Port Pegasus Salmon Farm

Indicative Business Case for new aquaculture in Southland

NZIER Final report to Ministry for Primary Industries

12 September 2017

About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

NZIER is also known for its long-established Quarterly Survey of Business Opinion and Quarterly Predictions.

Our aim is to be the premier centre of applied economic research in New Zealand. We pride ourselves on our reputation for independence and delivering quality analysis in the right form, and at the right time, for our clients. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review at various stages through a project by a senior staff member otherwise not involved in the project.

Each year NZIER devotes resources to undertake and make freely available economic research and thinking aimed at promoting a better understanding of New Zealand's important economic challenges.

NZIER was established in 1958.

Authorship

This paper was prepared at NZIER by Peter Clough and Daniel Pambudi

It was quality approved by John Ballingall

The assistance of all who have provided information is gratefully acknowledged.

NZIER
NEW ZEALAND INSTITUTE OF ECONOMIC RESEARCH

L13 Grant Thornton House, 215 Lambton Quay | PO Box 3479, Wellington 6140
Tel +64 4 472 1880 | econ@nzier.org.nz

Key points

This report presents an Indicative Business Case for establishing new salmon farming at Port Pegasus on Stewart Island.

We find that under a variety of assumptions, such an initiative **would deliver a net benefit to the Southland regional economy**. However, constraints placed on the current configuration of the salmon farm for environmental reasons limit the size of that net benefit to a low level.

The farm would support regional, national and industry growth strategies …

The proposed salmon farm uses a modern innovative system based on circular fish pens that would have lower visual impact than conventional pen farming. Located in Port Pegasus North Arm, an area flanked by conservation land, the salmon farm would have no shore based infrastructure in Port Pegasus but be serviced out of Bluff, and send its produce there for processing and distribution.

There is a strong strategic case for new salmon farming in Southland, as it would align with objectives in the Southland Regional Development Strategy, the Government's Business Growth Agenda, and the aquaculture industry's Aquaculture Strategy.

It would also support diversification and resilience of the regional economy by harnessing the natural resource of marine space to create a stream of value.

… and deliver net economic benefits under various assumptions

In this Economic Case, we examine eight 'central' scenarios which vary with the size of annual output and the intensity of use of marine farming equipment, to estimate their economic viability and their impact on Southland's GDP and employment.

The scenarios are based on two levels of intensity, leading to low output and high output variants for each of four configurations of growing pens used.

We find:

- All scenarios look moderately positive on the figures and assumptions we use. Benefit cost ratios are greater than one but not greater than 2, with most in the range of 1.1 to 1.2 under our central assumptions.
- Larger output volumes are more net beneficial than smaller volumes, which partly reflects the way scenarios are defined with similar fixed costs of equipment used at lower intensity in the low output options.
- The new farm would add 0.2% to 0.5% to Southland's GDP in our central scenarios, peaking in year 8 and generate between 97 and 238 Full Time Equivalent jobs, depending on the size of output.

The results are robust to changes in salmon volumes or values

- Under more optimistic price assumptions, the new farm would add 0.9% to Southland's GDP.

- Lower salmon prices or volumes will push down the present value of benefits. Our break-even analysis indicates that targeted tonnage could drop by between 9% and 27% for low output scenarios, or between 32% and 45% for high output scenarios, and the project would still break-even. The smallest scenarios (4a and 4b) would break even at about 2,540 tonnes annual production, and the largest (1a and 1b) at about 4,370 tonnes.

Further modelling could firm up estimates

Our positive economic results could be improved by more detailed assessment to resolve some of the uncertainties around cost items. They could also be improved with other configurations of growing pens which might improve the utilisation of the capital equipment employed.

Computable General Equilibrium modelling of selected scenarios could also broaden the impact analysis to examine the indirect flow-on effects through the economy of the new salmon farm, if established.

The latest changes to farm configuration and location to reduce environmental impacts have constrained the production of the salmon farm and reduced its potential contribution to economic and strategic aims. These contributions would increase with larger production than is currently provided by the current configuration.

Contents

Appendices

Figures

Tables

1. Introduction

The Southland Regional Development Strategy (SoRDS) has a goal of attracting 10,000 more people into the region by 2025. It has identified aquaculture as a leading opportunity to achieve greater sustainability by stimulating economic growth, creating jobs and providing economic diversity and resilience.

Farmed salmon has by far the highest return per hectare invested in marine farming in New Zealand and is a prime candidate for expansion in Southland.

SoRDS has identified five sites with potential for salmon farming. This report focuses on one which appears most likely for early development, the North Arm of Port Pegasus on Stewart Island's South East coast, about 50 kilometres south of Oban.

This report examines the prospects for salmon farming through eight scenarios derived from four different configurations of growing pens and two levels of fish stocking intensity (low and high). These scenarios are indicative (not fixed options), chosen to help assess effects on general locations of production in the inlet.

We use Treasury's Indicative Better Business Case (IBBC)[1] framework to examine the economic viability of the proposed marine farm, i.e. is it likely to produce benefits in excess of the opportunity costs of resources it uses?

Beyond this we look at the impact of new marine farming and processing of salmon on direct employment in Southland and for regional value added and Gross Domestic Product.[2]

The economic analysis is principally required for the Economic case, but it is also informative for the Strategic case and parts of the Commercial, Financial and Management cases. We focus on the Strategic and Economic cases with initial assessment of Commercial, Financial and Management cases which are usually refined as the project is fine-tuned after the Economic case has been established.

This report proceeds by

- Outlining the potential for salmon farming in Southland and the scenarios to be examined for Port Pegasus salmon farming
- Setting the Strategic case for salmon farming expansion in Southland
- Examining the Economic case for salmon farming at Port Pegasus
- Examining implications for the Commercial, Financial and Management cases for the Port Pegasus salmon farming proposal.

[1] http://www.treasury.govt.nz/statesector/investmentmanagement/plan/bbc/guidance/bbc-indbus-gd.pdf

[2] As modelled here, GDP is the value of outputs produced within a region less the intermediate consumption of inputs used in producing that output, at market prices including indirect taxes; Value added is similar but excludes indirect taxes.

2. Port Pegasus Salmon Farm

2.1. Preliminary considerations

New Zealand is currently a tiddler in global farmed salmon production but is seen by industry and Government as having potential for growth. It currently produces around 14,000 tonnes of farmed salmon per year from a mix of predominantly sea pen and a small contribution of freshwater production.

Industry and Government expect this could be raised substantially in view of annual production tonnages recorded in other countries, such as Tasmania (32,000 tonnes), Faroe Islands (59,000 tonnes), Scotland (132,000 tonnes) and Norway (937,000 tonnes). Southland has a range of deep coldwater sites with characteristics similar to those that have supported substantially higher salmon production in other countries.

New Zealand farms King (or Chinook) Salmon, which has a lower food conversion than the Atlantic Salmon which is more commonly farmed in other countries. But it is also less prone to sea lice and diseases and achieves a price premium relative to Atlantic Salmon on international markets.

The Global Aquaculture Index, which compares sustainable practice in 22 countries, recognises New Zealand Salmon farming as a leading producer. New Zealand supplies about 0.5% of global salmon, but 88% of King Salmon.

2.2. The Port Pegasus proposal

The North Arm of Port Pegasus is located behind Pearl Island and has a surface area of 3,071 hectares, about the same as that of Wellington Harbour. In its document on *A bright future for Aquaculture in Southland*, SoRDS identified that if 30 hectares were available for aquaculture it could support a farm of 3.4 surface hectares, allowing for movement of the structures to allow recovery of the sea-bed beneath.

SoRDS estimates that in full production, such farms could produce up to 2,000 tonnes per hectare,[3] with a potential value of up to around $15,000 per tonne.

Salmon hatcheries in freshwater strip the eggs from adult spawning fish, hatch them and raise them to young fish known as smolt. At this stage they can be transferred to saltwater to feed and grow, spending a second year for fattening and a third year for finishing to the required weight of 4kg. Fish oil is added to feed to boost omega-3, and astaxanthin, a carotenoid pigment, is used to give the fish their distinctive pink flesh for better appearance and marketing.

Farmed salmon are fed protein. About 10% of salmon feed is fishmeal, predominantly based on anchovies, but recent rises in anchovy prices have led to substitution to other protein-rich feedstuffs.

