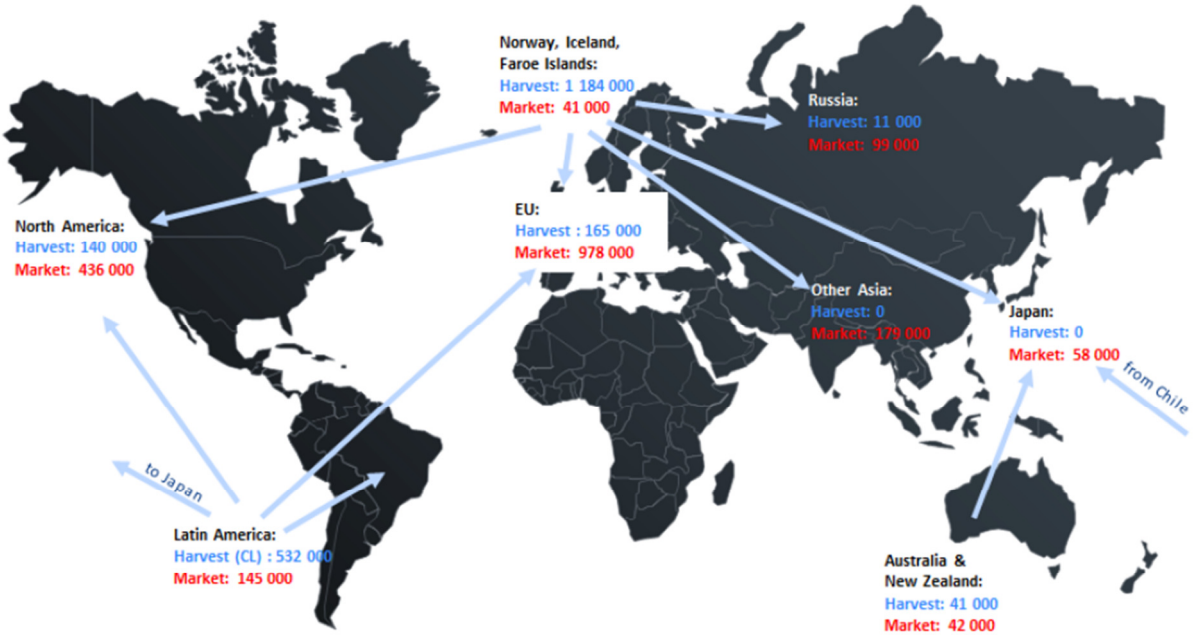
The largest market for Scottish salmon is the UK, where Scottish salmon products tend to achieve a premium price. However, such is the rising demand that Norwegian or Chilean salmon can be required to supplement Scottish supply, creating a branding challenge for buyers who cannot over-promote Scottish products because they must be able to supply alternatives when required.

Increasing appreciation of the health benefits from eating salmon through advice from medical, health and fitness professionals has helped to stimulate demand. Benefits related to the Omega 3 content of salmon include decreased risk of cardiovascular problems; improved mood and cognition (with mental health benefits); joint protection; decreased risk of eye-related problems; and decreased cancer risk. Benefits related to the protein and amino acid derived from eating salmon are also now appreciated – for example, bioactive peptides can provide support for joint cartilage, insulin effectiveness, and control of inflammation in the digestive tract.

A study of 3,000 Scottish farmed salmon by Douglas Tocher of Stirling University, published in the journal Scientific Reports, found that concentrations of Omega 3 in the average salmon had halved between 2006 and 2015 due to factors such as fewer Omega 3 anchovies being fed to salmon to preserve stocks. Thus, Government advice, which recommends one portion of salmon per week, should arguably be changed to at least two portions.

Due to limited available production sites, Scottish salmon production volume has not kept pace with the world market growth demonstrated in Figure Figure 2 at 3.1.1 above, and is thus falling behind on international market share. The main focus on supplying domestic UK demand is, however, logical from the perspective of the international companies which dominate the sector who can supply other countries from their farms in Norway, Chile, etc where production has been more possible to increase.

FIGURE 5: GLOBAL MARKET FOR ATLANTIC SALMON (FROM MARINE HARVEST SALMON FARMING INDUSTRY HANDBOOK 2016)[42]



The EU (predominantly Scotland) produces less than 17% of the salmon purchased in the EU, which, like North America and Asia, imports large volumes from Norway (plus Iceland and the Faroe Islands) and Chile. Scotland has had higher costs of production than Norway and Chile[43], and lower costs in the main producing countries has enabled the international companies that produce salmon to focus on increasing production in these countries.

Supermarket sales can be focused on *supermarket*, rather than *producer*, branding, e.g. Marks & Spencer have their own Lochmuir brand, rather than using the name of the firm with whom it has a

direct supply contract. Harbour Salmon (Marine Harvest) is an example of a company brand sold in supermarkets. Because supermarkets have clear supply chain volume requirements, with strict specifications, direct supply contracts are the norm rather than open market supplies. These large contracts take precedence over the spot-price, which can suggest a higher price than is being achieved for the majority of production volume. There is a risk, with supply constraints causing price volatility, that buyers (e.g. processors) will find it difficult to supply supermarket customers reliably, and/or rely on Scottish provenance to meet demand.

EXPORTS

The larger producers' dedicated supply agreements with UK supermarkets mean that their Scottish production tends to be more focused on the UK than export contracts. The figures below from Her Majesty's Revenue and Customs (HMRC) show that the UK's imports of salmon are now over half of the value of its exports. Some imported salmon is subsequently re-exported.

TABLE 15: UK TRADE IN FRESH, FROZEN AND SMOKED SALMON[44]

Flow		2010	2011	2012	2013	2014	2015	2016
Imports	**£000s**	126,133	149,821	150,496	266,540	265,404	222,695	367,196
	Tonnes	28,684	35,714	40,425	54,487	55,189	49,140	62,937
Exports	**£000s**	340,109	417,663	391,573	517,404	560,377	436,275	513,534
	Tonnes	72,323	81,494	89,001	100,023	112,808	100,558	89,823
Exports Value per Tonne (£000s)		4,703	5,125	4,400	5,173	4,968	4,339	5,717

After peaking in 2014 at 112,808 tonnes and £560,377 in value, salmon exports fell in volume and value in 2015 before recovering to a value of £513,534 in 2016, with a high value per tonne of £5,717, though with a further reduction in exported tonnage to 89,823. These export and import figures are difficult to interpret due to including imported salmon re-exported and species of salmon other than Atlantic Salmon (although we excluded codes that specifically exclude Atlantic Salmon, e.g. frozen fillets of Pacific Salmon). Also, exports include processed as well as whole salmon and the tonnages are therefore not directly possible to relate to farm production tonnages. The sources of imports of salmon have varied from year to year, with Norwegian salmon historically prominent and the Faroes relatively prominent in recent years (£161 million in 2016). £136 million of salmon was imported from Sweden in 2016 (which will have been principally farmed in Norway), together with £7 million of product from Norway itself.

The price competitiveness of Scotland's salmon exports has been greatly boosted by the depreciation of sterling over the past two years. From a high of £1.44 to 1 euro during 2015, sterling fell to a low of £1.11 around the end of 2016, with a fall of 12% between the referendum on leaving the EU in June 2016 and March 2017.

Table 15 suggests that future export potential is strong, particularly if sterling remains weak (though this will negatively impact on the cost of importing dollar-priced feed).

Scotland's farmed salmon was granted Protected Geographical Indication in 2004 in recognition of its unique marine environment, which will have been a factor in the export growth shown in the table above, with export growth by value well exceeding growth by volume since 2010.

Our consultation with Scottish producers and published information suggests that around 40% of the salmon produced in Scotland is exported from the UK (excluding products exported by the secondary processors to whom the Scottish producers sell their salmon).

The two smaller producers (Loch Duart and Wester Ross) are highly focused on niche export markets – Wester Ross now exports around three-quarters of its production and Loch Duart around two-thirds.

In 2016, salmon was exported from the UK to 65 countries, including:

- USA: £156m (down from a peak of £217m in 2014)
- France: £155m (an increase on previous years)
- China: £54m (fairly steady in recent years)

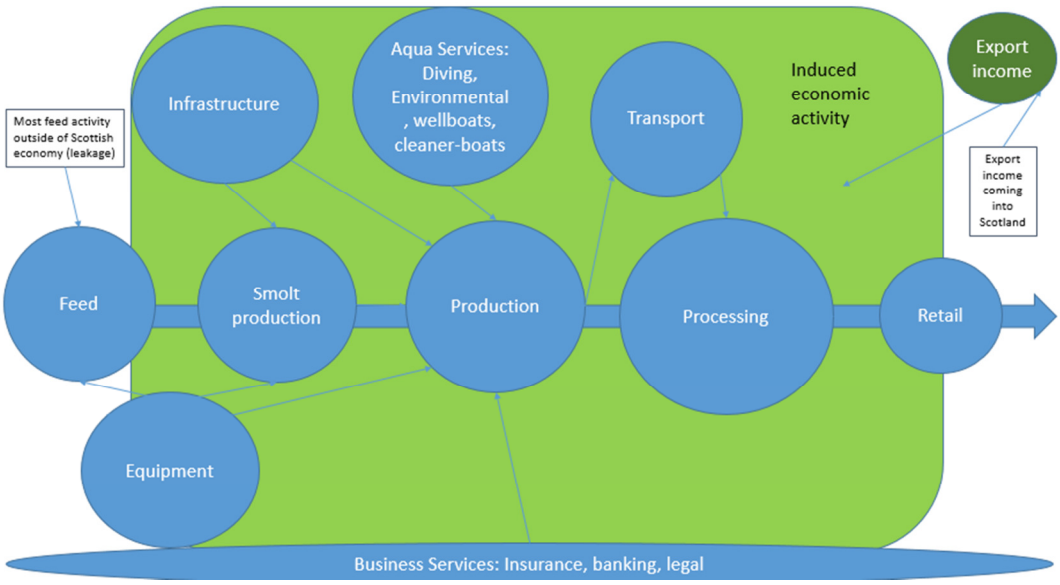
PRODUCT DIFFERENTIATION

Scottish salmon can be differentiated by specification (e.g. Label Rouge[45], Organic[46], Aquaculture Stewardship Council[47], though these can be low in volume relative to the overall market) or by producer and their production methods. There is some degree of differentiation by region and species – for example, Scottish Salmon Company have promoted a 'Native Hebridean' salmon.[48] The major differentiation remains in Scottish salmon being produced under a strong standards framework, good voluntary practices, and associations with scenic loch settings (these are illustrated in SSPO's promotional material and on supermarket packaging).

3.1.4. THE VALUE CHAIN FOR THE SALMON SECTOR

Figure 6 is a diagrammatic representation of the salmon sector in Scotland (which also reflects the emerging model for large scale rainbow trout production). The solid blue arrow shows the core production chain, with suppliers, infrastructure and services alongside. In Green, there is the wider economy which experiences additional economic activity. Export income (Dark Green) signifies income that is coming from outside the local / national economy.

FIGURE 6: THE SALMON VALUE CHAIN



Throughout the value chain, investments in new and extended property, new equipment, vessels, etc provide employment income at supplier sites and during on-site construction and installation.

While some parts of the supply chain require large numbers of employees, other impacts are less labour intensive. Feed supply is a substantial part of the cost of production of finfish, but most of the value is captured by other countries exporting feed components to Scotland. Scotland nevertheless benefits from jobs in formulating the feed, and it would be unviable (or too expensive) to source most of the ingredients from Scotland. Up to 10% of grains going into feed have been sourced in Scotland. Circular economy alternatives such as whisky grain waste have been explored, which could be beneficial initiatives but are unlikely to replace most of the cost of fish feed.

VALUE CHAIN SERVICES

The value chain for salmon production is diverse, from research, to feed, to equipment supply, to pharmaceutical supplies, to boat-based services going from farm to farm, to annual maintenance. Appendix 10.1 provides summary details of the principal businesses involved in the salmon value chain in Scotland, with key information provided at 3.1.5 below.

3.1.5. SUPPLIERS

FEED

Feed is currently supplied by Ewos in Bathgate and Biomar in Grangemouth (both Central Belt) and Skretting in Invergordon. Marine Harvest is planning a feed plant at Kyleakin in Skye at a cost of around £90 million, from which feed inputs would be supplied, and outputs distributed, by boat, and supply its farms in Scotland (and in other countries). This will inevitably displace employment in existing feed suppliers in the short term, although surplus feed would be offered for sale to other Scottish producers and there should be a growing net positive employment impact in feed production in Scotland through overall industry expansion. This Scottish feed plant follows the successful development by Marine Harvest of a plant in Norway which supplied 86.5% of the demand from its Norwegian farms in 2016 – achieving a good profit due to "favourable raw material purchases as well as good profitability", as stated in the company's 2016 Annual Report.

PHARMACEUTICALS & FISH HEALTH

Fish health supplies range from smolt selective breeding through to sea lice, fungal, and antibiotic treatments. Chemicals in the sea and in lochs can have a negative environmental impact through their effect on wild fish stocks, which is at the heart of the constraints on biomass limits set to ensure sustainability and site availability. Complementary to these measures, other treatments (mechanical removal of lice, and use of cleaner fish such as wrasse) are being tried so that the costs of fish health treatments (which have been increasing), and their environmental and health risks, are minimised.

Example suppliers are Fish Vet Group in Inverness (owned by Benchmark Plc) and Europharma in Clydebank.

EQUIPMENT

Equipment supply is a large part of investment in farm production. A number of suppliers in Scotland provide equipment and ongoing diving, boat and maintenance services to producers; although many services are provided from Norwegian firms (especially well-boats).

Example suppliers include:

- ***Gaelforce Marine:*** Based in Inverness, Gaelforce Marine has been a fast growing marine equipment supplier, stocking a wide range of leisure boating, commercial fishing and aquaculture products.
- ***AKVA Group:*** AKVA group has offices in Norway, Chile, Denmark, Scotland, Iceland, Canada, Australia and Turkey. AKVA group has the capability to offer both cage farming and land based aquaculture operations, with technical services. In Scotland, their base is in Inverness.
- ***Inverlussa Marine:*** Based in Mull, Inverlussa Marine is a workboat operator with a fleet of modern vessels servicing contracts throughout the UK and Europe.
- ***Fusion Marine:*** Fusion Marine offers a wide range of services for the aquaculture industry, and as well as fish farm pens and cages, supplies moorings, pontoons, anti-predator equipment, live fish transfer systems, feeding systems and hatcheries and robust offshore fish farm pens. Fusion Marine has been at the forefront of this technology with its High-Density Polyethylene products. Based in Oban, the company has six international offices.
- ***Kames Fish Farming Ltd:*** was established in 1972 with offices on the West Coast of Argyll. Alongside finfish farming, the business operates an equipment supply and installation service ranging from fish cages and moorings to jetties and rafts for both aquaculture and the leisure sector.
- ***Johnson Marine, Vidlin, Shetland:*** Johnson Marine offer on-site salmon harvesting and net washing services. They currently operate off Shetland, Orkney, the Isle of Skye and the West coast of Scotland. In January 2015, they provided harvesting services for 22% of all farmed salmon harvested in Scotland. Johnson Marine are innovating with the introduction of cleaning boats to 'wash' sea lice from salmon (akin to a small car-wash with brushes), and the development of on-board fish harvesting techniques, so that the live fish are disturbed as little as possible in transfers, and the landed product is ready for on-processing.
- ***Knox Marine:*** Knox Marine was established in June 2008 to provide workboat operations off the west coast. It is a division of the long established W & J Knox Ltd who supply cages and nets to the aquaculture industry. They are based in Kilbirnie, North Ayrshire.
- ***Alexander Noble & Sons:*** Based in South Ayrshire, Alexander Noble & Sons provide a range of engineering services for all types of vessels. Most of their work involves the repair, refit, and maintenance of steel workboats, including trawlers, windfarm support vessels, pilot tugs, and barges.
- ***Ace Aquatec:*** Based in Dingwall, Ace Aquatec won the inaugural aquaculture innovation award at Aquaculture UK in 2016. The company's involvement in innovation includes humane slaughter, seal scarers and biomass measurement.
- ***Transport & Logistics:***
    - ***Ferguson Transport:*** are based in Corpach, and with operating centres in Kishorn, Mallaig, Invergordon and Grangemouth, as well as vehicle bases in Kyle of Lochalsh, Inverness, Glasgow and Penrith.
    - ***Shetland Transport:*** recently bought by DFDS (which runs the Larkhall distribution centre), Shetland Transport was a family-run freight and haulage business, established in 1982. Initially, the company served the Shetland Islands only, but has since expanded to become a business with three main depots in Shetland, Aberdeen and Coatbridge on the outskirts of Glasgow.

3.1.6. WORKFORCE DEVELOPMENT

Our research for impact studies carried out for the businesses has identified that salmon producers have been prominent amongst industry sectors in Scotland in the extent to which they have put their staff through relevant courses. This relates to the technical nature of much of the work, the importance of health and safety at marine sites where extreme weather can be experienced, the longevity of typical employment (which justifies company investment in the skills of members of staff), and opportunities for staff to move into more senior jobs during their careers in the sector. Courses, typically ranging from a day to a week, include health and safety, biosecurity and hygiene, use of site equipment, boat training, forklift truck operation, understanding and monitoring of fish health and welfare and feed systems, IT, management, engineering, SVQ courses and Modern Apprenticeships (MAs).

According to the SSPO, at the close of 2015, salmon farmers reported that 88 employees had successfully completed Modern Apprenticeships at levels two and three while a further 74 employees had signed up to new MA programmes.

Courses at Scottish Universities and other educational institutions include distance learning courses in sustainable aquaculture that the University of St Andrews has delivered for more than six years. These range from focused 12 week courses through a 10 month undergraduate certificate to a 2 year postgraduate diploma/MSc. Recent developments include a technical apprenticeship scheme run by the NAFC Marine Centre in Shetland aimed at experienced aquaculture workers who wish to become managers – giving them an SVQ at Level 4. This course was introduced in response to demand from the Scottish industry.

3.2. OTHER FINFISH

3.2.1. PRODUCTION FIGURES AND RECENT TRENDS

Rainbow Trout: Production is shared between one large-volume producer (Dawnfresh), Kames Fish Farming (producing smolts in fresh water and sea grown rainbow trout) and diverse small inshore producers – in total twenty four companies. Dawnfresh has focused its production in Loch Etive near Oban, and its scale compared to other regions can be seen below from Marine Scotland's annual farm production report. Total rainbow trout production was 8,588 tonnes in 2015, mostly for food consumption, though a small proportion of production is for restocking of recreational fishing (6% in 2015). This volume was a 46% increase from the previous year, and the trend is towards seawater cages (54.5% of production in 2015) along the salmon production model. The map of sites taken from the MS report (overleaf) shows the more southerly distribution of sites compared with salmon farming – with none in the islands. Dawnfresh produces almost 2,000 tonnes of trout annually from freshwater lochs.

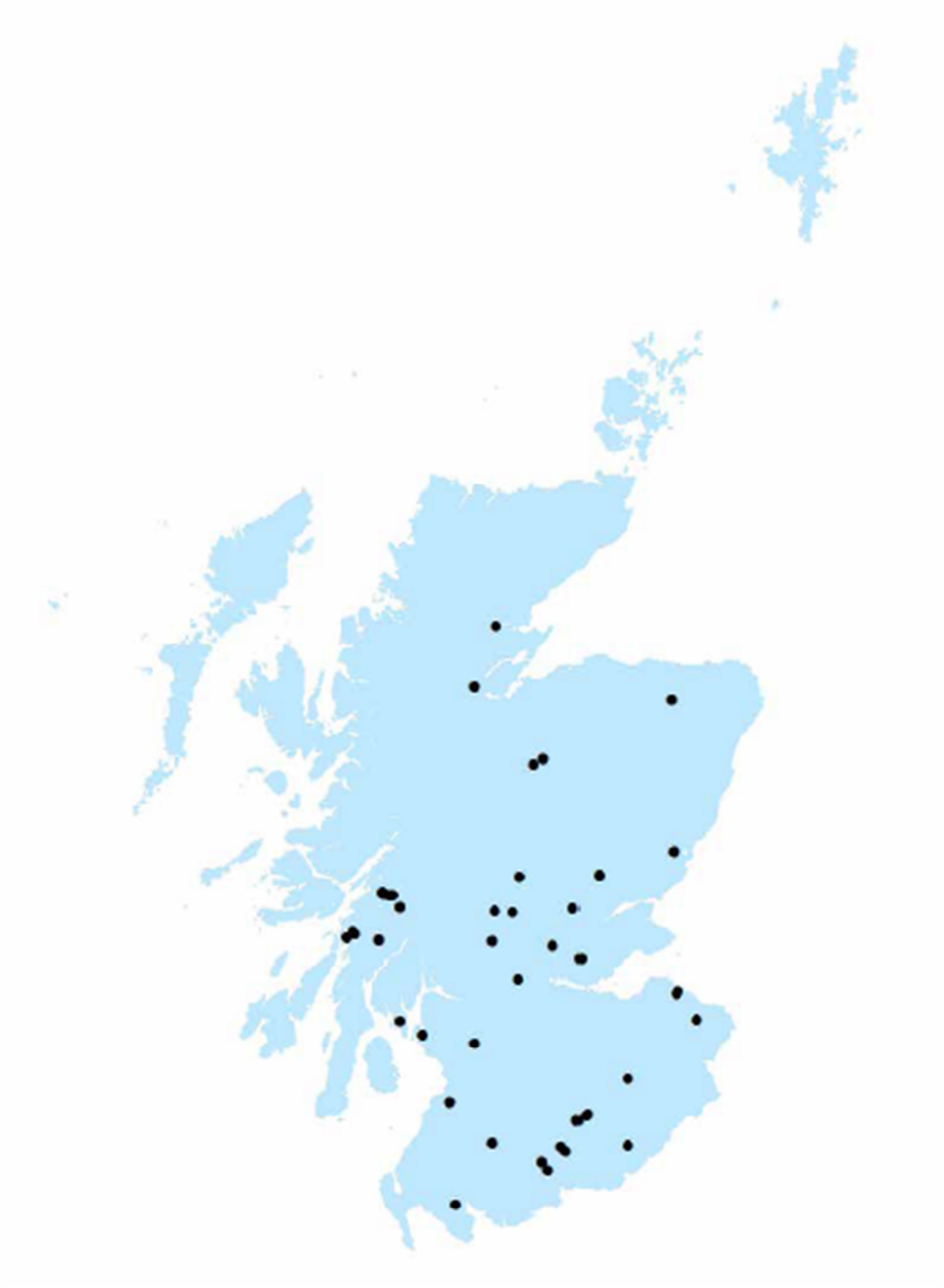
TABLE 16: RAINBOW TROUT PRODUCION AND EMPOYMENT BY REGION 2015 [49]

	Production		Employment		Production per
	Tonnes	**%**	**FTEs**	**%**	FTE
North	2	0.02%	8	7%	n/a
East	962	12%	41	34%	23
West	6,115	76%	48	40%	127
South	954	12%	22	18%	43
Total	**8,033**	**100%**	**119**	**100%**	**68**

The highest regional site labour productivity was 127 tonnes per FTE in the west of Scotland where there is salmon-style cage production; however, the average elsewhere with more traditional production was 68 tonnes per FTE. Freshwater trout aquaculture is more widespread than salmon production internationally, but Scottish provenance is considered an advantage alongside salmon, with a focus on water quality.

Previously, some 60% of UK trout [50] has been processed in Scotland; with the growth of Dawnfresh as a processor potentially increasing this as it continues to scale up.

FIGURE 7: THE DISTRIBUTION OF ACTIVE RAINBOW TROUT SITES IN 2015



Other Finfish Species: Other finfish production in Scotland is low, comprising halibut, brown trout / sea trout, lumpsucker and wrasse (the two latter types farmed to supply as cleaner fish to the salmon sector); although Marine Harvest is taking forward plans at Machrihanish for a major wrasse hatchery to supply its farms in Scotland to help combat lice.

Growth of other finfish species (except rainbow trout, and possibly cleaner fish) seems of limited opportunity and comparative advantage internationally.

