RAS Atlantic Salmon Industry on Vancouver Island

Financial Model & Economic Impact Analysis

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Executive Summary

We were tasked by Fraser Basin Council with assessing the impacts of a potential new industry in British Columbia: land-based Atlantic salmon farming using recirculating aquaculture system (RAS) technology. The industry, to be located in the Campbell River region on Vancouver Island, would produce 50,000 tonnes of Atlantic salmon annually.

Conducting an economic impact assessment for a nascent industry is challenging, since there is no concrete data to draw upon. The timing of the potential roll-out of the BC RAS Atlantic salmon industry is also unknown.

Accordingly, we developed a financial model to estimate the revenues and expenditures arising from a 50,000 tonne industry and chose to assess the industry at an unspecified date in the future when production efficiencies had been realized, and steady-state (ongoing) performance achieved.

We collected and considered a great deal of information in conducting this assignment. At length, we decided upon a base-case set of assumptions with which to populate our financial model. There not being a definitive data-set, we tested the sensitivity of the results to changes in the values of key parameters.

Our base-case financial model paints a picture of an industry with the following parameters:

- 50,000 tonnes of annual Atlantic salmon production, comprised of individual farms operating at a 3,000 tonne scale.
- A capital cost of $1.1 billion to set-up the industry.
- $400 million in annual revenue.
- $208 million in production (variable) expenses, $28 million in fixed (overhead) expenses, and $97 million in combined depreciation, interest, and income taxes.
- Annual net income of $79 million for the farming sector.
- Annual processing, trucking, and sales & marketing charges associated with handling the farmed salmon production totaling $114 million per year.

We fed the results of the base-case financial model into the BC Input-Output Model (BCIOM) to assess the economic impacts — direct, indirect, and induced — associated with this level of industrial activity.

There are three sources of economic impacts generated by the development and operation of RAS Atlantic salmon facilities on Vancouver Island:

1. One-time construction of the RAS facilities.
2. Ongoing operation of the RAS facilities.
3. Ongoing processing of salmon (including trucking, primary and secondary processing, and sales & marketing) produced by the RAS facilities.

The economic impacts associated with the construction phase are summarized as follows (dollar values are in millions). Note that these are one-time impacts that would be spread out over the years required to build the RAS facilities.

Indicator	Direct	Indirect	Induced	Total
Expenditures	$1,027.5	$573.6	$77.0	$1,678.1
GDP	$71.8	$286.0	$49.6	$407.5
Jobs	765	2,762	463	3,989
Employment	858	2,974	418	4,250
Household Incomes	$58.5	$211.8	$36.2	$306.5
Tax Revenues	$49.4	$56.0	$7.7	$113.2

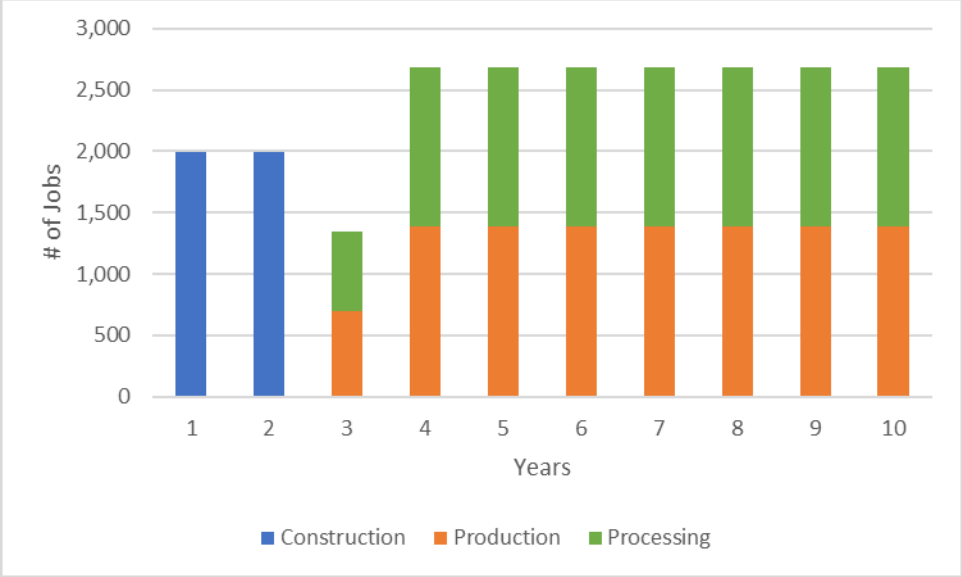
Source: BC Stats & Counterpoint Consulting Inc

The economic impacts arising from farming and processing operations are shown next. These would be annual, ongoing economic impacts.

Indicator	Direct	Indirect	Induced	Total
Expenditures	$515.7	$289.5	$31.9	$837.1
GDP	$211.3	$116.3	$20.5	$348.1
Jobs	1,413	1,080	191	2,685
Employment	1,465	1,094	173	2,732
Household Incomes	$58.7	$68.6	$15.0	$142.3
Tax Revenues	$40.0	$26.3	$3.2	$69.6

Source: BC Stats & Counterpoint Consulting Inc

The chart below summarizes the job-creation aspect of the RAS aquaculture industry, differentiating between the one-time start-up construction jobs and the ongoing jobs in salmon production and processing.



The economic impacts of a potential RAS Atlantic salmon farming industry on Vancouver Island are significant. However, Vancouver Island is only one potential site for land-based salmon aquaculture development globally; there are many other locales, notably the USA and Norway, with a head-start. Thus, it remains for BC to offer an attractive business environment for this industry, and actively engage would-be RAS aquaculturists to entice them to locate on Vancouver Island.

Introduction

The Fraser Basin Council, funded by Tides Canada and the Ritchie Foundation, has commissioned this analysis of the economic impacts of a potential roll-out of land-based Atlantic salmon farming in British Columbia using recirculating aquaculture system (RAS) technology.

The analysis is based on an assumed roll-out of RAS facilities capable of producing 50,000 tonnes of Atlantic salmon annually (about one-half of farmed Atlantic salmon production in British Columbia today). It provides estimates of the economic impacts generated by the development and operation of RAS facilities and the processing of their production of Atlantic salmon. The economic impacts captured extend throughout the backward-linking supply chain of businesses and industries supplying goods and services to the RAS Atlantic salmon industry imagined in this analysis.

The RAS facilities are assumed to be located near Campbell River on Vancouver Island. No assessment was made by the authors of this report whether the area is suitable for such an industry nor whether key characteristics such as water supply are suitable to support a 50,000 tonne RAS Atlantic salmon industry in and around Campbell River.

The parameters and scope of the analysis were set by the client. The focus is purely on the economic impacts associated with RAS production of 50,000 tonnes of Atlantic salmon. The analysis is not intended or designed to assess the feasibility of RAS technology for growing Atlantic salmon nor to gauge the probability or timing of the development of RAS-based Atlantic salmon production on Vancouver Island. Government regulation of RAS farms and incentives provided to encourage the establishment of a RAS industry in British Columbia are not considered in this report, nor is the time path over which the industry would grow and evolve into the mature 50,000 tonne industry foreseen in this static analysis. Finally, it does not address issues such as animal welfare or environmental impacts.

Economic Impact Analysis is a descriptive tool that measures economic activity throughout the economy using indicators such as Gross Domestic Product (GDP), job creation, employment, household incomes, and tax revenues. The economic activity measured by these indicators is generated by the expenditures of businesses and industries on goods and services used in production, and the provision of those goods and services by other businesses and industries. For example, the production of Atlantic salmon using RAS technology requires inputs such as, among other things, feed, energy, and labour. Expenditures on feed and energy create jobs and incomes in the businesses supplying them, which also pay taxes to federal, provincial, and municipal governments. Employees on RAS farms are direct jobs created by the RAS industry imagined in this analysis and their wages are direct household incomes. Indirect employment and household income are generated in industries further back along the supply chain. The spending of household incomes by those directly and indirectly employed as a result of a 50,000 tonne RAS Atlantic salmon industry on Vancouver Island create induced economic impacts.

The framework for the model of RAS Atlantic salmon production presented in this report, the results of which were used to seed the BC Input-Output Model (BCIOM) and to estimate economic impacts, is an early version of a model developed by Gary Robinson of Campbell River, BC. Robinson's is an extremely detailed, intertemporal model that captures the operations, output and sales, and revenues and costs of a single RAS farm producing 3,000 tonnes of Atlantic salmon per year.[1] The development of the Robinson model was funded by Tides Canada.

Mr Robinson has a long history and is widely known within the aquaculture industry. He is clearly recognized as an expert by his peers. Given that so few RAS facilities producing Atlantic salmon exist, it should

[1] Robinson (2017).

not be surprising that differences remain among experts about the specific calibration of any RAS model. Such was the case with our model.

The Fraser Basin Council assembled an Advisory Committee to support an evidence-based, independent Economic Impact Analysis (EIA) of RAS-based aquaculture on Vancouver Island. The role of the Advisory Committee was to:

- Provide information about, and connections to, related work that could be useful to the EIA.
- Suggest ways and means for this economic impact analysis to support a future comprehensive analysis of closed containment aquaculture systems.
- Suggest key interests to engage in efforts to build on this work.
- Review a draft report from this study and provide comments.[2]

The members of the Advisory Committee are:

- Alistair Struthers, Fisheries and Oceans Canada, Director, Aquaculture Operations
- Myron Roth, Ministry of Agriculture, Industry Specialist, Aquaculture & Seafood
- Steven Summerfelt, Superior Fresh LLC, Chief Science Officer
- Terry Brooks, Golden Eagle Sablefish Inc, President
- Eric Patel, Tides Canada, Aquaculture Innovation Fund, Board of Directors
- Yvette Wells, Tides Canada, Advisor (Observer)

The report begins with an explanation of economic impacts and Economic Impact Analysis.

The starting point for any analysis of economic impacts are the business expenditures of the project or program being analyzed, in this case, a RAS Atlantic salmon industry producing 50,000 tonnes on Vancouver Island. Using the Robinson Model as a starting point, we developed a model of such expenditures which is elaborated below, followed by presentation of the results of our financial analysis, and the sensitivity of the results to changes in values of key parameters.

The report concludes with the presentation of the Economic Impact Analysis results.