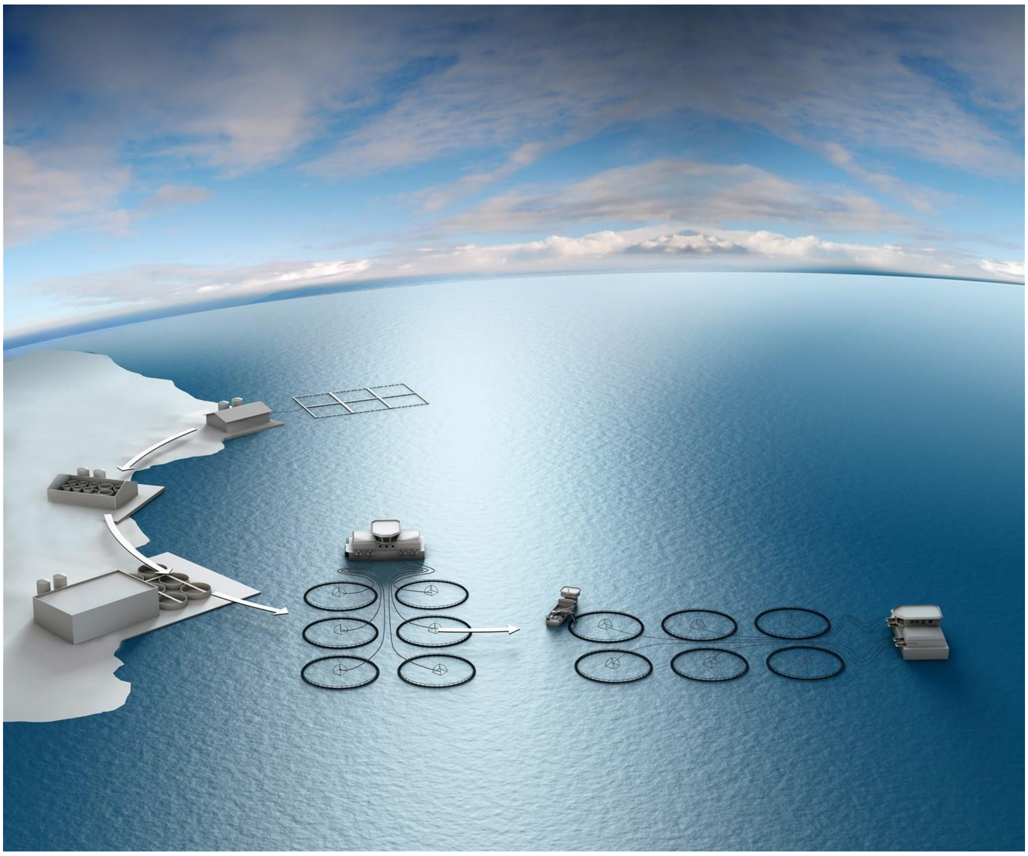
Currently in New Zealand the predominant feed is based on fish and fish oils supplemented by poultry by-products. If New Zealand national salmon production were to reach over 50,000 tonnes annually, it may become economic to make

3 This figure is obtained by dividing a farm's annual production by the area of enclosures containing harvest-ready fish. As it takes about three years for salmon to reach harvest size, average production per total farm hectares is about 650 tonnes.

protein feeds from cereals such as oats, which could also potentially be met by Southland production.

The production method currently envisaged for Port Pegasus would be based on a modern Norwegian system consisting of circular pens tethered behind a control vessel which contains crews' quarters and storage bins from which fishfeed is pumped to the pens. This system is more flexible in layout and presents a lower visibility profile than the rigid steel pens familiar from existing farms, which have multiple closely packed pen compartments in a single structure. The circular pen system is illustrated in Figure 1 below.

Figure 1 Poly-circle salmon farming pens



Source: Akva

Optimal salmon farming requires deep water (greater than 30 metres), good current flow (greater than 10 centimetres/second) to aerate the water and flush out residue feed and fish wastes, cold water (18^{o} C or lower), and placement away from rocky and high biogenic habitats and significant flora and fauna.

Preliminary results from surveys by the Cawthron Institute suggest Port Pegasus has 25-40 metre depth, water current of 4 – 9 centimetres/second, and sea-bed mainly consisting of sand and mud with sparse but common organisms.

Three tentative areas have been identified at Port Pegasus North Arm, a 72 hectare area of inner harbour suited to smolt pens, a 56 hectare area in the middle harbour and a 74 hectare area towards the edge of the inner harbour. A fourth potential area of 65 hectares has been identified in the harbour entrance at Big Ship Passage, but this is subject to large swells from the ocean.

Port Pegasus is flanked by conservation land but the proposed salmon farm would have no land facilities or infrastructure on Stewart Island. The farm will be supplied by feed and fuel from Bluff, and fish will be transported to Bluff for processing.

Operating conditions for the salmon farm would be similar to those of Sanford's operation in Big Glory Bay on the edge of Paterson Inlet, which sends its harvest by boat to its processing factory at Bluff. A Port Pegasus operation would face longer steaming time along the south-eastern coast of Stewart Island.

This report focuses on the latest farm configuration in which the smolt pens would be located in the upper part of the North Arm with some separation from growing pens in four clusters nearer to the centre of Big Ship Passage, where they would also be less visible from the shore (Figure 2). Further details on the choice of location and modelling of impacts on the sea-bed are provided in this report's Appendix B.

Figure 2 Location of proposed Port Pegasus salmon farming

Source: NZIER, using LINZ mapping

3. Modelling scenarios

3.1. Overview of scenarios

Having previously modelled eight scenarios for salmon farming established in Port Pegasus, this revised report models eight scenarios with different configurations of pens and output tonnages, based on four variants in areas of pens and two levels of production intensity (low a, higher b). Further explanation of the choice of scenario locations is given in Appendix B.1.The parameters are summarised in Table 1.

Table 1 Parameters of farm, by scenario

Scenario	Feed input tonnes	Annual Output tonnes	100m Smolt pens	160m grow pens	Total pens #	Smolt pen ha	Grow pen ha	Total pen ha	Output Tonnes /ha
1a	10,710	6,000	8	64	72	0.59	12.00	12.58	476.9
2a	7,994	4,478	6	46	52	0.44	8.62	9.06	494.2
3a	6,655	3,728	4	38	42	0.29	7.12	7.42	502.7
4a	5,001	2,801	4	28	32	0.29	5.25	5.54	505.6
1b	14,280	8,000	8	64	72	0.59	12.00	12.58	635.9
2b	10,658	5,971	6	46	52	0.44	8.62	9.06	658.9
3b	8,857	4,971	4	38	42	0.29	7.12	7.42	670.3
4b	6,667	3,735	4	28	32	0.29	5.25	5.54	674.1

Source: MPI

Annual output is the harvest from the final stage of production.[4]

The scenarios have been provided by MPI. Other information here has been provided by SoRDS, industry sources and publicly available sources. The scenarios are based on the poly-circle farm technology, which is considered more suited to Port Pegasus location adjacent to conservation lands.

These scenarios differ from those previously modelled, targeting lower annual production outputs with different configurations of pens, using 100 metre circumference smolt pens (compared to 60 metre previously) and 160 metre circumference grow pens (compared to 100 metre and 240 metre previously). Feed input also differs and is based on a ratio of 1.7 kg of feed per kg of fish output across the production cycle.

Salmon are reared on a 3 year cycle:

- 6 months in a freshwater hatchery rearing from egg to fingerling smolt
- 1 year in a smolt pen farm in saltwater

[4] Based on a three year production cycle the output tonnes per hectare are similar to the SORDS estimate of 2,000 tonnes per hectare in the harvest year – but vary with the intensity of use of the farmed pen area.

- 13-18 months in saltwater growing pens, before harvesting at the weight of about 4 kilograms.

There is sufficient hatchery capacity in the South Island to provide the smolt for a Pegasus Bay salmon farm, so there is no capital cost for hatchery expansion.

3.2. Farm location

The farm would be established in Port Pegasus with two areas of circle nets, forming a smolt farm and a growing farm. Assessments by Boffa Miskell have identified the most suitable locations for the smolt farm to be the northern shore of the North Arm, northeast of the mouth of Albion Inlet for all scenarios.

For the growth pen farms the location considered here is towards the mouth of the North Arm in Big Ship Passage. Pens would be arranged in four clusters of up to 16 pens each. The smolt farm is located with some separation from the growing pen areas, following advice from the industry (see Appendix B).

The smolt farm and the growing farm would each need to be established with a mooring grid. The smolt farm would be tethered to a control vessel which contains crew's quarters and storage bins from which fish feed is piped into the pens. The grow pen clusters would each be attached to a feeding barge distributing feed to each pen. The farms can be periodically shifted to enable the sea-bed beneath them to be refreshed, but such relocation is beyond the scope of this modelling.