- ***Cod:*** farming has been tried in Scotland with mixed success (with an ambitious project in Shetland, No Catch, failing to achieve profitability), and wild harvest will continue to supply most of market demand at lower cost. Levercliff's market analysis in 2011[51] highlighted an opportunity to 'develop species which are in line with demand [for] "mild tasting white fish"',[52] since this is a traditional UK market preference. However, efforts in Norway as well as in Scotland to farm cod have so far been unable to reach significant scale.
- ***Halibut:*** there is some potential (notably Gigha Halibut currently), but halibut is expensive to produce compared to other fish, and is likely to remain a small niche market.

3.2.2. PROCESSING AND SALES

Processing of trout for the table, including chilled products, is largely through Dawnfresh in Uddingston, just outside Glasgow, including chilled trout products. Dawnfresh's trout is smoked by RR Spink in Arbroath. Aquascot produce meals in Alness based on sea grown trout.

A number of small scale smokeries produce smoked trout alongside smoked salmon, giving scope for scaling up of trout smoking.

Trout sales growth increasingly relates to trout fillets being produced by processors (e.g. Dawnfresh, Aquascot) that are packaged for easy home preparation (in a similar manner to salmon fillets). A number of small scale smokers produce smoked trout alongside smoked salmon, giving scope for scaling up of trout smoking.

3.2.3. VALUE CHAIN FOR THE SECTOR

Given its relative scale of production, the majority of future growth in finfish value is likely to continue to be in salmon, though trout may proportionately increase as producers adopt comparable production methods through larger, marine cage-based production of rainbow trout and use similar marketing channels. Rainbow trout producers are likely to compete with salmon producers for new sites in certain areas as suitable unused coastal sites in Scotland are now so limited.

3.3. SHELLFISH AND ITS VALUE CHAIN

3.3.1. PRODUCTION FIGURES AND RECENT TRENDS

Mussels and pacific oysters are the main shellfish species produced in Scotland. Mussels produced for the table accounted for 7,270 tonnes in 2015 and pacific oysters at 215 tonnes according to Marine Scotland's annual survey. Shetland accounts for the largest share of mussels production, 77% of Scotland's total. The Strathclyde region accounted for 79% of Scotland's pacific oysters.

For species other than mussels, numbers produced for the table are more meaningful than tonnage, and these were as follows in 2015:

	000's
Pacific oyster	2,673
Native oyster	200
Queen	33
Scallop	30

There were 144 shellfish businesses operating in Scotland in 2015 with 335 active sites (i.e. consented and registered, but in some cases not producing, for example due to disease or low productivity) and 171 producing sites (i.e. those under active production). Scottish Shellfish Marketing Group (SSMG) has 16 members and is the leading supplier of rope-grown mussels and cultivated pacific oysters. There were 15 oyster operators across West Scotland supplying two seafood processors.

The shellfish sector employed 344 people, 166 of whom were full time. The majority were employed in rural areas of Scotland, particularly in the Highlands and Shetland.

The aquaculture shellfish market at first sale was £10.1m in 2015, but the sector in Scotland increasingly extends beyond production to value added processing and marketing.

TABLE 17: SHELLFISH PRODUCTION AND EMPLOYMENT BY REGION 2015[53]

	Shellfish			
	Production		Employment	
	Tonnes	**%**	**FTEs**	**%**
Highland	467	6%	58	24%
Orkney	-	0%	-	0%
Shetland	5,565	74%	71	30%
Strathclyde	755	10%	83	35%
Western Isles	719	10%	25	11%
Scotland Total	**7,506**		**237**	**100%**

3.3.2. PROCESSED PRODUCTION

SSMG expected a turnover of £26m of value-added shellfish products in 2016 – up from £22.5m in 2015, with direct employment of 170 FTEs. This includes some complementary products not based on Scottish shellfish aquaculture (i.e. some lobster and crab are included). However, its additional capacity has a dependency on the scale and capacity offered by Scottish aquaculture. This is echoed in their Shetland site, acquired in 2016, which processes some wild fisheries produce alongside the majority of mussel processing. Including other processors, the total value of value-added products was expected to exceed £30m, with Loch Fyne Oysters (see Appendix 10.1) demonstrating the scope for linkages to retail and food service beyond processing.

3.3.3. SALES

There are two main routes to market:

a) Cooperative vertical integration, with the SSMG bulking and processing mussels from multiple suppliers. SSMG members account for an estimated 80% of production.
b) Loch Fyne Oysters, which makes up the majority of oyster sales, and exports about 50% of its mussel production (small at 400 tonnes compared to total Scottish production) to countries such as Switzerland and Hong Kong.

The remainder sell through more direct routes such as to local retailers, caterers and consumers.

There is a shift from fish counter sales to value added shellfish products – in 2015 these represented 25% and 75% of retail respectively. The retail to out-of-home spend on shellfish is approximately 1:1; in mussels it is closer to 1:2.[54]

The Association of Scottish Shellfish Growers suggest that only 7% of the UK public consume vacuum packed mussels, and believe there is much more scope for growth. The French buy Scottish mussels when faced with their own supply problems (e.g. due to disease).

MARKET FACTORS

- **Country:** The provenance of Scottish shellfish is valued overseas, although most output (up to 95% for some producers) is supplied to the UK market.
- **Water quality:** Scotland has extensive Class A shellfish waters.
- **Sterling exchange rate:** The devaluation of sterling, leading to inflation of input prices such as butter used for sauces poses a significant cost pressure for processed shellfish. Because current sales are mainly in the UK, there is not a corresponding advantage in export revenue. However, a relatively low sterling exchange rate gives products aimed at the UK market an advantage over imported food products.
- **Product type:** Growth in demand for mussels is seen as the lead area of volume growth, with new entrants to the market (Aldi, Lidl, Cooperative shops) now selling processed and value-added mussels. Oyster production is also growing, which will allow for further market development.
- **Productivity for competitiveness:** Sterling exchange rate pressures in terms of increased input costs will have implications for competitiveness, but productivity is improving, with expansion of processing capacity, and more sophisticated / organised techniques on farms.
- **Increasing consumer demand:** The extent of consumer demand is not seen as a major issue – rather the challenge is to grow supply without 'overshooting' demand in any given year.

This has been achieved to date by having consolidated marketing through SSMG which has formed supply relationships with supermarkets.

3.3.4. VALUE CHAIN FOR THE SHELLFISH SECTOR

The figure below illustrates the two main value chain routes for shellfish production in Scotland summarised at 3.3.3 above: via the Scottish Shellfish Marketing Group, which operates a cooperative sourcing model with joint processing facilities and marketing functions; and the Loch Fyne model with integrated sourcing, production and sales. These value chain models will likely evolve with new entrants (such as Traigh Mhor Oysters). Local direct sales are another route to market but in small volumes.

FIGURE 8: THE SHELLFISH VALUE CHAIN

As noted above, there is a crossover between shellfish aquaculture and wild shellfish fisheries value chains, particularly at processing level.

3.4. SEAWEED

Seaweed can be cultivated and harvested for use as an edible food, for food extracts, pharmaceutical use, as a fertiliser, and as a biomass fuel source. While it is a multi-billion dollar industry globally[55], production remains relatively low in Scotland.

3.4.1. PRODUCTION

There is currently no fully commercial aquaculture production of seaweed in Scotland. Small to medium scale harvesting takes place in several locations, notably the Western Isles and Orkney, with small scale collection of seaweed for specialist high value products taking place in various locations including Fife and Argyll. Integrated Multi-Trophic Aquaculture (combining finfish, shellfish and seaweed in a production system) is being researched and trialled but none are seen as commercially viable at present.

There are four relatively well established small seaweed harvesting businesses:

- **Hebridean Seaweed** produce simple seaweed meals (ie dried/ground) for use in the animal feed supplement, soil enhancement, alginate, cosmetics and nutraceutical industries. They also produce a liquid seaweed extract fertilizer. The main source is *Ascophyllum nodosum*, harvested from natural beds using a mechanical harvester or hand harvesting.
- **Orkney Seaweed** co-produces seaweed extracts for use as fertilizer, with different formulations for commercial growers and hydroponic systems, turf products and garden products. The main source is the seaweed *Laminaria*. This remains a relatively small company (capital £75,000) but indications are that demand is growing.
- **Just Seaweed**, Isle of Bute, collect a range of seaweed species at low tide and prepare for the deli/online health food market. Mostly sold dried but some also sold fresh.
- **Mara Seaweed**, based in Edinburgh and source mainly from Scottish and UK coastline. They market a range of seaweed condiments and food additives primarily in the form of seaweed flakes. Main species used are dulse (*Palmaria* spp) and Kombu (*Laminaria* spp). Seaweed butter was recently launched for Scotland Week in New York.

It is estimated that there were around 50 FTEs jobs in small specialist seaweed businesses in 2016.

3.4.2. USES OF SEAWEED

Opportunities for the large scale cultivation of seaweed biomass for fuel are currently limited and are likely to be so for the foreseeable future[1]. Expensive hatchery and nursery systems are required. The product's bulk and weight, and the need for water resistance means that high levels of capital investment would be required for the anchoring, growing and harvesting systems. Very large areas of coastal water would be required to grow commercial quantities. The product has a very high water content making handling, transportation and pre-processing expensive. The prices paid for feedstock for anaerobic digestion and similar processes are currently far lower than the estimated cost of delivering farmed seaweed to sites.

The cultivation of seaweed as a means of bioremediation for nutrient inputs into coastal waters from fish farming and other coastal activities is unlikely to be acceptable in many of the sea lochs

[1] Hambrey Consulting in association with Nautilus Consultants 2011. The economic development potential of seaweed harvesting and cultivation in Scotland. Feasibility study: rationale and opportunities to facilitate and support innovation and commercialisation in seaweed cultivation. Report Commissioned by Scottish Enterprise.

currently used for aquaculture, viable or effective because of the sea-space required and the low value of the significant volumes that would be required to be effective.

3.5 THE EXPORT OF INTELLECTUAL CAPITAL AND SERVICES

Beyond the production and processing of fish, there is value in the intellectual capital of operating in the aquaculture sector, and this can be an exportable service. Kames Fish Farming and Fusion Marine[56] are exporters of both equipment and advisory services; similarly, Gaelforce Marine[57], Knox Marine[58] and others. This can include training and ongoing maintenance agreements within integrated packages, facilitating sales of cages / pens along with servicing pontoons, shellfish systems, boats and other physical equipment. Other specialised skills and services include marine training, diving and electronics, site design and planning.

The general trend has been for Scotland to be a net adopter or buyer of Norwegian intellectual capital and associated products, for example: adoption of high-density polyethylene (HDPE) cage collars, use of well boats, feed barges, live-haul-to-harvest / processing plants, underwater lighting, post-smolt RAS units. (For mussels, New Zealand plays a similar role in propagating new technology in Scottish production.) This has helped Scottish industry in adopting new technologies and methods, but this trend would be likely to continue as long as Scotland has a shrinking share of the global market (i.e. it is rational as a small player to adopt rather than lead).

Fusion Marine show their consultancy reach through a world map, demonstrating that human intellectual capital and services can be exported with few logistical constraints (similarly, Scottish shellfish farmers benefit from advisory services and other supplies from New Zealand).

FIGURE 9: EXAMPLE – FUSION MARINE EXPORTING OF CONSULTANCY SERVICES[59]

Others such as Kames Fishing Farming Ltd. have undertaken recent consultancy in, for example, Sri Lanka, Philippines and Falkland Islands.

In these companies, integrated services and goods supply gives scope for competitive advantage internationally over companies that just supply goods.

The University of Stirling's Institute of Aquaculture is prominent among Scottish research units in global aquaculture research and projects – and Stirling's Masters graduates are found as far afield as Asia and Malawi. Institute research has included studies into Omega 3 content in salmon, which has international and Scottish relevance. The AutoDEPOMOD computer modelling system is used to model the licensed discharge quantities of anti-parasitic chemicals and organic waste arising from marine fish-farm operations. It is licensed in other countries, and distributed by Map and Marine Ltd. on behalf of Scottish Association for Marine Science (SAMS). There could be similar opportunities with its successor model.

Based on the scale of firms and academic projects, the exporting of intellectual capital from Scotland, including international research and private sector sales of training and advisory services, is likely to be low in total value relative to the overall scale of the sector's impact as demonstrated in this report.

Exporting salmon-related intellectual capital will remain a challenge due to the relative scale of investment in Norway, but steps have been taken to strengthen Scotland's role through strategic research collaborations. In 2016, for example, the Scottish Aquaculture Innovation Centre[60] signed a Letter of Intent with Nofima to push forward with areas of mutual interest such as sea lice.

4. GEOGRAPHICAL SUMMARY OF CURRENT INDUSTRY ACTIVITY

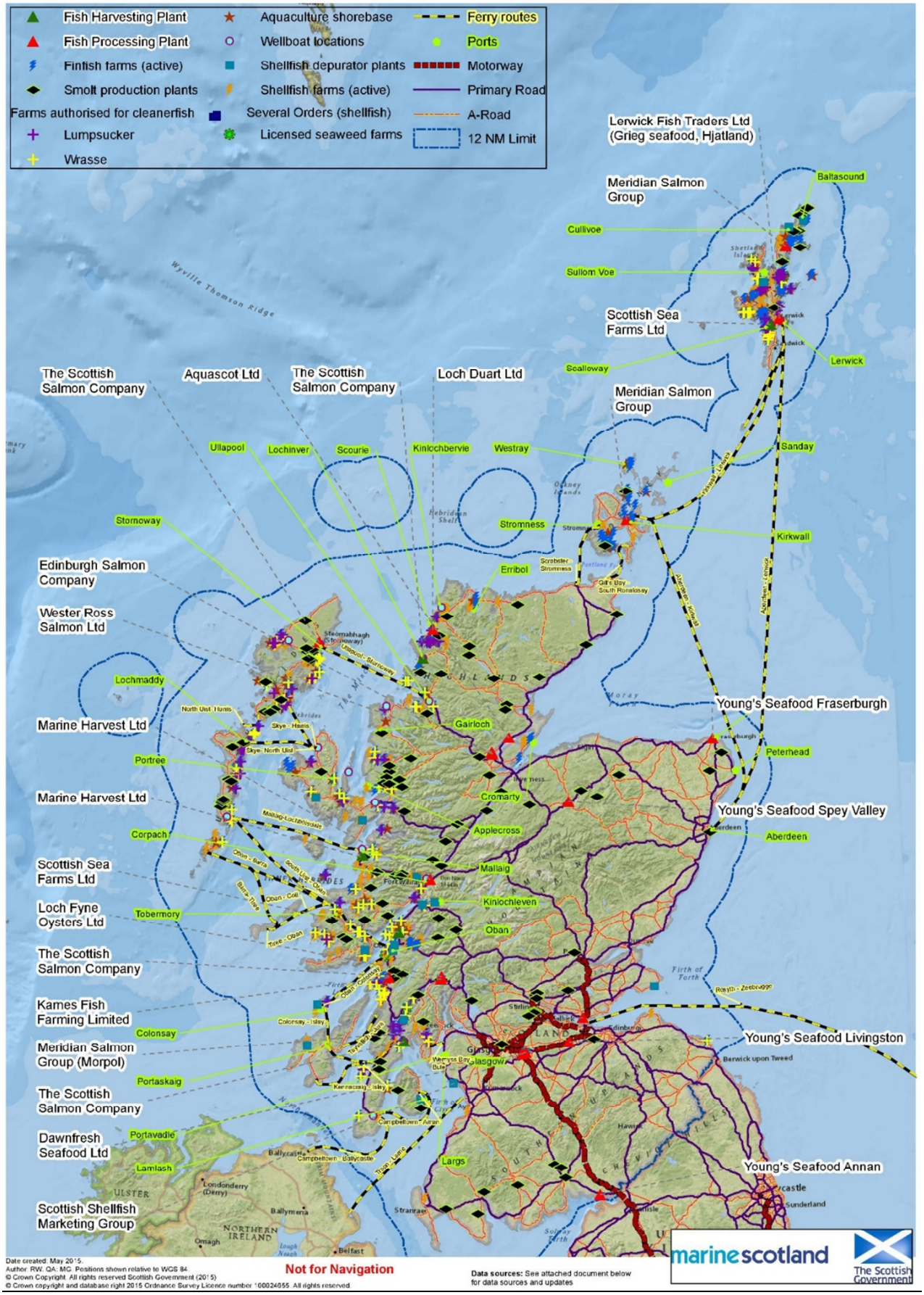
4.1. SCOTLAND

The map of Aquaculture Related Infrastructure in Scotland overleaf, produced by Marine Scotland in 2015, depicts the location of aquaculture related activities in Scotland and transport routes, though these are evolving as new commercial strategies are developed. For example, feed logistics have to date been influenced by road transport logistics, but new plans are based on sea supply routes. The location of processing operations are determined not only by cost of production but by utilisation of existing assets, vertical integration, provenance and buyer requirements (which include the importance of maximising shelf life through obtaining the freshest possible supply post-processing).

Changes since the map was produced include Cooke Aquaculture Scotland having taken over the Meridian Salmon Group's sites in Orkney & Shetland in 2014 which was related to Marine Harvest's takeover of Morpol.

Marine Scotland are currently updating the map.

FIGURE 10: MAP OF AQUACULTURE RELATED INFRASTRUCTURE IN SCOTLAND[61] (AS PRODUCED BY MARINE SCOTLAND IN 2015)



ACTIVITY IN SCOTLAND BY REGION

The summary data tabulated below are from Marine Scotland's 2015 Finfish & Shellfish survey reports. Due to confidentially, production and FTEs for finfish species other than salmon were not available for the areas given.

Tonnes of shellfish relate just to mussels as this is not a meaningful measure for oysters.

The % figures in the table relate to share of the Scotland total.

4.2. HIGHLAND

TABLE 18: PRODUCTION AND FTEs IN HIGHLAND

Highland		
Salmon Smolts	Thousands	24,788
	%	56%
	FTE	144
	%	54%
Salmon Production	Tonnes	54,741
	%	32%
	FTE	415
	%	29%
Shellfish	Tonnes	467
	%	6%
	FTE	58
	%	24%
Salmon and Shellfish Total	**FTE**	**617**
	%	**32%**

The Highland region has the highest salmon production (over a larger geographic area than other regions), comprising 38% of Scotland's production in 2015.

Highland has key associated service providers such as Ferguson Transport in Lochaber (haulage, barges) and the Fish Vet Group in Inverness. Marine Harvest has a harvest station in Mallaig and is planning to construct a feed mill at Kyleakin, just over the bridge into Skye, with mostly sea-based logistics.

Highland supplies a relatively small percentage of Scotland's shellfish.

Wester Ross Salmon and Loch Duart (salmon producers) operate solely in this area.

Based in Inverness, Gaelforce and AKVA are major suppliers of equipment to the salmon industry in Scotland. In Invergordon, Skretting is a major feed supply business, and there are a number of processors in the Inner Moray Firth area, including Aquascot in Alness and the Edinburgh Salmon Company in Dingwall.

4.3. SHETLAND

TABLE 19: PRODUCTION AND FTEs IN SHETLAND

Shetland		
Salmon Smolts	Thousands	3,372
	%	8%
	FTE	29
	%	11%
Salmon Production	Tonnes	42,786
	%	25%
	FTE	378
	%	26%
Shellfish	Tonnes	5,565
	%	74%
	FTE	71
	%	30%
Salmon and Shellfish Total	**FTE**	**468**
	%	**24%**

Shetland is the most concentrated area for salmon production, with its sea sites providing high quality lean fish. As a result, its produce can command a price premium, e.g. in London restaurants, which is important to compensate for the relatively high costs of transporting salmon from Shetland.

Shetland dominates the shellfish sector in Scotland, with 77% of mussel production, and some shellfish processing recently acquired by SSMG (from one of its member organisations, Blueshell Mussels).

Shetland salmon processing reduced in 2015 with Grieg Seafood Hjaltland ending processing operations (although continuing and seeking to grow farm production). The company's new hatchery in Shetland provides its own smolts.

Ferry services are critical to the logistics of Shetland aquaculture, and in turn aquaculture provides strong underlying volume demand for relevant inter-island services.

4.4. ORKNEY

The main salmon farm operators are Cooke Aquaculture and Scottish Sea Farms, with Cooke having a processing operation/office in Kirkwall.

Although the scale of salmon farming is relatively modest in Orkney, production has grown from 3,724 tonnes in 2006 to 11,074 in 2015, with the mean weight of salmon increasing from 3.7kg to 6.9kg. This compares with growth in Scotland from 4.7kg to 5.2kg. Further new sites are planned by both Scottish Sea Farms and Cooke.

As in Shetland, ferry services are critical to the industry.

TABLE 20: PRODUCTION AND FTES IN ORKNEY

Orkney		
Salmon Smolts	Thousands	142
	%	0%
	FTE	2
	%	1%
Salmon Production	Tonnes	11,074
	%	6%
	FTE	93
	%	6%
Shellfish	Tonnes	-
	%	0%
	FTE	-
	%	0%
Salmon and Shellfish Total	**FTE**	**95**
	%	**5%**

4.5. ARGYLL & BUTE AND CLYDE

Argyll & Bute and Clyde is a major producer of salmon, and the predominant producer of pacific oysters, and with some mussels farmed.

Salmon producers in the area include Marine Harvest, Scottish Sea Farms, the Scottish Salmon Company, and Cooke Aquaculture. Dawnfresh produce trout and Loch Fyne Oysters produce oysters and mussels, whilst Kames Fish Farming is a diversified business.

Fusion Marine, near Oban, is a supplier of equipment and cages to the industry. Inverlussa Marine Services on Mull combines boat and equipment services with small-scale mussel farming.

TABLE 21: PRODUCTION AND FTES IN ARGYLL & BUTE AND CLYDE

Argyll & Bute and Clyde		
Salmon Smolts	Thousands	11,446
	%	26%
	FTE	66
	%	25%
Salmon Production	Tonnes	35,911
	%	21%
	FTE	308
	%	21%
Shellfish	Tonnes	755
	%	10%
	FTE	83
	%	35%
Salmon and Shellfish Total	**FTE**	**457**
	%	**24%**

4.6. OUTER HEBRIDES

Marine Harvest and the Scottish Salmon Company are major salmon producers in the Outer Hebrides, both with fresh water and sea water sites.

The Scottish Salmon Company has a processing plant in Stornoway, and produces a native Hebridean salmon brand.

Originally established by a local family in 1987, Salar Smokehouse in Uist produces award winning hot smoked salmon. It was bought over by Loch Duart in 2008, but in 2015 it resumed trading under new ownership as Salar Smokehouse.

Net Services (Scotland) Ltd operate net washing in Scalpay following closure of an unviable Marine Harvest processing factory that had opened after a causeway had been built between Scalpay and Harris.

TABLE 22: PRODUCTION AND FTES IN OUTER HEBRIDES

Outer Hebrides		
Salmon Smolts	Thousands	4,823
	%	11%
	FTE	25
	%	9%
Salmon Production	Tonnes	27,210
	%	16%
	FTE	256
	%	18%
Shellfish	Tonnes	719
	%	10%
	FTE	25
	%	11%
Salmon and Shellfish Total	**FTE**	**306**
	%	**16%**

4.7. OTHER PARTS OF SCOTLAND

The rest of Scotland is a beneficiary of Highlands and Islands production, capitalising on the demand for services (for example, boat engineering) and processing and export of fish and shellfish. Marine Harvest's 220,000 square foot Rosyth processing plant enabled the company to win a reported £100 million contract with Sainsbury's in 2016 and increase the factory's employment by 260 jobs. The DFDS distribution depot in Larkhall channels salmon for onward transport to the rest of the UK and the world.

4.7.1. NORTH EAST

The North East of Scotland is primarily involved in salmon processing alongside its pelagic and white fish processing activities, although in recent years processing has moved to an extent to the Central Belt. Nevertheless, salmon processing has helped processing businesses to compensate for the decline in white fish processing. For example, MacDuff Shipyards won a contract for four feed barges and two landing craft from Scottish Sea Farms in 2014.

4.7.2. CENTRAL BELT

Industry segments in the Central Belt include:

- Company headquarters
- Rosyth processing
- Young's, Livingston
- Pharmaceuticals / bio-science
- SSMG processing
- DFDS Logistics
- Feed supply
- Equipment supply (e.g. cage nets)
- Research institutions (e.g. University of Stirling)

Labour supply, from low-skilled processing jobs to management, is more readily available in the Central Belt, and the area has good transport links (for example, Emirates flights from Glasgow to Dubai are a new route for exports of salmon).

