The Economic Contribution of Open Cage Salmon Aquaculture to Scotland:

A Review of the Available Economic Evidence

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Executive Summary

Open cage salmon aquaculture, as currently practised in Scotland, is damaging our marine environment[2]. At the same time, the Industry has an ambitious growth strategy that envisages a near doubling of farmed salmon production by 2030.

In deciding how best to serve Scotland as a whole, the Scottish Government faces a difficult question; **"is further damage to Scotland's inshore environment a price worth paying to realise the economic benefits from salmon aquaculture expansion?**"

Currently, the Scottish Government supports industry expansion, with ministers regularly citing empirical estimates relating to the economic contribution of salmon aquaculture to the Scottish economy. Since the Scottish Government's support for expansion seems evidence based, it is crucial the evidence used is fit for purpose.

Some stakeholders, worried about further damage to the inshore marine environment, have concerns and uncertainties about the evidence, and how that evidence seems to have influenced the Scottish Government. In commissioning this work, they are seeking re-assurance.

The conclusion of this study is that, having reviewed the evidence, we cannot provide that reassurance.

There are five reasons for our concerns about the apparent basis on which the Scottish Government currently supports a very substantial expansion of salmon aquaculture.

> 1. It would be difficult for the Scottish Government to claim that, in deciding to support industry expansion, it has demonstrably considered the best interests of Scotland as a whole. The problem is that the Scottish Government's support for industry expansion relies exclusively on estimates about income and employment creation. The reality is that the consequential damage to the marine environment will result in many other stakeholder groups being worse off. At no time, has the Scottish Government sought even to identify the stakeholder groups who would be worse off and to articulate why. The Scottish Government should consider undertaking a Cost Benefit Analysis (CBA). When using economics to evaluate the impact of a policy across our entire society, CBA is very much the cornerstone. A CBA would at least identify who is better off and who is worse off from industry expansion.
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> 2. The actual income and employment evidence cited by the Scottish Government does not describe the **net** impact on income and employment for Scotland as a whole. The Scottish Government has considered only the income and employment generated by industry expansion.[3] Various stakeholders are concerned about the adverse effects on expansion on their income and employment. These include businesses providing services for salmon and sea trout anglers, recreational divers, recreational sea anglers, sea safaris, marine wildlife tourism as well as general tourism and commercial fishing in coastal areas. In the absence of an analysis of all income and employment effects, the Scottish Government should be more circumspect and avoid creating the impression that income and employment

[2] See the Environment, Climate Change and Land Reform (ECCLR) Committee Report on The Environmental Impacts of Salmon Farming. March 2018.

[3] In reality, the evidence relates to the industry's total contribution and not its additional contribution (see point 4 below).

increases it cites are net gains to Scotland. The reality is that net expansion of income and employment is completely unknown.

3. The actual estimates cited by Ministers are either, large estimates that cannot be reconciled with official data (Imani 2017), or large estimates (e.g. £2bn) which do not relate to any coherent indicator of economic (impact) activity (Marsh 2019). For over forty years, Scotland has been carrying out detailed surveys/censuses of businesses in Scotland and has been identifying flows of products between industries. The data collected are used to construct Scotland's Input-Output Transactions Tables. These tables are regarded as the "Gold Standard" and fortunately, one of the industrial sectors is Aquaculture. Imani (2017) largely eschewed a traditional approach and internationally agreed protocols and relied on much data from the industry itself, rather than official Input-Output data. In our view, Imani (2017) was procedurally opaque, but produced impressively large estimates on income and employment. Unfortunately, these cannot be reconciled with official statistics.

We calculate that Gross Value Added (GVA), which has been extensively quoted and relied on by Highlands and Islands Enterprise and Marine Scotland, is possibly exaggerated by 124%, whilst employment could be overestimated by a massive 251% (see Table 6).

4. It is inappropriate to propose that more resources should be devoted to an industry simply because of the size of its current economic contribution. Since in the real world, relationships are not linear, a doubling of production does not necessarily mean a doubling of GVA and employment. The case for expansion has to focus explicitly on the additional benefits and costs that the expansion will deliver. No such analysis has been undertaken.

5. Marsh (2019) followed a traditional Input-Output based approach but did not estimate total employment. Marsh (2019) produced a much-quoted figure of £2bn for turnover. Since this figure does not relate to any coherent economic performance indicator it should not influence public policy.

In summary:

- The available economic evidence is **partial.** This is because it is limited to income and employment effects.
- The income and employment evidence itself is **incomplete.** This is because it does not include the loss of jobs and income in other marine based businesses.
- The income and employment evidence is **unreliable.** This is because opaque and non-standard estimation procedures were used. These appear to have generated significant over-estimates of income and employment.
- In public debate, estimates of income and employment (and the irrelevant £2bn turnover estimate) are being used **inappropriately** to justify salmon aquaculture expansion.

Faced with an evidence base that is partial, incomplete, unreliable and even irrelevant, it is difficult to understand how the Scottish Government can sensibly address the question of whether further damage to Scotland's marine environment is a price worth paying.

Pending further evidence, the Scottish Government should consider suspending its support for additional salmon production.

The Economic Contribution of Open Cage Salmon Aquaculture to Scotland

1 Background and Objectives

It is quite clear that open cage aquaculture, as practised in Scotland, can be harmful to Scotland's inshore marine environment[4]. There is no ambiguity about this basic proposition.

Currently, the Scottish Government (SG) supports the Aquaculture Industry Leadership Group as it seeks to deliver the industry's growth strategy. This has a target of 300,000 - 400,000 tonnes of farmed salmon annually by 2030, which will require a near doubling of current production levels, and a doubling of the number of jobs to 18,000 by 2030.

Below are some examples of public claims about the economic contribution that the industry makes to the Scottish economy.

- During a debate in the House of Commons (17th July 2019) which highlighted the importance of Scottish salmon farming to the UK economy, Stephen Kerr MP **said that Scottish salmon is worth more than £1bn to the UK,** according to 2017 figures. As the UK's largest food export, Scottish salmon is also more valuable than the entire UK fishing sector, he said.
- In the same debate, the Minister for Agriculture, Fisheries and Food, Robert Goodwill, highlighted the wider economic impact across the supply chain of around **12,000 jobs and £620m in gross added value,** and stated that employment in salmon farming provides valued jobs in remote, rural communities in the Highlands and Islands. Also, with an estimated average salary of £34,000 the sector provides well-paid, sustainable jobs which allow people to live and work in the areas they were brought up in.
- Scottish Salmon Producers Organisation's (SSPO) website states: *"Salmon farming is one of Scotland's economic success stories.* ***In 2016, its farmgate value was around £766m. It is estimated that the industry supports around 8000 jobs in Scotland****, with a significant number of these in the remote northern and western regions where it operates. Salmon producers are at the heart of their local areas, reporting a spend of £595m on suppliers and services and capital investment of £63m in 2016".*
- The Fish Farming Expert Website reports a study commissioned by SSPO and carried out by economist Richard Marsh, of Edinburgh-registered 4-consulting who stated: ***"Given an industry turnover of £1,027m, this suggests that the economic impact of the industry could support nearly £2bn of turnover*** *in Scotland's economy today and several thousand Scottish jobs".*
- In discussing the Marsh study, the SSPO's director of strategic engagement, Hamish Macdonnell, said: "*It should come as no surprise that the Scottish farmed salmon sector contributes a huge amount to the economy, but what these new figures reveal is quite how big that contribution is".* Macdonnell added: *"An overall economic impact of* ***more than £2bn*** *represents a major benefit to the Scottish economy in itself but with average salaries of* ***£34,000 for the 2,300 people directly employed,*** *the sector is injecting extremely valuable resources into some of Scotland's most fragile, sparsely populated, rural areas as well".*[5]

[4] See the Environment, Climate Change and Land Reform (ECCLR) Committee Report on The Environmental Impacts of Salmon Farming. March 2018

[5] Salmon Business Website Accessed 15/09/2019

- "*Recent research suggests that* **more *than 12,000 jobs*** *across Scotland rely on the aquaculture sector"*[6]*.*
- At the official opening of Aquaculture UK 2018 in Aviemore Rural Economy Secretary Fergus Ewing emphasised how important aquaculture was in sustaining communities that otherwise would not survive, pointing out that it **provided 12,000 jobs with higher-than-average wages.**

Since salmon production is a profitable activity, one can readily appreciate the motives of salmon producers and the other industry stakeholders as they pursue expansion. Less obvious, given the industry's impact on Scotland's marine environment, is the rationale underpinning the SG's support for such a large expansion.

Evidently, and quite legitimately, the SG is willing to trade off additional damage to Scotland's marine environment in return for more industry derived economic benefits. Essentially, these industry benefits are the additional jobs and income that industry expansion would deliver.

One hopes that the SG would not support industry expansion if that expansion would result in a net reduction in Scottish employment and income, whilst inevitably causing further damage to Scotland's marine environment. Thus, the case for further open cage salmon aquaculture relies critically on the scale of the economic and social benefits expected from the proposed industry expansion.

Given its declared support for expansion, the SG has apparently made a value judgement. Specifically, that industry expansion would make Scotland as a whole better off. Underpinning this judgement must be an implicit belief that the gains to industry stakeholders are so large they somehow compensate for any costs stemming from the resulting environmental damage.

From the quotes above, Ministers and others have cited the empirical evidence of the economic contribution of aquaculture to the Scottish economy. This is re-assuring because it implies that their support for expansion is evidence based, and not a matter of faith or partisanship. On that basis, the SG must somehow believe that the available evidence is sufficiently robust for SG to support industry expansion. Expressed differently, it would seem that the SG believes the economic evidence supports the view that further damage to Scotland's marine environment is a price worth paying.

It should be stressed that nobody should have any problem with SG making these kinds of interpersonal comparisons. The reality is that these judgements are simply unavoidable. This is because it is difficult to conceive of a public policy initiative that does make some stakeholders worse off. Thus, the SG is continually trading-off the well-being of different interest groups.

The key point is that, in seeking to advance the welfare of society as a whole, good governance requires that the interests of all stakeholders are represented in the decision process. As explained below, for a number of reasons, some stakeholder groups are experiencing difficulty in simply understanding the economic information about the industry now being widely disseminated.