3.3. Capital costs

The farm operation would be serviced out of Bluff, from which ships would depart to deliver feed and fuel and return. Because of Port Pegasus's remote location it is international best practice to harvest fish into a wellboat in which they are kept alive until delivered to the factory at Bluff. This leaves the fish in better condition for processing, resulting in higher value produce.

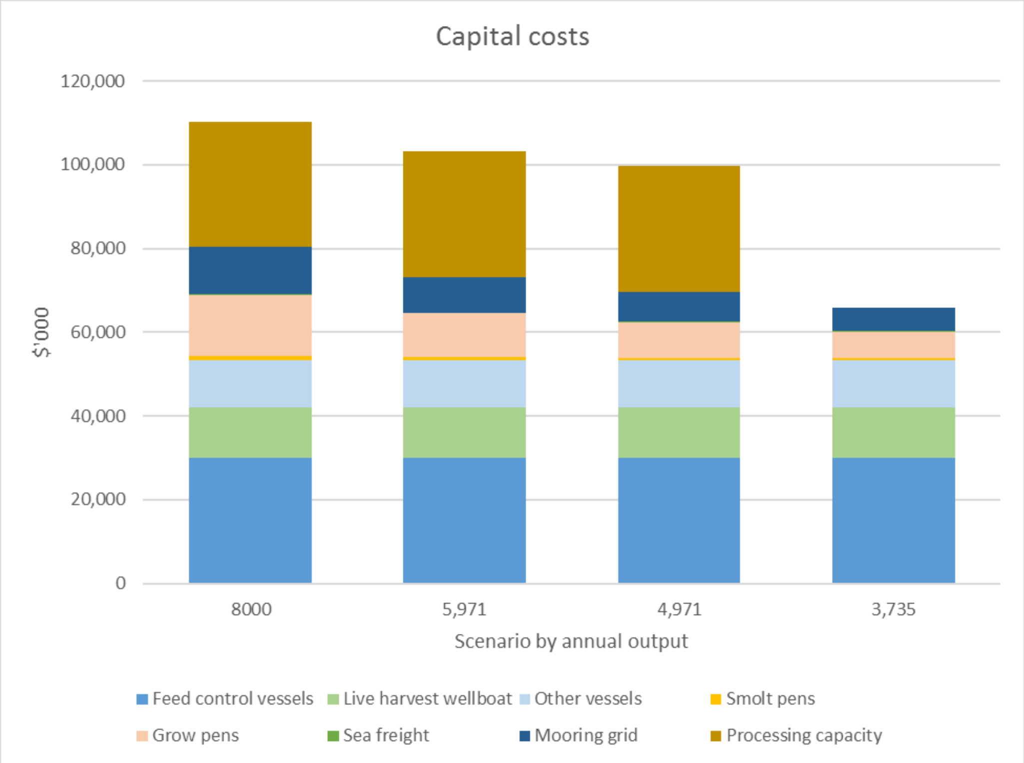
The eight scenarios summarised in Table 1, with two output levels (low and high) in four pen configurations, will have different capital costs for establishing a new salmon farm. These costs cover the purchase and installation of pens, mooring grids that vary with the configuration of pens, one control vessel for the smolt farm, four feeding barges for grow pens and one wellboat. They also provide for the construction of a new stand-alone processing plant to handle additional output of up to 8,000 tonnes per year. This is logistically best placed in Bluff (rather than on Stewart Island) to access labour, transport services and other supplies.

Figure 3 presents costs for the high output variants (8,000 tonnes fish maximum output). Capital costs are the same for low output variants (6,000 tonnes fish maximum) and for any given pen configuration, except with respect to processing.

Currently Sanford's has a salmon processing factory in Bluff handling around 3,500 tonnes greenweight throughput per year, with the capacity to double this throughput. This existing capacity could handle the additional annual outputs in Table 1 above for Scenarios 3a, 4a and 4b, so the capital cost of new processing capacity for those scenarios has been excluded in the first instance, and the effects of adding it in are considered in the sensitivity analysis.

Figure 3 Costs of farm establishment, across high output scenarios

New Zealand dollars, current values – Scenarios 1b (largest) to 4b (smallest)



Source: NZIER

We calculate a shipping cost for the pens on the assumption that they are obtained from Norway. From industry information we assume that all the components of the 100 metre smolt pens would require half of a 40 foot standard container (i.e. two such pens per container) and 160 metre pens would require one standard 40 foot container each. Freight is not a major component of supply cost.

These figures suggest the capital costs for the different size configurations for all scenarios fall within the range of around $65.8 million and $80.3 million excluding processing capacity, or up to $110.3 million including processing facility. These costs exclude costs of consenting, which are included in our broader analysis at $0.5 million in the years before the farm is established. This does not include other potential costs around amending legislation or regional plans.

Figure 3 shows the costs of vessels and processing capacity for all scenarios are the same, with variations in costs driven by the number of pens and the size of mooring grids to secure them.

If pens and equipment could be sourced or built within New Zealand there would be additional positive impact on the national and regional economy where that takes place. However, freight savings would be small and if New Zealand cannot match the economies of scale and specialisation obtained by overseas suppliers, capital costs could increase and reduce the viability of the operation.

3.4. Timing

There is some risk in establishing a salmon farm in a new location, in that the salmon may not “take” to the unfamiliar water conditions. Accordingly, a farm would probably be established in stages, with some investment held back until fish have been through the first established pens and proved them to be viable.

A likely staging of construction is illustrated in Figure 4. This entails:

- Establishment of a smolt farm first once consenting is completed
- Establishment of grow pens to accommodate the first cohort of smolt
- Construction of processing capacity in time for the first harvest of fish
- Further expansion of smolt and growing pens as the operation grows.

For each scenario the capital and establishment costs are distributed across the years according to the percentage shares identified in Figure 4. There is no hump in years 4 and 5 for those scenarios not requiring new processing capacity (3a, 4a and 4b).

Figure 4 Staging of farm and processing establishment

Largest pen configuration – Scenarios 1a, 1b

Source: NZIER

3.5. Operations and maintenance

We obtained salmon farm operations and maintenance costs from industry sources, usually in a cost per hectare farmed or per greenweight tonne of fish produced. With slight adjustment, these have been applied to the farms in each of the scenarios, with labour separated out as a distinct item because of its dual role as a cost to the farm enterprise but a benefit to the region as a source of incomes.

On farm operating costs comprise cost of labour (per hectare), cost of feed (as per Table 1 feed inputs) and other costs (per greenweight tonne produced).

Similar estimates are made of the cost of processing salmon, with labour as a separate cost item based on a cost per greenweight tonne processed.

3.6. Sales volumes and prices

Currently farmed salmon in New Zealand is divided roughly equally between exports and domestic market sales through retail outlets and the restaurant and hotel trade. But there is a strong export market for King Salmon that would easily absorb additional production.

Currently exported salmon yield a higher return than domestic market sales, averaging around $12,300 per greenweight tonne compared to $11,000 per greenweight tonne on the domestic market. We use these values in our central results, and $15,000 per tonne exported in the more optimistic scenario modelling.

We make a conservative assumption that under all scenarios the first 2000 tonnes of additional production from Port Pegasus will be sold on the domestic market and the balance will be exported. No salmon is exported in the early years of scenarios where production is less than 2000 tonnes. We also model more optimistic scenarios where all Port Pegasus production is exported.

Invercargill has limited air service connections for airfreighting exports so we assume most export produce will be transported in refrigerated trucks to Dunedin or Christchurch to make connections with their more frequent air freight services.

4. Strategic Case

The Strategic case for establishing Port Pegasus Salmon Farming rests on the contribution it can make to achieving changes aligned to national and regional long term objectives and strategic direction. The scenarios described have strategic relevance at several levels, including:

- Meeting the economic diversity, employment and population aims of the Southland Regional Development Strategy
- Creating opportunities aligned to the Government's Business Growth Agenda, export targets and regional development objectives
- Supporting the growth aims of the New Zealand aquaculture sector
- Increasing the diversity of the local or regional economy
- Changing the risk profile for the economy through diversity and using resources in a way complementary to other activities
- Overcoming constraints and dependencies in the current state of development.

4.1. Southland Regional Development Strategy

The 2014 Southland Regional Development Strategy identified issues of a population ageing and dwindling in the face of less labour intensive rural industries (due to improved labour productivity) and the threat of major business disruption (should the aluminium smelter cease operations).