4.7.3. OTHER

Trout production is spread across Scotland, including Perthshire and Dumfries and Galloway, with Dawnfresh the major processor.

SSPO is based in Perth (see 7.2 below for a summary of its role).

Boat engineering suppliers such as Knox Marine and Noble & Sons are based in Ayrshire.

5. ECONOMIC AND SOCIAL IMPACTS

5.1. BASELINE ECONOMIC IMPACTS

This section provides estimates for baseline full time equivalent employment (FTEs), associated earnings and GVA based on the most recent data from Marine Scotland as given in the 2015 Finfish and Shellfish Survey reports. Compared with data available for most other sectors of the Scottish economy, the information from these annual surveys on production and employment is very detailed and accurate due to the information required from companies.

5.1.1. PRODUCTION

2014 and 2015 figures are shown below from the MS surveys for averaging, which gives a better current baseline than using 2015 data, given fluctuations from year to year due to production cycles and biological factors. It is assumed that a part time job represents 0.5 of an FTE, and a casual job 0.2 of an FTE.

In their responses to MS's Finfish Survey in 2016, producers expected salmon production in 2016 to grow to 177,857 tonnes having fallen from 179,022 tonnes in 2014 to 171,722 tonnes in 2015. However, due principally to mortalities relating to the intensifying problem of sea lice, the 2016 harvested tonnage will be down on 2015. Marine Harvest's Annual Report for 2016, published in April 2017, shows a reduction in GWE tonnes of 3.7% in Scotland between 2015 and 2016 – down from 149,700 to 144,100. Applying this reduction to the MS production tonnage for 2015 of 171,722 would give 165,368 harvested tonnes (a reduction of 7.7% on 2014).

TABLE 23: ATLANTIC SALMON SMOLTS

	2014	2015	Average
No. of smolts produced (000s)	45,004	44,571	44,788
FTE employment	277	267	272

Productivity, in terms of smolts produced per employee varies from year to year but is currently around 7% higher than ten years previously.

TABLE 24: ATLANTIC SALMON PRODUCTION AND EMPLOYMENT

	2014	2015	Average
Tonnes harvested	179,022	171,722	175,372
FTE employment	1,258	1,310	1,284

Tonnes of salmon produced per person averaged over the past three years (2013-15) have been 9% lower than the average over the previous 8 years, even though production per site has grown significantly.

TABLE 25: RAINBOW TROUT PRODUCTION AND EMPLOYMENT

	2014	2015	Average
Tonnes harvested	5,882	8,588	7,235
FTE employment	103	118	111

The average rainbow trout tonnage of 7,235 was similar to the average over the 2002-2009 period, with a drop between 2010 and 2014. Some 7,415 tonnes was expected in 2016. Productivity was

broadly static between 2005 and 2014, except for the low production years of 2010 and 2011 (4,458 and 3,858 tonnes respectively) – which can be regarded as recession related.

TABLE 26: OTHER FINFISH SPECIES

	2014	2015	Average
FTE employment	39	43	41

Site FTE employment increased a little since 2009. Tonnage is misleading to aggregate across the six other finfish species covered by the survey, but, notably, halibut production fell from 73 tonnes in 2012 to 56 tonnes in 2015, though is expected to increase to 90 tonnes in 2016; and brown trout/sea trout tonnage is expected to rise to 58 in 2016 from 42 in 2015 (which was also the 2012 level).

TABLE 27: MUSSELS

	2014	2015	Average
Tonnes produced	8,946	9,111	9,029

There has been strong growth in the output of mussels over the past ten years, with the 2006 and 2007 average tonnage having been 4,569 – i.e. production has broadly doubled – although much of this had been achieved by 2010.

TABLE 28: OYSTERS (NATIVE PLUS PACIFIC)

	2014	2015	Average
000's produced	11,175	9,040	10,108

Although there was a reduction in oyster production between 2014 and 2015, production was higher in 2015 than in any other year since 2006.

TABLE 29: TOTAL SHELLFISH EMPLOYMENT

	2014	2015	Average
FTE employment	243	237	240
Total employment	345	344	345

There was little change in production employment for all shellfish between the two years.

5.1.2. BASELINE IMPACT ESTIMATES

As noted above, our baseline figures for site employment are taken from the MS national surveys. Other information drawn from a range of sources (some confidential) was then used to estimate direct plus indirect employment in Scotland for the different sectors of the supply chain (without double counting) and for processing plus onward transport where employment impacts are in Scotland. Data sources included information on staffing and purchases provided by companies (in confidence), including spend on capital investment, the latest Seafish survey report for processing employment, and estimates drawn from Input-Output and Scottish Business Statistics tables for Scotland (where considered valid). Similarly, earnings data per FTE are a blend of information provided by businesses, and national survey information – including the Annual Survey of Earnings and Hours (ASHE), which is reasonably robust at national level.

Drawing on Input-Output Type II multipliers for Scotland for the relevant sectors, induced employment is assumed to add 19% to direct plus indirect employment, and, consistent with other comparable analysis carried out by ourselves, induced FTEs are assumed to earn an average of £20,000 per annum (with a focus in sectors such as retailing).

GVA, approximately, is employment costs (gross earnings plus employers' pension and NI contributions) plus operating profit before tax plus depreciation added back. In general, GVA is assumed to be gross earnings x 2 across the aquaculture value chains as a whole – an approximation that is broadly endorsed by the accounts we have accessed for companies in the industry. With international ownership of the main companies, GVA is arguably not as useful an impact measure as earnings from employment and self-employment – although profits from their operations in Scotland will enable and encourage multi-national companies to invest further in Scotland; whilst earnings include money paid to migrant workers (particularly in processing) that will to an extent be spent in their home country.

Retail and catering impacts in Scotland are not quantified in the analysis below as the employment in these activities would largely be there if other products were sold or supplied. However, certain restaurants and other catering outlets might well have greater turnovers through the ability to sell quality Scottish aquaculture produce, which would generate some additional employment impact (though small in relation to the other impacts estimated below).

5.1.3. EMPLOYMENT, EARNINGS AND GVA IMPACTS IN SCOTLAND

As noted above, the figures in the tables below were calculated or estimated from a range of sources in the absence of pre-existing impact figures for aquaculture at this level of detail. Although the figures are not rounded due to the ways in which they were calculated, they should be regarded as no more than broadly indicative. More detailed analysis based on data from supply chain companies (which they would need to provide for the purpose in confidence) is recommended given the growing importance of aquaculture to Scotland's economy in terms of employment. Where FTEs and earnings below are aggregations of direct and indirect, this is because Type I multipliers from Scotland Input Output tables have been applied to estimates of generated turnover (while taking available information on direct employment into account).

Care was taken to avoid double counting, for example excluding the purchase of salmon in the estimation of indirect impacts from processing. The category "Other purchases by salmon farming businesses" includes purchases of supplies by smolt producers and by head offices and other administrative units (both inclusive of supply chain impacts).

TABLE 30: AVERAGE FTES AND EARNINGS FOR SALMON IN THE 2014-2015 BASELINE YEAR

Salmon	**FTEs**	**Earnings (£m)**
Smolt & salmon production	1,555	46.0
Management & administration	233	8.1
Fish feed supply (incl indirect)	416	10.2
Transport (incl indirect)	534	16.0
Vet services and medications (incl indirect)	596	23.1
Capital investment (incl indirect)	486	14.6
Other purchases by salmon farming businesses	1,530	42.5
Processing (primary plus secondary) direct	2,854	64.2
Processing indirect	285	7.1
Transport post processing (incl indirect)	200	6.0
Total direct plus indirect	***8,689***	***237.8***
Induced employment	1,651	33.0
Total employment impact	**10,340**	**270.8**
GVA impact would be around **£540 million**.		

TABLE 31: AVERAGE FTES AND EARNINGS FOR RAINBOW TROUT IN THE 2014-2015 BASELINE YEAR

Rainbow Trout	**FTEs**	**Earnings (£m)**
Direct employment	111	3.3
Supplies – indirect plus induced	180	4.9
Processing (incl indirect)	122	2.8
Transport (incl indirect)	12	0.4
Other induced	47	0.9
Total employment impact	**472**	**12.3**
GVA impact would be around **£25 million**.		

TABLE 32: AVERAGE FTES AND EARNINGS FOR OTHER FINFISH IN THE 2014-2015 BASELINE YEAR

Other Finfish	**FTEs**	**Earnings (£m)**
Direct employment	41	1.2
Supplies – indirect plus induced	10	0.3
Processing (incl indirect)	2	0.04
Other induced	8	0.2
Total employment impact	**61**	**1.7**
GVA impact would be around **£3.5 million**.		

Shellfish	FTEs	Earnings (£m)
Oysters – direct employment	98	2.9
Mussels – direct employment	132	3.9
Other shellfish – direct	22	0.7
SSMG processing – direct	170	3.8
Other processing – direct	255	5.7
Indirect impacts	169	4.3
Transport (incl indirect)	40	1.2
Total direct plus indirect	***886***	**22.5**
Induced employment	168	3.4
Total employment impact	**1,054**	**25.9**
GVA impact would be around **£50 million**.		

TABLE 33: AVERAGE FTES AND EARNINGS FOR SHELLFISH IN THE 2014-2015 BASELINE YEAR

TABLE 34: AVERAGE FTES AND EARNINGS FOR RELEVANT ORGANISATIONS WHOSE STAFF ARE INVOLVED IN AQUACULTURE IN THE 2014-2015 BASELINE YEAR

Relevant Organisations, Research Institutes, etc	FTEs	Earnings (£m)
Direct employment	70	2.5
Indirect employment	10	0.3
Induced employment	15	0.3
Total employment impact	**95**	**3.1**
GVA impact would be around **£4.5 million.**		

5.1.4. OVERALL IMPACT IN SCOTLAND

Summing the five categories of impact across the aquaculture sector's value chain tabulated above gives (for the average of the calendar years 2014 and 2015):

FTEs	**12,022**
Income from Employment	**£314 million**
GVA	**£620 million**

This FTE total of 12,022 is much higher than the 8,800 jobs given in the industry's Aquaculture Growth to 2030 strategic plan, which was taken from Imani's 2014 Benefits report. The differences are due to our more comprehensive coverage of the value chains for the different species (including capital spend impacts) and increases in output since the 2012 baseline used in the Imani report. Imani had been conservative in estimating impacts where they had limited information. However, the GVA estimated above to have been generated in Scotland is much lower than the statement in the strategic plan that *"The farming of Scotland's seas contribute over £1.8 billion annually to the Scottish economy"*, which is an estimate of gross output across the value chain of the sector, and not a meaningful measure of net economic impact (which is captured across the value chain in the GVA estimate above).

5.2. SOCIAL AND COMMUNITY IMPACTS

Aquaculture provides a range of social and community impacts in remote and rural areas where farms and related activities are located.

The employment that the sector provides in rural areas has helped to compensate for long term declines in agricultural and fishing employment as these sectors have reduced employment due to changing technology. The year-round employment offered by the sector has contributed towards the sustainability of family livelihoods with tourism and agricultural employment in rural and remote areas highly seasonal. Aquaculture and related employment has helped to keep young families in remote and rural communities through providing this relatively well paid year-round employment for at least one family member and has attracted other young people and families to move to these areas where new farms have opened or employment demand has otherwise expanded – improving the age structures of areas that would otherwise be increasingly elderly and, through employees' spending, supporting local service provision.

Unpublished studies carried out by Steve Westbrook over the past twenty years for Marine Harvest, the Scottish Salmon Company (SSC), and Wester Ross Fisheries have provided evidence of the following social and community impacts of aquaculture in remote and rural parts of the Highlands and Islands:

- A mixture of employment provided for existing residents (generally relatively young) and new residents when new farms have been established, with work available across a range of roles with career advancement potential locally.

- Long employment duration – reflecting the lack of alternative or more attractive employment, relatively high pay in the local context, and on and off the job training provided by employers to develop employees' skills.
- Company and employee expenditure that has helped to sustain local businesses and avert closures due to otherwise insufficient annual demand from residents and visitors. Businesses supported include hotels and other accommodation and catering establishments (which also provide for site visitors), fuel supply, hardware supply, divers, house building and maintenance, leisure boat moorings, and those providing repair and maintenance services to company operations, access roads and sites, etc.
- Local primary schools whose rolls have been increased through attendance by the children of aquaculture employees, which can be important in keeping schools open where rolls are small and reducing.
- The important work that can be carried out in local areas by the partners of aquaculture employees, e.g. school teaching, nursing, etc.
- The roles that aquaculture staff play in local voluntary coastguard, fire, etc. services – with their marine experience relevant.
- Use of company berthing facilities by other commercial and leisure boats, with company boats potentially available in emergencies.
- Sponsorships and other support that companies have provided to local groups – enabling events and activities to take place and for people to travel to participate in events elsewhere.

5.2.1. CASE STUDIES

A report produced for the SSPO by Thistle Environmental in September 2008 included the following local community case studies.

Loch Duart Ltd (North West Sutherland)

The 63 full time equivalent jobs (ftes) in North West Sutherland generated by the company's activities represented 5.9% of all economic active residents in the Sutherland North West Ward, with higher concentrations in Scourie (c100 economically active residents) and Drumbeg (c50).

The Post Office and Spar shop (which employed four people) in Scourie reported that Loch Duart was vital – *"without their trade, the shop would be dead, as would the whole village"*. The upgraded petrol station and B&Bs also benefitted significantly, helping to keep these services viable.

The 51 company staff had 26 spouses/partners and 30 other dependents, including five pre-school children, 11 primary children and 14 seniors. The population impact of the direct staff was therefore at least 107 – a valuable contribution to a very economically fragile area.

Some members of staff belonged to the voluntary fire brigade and one was a coastguard. Many spouses had locally important jobs, including paramedic and residential home officer. Staff used the local shops, were members of the local football team, and used leisure facilities in the area.

Finfish Ltd (Wester Ross & Sutherland)

Finfish employed 12 ftes with average pay more than 50% higher than the average estimated by Highlands and Islands Enterprise for Skye & Wester Ross. Ten of the staff lived in the fragile Achiltibuie area, with high staff retention – many of the employees having been with the company for more than ten years.

Children of staff attended the primary schools in Achiltibuie (the school roll was 27 in September 2005) or in Ullapool where there is also a secondary school.

The farm site manager was also a retained fireman and in charge of the volunteer rescue services in Achiltibuie. Other employees served on the local Grazings and Community Hall committees, wrote articles for the local paper and gave lectures on their hobbies to local societies. The wife of one member of staff was a primary school teacher, and another was a community nurse in Achiltibuie. Several members of staff and their families played a very active part in the musical and social activities of their local communities.

Marine Harvest

A more recent study that covered seven of Marine Harvest's salmon farms in the Western Isles found that eight of their staff were members of local fire brigades, two were coastguards, one worked in the ambulance service, and one was a Community Council chair. A number of spouses worked in important local jobs, including nursery, primary and secondary teaching, nursing, care, medical reception and police administration.

Within its first year of operation, the company's site on Barra had generated 70 passenger journeys on ferries and 60 seats on flights by its staff and associates. This demonstrates the role that aquaculture companies' operations can play in sustaining important transport services.

5.2.2. OTHER EXAMPLES OF SOCIAL AND COMMUNITY IMPACTS

Recent publicity has included the following:

- Between 2011 and 2015, 136 charities and community projects across Scotland were helped by the Scottish Sea Farms Heart of the Community Trust, with grants in total having exceeded £500,000.
- The Scottish Salmon Company is sponsoring the Western Isles Island Games Association for three years.
- Marine Harvest sponsors shinty in Scotland.
- Marine Harvest built five new homes on Muck to house staff for its 2014 investment in a new farm, which will help to sustain the local primary school.
- Marine Harvest's planned new feed mill in Kyleakin, Skye, will include an on-site gymnasium and sauna available for community use.
- Growth in salmon farming is the catalyst for plans to extend St Margaret's Hope pier in Orkney and create a marina. In a statement made in January 2017[2], the pier trustees said

[2] The Orcadian, 26/1/2017

that *"It's anticipated that the requirement for berths at St Margaret's Hope will continue to grow in the next few years as salmon farming continues to grow apace in the area."*

A new Community Charter covering SSPO's members includes commitment to a community benefit fund that could generate more than £1 million a year in benefits to communities around the c250 salmon farms across the Highlands and Islands.

5.2.3. SUSTAINABLE LIVELIHOODS

Appendix 0 summarises the "sustainable livelihoods" approach to understanding the social impacts generated through aquaculture development used by Imani in its 2014 report, "An Assessment of the Benefits to Scotland of Aquaculture".

Aspects include: additional employment and income; new and enhanced skills; enhanced community life; increased community resilience; improved infrastructure; sustained school provision through increased numbers of working families; and low carbon footprint compared with agriculture.

6. FUTURE SCENARIOS TO 2030

6.1. CONTEXT

The outlook for Scottish aquaculture was a focus in 2016 for industry representatives who have developed aspirations for the industry to 2030 as expressed in the strategic plan, "Aquaculture Growth to 2030" published by Scotland Food & Drink.

The priorities to 2030 in the industry's strategy comprise:

1) Industry leadership
2) An enabling and proportionate regulatory system
3) Accelerating innovation
4) Skills development
5) Availability of finance
6) Infrastructure

Across the value chain, increased production volumes and reduced year-to-year variations (if achieved) should overall give cost reductions per unit of output and encourage investment in new vessels, plant and machinery, with increased productivity. In processing, the impetus to gain economies of scale could lead to further concentrations in larger units in the south and east of Scotland and south of the border, with Marine Harvest's recent expansion of its Rosyth processing plant in order for it to be able to meet growing orders from Sainsbury's an example. However, niche smaller scale secondary processing could be further developed in local areas in the Highlands and Islands for more local markets (specialist retailers, the catering trade, etc).

In sectors of the industry, particularly processing, there is currently a high dependence on migrant workers whose availability might decrease through the consequences of the UK leaving the EU; and, combined with an increasing living wage, this could lead to labour cost pressures which would need to be compensated for through increased mechanisation – giving fewer jobs per unit of output (continuing the recent trend).

If aquaculture production is to grow in line with industry aspirations up to 2030, productivity increases will be needed through a combination of the measures tabulated at 0 below to retain/increase price competitiveness against other food products (whilst maintaining high quality), which will inevitably benefit from productivity increases.

Site labour productivity in finfish farming and smolt production has stalled in recent years, and industry contacts see future increases in productivity as depending on new larger sites and higher biomass consents for certain existing sites – though with some existing sites moving to lower output due to SEPA regulations and some shutting down. Freshwater production will continue to automate with higher efficiency and lower employment to production ratios. Rainbow trout farmed volumes could increase through sites no longer required by salmon farmers being taken on by trout farmers.

In transport, increased exports and supermarket sales in the rest of the UK will tend to focus haulage employment on journeys to and from the Central Belt and to airports principally south of the border.

The extent of output growth in aquaculture will, however, depend on overcoming constraints, including the current sea lice problems with salmon, diseases that can disrupt production for

periods, applications for planning consent for new sites turned down, etc. These constraints are analysed below along with the key positive factors.

6.2. RECENT AND PLANNED INVESTMENTS

Growth in output and employment achievable by 2021 and beyond will largely come through new investments that aquaculture businesses will make and from recent investments whose impacts have yet to be realised in full – in particular due to the length of production cycles once new sites and facilities are operational. The SSPO's most recent report gives a capital spending total for the salmon farming industry in 2015 of £63.1 million.

Investments relevant to future growth in output and value-added through supply chains that we have identified through this study are listed below, with some of these discussed elsewhere in this report. This is not a comprehensive list, however, and many additional plans and projects of significance will emerge by 2021 (based on past experience and company aspirations) that will influence growth in output and employment over this period, though more so between 2021 and 2030. Understandably, companies have been reluctant to provide information for this report where plans are not yet in the public domain and because of competition for sites between companies in some areas.

Overall, this profile of recent and planned investments is considered consistent with Scotland's aquaculture industry's aspirations for strong future growth in output. In addition to the production-related investments listed below, Marine Harvest has plans for a visitor centre in Kyleakin, with a planning application scheduled for later this year.

6.2.1. FINFISH RELATED INVESTMENTS

Hatcheries:

- Barcaldine - £38m investment – Scottish Sea Farms (6 million smolts per annum)
- Laxford hatchery, Lairg – lumpsucker – Loch Duart
- Inchmore (Glenmoriston) using Aquaculture System - £20m – Marine Harvest (5 million smolts and 6 million fry and parr per year)
- Furnace, Loch Fyne – Cooke Aquaculture
- Wrasse broodstock unit, Machrihanish – Marine Harvest

Feed plant:

- Kyleakin (with planning approval) - £90m – Marine Harvest (170,000 tonnes annual production)

Salmon farm sites recently approved but not yet having produced output recorded in MS surveys

- Westerbister, Orkney – starting November 2016 for first output in early 2018 – Scottish Sea Farms (1,800 tonnes)
- Eday, Orkney – expansion from May 2016 – SSF (doubling to 2,800 tonnes)
- Wyre, Orkney – SSF (1,800 tonnes)
- Kishorn West & Fuinary on the Scottish mainland – SSF

- Colonsay, Argyll and Bute – Marine Harvest (2,500 tonnes), now harvesting
- Maragay Mor, Western Isles – Scottish Salmon Company (2,000 tonnes)
- Scadabay – Western Isles – SSC
- Sound of Raasay (Outer Portree Fish Farm) – SSC
- Tabhaigh, Loch Erisort, Western Isles – Marine Harvest (2,500 tonnes peak biomass)
- Bastaness, Shetland – Cooke Aquaculture (1,910 tonnes biomass)
- Uig Bay, Skye – Grieg (1,700 tonnes biomass)
- Shuna SW, Argyll and Bute – Kames Fish Farming (2,500 tonnes biomass)
- Loch Pooltiel, Skye – salmon and rainbow trout – Kames Fish Farming (2,500 tonnes biomass)

Kames Fish Farming plan to increase their trout production from 800 tonnes per annum to 2,500 tonnes by 2020 through their new Shuna site.

Other:

- ***Trout -*** Etive 6, Argyll and Bute – Dawnfresh
- ***Other –*** Glasgow Aquaponics

Processing

- Rosyth plant expanded – Marine Harvest

Suppliers

- Inverlussa Marine Services has ordered two new vessels from Havyard Ship Technology in Norway as workboats for the aquaculture market.
- Johnson Marine intends to invest in equipment and capacity at a rate of 25% of turnover per annum.
- Cooke Aquaculture has spent £2m on upgrading pens on three of its Shetland sites. The pens have been purchased from Fusion Marine in Argyll and assembled on Shetland, providing work for local supplier networks.

Other plans include:

- An expansion of a site near Lochboisdale in South Uist by Marine Harvest, which would increase the team based in Lochboisdale from 13 to 18.
- A (speculative) proposed organic fish processing development in Staffin, Skye by Organic Sea Harvest, with organic salmon that would be produced at two 2,500 tonne capacity sites in Skye.

Loch Duart expect their average capital investment to have more than doubled between 2015 and 2021 to £3.5 million per annum – including spend on boats, cages, marine assets and freshwater hatcheries; as well as building up fish stocks.

6.2.2. SHELLFISH RELATED INVESTMENTS

- Shellfish spat hatchery - £1.9m (2015-16) –
    - UHI are the lead delivery partner for this project, with SSMG the industry partner. The Scottish Aquaculture Innovation Centre has brought in Xelect and there is significant investment from Highlands and Islands Enterprise and the Scottish Government.
- Traigh Mhor / Isle of Barra Oysters – expansion
- Scot-Hatch – investing in Little Loch Broom in Highland – 4 to 5 year development time.

