EnviroStrat
Impact Investment Project Development

New Zealand Trade and Enterprise

Open Ocean Finfish Aquaculture: Business Case

February 2020

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Executive Summary

Purpose

The purpose of this document is to provide information for potential investors and sponsors to make informed investment decisions and to understand Open Ocean Aquaculture (OOA) potential in New Zealand. It does this by assessing the attractiveness of the proposed investment from different dimensions, including an overview of the financial feasibility and an assessment of potential direct and in-direct economic benefits to the New Zealand economy to inform an overall view of the case for investment.

This report includes a financial model and economic analysis that provides projections for an OOA operation in New Zealand, including investment requirements, establishment timeframes, revenues and operating costs (including jobs created). The primary focus of the business case is open ocean farming of finfish with the key species being Chinook (King) Salmon. We have adopted a scenario approach tailored specifically for New Zealand that leverages sound international understanding and is underpinned by robust assumptions and commentary. The report also includes a high-level commentary regarding potential upside from farming other species relevant to the New Zealand context.

Overall Summary

Farmed salmon offers a very compelling environmental and human health story by comparison with other farming systems in New Zealand. Farmed salmon has a very low carbon footprint, low water use and low 'land use' from input of raw materials compared to all other animal farming systems. Farmed salmon are a very healthy choice for consumers offering significant health benefits over other animal protein sources. These two factors mean that there is and will continue to be a growing demand for farmed raised salmon for the foreseeable future.

Moving offshore is essential for the growth of the industry as this enables the capitalisation of opportunities associated with the open ocean environment. RAS systems are unlikely to be an effective solution in New Zealand as the cost of the systems will be high, and one of the offsetting costs is by locating these systems close to the market to reduce costs and time associated with moving fish to the end customer.

Growing fish in OOA systems is likely to have a significant payback in terms of fish health benefits (mostly associated with low temperature rearing), as well as creating greater scale in the sector. This type of approach would allow New Zealand to continue to claim more 'natural' farming rather than very high density on-land RAS systems, providing an advantage in competitive international markets.

Technologies being investigated include semi-closed systems to increase production in the existing sheltered coastal ribbon, land-based systems using RAS technology and offshore systems that can exploit much more energetic open ocean locations.

There are two main categories for offshore technologies. The first is more robust 'existing' net pen technology that can withstand greater wave action (up to H_s 6.0m). This type of system requires some shelter from genuine open ocean conditions and is still exposed to the same fish health challenges that farms in more sheltered locations experience. However, the capital cost is not excessive compared to existing technologies and the farmer benefits from economies of scale because each site is larger.

Second, the capital cost of emerging technologies that can operate in more exposed locations is much higher. For these to be successful they must offer a 'health benefit' that will offset the additional capital and operating costs associated with moving offshore. The economic performance of emerging technologies is not yet established. In parallel to the development of offshore technologies is the development of on land RAS production systems and coastal ribbon semi-closed systems. These systems may be used to reduce the production time in existing farms and/or to grow fish through to harvest size.

Semi-closed systems will have lower capital costs than offshore systems and RAS systems. They will have higher operating costs (especially energy costs and waste treatment costs) than traditional cage systems. But they will offer a significant health benefit for the fish that may off-set these costs.

The future for salmon farming is bright. Consumer demand for the product is high and the environmental case is strong. Farming systems need to change to accommodate the increasing demand as existing coastal water space is at or near capacity. It is likely that there will be a mix of the traditional (existing) farming systems, more exposed systems using more robust existing technology, genuine offshore farming technologies, semi-closed farming systems and RAS systems. At this stage what will emerge as the dominant production technology for the next 20 years is not clear. Over the next 5 years there will be significant progress made in all these different systems and much more robust information to determine what the shape of the industry will be.

New Zealand's competitive advantage is its natural marine environment. New Zealand is geographically isolated from the large salmon markets, so RAS systems will be a less attractive proposition in this region (unless it is to support more traditional farming systems by reducing the 'at sea' growing time). To take advantage of the marine environment, developing offshore technologies with more robust existing technology and with genuine offshore technology will be important and should get significant focus. This focus should address the technologies that are best suited in the New Zealand context and the regulatory framework to support the industry in these new farming areas.