Southland's working age population is insufficient to meet current job needs, so attracting and retaining more people would contribute to economic growth, vibrant communities and a better lifestyle with improved health, education and social services in Southland. The Strategy in 2014 set a target of attracting 10,000 more people by 2025, with a need for more job opportunities to increase the diversity and resilience of the economy to fluctuations and shocks.

Establishing salmon farming at Port Pegasus and additional processing capacity on the mainland would contribute job opportunities and incomes for people at a range of skill levels. It would attract some skilled people from outside the region but also increase the diversity of jobs for those already there, helping to retain them and retrain them for an industry with local growth potential.

One shock to the economy was the recent discovery of *Bonamia Ostreae* infection of the flat oyster farms in Stewart Island, which has led to the removal of farmed oysters as a precaution against it spreading to wild oyster stocks and the Bluff dredge fishery. This will impact on the lives and livelihoods of people in Stewart Island, strengthening the strategic advantage of establishing new enterprises that can generate employment and new business in and around the Island's community.

4.2. Government's Business Growth Agenda

Government's Business Growth Agenda recognises New Zealand's abundant natural resources are central to economic prospects, especially in non-urban regions. The Agenda specifically identifies realising greater value from freshwater, marine and aquaculture resources.

It also seeks to improve the productivity of resource-related industries while reducing their environmental impact to help create a more productive and competitive economy – adding diversity and resilience against changing world demands.

The Business Growth Agenda also stresses building export markets and earning a premium from New Zealand's natural resources. Utilising coastal resources in Southland for producing salmon for export would meet many of these aims. The Port Pegasus proposal would also be an innovative use of new poly-circle technology in New Zealand

4.3. Aquaculture strategy

An Aquaculture Strategy has been developed by Aquaculture New Zealand and Seafood New Zealand with the aims of expanding aquaculture and supporting New Zealand's reputation as a source of high quality produce. The Government through the Ministry for Primary Industries supports the aquaculture strategy goal of raising annual sales to $1 billion by 2025.

Aquaculture has become one of the fastest expanding agricultural industries in the world.[5] Currently, the aquaculture industry in New Zealand as a whole contributes $584 million to New Zealand's GDP, with $172 million generated from marine farming production and $412 million from aquaculture processing.

Around 12,000-14,000 tonnes of salmon are produced in New Zealand annually, including around 3,500 tonnes in Big Glory Bay on Stewart Island. The output from the smallest of the Port Pegasus scenarios would increase Stewart Island production by about 80%; output from the largest would raise New Zealand's total production by 55%.

Aquaculture's contribution to the economy depends on continued access to the marine environment, on the area allocated to marine farming production and the ability to add value through higher return species.

Aquaculture contributes to the social and economic fabric in the communities of Southland where most sector employees live and work. Port Pegasus Salmon farming would add to this by:

- Creating valuable outputs, based on the natural resources of the marine environment
- Delivering a significant share of national aquaculture production
- Generating export revenue
- Contributing to Southland's GDP

[5] FAO (2016) 'Fisheries and aquaculture resources', http://www.fao.org/fishery/resources/en.

- Providing wages and jobs for a share of Southland’s total employment
- Providing inputs to aquaculture processing inside and outside Southland
- Creating opportunities for iwi involvement through allocation of new aquaculture space, supporting community wellbeing and development
- Creating opportunities for New Zealand owned and operated companies that support the sector e.g. ropes, floats, seed-stocking and transport, and diversification options for sub sectors including recreational charter fishing and culinary tourism that can benefit from aquaculture in the region.

A viable salmon farm with modern, environmentally benign techniques would add to the incomes and wealth of Southland region, supporting its vibrancy and attraction as a place to live and do business to people from outside the region.

5. Economic Case

An economic assessment under an indicative business case may take one of two forms. One is a cost benefit analysis (CBA), which estimates whether the stream of benefits from the project exceeds its costs and yields a positive net return from the perspective of the economy at large. This is essentially an investment appraisal with results expressed as a net present value of benefits over a period of years, and sometimes as alternative measures such as the benefit cost ratio or internal rate of return.

The alternative assessment is an economic impact analysis (EIA) which measures how the project stimulates other business in the economy (e.g. for suppliers of services to the project, and from extra spending for those receiving income from the project). This indicates the distribution of impacts across the economy but says little about the return on investment.

Our assessment combines elements of both. It provides a CBA to establish at a high level the likely viability of salmon farming in Port Pegasus – whether and by how much a salmon farm would produce valuable produce to exceed its costs. We supplement this with a partial examination of impacts of the project on value added, GDP and employment.

Components of cost benefit analysis

The CBA considers the salmon farm as a new enterprise and compares the additional costs incurred to establish and operate it against the additional benefits from its production. Costs and benefits are projected in constant dollar terms over a 25 year period and discounted to present values, using Treasury's default rate for national assessments of 6%, and variants of 4% and 8%.

Costs and benefits are all valued in monetary terms, but an economic CBA is not a financial analysis. The CBA compares benefits against the community-wide average opportunity costs of resources used to achieve them, taking a perspective broader than single agencies or entities to examine the extent of positive social return from the costs incurred.

In Port Pegasus salmon farming, while most of the effects pertain to the salmon farm operator and developer, the perspective is that of the Southland economy and other factors (like environmental effects) can be taken into account if they can be quantified.

In this analysis we assume that adverse environmental effects will be avoided, remedied or mitigated through the consenting process, but we provide some qualitative comment about such effects in the interpretation of results.

An economic CBA is focused on the size of net benefits rather than the distribution of who gets what out of the project. Effects that simply transfer wealth between members of the community do not count in CBA, in particular tax, which is just a claim on the economic surplus rather than something that affects the overall size of that surplus.

This contrasts with a financial analysis which usually takes the perspective of particular agencies or entities, reflects their individual financial capacity and needs for cash flows, and focuses on an after-tax return. We discuss some implications for financial analysis in section 6 of this report.

Components of economic impact analysis

Economic impact analyses commonly examine how a project injects funds into an economy to stimulate spending, incomes and jobs. They are particularly employed where there is a large initial injection of spending on infrastructure or equipment which causes a flow of smaller stimulation and business into the future.

That is less suited to this situation, where much of the initial capital cost is likely to entail imports of equipment with limited stimulation of further business. The principal impact of a new salmon farm will be from its harnessing of natural resources to create products of value, and the stimulation of business and incomes arising from that value stream.

For this analysis we have drawn information from the CBA and our in-house regional model of the New Zealand economy to examine how the new spending on a salmon farm would translate to impacts on Southland's regional GDP. This model is based on economic accounting principles which include indirect taxes that are embedded in market prices.

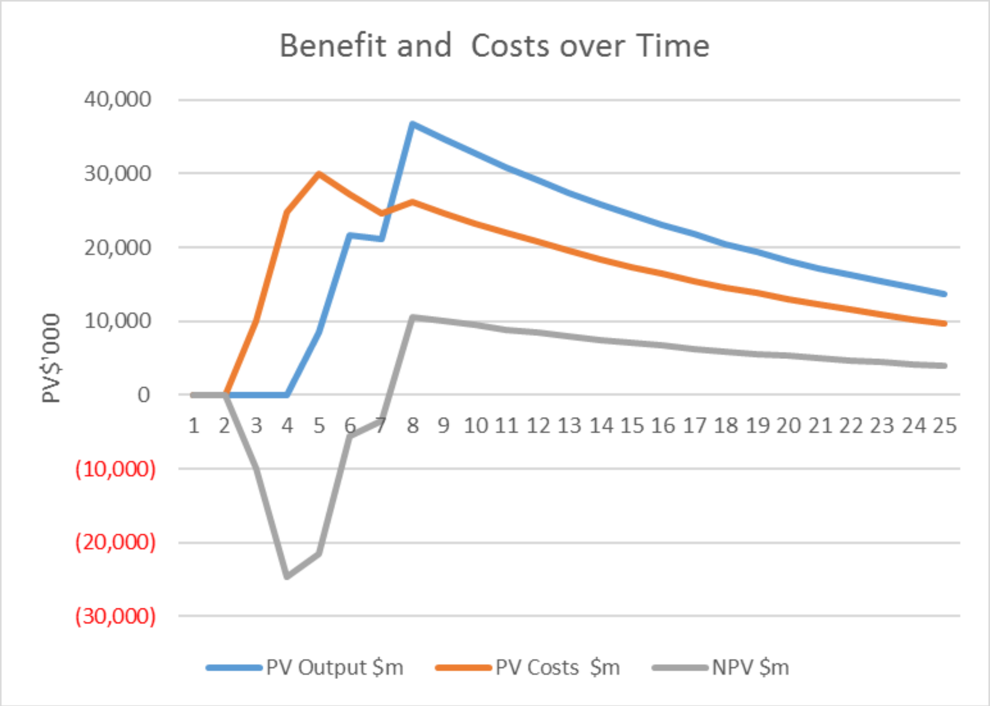
We present results for GDP (including those taxes) and value added (excluding those taxes) for comparison purposes. The national production accounts are compiled with indirect taxes embedded in market prices which can be removed, but before deduction of direct taxes on incomes and company profits.