Shellfish sites: there are many shellfish sites consented but not in production, with evidence of consented capacity up to 21,000t., including:

- Bunyasand, Shetland – Shetland Mussels
- East of Brunt Hamersland, Shetland – Laxfirth Shellfish
- Brandy Ayre, Shetland – Shetland Mussels Ltd

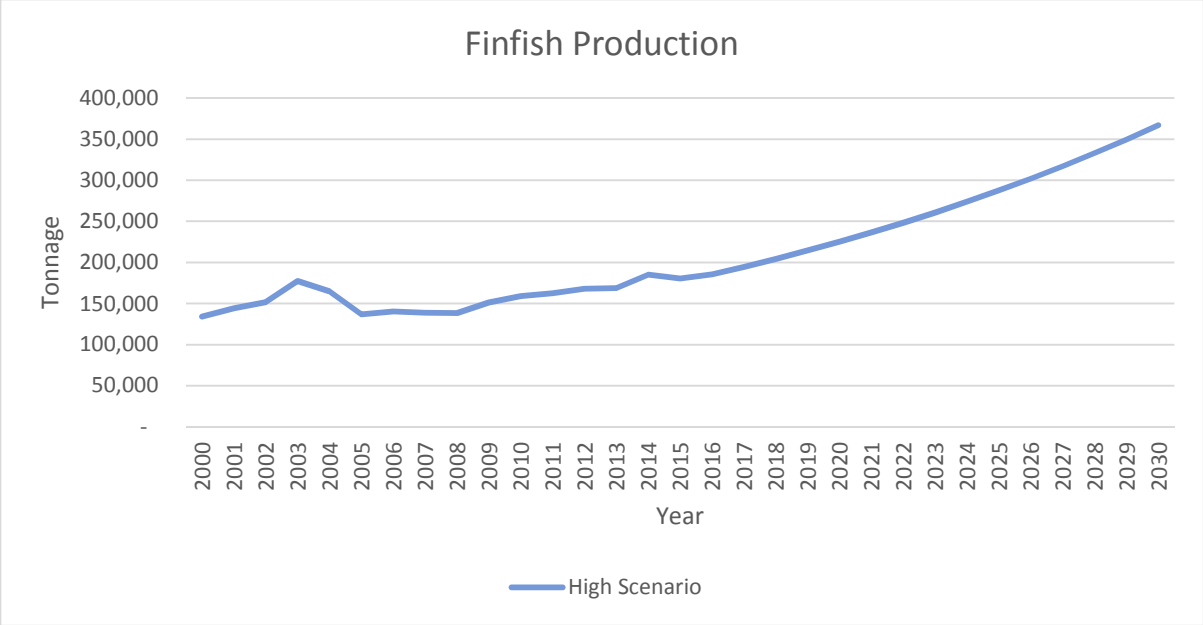
Blueshell Mussels has acquired 1,500 tonnes of extra growing capacity after taking over sites in Shetland from SI Seafarms.

At Ardtoe Marine Research Facility, Benchmark Holdings Plc has invested more than £4 million since it purchased the site in October 2013 through enlarging the centre of research and innovation as one of its FAI facilities.

6.3. THE RECENT AND POTENTIAL TREND IN FINFISH PRODUCTION

Figure 11 below illustrates the industry's doubling in output scenario to 2030 should growth be even throughout the period (which it would not be in practice with inevitable year to year fluctuations). As illustrated, growth between any two years varies considerably depending on which years are taken. As illustrated by the graph, the overall rate of growth needed to achieve this doubling scenario is much higher than the average over the past 15 years whichever years are used to quantify the growth trend, and as concluded later in this Section, we regard such growth by 2030 as a high end scenario.

FIGURE 11: SCENARIO FOR FINFISH PRODUCTION TO 2030



6.4. SALMON

As previously noted, salmon dominates finfish production in Scotland, followed by trout, which is replicating salmon in up-scaling production.

6.4.1. PROSPECTS TO 2030

The main factors that, taken together, could lead to (a) a relatively low growth scenario, or (b) the industry's growth scenario for salmon, can be summarised as follows, with elaboration of the key factors provided in paragraphs 6.4.2 – 6.5.2 below. In practice, as we conclude at 6.9 below, there is a very wide range of potential outcomes by 2021, 2025 and 2030 for aquaculture in Scotland depending on how the positive and negative factors analysed in this Section play out.

The following factors would reduce impact growth potential:

- Disease events and ongoing sea lice challenges continue to reduce productivity through mortalities and lower quality/size of harvested fish. Reductions in production, even if short term, tend to slow cumulative growth over time, and both investor and consumer confidence can be weakened through the impacts of such events and associated adverse publicity.
- Environmental and policy constraints on production become stricter and make production from some sites uncompetitive / unviable. The timescales and costs of planning for new sites are already a serious challenge for producers, especially the smaller companies with limited resources.
- Carrying capacity (spatial limits) constrain further growth, including the scenario that Deposition Zone Regulation (DZR) does not deliver a sufficient net gain in volume along with better distribution between sites.
- Planning consents increasingly difficult to obtain from Local Authorities due to local objections – which can relate to residents not wishing to see farm developments in their vicinity as well as to environmental and fish health concerns.

- Development of more exposed sites proves uneconomic – i.e. the rate of return on the initial investment required plus ongoing repair and maintenance costs would not be justified by annual surpluses from production.
- Imports from other countries reduce the market price of Scottish salmon in the UK through competition, and expansion in Scotland for export markets becomes less profitable the more price competitive the supply from other countries is. Sterling's exchange rate will be a key factor in competitiveness.
- Scotland's price premium is eroded through prominent negative publicity on producers' failures to address environmental and fish health concerns adequate.
- Failure to achieve sufficient productivity improvements across the value chain to retain competitiveness against other fish and food products that do achieve this. Imports of products other than salmon can create new or increasing competition, e.g. imported packaged farmed sea bass.
- Equipment is increasingly purchased from overseas, reducing employment in Scottish suppliers.
- Leaving the EU creates barriers to key European markets, and trade deals uncertainty means global buyers prefer dealing with competitor countries (at least for a period).
- Migration controls limit the labour supply available to the processing sector and other parts of the aquaculture value chain (including production sites in some areas), reducing competitiveness (without labour-saving capital investment which would increase productivity but lead to reduced job numbers).

The following factors would increase impacts:

- All parties adopting the industry's Vision 2030 strategy to work towards overcoming the barriers as set out in the document (and the negative factors summarised above).
- Transformational streamlining of planning and consenting processes – with DZR enabling, as is hoped, higher volume sites to be developed and a net increase in volume on a significant number of existing sites where computer models to-date have not been able to provide a reliable picture beyond the current 2,500t limit, but where those sites could tolerate higher volumes while still complying with regulations.
- Leaving the EU, or other economic factors, leads to a sustained low exchange rate for sterling, with no major concerns emerging regarding EU or global trade that cannot be addressed. Exports thrive and Scotland enjoys improved status as a more distinct fisheries and aquaculture player globally. There is increased automation in processing, which reduces the requirement for low skilled and low paid labour.
- Sea lice risks largely addressed through multiple techniques, and potentially also through new production models (see below).
- A higher proportion of vegetable protein (e.g. from soya bean) is sustainably used in feed formulations.

- More exposed sites produce large volumes at comparable or lower cost per tonne to the current close to the shore model.
- Onshore post-smolt development shortens the production cycle in sea sites, increasing average annual volumes at given biomass capacities. With the increasing difficulty in gaining consent for new close-to-shore sites in Scotland and the likely continuing closure of a number of small sites, some in the industry regard the development of high output RAS systems as the main opportunity to increase salmon volumes.

6.4.2. UNDERLYING STRENGTHS

The underlying strengths of salmon production in Scotland are:

- Ownership of most sites by profitable multinational companies that can access resources to expand production to levels required to meet their growth aspirations.
- Favourable reputation for provenance, supported by the robust regulatory regime, which translates into a price premium.
- Unfulfilled market demand for salmon (currently being met both in the UK and globally principally through growth in Norwegian and Chilean production).
- Expected growth in demand to 2030 (see below).

6.4.3. MARKETS

Internationally, the market for salmon is growing beyond the industry's ability to supply, which has been generating increases in product prices and strong profits for producers (especially in 2016 – see 3.1.1 above).

'The UN estimates that the global population will grow to approximately 9.7 billion by 2050.

Assuming consumption per capita stays constant, this implies a 40% increase in demand for protein. The UN however, estimates actual demand to double. Knowing that resources for increased land based protein production will be scarce, a key question is how protein production in sea can be expanded.'[62]

China's annual seafood consumption increased from 11.5kg per head in 1990 to 25.4kg in 2004, and current estimates suggest it may rise to 35.9kg by 2020. (Source: foodexport.org).63

While much of this growth will be taken up by volume Asian aquaculture, there is increased demand in Asia and other parts of the world (including North America) for niche quality products like Scottish salmon. Ideally, Scottish capacity would be sufficient to satisfy all those in the UK market who prefer Scottish provenance, as well as to export increasingly large volumes.

The UK market has further growth potential as consumers' demand for aquaculture products is expected to increase, with a focus on easy preparation (i.e. fillets for cooking, or ready-meals) and health improvements through diet (physical and mental).

Should salmon production move towards doubling by 2030, it is expected that proportionately more will be exported than currently – i.e. even with strong growth in demand it is considered unlikely that salmon and salmon product purchases in the UK would double, with companies expecting a high proportion of additional sales to be exports.

6.4.4. *International Competition*

Constrained supply in Scotland will inevitably limit the development of new overseas markets, with Norway and Chile seeking to grow significantly to keep up with international demand, and Canada having declared significant ambition for growth. In 2016 one analyst stated "it would probably be more sustainable in the long term to have (annual) supply growth of 4%, 5% or 7% and more stable prices, than reduced supply and 20% higher prices – that's a more short term opportunity for the salmon farmers, but it's not the way to grow the industry". [64]

6.4.5. *Regulatory Considerations*

The Independent Review of Scottish Aquaculture Consenting offers options for streamlining the regulatory landscape, though there is still a lack of clarity in the National Marine Plan development about how the coastline and inshore waters will look and be managed to 2030. However, the main determinant for aquaculture is the scope for salmon producers to grow under the new DZR regime (see 6.4.7 below). In Norway, a site can have 5-10 licences, each permitting 1,000 tonnes of biomass. This is a key reason for the higher levels of production and productivity in Norway compared with Scotland. The DZR should allow for Scotland to increase production capacity where it can demonstrate compliance with standards – until now, the impact modelling was limited in scale up to 2,500t, whereas improvements in modelling should mean that larger volumes would be demonstrated as compliant in future.

It took Kames Fish Farming 4 years to achieve consent for its new site in Skye, and 3 years for its new rainbow trout site in Argyll & Bute (see 6.2.1 above). This time lag and associated costs (especially for smaller companies) are constraints on the development of the sector.

6.4.6. *Disease and Sea Lice Minimisation*

Control of sea lice (and disease threats such as Amoebic Gill Disease) poses an immediate and significant risk to consenting, costs of production, and fish welfare, and in turn to overall production volumes and productivity growth. Sea lice may be treated chemically, requiring controls on environmental impact, mechanically through scrubbing in a boat, or biologically through wrasse and other cleaner fish. Figures aggregated by the SSPO show that £26 million was spent in 2015 on sea lice treatment, of which around 70% was on medicine, and £55 million was spent in 2016, of which around 70% was on non-medicinal treatments. In 2016, for example, 69% of Marine Harvest's salmon farms in Scotland exceeded statutory sea lice limits, with factors including abnormally high water temperatures for extended periods and insufficient cleaner fish capacity.

The sea lice problem has led to a negative perception of the industry (as evidenced by recent media coverage, including articles and readers' letters published in national and regional papers). It is a priority of the Scottish Aquaculture Innovation Centre and other supporting institutions to help the industry address these challenges, and RD&I programmes are underway to manage the risk to future viable production.

6.4.7. *Scope for Production Growth – Existing Sites and New Sites (Hatcheries, Smolt Production and Salmon Farming)*

Innovation to 2030 will be geared to increasing the carrying capacity of fish farms in Scotland, and there will need to be a combination of the following if output growth is to be maximised. New techniques, or significant modifications of existing ones, are emerging, including developments in:

a) ***New biomass regulations (through Depositional Zone Regulation – DZR)***: the method by which biomass limits are established will change, allowing a rationalization of existing sites, increasing volumes in some, and reducing volumes in others (see further at 8.4.2 below), on the basis that disease, water quality and other parameters are met. This is considered viable and achievable with existing technology, and up to 25-30% of growth in current annual volumes could come through this process. A new computer model, NEWDEPOMOD, is being used to provide site-specific information on currents, depth and husbandry in order to predict waste deposition and associated seabed impacts near to farms.

b) ***More exposed sites further from the shore***: the requirements for these sites are under consideration, but developments over the next 5-10 years are likely to be based on modifications to existing, rather than new technologies. Rather than being fully offshore systems, they are likely to be akin to the current more exposed sites off Muck and other areas that are not in traditional 'inshore' lochs (see 6.4.8 below). This segment of sites is seen as relatively undeveloped and, with larger permitted biomass per farm (possibly up to 4,000-6,000t per site), such new sites would help to meet the industry's growth target to double production by 2030 (see further at 6.4.8 below).

c) ***Recirculation Aquaculture Systems (RAS)***: up to 2030, trialling and (it is intended) scale rollout of RAS facilities to enable on-shore post-smolt production will help increase harvested volumes within the current complement of sea sites, through reducing the time that salmon need to spend in sea sites prior to harvesting (potentially by up to a half). This will enable a larger number of fish to complete their growth within a fixed number of farm sites, as well as giving more control over sea lice and other biological factors. These post-smolt RAS units are starting to be built in Norway; although they are expensive and require operators with relevant qualifications.

There is consensus among producers that lice and disease management and the planning process are key constraints that will need to be addressed in order to improve productivity and increase volume.

6.4.8. More Exposed Sites and Viable Growth

From our consultations, producers' focus pre-2025 is on near-shore, more exposed sites in less sheltered lochs or further off mainland Scotland into the Outer Isles than current seawater sites. These sites require specialised equipment to cope with the more dynamic environmental conditions, including more robust cages, nets and moorings. Additionally, they depend on services (including power supply and boat access) that will be more demanding – whereas in the early days of salmon farms, feed might have been distributed by a hand-held bucket and scoop, now wellboats and feed blowers can provide services to more exposed farms. Sea lice though may also prove more challenging to treat in higher energy seas.

The technology for these exposed sites is feasible and deployable, though at a higher investment and servicing cost per farm than inshore systems, which means that higher production levels will be required for profitability. The emerging technology and services ecosystem (i.e. supply boats and IT) and economies of scale through expected larger biomass under Depositional Zone Regulation (DZR) should make these sites the next frontier for growth. It should be noted that the current limit of 2,500t is based on modelling limitations – with an improved computer model there can be more

reliable modelling of impact above 2,500t which was not previously possible. The conditions and requirements, while more challenging, appear to be within the bounds of current conditions in Shetland, and off west coast island areas such as the Inner Hebrides (and indeed the Faroe Islands).

In summary, the speed at which these higher-energy offshore sites can grow will depend on the trade-off between higher investment costs for installation and economies of scale through increased annual production levels through higher biomass allowances (and possibly reduced susceptibility of negative factors such as sea lice) – i.e. for example, producing twice as much salmon in the average year from a new site than from an existing site would require much lower than proportionate site staffing (with automatic feeding), and also with logistical economies in feed supply and transportation from sites for harvesting.

More remote 'offshore' systems are currently being trialled by different companies[65] and could have an important role long-term, but it is unlikely this will provide a short term contribution to increased production volumes in Scotland. However, licences are being progressed in Norway for several different technologies, and the internal linkages between Norwegian and Scottish production companies and suppliers such as Akva mean that technology is likely to transfer if and when viable.

Models range from large globe-shaped cages to off-shore-style rigs.[66] As with offshore renewables, there will likely be an attrition process as the best model is found, and the supply chains for equipment, logistics and feed are modified to support it. Full exploitation, once successful technologies have been established, could extend beyond 2030. This will entail new technology, automation, new modes of operation, and potentially quite different cost structures. New methods of production will be competitive, however, and firms may be unwilling to share with others how successful, and at what cost, further offshore sites can be rolled out. There are a range of challenges, from cost, to new requirements for equipment, health and safety in rougher working conditions, and tolerance limits of the fish themselves within a cage.

6.4.9. Plant and Equipment Supply Chain Development Potential

The Co-Chair of the Vision 2030 Strategy Group (who is a key industry supplier) estimates that capital equipment purchases in Scotland (comprising perhaps 55% renewals and 45% new equipment) currently total around £85 million per annum at first sale price, of which a half at most is purchased from Scottish suppliers.

According to the estimate, if Scotland were to achieve 350,000 tonnes of finfish production annually and 30,000 tonnes of shellfish production, this would have required some £550 million of investment in new capital equipment by 2030 (£540 million in finfish farming and £10 million in shellfish farming), plus an additional annual average spend on renewal of capital equipment of around £48 million (£47 million by finfish farmers and £1 million by shellfish farmers).

This boost in scale would enable Scottish equipment suppliers to increasingly target growing export markets for new and replacement equipment.

On these calculations, there is potential for the annual production level of equipment suppliers in Scotland, if the sector is strategically developed with an emphasis on technology and engineering, to be around £177 million by 2031 (at current prices) – comprising £42 million for new capital equipment, £47 million for existing renewals, and £48 million for additional renewals. Increased exports would be additional to these totals.

This is an example of how the Scottish supply chain could benefit from growth of the country's aquaculture sector through new investment. It is also possible, however, with regard to equipment supply, that new models for cages further offshore and/or more advanced onshore recirculation units might be developed first in Norway and then be introduced or adapted for Scotland. On this scenario, companies outside Scotland who will have been involved in supplying Norway might tend to export their equipment and components into Scotland, with more limited Scotland supply chain impacts. This suggests that Scottish equipment companies should be encouraged to participate in R&D work in Norway to gain the early advantage, as well as investing in innovation in Scotland to grow their scale and capacity to serve Scotland's aquaculture.

6.4.10. Scope for Increased Productivity (Production, Supply Chain and Processing)

The salmon industry has become increasingly concentrated in ownership and organisational structure, with cost reductions per unit of output achieved through the purchasing power of the main businesses, hatchery and processing facilities developed to service company sites, larger well boats, etc.

Employment per tonne of salmon harvested will tend to fall across the value chain as labour productivity improves (for reasons discussed in this report), although some producers expect certain ratios (e.g. 5-6 workers per farm) to remain relatively constant. These two perspectives are likely to be consistent in the existing farm site model, but certain sites may produce more fish through a shorter cycle (due to plans to produce larger smolts), and new production models through larger sites could have a wholly different labour requirement – in terms of numbers and skills.

Producers are confident that there is still much scope for efficiency gains within the current model, from lice and disease control, to improved logistics, to vertical integration, to technological innovation, to better planning and consenting, to better systems leading to larger biomass in existing sites, to economies of scale in management, administration and marketing within companies.

FIGURE 12: ALBATERN ENERGY ARRAY - INSTALLATION

While it is unclear how much they will change productivity or costs, improvements in renewable energy equipment may allow for more remote management or power use for salmon farms. One example is Albatern, which is developing wave technology for supplementary energy supply in conjunction with Marine Harvest and Scottish Salmon Company.

Logistics: Marine Harvest are investing in their own wellboats and currently operate their own harvesting and processing. Logistics are outsourced with Ferguson Transport, which involves significant investment in high specification vessels, financed against contract value.

Smolt Production: similarly, Scottish Sea Farms are investing substantially, including around £38 million in a hatchery at Barcaldine, near Oban, with the industry moving to more onshore recirculation systems before smolts are transferred to sea sites.

6.4.11. TRENDS IN FEED

Feed is a critical factor in the salmon production value chain and the biggest single category of purchase for salmon farmers. Feed supply cost is not currently considered a significant threat or constraint, but as feed has a high import content, its production costs in the UK have recently risen, and this could become important for salmon producers if their profitability falls for reasons other than an exchange rate increase for sterling (which would reduce feed input costs) – for example if continuing sea lice problems and/or disease give producers high costs to combat these and reduce their annual production volumes.

Farm level: By minimising the amount of food waste which sinks to the benthic zone, producers can both improve production efficiency and minimise environmental impacts. While there will remain the impact of excreta and undigested feed regardless, much future growth from now to 2030 is likely to be at more exposed sites where it is expected that greater dispersal and less concentrated impacts will be possible.

Feed production: the feed industry responds to demand from consumers' expectations on feed content, but is otherwise seeking to:

- Reduce carbon footprint
- Reduce marine content
- Increase offcut / salmon waste content (supply chain efficiency)[67]

Using offcuts is welcomed as an attainable marine content source, while obtaining high cost fish meal is more expensive and under greater sustainability pressure. Over time, a greater focus on carbon efficiency of food production (as there is a focus on the carbon footprint of cars) could help bring down feed costs. This may be welcome, but could have a negative impact on the nutritional content of salmon deriving from fish meal in feed. However, there are also contested issues around health and wellbeing of salmon being fed non-marine components in their diet and changes in nutritional content for the consumer.[68]

Feed Supply Chain Development: Marine Harvest is to develop its own feed plant at Kyleakin in Skye, which will also supply feed to non-Scottish MH fish farms. Delivery by sea should save an estimated 10,000 annual road journeys. The plant will require around £90 million of investment with 250 jobs during the construction phase, and 55 direct operational FTE jobs.[69] The total wage bill is estimated at £1.7m per year, reflecting (relative to construction and estimated production volumes) the high cost of feed inputs, i.e. feed processing is not labour intensive.

Feed is currently supplied mainly by three companies in Scotland (see Appendix 10.1).

Marine Harvest's development will:

- have a positive effect on the Highland economy through new jobs

- displace some feed demand from the Central Belt and Easter Ross in the Highlands; although industry growth will in time increase demand in both existing and new feed production units; and
- give a net gain to the UK economy through exporting feed (as planned)
- give the company significantly more control over a vital input to the production of farmed salmon.

6.4.12. SUMMARY OF POTENTIAL TRENDS

- **Up to 2021:** A degree of output growth will be achieved through recently committed and planned investments in production sites, but there is uncertainty in the extent and timing of success in addressing the problems associated with sea lice and in whether DZR technology, within this timescale, will enable a significant number of existing and new sites to be given higher biomass limits. Thus, constraints could counter-balance the output growth through new sites (to an uncertain degree) through reducing (or limiting) the production from existing sites.
- **Up to 2025/2030:** Within this timescale, there are expectations that increased biomass limits will enable significant increases in annual production from existing sites and that new sites will on average have significantly higher biomass limits than the average current sites, including more exposed sites further from the shore in suitable locations. Such production increases will depend, however, on addressing the potential constraints associated with sea lice, disease threats and planning consents for new sites. It is considered likely that growth in UK and overseas demand will be more than sufficient to support output growth of up to double current production, but it is not yet possible to assess the extent to which leaving the EU will disrupt international trade (at least for a period) and/or adversely affect the labour supply available to the sector and its value chain. Also, recent experience suggests that sterling's exchange rate will be an important determinant of the profitability of the sector, and trends in this are also difficult to predict at this stage. Lower annual profitability will tend both to limit companies' resources available for new investment and their confidence in the future – especially where the development of larger sites will involve expensive upfront investment.