Given that background, the objective of this study is

"**to review the available evidence on the economic contribution to Scotland of salmon aquaculture and to consider how that evidence should influence the Scottish Government's support for further expansion of open cage salmon aquaculture".**

Having reviewed the evidence, we have some professional concerns about the evidence and can therefore fully appreciate the confusion experienced by others as they seek to engage in

[6] As published on SSPO website (26th April 2019)

the public debate about a major economic development that will have potentially significant consequences for Scotland's marine environment.

Our concerns about the available evidence are addressed under the following headings:

- The reliance on Economic Impact Assessment evidence
- The partial nature of the economic impact evidence
- The reliability of the (partial) economic impact evidence
- Inappropriate use of the economic impact evidence

In explaining these concerns, it has been necessary to present explanations of some key economic concepts and procedures.

2) The Reliance on Economic Impact Assessment.

In theory, two economic evaluation frameworks can be used to inform decision-making in the public sector. Each type focuses on a different aspect of the consequences for expanding aquaculture.

The two types of economic evaluations are; the **Net Economic Value / Cost Benefit Analysis (NEV/CBA) Framework** and **Economic Impact Assessment (EIA).**

These two types of economic evaluation are not mutually exclusive. This is because they share a common aim of providing insights into how aquaculture expansion affects some dimension of the public's well-being. It is necessary briefly to explain these frameworks.

Net Economic Value / Cost Benefit Analysis (NEV/CBA)

A NEV/CBA evaluation arises from a branch of economics called welfare economics. Most western governments including the UK have produced guidebooks for the application of CBA to areas such as environmental regulation, health, transport etc. CBA is very much the cornerstone when using economics to evaluate public policy. A short explanation of its foundations will help to appreciate why it has this status.

At the heart of welfare economics is a subjective assertion that; "all individual preferences should count". This is simply a non-testable proposition, but has the merit of being consistent with the moral ethic of Western style democracy. Welfare economic analysis would thus reject the notion that the preferences of some stakeholders can be ignored or otherwise discounted.

Moreover, in assessing how a marine pollution incident has affected individuals' well-being, a CBA would seek to establish how individuals themselves perceive the extent of their welfare loss. Welfare economics and therefore CBA would thus normally reject the notion that, with complete disregard for the views of all those affected, an elite or other constituted body should make these assessments.

At the procedural level then, economics seeks to determine individual's preferences, whatever the individual's tastes, motivations, status or knowledge. This at least is the aspiration of economics, though in practice economists often have to work with the average for a representative group of individuals.

Given the above, a relevant question is how does one measure the strength of preference and therefore changes in well-being? In CBA the strength of an individual's preference is usually measured in terms of their Willingness To Pay (WTP), or alternatively their Willingness To Accept Compensation (WTA). Ignoring for the moment the problem of whether to use WTP or WTA, the rationale for using this type of monetary measure is based on a simple proposition. Namely, that the more positively (or negatively) individuals are affected by a change the more of their finite income and wealth they will be WTP in order to secure (or prevent) the change.

When markets exist, economists can manipulate market data to estimate consumers' underlying WTP/WTA. Therefore, some impacts of aquaculture expansion are readily

measurable. For example, CBA can easily measure the benefits from industry expansion by manipulating market data on the value of additional output and the value of resources used to produce it.

Unfortunately, some adverse effects of expansion may not be directly measurable in money terms. For example, a proportion of the Scottish population will have a vicarious concern for the quality of the marine environment, which might be unrelated to direct consumption of marine environmental service flows. These individuals are worse off, but this impact is not recorded in any market transaction.

Whilst techniques exist that can estimate WTP when markets data is absent, their application can be time-consuming and expensive. Nevertheless, the description and articulation of non-monetary impacts should help to ensure that decision makers at least understand and appreciate the diverse and complex values individuals and groups derive from the inshore marine environment. If these wider considerations are embraced, decision making will be seen by the public to be more legitimate and credible.

Provided governments are concerned about the well-being of society as a whole, as reflected in the well-being of all individuals, then CBA provides the information that Governments need. This is why CBA is the cornerstone of policy evaluation, and it is re-assuring to know that, generally, governments are guided by CBA, especially when it comes to big investment projects and/or policy initiatives having wide-ranging impacts.

The conclusion drawn here is that, within the CBA framework, the evaluation of the proposed aquaculture expansion policy should take cognisance of the welfare of everyone affected, irrespective of whether they have been made better off or worse off.

Economic Impact Assessment (EIA)

The basis of an EIA is an underlying judgement that “what matters” is the impact on household income and employment. In other words, the scope is much narrower that the NEV/CBA approach, with the primary focus the impact of industry expansion on household income in the form of wages, self-employment, and profits (the sum of these is known as Gross Value Added (GVA)) and/or employment (measured in Full Time Job Equivalents (FTEs)). An EIA normally has to specify a geographical area, which might be an administrative region, or Scotland as a whole.

Although not additive, taken together, the two frameworks can provide a rich insight into the effects of a policy initiative. Indeed, the data they use can overlap. For example, both frameworks focus on profit, but for quite different reasons. In CBA, profit is a component of Net Economic Value and, in EIA, profit is a component of GVA.

The irregular aspect of the SG’s support for industry expansion is that the SG has completely eschewed the CBA analytical framework. **The only economic data being reported is the income and employment created by the industry**.

At no time, has SG sought to identify even the stakeholders groups who would be worse off. It would therefore be very difficult for the SG to sustain a claim that it is seeking to foster the best interests of Scotland as a whole.

Since the SG does not know who gains, who loses and by how much, there is insufficient evidence to support the view that further damage to the Scotland’s marine environment is a price worth paying. It is appropriate to outline some of the impacts that are currently being completely ignored.

Commercial fishers, particularly creel fishers and scallop hand divers, who operate in inshore areas believe that expansion of open cage aquaculture will further reduce their net profit (within CBA this is a component of Net Economic Value).

Salmon and sea trout anglers on the West Coast and Northern Isles of Scotland believe that some of the decline in their catches is attributable to open cage salmon production. They are concerned that industry expansion will reduce their well-being by further reducing the quality of their recreational experience.

Some sea anglers and recreational divers complain of loss of ground, localised reductions in bio-diversity and biomass and do not welcome further expansion.

Some participants in sea safaris believe that the visual impact detracts from the quality of their experience and some sea safari operators report cages being located, or proposed for, seal haul out areas. Operators are concerned about acoustic deterrent devices affecting the local activity of dolphins, porpoises and whales and thereby impacting on the quality of their customers' experience.

Within a CBA we have also to consider the adverse impact of open cage aquaculture on the **profits of firms (a measure of NEV) providing services** for anglers, divers and sea safari experiences.

In addition to those who interact directly with the marine environment, such as anglers and divers, other individuals **have a vicarious concern for the marine environment.** A proportion of these stakeholders would judge themselves to be worse of if the proposed expansion of open cage aquaculture was to become a reality. Members of, or supporters of Scotland's Coastal Communities Network and other such environmental groups exemplify these individuals. Whilst individually they might not be willing to pay very much to prevent the proposed expansion, they are numerous and their collective WTP could be highly significant.

Conclusion on relying exclusively on EIA

Since there has been no SG funded CBA analysis or, even an articulation of the costs and benefits, one cannot know if a Scottish CBA would be supportive of industry expansion.

Our view is that, given the magnitude of proposed industry expansion, the SG should not rely on EIA evidence. In doing so, the SG is effectively choosing not to consider the effects of expansion on a range of stakeholder groups. If this is simply an error it can be rectified by a SG sponsored CBA analysis.

2. The Partial Nature of the Economic Impact Evidence

The EIA evidence, quoted on Page 3, relates only to the jobs and income currently created by the industry. There is no evidence on the number of jobs that might be at risk as the industry expands.

Of course, it is quite normal for firms or industries to assert that their expansion will create **X** number of jobs. For example, supermarkets seeking to open a new store will make such claims. However, they will ignore the jobs lost in smaller local retailers. In some instances, the net job creation will be a small fraction of the number claimed by the supermarket.

Since the aquaculture sector operates in the best interests of its shareholders, we would expect their advocacy, and their planning and regulatory submissions, to highlight the jobs and income created, whilst ignoring consequential job losses elsewhere.

The role of the SG and planning authorities should be to serve the interests of a broader constituency and consider all employment and income effects of industry expansion. It is

surprising that Ministers have been somewhat uncritically quoting highly partial evidence produced by the industry.

Our conclusion is that the EIA evidence is partial because it does not consider the following threats to income and employment.

Threats to jobs and income especially commercial shellfisheries
In addition to the obvious loss of fishing grounds, the Scottish Creel Fishermen's Federation (SCFF) have highlighted concerns about the impact of waste and chemicals, such as emamectin benzoate, on prawns, lobster, and crabs and worry about the long-term effects of neurotoxin pesticides on scallops and mussels. Scallop and prawn stocks appear to be declining in areas with salmon farms. SCFF worry that there is too little independent research on bio-accumulation and on the long term effects on inshore water ecosystems. SCFF is convinced that a significant industry expansion will adversely impact on shellfish fisheries with commensurate impacts on income and employment among creel fishers and scallop hand divers.

Threats to jobs and income in Recreational Fishing and Diving
Salmon and sea trout fisheries used to attract many visiting anglers who would spend large sums renting fishing and accommodation. Radford et al[7] estimated that in the Highland Region salmon and sea trout angling supported 781 jobs. It is interesting to note that Radford et al estimated that each salmon and sea trout angling day resulted in spending of £290 (at 2018 prices) of which £168 became household income.

Unfortunately, the rivers making this Highland contribution were largely on the North and East coasts, because the salmon and sea trout runs on the West Coast had declined quite dramatically. For example, Loch Maree was one of the most famous sea trout fisheries in Scotland, and Loch Maree Hotel's boats were regularly used by sea trout and salmon anglers. In the 1970's and 1980's the hotel itself employed nine ghillies through the fishing season. There is a strongly held view that open cage aquaculture has contributed to the declines in salmon, and particularly sea trout, catches noticed along the West Coast. The economic costs in terms of income and employment are unknown but potentially highly significant.

Additional open cage salmon farming simply adds to the burden and further constrains Scotland capacity to exploit the enormous potential of sea angling, salmon and sea trout angling and recreational diving.

Threats to jobs and income of providers of Sea Wildlife Tourism
The biodiversity of our marine environment is important to tourist visitors, especially marine ornithologists and participants in marine ecotourism and safaris. As explained earlier, additional visual intrusion, additional chemical use, additional waste and more acoustic deterrent devices are generally incompatible with activities promoted on the on the quality of the marine environment.