5.1. Profile of salmon farm impacts

Figure 5 outlines the profile of benefits and costs over time, using the example of scenario 3b – 4,971 tonnes annual production, which is the scenario closest to the mean annual output of all eight scenarios modelled here. All scenarios have similar profiles, although the levels of the graphed lines differ between them.

Figure 5 Benefit and cost profile – Scenario 3b (4,971 tonnes/year)

Discounted over 25 years



Source: NZIER

The high initial establishment costs are staged so that annual costs in the early years are not much different from the annual operating costs thereafter. Once production starts in year 5 it rapidly climbs to a present value peak in year 8, after which the operation yields a net benefit. Discounting drives the decline in present value of costs, benefits and net benefits over time after this peak.

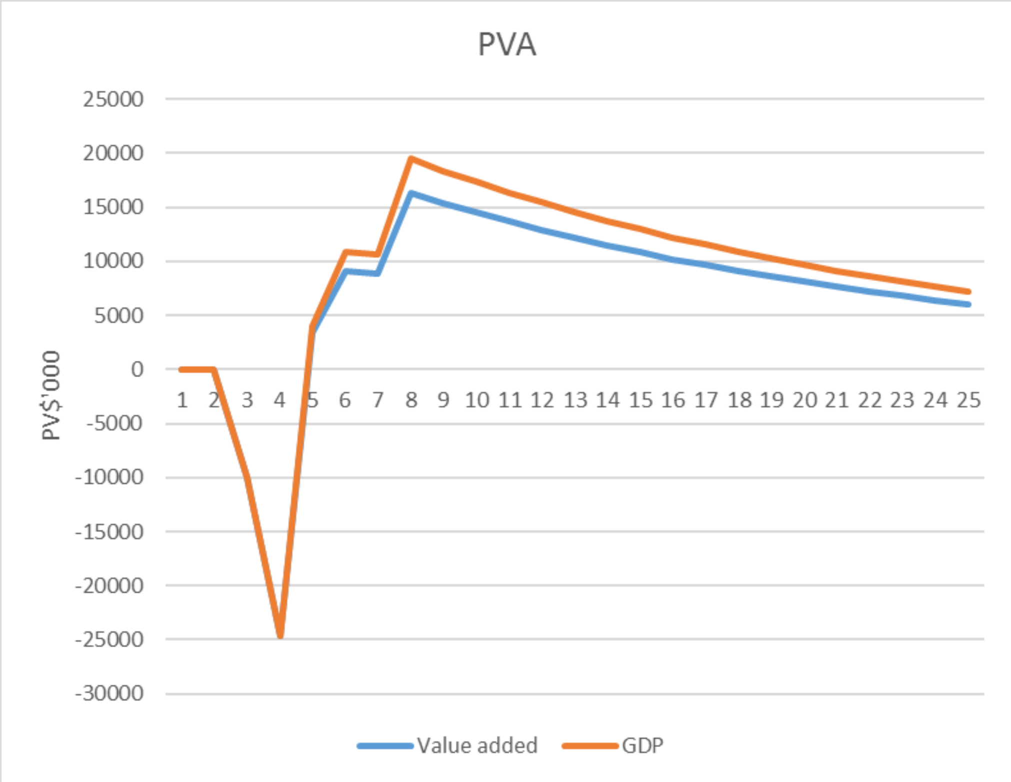
In this scenario 3b the *cumulative* net present value turns positive from year 15. In the highest output scenario, 1b (8,000 tonnes), that point occurs earlier in year 11, whereas for the lowest output scenario 1d (2,801 tonnes) it occurs later in year 22.

The corresponding GDP and value added impact profiles for scenario 3b are presented in Figure 6. In the early establishment years spending precedes production so there is a dip in value added and GDP, but these become positive once production ramps up from year 5. GDP would peak in year 8 with a present value of $19.5 million with value added of about $16.3 million.

The difference between GDP and value added is the value of indirect taxes embedded in prices, such as excise taxes. These are not retained in the Southland region, so value added might be regarded as a better measure of regional impact.

Figure 6 Present Value Added – Scenario 3

Discounted over 25 years at 6% real



Source: NZIER

By way of comparison, the highest output scenario modelled here, (1b, 8,000 tonnes per year) would have GDP peaking in year 8 at around $33 million and value added of about $27 million.

The smallest output scenario (4a, 2,801 tonnes per year) would have GDP peaking in year 8 at around $10 million and value added at $8.4 million.

5.2. Analysis results

This section presents results of the analysis of the project scenarios described in Section 3 above.

5.2.1. Results for low output scenarios

The results of the central assumption set for the four low output scenarios (1a-4a) are summarised in Table 2.

The table shows all scenarios are net beneficial, achieving a benefit cost ratio greater than 1. But they are not strongly net beneficial, and scenario 4a is borderline.

Generally, they become more net beneficial the larger their production, with the highest net benefit applying to the 6,000 tonne output level. But 3a is an exception, having higher NPV than that of 2a, because of the assumption it avoids the capital cost of new processing capacity.

This reflects economies of scale and greater utilisation of salmon farm equipment and vessels – which are mostly fixed at the same level for all scenarios – with larger output tonnages.

Table 2 Central results – low output scenarios

Present values over 25 years from present

Scenario		1a	2a	3a	4a
Targeted annual output - tonnes		**6,000**	**4,478**	**3,728**	**2,801**
Discount rate		**6.0%**	**6.0%**	**6.0%**	**6.0%**
25 year Benefits	PV$m	591.2	435.5	358.5	264.8
25 year Costs	PV$m	526.1	406.7	325.1	254.6
25 year Net Benefits	**PV$m**	**65.1**	**28.8**	**33.4**	**10.2**
Benefit:Cost Ratio		**1.12**	**1.07**	**1.10**	**1.04**
25 year Value Added	**PV$m**	**226.3**	**154.8**	**131.4**	**88.6**
25 year GDP	**PV$m**	**278.0**	**192.2**	**161.7**	**110.4**
25 year V A (undiscounted)	$m	550.9	387.6	322.1	223.7
25 year GDP (undiscounted)	$m	668.2	472.4	390.9	273.0
Full Time Equivalent (Years)		**5,634**	**4,102**	**3,373**	**2,527**
Annual Average FTE Total[6]		217	158	130	97
Annual average GDP	$m	21	15	12	9

Source: NZIER

These scenarios create new full time equivalent jobs rising from 97 per year on average for the 2,801 tonne farm up to 217 per year on the 6,000 tonne farm.

The contribution to regional GDP would range from $9 million per year at current prices for the 2,801 tonne farm to $21 million per year from the 6,000 tonne farm.

5.2.2. Results for high output scenarios

Table 3 shows the corresponding results for the four high output scenarios (1b-4b). Again, all the results are positive and increase with larger tonnages of production.

The annual production per hectare of farm space for the higher output "b" scenarios is higher than from the lower output "a" scenarios (see Table 1 above).

[6] These are direct full time equivalents employed, derived from a FTE per farmed area for on-farm employment and FTE per greenweight tonne for processing employment.

Table 3 Central results – high output scenarios

Present values over 25 years from present

Scenario		1b	2b	3b	4b
Targeted annual output - tonnes		**8,000**	**5,971**	**4,971**	**3,735**
Discount rate		**6.0%**	**6.0%**	**6.0%**	**6.0%**
25 year Benefits	PV$m	795.9	588.3	485.7	359.6
25 year Costs	PV$m	650.8	499.7	425.6	312.8
25 year Net Benefits	**PV$m**	**145.2**	**88.6**	**60.1**	**46.8**
Benefit:Cost Ratio		**1.22**	**1.18**	**1.14**	**1.15**
25 year Value Added	**PV$m**	**322.3**	**226.5**	**179.2**	**132.6**
25 year GDP	**PV$m**	**392.9**	**277.9**	**221.2**	**163.0**
25 year V A (undiscounted)	$m	768.1	549.7	442.0	324.0
25 year GDP (undiscounted)	$m	928.0	666.4	537.3	393.0
Full Time Equivalent (Years)		**6,199**	**4,524**	**3,725**	**2,791**
Annual Average FTE Total		238	174	143	107
Annual average GDP	$m	30	21	17	12

Source: NZIER

Regarding economic impacts, the table shows the higher output scenarios create more FTE jobs, ranging from 107 with the 3,735 tonnes output to 238 with the 8,000 tonnes output.