The main conclusions from this work include:

- There is a severe shortage of salmon smolt and other finfish production facilities (lack of hatcheries for all species in general) in New Zealand; an increase to 264m smolt per annum is required to meet each additional 10,000t of production.
- Much of the equipment used for OOA is not currently made or available in New Zealand.
- There is no barrier to applying feed delivery systems to offshore farms.
- The technology used for growing smolts in New Zealand is old and inefficient (not state of the art). New (RAS) technology is available and widely used in the salmon farming industry overseas and would be suitable in the New Zealand context.
- There are limited locations in New Zealand's marine environment to establish new salmon farms, however Southland and Cook Strait are the most promising locations for future salmon OOA. The Ports of Bluff, Nelson and Picton are well suited to establishing a salmon farming and processing base to service OOA farms.
- The allocation of water space for salmon farming in the open ocean environment is an urgent pre-requisite.
- OOA, if developed in New Zealand, and particularly for salmon, in the South Island, would be profitable and of substantive regional economic benefit to the country.

Financial and Economic Summary

Financials

To calculate the cost of developing an OOA farm, NZTE assumed that each consent application, and subsequent development, will be undertaken to grow 10,000t of Chinook Salmon. It is assumed that the OOA farms developed will be completely independent of each other and will not rely on any existing aquaculture infrastructure that is privately owned. Each 10,000t operation requires approximately $188m of capex to set-up and the annual operating cost when fully operational equates to $124m excluding additional processing costs from transitioning into high value products. The annual revenue from such an operation is estimated to be $181m per annum when fully established.

The base case assumptions conservative resulted in an IRR of 12% and a payback period of 17 years. When more aggressive assumptions were applied (such as increased sale price growth) the IRR increased to 19% with a pay-back period of 14 years. The investment metrics and analysis, despite being at a high level, does suggest that open ocean aquaculture is a commercial opportunity that the private sector may be interested in. It is likely that the biggest commercial hurdle is the time it takes to set-up an open ocean operation. From the date of first investment it is estimated that it will take approximately 9 years before any revenue is generated and that is dependent on various assumptions that are highly unpredictable. As such, the risk profile associated with such an investment is very high. The financial analysis undertaken considered the performance of one consent application and the performance of multiple consent applications (which generated a view of the potential industry).

Economics

Using the base assumptions, the OOA industry will deliver a positive net position under low discount rates (up to 6%) with the net benefit position being $242m over 30 years. This is equal to an annual gain of $8.1m. The export revenue is substantial, with a present value of $8bn. The value of the employment benefit is estimated at $355m over 30 years. The Present Value of the costs (both capex and opex), is estimated at $8.1bn with the opex component accounting for 88% of the costs. Overall, establishing the OOA industry is expected to deliver benefits outweighing the costs, returning a Cost Benefit Ratio (CBR) of 1.03.

At the peak of the construction phase, the OOA will support over 3,900 construction jobs throughout New Zealand. The construction and set-up phase span several decades, ramping up from year five, with intermittent peaks every two/three years. It then tapers off after 2040. In contrast, the jobs supported by the ongoing activity, start in the second decade, increasing to 58,300 once operating at full capacity.

1 Introduction

1.1 Purpose of the Document

The purpose of this document is to provide information for potential investors and sponsors to make informed investment decisions and to understand OOA's potential in New Zealand. It does this by assessing the attractiveness of the proposed investment from different dimensions, including an overview of the financial feasibility and an assessment of potential direct and in-direct economic benefits to the New Zealand economy to inform an overall view of the case for investment.

For this report we have adopted a definition of OOA provided by NZTE: *"areas requiring upgraded technology (i.e. where the existing inshore or semi-exposed infrastructure becomes unsuitable)"* as well as *"the transfer between legislative boundaries (i.e. territorial sea / Exclusive Economic Zone)"* or, *"the next big step"*[1].

The intended audience for this report is New Zealand Trade and Enterprise (**NZTE**), the Ministry for Primary Industries (**MPI**), and commercial entities looking to explore OOA opportunities in New Zealand.

The document is structured to answer the following:

- What will future industry demand be for seafood produced in the open ocean? (Strategic Case)
- What are the pre-requisites and assumptions for open ocean aquaculture to occur in New Zealand? (Functional Requirements)
- Is open ocean aquaculture financially feasible in New Zealand? (The Financial Case)
- What are the expected economic costs and benefits? (The Economic Case)

This report includes a financial model and economic analysis that provides projections for an OOA operation in New Zealand, including investment requirements, establishment timeframes, revenues and operating costs (including jobs created). The primary focus of the business case is open ocean farming of finfish with the key species being Chinook (King) Salmon. We have adopted a scenario approach tailored specifically for New Zealand that leverages sound international understanding and is underpinned by robust assumptions and commentary. The report also includes a high-level commentary regarding potential upside from farming other species relevant to the New Zealand context.