Economic Impact Analysis

Purchases of goods and services as inputs to primary productive processes, such as building and operating RAS-based Atlantic salmon farms, stimulate economic activity in the provincial economy that are the focus of **Economic Impact Analysis.**

Economic impacts are typically classified into three types:

- Direct impacts
- Indirect impacts
- Induced impacts

RAS salmon farmers and firms processing their production of Atlantic salmon would purchase goods and services from a host of businesses, creating **Direct Impacts**.

Those businesses in turn spend money in subsequent rounds of purchasing to acquire an even wider array of goods and services that they use as inputs to their production processes. In fact, there are multiple rounds of such purchases, extending backwards through the supply chain, creating **Indirect Economic Impacts**.

[2] Fraser Basin Council (2018), RAS EIA Advisors Group – Terms of Reference.

The companies and businesses creating Direct and Indirect Impacts employ workers who earn wages and salaries. Household incomes are spent on everything from necessities such as food, shelter, and clothing to discretionary items such as entertainment and holidays, and everything in-between. Household expenditures create economic activity in a wide range of businesses throughout the economy that are collectively known as **Induced Economic Impacts**.

Government, business, and household expenditures may be made within the provincial economy or beyond provincial borders (such as when inputs are purchased from other provinces or countries, or when households purchase imported goods and services, or take holidays outside the province or country). Only economic impacts accruing within British Columbia are counted in the assessment of economic impacts. For example, the purchase of RAS equipment from European suppliers would create economic impacts in Europe that would not be counted in this analysis.

Economic impacts are calculated by a computer model of the provincial economy designed to trace back through the supply chain the direct expenditures fed into it as input data. The British Columbia Input-Output Model (BCIOM), as it is known, is managed by BC Stats. The economic impact results reported herein were calculated using the BCIOM.

In the case of a RAS-based Atlantic salmon industry in BC, the input data consist of the expenditures of businesses building and operating the RAS production facilities and the businesses processing their production of Atlantic salmon.

Economic impacts calculated by the BCIOM are measured using four indicators:

1. **Gross Domestic Product (GDP)** is a measure of value-added in the BC provincial economy by current productive activities – the transformation of inputs (labour and materials) into outputs. Because it avoids double counting (by measuring value added), it tends to be less than the raw expenditure numbers used as inputs to economic impact analysis.

2. **Jobs** estimates generated by the model measure the number of jobs created. Each job counted is equal to the amount of employment typical of a job in that industry, which may range from seasonal to full-time work.[3] BC Stats recently added an **Employment** indicator to the BCIOM measures Full-Time Equivalents (FTEs) assuming an average work-year of 50 weeks at 35 hours per week = 1,750 hours per year.

3. **Household Income** includes more than what is suggested by the everyday use of this phrase: in addition to wages and salaries from employment, Household Income in the BCIOM includes: employment benefits, income earned by proprietors of unincorporated businesses; and profits and other income earned by corporations.[4]

4. **Tax Revenues** include personal and corporate income taxes, PST and GST, and commodity taxes (eg, gas taxes, liquor and lottery taxes and profits, air transportation taxes, duties, and excise

[3] For a discussion of BCIOM employment output numbers and other estimates of Jobs, Employment and Labour Market Participants, see BC Stats (2012), pages 82-88.

[4] Average household income for the induced impact only is based on income excluding imputed rent estimate for owner-occupied households. Thus, average household income (induced impact) is lower than it might otherwise be.

taxes). Municipal tax revenues consist primarily of accommodation taxes; property tax revenues are not included.

Input-output analysis is based on various assumptions about the economy and the inter-relationships between industries. The major assumptions are listed below:[5]

- Input-output models are linear. They assume that a given change in the demand for a commodity or for the outputs of a given industry will translate into a proportional change in production.
- Input-output models do not take into account the amount of time required for changes to happen. Economic adjustments resulting from a change in demand are assumed to happen immediately.
- It is assumed that there are no capacity constraints and that an increase in the demand for labour will result in an increase in employment (rather than simply re-deploying workers).
- The BCIOM assumes that consumers spend an average of 80% of their personal income on goods and services. The remaining 20% of personal income is consumed by taxes or goes into savings.[6] (This assumption can be changed if there is evidence to suggest doing so in particular applications.).
- The BCIOM is derived from a "snapshot" of the structure of the BC economy in 2015. It is assumed that relationships between industries are relatively stable over time, so that the 2015 structure of the economy can be used to estimate the economic impact associated with a particular project.

Future, Steady-State British Columbia RAS Industry

Producing farmed salmon to market size on land using RAS technology is an emerging industry, albeit it apparently a rapidly emerging one. A scan of RAS projects planned or underway reveals some ambitious plans, including three facilities of greater than 25,000 tonnes in the USA (one in Florida and two in Maine), and almost 300,000 tonnes of potential production worldwide.[7]

Total production of ocean-reared farmed Atlantic salmon, in contrast, is 90,000 tonnes in BC and 2.45 million tonnes worldwide.[8] Norway has a goal to be producing 1.9m tonnes of Atlantic salmon (without reference to technology) by 2030, and

Table 1: Global Production of Atlantic Salmon (,000 tonnes)

Source	2014	2015	2016	2017	2018	*2019*
Norway	1,199	1,234	1,171	1,208	1,263	*1,319*
Chile	644	622	532	614	690	*702*
UK	171	166	157	177	151	*177*
North America	119	155	169	161	165	*170*
Others	157	163	166	183	176	*194*
Total	**2,290**	**2,340**	**2,195**	**2,343**	**2,445**	***2,562***
Change YoY	*8.5%*	*2.2%*	*-6.2%*	*6.7%*	*4.4%*	*4.8%*

Note: 2016: algae bloom in Chile reduced production. *2019 forecast*

Source: undercurrent news. https://www.undercurrentnews.com/2019/01/18/atlantic-salmon-demand-still-outstripping-supply-despite-likely-2019-production-increase/

[5] Following is taken from BC Stats (2010), page 2.
[6] BC Stats (2019), Lillian Hallin, pers comm.
[7] IntraFish (2018a).
[8] Undercurrent News. https://www.undercurrentnews.com/2019/01/18/atlantic-salmon-demand-still-outstripping-supply-despite-likely-2019-production-increase/

3.3m tonnes (both Base Case forecasts) by 2050.[9]

Counterbalancing ambitious projections is the reality that no large-scale Atlantic salmon facilities are yet in production. Most projects to date are pilot-scale (including Kuterra, a 260-tonne facility in Port McNeil, BC) although Atlantic Sapphire's Langsand Laks farm in Denmark was reported at the Miami Aquaculture Innovation Workshop (AIW) to be nearing completion of its expansion to 3,000 tonnes.[10]

We have chosen to use a 3,000-tonne farm as our base production unit. This is small based on some of the plans outlined above, but large relative to existing operations. We believe this is a reasonable scale to choose, balancing potential activity with the here-and-now. The Atlantic Sapphire Miami Bluehouse™ will operate at capacity with 65 independent growing systems, to mitigate risk, each producing less than the 3,000-tonne production unit contemplated in this analysis.[11]

The intense level of interest, investment, research, and planning surrounding RAS makes it likely that this means of farming Atlantic salmon will take hold. But the timing of implementation, especially given the technical complexity of the activity, is uncertain.

Given this uncertainty, rather than try to forecast when and how a BC RAS Atlantic salmon industry will scale-up from its current size (a single 260-tonne farm) to a 50,000-tonne production level, we modeled that production as occurring in some unspecified year in the future when the BC Atlantic salmon RAS industry has realized production efficiencies and is performing smoothly at reasonable (ie, not optimistic, not pessimistic) values for key parameters.

Financial Model of RAS Production of Atlantic Salmon in BC

The financial model we deploy in this study is based on an early version of a spreadsheet model developed by Gary Robinson.

Mr Robinson developed a large, complex spreadsheet, including biological, engineering, and financial parameters, that models a RAS farm producing 3,000 tonnes of Atlantic salmon annually.[12] Mr Robinson, a recognized expert in the field, drew upon his own knowledge in developing the model, as well as that of other informed players in the RAS community.

We familiarized ourselves with the model, both independently and in conjunction with Mr Robinson, who, during two working sessions, took us through the methodology and described its workings in detail.

While the Robinson model includes a financial component — revenues and costs — its focus is the operations of the RAS farm and the production of Atlantic salmon, intertemporally modeled in explicit cohorts as output grows to capacity over time.

Given the purpose of our work, we abstracted from the operational details of Mr Robinson's model, creating a static model providing a snapshot of a 3,000 tonne RAS farm. We developed the financial focus of the model by building in a GAAP[13]-consistent Income Statement and Cash Flow Statement. For many variables we accepted the Robinson model's parameter values, but we adjusted others based on the findings of our research, counsel from our Advisory Committee, and our expertise in corporate finance.

[9] Stefansson (2018), page 12. The 5m tonne target is Norway's optimistic scenario. Stefansson reports that, "only 1 in 3 in the industry (in Norway) believe in a production volume of 5m tonnes in 2050."
[10] Atlantic Sapphire (2018).
[11] Atlantic Sapphire (2018), page 17.
[12] Robinson (2017).
[13] Generally Accepted Accounting Principles.

We then scaled up to 50,000 tonnes of annual production assuming multiples of the 3,000-tonne facility.

All values used in our analysis are in real (constant) 2018 Canadian dollars.

RAS Financial Model Framework

Our financial model, designed to output an income statement to feed into the BCIOM, utilizes the following key variables:

Financial Variables

- Capital cost of establishing a 3,000 tonne RAS facility, including land assembly and pre-development costs, site preparation, building, and RAS components and equipment.
- Capitalization – percentage of equity and debt.
- Loan terms (interest rate and duration) in the event of debt financing.
- Depreciation rates for various classes of fixed assets.
- Annual capital investments (to keep equipment and systems up to date).
- Corporate tax rate.

Production Variables

- Number of smolts per cohort.
- Number of smolt cohorts per year.
- Mortality rate.
- Average weight at harvest.