Threats to General Tourism
Tourism is an extremely difficult industry to define and measure. The traditional sectors of Accommodation and Food & Drink only tell half the story in an area where a very large proportion of the tourists are in self-catering accommodation, which tourists may themselves own.

In the more remote areas of the North and West of Scotland, many locals own two or more properties, one their residence and the other(s) rented to visitors. Of the other sectors, a high percentage of construction activity will be linked to tourist accommodation, both new construction and maintenance. Almost all transport is tourist (if not holidaymaker) related; and retail/wholesale serves self-caterers directly.

[7] https://www2.gov.scot/Publications/2004/03/19079/34371

Meanwhile the vast majority of both public and private services go to supporting those providing services for tourists.

Along the West Coast of Scotland, tourism is undoubtedly the most important industry. Most of the accommodation is on, or near, the coast and many areas promote themselves on marine biodiversity, remoteness and topography.

Unfortunately, the inshore marine environment on the West Coast has reached the state where not a single vessel can make a living just targeting inshore demersal fish. In the past, a key tourist attraction was fresh seafood, caught locally and served from sea to plate, or bought by self-caterers directly from fishermen. The area now imports finfish and visitors are surprised they can no longer source a broad range of sustainable locally caught finfish products, or even rely on catching their own.

The reality of Scotland's marine biodiversity and biomass could therefore be quite different from what our visitors are led to expect. Unfortunately, it is undeniable that more of our visitors are now disappointed with the reality of local marine environmental services. Visitors in some areas are now less likely to return, to recommend the area or to report positively on social media. Given the reach and effectiveness of social media, the on-going risk to the area's reputation and its tourist numbers is, for some, a matter of very real concern. The massive importance of tourism to Scotland's west coast means that any contraction in tourist numbers threatens to undermine the economic development of the entire area and the sustainability of population levels.

Conclusion on the partial nature of the EIA evidence.
Given the above issues, the net employment and income impact of salmon aquaculture could be significantly less than the industry is claiming. Indeed, a relatively small reduction in tourism could swamp any gains from the proposed aquaculture expansion.

Rather than citing partial industry evidence, the SG should perhaps be undertaking research into the impact of salmon aquaculture on income and employment in other sectors. The SG should consider surveying and consulting with these stakeholders to better understand both the on-going and the potential impact of aquaculture expansion.

We conclude that, if the SG is going to be influenced by EIA type evidence, it must not be the evidence produced by the industry, unless that evidence demonstrably embraces all the relevant income and output effects.

3. The Reliability of the (Partial) Economic Impact Evidence.

Until recently, the most referenced research is by Imani Development and Steve Westbrook (2017).[8] This study was the basis of most of the public claims about the size of the industry. More recently, Marsh (2019)[9] in a study funded by SSPO, has examined the economic contribution of the industry. This study appears to be responsible for using total industry turnover (£2bn) as an industry performance indicator.

Before we consider each study in turn, it is necessary to provide some background explanation about EIA concepts and how usually they are estimated.

3.1 EIA Concepts and Their Estimation Using National Input-Output Data

[8] *The Value of Aquaculture to Scotland.* A Report for Highlands and Islands Enterprise and Marine Scotland. Imani Development and Steve Westbrook June 2017

[9] http://scottishsalmon.co.uk/wp-content/uploads/2019/04/Salmon-Impact.pdf

An increase in a part of a sector's supply chain **output,** such as open cage production**,** produces a **Direct Effect** on GVA and employment in that part of the chain. For example, increased output in a salmon production facility, through increased wages of workers and profits for shareholders, would increase GVA. Numbers employed might also increase.

A Multiplier effect occurs because **Indirect Effects** can arise from the direct effect. For example, an operator of a salmon production facility may purchase vessel repair services thus supporting the GVA and FTEs in the local ship repair company. In turn, the repair company itself may purchase materials from local suppliers thereby generating a further round of (successively smaller) indirect effects in other companies.

The collective increase in GVA and FTEs is therefore greater than the initial direct effect on the workers and owners of the production facility. Indeed, the eventual increase will be a multiple of the direct effect. A multiple of 2 would imply that if the direct effect on GVA was £1m the sum of the direct and indirect effects would be £2m. This type of multiplier is known as a **Type I Multiplier**.

The process does not end with direct and indirect effects. This is because the direct effect and every round of indirect effects increases household wages and profits. The gives rise to additional household spending increases. This additional spending increases the GVA in companies selling to households. This is known as the **Induced Effect**. The sum of the direct, indirect and induced effects is some multiple of the initial direct effect. A multiplier which includes the induced effect is known as a **Type II Multiplier.**

We can therefore refer to Type I and Type II employment multipliers or GVA multipliers. Indeed we can produce output or turnover multipliers which describe the ratio between the initial output and the direct, indirect and induced output effects.[10]

Table 1 below gives the Type 1 and Type II Multipliers for aquaculture. The Rank shows how they compare with the other 96 industries. For example, the output multiplier for aquaculture is high relative to other industries because the supply chain is long. Of all the industries, aquaculture has the 5th largest output multiplier. For the same reason, the income and GVA multipliers are low because there exists a lot of double counting through the supply chain as each "bit" simply adds only a little value to the process.

Table 1. Type I and Type II Multipliers for Scottish Aquaculture[11]

Aquaculture 2016	**Type 1**	**Type 2**
Output multiplier	1.7	1.8
Rank	5	5
GVA effect	0.5	0.6
Rank	87	91
Income multiplier	2.3	2.6
Rank	3	3
Employment multiplier	1.9	2.2
Rank	14	20

[10] Appendix 2 discusses in much more detail the way multipliers are derived and the data and assumptions in the underlying model. It also discusses the resulting limitations and some of the methods that can be used to overcome these.

[11] Source: https://www2.gov.scot/Topics/Statistics/Browse/Economy/Input-Output

GVA multiplier	2.2	2.6
Rank	4	5

Table 2 presents our analysis, using Input-Output derived multipliers of the loss Scotland would suffer if the industry completely collapsed

Table 2 The loss to Scotland with the Demise of Salmon Aquaculture

	Direct	Type I	Type 2	Indirect	Induced
Output	792.8				
Income	83.3	207.2	235.2	123.9	28.1
Employment	2280.0	3272.0	3511.0	992.0	239.0
GVA	176.4	285.3	315.6	108.9	30.3

The output from salmon production is £792.8, the GVA £176.4 and the employees 2,280.

Marine Scotland has produced statistics on Aquaculture. These are presented below in Table 3 and reassuringly these figures correspond closely, as one would expect, with the Scottish Input-Output Tables.

Table 3 Marine Scotland's Statistics on Aquaculture[12]

Year	GVA £M	Turnover £m	Employment Headcount 000's	GVA Per Worker £
2008	108	415	1.83	59,028
2009	128	488	1.76	72,780
2010	163	617	1.92	84,752
2011	174	656	1.81	96,255
2012	157	594	1.90	82,689
2013	220	729	1.86	117,855
2014	254	763	2.14	118,705
2015	110	683	2.18	50,713
2016	216	797	2.28	94,833

3.1.1 A note on the impact of ownership on GVA

Three of Scotland's big six salmon farming firms are owned by Norwegian companies: Mowi (formerly Marine Harvest), Scottish Sea Farms and Grieg Seafood. The parent company of Scotland's third largest salmon producer, The Scottish Salmon Company, is registered in Jersey, and listed on the Norwegian Stock Exchange. The two other major salmon producers in Scotland are Cooke Aquaculture, which is Canadian, and Loch Duart, which has major shareholders in the US. These six companies account for 99 per cent of all Scotland's farmed fish production. According to Imani (2017), about 50% of GVA is profit and it is reasonable to expect a proportion of this element to leave Scotland.

In our view, only wages, and possibly UK revenues from taxing profit, should be considered an economic benefit to Scotland. Otherwise, Scotland effectively will be pursuing policies and damaging our environment because of the benefits to Norwegian and US nationals. The

[12] Source: https://www2.gov.scot/Topics/marine/Publications/TopicSheets/tslist/economy

flow of income to overseas household is irrelevant. It is misleading to quote GVA including all profits as a measure of increased income to Scotland.

3.1.2 Foreign Ownership, Foreign Labour and the Induced Effect

The induced effect is calculated by taking the additional value, removing "average" deductions (taxation, national insurance and saving) and then splitting the net income according to the averages derived from the Household Expenditure Survey. These figures are then assumed to be the subsequent additional expenditure/demand for each industry.

Much of the profit from a UK owned business is simply additional income to UK citizens and spent within the UK (like wage income). On the other hand, much of the profit from foreign owned companies will not be spent in the UK. In this case the induced effect will be zero.

In addition, increasingly the labour working in the industry operates on a 2 week on /2 week off basis similar to the employment pattern for oil rigs. If aquaculture is similar to other offshore jobs, the "home" of the employee is likely to be outside Scotland. It is debatable if we should be destroying Scotland's environment to produce jobs for people not living in Scotland. Moreover, the vast majority of any income will be spent outside Scotland and consequently the induced effect will again be close to zero.

Given the pattern of ownership and employment in aquaculture it would seem more appropriate to use the Type 1 Multipliers in any estimation of Impact. Induced effects add around 10% on to the estimates of income, employment and GVA. The estimates we generate later are thus undoubtedly too large.

3.2 The Idiosyncratic Approach of Imani

The main focus of Imani as a company is development, with a strong background in assisting developing countries in establishing inter alia, aquaculture. As part of that process, Imani have developed what they term "A Sustainable Livelihoods Assessment Framework" which considers, in a rigorous fashion, the needs and impediments in starting and growing an industry.

Consequently, their assessment approach is based on surveys of what will be demanded from other sectors to produce output and what is needed to deal with this output and get a finished product to market. Inevitably, stated demands from the embryo industry are central and form the basis of estimates of impact. One can appreciate them using this approach in developing economies where, unlike Scotland, they have not been collecting and updating data for 40 years.

Critics of Input-Output point to substantial errors in the past, driven in part by definitional changes and national accounting conventions and in part by self-reporting; however, the "official" figures are continually corrected and updated. In the view of many, National Input-Output Statistics are the "Gold Standard".