6.5. OTHER FINFISH SCENARIOS

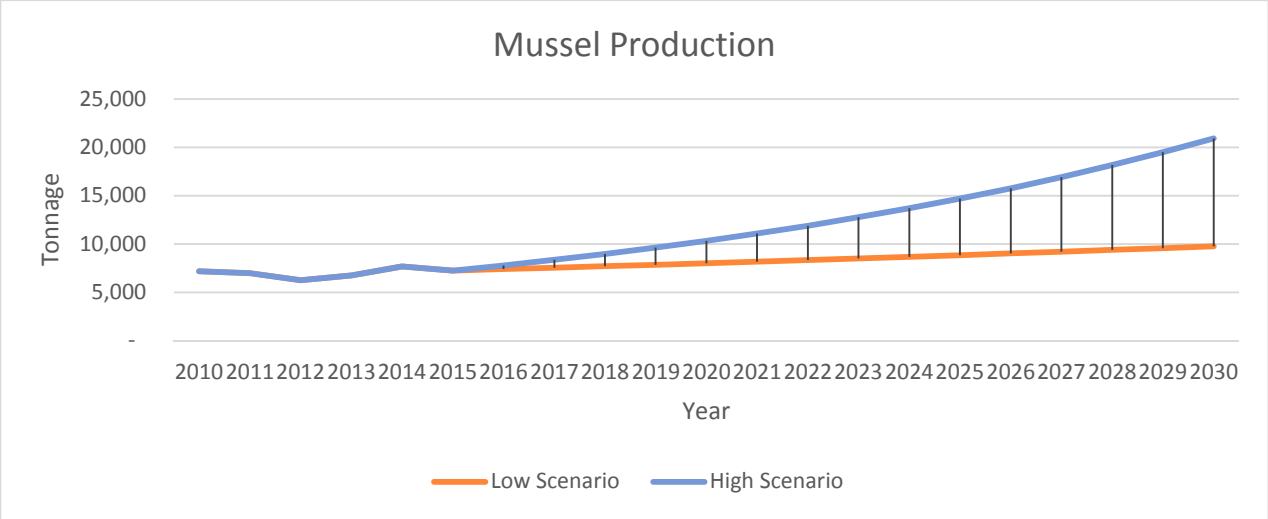
The recent rate of rainbow trout volume growth (see 3.2 above) is not expected to be achievable in all future years, and in 2016 volumes are expected to have dropped from 2015. However, the 2015 increase does illustrate how the consenting of a small number of sites can grow the relatively small trout sector significantly. From our industry consultation, a doubling of volume is considered possible to 2030 from a supply perspective, and trout could become larger as a proportion of Scottish finfish production and as a supermarket customer purchase (filleted or processed). It is possible that as the trout market grows, salmon companies may enter the sector as a diversification / alternative to salmon, though if there is competition for sites in particular areas, this could be at the expense of salmon volumes. Another growth scenario would be for trout producers such as Dawnfresh to take on the sites that salmon producers might stop using as they focus more on larger sites. Smaller trout producers are likely to have an increased role in supplying smolts.

6.6. SHELLFISH SCENARIOS

The majority of Scottish shellfish production is mussels (nearly 90% of farm production by value), with oysters and scallops the remaining 10%. Whilst the shellfish sector site ownership is diffuse with 144 companies, output is highly concentrated within a small number of producers. Shetland producers comprise 77% of mussel production and Strathclyde farmers (principally within Argyll & Bute) comprise 79% of oyster production.

At 2015 prices, aspirational growth by the industry (mainly in mussels) to 21,000MT would give a turnover for Scottish-processed shellfish of up to £90m in 2030. This level of production would theoretically be possible under current consented production volumes across all sites in Scotland. Utilisation of available capacity is generally low, with the highest (Shetland) at 49%.

FIGURE 13: DRAFT MUSSEL VOLUME SCENARIOS TO 2030



Based on current site consents in conjunction with higher site utilisation, growth in mussel production to 21,000 tonnes by 2030 would be possible, although the sector will need to avoid the lower scenarios factors set out below.

Oysters and other shellfish tend to be measured by shell numbers (millions), rather than tonnage. Oyster production value is currently around £1m and around 3 million shells per year. Producers are seeking to increase production significantly, with some aiming to nearly double before 2021. Also, oyster production is significantly underestimated in the latest MS shellfish survey because Charlotte Despress, who produces oysters at the Kyle of Tongue (Sutherland), had not by then submitted returns (producing some 6 million shells per annum).

6.6.1. PROSPECTS TO 2030

The following factors would reduce impact growth potential:

- The UK leaving the EU stifling efforts to diversify into export markets.
- Disease events or algal blooms cause significant setback through reducing production in particular years. The SSMG model is well placed to diversify risk by sourcing from producers from different regions of Scotland. This risk mitigation was evident during an algal bloom event in 2013. However, as the industry grows it will need to invest increasingly in coping mechanisms to deal with the short term effects of disease outbreaks and algal blooms through increased research; with longer term negative impacts where consumer confidence is eroded.
- Labour supply constraints or input cost inflation through changes in EU trade arrangements.
- Poor spat settlement/availability and/or other production problems (e.g. fouling, predation).
- Increased competition from shellfish imports (on supermarket shelves and as restaurant supplies)

The following factors would increase impacts:

- Rationalisation of ownership and sites with an active influx of capital and increased production capacity – expansion, integration and intensification of current sites, plus new sites.
- Improved planning and consenting, with a change in ambition elsewhere in Scotland to echo approaches in Shetland.
- Spat availability no longer a significant constraint or risk (through collection and/or hatchery initiatives).
- Increased capital investment through improvements in financiers' understanding of the valuation of shellfish businesses – a current barrier since rope lines and sporadic volumes are not seen as reliable collateral. Scandinavian banks have made headway in financing Scottish sites, and there is an opportunity for Scottish banks to offer similar/competitive services.
- Increasing recognition of Scottish mussels as a high value product.
- Increased sales through high value added products (e.g. packs with sauces sold in supermarkets).
- Scotland enjoys improved status as a more distinct fisheries and aquaculture supplier globally.

Quality is a main focus for producers, with the aim, in particular, of clear differentiation between Scottish rope-grown product and large volume dredged mussels. It will be important to maintain a strong reputation for high quality through environmental monitoring of water quality. However, some consultees point out that the approach on water quality can be inflexible and should be site-specific.

6.6.2. SCOPE FOR PRODUCTION GROWTH

Increased production will depend on spat availability, and more formal and better organised spat production and/or collection techniques would be beneficial. Hatchery capacity is being improved, but due to the diffuse nature of the industry, this must be coordinated collectively rather than carried out by a single company. Mussel production currently depends on variable settlement of wild spat; whilst oyster production depends on sourcing from a limited number of commercial hatcheries – mainly in England. New government supported initiatives are underway, including an innovative mussel hatchery in Shetland, co-funded by HIE and MS Scotland, exploring the scope to pre-seed ropes with baby mussels and transferring them to suitable waters around Scotland. SAIC are supporting a secondary research project aimed at product quality enhancement.

6.6.3. SCOPE FOR INCREASED PRODUCTIVITY

Productivity gains are most likely to be achieved through coordination of processing and marketing (as with SSMG) and the professionalisation of services. There could be an increase in contract management and satellite operations, allowing the more efficient use of capital. Up to 2025/2030 there is scope to expand sites outwith Shetland through broader consolidation of suppliers, either through ownership or extension and cooperative services – hatcheries, disease control, boats, consenting expertise, joint financing, etc. Increased output (from a relatively small level compared

with salmon) should increasingly give economies of scale through the value chain. This would help competitiveness in supermarket pricing compared with salmon as unit production costs are currently higher.

6.6.4. SUMMARY OF POTENTIAL TRENDS

- **Up to 2021:** Immediate gains could be achieved from improved cooperative marketing and efficiencies in processing models.
- **Up to 2025/2030:** Continued gains could be achieved through increased mussel marketing. Increased exports would bolster shellfish against adverse sterling risks, but the UK is expected to remain the core market for Scottish shellfish, with consolidation of production (not necessarily ownership) the key to unlocking industry potential. Increases in larger scale rope production in a few suitable sites supported by hatchery and/or more effective wild spat collection would increase production.

6.7. SEAWEED

6.7.1. COMMERCIAL PRODUCTION OF SEAWEED

*As noted in 3.4 above, there are currently **no commercial seaweed aquaculture producers**, though there have been pilots conducted on and off for decades. These have been mainly directed at mass production of common seaweeds for biofuel – something which is unlikely to be economic in the foreseeable future. The more interesting less common and more valuable seaweeds have been rather ignored in aquaculture trials in the UK, though more has been done in Ireland, Norway and Brittany.*

6.7.2. MARKETS FOR SEAWEED

Although there are constraints facing the seaweed industry, there is growing demand in several important markets. These opportunities include:

- The sea vegetable and the **"healthy snack"** markets.
- **Condiments**, and general organic cooking additives: ***Mara Seaweed*,** based in Edinburgh, has had a lot of publicity recently and sells seaweed condiments and additive flakes to the likes of Marks & Spencer, Morrisons and Harrods. The business is based on collection of wild seaweed – Dulse (*Palmaria*), Kombu (*Laminaria*) and other seaweeds. They employ around 10 people full time and around 20 part-time and seasonally, and more than doubled their sales in 2016.
- **Speciality baking:** the range of biscuits, oatcakes, shortbreads etc with seaweed additives is steadily growing and represents a classic Scottish food image/tourism marketing opportunity.
- **Animal feeds.** Seaweed contains important nutrients and binding agents that are increasingly valued in a wide range of animal feeds
- **Fertilizers, soil conditioners.** Seaweed has been used for centuries by coastal communities to improve soils and is now increasingly available for market gardeners and farmers more generally.
- **"Natural" cosmetics and skin care: *Seaweed Organics***, based in Argyll produce skin creams, oils and tonics, soaps, and use a range of seaweeds hand harvested from the Hebrides.

Based in Lewis, **Ishga**: produce skin creams from hand harvested seaweed from the Hebrides.

- **"Nutraceuticals**" – high value health products and supplements.

There has been rapid development in seaweed snacks, condiments and skin-care products in recent years and there is growing demand for basic seaweed "meals". While wild harvest is likely to remain the most cost effective form of supply there will undoubtedly be demand for aquaculture production of higher value species as markets develop. This will require very commercially focused R&D working with existing growing supply companies.

6.7.3. EMPLOYMENT & PRODUCTION

The number of employees in seaweed harvesting plus cultivation could easily double in size over the next 15 years (from the current estimate of 50 FTEs). However, current employment relates mainly to harvesting wild seaweed, and although this can be considered farming, businesses are cautious about investing – they can still collect it, and wild product probably has a premium. Nonetheless it is likely that production will be constrained by raw material supply as these companies expand, and hand cutting with scissors is unlikely to last. Mara is already pushing commercial orientated mariculture research.

It is likely that farming, e.g. of Dulse (*Palmaria*) and Ulva, will begin to take off during the next 10 years and become the dominant source of supply within 25. Scotland is best placed within the UK to cultivate seaweed due to environmental conditions. However it is unlikely there will be more than 20-30 people directly involved in commercial aquaculture production in remote rural areas before 2030, although they would then be supplying a significantly expanded wholesale and retail sector producing a wide range of speciality food and health products. This could generate a total of more than 100 jobs.

Worldwide, demand for seaweed products has grown rapidly and this growth is expected to continue. Compared with 15,000-20,000 tonnes being harvested annually in the UK, about 170,000 tonnes is harvested in Norway and 12 million tonnes are being produced in China. Some believe that industrial scale cultivation in the UK is a possibility – offshore and perhaps on land in giant tanks filled with seawater.

6.8. QUANTIFIED IMPACT SCENARIOS TO 2021, 2025 AND 2030

The industry's Aquaculture Growth to 2030 report states that "sustainably achievable projections for 2030 could be in the range of 300,000 to 400,000 tonnes per annum for finfish production, with "a medium production figure of 350,000 tonnes of salmon". This would be approximately double the average 2014/2015 harvest of 175,372 tonnes (see 5.1.1 above). "In shellfish production, there is potential to reach 21,000 tonnes of mussels per annum by 2030 and to significantly increase the value of oyster production". Some 21,000 tonnes of mussels would be a 133% increase on the average 2014/2015 production of 9,029 tonnes.

The degree to which either of the two principal indicative scenarios described below and quantified in Table 35-Table 38 will materialise will be dependent on how the key drivers and constraints whose potential influence is analysed in this Section and summarised in Section 8 below influence outcomes. The role of the public sector and the organisations that it funds in the extent to which the indicative scenarios are achieved is discussed in Section 8.4, together with a summary of the measures that the industry will need to take to turn potential into reality.

It is assumed for future impact modelling that average earnings per FTE will stay the same as assumed for 2015 at £26,100 in real terms (i.e. net of inflation) – although in practice there might be an overall average increase related to assumed productivity increases in value chain sectors. Recent analysis has shown that average earnings in the UK economy in real terms have changed little over the past ten years, and internationalisation suggests that this trend might well continue for the next 15 years. Also, it is assumed, as for 2015, that GVA continues to be approximately double gross earnings across aquaculture value chains taken together.

Indicative Scenarios to 2021

If aquaculture production were to approximately double between 2015 (i.e. the average of 2014 and 2015) and 2030, a proportionate annual increase would imply 40% growth by 2021.

The research and analysis for this report, however, suggests that growth of 20% across the sector as a whole would be a good achievement given the reduction in salmon output in 2016 due to sea lice problems (giving a lower production base from which to grow), the developments in the pipeline summarised in this report and the time lag involved in achieving production on sites not yet submitted for planning consent; although higher growth would be possible with variables sufficiently positive in combination over the 2016-21 period. These positive factors principally include consents for new sites, biomass limits, growing domestic demand, growing export sales, success in tackling sea lice, and lack of major disease events.

Alongside such growth of 20%, it is assumed that an annual labour productivity increase averaging 2% would be achieved across the industry and its supply chain as a whole – i.e. a labour input unchanged from the previous year would produce a 2% increase in the volume of final sales. This assumes that achieving relatively high growth compared with the UK economy as a whole would be likely to be accompanied by a relatively high productivity increase.

Across the industry and its value chain as a whole, this would give employment growth to 12,022 FTEs x 1.2 x 0.888 = 12,811 (+ 789 FTEs) – i.e. baseline employment plus 20% with a reduction for productivity totalling 11.2% over 6 years. At 2014/15 prices, this would give corresponding increases in Scotland of £20.6m in related earnings and c£40m in GVA.

In less favourable circumstances, growth by 2021 might be c10%, with a probable smaller productivity increase (assumed at 1.5% per annum). This would give an employment increase to 12,022 FTEs x 1.1 x 0.915 = 12,100 (a small increase of 78 FTEs on 2014/15).

Indicative Scenarios to 2025 and 2030

As illustrated in this report, there are an extremely wide range of factors that will influence production levels, market price, productivity and employment impact between now and 2030 across the aquaculture industry and its value chain. Production could grow little (if at all) on the most pessimistic scenario up to doubling (as targeted by the industry with appropriate support), and with any level in between considered possible. GVA is rounded to the nearest £10 million in the tables below.

Should output double (in line with the industry's aspirations) with an average productivity gain of 2% per annum, impacts by 2030 would grow as follows:

TABLE 35: 2030 IMPACT WITH 100% OUTPUT GROWTH AND 2% PRODUCTIVITY GAIN PER ANNUM – SCENARIO 1

	2014/15 average	Growth	Total
Employment (FTEs)	12,022	5,841	17,863
Earnings (£m)	314.0	152.6	466.6
GVA (£m)	620	300	920

In as far as this level of growth would depend on higher production in the principal species of salmon through the development of larger production capacity sites further from the shore, 50% of this overall production growth might occur between 2025 and 2030; giving the following impacts by 2025:

TABLE 36: 2025 IMPACT WITH 50% PRODUCTION GROWTH AND 2% PRODUCTIVITY GAIN PER ANNUM – SCENARIO 1

	2014/15 average	Growth	Total
Employment (FTEs)	12,022	2,771	14,793
Earnings (£m)	314.0	72.3	386.3
GVA (£m)	620	140	760

If, in practice, growth rates in production by 2025 and 2030 were to be half of those relating to the industry's targets as profiled above, and with productivity growth averaging 1.5% per annum rather than 2%, impacts would be as follows, with volume growth to 2021 and 2025 pro-rata to growth to 2030. As noted above, growth from the 2014/15 average to 2021 due to a reduction in salmon output in 2016 might well be less than pro-rata, with the positive growth factors discussed in this report (including overcoming biological constraints) having more influence on production levels after 2021 than before.

TABLE 37: 2030 IMPACTS WITH 50% PRODUCTION GROWTH AND 1.5% PRODUCTIVITY GROWTH PER ANNUM – SCENARIO 2

	2014/15 average	Growth	Total
Employment (FTEs)	12,022	2,402	14,424
Earnings (£m)	314.0	62.7	376.7
GVA (£m)	620	120	740

TABLE 38: 2025 IMPACTS WITH 1.5% PRODUCTIVITY GROWTH PER ANNUM – SCENARIO 2

	2014/15 average	Growth	Total
Employment (FTEs)	12,022	1,791	13,813
Earnings (£m)	314.0	46.7	360.7
GVA (£m)	620	90	710

TABLE 39: 2021 IMPACTS WITH 1.5% PRODUCTIVITY GROWTH PER ANNUM – SCENARIO 2

	2014/15 average	Growth	Total
Employment (FTEs)	12,022	1,173	13,195
Earnings (£m)	314.0	30.8	344.8
GVA (£m)	620	60	680

Given the number of variables that will influence actual growth to 2025 and 2030, and taking trends during the past 10-15 years into account, these increases in employment and GVA impact might be considered more likely than the industry's scenario (which our analysis suggests is highly optimistic). Indeed, they would be a good achievement in the context of UK and Scotland economies that might overall have grown at best modestly. In summary, on this scenario, growth on 2014/15 would be as follows:

TABLE 40: GROWTH IN EMPLOYMENT, EARNINGS AND GVA BY 2021, 2025 AND 2030 WITH 50% GROWTH IN OUTPUT BY 2030 AND 1.5% PRODUCTIVITY GROWTH PER ANNUM – SCENARIO 2

	2021	2025	2030
Growth in employment (FTEs)	1,173	1,791	2,402
Growth in earnings (£m)	30.8	46.7	62.7
Growth in GVA (£m)	60	90	120

It should be appreciated that these levels of growth, when combined with the retention of 12,022 FTEs and associated income of £314 million, would represent a very valuable contribution to Scotland's economy; especially in those relatively remote and rural areas where there are employment clusters of high importance in the local employment context. Without (or with small) volume growth but with productivity growth to retain competitiveness against other produce, employment would otherwise fall.

Impacts in the UK as a whole would be greater than in Scotland through higher indirect and induced impacts and increased impacts through the value chains of the aquaculture sub-sectors, in particular through processing.

7. SUPPORTING AND REGULATORY BODIES

The aquaculture sector comprises not only the private sector firms across the supply chain, but also the supporting and regulatory functions of other organisations. Each of the organisations below provide a necessary function for a sustainable industry.

7.1. PUBLIC ORGANISATIONS

Marine Scotland:

Marine Scotland is a Directorate of the Scottish Government whose purpose is to manage Scotland's seas for prosperity and environmental sustainability, working closely with key delivery partners and others. Marine Scotland created Scotland's first National Marine Plan, which aims to ensure increasing demands for the use of the country's marine environment are managed, economic development of marine industries is encouraged and environmental protection is incorporated into marine decision making.

The organisation provides advice and guidance to ensure that developments are compatible with the National Marine Plan. The organisation looks to educate and engage with the public about the marine environment through promotion and events, engages with a number of different organisations and participates in different forums, such as the Marine Strategy Forum and previously the Ministerial Group for Sustainable Aquaculture.

Marine Scotland also provides the Scottish Government Audit and Review Process, which grants planning permission to farms that were previously consented by the Crown Estate (prior to 2007) and Permitted Development Rights, which permit the addition or change to equipment on a farm and changing production from one species to another without the need to apply for planning permission. The Directorate is also responsible for allocation and administration of the European Maritime and Fisheries Fund. Within Marine Scotland there are a number of organisations and teams:

- ***Marine Scotland Science*** which provides expert scientific, economic and technical advice and services on issues relating to marine and freshwater fisheries, aquaculture, marine renewable energy, and the aquatic environment and its flora and fauna, as well as providing the evidence to support the policies and regulatory activities of the Scottish Government and representing the Scottish Government at national and international meetings
- ***The Fish Health Inspectorate (FHI) – which sits within MSS*** **-** whose goal is to prevent the introduction and spread of listed and emerging fish and shellfish diseases in Scotland. They do this by undertaking statutory and diagnostic inspection and sampling programmes, providing advice to stakeholders and implementing regulatory functions in accordance with the current aquaculture and aquatic animals health regulations. The FHI providers a free diagnostic service to fish and shellfish farmers and other parties responsible for the care of fish and will investigate reports of unexplained mortalities, take samples and diagnose the cause where possible. This covers inspecting measures to contain sea lice and prevent escapes.
- ***Marine Scotland Licensing Operations Team*** provides a "one stop shop" for all marine licence applications in Scottish waters.
- ***Marine Scotland Aquaculture Policy Team*** supports policy and strategy matters, along with the Ministerial Group and technical working groups.

***European Maritime and Fisheries Fund* (EMFF) Grants**

Marine Scotland manages the EMFF, and grants cover a number of areas supporting long term sustainable growth of the industry, including:

- Innovation in aquaculture
- Productive investments in aquaculture
- Management, relief and advisory services for aquaculture farms
- Promotion of aquaculture human capital, networking, training and education
- Increasing the potential of aquaculture sites
- Encouraging new aquaculture farmers practising sustainable aquaculture
- Aquaculture providing environmental services
- Animal health and welfare measures
- Marketing measures
- Processing products[70]

Highlands and Islands Enterprise:

HIE is the Scottish Government's economic and community development agency for the north and west of Scotland. Its purpose is to generate sustainable economic growth across the Highlands and Islands. Aquaculture sits within Food and Drink, a key growth sector supported by HIE. It is headquartered in Inverness, with eight regional offices, providing coverage for a wide geography including remote and rural communities. HIE (and its predecessor HIDB) has been an important supporter of salmon farming since its early tentative stages of development and gives aquaculture a high policy priority due to its concentration in outlying and fragile areas. It invests in research, innovation, development grants, and a range of assistance to account managed businesses to support the industry's development.

Scottish Enterprise:

Scottish Enterprise (SE) is Scotland's main economic development agency for the east and south of Scotland and a non-departmental public body of the Scottish Government with, also, Scotland-wide responsibilities. SE works with partners in the public and private sectors to identify and exploit the best opportunities to deliver a significant, lasting effect on the Scottish economy. Food and Drink is an area of focus for the organisation, with specific support offered in networking with other food and drink professionals, developing healthy food products, and providing supply chain development support. It is headquartered in Glasgow, with regional offices in other centres.

Skills Development Scotland:

Skills Development Scotland (SDS) is the national skills body supporting people and businesses to develop and apply their skills. In early 2017, SDS launched their refreshed Skills Investment Plan for Food and Drink, which has a specific requirement to deliver targeted support to the growing aquaculture sector. The Skills Investment Plan identifies planned activity to assess and forecast demand for employment and skills within the aquaculture sector, review current skills provision and develop and implement a workforce planning strategy, in partnership with Highlands and Islands Enterprise.

LANTRA:

LANTRA is the Sector Skills Council which supports skills and training for people and businesses in the land-based and environmental sector, including aquaculture. LANTRA has developed Modern Apprenticeships in Aquaculture at SCQF levels 5, 7 and 9 to support the industry in Scotland. LANTRA estimates that there will be 92 registrations on all aquaculture apprenticeships in 2016/2017.

Local Authorities:

Local Authorities are responsible for local economic development and planning decisions for all new aquaculture developments, change of use and alterations to existing approved sites. Planning departments may have staff members with a specific focus on aquaculture, and Business Gateways (operated or funded by the Authorities) assist start-ups and early stage growth businesses.

Community Councils: represent community views in local development decisions.

SEPA:

The Scottish Environment Protection Agency is Scotland's principal environmental regulator, protecting and improving Scotland's environment. To negate the adverse effect that aquaculture can have on the environment, SEPA promotes compliance with legislation and sustainability through the application of the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) and their amendments, which licence and monitor aquaculture activities. SEPA has 22 offices throughout Scotland, including eight in the Highlands and Islands.

The Crown Estate (Scotland Portfolio):

The Crown Estate, owning almost half of the foreshore in the UK and almost all of the territorial seabed, has been an active manager of aquaculture-related shoreline activities, and it has sought through its leasing to support the growth of aquaculture along with other marine industries. Recently, The Smith Commission recommended that the management of Crown Estate assets in Scotland and their revenues should be devolved, and the Scotland Act includes provisions for the UK Government to complete the transfer of assets and devolution of legislative competence.

Scottish Aquaculture Innovation Centre (SAIC):

The Scottish Aquaculture Innovation Centre aims to transform the relationship between the aquaculture industry and research community, generate closer connections between these two communities, and foster innovative industry-relevant collaboration. SAIC's current priority areas as given on its website are:

- Addressing environmental and health challenges, particularly sea lice and gill disease
- Developing feeds that optimise fish health and nutrition
- Unlocking additional capacity for aquaculture development through innovative, evidence-based approaches
- Establishing a reliable supply of mussel spat (baby mussels).