Operating Variables

- Average selling price per pound.
- Feed conversion ratio (FCR).
- Feed cost per kilogram (kg).
- Cost to produce smolts.
- Energy consumption in kilowatt hours (kwh) and energy costs per kwh
- Purchase of water treatment chemicals.
- Crop insurance.
- Variable costs including sludge disposal, fish health treatments, chemicals and disinfectants, oxygen, supplies & consumables.
- Repairs and maintenance of farm and equipment, including RAS equipment, oxygen generator, HVAC equipment, buildings, monitoring & control equipment.
- Labour to run the facility, including management, technicians, and maintenance.
- Corporate/head office salaries.
- Overhead costs such as office expenses, property taxes, property and liability insurance, professional services, rentals, leases, and site security.

The methodology by which we assigned values to the above parameters is described next.

Information Collected and Considered

Interviews

We sourced data – ranging from financial reports to expert opinion on capital costs, operating costs, market prices, and the like – from the following individuals:

- Garry Ullstrom, CEO, Kuterra LP.
- Myron Roth, Industry Specialist – Aquaculture & Seafood, Province of BC.
- Samuel Chen, Corporate & Business Development, Hudson Valley Fish Farms.
- Guy Dean, Vice-President & Chief Sales Officer, Albion Farms & Fisheries.
- Justin Henry, Aquaculture Consultant, Henry Aquaculture Consult Inc
- Steve Summerfelt, Chief Science Officer, Superior Fresh LLC, Wisconsin

Literature Search

We considered concrete financial data found in the following articles or publications:

- Billund Aquakultur Service A/S Billund Aquaculture services (undated), Estimated Production Costs: Salmon Growout (4.5kgs) 2,000 tonnes/year.
- Fisheries and Oceans Canada (2010), Feasibility Study of Closed-Containment Options for the British Columbia Aquaculture Industry (Boulet, Struthers, and Gilbert).
- Liu et al (2016), Comparative economic performance and carbon footprint of two farming models for producing Atlantic salmon: Land-based closed containment system in freshwater and open net pen in seawater.
- Rosten et al (2013), Land-Based RAS and Open Pen Salmon Aquaculture: comparative economic and environmental assessment.
- DNB Markets (2017), Seafood – Special Report: Deep dive into land-based farming.
- Bjorndal and Tusvik (2017), Land-based Farming of Salmon: Economic Analysis.
- DNB Markets (2018), Atlantic Sapphire: Merging the biologically possible with the economically viable.

While the above-cited publications contained specific price/cost data, we reviewed an array of publications providing background on RAS aquaculture (see Selected References).

Aquaculture Innovation Workshop 2018

We attended the Aquaculture Innovation Workshop held in Miami, FL, December 4-6, 2018. The workshop was focused on RAS technology with a heavy emphasis on RAS farming of Atlantic salmon. The workshop presentations and informal conversations with experts in attendance helped us to validate our model and broaden our understanding of RAS technology. We toured the world's largest RAS Atlantic salmon farm (by far), now being constructed by Atlantic Sapphire in Homestead, FL, south of Miami.

Advisory Committee Advice

Our work was reviewed by an Advisory Committee whose members (listed in the Introduction) are experts in aquaculture who are closely familiar with marine and land-based salmon aquaculture. Once back from the AIW in Miami, we prepared a draft RAS financial model for their review, populated with a combination of Mr Robinson's Base Case values and parameters amended by us.

The members of the Advisory Committee generally found that our model was too optimistic. They advised that our selling price assumption was too high and several specific cost items (eg, oxygen and energy) were too low. They advised that some operating parameters (eg, FCR and mortality) were optimistic.

On a broader scale, they also observed that the average production expense (variable cost) per kilogram of production in our model was well below the range reported in RAS salmon aquaculture models published in recent years.[14]

We considered this advice, along with all other input gathered, in arriving at the final version of our model presented here. The adjustments we made to particular production expenses and model parameters resulted in our average production expense per kilogram being right in the middle of the range of the studies cited by the Advisory Committee.

Key Assumptions and Parameter Values

Arriving at a final set of assumptions to populate the model was challenging.

A key issue is that there is no definitive dataset. There are no 3,000-tonne operating farms, and if there were, owners would be disinclined to divulge sensitive financial results. So providing "right and wrong" values is not possible. There is of necessity a grey area requiring considered judgement.

While our initial model was deemed unanimously by the members of the Advisory Committee to be too optimistic, when we incorporated the changes they suggested — again, working from very little data and none of it directly relevant to either a 3,000 tonne RAS facility nor one operating in some future steady-state — the model was not compelling in that its viability would be constantly threatened by even minor changes in markets, and the investment thesis was not credible: investors would be exceedingly unlikely to part with their capital for such meagre returns. That latter observation at least, is at odds with the almost daily announcements of new RAS facilities being planned.[15]

We present as our Base Case a less optimistic version than our draft model but one that could plausibly operate and be viable and sustainable in a competitive market with changing input and output prices, and supply chain issues, and that could plausibly attract the investment capital needed to get off the ground in the first place.

Selling prices reflect the 2018 actual averages ($4.31 per HOG lb), and production costs are higher than our draft model, but lower than current-day practitioners may be experiencing. This approach yields reasonable projected profitability on an absolute level, though rates of return on investment are modest, suggesting the need for government to provide incentives to attract the required investment capital. These Base Case assumptions were used to seed the BCIOM to generate all the economic impacts presented later in this report.

We subjected our Base Case to two Sensitivity Analyses.

In the first, selling price is increased to $5.00 per HOG pound from $4.31, while all costs remain unchanged. The higher price reflects the high-end of 2018 values and is more consistent with the belief that continued growth in demand will lead to strengthening prices in the future. Or, that RAS product

[14] DNB (2017), Rosten et al (2013), Bjorndal & Tusvik (2017), Liu et al (2016), Iversen et al (2013), Kuterra (2015b), Kuterra (2016a).

[15] DNB recently reported that there is 500,000 tonnes of new planned RAS salmon production, twice what there was two years ago. https://www.undercurrentnews.com/2019/02/11/dnb-estimated-salmon-volumes-from-land-based-production-at-500000t-by-2026/.

may attract a price premium. We are not suggesting that $5.00 represents a cap on potential prices, but rather provide this scenario to demonstrate that profitability escalates rapidly with improvements in selling price.

In the second, selling price remains at $4.31 per HOG pound, while production (variable) costs rise by one-third (33%) in aggregate. The increase in production costs was chosen to arrive at an average production cost in the middle of the range cited by the Advisory Committee. Thus, this scenario reflects the essence if not the specifics of the advice we received from the Advisory Committee.

As specified in our Statement of Work, the model represents a snapshot of a future state in which RAS technology for growing Atlantic salmon has matured and reached a steady-state. While experts may disagree about the values of specific parameters, we feel the Base Case model as calibrated portrays a reasonable vision of a hypothetical future of RAS production of 50,000 tonnes of Atlantic salmon in British Columbia on which to base the estimation of economic impacts.

Next, we detail the key assumptions utilized in our Base Case model.

Capital Expense

The breakdown of capital costs to build one 3,000 tonne RAS farm are shown in Table 2.

Table 2: Capital Expenses

Capital Expenses	Amount	Depreciation Rate
Land	$5,000,000	0%
Building & site prep	$18,495,117	10%
RAS equipment, other	$43,155,274	20%
Total	**$66,650,391**	

Production Volume

Table 3 shows the values of various production parameters that combine in the model to yield an annual production of 3,001 tonnes per RAS farm.

Table 3: Production Volume Parameters

Production Volume Parameters	Amount
Smolts per cohort	146,625
Cohorts per year	4
Mortality rate	5.34%
Average fish weight at harvest (kg)	5.41

This approach indicates production of uniform, top-quality product (no off-grades, no under-size) that results in the full selling price being realized for every kilogram of production. We have used these parameters in order to describe a fully-mature RAS operation that has perfected its production processes and realized full production capability. In current practice, the production mix would likely include some product that, due to slower growth, early maturation, or other defects, would be down-graded and fetch diminished prices.

Selling Price

With the assistance of Brian Vinci of The Conservation Fund, we obtained weekly (HOG equivalent) salmon prices from 2013 Q2 (week 14) to present from the NASDAQ Salmon Index: https://salmonprice.nasdaqomxtrader.com/public/report?1

We converted these prices from euros to CAD (Canadian Dollars) using weekly exchange rates and then used the Consumer Price Index (monthly values) to bring all values to 2018 real (constant) CAD.

Next, we calculated the average price for the entire time series (2013 Q2 – 2018 Q4 inclusive) and for 2018, and converted to 2018CAD$/HOG lb. The resulting values were: $3.85/HOG lb for the past six years and $4.31/HOG lb for 2018.

In our base-case model we use the 2018$/lb value of $4.31/lb.[16]

The NASDAQ Salmon Index prices appear to be FOB[17] Oslo. The landed price in North America would therefore be higher to account for the cost of insurance and freight (and possibly other costs). These costs would offset the higher price, leaving Gross Profit, EBITDA, and Net Income unchanged in our financial model.

Yields

The following recovery rates are used throughout the analysis:

Table 4: Product Yields

Product Form	Yield	Yield from Live
Live (whole fish)	100.0%	100.0%
Live -> Stunned & Bled	94.0%	94.0%
Stunned & Bled -> HOG	90.5%	85.1%
HOG -> Fillet	63.8%	57.7%

Production Expenses

The inputs for key production expenses (smolts, feed, and energy) are shown in Table 5.

Table 5: Production Expenses

Production Expense Assumptions	Amount
Smolt cost per unit	$1.56
Feed conversion ratio (FCR)	1.10
Feed cost per kg	$2.11
Energy rate per kwh	$0.086
Kwh of energy per year	15,108,962

Smolt cost is the inferred cost of producing each unit in an in-house hatchery (no vaccinations are included in the cost).

Labour

Table 6 shows the labour costs incurred by a single RAS facility.

Table 6: Labour Costs

Labour Costs	Amount
Production labour & supervision	$1,275,982
Administrative salaries	$515,000
Professional fees & services	$308,235
Labour portion of R&M	$362,690
Total	**$2,518,812**

[16] DNB is forecasting market prices of CAD$4.19/HOG lb in 2019 and CAD$4.12/HOG lb in 2020. https://www.undercurrentnews.com/2019/02/11/dnb-estimated-salmon-volumes-from-land-based-production-at-500000t-by-2026/

[17] Free-on-board, meaning the buyer assumes responsibility and liability for the products at the point of departure to the destination market, and pays all costs associated with getting the product from the producer to the market/customer.