Imani give four reasons for specifically rejecting the traditional approach of utilising Input-Output Tables produced by government statisticians:

1. Vertical integration within aquaculture means that indirect impact ratios are not meaningful. We do not understand this comment.
2. Input-Output Tables are historic. There is inevitably a delay in incorporating the latest data to produce an updated I-O table and the latest table is for 2016. However it should be noted that the latest data used by Imani is 2016 and most is dated 2015.
3. There has been a startling increase in productivity in aquaculture, such as automatic feeding systems, and it should be taken into account.
4. Discussion with the main players provides valuable insight into social and economic impacts. Our view is that where possible, practitioners should use data generated by

an independent authority (ie Government) rather than sources who might not be disinterested in the results.

Generally, the procedures adopted by Imani are somewhat opaque. The commentary notes ***"they should be regarded as no more than indicative"*** **and "*FTEs and earnings are aggregations of direct and indirect ..because Type 1 multipliers ..have been applied to estimates of generated turnover (while taking available information…. into account "** Imani (2017 p55).

There is a lack of clarity about how the business surveys and consultations were undertaken (e.g. sample size, response rate etc.) and more importantly how the survey results, together with industry surveys by Marine Scotland, were processed to produce the estimated impacts. Important questions on, for example, division of activity in fish processing, are not discussed and definitions seem flexible.

As a consequence, there is inevitably limited confidence in the estimates, especially where there appears to be independent Input-Output derived evidence to contradict the results.

The key Imani (2017) estimates are given in Table 4 below. These are important because they have been extensively quoted by the industry and by Ministers. Given their timing, these estimates are clearly the basis upon which the SG has decided to support industry expansion.

Table 4 Summary of Imani (2017) Estimates

Salmon	FTEs	Earnings (£m)
Smolt & salmon production	1,555	46
Management & administration	233	8.1
Fish feed supply (incl indirect)	416	10.2
Transport (incl indirect)	534	16
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
Total direct plus indirect	**8,689**	**237.8**
Induced employment	1,651	33
Total employment impact	**10,340**	**270.8**

The Imani consultants then estimate GVA as £540m on the basis that it is approximately double the earnings. Adding Trout, Other Finfish, and Employment in government and research institutes they record some 12,022 jobs and £620m GVA as the impact of Aquaculture.

Comparisons with the Transactions Matrix suggest Imani fails to identify flows of goods from outside Scotland into the process and flows of fish out of Scotland for processing. It thus exaggerates the importance of aquaculture to Scotland.

One of the most surprising (and unbelievable) findings of Imani is the expenditure and manpower associated with veterinary services; 596 FTEs as opposed to £1.3m in the Transactions Table. The addition of pharmaceuticals, and other chemicals adds another £0.8m and there are small indirect and induced effects, but the Imani vet services expenditure is still **300 times bigger** than would appear reasonable.

The treatment of capital expenditure in Imani is idiosyncratic. In contrast, the Transactions Table records purchases (e.g. Buildings) and recognises any change in capital value by the flow (positive or negative) in the value of the capital account.

The remuneration of employees in the industry is identified in the Transactions Tables as £83.3m, substantially higher than Imani. The reasons are unclear. The Marine Scotland survey figures put the number employed in the sector as 2,280 which gives average remuneration as £36,535.

The Transactions Table details what has been recorded from HMRC. In contrast the Imani table appears to take the employees declared by the companies and multiplies these by an average remuneration of £30,000. In that process certain services such as well-boat operation or fish slaughter may have been included in the aquaculture industry but not by Imani, or certain labour costs (e.g. National Insurance and pension payments) may have been omitted from Imani. Finally the total GVA impact is recorded by Imani as £540m compared to a GVA for the sector from the Transactions Table of £176.4m, an implied Type II GVA multiplier of over 3.

Table 5 compares the results one might produce using government multipliers (Table 1) and SABS figures for 2016. It should be noted that these are for aquaculture as a whole; salmon alone would be around 95% of the totals.

Table 5: Estimates for 2016 using standard multipliers

	Direct	Type I	Type 2	Indirect	Induced
Output	792.8				
Income	83.3	191.59	216.58	108.29	24.99
Employment	2280	4332	5016	2052	684
GVA	176.4	388.08	458.64	211.68	70.56

Table 6 attempts to compare estimated salmon figures with the estimates produced by Imani 2017 using industry source and the apparent over estimation by Imani.

Table 6: Imani v Traditional Methods

		Imani	Salmon Only	Overestimate
Direct	**Output**	1,080	753	143.4%
	Earnings	108	79	136.5%
	employment	1,788	2,166	82.5%
	GVA	54	168	32.3%
Direct, Indirect and Induced	**Income**	271	206	131.4%
	Employment	10,340	4,115	251.3%
	GVA	540	435	124.1%

The most significant difference is in employment. Despite starting with a higher number of direct employees the final impact on jobs is far less. Part of this would appear to be mistakes (596 vets or their assistants fully employed on fish farms seems very unlikely), and some a

failure to recognise that fish processing does not solely deal with aquaculture and that a lot of the processing occurs outside Scotland. Similarly, the model does not take into account purchases from outside Scotland.

3.3 Marsh (2019)

A recent study by Marsh (2019), funded by SSPO, looks at the impact of salmon farming not only on the economy as a whole but also on government finances. It uses a traditional Input-Output methodology by applying the 2016 Input Output multipliers to 2018 data on industry output.

We have considerable problems not with the approach but with the data produced by Marine Scotland. Table 7 shows the data.

Table 7: Marine Scotland Statistics for Aquaculture

Year	GVA	Turnover	Employment Headcount	GVA Per Worker
	£m	£m	000's	£
2008	110	424	1.83	60,278
2009	131	498	1.76	74,297
2010	167	630	1.92	86,562
2011	178	670	1.81	98,257
2012	160	606	1.9	84,408
2013	224	744	1.86	120,294
2014	259	778	2.14	121,161
2015	*113*	697	2.18	*51,759*
2016	*221*	814	2.28	*96,814*
2017	*436*	905	2.24	*194,399*

Specifically, it is difficult to believe that the Gross Value Added per employee more than doubled 2016-2017 given a rise in turnover of only 11% and a fall in employment of just 2%. Variations like these suggest that the double counting methods of the SABS might be preferable.

Table 8 shows the 2018 key figures, the most important of which is a decrease in GVA with an increase in turnover and almost the same workforce.

Table 8: Scottish salmon key facts (2018 prices)[13]

Economic Indicator	Value (£m)
Turnover	£1,027
Gross Value Added (GVA)	£365
Gross capital investment	£72
Corporation tax	£50
Total salary costs	£86

[13] Source: 4-consulting

Total wages	£76
Income tax & national insurance	£24
Average wage (£)	£34,000
Employment	2,300

The Marsh paper then calculates the change in total output in Scotland using the output multiplier and produces the headline grabbing figure of £2bn in turnover (see page 1).

It does not highlight the much more relevant GVA and Employment in Scotland as a whole. The employment figure, for example, would be less than half the widely publicised Imani (2017) figure of over 10,000.

The principal purpose of Marsh seems to be estimation of tax receipts. Using established ratios between corporation tax and turnover, income tax and NI and income and the income multiplier, Marsh estimates income tax receipts arising from the operations of aquaculture and other companies in the supply chain.

This allows the industry to claim that it was responsible for £216m of government revenue. This compares with the £74m that companies and employees in the industry actually paid directly. Since profits are largely repatriated, this might explain some of the difference.

A flaw of this work is the failure to identify the alternative vision. For example, whilst it is likely that the processing sector would contract without aquaculture, it is expected that alternative raw materials for processing would be sourced. The economic impact would then be considerably reduced.

Marsh seems to be responsible for using total industry turnover (£2bn) as an industry performance indicator. Total Industry Output or Total Turnover are essentially meaningless measures. To explain this, consider a hypothetical industry X that has two stages. The first produces an intermediate product that passes to the final producer for £10m. The second stage takes the £10m and adds a further £10m in GVA which is sold to the final customer. The total turnover/output is £30m (£10m +£20m) and the GVA is £20m. Another hypothetical industry Y has 5 stages. Stage A initially sells £5m of good to B, who sells £10m to C, who sells £15m to D who sells £18m to E who finally sells £20m to the customer. The total output is £68m but GVA is still only £20m.

In our view total turnover figures should never be used. It is used for advocacy purpose because it is usually very large, but it does not relate to any recognised concept of value.

3.4 Scottish Government's Proposed Further Research

Appendix 2 is an extract from Marine Scotland invitation to quote for **Estimation of the wider economic impacts of the Aquaculture Sector in Scotland**

- *"Direct impacts – this is the economy activity carried out by the aquaculture sector itself, such as impacts associated with farm-level production.*

- *Indirect impacts – changes in sales, income or jobs in sectors that supply goods and services to the aquaculture sector. These can be upstream (suppliers inputting into production e.g. feed, vet services), or downstream (activity between production and consumption, e.g. processing and transport).*

- *Induced impacts – increased sales from household spending of the income earned in the sector and its supporting sectors.*

The above direct, indirect and induced impacts together can be thought of as the wider economic impacts of the sector. Marine Scotland already publish estimates of the direct contribution that aquaculture makes to the Scottish economy annually within its Marine Economic Statistics publication.

Additional work on the economic benefits is warranted, given the uncertainty about previous studies reconciling with each other and with official statistics, However, there is still no proposal to generate evidence on:

- The impact of additional damage to the marine environment on the well-being of non-industry stakeholder groups (i.e. CBA type analysis)
- The impact on jobs and incomes of those who own and work in businesses which rely on inshore marine environment service flows
- The likely future economic benefits and costs per tonne of salmon production.

3.5 Conclusion on the reliability of the partial economic impact evidence

Whilst we have no fundamental worries about the research by Marsh, we note the calculation and publication of the misleading "Total Turnover", the failure to calculate the much more meaningful employment figures, and issues with reconciling tax payments with HMRC data.

Clearly, Imani is fundamentally flawed and consistently seems to overstate the importance of the industry. The ready adoption of Imani by HIE and sectors of the SG despite major conflicts with SG's own data is worrying. A traditional model, such as Marsh, should be preferred.

Collectively, the estimates produced by Imani and Marsh **(£2bn turnover, 12,000 current aquaculture dependent jobs, 8,000 salmon jobs, 18,000 salmon jobs by 2030, government tax receipts of £216m)** create the impression of an industry making a massive contribution to income and employment.