The impact on GDP contribution ranges from about 41% larger to nearly 48% larger than the corresponding low output scenario: for instance, the annual average increase in GDP under scenario 1b is 41% larger than that under scenario 1a; scenario 2b is 45% larger than 1b; 3b is 36% larger than 3a; and 4b is 48% larger than 4a.

The apparent anomaly of 3b's proportionate margin being a smaller than those of 2b and 4b is due to the assumption that 3a's output could be processed in existing facilities and does not incur the capital cost of new processing facilities whereas 3b does, which means that 3b's value added is a proportionately smaller share of the value of its output than is the case with 3a. If that assumption is changed so 3a *does* incur the capital cost of new processing capacity, 3b's GDP becomes 47% larger than that of 3a.

5.2.3. Results for higher price scenarios

Table 4 shows the results of optimistic assumptions in which all salmon output is exported and realises a higher value of $15,000 per tonne greenweight equivalent. This lifts the average GDP and net benefits and raises the BCR to around 1.4-1.6.

The table shows just the scenarios with largest and smallest outputs across the a and b groupings to indicate the range of impacts from the optimistic assumptions.

The benefit cost ratios of 1b and 4b exceed 1.5 under these assumptions, but those of 1a and 1b are just under 1.5. The benefit cost ratio of 4a exceeds that of 1a because its costs are lower due to the assumption 4a does not need new processing capacity.

Table 4 Optimistic results – all exports at higher prices

Present values over 25 years from present: Salmon all exported at $15,000/greenweight tonne

Scenario		1a	4a	1b	4b
Targeted annual output - tonnes		**6,000**	**2,801**	**8,000**	**3,735**
Discount rate		**6.0%**	**6.0%**	**6.0%**	**6.0%**
25 year Benefits	PV$m	760.7	378.9	1,014.3	473.8
25 year Costs	PV$m	526.1	254.6	650.8	312.8
25 year Net Benefits	**PV$m**	**234.6**	**124.2**	**363.5**	**161.0**
Benefit:Cost Ratio		**1.45**	**1.49**	**1.56**	**1.51**
25 year Value Added	**PV$m**	**409.2**	**211.8**	**558.0**	**256.0**
25 year GDP	**PV$m**	**496.9**	**257.8**	**674.9**	**310.6**
25 year V A (undiscounted)	$m	950.1	472.5	1,282.2	593.3
25 year GDP (undiscounted)	$m	1,145.9	570.6	1,543.2	715.2
Full Time Equivalent (Years)		**5,634**	**2,527**	**6,199**	**2,791**
Annual Average FTE Total		217	97	238	107
Annual average GDP	$m	37	18	49	23

Source: NZIER

To put these GDP estimates in perspective, the largest output of 8,000 tonnes under the optimistic scenario results in additional GDP equivalent to 0.9% of Southland's total regional GDP of about $5.5 billion, while the 2,801 tonne scenario adds just 0.3% to GDP.

Under the central (non-optimistic) assumptions the GDP shares are in the range of 0.2% (4a, 2,801 tonnes) to 0.5% (1b, 8,000 tonnes).

5.2.4. Sensitivity analysis results

Table 5 shows the effects of changing discount rates, using the example of scenario 3b (4,971 tonnes) under central assumptions. A lower discount rate increases the net present value and benefit cost ratio; a higher discount rate has the opposite effect.

The overall effect is not great, as the time profile of costs and benefit of all scenarios is much the same. Labour and undiscounted value added and GDP are not affected by discount rates.

Table 5 Effects of changing discount rates

Present values over 25 years from present

Scenario	3b	3b	3b
Discount rate	**4.0%**	**6.0%**	**8.0%**
Benefits PV$m	642.0	485.7	373.7
Costs PV$m	544.6	425.6	339.0
Net Benefits PV$m	**97.4**	**60.1**	**34.6**
Benefit:Cost Ratio	**1.18**	**1.14**	**1.10**
Value Added PV$m	**245.7**	**179.2**	**132.0**
GDP PV$m	**301.3**	**221.2**	**164.3**

Source: NZIER

Table 6 shows the effect of break-even analysis identifying how much costs and benefits would need to change to achieve net benefits of zero and a benefit cost ratio of 1 (i.e. present value of benefits just equals the present value of costs).

The higher output "b" scenarios have more leeway for output to vary while still breaking even than the low output "a" scenarios. This is accentuated by each output level facing the same configuration of pens and boats and the same capital costs.

Table 6 Break-even analysis

Present values over 25 years from present

Scenario	1a	4a	1b	4b
Discount rate	**6.0%**	**6.0%**	**6.0%**	**6.0%**
Benefits PV$m	424.9	238.5	425.3	238.4
Costs PV$m	424.8	238.5	425.1	238.4
Net Benefits PV$m	**0.0**	**0.0**	**0.2**	**0.0**
Benefit:Cost Ratio	**1.00**	**1.00**	**1.00**	**1.00**
Value Added PV$m	**148.2**	**76.5**	**148.4**	**76.4**
GDP PV$m	**184.6**	**95.8**	**184.9**	**95.8**
Value Added (undiscounted) $m	374.3	195.9	374.8	195.8
GDP (undiscounted) $m	457.0	239.8	457.5	239.6

Source: NZIER

Table 7 summarises for each scenario how much the value of costs or benefits would need to change for the analysis to break even.

Table 7 Change in cost or benefit values at which break-even occurs

Central assumption set, 6% discount rate

Scenario	1a	2a	3a	4a	1b	2b	3b	4b
Costs increase by	12%	7%	10%	4%	22%	18%	14%	15%
Benefits reduce by	11%	7%	9%	4%	18%	15%	12%	13%

Source: NZIER

An alternative way of looking at break-even, Table 8 illustrates the production tonnage at which each scenario produces benefits just equal to its costs. This shows that the larger output "b" scenarios have a larger buffer to lose before benefits just break-even with costs; conversely, "a" scenarios with lower output have limited leeway and could be susceptible to fluctuations in output caused by environmental variation or enhanced mortality.

Table 8 Reduction in output tonnages at which break even occurs

Central assumption set

Scenario	1a	2a	3a	4a	1b	2b	3b	4b
Break-even tonnage	4,370	3,759	3,461	2,541	4,374	3,750	3,465	2,541
Reduction from target	27%	16%	7%	9%	45%	37%	30%	32%
Direct FTE per year	199	150	127	94	199	150	127	94
Average annual GDP $m	14	12	11	8	14	12	11	8

Source: NZIER

5.3. Interpretation

On the information available, the analysis above shows the proposed salmon farm would have moderately positive results.

The benefit cost ratios indicate the "headroom" in results and how much benefits and costs could change from those assumed in this analysis without overturning the result. A benefit cost ratio greater than one is sufficient to indicate net benefits, but a larger ratio is preferable to cover the risk that costs and benefits or their timing differ from what is assumed. Some of the smaller output tonnage scenarios have ratios so small as to be susceptible of being overturned with small changes in input data.

These results should be regarded as indicative, preliminary and subject to change should improved information become available. In particular:

- While the analysis identifies results with larger output tonnages are more robust, it does not give conclusive findings on the relative performance of different pen sizes because of the way the scenarios are structured: the pen configurations are the same for the low and higher output levels, so pen sizes and costs are not optimally aligned to the production level.
- Similarly, the smaller output scenarios may be more fragile because a lot of the capital costs of vessels and processing are the same regardless of

intensity of use and size of output: if these costs are more variable with scale the performance of the smaller output scenarios could improve.

- There are some uncertainties around whether the inputs and assumptions used reflect the costs that would eventuate in practice: use of a well-boat is a new technology in New Zealand so its operational costs in an open coastal setting like Stewart Island are not known with precision.
- There is some upside to the analysis if salmon prices or the proportion exported are higher than in the central assumptions. Table 4 shows more positive results from all fish being exported at higher prices.
- There is also downside risk of biosecurity incursion or disease reducing net benefits which could have significant impact, in disrupting production and closing access to premium markets; the risk of this is unknown.

The impact results show a positive contribution to regional GDP and jobs. GDP would rise if the value of output increased but the number of jobs would not change as employment is not modelled as proportional to value of output, but to its *volume* (for processing employment) or farmed area.