Other Farm Expenses

We have made a host of assumptions for the lesser production and overhead expenses; these are presented subsequently in the "RAS Financial Model Results" section.

Income Taxes

We have applied the following combined federal and provincial income tax rates for the analysis:

- Initial $500,000 of net income: 11%
- Income above $500,000: 26.5%

Trucking, Processing, and Sales/Admin

Our base assumptions for this portion of the analysis are shown in Table 7. We assume that these functions will not be performed at the farm level but rather will be borne by the buyer of the farm's product.

Table 7: Trucking, Processing, & Marketing Costs

Trucking, Processing, and Sales & Marketing Costs	Amount
Trucking rate/kg from farm to local processor	$0.07
Trucking rate/kg from local processor to customer	$0.64
Primary processing rate per finished kg (include packaging)	$1.15
Secondary processing rate per finished kg (include packaging)	$2.55
Marketing, sales, and admin fees (% of farmgate value)	5%

These values are drawn from the Robinson model, with the exception of the Marketing et al assumption, which is our own estimate. While trucking, processing, and sales/administration do not factor into the income statement of the RAS farm, they do count as economic impacts in the EIA.

RAS Financial Model Results

We present the output of our financial model — a single-year snapshot of operations several years after start-up — as follows. Both single-farm results and industry-wide results (50,000 tonnes of production comprised of 3,000 tonne farms) are shown.

Capitalization

The up-front investment costs are shown in Table 8.

Table 8: RAS Capital Costs

Capital Cost	One RAS Facility	All RAS Facilities
Land	$5,000,000	$83,333,333
Facility	$61,650,391	$1,027,506,514
Totals	**$66,650,391**	**$1,110,839,847**

The facility cost (excluding land) works out to $20.00 per kilogram of output. We added a component for assembly of land (including land purchase, development, and permitting costs).

The sources of funding for this investment are shown in Table 9.

Table 9: Sources of Funding

Source of Funds	One RAS Facility	All RAS Facilities
Equity (60%)	$39,990,235	$666,503,908
Debt (40%)	$26,660,156	$444,335,939
Totals	**$66,650,391**	**$1,110,839,847**

Sixty percent of the capital cost would be funded through equity, with debt (10-year term, 7% interest rate, blended principal & interest payments) making up the balance.[18]

Production and Product Forms

The amount of live fish grown, and the amount of finished production by product form (accounting for processing weight-loss), are shown in Table 10. Farmed Atlantic salmon is processed into two major product forms: head-on gutted (HOG) and fillets.

Table 10: Production & Pricing Summary

Production and Pricing Summary	One RAS Facility	All RAS Facilities
Production Volume (kgs live weight)	3,001,000	50,016,667
HOG production to market (kgs finished product)	1,914,713	31,911,884
Fillet production to market (kgs finished product)	407,196	6,786,594
Total finished product weight (kgs)	2,321,909	38,698,478

In arriving at production output, we used Robinson's assumptions regarding annual smolt intake, mortality rates, and growth rates (size at maturity).

We assumed that 75% of production would be directed to market in HOG form and 25% processed into fillet form. While this ratio may be reversed for small amounts of production that could be sold locally, we judged that, for industrial volumes of BC RAS salmon, the bulk of production would likely be sold into further-flung markets (primarily, the western USA). When trucked significant distances, customers generally prefer the HOG product form.

Sales Revenue

Prices in the industry are typically quoted for HOG product. As described above, we have chosen an average selling price of $4.31 per HOG lb. We then converted it to a per kilogram price and backed out the yields to express the farmgate price per live kilogram, which equals $8.08/kg. The resulting revenue is shown in Table 11.

Table 11: RAS Farm Revenues

Sales Revenues	One RAS Facility	All RAS Facilities
Gross Sales Revenue	$24,257,913	$404,298,557
Less: in-plant processing (stun & bleed)	$142,965	$2,382,744
Net Sales Revenue	**$24,114,949**	**$401,915,813**

We offer the following considerations regarding selection of a selling price:

- There is much bullish sentiment in the farmed salmon industry with respect to pricing, given that prices have risen in recent years despite growth in production levels. This points to favourable demand dynamics.
- Some people think that RAS Atlantic farmed salmon will earn a premium over the commodity price level, while others think that the premium will evaporate as RAS production reaches industrial volumes.
- The anecdotal evidence largely favours the notion that, even if a price premium can be commanded in certain markets, at certain times, and for certain (relatively small) production volumes, they tend to disappear once production is scaled up. This conforms with the economic fundamental that prices will not long deviate from their true equilibrium levels.

[18] Currently, few RAS facilities are able to borrow, given the novelty of the business model, but we assume this will change as the industry matures.

- We were told that RAS salmon producers are building facilities based on the assumption of average, commodity (not premium) prices for their product.
- Our analysis tells us that selling price is the single most important variable in the profitability equation for a RAS facility: results are more sensitive to this factor than to any of the cost variables).
- Notwithstanding the above, the revenue-side is not an important factor in an Economic Impact analysis, it is the cost-side that drives impacts.

We believe that $4.31 is a realistic selling price estimate, neither optimistic nor pessimistic. To demonstrate the effect of higher prices, we provide a scenario subsequently (Sensitivity Analysis section) that shows the impact of a $5.00 price point.

Production Expenses (Variable Costs)

For production expenses, we began with the ratios and costs in the Robinson model, and made adjustments based on various input and feedback.

Table 12: Production Expenses (Variable Costs)

Production Facility Expenses (including Hatchery)	One RAS Facility	All RAS Facilities
Feed	$7,408,355	$123,472,579
Energy	$1,409,164	$23,486,059
Labour	$1,275,982	$21,266,367
Water treatments	$791,225	$13,187,083
Crop insurance	$174,743	$2,912,383
Solid Waste/Sludge Disposal	$122,981	$2,049,687
Fish Health & Treatments	$93,799	$1,563,321
Chemicals, Cleaners and Disinfectants	$62,533	$1,042,214
Oxygen	$200,626	$3,343,769
Supplies & Consumables	$35,956	$599,273
Effluent Discharge	$10,526	$175,439
Disposal Mortalities	$9,693	$161,543
R&M - RAS Equipment	$375,197	$6,253,283
R&M - Oxygen Generator	$250,131	$4,168,855
R&M - HVAC Equipment	$87,546	$1,459,099
R&M - Buildings	$46,900	$781,660
R&M - Monitoring & Control Equip.	$46,900	$781,660
R&M - Feed Equipment	$37,520	$625,328
R&M - Machinery and Equipment (Other)	$37,520	$625,328
R&M Site and All Other	$25,013	$416,886
Totals	**$12,502,309**	**$208,371,816**

The production costs shown above are the key drivers of the economic activity that is measured by an Economic Impact Analysis. The first three — feed, energy, and labour – account for 81% of total Production Costs.

While we have identified values for each specific line item, we are most concerned that the total for production costs is of the correct order of magnitude. We subsequently provide a scenario that analyzes the impacts of a substantially higher production cost level.

Embedded within the Production Cost schedule shown above are the costs to produce each year's smolts in an in-farm hatchery. This cost is shown by major expense category as follows:

Table 13: Annual Hatchery Cost for a single farm

Hatchery Cost Component	Annual Cost
Feed	$448,321
Energy	$109,793
Labour	$201,287
Water treatments	$82,345
Other operating	$73,195
Total	**$914,940**

The indicated cost per smolt is $1.56.

Fixed Expenses (Overheads)

Our assumed level of overhead for a RAS farm is light relative to the volume of business activity, even after bolstering the costs in the Robinson model. We developed the following estimates, based on the detailed expense categories in the Robinson model.

Table 14: Fixed Expenses

Fixed Expenses	One RAS Facility	All RAS Facilities
Head office salaries & benefits	$515,000	$8,583,333
Insurance (general)	$215,776	$3,596,273
Office Supply, Equipment and Furnishings	$28,452	$474,207
Communications and IT (hardware and charges)	$18,968	$316,138
Property Tax Expense	$147,004	$2,450,071
Government Fees & Permits	$4,742	$79,035
Professional Services- Financial	$23,710	$395,173
Bank charges and Line of credit interest	$4,742	$79,035
Audit Charges	$9,484	$158,069
Travel Expense	$42,679	$711,311
Meetings & Entertainment	$28,452	$474,207
Vehicle Fuel, repair, licence, etc	$14,226	$237,104
Vehicle lease	$47,421	$790,345
Equipment Rental	$33,195	$553,242
Disposal - Garbage	$18,968	$316,138
Misc Supplies (non -production)	$9,484	$158,069
Professional Services- Engineering	$47,421	$790,345
Professional Services- Environmental	$47,421	$790,345
Professional Services- Legal	$56,905	$948,415
Professional Services- Other Technical	$28,452	$474,207
Training & Courses	$61,647	$1,027,449
Labour Recruitment (ongoing)	$9,484	$158,069
Tools & Small Equipment	$33,195	$553,242
Propane	$9,484	$158,069
Land Freight & Postage	$4,742	$79,035
Work Outfits	$9,484	$158,069
Fish Testing - Non Fish health	$37,937	$632,276
Veterinarian visits and fish health testing	$47,421	$790,345
Other Testing (non-fish)	$9,484	$158,069
Site Security	$113,810	$1,896,829
Totals	**$1,679,191**	**$27,986,515**

Other Values

Other variables significantly impacting income and cash flow are shown in the next table.

Table 15: Financial Items

Other Items	One RAS Facility	All RAS Facilities
Depreciation	$2,484,095	$41,401,577
Interest on capital loans	$1,129,791	$18,829,847
Principal payments	$2,666,016	$44,433,594
Capital expenditures	$500,000	$8,333,333
Income taxes	$1,597,184	$26,619,738

We have calculated Depreciation using a declining balance formula and the depreciation rates set out in Table 8 (page 11). The Depreciation figure shown in Table 15 is the value for Year 10 after the commencement of construction and is representative of steady-state operations for the RAS facilities.

The Interest on Capital Loans and Principal Payments shown in Table 15 were calculated using a blended annual formula for a loan with a ten-year term paying 7% interest, as discussed with reference to Table 9 (page 11). These are annual values that would be constant over the ten-year life of the loan.

Trucking, Processing & Sales

Trucking, processing, and sales & marketing costs (after farm-gate) would be borne by buyers but conducted within BC. These costs are shown in Table 16.