The reality is that these estimates have, whether innocently or culpably, been overestimated, or do not relate to a meaningful performance indicator (e.g. £2bn turnover).

The quality of the economic analysis has been subjugated to the desire of the industry to put up a very strong case to the Scottish Government to continue to support expansion. With little opposition, false and flawed estimates of the economic impact effects have become accepted official figures.

4 The Inappropriate Use of the Available Evidence

It is important to appreciate that, just because an industry is large and making an economic contribution, it does not mean that we should devote more resources to it. The case for expansion has to focus on the additional benefits and costs that the expansion will deliver. The only estimates we have relate to total current production and, unless all the underlying relationships are linear, the current totals have limitations when used to advocate a change in resource use, though for advocacy purpose they appear to have traction.

We are concerned there has been no formal analysis of the benefits and costs associated with the proposed expansion. The inference is given that if we double production, GVA and employment will double. In the real world, relationships are not linear. Consequently, the average employee or GVA per tonne calculated using current levels of exploitation will differ from post expansion (or contraction). For instance, automation of the industry will pro rata

reduce the number of jobs per tonne of production. The following is an extract from the Mowi Annual Report 2018, page 128:

> *"Another major ongoing development is the creation of the Most Automated Farms (MAFs) and related Remote Operations projects in Mowi Norway. MAF is a phased approach to assemble the open pen production platform of the future, primed for further and ultimately complete rollout throughout Mowi Farming. The MAF phase 1 scope is concentrated around simplifying daily tasks by way of automation. Projects revolve around developing and implementing solutions to create a paperless working environment as a step in our digitalisation process; to utilise drone technology for improved sub-surface surveillance and as deterrent for birds and other scavengers so that costly accessories can be removed from our pens, in addition to centralisation of dead fish handling, cleanerfish feeding and cleanerfish accessory management. Furthermore, a major part of the MAF project entails the establishment of the Mowi standard of Remote Operations centers, where a complete service provision - covering fish feeding, site monitoring (environment and infrastructure), fish health support and remote maintenance support - will be given to clusters of seawater farms. This approach leverages in full the opportunities brought about by ongoing development of the Mowi Cloud (see the section Bringing it all together), and expands the notion of Remote Operations far beyond that of remote feeding as a sole service as is the common approach employed by our competitors. MAF Phase 2 and 3 will undergo detailed planning in 2019, with the main goal of fully automised marine food production, as we carry out and document the anticipated benefits of MAF phase 1".*

It is therefore perfectly possible, indeed likely, that wages as a component of GVA will decline and profits increase. Since a very large proportion of the latter are not part of Scottish household income, the economic contribution to Scotland per tonne of production is likely to decrease.

Also, a general presumption is that, as a society, when we produce more of something each additional unit becomes less valuable; each additional tonne of salmon is less valuable than the previous. The problem is that, if we uncritically use current averages to approve all current proposals, the collective impact means the actual economic benefits per tonne of production will be less than expected.

At the same time, there is also a general presumption that when we have less of something, the remaining units become more valuable. Thus, as marine biomass and diversity declines, the remaining units become more valuable and worthy of greater protection. If all salmon farm proposals are evaluated using current values the eventual economic costs could be significantly greater than expected.

There is therefore an inherent bias when deciding whether to expand salmon aquaculture. This is because, using current averages, we are inclined simultaneously to overestimate benefits of more salmon production and to underestimate the environmental costs.

An added complication is that environmental damage costs are much more difficult to calculate. This is because the true extent of the physical damage to the marine environment remains uncertain. Even if we fully understood the environmental damage, its consequential impacts on human welfare are very complex and less readily quantified by economic analysis. It is perfectly possible that the decision process downplays highly significant economic costs in favour of more readily quantifiable economic benefits.

The inherent bias and the difficulty in estimating the economic value of environmental damage costs are not trivial issues, especially given the level of expansion being proposed.

5 Conclusions and Implications

It is regrettable that the publicly declared SG support for industry expansion has apparently been influenced by its reliance on:

- An inappropriate evaluation framework (EIA), which effectively ignores the adverse impacts that industry expansion will have on the well-being of other Scottish stakeholders
- A highly partial EIA which ignores the potential for job losses elsewhere
- A poorly executed EIA (Imani 2017) funded by HIE and Marine Scotland deploying unusual methods and data supplied by the industry and a study (Marsh 2019) which produced impressively large monetary sums which do not relate to any coherent performance indicator.

The SG is faced with the difficult question **"is further damage to Scotland's inshore environment a price worth paying to realise the economic benefits from salmon aquaculture expansion**".

It is difficult to understand how this question could even be addressed using currently available information.[14] Fundamentally, this is why some fail to see a clear rationale for the SG's current support for industry expansion. The SG needs to either explain its rationale, or pending further research, suspend its support.

[14] The additional research on industry benefits is simply not capable of providing the information SG requires to make an informed judgement about the benefits to Scotland as a whole (see Section 3.4)

APPENDIX 1

The 2016 Transactions Matrix Entries for Aquaculture

From Industry	***Aqua-culture***	***% of Costs***	***To Industry***	*Aqua-culture*	*%of Sales*
Agriculture	0.4	0.0%	*Agriculture*	0.1	0.0%
Forestry planting	0.1	0.0%	*Forestry planting*	0.0	0.0%
Forestry harvesting	0.0	0.0%	*Forestry harvesting*	0.0	0.0%
Fishing	0.0	0.0%	*Fishing*	0.0	0.0%
Aquaculture	**117.1**	**14.8%**	*Aquaculture*	117.1	14.8%
Coal & lignite	0.0	0.0%	*Coal & lignite*	0.0	0.0%
Oil & gas extraction, metal ores & other	0.3	0.0%	*Oil & gas extraction, metal ores & other*	0.0	0.0%
Mining Support	2.5	0.3%	*Mining Support*	0.0	0.0%
Meat processing	1.7	0.2%	*Meat processing*	0.0	0.0%
Fish & fruit processing	0.4	0.1%	*Fish & fruit processing*	76.8	9.7%
Dairy products, oils & fats processing	0.0	0.0%	*Dairy products, oils & fats processing*	0.0	0.0%
Grain milling & starch	0.2	0.0%	*Grain milling & starch*	0.0	0.0%
Bakery & farinaceous	0.6	0.1%	*Bakery & farinaceous*	0.0	0.0%
Other food	0.2	0.0%	*Other food*	0.0	0.0%
Animal feeds	**23.8**	**3.0%**	*Animal feeds*	0.0	0.0%
Spirits & wines	0.5	0.1%	*Spirits & wines*	0.1	0.0%
Beer & malt	0.0	0.0%	*Beer & malt*	0.0	0.0%
Soft Drinks	0.0	0.0%	*Soft Drinks*	0.0	0.0%
Tobacco	-	0.0%	*Tobacco*	-	0.0%
Textiles	1.3	0.2%	*Textiles*	0.0	0.0%
Wearing apparel	0.2	0.0%	*Wearing apparel*	0.0	0.0%
Leather goods	0.1	0.0%	*Leather goods*	0.0	0.0%
Wood and wood products	0.4	0.1%	*Wood and wood products*	0.0	0.0%
Paper & paper products	0.3	0.0%	*Paper & paper products*	0.0	0.0%
Printing and recording	0.0	0.0%	*Printing and recording*	0.0	0.0%

Coke, petroleum & petrochemicals	1.1	0.1%	*Coke, petroleum & petro-chemicals*	0.0	0.0%
Paints, varnishes and inks etc	0.0	0.0%	*Paints, varnishes and inks etc.*	0.0	0.0%
Cleaning & toilet preparations	0.1	0.0%	*Cleaning & toilet preparations*	0.0	0.0%
Other chemicals	**0.2**	**0.0%**	*Other chemicals*	0.0	0.0%
Inorganic chemicals, dyestuffs & agrochemicals	**0.1**	**0.0%**	*Inorganic chemicals, dyestuffs & agro-chemicals*	0.0	0.0%
Pharmaceuticals	**0.5**	**0.1%**	*Pharmaceuticals*	0.0	0.0%
Rubber & Plastic	3.1	0.4%	*Rubber & Plastic*	0.0	0.0%
Cement lime & plaster	0.0	0.0%	*Cement lime & plaster*	0.0	0.0%
Glass, clay & stone etc	0.0	0.0%	*Glass, clay & stone etc.*	0.0	0.0%
Iron & Steel	0.0	0.0%	*Iron & Steel*	0.0	0.0%
Other metals & casting	0.0	0.0%	*Other metals & casting*	0.0	0.0%
Fabricated metal	3.0	0.4%	*Fabricated metal*	0.1	0.0%
Computers, electronics & opticals	0.9	0.1%	*Computers, electronics & opticals*	0.1	0.0%
Electrical equipment	0.3	0.0%	*Electrical equipment*	0.0	0.0%
Machinery & equipment	2.7	0.3%	*Machinery & equipment*	0.1	0.0%
Motor Vehicles	0.1	0.0%	*Motor Vehicles*	0.0	0.0%
Other transport equipment	**11.7**	**1.5%**	*Other transport equipment*	0.1	0.0%
Furniture	0.1	0.0%	*Furniture*	0.0	0.0%
Other manufacturing	0.7	0.1%	*Other manu-facturing*	0.0	0.0%
Repair & maintenance	**9.8**	**1.2%**	*Repair & maintenance*	0.0	0.0%
Electricity	**30.3**	**3.8%**	*Electricity*	0.1	0.0%
Gas etc	6.0	0.8%	*Gas etc.*	0.1	0.0%
Water and sewerage	3.1	0.4%	*Water and sewerage*	0.0	0.0%
Waste, remediation & management	2.9	0.0%	*Waste, remediation & management*	0.0	0.0%
Construction	**19.8**	**2.5%**	*Construction*	0.4	0.1%