It is one of eight Innovation Centres established by the Scottish Government in 2013-2014. The SAIC is funded by the Scottish Funding Council (in partnership with SE and HIE) and by industry. It is based in Stirling.

7.2. INDUSTRY ORGANISATIONS

The organisations for salmon, shellfish and trout whose roles are summarised below represent individual members and address issues common to many firms, with collective action often required.

Scottish Salmon Producers Organisation: SSPO has its headquarters in Perth and a base in the Shetland Seafood Centre in Lerwick. The organisation plays a central role in representing the industry on political, regulatory, media and technical issues in Scotland, the UK, EU and internationally.

Association of Scottish Shellfish Growers:

Based in Rosemarkie on the Black Isle in Highland. The main objectives of the ASSG are:

- To improve the financial returns of all Scottish shellfish producers;
- To increase demand for Scottish farmed shellfish by promotion;
- To set and encourage acceptance of quality standards for Scottish shellfish, and to establish appropriate Codes of Practice;
- To collect and disseminate shellfish industry statistics;
- To provide a forum and lobby to enable government and others to be properly advised on matters concerning the shellfish industry; and
- To carry on trades, industries and businesses which will further the above objectives.

British Trout Association:

The British Trout Association was set up in 1983 and represents around 80% of trout production in the UK. BTA has over 100 members made up of trout farmers, feed suppliers and a number of aquacultural academics. It aims to provide a legislative framework for the industry, to support research and development and to promote marketing activities within the industry. It is based in Ingliston (Edinburgh), is entirely funded by trout farmers and feed suppliers and receives no direct funding from the Government.

Scotland Food & Drink:

Scotland Food & Drink is a unique leadership organisation – supported by the Scottish Government – tasked with growing the value of Scotland's food and drink sector, making it more profitable and delivering greater global success in a challenging and competitive environment. It is based in Ingliston, Edinburgh.

Scotland Food and Drink is not specifically aquaculture-focused but plays a role in its development as a key food sector.

7.3. RESEARCH, DEVELOPMENT AND INNOVATION

The RD&I landscape in Scotland includes:

Research & Skills

- ***University of Stirling Institute of Aquaculture:*** Founded in 1971, the Institute of Aquaculture is the leading international centre in its field, and the largest of its kind in the world. It undertakes research and project work globally and regularly contributes to both finfish and shellfish work regularly in Scotland.
- ***University of St Andrews:*** operates programmes on Sustainable Aquaculture, and hosts the multi-institution research platform MASTS (see below).
- ***MASTS:*** Marine Alliance for Science and Technology in Scotland. Includes research and contributors from various Scottish universities.
- ***SARF:*** Scottish Aquaculture Research Forum. SARF is undertaking a wide range of current projects, with a total value of almost £1 million. Subject areas range from shellfish planning issues to specific treatments for AGD and sea lice.
- ***SAMS:*** The Scottish Association for Marine Sciences (part of the University of the Highlands and Islands) – conducts research (and consultancy work through its associated SRSL arm) into marine industries, including aquaculture. SAMS have set up a new dedicated Centre for Aquaculture.
- ***The NAFC Marine Centre*** is a UHI partner institution located in Shetland. The Centre delivers training and education, carries out applied research and development, and provides consultancy, advisory and other services for the maritime industries.
- ***Marine Scotland Science (part of Marine Scotland)*** provides expert scientific, economic and technical advice and services on issues relating to aquaculture (along with other marine topics).

A three year project funded by the EU Horizon 2020 Programme, Aquaspace, led by SAMS, with partners including Marine Scotland Science and the James Hutton Institute, is identifying and mapping the key constraints on spacial expansion experienced by the industry. This is important in Scotland with the best inshore or close to shore sites already having been developed, with many at capacity.

SAIC has funded more than 30 projects and facilitated others. Examples include the following:

- A project, led by BioMar, in partnership with Morrisons and the Institute of Aquaculture at the University of Stirling, is identifying alternative protein sources that are locally sourced and have low environmental impact for use in feeds, with a focus on avian-derived protein which could significantly reduce feed costs.
- A project involving Alltech partnering with the University of Glasgow and Marine Harvest to explore inefficient digestion, a key cause of poor growth in salmon, in relation to the fish's metabolic rate.
- A project led by Kames Fish Farming, in partnership with the University of the West of Scotland, Marine Harvest, Randox Food Diagnostics and Europharma, to create a method of

assessing fish health with earlier and more specific diagnoses that would reduce veterinary requirements.

- A project involving Marine Harvest, SAMS, Inverness College Rivers and Lochs Institute and SEPA to develop a more efficient method of testing seabed diversity using metagenomics, a technique which takes DNA samples direct from the environment.

Glasgow University, with research partners Biomar, a salmon feed firm, and Marine Harvest, have developed a simple test to aid the diagnosis of salmonid alpha virus, which causes pancreas disease and can cost millions of pounds to eradicate.

In 2016, SSF made a £4 million investment in the first Thermolicer to be used in Scotland (with £425,000 EMFF support). This Norwegian-built system offers an alternative to the use of medicines by using water temperature changes to rid fish of sea lice. The Thermolicer removes 95% of the sea lice on a fish, although there have been fish mortalities following its use (and elsewhere through failed sea lice treatments by other companies). This reflects the learning that is not unusual when innovative processes are introduced.

In October 2016, the drive to reduce sea lice received a £1.76 million boost following a successful application to the European Maritime Fisheries Fund (EMFF). Co-ordinated by SAIC on behalf of eleven companies, the project will enable a range of alternative technologies and approaches to reducing sea lice to be trialled in Scottish waters.

Other:

- Marine-related college courses.
- RD&I carried out by commercial companies, with knowledge transfer from this potentially of wider sectoral benefit (see Marine Harvest example at 7.3.1 below).

Interface is a mechanism for commercial and academic partnership. The Interface team helps businesses with the creation and development of new products, services and processes by connecting them to the most appropriate academic expertise within Scotland, and can help in accessing funding.

For more information on the above institutions, see Appendix 10.1.

Salmon (and trout, through Dawnfresh) producers tend to be focused on R&D through their own company investment, or through suppliers (e.g. pharmaceutical firms and engineering / equipment providers). In addition to direct company investment, public bodies are investing in the core challenges faced by the industry, including sea lice. In October 2016, the drive to reduce sea lice received a £1.76 million boost following a successful application to the European Maritime Fisheries Fund (EMFF). Co-ordinated by SAIC on behalf of eleven companies, the project will enable a range of alternative technologies and approaches to reducing sea lice to be trialled in Scottish waters.

There is a distinction between firms with strong international – particularly Norwegian – production linkages, and those without. The level of R&D investment in Norway is considerable, both within firms such as Marine Harvest (see below), and through bodies like the Norwegian Institute of Food, Farming and Aquaculture (NOFIMA)[71]. This investment should cascade rapidly through to Scottish firms via group or parent companies. Scotland can thus draw on this intellectual property, although

there are many areas where Scottish-specific solutions (due to geography, industry structure, and regulations) are necessary.

7.3.1. INTERNAL COMMERCIAL R&D, MARINE HARVEST

Internal commercial research is prominent in the larger companies (though they are also engaged in collaborative research efforts). For example, the Marine Harvest Global R&D Department has recently comprised the following staffing and functions:

- 16 FTEs, 6 PhDs
- Veterinary medicine, aquaculture, nutrition, genetics, engineering, marine biology
- 5 functional areas
    - Environment & sustainability
    - Farming technology
    - Fish health & welfare
    - Quality, food safety & processing technology
    - Feed & fish performance
- Management, coordination and conduct of research, development and innovation
- Competency development and exchange of knowledge across the entire organisation
- Development of best practices, group policies and minimum standards across all business units
- International competency teams' [72]

R&D contributions towards long-term ambitions include:

New farming systems	Develop and test new closed containment technology
Sea lice control mainly by non-medicinal means	Develop non-medicinal methods, large-scale implementation and validation of zero adult female strategy, further develop clean fish farming
Feed raw materials no limit for sustainable growth	Identify and implement safe and sustainable alternative feed raw materials, support development of new sources for marine Omega-3 fatty acids, and ensure nutritional requirements

8. Actions That Would Assist The Industry to Maximise Impacts To 2030

8.1. Delivering on Industry Aspirations

The industry has put forward aspirations to double volume and impact by 2030, and has set out the actions required to achieve this. With concerted effort and a favourable context this might be possible, but there are a number of factors discussed in Section 6 above that could limit the industry to a lower growth scenario unless they are overcome.

The key drivers of future growth are summarised below, with actions recommended for industry and supporting / regulatory institutions: these are broadly in line with the Vision 2030 report's call to action in October 2016. Some of the actions are already underway, and suggestions are given in the Aquaculture Growth to 2030 document on particular measures that are considered particularly important and who might take or share responsibilities for taking these forward. The drivers include the actions that will be required to address key constraints which could otherwise greatly reduce growth potential – including the availability of new sites, biomass limits, sea lice, diseases, difficulty in financing new investment, and skills availability within Scotland's workforce.

Key variables such as sterling's exchange rate, the availability of migrant labour after the UK leaves the EU, and trends in the UK and international economies are outside the influence of the sector and its support organisations – although wider actions by the Scottish Government will be relevant in some domains.

The time periods in the table below are approximate and, in practice, actions and their impacts could overlap the time periods.

8.1.1. KEY DRIVERS OF FUTURE INDUSTRY GROWTH

TABLE 41: KEY DRIVERS OF FUTURE GROWTH

Activity by period to 2030	Industry	Supporting / Regulatory institutions
To 2021:		
Containment and ameliorating the effect of sea lice on salmon giving a higher harvested output ratio	Internally funded company research. Innovation by suppliers (e.g. 'cleaner boats') Marine Harvest's planned new wrasse hatchery	SAIC tasked with sea lice as a priority area and suitably resourced. Regulators managing environmental risks created by sea lice containment.
Rationalisation of existing sites and operations, with an increased focus on the larger, more productive sites, whilst leaving scope for growth in new or currently minority species	Commercial drivers – takeovers or amalgamations and improving efficiencies of supply chains to give productivity improvements. Decommissioning of less productive salmon sites and increasing biomass up to 4,000t or more capacity possible on suitable sites. The net output gain could be up to 25-30%, with site usage distributed to manage disease and environmental risks.	Introduction of Deposition Zone Regulation (DZR) from 2017. Monitor and manage competition considerations as industry concentration increases. Provide mechanisms for easier changes in the utilisation of current sites.
Shorter farm cycles with more regularised output	Investment in recirculation systems. Research, Development and Innovation investment in more exposed site operations (giving productivity improvements post 2021).	Consider planning and biomass implications of new systems of operation and provide clear guidance.
Shellfish: address access to finance	Industry associations and ILG initiatives to engage financial institutions to understand and invest in the sector. UK-based banks are being encouraged but Nordic finance should also be considered (as in Shetland) to ensure access to finance does not constrain growth.	Support industry bodies in raising awareness within the finance sector.
Shellfish: mussel farmers to address spat availability	Take collective measures for a systemic threat, and support individual farmers to increase productivity through more active spat management.	Underway – support of hatchery through collaboration of institutions (including SAIC).

Activity by Period to 2030	Industry	Supporting / Regulatory institutions
To 2025:		
Streamlined planning and consenting	Industry to give planners clear guidance of needs, and of emerging new techniques that may require or allow new consenting processes.	Marine Scotland, Crown Estate, SEPA and local authorities to work together.
Biomass limit models allow for new methods of measure and production	Ensure sea lice controls meet new biomass impact requirements.	To provide a framework that allows increases in biomass so long as these meet required impact parameters.
Continued industry rationalisation	Industry will continue to rationalise processes – some investments will remain competitive and firm-specific.	Competition law monitors the industry. Supporting institutions might seek ways to support industry diversity, e.g. through access to finance.
International competition and markets	Scottish industry must be on a competitive scale and cost of production footing in the global market.	Regulators should anticipate and adapt as far as possible to new models of operation.

Table continued overleaf

Activity by Period to 2030	Industry	Supporting / Regulatory institutions
To 2030:		
Continuing strong growth in demand for aquaculture products globally, including focus on food's carbon footprint, and fish being healthier than meat	Industry and consumers to explore and welcome new models for feed (possibly with greater vegetable content). Possible carbon footprint scoring measures could greatly support the case for aquaculture products in diet.	Regulators to consider the environmental impact of aquaculture more broadly, taking into account the global as well as local impacts.
Adapt to climate change risks	Algal blooms, diseases and suitability of sites should be addressed within firms and as a collective challenge.	Anticipate needs for adaptation, disease control and changes in site impacts.
Larger scale salmon farming operations in more exposed sites, and controlled recirculation systems for smolts	Under development – clarity of viable production should be clearer by 2021, though current capacity likely to continue in addition to new production models. Industry expects that use of sites further from the shore will *not* require a paradigm shift in operational model (to an Oil & Gas-style 'offshore rig' model) but that there are a large number of exposed sites that are suitable and could be accessed using available technology.	Regulators should adapt planning and consenting processes to allow for new production models. Consider a proactive approach to planning, with site scoping and allocation to mitigate conflicts.
Process change requiring new skills	Industry invests internally in training and provides clear requirements to institutions providing courses and Skills Development Scotland on future skills needs	Skills Development Scotland to work with HIE, training providers and the industry to align provision to future needs

In the short term, the most important challenge that will need to be met is the sea lice problem faced by salmon producers, whilst the main potential opportunity is considered to be increased salmon production from sites where biomass limits might be raised should new modelling show that this can be achieved while still complying with regulatory standards. In the longer term, the greatest increases in volume and value could come from developing larger more exposed sites further from the shore for salmon production subject to environmental acceptability and operational viability relative to development costs.

With regard to rainbow trout, the main growth route is considered to be through increasingly adopting the model of production and value added product development that has been successful for salmon; with UK marketing focused on sales of standard and new products in supermarkets

alongside salmon products. In the shellfish sector, growth is considered most likely to be achieved through collaborations as well as through expansion by the more ambitious businesses.

With the extent of international growth in demand that is expected, the market for Scotland's aquaculture is not considered likely to constrain growth – provided that its productivity growth compares well enough with international productivity growth for its price competitiveness not to be eroded. As currently, planning and other consents are likely to be more of a constraint in some areas than others, and it will be important that these do not increase as a barrier. Workforce development needs should be possible to meet through planned private/public sector programmes based on identified needs as the sector evolves. Encouraging young people to work in the industry will be an important aspect of future workforce development.

With the increase in producing sites that will be required to achieve significant growth, rural and remote parts of Scotland should continue to benefit significantly from this growth.

8.2. R&D PRIORITIES

Research, Development & Innovation (RD&I) in Scotland should, above all, successfully address Scottish aquaculture industry challenges for a sustainable industry, and ideally provide economic benefit from the commercialisation of Scottish innovation. This is in the context of a wider global aquaculture R&D landscape, which for salmon needs to be related to Norwegian activities. Knowledge transfer from these activities is largely positive because (a) the ownership structure of the Scottish salmon industry means that RD&I should transfer from Norwegian to Scottish firms (though this will be uneven across companies for the same reason), and (b) in 2016 the Scottish Aquaculture Innovation Centre[73] agreed to collaborate with Nofima on areas of mutual interest such as sea lice. Scotland-specific RD&I priorities are set out in the recently published innovation 'roadmap' entitled Scottish Aquaculture: A view to 2030 (2017)[74].

The recent Aquaculture Science and Research Strategy[75] (2014) summarises some of the research challenges in Aquaculture, giving prioritisation to, and actions recommended before 2021 on:

- Nutrition
- Stock Improvement
- Health & Welfare
- Food Safety & Hygiene
- Technology & Engineering
- Wild-Farmed Interactions
- Markets, Economics & Social Science
- Capacity
- Blue Biotechnology & Growth

A more detailed breakdown of activities is given in the above strategy.

8.2.1. GLOBAL DRIVERS IN SCOTTISH RD&I

The Vision 2030 group and most industry participants recognise the need for RD&I to benefit the Scottish suppliers and producers within the supply chain. The industry structure benefits from rapid technological transfer from Norwegian investment, but the same vertical integration:

a) Still requires extensive Scottish-specific research to address Scottish-specific aquaculture challenges (see 0 above and the Innovation Roadmap)

b) Can prevent Scottish supplier firms and innovators access to the vast farmer/producer company demand for goods and services; and

c) Can be a barrier to entry for Scottish supplier firms who must get their products 'recognised', formally and informally, in comparison with Norwegian innovation. The Scottish Technical Standard may help deliver this.[76]

Further, the industry should seek methods to:

d) Innovate rapidly, with the ability to validate or endorse innovation beyond academic research.

e) Trial new techniques without overly deterministic constraints on risk – often new techniques require some risk and there can be uncertain impacts. This must be embraced as a means of avoiding ongoing negative impacts. For example, a sea lice trial must be undertaken in the knowledge it can accelerate the mitigation of a current and widespread negative impact.

f) Allocate catalytic funding (as in SAIC model, but possibly expanded out to a virtual and actual RD&I centre) appropriately and with a view to systemic value. This may include supporting individual company initiatives if the case can be made that it will benefit all in the long run.

To address these needs, a scoping study into a 'Centre of Excellence' concept ('Exploring the concept of a centre of innovation excellence for Scottish aquaculture', 2016[77]) has been undertaken for SAIC, which was positively received. The priorities are to build on existing industry capacity but with

coordination under one organisation using a consortium approach. Public sector investment is seen as desirable for pump-priming, but the sector should be delivering on a commercially sustainable model in the longer term.

In addition to their use in rearing smolts, it is possible that RAS systems could enable salmon to be grown onshore rather than at sea. Niri[78], a Norwegian-Irish firm, has set up and started to stock a site near Campbeltown using RAS systems, where they plan to grow up to 40,000 tonnes of salmon in tanks.

8.2.2. INDUSTRY RECOMMENDATIONS TO 2030

Within the report 'Aquaculture Growth to 2030' (referred to as Vision 2030), there is specific reference to the need for and importance of RD&I in the aquaculture sector going forward. Of twenty specific actions recommended, the development of Innovation Sites in Scotland features in the top three, and the Vision demonstrates the degree to which innovation will need to be a driver for many of the developments in the industry to 2030.

Both the Vision 2030 report and the Roadmap to 2030 produced by SAIC have highlighted the need for fostering RD&I capacity in Scotland, both for new innovation / entrepreneurship and techniques, and for taking innovations introduced elsewhere and tailoring them to the Scottish context.

Recommendation 11 in Vision 2030 states the need for specific innovation sites that enable growth of the sector by providing space for 'controlled trials, development of equipment, technologies or disease control measures and regulation'. Such a development is needed in Scotland and would ultimately benefit all parties through a collaborative approach with Marine Scotland, SAIC, SEPA and the newly established Industry Leadership Group.

The Vision 2030 report goes on to suggest, in Recommendation 12, that the ILG adopt the Roadmap to 2030 which provides further detail on specific innovation requirements that require attention in Scotland.

8.2.3. INNOVATION ROADMAP

The roadmap, Scottish Aquaculture: A view to 2030 (published February 2017) breaks down the industry's requirements by thematic area using a Market Systems Approach, with innovation addressed as a cross cutting issue throughout but also with key requirements identified, including (across all aquaculture):

- Review of innovation pathways (as above)
- Fostering Scottish entrepreneurs
- Offshore / closed containment technologies (to address capacity and disease management)
- Use of innovative technology from other sectors (as the industry overcomes technical challenges and upgrades)
- Further development of IT infrastructure in local areas (essential for business efficiency and quality of life for staff).

For shellfish, the requirements are:

- To develop hatcheries to ensure spat availability (underway, but in the early stages across the industry)

- Research and early warning systems into disease and environmental events (including algal blooms)
- To develop financial mechanisms – 'innovative' financial products to overcome limitations on investment (based mostly on demonstrating business income over traditional collateral for loans).

It is clear from the three high-level reports referenced above that innovation will be of significant importance to the future development of Scottish aquaculture. In order to grow the volumes required and meet environmental requirements in Scotland there will be a need for new technologies and methods for combatting disease and management issues that arise from increased scale. A key task of the newly formed ILG will be to identify the specific RD&I requirements that require immediate action as suggested by these reports, and work towards addressing them in a collaborative manner.

8.3. WORKFORCE DEVELOPMENT

Vocational and technical training will be required as aquaculture operations increasingly rely on automated and technology-dependent systems. Scotland has strong academic training capacity, but more aquaculture-specific engineering and technology training schemes are called for, with many new innovations and methods being brought in at farm level. This relates to the industry's general upgrading of systems, from traditional farm practices (e.g. manual feeding of fish) to automated systems of monitoring, feeding, harvesting, and communications in more capital-intensive production. More of the input involved in such systems could be by staff not permanently employed at farm sites; and equipment suppliers in Scotland will need appropriately qualified and trained staff for this sector to maximise its growth potential, especially as new technologies are developed.

Beyond changes in specific skills requirements by producers and businesses in the value chains of the different sub-sections of aquaculture, workforce requirements will depend on:

- The geographical location of job vacancies, whether these are additional or due to labour turnover.
- The extent to which the industry's aspirations to double turnover by 2030 are achieved – albeit that employment to output ratios will tend to fall due to productivity improvements.
- Ageing of the workforce. By 2030, the age profile of the sector will have become older – although currently age structure is not as much of an issue as in sectors such as construction since the sector is still relatively new, with relatively young people tending to have been recruited when new farms have started production.

As part of the new Skills Investment Plan for Scotland's Food & Drink the Plan under preparation for aquaculture, being led by HIE with SDS and other partners, the following support has been identified as required by the growing sector:

- Assess current and forecast demand for employment and skills within the sector.
- Review current skills provision, including MAs and FE/HE, with a view to identifying potential gaps or areas for development.
- Develop and implement a workforce planning strategy to ensure that the sector has the supply of skills required to support future growth.

Employers report that it has become increasingly difficult to interest young people in working in aquaculture, and engagement with schools should emphasise the roles in the sector that require particular skills and qualifications and are relatively well paid.

The role of employers in skills development in aquaculture has been strong to-date (as illustrated at 3.1.6 above), and course providers should work very closely with businesses to share responsibilities in a co-ordinated way.

8.4. THE ROLE OF THE PUBLIC SECTOR

The public sector's role in aquaculture covers diverse areas, including: regulation and planning (e.g. SEPA, Marine Scotland, Local Authorities), market and sectoral development (e.g. Scotland Food and Drink), and support in research and innovation (e.g. Scottish Aquaculture Innovation Centre).

The Scottish Aquaculture 2030 Vision for Growth sets out a set of priorities and proposed actions, including public sector regulators and partners.

8.4.1. INSTITUTIONAL FRAMEWORK

The UK leaving the EU will have implications relating to environmental directives, trade arrangements, and loss of access to the European Marine and Fisheries Fund (EMFF). It is unclear what new arrangements will emerge but there are calls from the sector that the EMFF's value should be replaced or replicated by a similar fund to support industry development – particularly in shellfish where commercial investment is weaker.

Activities and responsibilities include Marine Scotland Science research, Fish Health Inspectorate (FHI) and diagnostic functions, planning advice, audit and review, engagement, promotion and events, and cooperation with other countries. These regulation and promotion functions together relate to an industry that has been considered largely from a production perspective, rather than a market development one.

The Ministerial Group for Sustainable Aquaculture (MGSA) has tackled industry challenges by theme and work package – now the ILG will add a more focused industry voice to those functions. Public institutions should retain a strong and active voice, and bear in mind that Scotland's aquaculture sector could contribute significantly to its growth objectives if it is managed well.

Focus for Marine Scotland and other public sector bodies: Tackle production constraints as actively as possible, within the bounds of robust standards, with a view to achieving secure growth for rural communities. The global market is sufficiently attractive to justify significant investment in supporting industry development. The multinational companies in the sector might focus their future investment in other countries without a sufficiently supportive context in the UK, which could further reduce Scotland's relative competitiveness in terms of unit costs of production across its aquaculture sector.