Most of the new employment would be created in processing, which logistically is likely to be located at Bluff and attract workers from the mainland rather than Stewart Island. The marine farm crew could also be serviced directly from Bluff, but there may be some jobs for Stewart Islanders in supporting services for salmon farming, building on those at the Big Glory Bay farm.

It is possible that other configurations of pens could strengthen the results. For instance, if farms with smaller output tonnages needed only three clusters of pens and feeding vessels – as might be the case if the farm was developed in stages, with large scale operation deferred until the smaller scale had been proven - they would save some capital costs in achieving their outputs and improve their results.

A CBA can take account of environmental effects, such as concentration of food residues and fish wastes on the sea-bed, impacts on water quality, wildlife and visual amenity, and obstruction of navigation and recreation. There can be tangible economic costs if a new development displaces or encroaches on other activities so that they incur extra cost in continuing (e.g. increased travel cost in relocating recreation) and intangible economic cost if the development reduces some scarce environmental quality which is difficult to replicate elsewhere.

Such effects are difficult to quantify in economic terms, but the consenting process can assess them and place conditions to ameliorate them, internalising them in the design and costs of the development. We assume this is incorporated in our costs of pens and structures which are higher than a conventional compact pen farm, and our operating cost information includes an “average” cost of mitigation measures.

The scenarios examined here incur opportunity cost in constraining output for the benefit of meeting standards for deposition on the sea-bed, and in relocating grow pens further from the shore. The implication is that the preservation of sea-bed and the natural character of coast is worth at least as much to the community as the forgone value of greater production that may be possible without environmental constraints.

6. Implications for Commercial, Financial and Management cases

Economic analysis is principally required for the Economic case, but it can also be informative for the Strategic, Commercial, Financial and Management cases. This Indicative Business Case provides only an initial assessment of Commercial, Financial and Management cases which are usually refined as the project is fine-tuned after the Economic case has been established.

6.1. Commercial case

The Commercial case in an Indicative Business Case considers the proposed way forward from the options established in the Economic case, with further examination of its commercial viability and resilience to changes in production and prices that might arise, and whether there are barriers that could be overcome to move the project forward.

The Economic case has identified the Port Pegasus salmon farm scenarios are mostly net beneficial, but not strongly so. Some of this may be down to the "indicative" nature of assumptions used, which may be refined and improved upon.

For instance, many of the vessel and factory costs are common for all scenarios, so they weigh more heavily on the smaller output tonnages: they would look more net beneficial if some of these costs were unnecessary for smaller operations, or the new marine farm could rely on hiring resources at marginal cost when needed rather than incurring the full capital and operational cost of owning and maintaining them.

The Economic case assumes a stand-alone salmon farming and processing operation and is neutral on who actually owns and operates them. For the Commercial case the potential synergies and joint operations with existing facilities becomes more relevant, as entities with spare capacity may be able to meet some parts of the operational requirements at lower cost than those assumed in the economic analysis.

For instance, there may be advantages that Sanford could bring to Port Pegasus in view of its experience with Big Glory Bay salmon farming and its salmon processing plant at Bluff. There might be other fishing operators or iwi interests who see opportunities for synergies between their current operations and parts of the Port Pegasus marine farming operation.

A Commercial case needs to look beyond the high level economic analysis to consider the steps in the marine farm and processing operation, whether these steps need to be undertaken by the farm operator or outsourced to contractors, and outline a practical plan of components that can be offered for commercial uptake. This is beyond the scope of this current report.

6.2. Financial case

The Financial case in an Indicative Business Case examines the affordability of the proposal for the contributing parties, considering variations in cost spreading across different contributors to the project and across different generations that can benefit from it.

It builds on the Commercial case to examine the effects on each of the contributing parties, the return they can expect to obtain from their involvement and whether there are any temporary issues or risks to the project that would be "mission critical" to their involvement.

Whereas the economic analysis is focused on broad level indication of whether the benefits of the project exceed the opportunity cost of resources used in it, the financial analysis needs more detailed consideration of when costs are incurred and who bears them.

As private companies are interested in after-tax returns, tax implications are relevant to a financial analysis and cover all forms: the company and income tax liabilities of all the entities involved, the indirect tax liabilities (such as GST), specialised tax instruments such as rental payments for occupying the sea-bed (if any).

Side calculations of company and income tax could be made from the economic analysis, but these are unlikely to reflect the opportunities in tax law to shift liability between years or avoid parts of it through use of depreciation allowances and other deductible measures.

A financial analysis can also consider how best to pay for the project, through a mix of reserve drawdowns and borrowings through a range of instruments, including loans, bonds and equity shares. It might also consider changes in the timing of some investments from those in the economic case, which has a profile of establishment of marine farm, vessels and processing capacity that might be capable of being stretched out over a longer period to deal with the risks of early operation before the larger commitment.

The financial implications of such options and their implications for affordability are beyond the scope of this report.

6.3. Management case

The Management case in an Indicative Business Case examines the achievability of the project, the management capability needed to implement it and the governance structure required to oversee, monitor and control its successful implementation. It requires identifying the characteristics and capabilities of organisation to implement the project and oversee its successful operation.

The Economic case has little to say about the management case beyond indicating the scale of likely operation at the Port Pegasus salmon farm. The Economic case suggests that the cost structure of the circular pen farms and the vessels used with it favour larger output farms over the smaller output farms. The Management case would therefore need to identify the best options for large farm structures, but this is beyond the scope of this report.

7. Conclusions

This report follows the Treasury's Indicative Business Case framework to assess the proposed establishment of salmon farming at Port Pegasus on Stewart Island, with associated processing at Bluff.

It compares eight scenarios provided by the Ministry for Primary Industries covering different options for a salmon farm in respect of the targeted tonnage of output and the configuration of pens for growing the salmon.

All these options use an innovative farming method of circular pens tethered to a feed control vessel which is anchored to the sea-bed with no land infrastructure on the adjacent coast. This has been chosen as it has lower environmental impact and visual intrusion in an area flanked by conservation land. The options considered here have reduced feed inputs and fish output to lower the impact on the sea-bed.

The Strategic case for development of salmon farming in Port Pegasus rests on its contribution to the strategic aims of:

- Southland Regional Development Strategy's aims of diversifying its economy and attracting more people
- Government's Business Growth Agenda aims to strengthen exports and support regional development through improved use of natural resources
- The Aquaculture industry's aims to raise sales to $1 billion by 2025.

The Economic case examines the viability of the different options for the proposed salmon farm and their impacts on direct employment and regional GDP. This finds:

- All scenarios look moderately positive on the figures and assumptions we use. Benefit cost ratios are greater than one but not greater than 2, with most in the range of 1.1 to 1.2 under the central assumptions
- The performance of salmon farming improves with larger output tonnages
- A new marine farm would employ in farming and processing between 97 and 238 full time equivalents and add 0.2% to 0.5% to Southland's GDP (peaking in year 8) under our central scenarios, depending on size of output; or up to 0.9% under more optimistic assumptions
- Uncertainties remain around some of the cost items in the analysis which can be improved on with industry expert assistance.

The positive economic result indicated could be improved with more detailed assessment to resolve some of the uncertainties in the analysis. Computable General Equilibrium modelling of selected scenarios could also broaden the impact analysis to examine the indirect flow-on effects through the economy.

The commercial, financial and management cases need to look beyond the high level economic analysis to consider the steps in establishing, managing and financing a new marine farm and processing operation.

The latest changes to farm configuration and location to reduce environment impacts have constrained the production of the salmon farm and reduced its potential contribution to economic and strategic aims. These contributions would increase with larger production than is currently provided by the current configuration.