Table 16: Processing, Trucking & Sales Costs

Processing, Trucking, Sales Costs	One RAS Facility	All RAS Facilities
Trucking	$1,660,777	$27,679,618
Primary processing	$2,923,129	$48,718,809
Secondary processing	$1,040,018	$17,333,640
Sales, marketing, administration	$1,205,747	$20,095,791
Totals	**$6,829,671**	**$113,827,858**

It is assumed that all this activity would take place in BC using local facilities and suppliers, so the substantial economic impacts are fully accounted-for in the analysis.

Our rationale for excluding processing, trucking, and sales from the income statement of the RAS farms is as follows:

- The presence of existing processing facilities in the region is one of the draws for attracting RAS investment.
- Canadian processing regulations are highly complex and onerous, so in-house processing would add significant cost and complexity to a farm operation.

Had we opted to include these activities in our farm income statement, the net effect on the bottom line – increasing revenues and costs to the farm by similar amounts – would have been nil. Further, the results of the economic impact analysis are unaffected by whether the farms or the buyers are responsible for these activities, since the analysis is from the perspective of the province, not the individual firm or industry.

Summary of RAS Farm Results

For a single 3,000-tonne farm, and for a 50,000-tonne industry, net income and cash flow are summarized in Table 17.

Table 17: RAS Model Results: Summary

Summary	One RAS Facility	All RAS Facilities
Revenue	$24,114,949	$401,915,813
Less: Production (variable) expenses	$12,502,309	$208,371,816
Gross Profit	**$11,612,640**	**$193,543,996**
Less: Fixed expenses	$1,679,191	$27,986,515
EBITDA	**$9,933,449**	**$165,557,481**
Less: Depreciation	$2,484,095	$41,401,577
Less: Interest on long term debt	$1,129,791	$18,829,847
Earnings before Taxes	**$6,319,563**	**$105,326,057**
Less: income taxes	$1,597,184	$26,619,738
Net Income	**$4,722,379**	**$78,706,319**
Add: depreciation	$2,484,095	$41,401,577
Less: principal payments	$2,666,016	$44,433,594
Less: capital expenditures	$500,000	$8,333,333
Cash Flow	**$4,040,458**	**$67,340,968**

We characterize these Base Case forecast results as follows:

- The business shows a healthy level of profitability, with gross margins of 48%, and net income as a percentage of gross sales equaling 19%. These are respectable levels for an industrial activity.
- While profits are solid, this is a business with high up-front capital requirements and a multi-year time lag between initial investment and sale of the first crop cohort. Our Base Case scenario shows tepid returns on investment, with internal rate of return (IRR) ranging from 3% to 9% depending upon the assumptions used in the calculation.[19]

Next, we show how two variations – one showing higher prices, the other higher costs – impact the Base Case results presented above.

Sensitivity Analysis

In this section, we examine the sensitivity of our RAS financial model to changes in key parameter values.

Higher Selling Price

Examination of Base Case results could trigger the question: why would an investor back RAS salmon aquaculture when the indicated rates of return are so marginal? The answer, in our view, is that an investor would be attracted to this business model in large part because of a bullish outlook on the market for farmed Atlantic salmon.

RAS proponents point to a track-record of rising selling prices for farmed Atlantic salmon despite steadily increasing supply. They believe that RAS is a superior means of growing Atlantic salmon, from both sustainability and product quality perspectives, and hold the expectation that prices for RAS salmon will continue to firm.

[19] The high-end value of 9% assumes, over a 10-year investment horizon, a 100% residual value in year 10 and full cash flows realized in year 3; the low end value (3%) is based on a 50% residual and full cash flow not realized until year 4 (50% of full cash flow would be realized in year 3).

While we have chosen to apply what we believe is a realistic forecast of selling price ($4.31/lb HOG), others may feel higher expected prices are warranted. We provide a scenario that substitutes a $5.00 per pound selling price. Summary income statement and cash flow values are provided next:

Table 18: Scenario – Higher Selling Price

Income Statement	Base Case	Scenario: Selling Price @ $5.00	Unit Change	Percentage Change
Gross sales revenue	$404,298,557	$469,023,848	$64,725,291	16%
Net sales revenue	$401,915,813	$466,641,104	$64,725,291	16%
Less: Production expenses	$208,371,816	$208,371,816	$0	0%
Gross Profit	**$193,543,996**	**$258,269,287**	**$64,725,291**	**33%**
GM % gross sales	*48%*	*55%*	*7%*	*15%*
Less: Fixed expenses	$27,986,515	$27,986,515	$0	0%
EBITDA	**$165,557,481**	**$230,282,772**	**$64,725,291**	**39%**
Less: interest	$18,829,847	$18,829,847	$0	0%
Less: depreciation	$41,401,577	$41,401,577	$0	0%
Earnings before Taxes	**$105,326,057**	**$170,051,348**	**$64,725,291**	**61%**
Less: Income taxes	$26,619,738	$43,771,941	$17,152,202	64%
Net Income	**$78,706,319**	**$126,279,408**	**$47,573,089**	**60%**
NI % Gross Sales	19%	27%	7%	38%

Cash Flow	Base Case	Selling Price @ $5.00	Unit Change	Percentage Change
Net income	$78,706,319	$126,279,408	$47,573,089	60%
Add: depreciation	$41,401,577	$41,401,577	$0	0%
Deduct: principal payment	$44,433,594	$44,433,594	$0	0%
Deduct: capital expenditures	$8,333,333	$8,333,333	$0	0%
Cash Flow	**$67,340,968**	**$114,914,057**	**$47,573,089**	**71%**

The Increase in selling price yields a dramatic improvement in profitability and returns. The 16% higher price results in a 60% rise in net income, and a 71% increase in cash flow. This leverage is because revenue from higher prices falls directly to the bottom line; expenses are unchanged (other than income taxes).

The IRRs resulting from this scenario range from 10% to 14% (using the same methodology as applied to the Base Case).

Higher Production Costs

We received feedback that some of the production expenses we used in our Base Case scenario were on the low side; that given the un-tried state of industrial-scale RAS Atlantic salmon culture, use of a higher cost base was appropriate. This feedback was couched in terms of specific production expenses, such as energy and waste disposal, and some model parameters such as FCR and mortality rates, but also in terms of the range of average production expense (variable cost) per kilogram of production drawn from other published studies of RAS production of Atlantic salmon, where our model was substantially below even the low end of that range.

We thus provide a scenario showing how higher production costs impact forecast financial performance. We assumed an across-the-board increase in production expenses that resulted in an average production expense of $5.54/kg, right in the middle of the range of published values.[20]

[20] DNB (2017), Rosten et al (2013), Bjorndal & Tusvik (2017), Liu et al (2016), Iversen et al (2013), Kuterra (2015b), Kuterra (2016a).

All other assumptions – including revenues and fixed costs – were held the same as in the Base Case.

Table 19: Scenario – Higher Average Production Expense (Variable Cost) per kilogram of Production

Income Statement	Base Case	Scenario: Higher Production Costs	Unit Change	Percentage Change
Gross sales revenue	$404,298,557	$404,298,557	$0	0%
Net sales revenue	$401,915,813	$401,915,813	$0	0%
Less: Production expenses	$208,371,816	$277,134,516	$68,762,699	33%
Gross Profit	**$193,543,996**	**$124,781,297**	**($68,762,699)**	**-36%**
GM % gross sales	*48%*	*31%*	*-17%*	*-36%*
Less: Fixed expenses	$27,986,515	$27,986,515	$0	0%
EBITDA	**$165,557,481**	**$96,794,782**	**($68,762,699)**	**-42%**
Less: interest	$18,829,847	$18,829,847	$0	0%
Less: depreciation	$41,401,577	$41,401,577	$0	0%
Earnings before Taxes	**$105,326,057**	**$36,563,358**	**($68,762,699)**	**-65%**
Less: Income taxes	$26,619,738	$9,240,895	($17,378,844)	-65%
Net Income	**$78,706,319**	**$27,322,463**	**($51,383,856)**	**-65%**
NI % Gross Sales	19%	7%	-13%	-65%

Cash Flow	Base Case	Higher Production Costs	Unit Change	Percentage Change
Net income	$78,706,319	$27,322,463	($51,383,856)	-65%
Add: depreciation	$41,401,577	$41,401,577	$0	0%
Deduct: principal payment	$44,433,594	$44,433,594	$0	0%
Deduct: capital expenditures	$8,333,333	$8,333,333	$0	0%
Cash Flow	**$67,340,968**	**$15,957,112**	**($51,383,856)**	**-76%**

Raising production expenses by one-third to achieve the desired average production cost per kilogram has a material impact on results. While still profitable in absolute terms, the increase in costs has taken much of the lustre out of the project. The IRRs returned under this scenario range from -3% to 4% (using the same methodology as applied to the Base Case).

If this set of assumptions reflected expectations for RAS aquaculture, it is unlikely that the required level of investment to develop an industry would be summoned.

To assist decision-makers in understanding the intricacies and prospects for land-based RAS salmon aquaculture in British Columbia, we present in Appendix A our original model based on the Robinson model but amended by us in a number of ways, and the version of that model based on comments received from our Advisory Committee (that also achieves an average production cost in the middle of the range of other published studies of RAS salmon aquaculture).

Economic Impact Analysis

There are three sources of economic impacts generated by the development and operation of RAS Atlantic salmon facilities on Vancouver Island:

1. One-time construction of the RAS facilities
2. Ongoing operation of the RAS facilities
3. Ongoing processing of salmon (including trucking, primary and secondary processing, and sales & marketing) produced by the RAS facilities

To estimate these economic impacts, we rely on the financial models of RAS production and the processing of their production presented in the first part of this report.

Those data were provided to BC Stats where they were used to calibrate runs of the BC Input-Output Model (BCIOM). Significant and special thanks go to Lillian Hallin, Manager of Economic Accounts & Analysis at BC Stats for completing this work with her usual attention to detail and with record speed.

Construction of RAS Atlantic Salmon Infrastructure

The economic impacts stemming from the construction of 50,000 tonnes worth of RAS production facilities are shown in Table 20.