Wholesale & Retail - vehicles	2.0	0.3%	*Wholesale & Retail - vehicles*	0.0	0.0%
Wholesale - excl vehicles	**24.7**	**3.1%**	*Wholesale - excl vehicles*	0.1	0.0%
Retail - excl vehicles	0.3	0.0%	*Retail - excl vehicles*	0.1	0.0%
Rail transport	0.0	0.0%	*Rail transport*	0.0	0.0%
Other land transport	**35.2**	**4.4%**	*Other land transport*	0.0	0.0%
Water transport	1.0	0.1%	*Water transport*	1.7	0.2%
Air transport	0.0	0.0%	*Air transport*	0.0	0.0%
Support services for transport	0.1	0.0%	*Support services for transport*	0.0	0.0%
Post & courier	0.0	0.0%	*Post & courier*	0.0	0.0%
Accommodation	2.6	0.3%	*Accommodation*	1.4	0.2%
Food & beverage services	1.6	0.0%	*Food & beverage services*	**4.3**	0.5%
Publishing services	0.0	0.0%	*Publishing services*	0.0	0.0%
Film video & TV etc; broadcasting	0.0	0.0%	*Film video & TV etc.; broadcasting*	0.0	0.0%
Telecommunications	1.2	0.2%	*Telecommunications*	0.0	0.0%
Computer services	0.0	0.0%	*Computer services*	0.0	0.0%
Information services	0.0	0.0%	*Information services*	0.0	0.0%
Financial services	8.4	1.1%	*Financial services*	0.1	0.0%
Insurance & pensions	**22.8**	**2.9%**	*Insurance & pensions*	0.2	0.0%
Auxiliary financial services	0.0	0.0%	*Auxiliary financial services*	0.0	0.0%
Real estate - own	6.5	0.8%	*Real estate - own*	0.0	0.0%
Imputed rent	-	0.0%	*Imputed rent*	0.0	0.0%
Real estate - fee or contract	0.0	0.0%	*Real estate - fee or contract*	0.0	0.0%
Legal activities	0.0	0.0%	*Legal activities*	0.0	0.0%
Accounting & tax services	0.5	0.1%	*Accounting & tax services*	0.0	0.0%
Head office & consulting services	0.0	0.0%	*Head office & consulting services*	0.0	0.0%
Architectural services etc	0.5	0.0%	*Architectural services etc.*	0.0	0.0%
Research & development	0.1	0.0%	*Research & development*	0.0	0.0%
Advertising & market research	0.0	0.0%	*Advertising & market research*	0.0	0.0%

Other professional services	0.0	0.0%	*Other professional services*	0.0	0.0%
Veterinary services	**1.3**	**0.2%**	*Veterinary services*	0.0	0.0%
Rental and leasing services	0.0	0.0%	*Rental and leasing services*	0.0	0.0%
Employment services	0.0	0.0%	*Employment services*	0.0	0.0%
Travel & related services	0.0	0.0%	*Travel & related services*	0.0	0.0%
Security & investigation	0.0	0.0%	*Security & investigation*	0.0	0.0%
Building & landscape services	0.2	0.0%	*Building & landscape services*	0.0	0.0%
Business support services	0.1	0.0%	*Business support services*	0.0	0.0%
Public administration & defence	0.0	0.0%	*Public administration & defence*	0.2	0.0%
Education	0.0	0.0%	*Education*	0.1	0.0%
Health	2.8	0.4%	*Health*	0.2	0.0%
Residential care and social work	0.0	0.0%	*Residential care and social work*	0.2	0.0%
Creative services	0.0	0.0%	*Creative services*	0.0	0.0%
Cultural services	0.0	0.0%	*Cultural services*	0.0	0.0%
Gambling	0.0	0.0%	*Gambling*	0.0	0.0%
Sports & recreation	0.0	0.0%	*Sports & recreation*	0.0	0.0%
Membership organisations	0.0	0.0%	*Membership organisations*	0.0	0.0%
Repairs - personal and household	0.0	0.0%	*Repairs - personal and household*	0.0	0.0%
Other personal services	0.1	0.0%	*Other personal services*	0.0	0.0%
Households as employers	-	0.0%	*Households as employers*	-	0.0%
Total domestic use	359.2	45.3%	***Total intermediate use***	**204.4**	25.8%
Imports from rest of UK	144.8	18.3%	*Households*	**23.5**	3.0%
Imports from rest of world	65.3	8.2%	*NPISHs*	0.1	0.0%
Total intermediate use at basic prices	569.3	71.8%	*Central government*	0.2	0.0%
Taxes less subsidies on products	47.1	5.9%	*Local government*	0.3	0.0%

Taxes less subsidies on production	0.6	0.1%	***Total***	**24.1**	3.0%
Compensation of employees	**83.3**	**10.5%**	*Gross fixed capital formation*	0.3	0.0%
Gross operating surplus	92.5	11.7%	*Valuables*	-	0.0%
Gross value added	**176.4**	**22.3%**	*Change in inventories*	1.7	0.2%
Total output at basic prices	792.8	100.0%	***Total***	**2.0**	0.3%
			Non-resident households	4.8	0.6%
			Rest of UK	**254.1**	**32.0%**
			Rest of world	**303.4**	**38.3%**
			Total	**562.3**	**70.9%**
			Total final use	**588.4**	74.2%
			Total use for industry output	**792.8**	100.0%

Source: https://www2.gov.scot/Topics/Statistics/Browse/Economy/Input-Output

APPENDIX 2

Impact Analysis and Multipliers

1. Introduction

When investing in or approving of an economic action it is normal to require some idea of the impact that it will have. Typically a company wanting public support or to make a major change in the public environment will wish to, or be required to, conduct an Economic Impact Assessment to justify the investment or permission. Unfortunately, because such analyses are normally commissioned by and paid for the applicant, Economic Impact Assessments have often become little more than exercises in public relations. A consultancy that finds little to recommend in a client's proposal (even if the client is a government agency) will have a short life.

Sometimes fundamental distortion has been hidden by failing to detail critical assumptions and methods and the misuse of jargon. This appendix looks at typical problems and also tries to explain some of the jargon and "black box" methods that are present in many studies. The studies by Imani and Marsh are sadly not untypical.

2. The failure to examine alternatives

An EIA is a forecast of the future with and without the investment. This requires a forecast not only of the future with the investment but also of the future without. Thus, when the HIE decided to invest in a funicular railway up Cairngorm it had to look at the impact not only on the economy of Aviemore but also on the economy of the gondola at Aonach Mor by Fort William and the economy of the whole of the Highlands. Identifying and predicting substitution effects are absolutely central to a properly conducted analysis.

For an example in aquaculture of the distortion without this critical element the economic analysis of the new Feed plant on Skye failed to identify the closure of the feed plant in Inverness that resulted. The planning committee report simply states "*Economic Benefits – when operational, the plant is projected to create some 55 jobs with the Scottish Council for Development and Industry estimating that this will generate some £1.7M in salaries. It is considered that, in a local context, this is a significant input to the economy ".*[15]

3. Worth, Output and Turnover

One of the most common and possibly the most misleading outputs relates to the erroneous idea that economic activity can be simply measured by examining the expenditure in an industry and its partners in a supply chain. For example, a typical statement might read "the economic impact of starting the Tour de France in Yorkshire was worth £102m to Yorkshire". This statistic emerges by aggregating the expenditure in the area by visitors in shops and hotels and by local firms supplying

[15] THE HIGHLAND COUNCIL Agenda Item 7.4 NORTH PLANNING APPLICATIONS COMMITTEE 21 February 2017 Report No PLN/015/17

goods to those companies. However, in some industries such as fuel supply, only a tiny proportion of the expenditure goes into the local economy, the balance going to national suppliers and the government.

The length of the supply chain also has an important role in determining the turnover (as opposed to the value of the industry). Marsh seems to be responsible for using total industry turnover (£2 billion) as an industry performance indicator. Total Industry Output or Total Turnover are essentially meaningless measures. To explain this, consider a hypothetical industry X that has two stages. The first produces an intermediate product that passes to the final producer for £10m. The second stage takes the £10m and adds a further £10m in GVA which is sold to the final customer. The total turnover/output is £30m (£10m +£20m) and the GVA is £20m. Another hypothetical industry Y has 5 stages. Stage A initially sells £5m of good to B, who sells £10m to C, who sells £15m to D who sells £18m to E who finally sells £20m to the customer. The total output is £68m but GVA is still only £20m.

In our view total turnover figures should never be quoted. It is used for advocacy purpose because it is usually very large, but it does not relate to any recognised concept of value.

4. The Choice of Data

It is almost the norm with undergraduate or graduate research for the proposal to include a survey of some form. Sadly, well designed and comprehensive national surveys that cover the same areas are often ignored.

Within the UK undoubtedly the best source of data on the UK or Scottish Economy is the Annual Business Survey (ABS) which, with its predecessor the Annual Business Inquiry, has been running since 1995. The ABS publish financial information from businesses representing the UK non-financial business economy (about two-thirds of the UK economy). The financial variables covered include turnover, purchases, employment costs, capital expenditure and stocks. The Office for National Statistics can then calculate approximate gross value added (aGVA), which is a measure of the income generated by the surveyed businesses (and the industry or sector they represent) less their intermediate consumption of goods and services used up in order to produce their output. This is an input into the measurement of the UK's Gross Domestic Product (GDP).

For reasons of confidentiality the ABS only publish variable data down to four-digit class level of Standard Industrial Classification 2007: SIC 2007 at the national level and two-digit Division at the NUTS1 region level but is actually capable of identifying, for example, the expenditure of the aquaculture industry in Wester Ross.

One extremely important feature that results from the comprehensive nature of the Survey is the ability to match income in industry X from industry Y to expenditures from Y on the products of X. The “double entry” accounting is a major check on areas like incorrect industry specification and under/over reporting by businesses and leads to the core input-output table known as the *Transactions Matrix*.

The balancing process in reality relies on modifying and scaling previous estimates. This process has the effect of smoothing out serious problems but not responding quickly enough to major investments that affect *inter alia* productivity.

Definitional changes such as the introduction of an extensively modified industrial classification system in 2007 can and did initially cause serious problems. However, the widespread use of the data soon identified and corrected most errors although it may be possible that some still persist.

Marine Scotland (MS) also conducts its own survey which covers aquaculture in Scotland and provides an alternative set of estimates for GVA, Turnover and Employment. MS argue that their aquaculture survey statistics are more complete than the ABS surveys. Estimates for 2015 showed a considerable variance between the ABS and estimates based on aquaculture data. This has been explored by MS and the estimates seem to more accurately reflect the situation. In 2015, production was lower and costs higher due to biological problems such as sea lice and disease. This does not appear to have substantially affected ABS survey estimates.

For forecasting the choice would appear to be between the robustness and reliability of the ABS estimates compared to the responsiveness to immediate events that characterises those of MS.