8.4.2. RULES: LICENCING AND REGULATION

The Scottish aquaculture industry has a reputation for quality products produced under robust but proportionate regulation, which (e.g. a reputation for clean waters, in a Scottish loch setting) translates into a premium for the product. Planning/consenting procedures are intended to manage

competing claims on marine space and balance the growth of aquaculture with other social and economic (other industry) objectives.

SEPA's regulatory approach is predicated on limiting the scale of development to match the environment's capacity to bio-degrade the wastes arising, including sea-bed capacity to tolerate solid wastes from faeces and waste food, and the local environment to assimilate the release of toxic medicines and other chemicals. If the natural seabed invertebrates can effectively capture and process the organic waste without the ecosystem dying, then this type of externalized treatment of waste is acceptable from SEPA's point of view, SEPA's assessment takes account of site-specific capabilities here and larger tonnages can be accommodated in more open, well-flushed areas.

The aim is to achieve sustainable growth, and to that end the recommendations of the Independent Consenting Review are being progressed through the Capacity Working Group.

IMPLICATIONS FOR SITES

These considerations influence the viability of existing and future sites (and indeed the risk and strategic profile of the industry). Despite relative consensus on these considerations of value and environmental management, however, there are concerns that:

- **SEPA's regulatory framework** for ensuring acceptable water quality may not allow for sufficient local flexibility, nor allow for impacts that are tolerable in the context of the economic benefits they could bring. Regulations are perceived to be increasingly constraining, rather than more discretionary.

  Clearly, more flexibility or alternative discretionary approaches could introduce a higher *risk* of negative environmental impacts, as demonstrated in the Chilean salmon industry (which has faced significant disease and environmental problems; yet it maintains production volumes well beyond Scotland's current capacity (though with regular relapses/crashes). This should be addressed with the introduction of a new deposition zone regulation (DZR) (see below) which is based on a new predictive mathematical model for setting a sustainable starting biomass (the current model is considered reliable in modelling impacts up to 2,500MT, but less reliable beyond that). The new model should overcome this constraint and allow for larger stocking and therefore production volumes where the impact is within acceptable limits.

- **According to SEPA, DZR** will promote sustainable growth in the right areas, providing opportunities for expansion of sites and development of new sites in areas best able to cope with the wastes arising. Some in the industry are very optimistic about the outcomes from this new methodology, whilst others worry it may not produce the results hoped for. The intention is that the method by which biomass limits are established will change, allowing a rationalisation of existing sites, with likely increasing volumes in some, but maintaining the status quo in others. It is expected to ultimately create a net increase in the capacity of existing sites and permit new close-to-shore, but exposed, sites to be developed with high productivity. This is seen as viable and achievable with existing technology.

The DZR approach has been developed to match as closely as possible the environment's capacity to accommodate the wastes arising (cage fish farms have no means to treat wastes prior to discharging them to the environment), and it warrants increased analysis and attention to ensure the balance of risks and impacts is right – creating a virtuous circle of sustainable impacts and larger production

volumes. SEPA proposes to offer the model to fish farmers to use as a planning tool on different proposed sites, which will allow producers to gauge, at as early a stage as possible, which sites will be suitable to take forward for planning and licensing.

Recirculation Systems and Larger Smolt Production

Smolt production is based on abstracting a freshwater supply from rivers, and discharging waste water, and the factors for compliance are well established.

RAS sites will require an initial supply of water, then some replenishing, but as a controlled environment will have relatively strong controls on waste. Subject to compliance, this is not considered a challenge in the same way as seawater cage farm sites, and so RAS may, in due course emerge as a mitigation measure as producers overcome site, disease and environmental factors.[79]

Focus for site licencing: in the context of much contested problems of local environmental impact and sea lice threats, there is an opportunity through the NEWDEPOMOD system, and with more exposed sites, to move far beyond the current production level.

8.4.3. INFRASTRUCTURE

In addition to supporting R&D, and ensuring compliance with the regulatory framework to catalyse good growth, the public sector could play a role in supporting and co-ordinating improvements in infrastructure.

Telecoms infrastructure will be increasingly important – as sites move further from shore, accessible days will become fewer, and more remote technological solutions will be needed. Telecoms are also important in attracting and retaining staff, who expect more connectivity, particularly when deployed in remote areas. This will require balancing public with company interests, though ferry and pier/jetty provision is a comparable example where public infrastructure can unlock, and be made viable by, commercial activity.

Road and ferry transport has been cited as a challenge for aquaculture because production tends to be in remote and sparsely populated regions, or islands. Increasingly the supply of feed and other production services will be sea-based. This will have an impact on the appropriate balance between public and private investment, e.g. in pier and harbour infrastructure.

Focus for infrastructure: with increased volumes to 2030, infrastructure investment should take into account the potential economic value from this, with joint planning at local level between companies, local development trusts and the public sector (Staffin slipway in Skye being an example).

8.4.4. MARKET (AND WIDER SECTORAL) DEVELOPMENT

Scotland Food and Drink recognises aquaculture's strategic potential within the Food and Drink sector. Its aim is:

> '*to guide the [food and drink] industry [to] make the most of our natural resources, the skills of our people and the energy of businesses operating right across the supply chain. So to achieve a sustainable and profitable food and drink industry that is consumer-focused, market-led and internationally competitive - and benefiting our primary and secondary producers - we must work hard if we are to reach those strategic goals.*

Exploiting premium markets both in the UK and internationally, making our supply chain more effective, encouraging collaboration through communication and striving to improve the high level of skills within the food and drink industry have never been more important.'[80]

This clear call to develop a brand that includes Scottish salmon and other aquaculture products is strongly consistent with the industry's interests, and (for reasons laid out in this report) those of Scottish communities engaged in aquaculture. However, it should be noted that for the international industry, profitable Scottish production is complemented by volume growth in other countries. For Scotland (and the wider UK), it is in the interests of public bodies to see more global market share captured, even if it starts with realising more of the UK market through growth in the ability to supply.

Focus for market development: In the context of supply volume constraints, Scotland's ability to export is limited, and prioritising the domestic UK market can be rational. Nevertheless, a Scottish provenance premium appears to apply in niche international markets as well as in the UK, and given the growing global market this should act as a catalyst to spur investment in production. Also, it would seem unlikely, for the main species of salmon, that UK market growth would be sufficient to contribute proportionately to the aspiration to double the industry's output by 2030. Producers are thus likely to need to focus their market development on the many opportunities across the world, including countries such as China with relatively rapidly increasing GDPs and numbers of people able to afford food products such as salmon.

9. SUMMARY OF CHALLENGES AND OPPORTUNITIES

Scotland's aquaculture sector has a more certain future in terms of customer demand and scope to grow to meet this than most other sectors of its economy. As evidenced in this report, this confidence relates to:

- The rapidly growing world population, with a large number of people in developing countries each year moving into income brackets where they can afford to buy Scotland's aquaculture produce. For example, 'China's share in global salmon net imports is projected to increase from a third in 2006 to more than half by 2030.'[81] Allied to this is limited scope for growth in wild fisheries and the limited number of countries that can farm salmon healthily and cost-effectively. A wider discussion of global trends is available in the FAO's Fish to 2030: Prospects for Fisheries and Aquaculture (2013).
- The international focus of the companies that farm salmon, which means that Norwegian and Chilean production growth will tend to be focused on supplying world growth in demand (which is expected to be high) rather than competing in the UK or with the export markets targeted by the multinational companies and the smaller Scottish companies for Scottish whole and processed product (which is small in relation to international supply).
- The scope for productivity improvements across Scotland's aquaculture value chains – including efficiencies in feed production costs; new systems for rearing young fish to shorten their time in sea water; increases in permitted biomass through a better understanding of the biomass limits of sites; larger sites for salmon further offshore; increased mechanisation in processing; and production increases and economies of scale in other aquaculture sectors through co-operation and amalgamations.
- The appetite for growth and the financial strength (from their past profits) of the major businesses in the sector.

Specific opportunities include:

- Growing the UK market through messages about the health benefits of eating farmed salmon, trout and shellfish, increasing product diversification (including sauces), strong Scottish branding, and maintaining price competitiveness.
- Growing overseas markets through maintaining a margin for Scottish provenance, collaborating with other Scottish food and drink producers in marketing and establishing new forward linkages with processors and agents.
- Stressing the low carbon footprint of aquaculture compared with typical agriculture to those concerned with the climate change impacts of their consumption – countering, for some people (e.g. councillors making planning decisions), local negative environmental impacts.
- Creating additional relatively skilled and well paid jobs in Scotland through the value chain as the sector grows through a transition from manual work to supervisory and technical roles as mechanisation increases – particularly in processing.
- Increasing R&D employment through collaborations between companies, support organisations and academic institutions across the supply chain, with a combination of public and private funding.
- Success, through R&D, in developing larger sites for salmon in deeper waters that can be developed and operated (without damage to cages, nets or moorings) cost-effectively

through producing large volumes – which will be necessary given the higher development and operational costs per site that will be involved.

- Growing employment in Scotland in equipment supply and maintenance, with import substitution and increasing scope for exporting equipment as company scale and expertise grow.
- Identifying innovation sites, as recommended by the industry working group, to permit controlled trials and development of innovative equipment, technologies, disease control measures, and regulation. These sites might be shared by public and private users.
- Continuing to play a role in supporting peripheral and fragile areas that are losing population and have ageing resident profiles through increasing year-round sustainable employment through investments in new sites and other facilities in local areas.

The main challenges in achieving potential growth currently identifiable are:

- The problem of sea lice on salmon that has been increasing and which the sector is attempting to alleviate through a range of measures.
- Achieving environmentally sustainable higher biomass limits on a significant number of sites through the new depositional zone regulation (DZR) that SEPA proposes to introduce, and enabling new sites further offshore to be given higher biomass limits through the scientific work being undertaken. The potential increases in annual production through the DZR is based on more reliable modelling beyond 2,500 tonnes of biomass than has been possible to-date.
- Maintaining and developing international trade relationships with suppliers and customers after the UK leaves the EU, together with sterling's exchange rate in the short and longer term keeping its exports competitive and competing food imports relatively expensive.
- Attracting and maintaining an adequate labour supply as the regulations on employing overseas nationals change, and encouraging young people in Scotland to take up aquaculture as a career. Interesting young people in outdoor work is an increasing challenge.
- Improved access to loan finance and other private investment by shellfish producers, with production growth constrained if reliant on re-investment of profits.
- Alleviating local concerns around existing sites and new developments – making the case across the value chains that activity is on balance beneficial to livelihoods, with due consideration of the economic, social and environmental impacts.
- Identifying value added product development opportunities for Scottish seaweed producers as this industry expands internationally, with scope for cultivation to supplement harvesting.

10. APPENDICES

10.1. DETAIL ON THE INDUSTRY AND ITS VALUE CHAIN AND SUPPORTING ORGANISATIONS

TABLE 42: MAIN INDUSTRY ACTORS

INDUSTRY ACTOR	*Description, Area(s) of Operation*
Producers	
Salmon	
Marine Harvest:	In 2016, Marine Harvest produced c45,000 tonnes of farmed salmon in Scotland – 12% of its worldwide production. Marine Harvest are involved throughout the salmon supply chain, and have plans to invest £90 million plus in a new feed factory in Skye that could be operational in 2018, subject to approval. In addition, they are planning a wrasse hatchery at Machrihanish in Argyll for full scale commercial production. ***Ownership:*** Marine Harvest ASA is one of the largest seafood companies in the world, and the world's largest producer of Atlantic salmon. The company employs some 11, 700 people, and is represented in 24 countries. In 2015 the company had a turnover of NOK 28 billion. Marine Harvest is listed on the Oslo Stock Exchange (OSE) and the New York Stock Exchange (NYSE). ***Area:*** The company has four hatcheries, five freshwater loch sites and 49 sea farms, situated in the Outer Hebrides, Skye, Argyll, Wester Ross and Inverness-shire. Live fish are transported by wellboat to be harvested at Mallaig with primary processing in Fort William (a new Corpach plant replacing the Blar Mhor facility) and a major processing unit at Rosyth. Office functions are shared between Rosyth and Fort William.
Scottish Sea Farms:	Scottish Sea Farms are based in Stirling and South Shian with farms around Scotland. Currently, they export to over 25 different countries and supply Scottish salmon to retailers, such as Marks and Spencer. ***Ownership:*** Scottish Sea Farms are owned by SalMar and the Lerøy Seafood Group ASA of Norway. ***Area:*** Two hatcheries on the west coast of Scotland (Couldoran and Knock hatcheries), as well as five freshwater loch sites (including Loch Damp and Lock Frisa) and 45 farms along the west coast of Scotland, as well as in Orkney and Shetland. Two processing plants – one in Scalloway, one near Oban. Head offices in Stirling.

Cooke Aquaculture Scotland:

Cooke Aquaculture Scotland is a recent entrant (2014) to the Scottish industry. Internationally, Cooke Aquaculture processes and sells around 115,000 tonnes of Atlantic salmon and 20,000 tonnes of sea bass and sea bream, with annual sales valued at nearly $1 billion.

Ownership: Cooke took over former Meridian Salmon Group's Orkney & Shetland sites in 2014 as a consequence of MH Global's takeover of Morpol and having to relinquish some of the business due to competition rules. Cooke is a family-owned company, established in 1985. It has operations in New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland, Maine, Chile, Spain and Scotland, as well as sales in the United States and Canada.

Area: Cooke Aquaculture Scotland have a hatchery on Unst and 45 sites in Shetland's northern isles and Orkney. Their distribution hub and head offices are in Glasgow. They have one broodstock facility, five egg incubation sites and four sites for fry production. These supply Cooke Aquaculture Scotland farms and other salmon farming companies. They currently employ 230 people.

For smolt production, Cooke Aquaculture Scotland has 8 freshwater facilities, on the west coast of Scotland and on the Shetland Islands. They have 45 licensed sites for ongrowing: 16 on the Orkney Isles, and 29 on the Shetland Islands.

Grieg Seafood:

Grieg Seafood specialise in salmon farming annual production capacity of 90,000 tons (gutted weight). At present, they employ 700 in Norway, British Columbia (Canada) and in Shetland (Scotland).

Ownership: Group headquarters are located in Bergen, Norway. Grieg Seafood was listed on the Oslo Stock Exchange (OSEBX) in June 2007. The company in

Scotland is Grieg Seafood Hjaltland (GSFSH) and operates in Shetland and the Isle of Skye.

Area: GSFSH is the largest salmon farmer in Shetland. The company has activities in the complete value chain (Hatcheries, Grow-out and Processing) and employs 166 people. The operation in Shetland has an estimated production capacity of around 22,000 tonnes gutted weight.

GSFSH has recently built a new hatchery in Shetland with recycled fresh water technology and is now self-supplied with smolts. This facility will eventually produce 70-90% of its smolts (around 16,400 tonnes).

The sales company Ocean Quality UK serves the British markets, with the Scottish salmon produced by GSFSH mainly being consumed in Great Britain.

Scottish Salmon Company (SSC):

The Scottish Salmon Company (SSC) harvested a total of 25,569 tonnes in Scotland in 2015. Production of Native Hebridean Sea Trout continues to develop, with an ambition to produce up to around 500 tonnes in 2018.

The SSC exports Scottish salmon to 24 countries worldwide, through partnerships with leading retailers, smokers and restaurants. Export performance has remained stable, accounting for 42% of revenues at the end of 2015.

Ownership: The Scottish Salmon Company PLC (The Group) is the parent company of the Scottish Salmon Company Limited (The Company). The Group is listed on Oslo Børs, the Norwegian Stock Exchange, and is registered in Jersey. The Company is registered and managed in Scotland.

Area: They operate from ~60 locations and employ +480 people. Production is focused in the Outer Hebrides and Argyll and the Islands (including Mull, and Arran), with an additional site on the Highland west coast. The company runs two processing plants, one in Stornoway and the other in Cairndow (Argyll). The head offices are in Edinburgh.

Loch Duart: Loch Duart is a small Scottish salmon farming company with its main operations in North West Sutherland. They market themselves as sustainable and harvest ~5,000 tonnes of fresh salmon annually, generating annual sales of +£25 million.

Area: The company owns and operates eight sea sites and two hatcheries in Sutherland and the Outer Hebrides and employs 100 people.

Sales, marketing and finance departments are in Montrose and French sales and marketing offices are in Brittany.

Wester Ross Fisheries (WRF): ***Ownership:*** Wester Ross Fisheries (WRF) is Scotland's oldest independent, owner-operated salmon farm and has been hand rearing fish in the northwest Highlands since 1977.

Area: The company currently operates three seawater sites in Loch Kannaird, Loch Broom and Little Loch Broom. WRF also has a freshwater smolt production unit at Elphin in Sutherland, a processing unit in Dingwall, and a sales and administration office in Auldearn.

Trout

Dawnfresh: Dawnfresh is one of the UK's largest producers of fish and seafood. In addition to using its own farmed trout, Dawnfresh works with many other species. It is the largest trout producer in the UK, the largest supplier of Scottish loch trout

in the world, and one of the UK's leading food manufacturers, delivering chilled, frozen and finished fish and seafood products. Key customers include the UK's major retailers and food service companies, and international food businesses. Dawnfresh employs more than 550 full time staff, with up to 200 additional temporary workers at key periods.

Ownership: Dawnfresh is a private limited company owned by Alastair Salvesen.

Area: They have 7 fish farms in Scotland and one in Northern Ireland. Freshwater trout are raised in Tervine, Braevallich and Loch Earn. Loch trout are grown at Loch Etive. Their farms include three in Argyll, two in Tayside, one in Highland and one in Grampian. Processing sites are in Uddingston and Arbroath. Daniel's Sweet Herring is produced in Grantown-on-Spey; illustrating the company's wider focus.

Diverse small producers: There are various small trout businesses in Scotland mostly listed under British Trout Association (BTA) – these often produce for the 'table' and / or for restocking of sites for fishing.

Mussels and Oysters

Scottish Shellfish Marketing Group (SSMG): The Scottish Shellfish Marketing Group (SSMG) is the UK's leading supplier of rope-grown mussels and cultivated Pacific oysters. They supply to supermarkets, wholesalers and restaurants. They employ between 51 and 200 employees across the group, taking in account seasonality.
Ownership: Run as a cooperative with 16 member farms which supply to a processing factory and offices in Bellshill, Lanarkshire, which employs 170 people (not only processing farmed shellfish).

Area: 18 farms on the West coast of Scotland and 19 on the Shetland Isles.

Shetland Mussels Ltd.: Shetland Mussels is a producer of rope grown mussels around Shetland. They produce over 1,000 tonnes of mussels every year and sell to markets throughout the UK both directly and through the SSMG.

Ownership: Family owned business.

Area: They have 24 sites around the west coast of Shetland. The mussels are then processed and packed in a custom-built factory in Walls on the West coast of Shetland.

Blueshell Mussels: Blueshell Mussels in Shetland started in 1997 and went into full time mussel farming in 2000. They sell directly to markets and through the SSMG, and offer

grading services for other farms. Total Scottish production is estimated at 5,700 tonnes. Blueshell is currently undergoing an additional two-year £1m investment programme to develop the efficiency and quality of their mussels.
Ownership: Over the last 10 years they have acquired several existing producers (including a Yell crab processor).

Area: It currently operates the largest rope-grown mussel farm in the UK with 18 sites in Shetland and processing facility (now integrated with wider SSMG processing). They also process landed scallops.

Loch Fyne Oysters: Loch Fyne Oysters is a company operating along the value chain, from farm production of oysters and mussels, to processing, to retail and hospitality sales.

Its own products include smoked and cured salmon, oysters, mussels, and other shellfish. There is a Restaurant & Oyster Bar on the shore of Loch Fyne; with Loch Fyne Restaurants elsewhere in the UK a separate company.

They have partnered with the Scottish Salmon Company to develop an approach to sustainable best practice aquaculture.

In 2012, the then employee-owned company was taken over by Scottish Seafood Investments.

Area: Oysters are grown at Loch Fyne and by partner growers throughout Scotland.

Others: Isle of Mull Oysters: Produce in excess of 500,000 oysters per year.
Traigh Mhor Oysters: A new venture between AP Jess & Isle of Barra Oysters set up in 2015, with growth from 6 million to 10 million oysters and an increase in employment from 3 part time to 6 full time.

Regulatory and Industry Bodies

Marine Scotland: Marine Scotland is a Directorate of the Scottish Government and is responsible for the integrated management of Scotland's seas. Marine Scotland's purpose is to manage Scotland's seas for prosperity and environmental sustainability, working closely with key delivery partners and others.
It is headquartered in Edinburgh with offices and other facilities around Scotland.
See Section 7.1 for more detail.

Scottish Salmon Producers Organisation (SSPO): SSPO has its headquarters in Perth and an office in Shetland Seafood Centre in Lerwick.

The organisation plays a central role in representing the industry on political,

regulatory, media and technical issues in Scotland, the UK, EU, and internationally.

British Trout Association Ltd. (BTA):

The British Trout Association (BTA) was set up in 1983 and represents around 80% of trout production in the UK. They aim to provide a legislative framework for the industry, to support research and development and to promote marketing activities within the industry. It is based in Ingliston (Edinburgh).

BTA has over 100 members made up of trout farmers, feed suppliers and several aquaculture academics. The Association is entirely funded by trout farmers and feed suppliers and receives no direct funding from the Government.

Association of Scottish Shellfish Growers (ASSG):

The main objectives of the ASSG are:

- To improve the financial returns of all Scottish shellfish producers;
- To increase demand for Scottish farmed shellfish by promotion;
- To set and encourage acceptance of quality standards for Scottish shellfish, and to establish appropriate Codes of Practice;
- To collect and disseminate shellfish industry statistics;
- To provide a forum and lobby to enable government and others to be properly advised on matters concerning the shellfish industry; and
- To carry on trades, industries and businesses which will further the above objectives.

It is based in Rosemarkie on the Black Isle, Highland.

The Crown Estate:

The Crown Estate, owning almost half of the foreshore in the UK and almost all of the territorial seabed, has been an active manager of aquaculture-related shoreline activities, and it has sought through its leasing to support the growth of aquaculture along with other marine industries. Recently, The Smith Commission recommended that the management of Crown Estate assets in Scotland and their revenues should be devolved, and the Scotland Act includes provisions for the UK Government to complete the transfer of assets and devolution of legislative competence.

Scottish Aquaculture Innovation Centre (SAIC):

The Scottish Aquaculture Innovation Centre (SAIC) aims to transform the relationship between the aquaculture industry and research community, generate closer connections between these two communities, and foster innovative industry-relevant collaboration.

It is one of eight Innovation Centres established by the Scottish Government in 2013-2014 and is funded by the Scottish Funding Council (in partnership with Scottish Enterprise and Highlands and Islands Enterprise) and by industry. It is based in Stirling.

Scottish Environment Protection Agency (SEPA):

The *Scottish Environment Protection Agency* (*SEPA*) is Scotland's principal environmental regulator, protecting and improving Scotland's environment.

To manage the effects that aquaculture can have on the environment, SEPA promotes compliance with legislation and sustainability through the application of the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) and their amendments, which licence and monitor aquaculture activities. SEPA has 22 offices throughout Scotland, including eight in the Highlands and Islands.

Local Authorities and Community Councils:

Local authorities are responsible for local economic development and planning decisions for all new aquaculture developments, change of use and alterations to existing approved sites. Planning departments may have staff members with a specific focus on aquaculture. Planning permission from the relevant local authority is required for all new aquaculture developments, change of use and alterations to existing approved sites. Planning departments may have staff members with a specific focus on aquaculture.

Community councils represent community views in local development decisions.

Seafood Scotland:

Dealing with all seafood species, Seafood Scotland is a non-political organisation that works throughout the supply chain with fishermen, fish/shellfish farmers, processors, retailers, food service companies, caterers, NGOs and consumers**.** Based in Edinburgh.

Scotland Food and Drink:

Scotland Food & Drink, established in 2007, is a not-for-profit organisation that was created to guide food and drink companies of all sizes towards increased profitability.

Scotland Food & Drink is a unique leadership organisation - supported by the Scottish Government - tasked with growing the value of Scotland's food and drink sector, making it more profitable and delivering greater global success in a challenging and competitive environment.

It is based in Ingliston, Edinburgh.