Table 20: Economic Impacts: RAS Capital Expenditures

Indicator	Direct	Indirect	Induced	Total
Expenditures	$1,027.5	$573.6	$77.0	$1,678.1
GDP	$71.8	$286.0	$49.6	$407.5
Jobs	765	2,762	463	3,989
Employment	858	2,974	418	4,250
Household Incomes	$58.5	$211.8	$36.2	$306.5
Tax Revenues	$49.4	$56.0	$7.7	$113.2

Source: BC Stats & Counterpoint Consulting Inc

Direct expenditures are $1.027 billion. The spending of the RAS facilities in turn generates an additional $650.6 million in indirect and induced expenditures as impacts are traced through the backward-linking supply chains, for a total of $1.678 billion as a result of building and equipping the RAS facilities.

The contribution to GDP, focusing on value-added as it does, is necessarily less than the impact measured by expenditures, which double counts a lot of expenditures, as can be seen by the difference between the two measures. Construction of the RAS facilities generates a one-time contribution to GDP of $407.5 million, as shown in Figure 1 (along with Household Incomes and Tax Revenues).

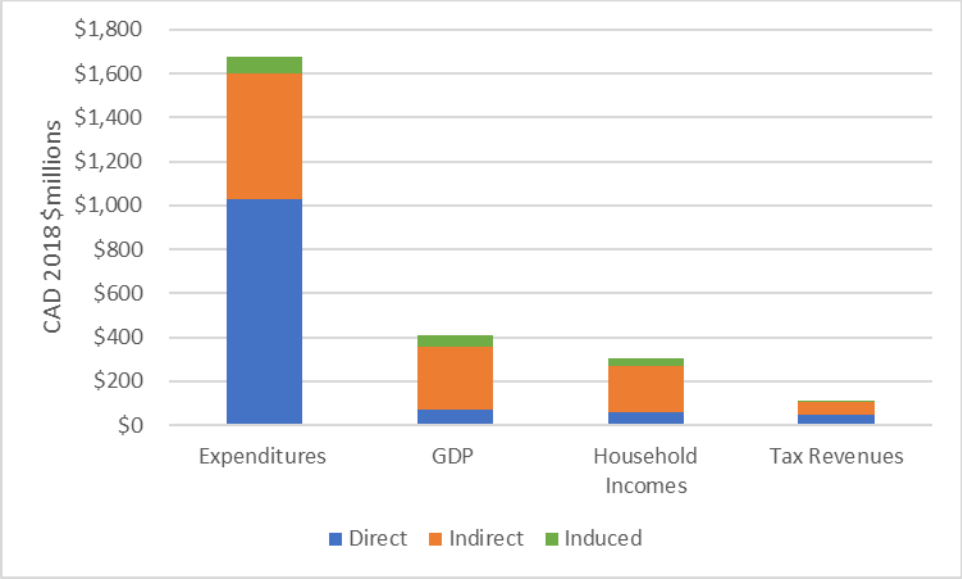


Figure 1: Dollar Denominated Economic Impacts of RAS Construction Phase

The construction of the RAS facilities would occur over a defined, relative short period of perhaps one to three years. The economic impacts generated by construction of the RAS facilities would therefore end once construction was complete: they would not be ongoing (as would be the economic impacts of producing and processing Atlantic salmon using RAS technology). The total impacts of RAS construction would be spread out over however many years would be required for the facilities to be completed. For

example, if construction of the RAS facilities took two years, then on average GDP in British Columbia would be increased by $203.7 million in each of those two years.

The estimated expenditures of $1.027 billion would support 1,750 construction jobs with another 1,777 jobs in supplier industries such as engineering, manufacturing, wholesale trade and other related services. These are the direct plus indirect jobs. The remainder of the total 3,989 jobs created by the construction of the RAS facilities — 463 jobs — are created by induced expenditures (ie, the spending of households on goods and services).

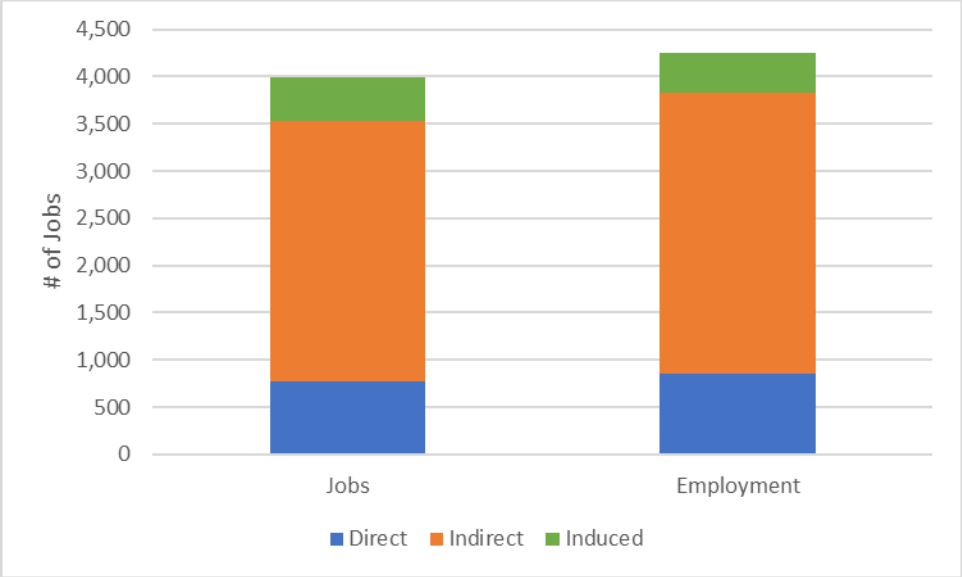


Figure 2: Jobs & Employment Impacts of RAS Construction

That the jobs and employment impacts are so similar (see Figure 2) means that the jobs created by RAS construction are full-time equivalent (ie, not seasonal or part-time) jobs.

These are well-paying jobs, with average annual wages ranging from $66,265 to $81,458, as calculated in the BCIOM. In total, construction of the RAS facilities contributes $306.5 million to the incomes of BC households. Again, these are one-time infusions that last for the duration of the construction period. If that were two years, BC household incomes would rise by $153.2 million on average in each of those two years.

Finally, the construction of the RAS facilities can be expected to contribute $113.2 million to federal, provincial, and municipal tax coffers. This one-time contribution to tax revenues would be spread out over the number of years of the RAS facilities' construction period.

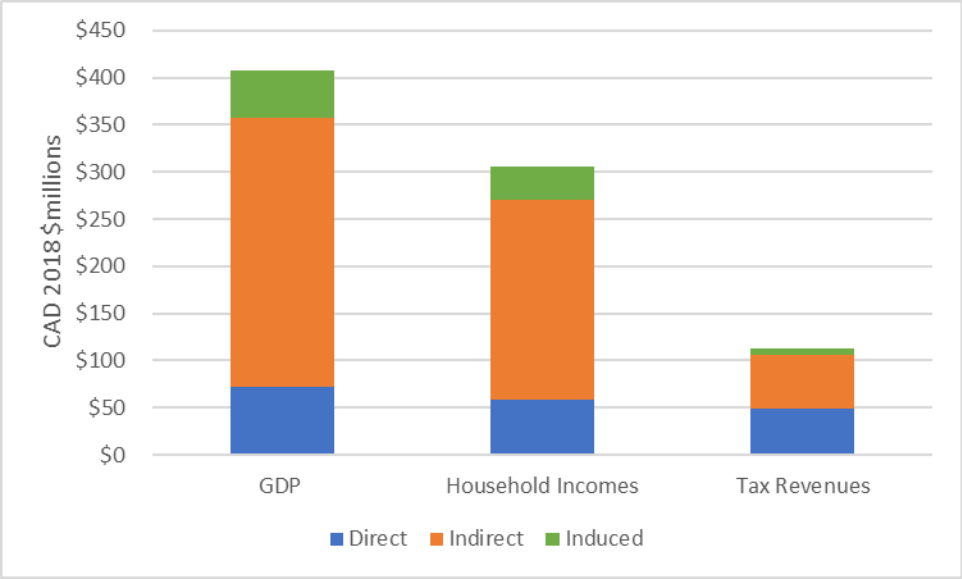


Figure 3: GDP, Household Income, & Tax Revenue Impacts of RAS Construction

The geographical distribution of economic impacts generated by the construction of the RAS facilities is shown in Figure 4. The RAS construction impacts are about evenly split between the Campbell River Area and the rest of British Columbia.

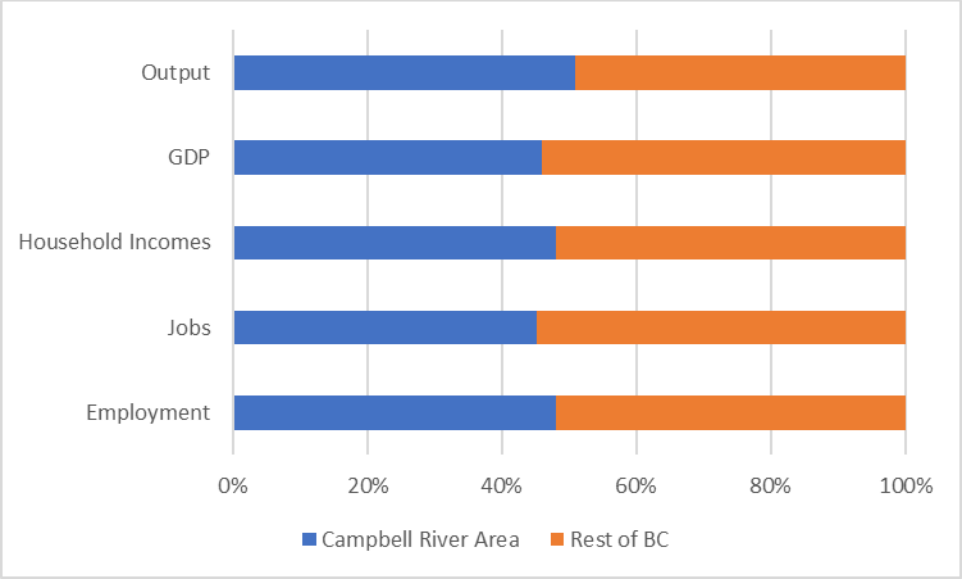


Figure 4: Geographic Distribution of RAS Capex Economic Impacts

The Duration of RAS Economic Impacts

The economic impacts arising from construction of RAS facilities, discussed in the preceding section, are one-time impacts the duration of which will be the length of the construction period.