5. Modelling the Supply Chain and the derivation of Multipliers

If we have an accounting model for a nation or region that identifies the flow between industries and between the workforce as producers and households as consumers, then we can trace the impact of change. As a very simplified example suppose we have an economy with only three sectors A, B and C with the transactions between them being illustrated as a table (matrix) thus:

		TO				
		A	**B**	**C**	**Households**	***Output***
FROM	**A**	20	80	20	10	*130*
	B	30	15	100	50	*195*
	C	10	25	50	100	*185*
	Labour	70	75	15	***160***	
	Output	*130*	*195*	*185*		***510***

The column headed households is the value actually consumed and is known as the vector of final demands. Not surprisingly the total of this column is the real "value" of the economy and equivalent in this case to the value of the work put in by the workforce (ie the GVA is 160). This is associated with a Total Output of 510.

The key assumption that underlies the model is that the ratio of input to output, known as the technical coefficient, is constant, and gives us the next table.

	A	B	C
A	20/130	80/195	20/185
B	30/130	15/195	100/185
C	10/130	25/195	50/185

Table of Direct Coefficients

This equals

0.153846	0.410256	0.108108
0.230769	0.076923	0.540541
0.076923	0.128205	0.27027

However if we want to produce 10 units of A for final consumption we need not only the 10 units but

1. An additional 0.153846*10 units of A directly to produce the 10 units
2. 0.230769*10 units of B
3. 0.076923*10 units of C
4. a further 0.153846 *(0.153846*10) A to produce the additional A
5. 0.2307698*(0.153846*10) of B to produce this additional A
6. 0.76923*(0.153846*10) of C to produce the additional A
7. 0.153846*(0.230769*10) units of A to produce the additional B
8. 0.153846*(0.076923*10) units of A to produce the additional C
9. In addition we need more B to produce B to produce the A and more C to produce the B to produce the A and so on ad infinitum.

This horribly complex chain can in fact be solved by a neat and simple piece of matrix maths which generates what is known as the Table of Direct and Indirect Coefficients or the Leontief Matrix[16]. In this case we obtain

1.458569	0.756047	0.776119
0.506819	1.470278	1.164179
0.242795	0.338008	1.656716

This shows that for 1 unit of A for final consumption we need to produce 1 unit for sale, 0.153846 for direct consumption in its production and 0.340723 indirectly to produce the unitsneccesary to produce these extra units. The aggregation of the these Direct and Indirect Coefficients, in this case 0.458569 + 0.75604 + 0.776119, tells us the change in total output of A to produce an extra unit of A. This is the **Type 1 Multiplier = 2.990736**

[16] If A is the Matrix (table) of Direct coefficients, Y the vector (column) of Household Consumption, X the vector (column) of Outputs and I the identity matrix then since $A*X + Y = X$, $Y = (I-A)^{-1}*X$. The Table of Direct and Indirect Coefficients is thus the Inverse of the Identity Matrix minus the Table of Direct Coefficients.

Of course, there are costs other than labour in the economy (e.g. imports and interest) and expenditures other than household consumption such as capital accumulation and exports. Thus, in a full model we can also include the fact that increases in incomes will lead to increases in household consumption. This effect is known as induced demand and, via a table of Direct, Indirect and Induced coefficients, we derive a **Type 2 multiplier**.

6. The Extension and Application of Multipliers

Central to this model is the assumption of constant returns to scale i.e. to produce the 100th unit requires inputs in exactly the same proportions as the first. Similarly, we assume the product to be produced in 2030 will be produced in exactly the same way as the latest figures we have. Under the same assumptions the model incorporates constant ratios between value added and output and labour numbers and output (or value added). It is thus possible to define other multipliers relating, for example, initial employment to final employment.

The simplicity has encouraged a "Black Box" approach exemplified by the Scottish Government's Topic Paper https://www2.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Mulitipliers:

"Example 1 - Use of employment multipliers: the effect of a company opening or closing
Multipliers can be used to look at the impact of a specific event on the Scottish economy - for example a company opening or closing. To illustrate this, a hypothetical opening of a company in the "Publishing services" industry, employing 100 people on a full-time basis is considered.

In assessing the impact of this new company we estimate:

- *effects on suppliers of the company*
- *effects on the economy due to an increase in the spending of employees*

This is achieved by employing the appropriate multipliers for the type of industry concerned. For the illustrative example, the multipliers used will be for the "58 - Publishing services" Input-Output group.

Effects on Suppliers (Indirect Employment Effect)
Multiplying the direct increase in jobs by the "Publishing services" Type I employment multiplier gives: 100 x 1.1 = 110 direct and indirect full-time equivalent jobs. Subtracting the initial direct job increase gives the additional indirect number of jobs supported throughout the Scottish economy as 10 (full-time equivalent).

Effect of increased Household Expenditure (Induced Employment Effect)
In addition to the effect of increased employment, we would expect to see an increase in household expenditure among the people who have gained employment through both the direct and indirect employment effects. This is the induced effect and is estimated using the Type II multipliers.

*Multiplying the direct increase in jobs by the "Publishing services" Type II employment multiplier gives: 100 x **1.3** = **130 direct, indirect and induced jobs.** As we have already calculated a direct and indirect increase in employment of **110** (FTE), we estimate that **20** further jobs will be supported as a result of this induced demand.*

Example 2 - Estimating the effects of a change in final demand

The above example used an estimate of jobs supported directly in one industry to estimate the numbers of jobs supported indirectly and through induced use throughout the economy. However, the direct impacts upon an industry are often presented in monetary terms, i.e. increased exports or a change in Government spending. The following example uses the hypothetical scenario of an additional £5m of exports to the Rest of the World by the "Manufacture of other metals and castings" industry.

The effect on output (using Output Multipliers)

The direct impact upon "24.4-5 - Man. of Other basic metals and castings" will be a requirement to increase its total output by £5m to meet this additional final use, this is the ***direct effect****. To estimate the indirect effect on this industry's suppliers, we multiply the direct impact (£5m) by the Type I output multiplier for this industry (****1.4****) giving a* ***total of direct plus indirect impacts of £7m****. Similar to the example above, we would expect the direct and indirect increases in output to lead to increased employment in the affected industries and subsequently to an increase in household consumption. Multiplying the direct impact (£5m) by the Type II output multiplier (****1.5****) gives* ***£7.5m of increased output (direct, indirect and induced effects).***

The effect on employment (using Employment Effects)

The direct change in output can be also be used to estimate the effect upon employment in Scotland. Multiplying the direct output change by the Type I employment effect for this industry gives an estimate of the direct + indirect employment changes resulting from this additional output: £5m x ***4.4 gives 22 full-time equivalent jobs supported directly and indirectly throughout the Scottish economy.*** *The direct, indirect and induced employment change can be estimated using the Type II employment effects.*

The effect on compensation of employees (using Income Effects)

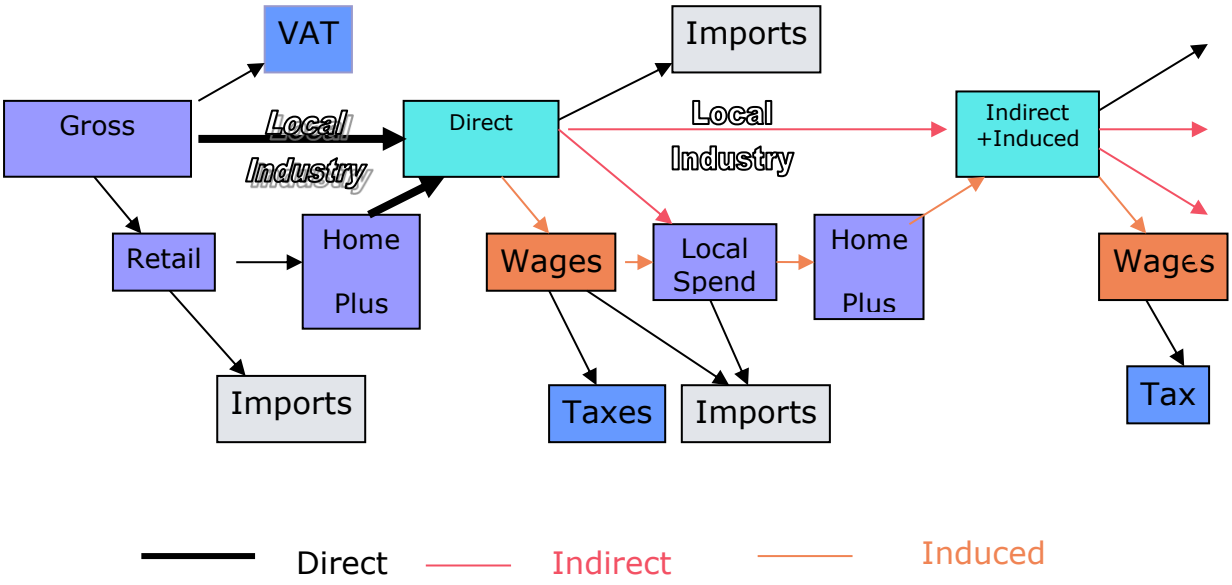
If employment were to rise, we would expect to see an associated rise in compensation of employees (wage income) as these new posts are filled. The Income effects estimate the effect of the direct change in output upon compensation of employees in Scotland. Multiplying the direct output change by the Type I Income effect for this industry gives an estimate of the direct + indirect income changes resulting from this additional output: £5m x ***0.3*** *=* ***£1.5m of additional compensation of employees income supported directly and indirectly.*** *The direct, indirect and induced wage income change can be estimated using the Type II employment effects."*

Inevitably there is likely to be misapplication. One of the most common of these is to apply national multipliers to regional situations. The smaller the area the greater the likelihood that supply will be sourced from outside and the greater the leakage the smaller the multiplier. By way of contrast changes in smaller areas may well have greater impact within those areas because there are fewer opportunities for substitution. Thus the Economic Impact study of the Cairngorm Funicular had a

bigger multiplier at Highland Council level than on Strathspey but the overall impact was smaller because of the **Substitution Effect** particularly on the Fort William gondola**.**

7. Criticisms of the Multiplier Approach and Alternatives

In many cases it is clear that the assumption of constancy within the forecast range cannot be justified and/or there are serious questions about data validity. One alternative, which is used in the DREAM suite of models is to work along the "chain" step by step, but only for one or two rounds. This is shown diagrammatically in Fig 1:



This approach allows direct adjustments to the coefficients at each round to incorporate expected changes in, for example, productivity or to correct known data problems. Although the effects are normally minimal this approach loses the impact of later rounds, is considerably more complex and requires a very clear statement of the adjustments made and their justification.