1.2 Background

NZTE is seeking to understand the potential direct and indirect economic impact of the open ocean aquaculture industry in New Zealand, and its implications for potential investment. OOA is new to New Zealand and although the topic has been discussed at a high level by the aquaculture industry over recent years, there has been little work done attempting to quantify the potential benefits to New Zealand's economy[2].

This business case provides a financial and economic analysis of a hypothetical OOA sector located in New Zealand waters, and serves to provide expert advice to government and potential investors of the scale and key considerations that need to be taken into account when planning for a new offshore industry.

[1] Definitions provided by NZTE following consultation with Cawthron Institute.

[2] Based on relevant grey literature and personal communications with NZTE and MPI.

1.3 Strategic Case for OOA in New Zealand

1.3.1 Global Food Demand

As the global population increases and becomes more affluent, a large middle-class is emerging in countries like China and India. It is estimated that by 2030 Asia will represent 66% of the global middle-class population and 59% of middle-class consumption[3]. Increasing consumer awareness and connectivity to markets combined with greater middle-class wealth is driving demand for higher quality, healthy and sustainably produced food with a small environmental footprint. By 2027, per capita fish consumption is estimated to be 21.3 kg; an increase from 20.8kg in 2018[4] (see Figure 1). This is equivalent to another 23 million tonnes of seafood supply, much of which will come from aquaculture.

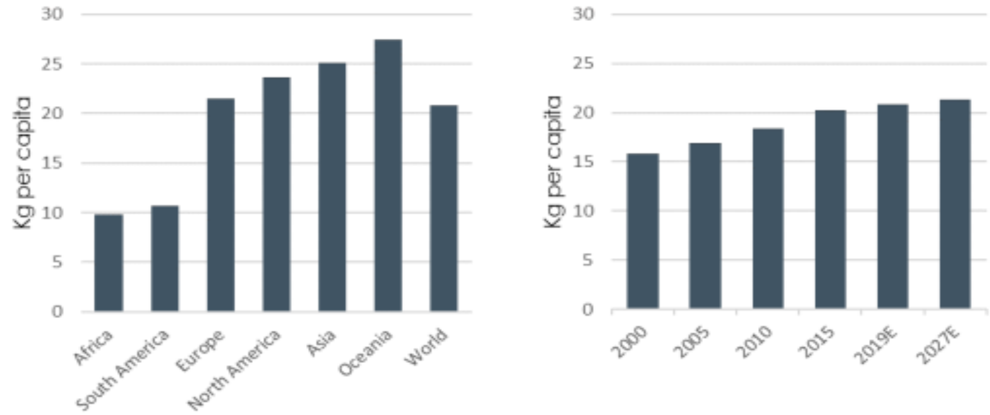

Figure 1. Fish consumption per continent 2019E (left). Development of global average fish consumption (right).

Source: The State of World Fisheries and Aquaculture OECD-FAO (2018).

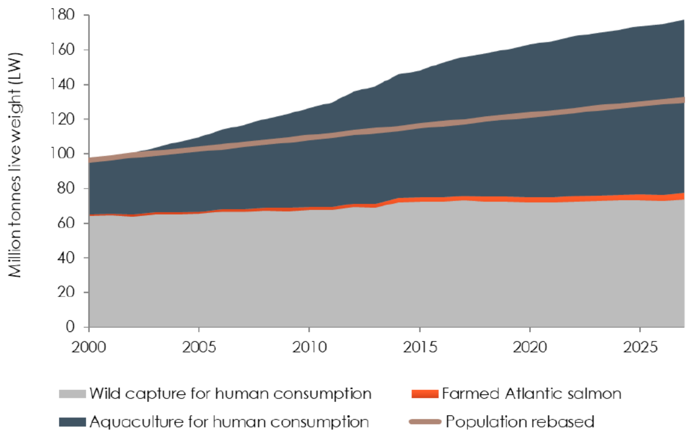

Figure 2. Estimated growth of aquaculture relative to wild caught seafood.

1.3.2 Premium Market Positioning of Salmon

Improved marine farming and feeding technology have seen the rapid expansion of profitable salmon farming on a global scale. The industry is now well respected for providing jobs in rural and coastal communities as well as a reliable source of high-quality seafood. The expansion of salmon farming internationally has been supported by a stable supply of salmon smolts, improved salmon nutrition and better fish health. Growing demand (driven by health-conscious consumers) in foreign markets (Asia in

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[3] http://oecdobserver.org/news/fullstory.php/aid/3681/An_emerging_middle_class.html

[4] FAO (2018); The State of World Fisheries and Aquaculture OECD-FAO (2018) Agricultural Outlook 2018-2027

particular) for high quality farmed salmon from New Zealand is currently outpacing our ability to supply product; local producers are no longer fully capable of servicing these markets.