In contrast, the economic impacts generated by the operation of those RAS facilities and the processing of the Atlantic salmon they produce, would be ongoing: they would occur and reoccur annually, once the facilities reach full production capacity.

The effect is shown in Figure 5 which shows the number of jobs created each year by each component of the RAS Atlantic salmon industry imagined in this analysis:

- Construction of RAS facilities
- Operation of RAS facilities: production of Atlantic salmon
- Processing of Atlantic salmon produced by RAS facilities

For the purposes of Figure 5, we have assumed that RAS facilities produce at 50% capacity in their first year of operation.

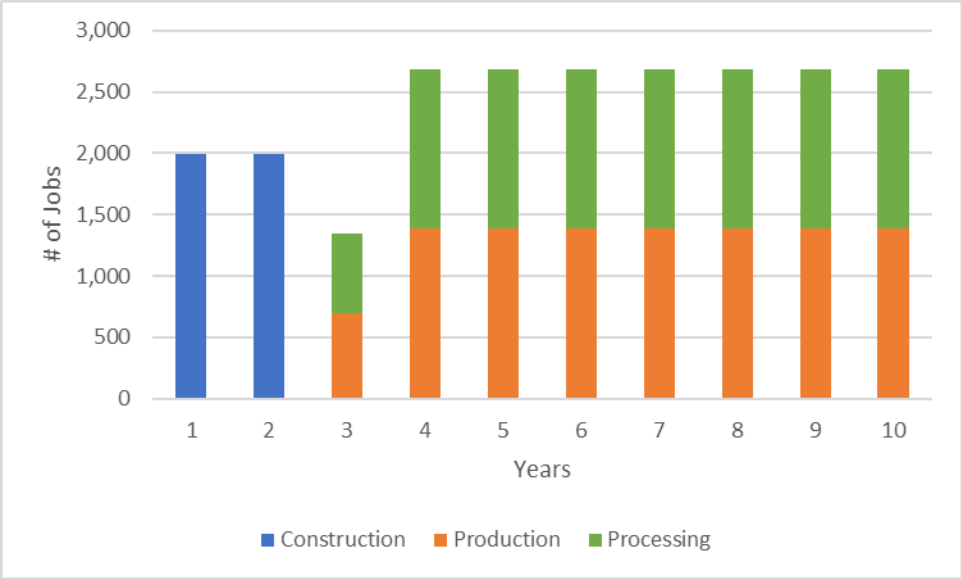


Figure 5: Magnitude and Timing of Job Creation Impacts of RAS on Vancouver Island

The blue bars in Figure 5 are the one-time jobs created during the construction of RAS facilities on Vancouver Island.

The orange and green bars show the ongoing jobs supported by production and processing, respectively, of 50,000 tonnes of Atlantic salmon using RAS land-based technology.

A Note on the Economic Impacts of RAS Atlantic Salmon Production

The economic impacts described in this report are the gross changes in economic activity that would be expected by the establishment of a 50,000 tonne per year RAS Atlantic salmon industry on Vancouver Island.

If it is assumed that the RAS Atlantic salmon production adds to the provincial output of Atlantic salmon (almost entirely marine-based, open net-pen production), then the economic impacts described here would also measure the net change in economic activity. That is, there would be no offsetting losses elsewhere.

However, if the assumption were that the RAS production of Atlantic salmon were replacing equivalent production of Atlantic salmon using marine-based net-pens, then there would be offsetting losses and the net effects would be smaller. The effect on production of Atlantic salmon would depend on whether economic impacts of ONP salmon aquaculture are greater or less than those of RAS salmon aquaculture. The offset in processing could be assumed to be one-to-one.

If the assumption is that the RAS production is not offset by any decrease in ONP production, an unanswered question is whether existing fish processing infrastructure and capacity would be sufficient to handle the additional 50,000 tonnes of production (a question that is beyond the scope of our analysis).

If not, then additional economic impacts not quantified in this report (albeit time-limited, not ongoing) would likely be generated by the construction of new processing infrastructure/capacity.

Production & Processing of Atlantic Salmon

The ongoing economic impacts of producing and processing 50,000 tonnes of Atlantic salmon in RAS facilities are shown in Table 21.

Table 21: Economic Impacts: Salmon Production & Processing

Indicator	Direct	Indirect	Induced	Total
Expenditures	$515.7	$289.5	$31.9	$837.1
GDP	$211.3	$116.3	$20.5	$348.1
Jobs	1,413	1,080	191	2,685
Employment	1,465	1,094	173	2,732
Household Incomes	$58.7	$68.6	$15.0	$142.3
Tax Revenues	$40.0	$26.3	$3.2	$69.6

Source: BC Stats & Counterpoint Consulting Inc

A RAS land-based salmon farming industry on Vancouver Island would generate $837 million in expenditures annually from production and processing of 50,000 tonnes of Atlantic salmon and contribute $348m to provincial GDP (see Figure 6, page 23).

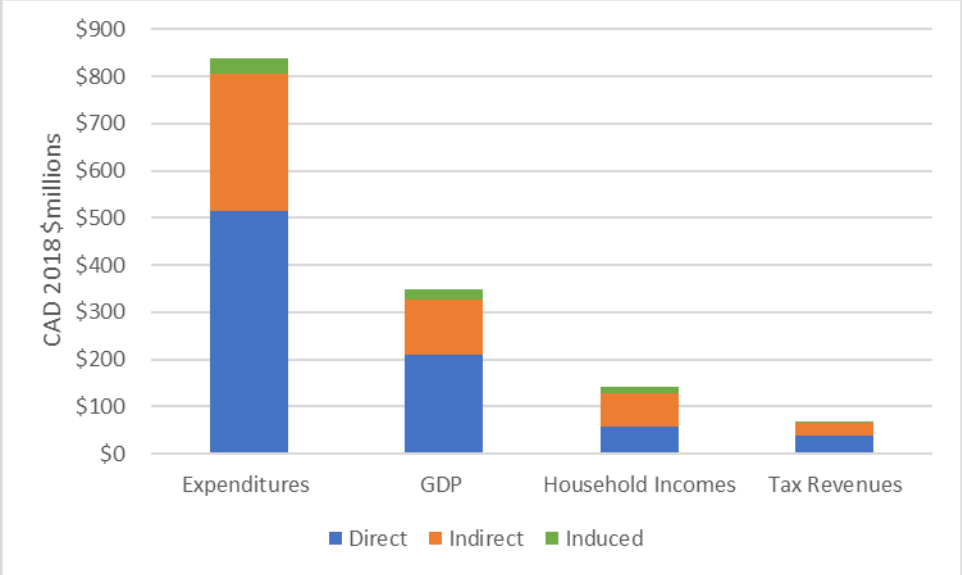


Figure 6: Dollar Denominated Economic Impacts of Production & Processing of RAS Farmed Salmon

Salmon production and processing would support 2,685 jobs in British Columbia every year. Figure 7 shows the jobs and employment in salmon production and processing with a 50,000 tonne RAS land-based salmon farming industry on Vancouver Island.

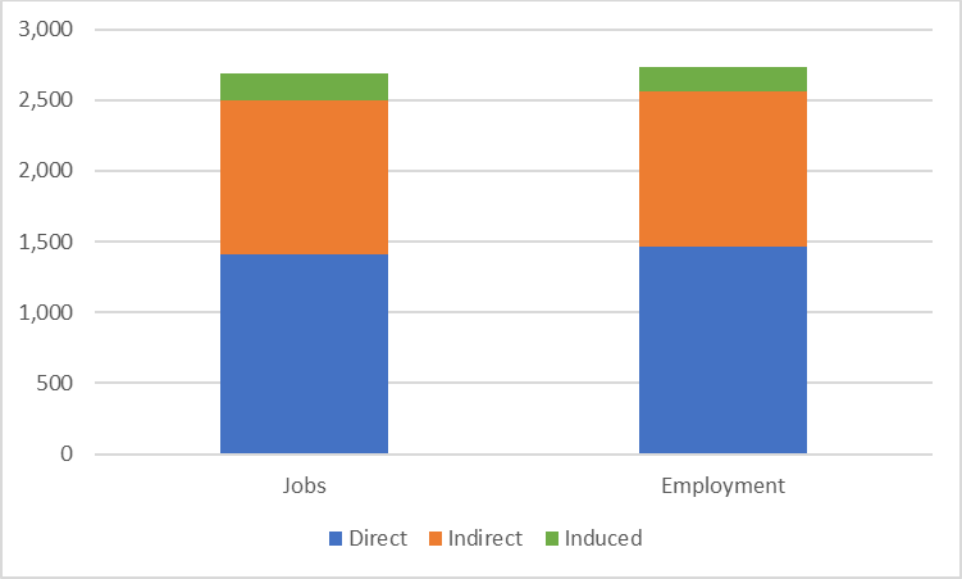


Figure 7: Salmon Production & Processing Jobs & Employment

There is quite a mix of jobs and skill requirements in salmon farming and processing. Farm hands and fish plant workers receive relatively lower wages than skilled technicians, professional biologists and engineers, and veterinarians. Direct jobs in salmon processing pay an average of $33,350. At the other end of the scale, the highest average annual income is almost $78,305 but even that would not capture the high-end salaries of professionals and veterinarians.

In all, RAS salmon production and processing would contribute $142.3 million to the incomes of household in BC each year and $69.6 million to federal, provincial, and municipal tax revenues.