It may be argued that in most cases the effort involved may not be justified. However serious damage may actually be justified by inadequate or even incorrect economic analysis. A serious independent economic study of the Golf Course proposals at Balmedie in Aberdeenshire would have prevented the destruction of a unique natural environment.

APPENDIX 3.

Extract from Marine Scotland invitation to quote for <u>Estimation of the wider economic impacts of the Aquaculture Sector in Scotland.</u>

2. Background

2.1 The Scottish aquaculture sector directly employs more than 2,000 people and contributed around £220m in gross value added (GVA) to the Scottish economy in 2016. The sector has significant wider impacts across the supply chain, which have previously been estimated at around £620m in GVA and 12,000 FTE jobs across the Scottish economy. The Scottish aquaculture sector is mostly comprised of salmon production with trout, mussels and oysters in particular being other important species. Salmon, almost entirely produced in Scotland, is one of the UK's top food exports, with £505m of fresh salmon exported from the UK in 2018.

2.2 There are currently a number of estimates of the various components mentioned above:

- *The Fish and Shellfish Farm Production Surveys, published by Marine Scotland Science, collate annual production data from registered Scottish fish and shellfish farm sites, in terms of production value and volume.[1] These indicate the direct turnover and amount of employment in the aquaculture sector.*

- *Estimates of the direct GVA and employment contribution are published as part of the annual Scotland's Marine Economic Statistics publication, which are used to compare aquaculture to other marine sectors.[2]*

- *Estimates of aquaculture's multipliers are published within the Scottish Government's Input-Output tables.[3] These have a significant time lag and the underlying supply chain linkage are based on an infrequent survey. In isolation, these data are unlikely to hold the required information to answer the objectives above.*

- *Detailed revenue, cost, and employment estimates at the UK level are published by the European Commission's Scientific, Technical and Economic Committee for Fisheries (STECF).[4]*

- *Scottish Salmon Producer's Organisation (SSPO) published a report on the economic impact of Scottish Salmon Farming[5]. It includes key economic data for the production of Scottish Salmon such as GVA, Tax, Wages and Employment.*

- *Imani (2014) estimated the wider economic impacts of the Scottish aquaculture sector in terms of turnover at £1.4bn in 2012.[6]*

- *HIE (2017) estimated the wider economic impacts of the Scottish aquaculture sector in terms GVA at £620m as an average across 2014 and 2015.[7]*

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[1] https://www2.gov.scot/Topics/marine/Fish-Shellfish/FHI/surveys
[2] https://www.gov.scot/publications/scotlands-marine-economic-statistics
[3] https://www2.gov.scot/Topics/Statistics/Browse/Economy/Input-Output
[4] https://stecf.jrc.ec.europa.eu/dd/aqua
[5] http://scottishsalmon.co.uk/wp-content/uploads/2019/04/Salmon-Impact.pdf
[6] https://www2.gov.scot/Resource/0045/00450799.pdf
[7] http://www.hie.co.uk/regional-information/economic-reports-and-research/archive/value-of-aquaculture-2017.html

- *The Scottish Annual Business Statistics (SABS) surveys businesses, presenting information on employment, turnover, purchases, approximate gross value added and labour costs.[8] SABS is used to benchmark the Food and Drink sectors. However, this is based on a smaller sample size than the Marine Scotland production census.*

2.3 *The Scottish aquaculture sector is comprised of finfish (primarily salmon and trout) and shellfish cultivation (primarily mussels). The finfish part of the sector is concentrated in terms of ownership with substantial foreign ownership and investment. While the shellfish part is primarily composed of small-scale domestic producers, who tend to be organised within a co-operative structure. As such, their respective supply chains may have substantial differences in operation. There are also geographic differences between these sectors, with different clusters.*

3. Aims and Objectives of Research

3.1 *The Scottish Government's vision for Scotland's marine environment is to have: clean, healthy, safe, productive and diverse seas; managed to meet the long term needs of nature and people. This is set out in Scotland's National Marine Plan. Monitoring and evaluating the impacts of Scotland's marine environment and economy is important, of which the aquaculture sector is a key part and evidence is needed to measure the progress on the objectives and marine policies relating to the aquaculture sector.[9]*

3.2 *As such, there is a need to quantify the wider economic impact that the Scottish aquaculture sector has on Scotland's economy and local communities as well as what this means for public sector tax receipts. In particular, this is to complement existing estimates of the size of the sector, including Marine Scotland's Marine Economic Statistics publication which estimates aquaculture's direct contribution to Scotland's economy in terms of GVA and employment. Understanding the wider economic impacts (indirect and induced) on a regular basis is an essential piece of evidence to help guide policy in how best to support the sustainable and inclusive economic growth of the sector.*

- *This research aims to provide a tool or framework for regularly updating the wider economic impacts and associated public sector tax receipts of the aquaculture sector in Scotland. This will help expand the evidence base of the size of the aquaculture sector and understanding the interactions within the aquaculture sector as well as its associated supply chain. For the purposes of this study, the aquaculture sector includes both marine and freshwater farming, and is primarily composed of finfish cultivation, shellfish cultivation and cultivated finfish and shellfish processing.*

3.3 *The aquaculture sector plays an important role in many of Scotland's remote and coastal communities, through delivering sustainable and inclusive economic activity and employment. Therefore, evidence around how these benefits of aquaculture's wider impacts are spread geographically are also essential components.*

3.4 *The aquaculture sector impacts the Scottish economy through several channels:*

[8] https://www2.gov.scot/Topics/Statistics/Browse/Business/SABS
[9] https://www.gov.scot/publications/scotlands-national-marine-plan/pages/8/

- *Direct impacts – this is the economy activity carried out by the aquaculture sector itself, such as impacts associated with farm-level production.*

- *Indirect impacts – changes in sales, income or jobs in sectors that supply goods and services to the aquaculture sector. These can be upstream (suppliers inputting into production e.g. feed, vet services), or downstream (activity between production and consumption, e.g. processing and transport).*

- *Induced impacts – increased sales from household spending of the income earned in the sector and its supporting sectors.*

  The above direct, indirect and induced impacts together can be thought of as the wider economic impacts of the sector. Marine Scotland already publish estimates of the direct contribution that aquaculture makes to the Scottish economy annually within its Marine Economic Statistics publication.

3.5 The specific objectives of the research are to:

(a) Produce and present a robust and replicable methodology. The aim is to develop a formal tool or framework for regularly updating the wider economics impacts associated with aquaculture production in Scotland as well as its tax receipts. This encompasses that it can be updated as the structure of the industry and its links to the wider economy change over time.

Therefore, the methodology will map out existing data sources, how best to produce accurate indirect and induced impacts, given what is available on direct impacts, plus how to disaggregate these estimates geographically by Local Authority and Scottish Marine Region[10], and splitting out by salmon, trout, and mussels. This should include estimates in the form of GVA, turnover, and FTE employment. Where possible, these estimates should be methodologically linked with Marine Scotland's estimates of the direct impacts from aquaculture. In terms of tax receipt estimates, these should be for profit-, earnings-, and product and production-related taxes and disaggregated by both the direct and wider economic impacts of the aquaculture sector where possible. Where additional data are required, the survey design should be robust and replicable in the sense that future one-off estimates can be comparable. Lastly, the estimates of wider impacts should be limited to those that exist due to the presence of a large aquaculture production sector in Scotland.

(b) Provide estimates of the indirect and induced impacts of the Scottish aquaculture sector for 2018, including associated tax receipt estimates. These estimates should use the methodology laid out following completion of Objective 1 above and with the same disaggregation. This should include a careful consideration of the possible uses, and limitations, of these wider economic impact estimates and accompanying methodology. For instance, around the robustness of up- and down-stream supply-chain elements of the estimates and their dependence on aquaculture production within Scotland.

4. Deliverables/Reporting Requirements

The outputs required from the research are:

[10] *http://marine.gov.scot/information/scottish-marine-regions*

4.1 An inception report setting out the approach for the project that will be agreed with the project steering group, due by 4 September 2019.

4.2 An interim report setting out a detailed methodology including preliminary estimates of the wider economic impacts and a discussion of how the estimates can be used, due by 7 October 2019.

4.3 A final report presenting the final estimates of Scottish aquaculture's economic impact alongside a brief overview of methodology and appropriate use of estimates, and presented separately a detailed and replicable methodology, due by 27 November 2019.

4.4 Presentation of methodology and results to Scottish Government officials and to other stakeholders as requested.

APPENDIX 4

Bibliographic details

Alan Radford is an environmental economist who has retired from a Senior Lecturer position at Glasgow Caledonian University. He has been an External Examiner of Fisheries Economics and Management masters degrees at the Universities of Hull and the University of Portsmouth. He has competed many significant research reports on environment and natural resource issue for among others the Ministry of Agriculture and Fisheries, the Environment Agency, the British Council, Scottish Executive Environment and Rural Affairs Department and Marine Scotland.

Geoff Riddington is a statistical economist who was Reader in Quantitative Economics at Glasgow Caledonian. He has a PhD in Economic Forecasting and is an expert in Business Appraisal and Economic Impact Analysis. He has advised, *inter alia,* The Scottish Parliament, The Scottish Government, SNH, EA, DEFRA, SEPA and Loch Lomond NP. In addition to publicly available consultancy reports he has published articles *inter alia* in refereed journals on Cost Benefit Analysis (in high risk situations), on the Development of Small Area Input-Output models and on Estimating the Economic Impact of Wind Farms on Tourism.

Hervey Gibson was a founder of the Cambridge Econometrics consultancy which specialised in models based on the new UK Input-Output data before becoming Head of Economics at BNOC, then Head of Economics at Scottish Enterprise. Along with developing the CogentSI consultancy business he then became a Professor in Economics at Glasgow Caledonian. He is an acknowledged expert on both National and Regional Economic Accounting Models and is a key consultant at the national level. He produced the first ever Scottish National Accounts and was the author of the DREAM system for generating regional models which includes methods for integrating Tourism into the traditional structures.

Hervey has a remarkable knowledge of Scottish Business and has consulted in industries as different as Oil & Gas, Tourism and Fishing along with the development of Business Clusters. In addition to the UK he has carried out work in Scandinavia, Canada and Ireland.