Appendix A Assumptions behind central results

Table 9 Key assumptions behind central results

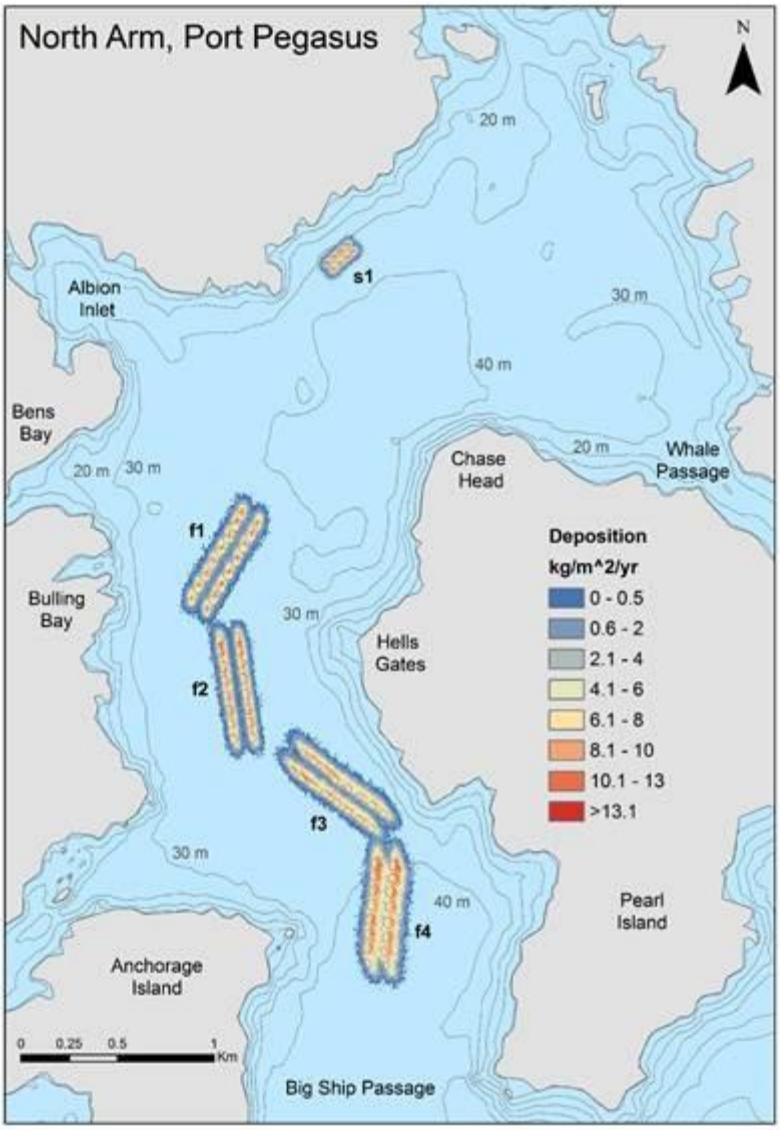
Item	Value
Salmon price	
Domestic $/greenweight tonne	$ 11,000
Export $/greenweight tonne	$ 12,300
Tonnes sold to domestic market	2,000
Labour average salaries/wages	
On farm $/year	41,360
Off farm $/year	38,200
Marine Farm FTE/ha	14.7
Oslo-Auckland freight rates	
20 foot container…..$/unit	1,584
40 foot container $/unit	2,365

Source: NZIER

Appendix B Scenario setting

B.1 Selection of potential farm areas:

Figure 7 Location of pen clusters within Port Pegasus North Arm



Source: Cawthron Institute

Results of the benthic habitat assessment were used to prioritise potential locations for finfish farming operations within the Port Pegasus North Arm area. Circular exclusion 'buffers' were placed around areas of hard substrate or coarse-grained sediments (100 m radius) and areas containing potentially sensitive taxa (250 m radius), identified through sonar imagery and drop-camera transects. Larger exclusion zones were used for potentially sensitive taxa as their exact densities and distributions are unknown.

To provide additional guidance on suitable locations for potential farm sites, an Index of Suitable Location (ISL) for finfish farming was calculated for the entire North Arm area, based on depth and water current data. Results of the ISL analysis indicated that mid-channel areas in Big Ship Passage have the greatest potential for farming, when taking into account exclusion buffers and water depth.

Four potential farming (grow out) areas (c. 10 h each) were subsequently selected within Big Ship Passage (f1, f2, f3 & f4), along with a smaller smolt growing area (c. 1.3 h) at the northern coastline. The smolt farm location was selected as it provided some separation from grow-out areas, a feature that was requested during discussions with industry. A maximum of 16 x 160 m circumference pens (two rows of eight pens, c. 20 m spacing between pens) was considered at each of the four potential farming areas. A maximum of 8 x 100 m circumference pens (two rows of four pens, c. 15 m spacing between pens) was considered for the smolt growing area.

B.2 Depositional modelling and feed inputs:

As an indicator of likely finfish production capacity within the North Arm area, varying feed input and pen configuration scenarios (a, b, c & d) were modelled across the four farming areas using DEPOMOD v 2.2. Two sets of scenarios were modelled (1 & 2), based on the farming areas operating in a similar way to either low-flow or more dispersive (high-flow) sites within the Marlborough Sounds. This modelling was undertaken to test two different biophysical response regimes to varying feed inputs.

Maximum feed inputs per pen for each farm area were based on preliminary DEPOMOD assessments for a range of feed inputs for a single pen at each farm area (131 - 400 t). Feed inputs that resulted in maximum depositional rates of ~6 kg m^{-2} yr^{-1} at the net pen edge were used for DEPOMOD assessments for the low-flow farm scenarios. Feed inputs that resulted in maximum depositional rates of ~13 kg m^{-2} yr^{-1} at the net pen edge were used for DEPOMOD assessments for the high-flow farm scenarios. These levels of deposition are predicted to result in c. ES 5 conditions if the effects of the farm are similar to low-flow or high-flow farm sites in the Marlborough Sounds region, respectively.

A maximum of 64 grow-out pens (16 pens per area) across the four farm areas were assessed in the modelling, so maximum production was associated with all pens operating at all farms (Table 1). Scenarios with lower levels of production were achieved by reducing the number of pens at each of the farm areas. Across the two sets of scenarios (low-flow/high-flow), feed input per pen over a 1-year period varied depending on whether the effects of the farms were modelled as behaving like low-flow or high-flow sites.

As the total number of pens varied across scenarios, the total feed input at each farm area also varied. The feed inputs resulted in scenarios with a range of production levels at each site (~2,800 - 8,000 t production, per annum; Table 1). The likely production from each scenario was estimated using a feed conversion efficiency (FCE) ratio of 1.7:1.

For the smolt farm, a feed level of 5% of the total feed input across the four grow-out farms was used across the two sets of scenarios (238 - 680 t per annum; Table 1).

Smolt feed was spread evenly across 4, 6 or 8 smolt pens in each scenario, which resulted in feed inputs of 60 - 102 t per pen (per annum).

Table 10 Farm scenarios and parameters

Including feed input per pen (tonnes per annum), number of pens (160 m circumference for grow-out and 100 m circumference for smolt), total feed input and estimated production (tonnes per annum) for the four grow-out areas (f1-f4) and the smolt growing area (s1). The Feed Conversion Efficiency for all scenarios is 1.7 tonnes of feed per tonne of fish output

Scenario	Input parameters	Farming area				Grow-out	Smolt
		f1	f2	f3	f4	totals	totals
1a	Feed per pen (tonne)	**131**	**131**	**150**	**225**		64
	Number pens	16	16	16	16	64	8
	Total feed (tonne)	2100	2100	2400	3600	10200	510
	Total production (tonne)	1235	1235	1412	2118	6000	
2a	Feed per pen (tonne)	**131**	**131**	**150**	**225**		63
	Number pens	8	10	14	14	46	6
	Total feed (tonne)	1050	1312.5	2100	3150	7613	381
	Total production (tonne)	618	772	1235	1853	4478	
3a	Feed per pen (tonne)	**131**	**131**	**150**	**225**		79
	Number pens	6	8	12	12	38	4
	Total feed (tonne)	787.5	1050	1800	2700	6338	317
	Total production (tonne)	463	618	1059	1588	3728	
4a	Feed per pen (tonne)	**131**	**131**	**150**	**225**		60
	Number pens	4	6	8	10	28	4
	Total feed (tonne)	525	787.5	1200	2250	4763	238
	Total production (tonne)	309	463	706	1324	2801	
1b	Feed per pen (tonne)	**175**	**175**	**200**	**300**		85
	Number pens	16	16	16	16	64	8
	Total feed (tonne)	2800	2800	3200	4800	13600	680
	Total production (tonne)	1647	1647	1882	2824	8000	
2b	Feed per pen (tonne)	**175**	**175**	**200**	**300**		85
	Number pens	8	10	14	14	46	6
	Total feed (tonne)	1400	1750	2800	4200	10150	508
	Total production (tonne)	824	1029	1647	2471	5971	
3b	Feed per pen (tonne)	**175**	**175**	**200**	**300**		102
	Number pens	6	8	12	12	38	4
	Total feed (tonne)	1050	1400	2400	3600	8450	407
	Total production (tonne)	618	824	1412	2118	4971	
4b	Feed per pen (tonne)	**175**	**175**	**200**	**300**		79
	Number pens	4	6	8	10	28	4
	Total feed (tonne)	700	1050	1600	3000	6350	317
	Total production (tonne)	412	618	941	1765	3735	

Source: MPI