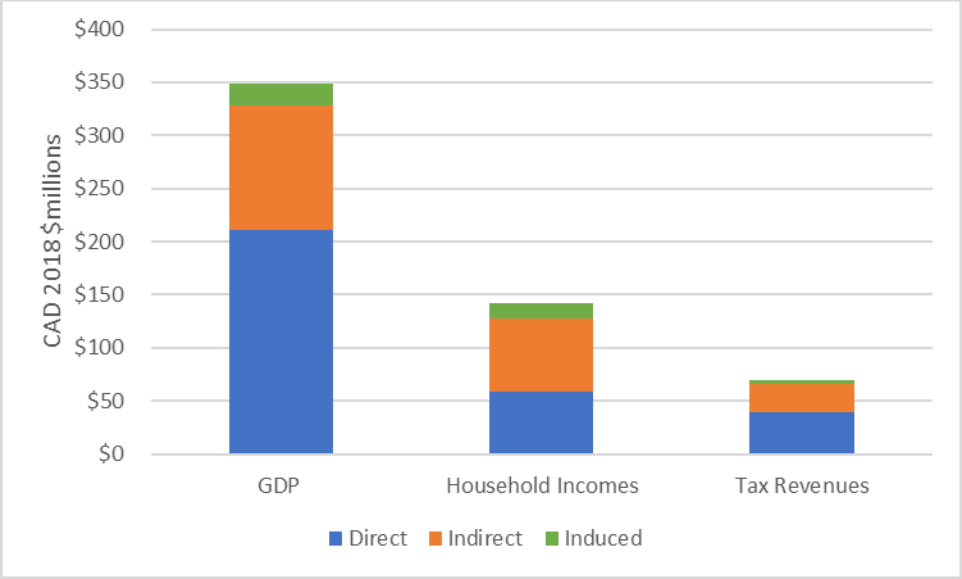


Figure 8: GDP, Household Income, & Tax Revenue Impacts of Salmon Production & Processing

About one-fifth of the total economic impacts of producing and processing Atlantic salmon on Vancouver Island would accrue in the local area, as shown in Figure 9.

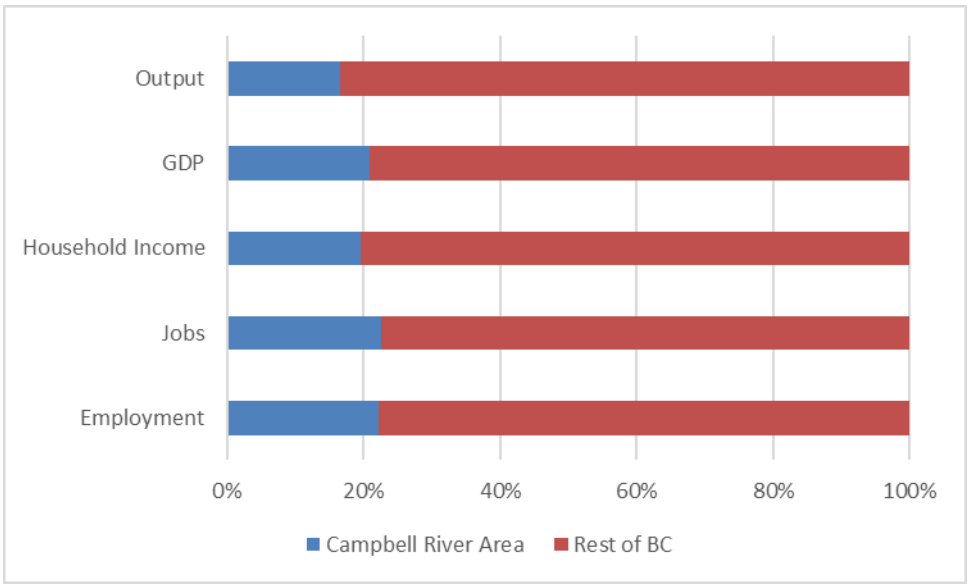


Figure 9: Geographic Distribution of Production & Processing Economic Impacts

The breakdown of economic impacts between salmon production and processing is shown in Table 22.

Table 22: Economic Impacts: Salmon Production & Processing

Indicator	Production	Processing	Total
Expenditures	$632.7	$204.4	$837.1
GDP	$273.6	$74.5	$348.1
Jobs	1,386	1,299	2,685
Employment	1,417	1,315	2,732
Household Incomes	$83.1	$59.2	$142.3
Tax Revenues	$55.9	$13.7	$69.6

Source: BC Stats & Counterpoint Consulting Inc

This breakdown can be visualized in Figure 10.

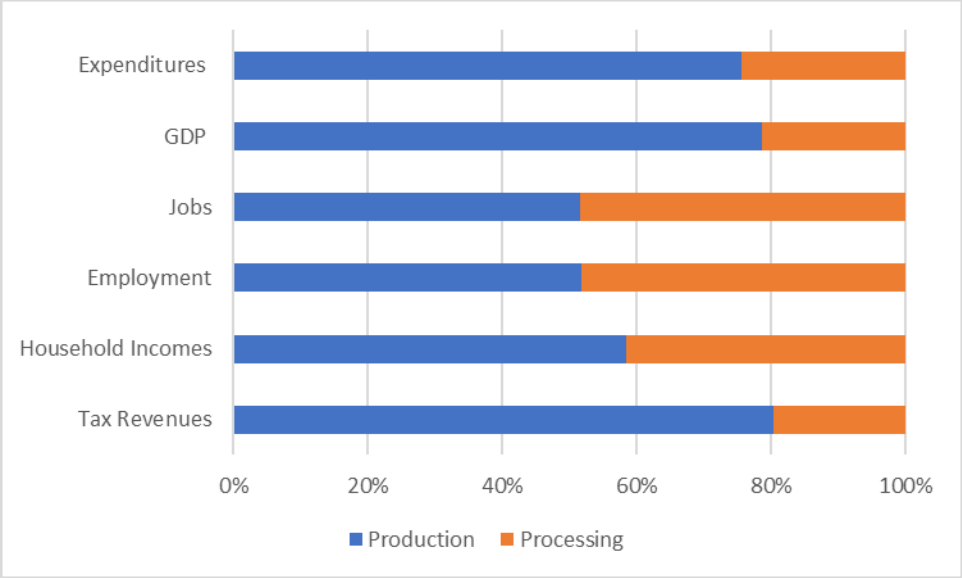


Figure 10: Distribution of Economic Impacts between Production & Processing

While the number of jobs supported, employment created, and household incomes generated are about equally split between the production and processing of Atlantic salmon, about 80% of the expenditures, GDP and tax revenues are attributable to salmon production.

Practical Considerations

The indicated economic impacts associated with bringing a new industry to Vancouver Island are enticing. With the impacts of a 50,000 tonne RAS industry now evaluated, it remains to attract would-be RAS aquaculturists to locate in British Columbia.

This is a period of intense interest in RAS production of Atlantic salmon and the RAS business model, and on paper at least, projects are cropping-up around the globe. A key siting consideration is proximity to markets; the paradigm of locating salmon farms in remote locations featuring pristine environmental conditions does not apply to this model. Access to clean, abundant water to run the facility, and ability to discharge waste-water, are critical considerations, as is a source of reliable, affordable power.

Our most recent scan of contemplated RAS projects (Intrafish 2019) revealed some ambitious plans. The USA shows the highest intensity of projects, summarized as follows:

Location	Company	Capacity (tonnes/yr)
Homestead, Florida	Atlantic Sapphire	90,000
Belfast, Maine	Nordic Aquafarms	33,000
Bucksport, Maine	Whole Oceans	25,000
Tazewell County, Virginia	Pure Salmon	20,000
Sheridan, Wyoming	Aquabanq	10,000
Eureka, California	Nordic Aquafarms	22,860
Total		**200,860**

The bulk of these projects are positioned to service the Northeast market, though the Eureka, CA project would supply the Western USA market (in direct competition to product produced in BC).

Norway, the pre-eminent grower of ocean-reared salmon, has about 60,000 tonnes of RAS projects on the books. RAS Atlantic salmon farms are also potentially in the works in Russia, China, and Japan. There are no projects slated for British Columbia (at least according to IntraFish 2018a).

In this paper we have identified a significant stream of economic impacts that can accrue from securing a RAS industry on Vancouver Island. BC must recognize, however, that attracting RAS investment means competing against other jurisdictions, and that we are currently not high on the radar within the RAS investment community.

BC is not used to competing with Florida or Wyoming in the production of salmon. A new competitive reality must be recognized, and a crucial next step in attracting this industry is developing a cohesive plan for making BC competitive, and touting the advantages of locating here.

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Appendix A: Other Versions of our Model

As indicated in the body of the report, deciding on a set of assumptions to apply to the financial model feeding the EIA was challenging. While we provided two sensitivity scenarios in the report, for readers interested in additional scenarios, we offer summary outputs for the following:

1. The model we used in our draft report (submitted to the client).
2. The model when populated with assumptions reflecting the advice of our Advisory Committee.

Table 23: RAS Model Results: Summary of Draft Report version

Summary	One RAS Facility	All RAS Facilities
Revenue (@ $4.75 selling price per HOG lb)	$26,591,395	$443,189,911
Less: Production expenses (G Robinson model + tweaks made by us)	$12,029,372	$200,489,534
Gross Margin	**$14,562,023**	**$242,700,377**
Less: Fixed expenses (G Robinson model + tweaks made by us)	$1,679,191	$27,986,515
EBITDA	**$12,882,832**	**$214,713,862**
Less: Depreciation	$2,484,095	$41,401,577
Less: Interest on long term debt	$1,129,791	$18,829,847
Earnings before taxes	**$9,268,946**	**$154,482,438**
Less: Income taxes	$2,409,926	$40,165,434
Net Income	**$6,859,020**	**$114,317,004**
Add: Depreciation	$2,484,095	$41,401,577
Less: Principal payments	$2,666,016	$44,433,594
Less: Capital expenditures	$500,000	$8,333,333
Cash Flow	**$6,177,099**	**$102,951,654**

Table 24: RAS Model Results: Summary of version incorporating Advisory Committee (AC) advice

Summary	One RAS Facility	All RAS Facilities
Revenue (@ $4.31 selling price per HOG lb)	$24,114,949	$401,915,813
Less: Production expenses (our draft model + higher costs per AC)	$17,215,909	$286,931,809
Gross margin	**$6,899,040**	**$114,984,004**
Less: Fixed expenses (per our draft model)	$1,679,191	$27,986,515
EBITDA	**$5,219,849**	**$86,997,489**
Less: Depreciation	$2,484,095	$41,401,577
Less: Interest on long term debt	$1,672,802	$27,880,034
Earnings before taxes	**$1,062,953**	**$17,715,878**
Less: income taxes	$209,573	$3,492,883
Net Income	**$853,380**	**$14,222,995**
Add: depreciation	$2,484,095	$41,401,577
Less: principal payments	$2,666,016	$44,433,594
Less: capital expenditures	$500,000	$8,333,333
Cash Flow	**$171,459**	**$6,689,568**

These results provide further demonstration that a range of model inputs are possible, and that seemingly minor changes in inputs can have major impacts on results. It rests with RAS investors to decide which scenarios suit their risk-reward profiles.