Highlands and Islands Enterprise (HIE):

HIE is the Scottish Government's economic and community development agency for the north and west of Scotland. Its purpose is to generate sustainable economic growth across the Highlands and Islands. Aquaculture sits within Food and Drink, a key growth sector supported by HIE.

It is headquartered in Inverness, with eight regional offices, providing coverage

for a wide geography including remote and rural communities.

Scottish Enterprise (SE): Scottish Enterprise is Scotland's economic development agency for the east and south of Scotland and a non-departmental public body of the Scottish Government with also Scotland-wide economic development responsibilities.

SE works with partners in the public and private sectors to identify and exploit the best opportunities to deliver a significant, lasting effect on the Scottish economy. It is headquartered in Glasgow, with regional offices in other centres.

Scottish Development International (SDI): SDI is the international arm of Scotland's enterprise agencies. SDI can offer significant financial incentives and other assistance to help establish and grow businesses in Scotland and worldwide

It has its head office in Glasgow, with offices throughout Scotland, and over 40 offices in 20 countries globally.

INDUSTRY ACTOR	*Description, Area(s) of Operation*

Suppliers

Engineering and Equipment

Gael Force Marine:	Based in Inverness, Gaelforce Marine is a fast growing marine equipment supplier, stocking a wide range of leisure boating, commercial fishing and aquaculture products. The company acquired Mohn Aqua (Forres) in 2016 to strengthen its capabilities.
AKVA Group:	AKVA group has offices in Norway, Chile, Denmark, Scotland, Iceland, Canada, Australia and Turkey. AKVA group can offer both cage farming and land based aquaculture operations with complete technical solutions and service.
Inverlussa Marine:	Based in Mull, Inverlussa Marine is a workboat operator with a fleet of modern vessels servicing contracts throughout the UK and Europe.
Fusion Marine:	Fusion Marine provides fish farm pens and cages, supplies moorings, pontoons, anti-predator equipment, live fish transfer systems, feeding systems and hatcheries and robust offshore fish farm pens. Fusion Marine has been at the forefront of this technology with its High Density Polyethylene products. Headquartered in Oban, the company has six international offices.
Johnson Marine:	Johnson Marine offer on-site salmon harvesting and net washing services. They currently operate off Shetland, Orkney, Isle of Skye and the West coast of Scotland. They service nearly a third of the salmon industry in Scotland.
Kames Fish Farming:	Kames Fish Farming Ltd was established in 1972 with offices on the West Coast of Scotland. Alongside farming the business operates an equipment supply and installation service ranging from fish cages and moorings to jetties and rafts for both aquaculture and the leisure sector.
Knox Marine:	Knox Marine was established in June 2008 and operates as a division of the long-established W & J Knox Ltd who supply cages and nets to the Aquaculture Industry. They are a coastal workboat operations provider set up primarily to service the Aquaculture Industry on the West Coast of Scotland. They are based in Kilbirnie, North Ayrshire.
Alexander Noble & Sons:	Founded in South Aryshire, Alexander Noble & Sonds provide a range of engineering services for all types of vessels. Most of their work involves the repair, refit, and maintenance of steel workboats including trawlers, windfarm support vessels, pilot tugs, and barges.

Wellboats

Sølvtrans:	The world's largest wellboat company for transport of live salmon and trout.

The fleet consists of 14 modern wellboats, mainly employed on long-term contracts with leading fish-farming companies in Norway, Scotland, Canada, Chile and Australia.

Inverlussa Marine Services: Based in Mull, Inverlussa Marine is a workboat operator with a fleet of modern vessels servicing contracts throughout the UK and Europe.

Johnson Marine: Based in Shetland and operating across the islands and the West Coast, Johnson Marine provides wellboat and sealice management operations.

Intership: Based in Norway, the company has three vessels, the newest of which has been contracted to Marine Harvest on a long term lease.

Pharmaceuticals

Pharmaceutical suppliers (examples): Fish health supplies can range from smolt selective breeding, through to sea lice, fungal, and anti-biotic treatments.

Europharma: To help avoid disease losses and planning disruptions, Europharma Scotland has developed fish health and welfare programmes drawing upon the wealth of experience and knowledge coming from teams both in the UK and internationally, with the goal to advise and assist customers in achieving healthier, more sustainable and more profitable production.

Fish Vet Group: The world's largest provider of dedicated evidence-based veterinary services, diagnostic technologies and environmental monitoring to the aquaculture sectors. It is based in Inverness, with offices in Ireland, the US, Norway and Thailand.

Feed supply

Ewos: The company has been producing fish feed since 1935, and today operate in all four of the world's major salmon farming regions: Norway, Chile, Canada, and Scotland. They also operate in Vietnam, producing feed mainly for tropical species.

They hold a 1/3 share of the world market for salmon and trout feed.

EWOS operates 22 production lines in 7 feed factories, 3 of which are located in Norway, whilst Chile, Canada, Scotland and Vietnam each have one factory. The Scotland factory is in Bathgate.

Skretting: Skretting is a global aquafeed company with production on all continents, and sales in more than 40 countries. There are two offices in Scotland, and a factory in Invergordon.

BioMar: BioMar business areas are feed for salmon and trout in Norway, the United Kingdom, and Chile, feed for trout, eel, sea-bass, and sea-bream in Continental Europe, and feed for shrimp and tilapia in South and Central America.

Worldwide the BioMar Group supplies feed to around 80 countries and to more than 45 different fish species.
BioMar UK designs, manufactures, markets and distributes feed for fish farming in Scotland and Ireland. Headquarters and production in Grangemouth.

Internal unit within Marine Harvest: Marine Harvest expanded into fish feed with their first factory opening at Bjugn during 2014. Its new £80m plant planned for Kyleakin on Skye will support 55 full-time permanent jobs. The plant will produce food for the firm's Scottish fish farms as well as those in Norway, Ireland and the Faroe Islands.

Logistics

Haulage and Logistics (examples): ***Ferguson Transport & Shipping:*** provides tailored logistic solutions and works in a range of sectors in addition to aquaculture.

Based in Corpach, and with Operating Centres in Kishorn, Mallaig, Invergordon and Grangemouth, as well as vehicle bases in: Kyle of Lochalsh, Inverness, Glasgow and Penrith.

Shetland Transport: was established in 1982 as a family-run freight and haulage business. Initially, the company served the Shetland Islands only, but expanded to become a business with three main depots in Shetland, Aberdeen and Coatbridge on the outskirts of Glasgow. Recently sold to DFDS.

Ferry Providers: NorthLink Ferries (serving Orkney and Shetland) and Caledonian MacBrayne (serving Scotland's west coast and islands) provide key ferry links to the islands.

DFDS: DFDS is Northern Europe's largest shipping and logistics company. DFDS has a distribution centre in Larkhall, in South Lanarkshire, through which much of Scotland's aquaculture exports are channelled.

INDUSTRY ACTOR	*Description, Area(s) of Operation*
Processors	
Internal processors within salmon production companies	These are given above under the major salmon companies.
Miscellaneous salmon processors:	A number of processors combine salmon with other fish processing, particularly in the North East of Scotland. An example is John Ross Jr., employing 54 people, in Aberdeen.
Aquascot:	Aquascot is an employee-owned business based in Alness, near Inverness, focusing on high quality aquaculture processing.
Scottish Shellfish Marketing Group (SSMG):	See shellfish section above
Loch Fyne Oysters:	See shellfish section above

INDUSTRY ACTOR	*Description, Area(s) of Operation*
Research Institutions / Units	
University of Stirling Institute of Aquaculture:	Founded in 1971, the Institute of Aquaculture is the leading centre in its field in the world. It undertakes research and project work globally and has contributed to both finfish and shellfish work in Scotland.
University of St Andrews:	Operates programmes on Sustainable Aquaculture, and hosts the multi-institution research platform MASTS (below).
Marine Alliance for Science and Technology (*MASTS):*	Marine Alliance for Science and Technology in Scotland. Includes research and contributors from various Scottish universities.
Scottish Aquaculture Research Forum *(SARF):*	SARF is undertaking a wide range of current projects, with a total value of almost £1 million. Subject areas range from shellfish planning issues to specific treatments for AGD and sea lice.
University of the Highlands and Islands (UHI)	The UHI has a wide ranging research capacity in relation to aquaculture in addition to the relevant courses that its partner colleges and institutions run. It has plans for a Chair in Seafood Industries and the development of a UHI aquaculture hub for research, teaching and knowledge exchange. The Scottish Association for Marine Sciences ***(SAMS)*** is part of the University of the Highlands and Islands. It conducts research (and consultancy work through its associated SRSL arm) into marine industries, including aquaculture. ***The North Atlantic Fisheries College (NAFC) Marine Centre:*** NAFC is part of the University of the Highlands and Islands, located in Shetland. The Centre delivers training and education, carries out applied research and development, and provides consultancy, advisory and other services for the maritime industries. The Centre is operated by the Shetland Fisheries Training Centre Trust.

10.2. SUSTAINABLE LIVELIHOODS

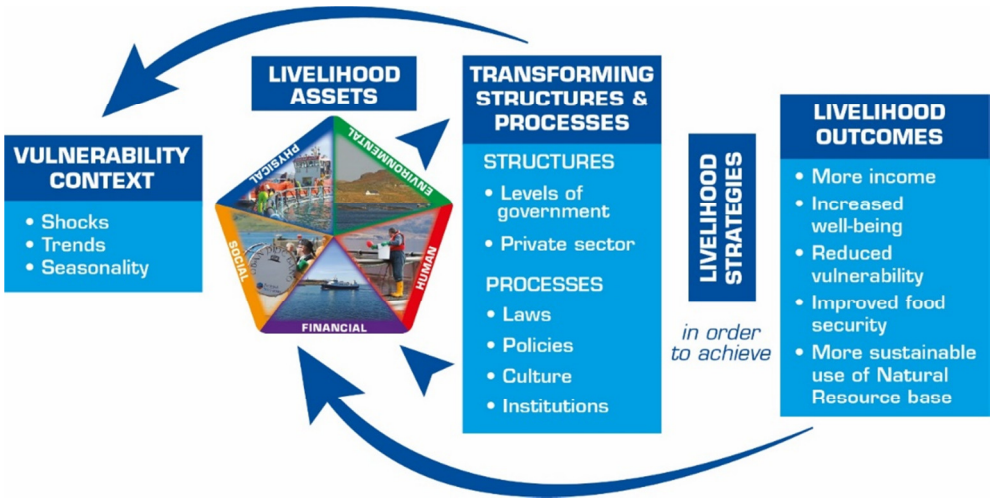
The sustainable livelihoods assessment framework described and illustrated below was developed by Imani in its 2014 report "An Assessment of the Benefits to Scotland of Aquaculture".

Understanding the social impacts of aquaculture production requires looking beyond raw economic GVA data and identifying what health, social, risk-avoidance and environmental factors are also affected. Even food security (usually relevant for poorer societies than Scotland) is relevant in understanding the challenges of low carbon, affordable food production when fish stocks are under pressure. A 'balanced scorecard' of social, economic and environmental impacts is required. A variety of research areas, primary case studies and local consultations provide evidence for these factors as appropriate.

There are five types of *capital* or livelihoods factors considered in a 'sustainable livelihoods approach':

- **Human** i.e. employment / skills / education / health
- **Social** i.e. family / community life
- **Financial** i.e. income / earnings for business
- **Environmental (Natural)** i.e. land / water / wildlife / biodiversity
- **Physical** i.e. infrastructure / shelter / water / energy / communication

Figure 14: Sustainable livelihoods assessment framework



In addition, the ***vulnerability context*** of these, i.e. how resilient is a community to changes or shocks, is a key consideration in relatively remote and fragile economic areas.

Taking a livelihoods approach provides alternative ways of thinking about the objectives, scope and priorities for developing an industry within a community context – essentially it puts people and their priorities at the centre of development. People are given the opportunity to improve their well-being, avoid economic and environmental vulnerability, and face a viable future livelihood.

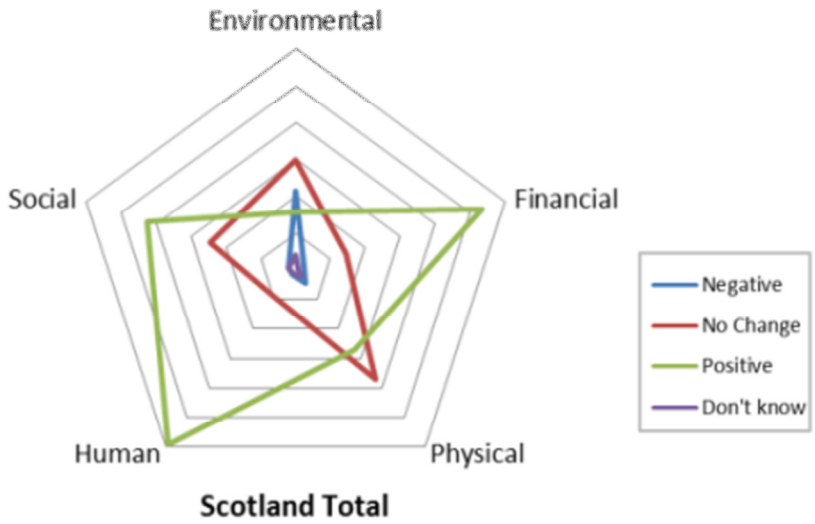
10.2.1. SUMMARY OF SUSTAINABLE LIVELIHOODS FINDINGS

The 2014 Assessment of the Benefits to Scotland of Aquaculture report found that:

'*There is a strong indication that human capital is perceived as being the greatest benefit, which was largely in terms of employment or availability of jobs […] The financial benefit through income to ancillary businesses and local community follows closely after, with social benefits next. The negative opinions are generally low, but with a clear focus towards the environment and negative impact of aquaculture both directly through inputs to the environment and also through the landscape and visual impact*.'[82]

The definition of human capital (skills, employment, education, health) is important here – jobs have a dual impact of both providing a) financial capital, but b) also job satisfaction, achievement, and an opportunity to develop. Combining both the human and financial capital contributions, the livelihoods benefit is very strongly linked to job creation, with social benefits also being recognized: the social priorities being improved communication (between companies and communities) and school provision made possible by increased numbers of working families.

FIGURE 15: IMPACTS OF AQUACULTURE ON SUSTAINABLE LIVELIHOOD ASSETS (2014)[83]



The conclusion of this research is that the employment and supply chain impacts matter to communities as much as what is traditionally put in the 'community benefits' box.

This is important when making the case for growth: what are tolerable negative impacts, and desirable positive ones?

10.2.2. COMMUNITY AND BUSINESS

The SSPO Community Charter sets out the principles of how salmon producers can engage with communities in which they work (and indeed are a part of).

Further, it recognizes that economic and social impacts for a community go beyond sponsorships and 'good citizenship' – people's livelihoods improve, for the most part, through the *core business operations* which include direct employment and skills development. [84]

The schematic above illustrates the spectrum, from core business to 'good citizenship', along which different types of impact are found.

10.2.3. ENVIRONMENTAL IMPACT

The environmental impact of aquaculture is a focus and concern of local communities, of SEPA and Scottish Government, and indeed the industry itself which relies on a strong reputation for environmental and water quality. The perception of environmental impacts directly affects the expansion and therefore the other impacts of aquaculture, from economic, to social, to physical infrastructure.

From Marine Harvest Handbook:

FIGURE 16: CARBON FOOTPRINT OF ATLANTIC SALMON

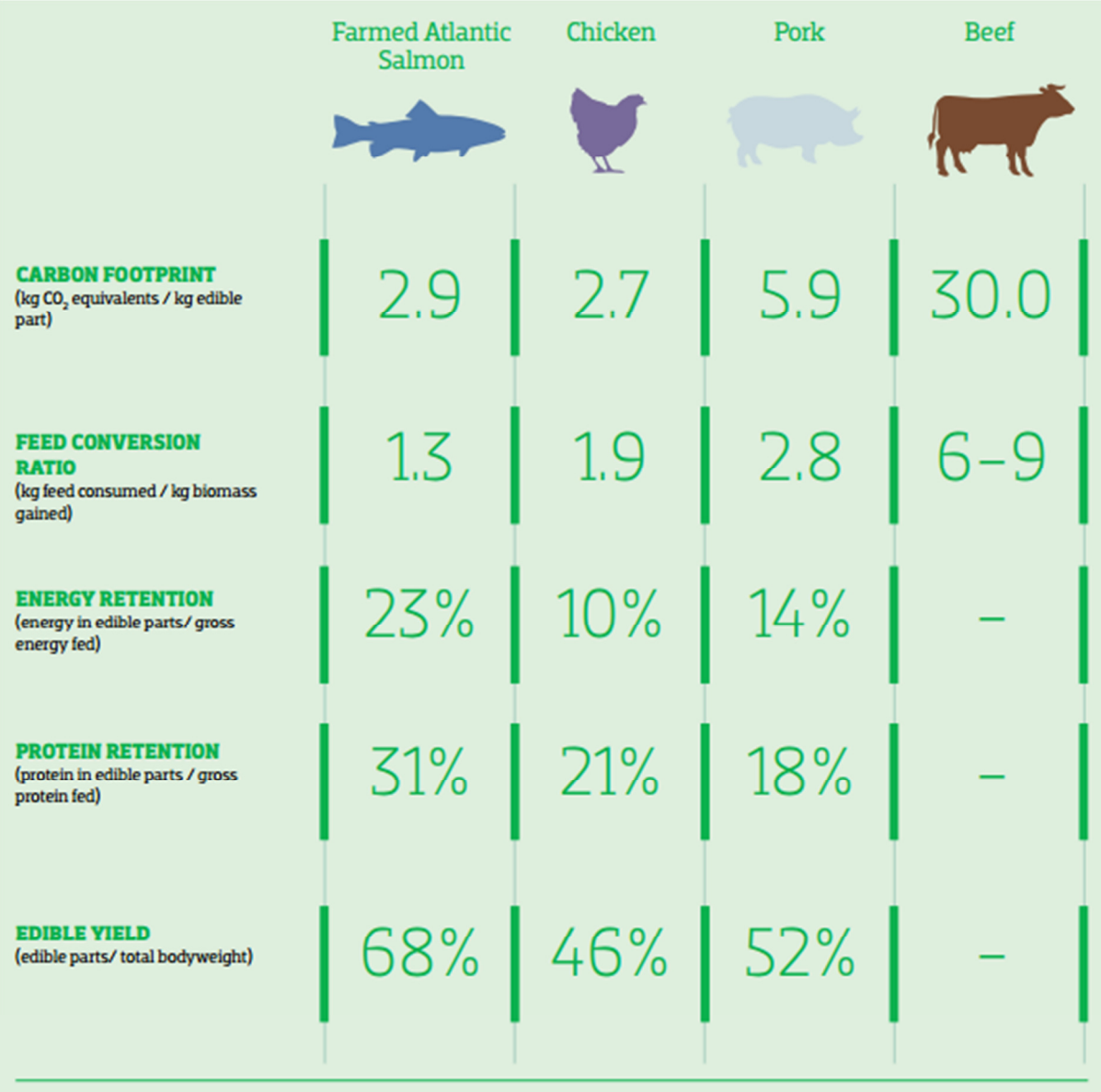
'In addition to the resource efficient production, farmed fish is also a climate friendly protein source. It is expected to become an important solution to providing the world with vitally important proteins while limiting the negative effect on the environment. There is for example less environmental impact in salmon production compared to other protein producers.

When comparing the carbon footprint of farmed salmon to traditional meat production, the carbon footprint for the farmed salmon is 2.9 carbon equivalents per kilogram of edible product whereas corresponding numbers are 2.7kg, 5.9kg of edible product for chicken and pork, respectively. Cattle's carbon footprint is as much as 30 carbon equivalents per kilogram of edible product.

Freshwater is a renewable but limited natural resource, and human activities can cause serious damage to the surrounding environment. In Norway**,** farmed Atlantic salmon requires 2,000 litres per kg of fresh water in production which is significantly less than other proteins.'

10.2.4. *Farmed Salmon Compared to Traditional Meat Production*

FIGURE 17: FARMED SALMON COMPARED TO TRADITIONAL MEAT PRODUCTION [85]



Mussels are considered to be very low carbon footprint compared to all of these alternatives, at 252 kilogrammes of carbon dioxide equivalents (kg CO2-eq) per tonne for suspended mussels (i.e. less than a tenth even of salmon), and 1,281 kg CO2-eq per tonne for intertidal oysters.[86] Further, shellfish sequester carbon.

On managing the natural capital of Scotland up to 2030 by minimizing the environmental impacts on water quality, disease, and visual impacts it is likely that a much more intensive engagement in the positive carbon footprint credentials, and the normalization of aquaculture farms as part of the landscape, will be important alongside regulatory and business measures. The 2014 report found that there were many examples where aquaculture complemented, rather than clashed with, tourism objectives.

10.2.5. SCOTTISH SEA FARMS, EDAY: PROPOSED EXPANSION OF ORKNEY OPERATIONS

This is an example of the application of the sustainable livelihoods assessment framework (based on information on the company's website supplemented by direct liaison).

Scottish Sea Farms (SSF) is the second largest producer of farmed salmon in the UK, with over 380 employees and a turnover in excess of £100 million. It currently produces around 27,000 tons of salmon per year for some of the UK's top retailers, as well as for key export markets globally.

Scottish Sea Farms acquired Orkney Seafarms business in 2007 – a business that had incurred major losses from farming salmon in Orkney. Since acquisition, SSF has invested £4.4 million in infrastructure on its Orkney sites. This has helped secure 24 full-time jobs, including five new full-time positions on the remote island of Eday. The development of the Eday site during 2012 was particularly challenging as the site had been mothballed by the previous owners due to the issues caused by farming on an exposed site with the strongest average current speed in the UK. SSF have successfully grown the business in Orkney from an annual 500T to 3,500T; however production was not balanced and once every two years the company went through a four to five month period of not having salmon to sell to its customers. SSF realised that in order to be successful in Orkney, it had to offer all year round supply of salmon to its customers and the development of the Eday site has allowed it to achieve this.

SSF believed it had the knowledge and expertise to redevelop the site and make it a financial success. The decision was made to invest £1.5 million in new "fit for purpose" infrastructure. Five Eday residents were recruited, who all had zero fish farming experience, and SSF embarked on a journey through its comprehensive training programme to give them the knowledge and skills to produce a high quality healthy food for its customers. To date, the site has performed exceptionally well, producing the first salmon for seven years. SSF fully appreciates the effort put into the site by its staff, and is also extremely proud of the fact that it has created highly skilled, well-paid jobs in such a remote community which allows the island to retain its identity.

Scottish Sea Farms Board has approved a 3 year plan to invest in excess of £30 million in capital projects to develop six new farms in Orkney.

The basis for this investment is to build the Orkney brand and capture the increased demand for "Orkney Salmon" in international markets. A project began in 2011 to identify new site potential within Orkney waters, a list of potential sites was drawn up, and current meters were deployed to collect hydrographic data. A lengthy process of stakeholder consultation then followed to determine which sites were the most suitable for salmon farming development. As a result of this consultation, a definitive development plan for six new farms was produced and the first two sites have been submitted to OIC planning for determination with a further four sites to be submitted within the next 6 months. Due to the high level of pre-application consultation, SSF are quietly confident that all six sites will be approved and this will increase the company's annual production levels in Orkney to over 10,000T. These new sites will lead to the creation of 30 highly skilled farming jobs and to a working capital investment of £20 million plus with Scottish based equipment suppliers.

This development will bring a strong viable and secure business to the Orkney community and Scotland as a whole, with rewards for the local community, the company's staff, and customers who will have the pleasure of tasting Orkney salmon.

TABLE 43: SUSTAINABLE LIVELIHOODS SUMMARY OF IMPACTS

Human capital	*Jobs ecosystem in remote communities*
	Training of unskilled to skilled – 30 jobs, including 5 in Eday
Social capital	*Collaborative / democratic planning*
	De-risking business insecurity from previous owners
	Island identity – a productive environment for families
Physical capital	*Development Plan*
	Infrastructure investment – will benefit other businesses (£4.4m)
Financial capital	*£20m+ spend on suppliers*
	£30m+ capital investment over 3 years
Natural capital	Access and population in island regions maintained
Economic Sustainability/Resilience	De-risking of Orkney income, wider supply chain opportunities

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