The complex regulatory situation for sea cage farming has led to limited inshore water space consented for salmon farming activity in New Zealand. An acute shortage of hatchery produced juvenile salmon smolts and other finfish has historically been a significant constraint to the growth of the sector here. The industry in New Zealand is seeking to expand to take advantage of favourable prices and consistent market demand. On the supply side, a key competitive advantage for New Zealand producers is that few other places in the world produce Chinook Salmon; Chinook Salmon sells for a premium (compared with Atlantic Salmon) on global markets. In New Zealand, Chinook Salmon is primarily farmed in the marine environment in Marlborough, Southland and Akaroa Harbour. However, freshwater operations in Canterbury, Otago and Tasman utilise ponds, raceways and hydro canals for grow-out operations.

1.3.3 The New Zealand Aquaculture Strategy

The New Zealand Aquaculture Strategy[5] (the Strategy) published in September 2019 outlines a work programme over the next five years to enable the sector to reach the ambitious sales target of $3b per annum by 2035. Currently, the sector as a whole (including shellfish production) achieves $670m in annual sales despite having a strong year on year track record for growth. In order to expand the sector by another $2.4b by 2035, the Strategy identifies three key drivers that will enhance growth:

1. Maximising the value of existing farms through innovation.
2. Extending into high value land-based aquaculture.
3. Extending aquaculture into the open ocean.

Transformational change must occur within the sector if these drivers are to facilitate growth, this will include (but is not limited to) overcoming significant technological hurdles (especially to enable OOA), additional investment in R&D and commercialisation of the outputs of the R&D, building resilience to climate change, creating additional scale, a review of the regulatory environment, and locating new sources of investment.

Although growth is central to the Strategy, it also recognises aquaculture's benefit to the country as a primary sector with the potential to deliver high quality seafood products with relatively low environmental impact. The sustainability narrative applies to every aspect of the aquaculture value chain, and this is reflected strongly in the Strategy. It seeks to reduce the impacts of aquaculture on the environment while also reducing the industry's waste and emissions. New Zealand's well-managed aquaculture industry that incorporates strong sustainability elements is also highly aligned with the United Nations *Sustainable Development Goals*[6], and in particular, Goal 14: *'Life Below Water'*, which seeks to "conserve and sustainably use the oceans, seas and marine resources"[7]. Aquaculture's contribution to the economy depends on continued access to the marine environment, on the area allocated to marine farming production, the ability to add value through higher return species, and market demand. Considering that the social license for undertaking marine finfish farming in the nearshore coastal waters around New Zealand is near capacity, the future of fish farming in New Zealand waters is increasingly looking to be either in the open ocean or on land.

> ***"The growth pathway also sets objectives of a sustainable, resilient and inclusive aquaculture industry. This means aquaculture will lead in environmental practices across the value chain; be strong and protected from external risks of pests, disease and climate change; and work in collaboration with Māori and communities to realise meaningful jobs, wellbeing and prosperity"***
>
> – Hon. Stuart Nash, Minister of Fisheries.

[5] https://www.mpi.govt.nz/dmsdocument/15895-the-governments-aquaculture-strategy-to-2025
[6] https://www.un.org/sustainabledevelopment/sustainable-development-goals/
[7] https://www.un.org/sustainabledevelopment/oceans/

1.3.4 Open Ocean Aquaculture Solution?

Open ocean aquaculture has great potential to contribute to food security, livelihoods (both in the regions and main centres) and the economic growth of New Zealand. However, this growth needs to happen in a sustainable manner with minimal to no impact upon natural ecosystems, whilst maintaining a low emissions profile and providing new economic opportunities for Māori. New Zealand's experience with salmon farming, combined with our solid reputation for high quality products, and suitable oceanic environment provides a strong platform for the country to become a global leader in open ocean aquaculture. Significant local expertise and the presence of a mature inshore (and canal-based) salmon farming industry should provide confidence to potential investors that open ocean aquaculture is possible.

Developing an open ocean farming industry will, however, require a degree of tolerance by regulators and investors for uncertainty and adaptation, both around the production aspects, as well as the potential impacts upon the offshore marine ecosystem. Since this industry is a new frontier for New Zealand's marine farming sector, there is little in the way of direct comparisons. Therefore, it is important that we leverage international understandings and technologies to enable the development of a new open ocean aquaculture sector in New Zealand.

1.4 Current International Aquaculture Context

1.4.1 International Trends

This overview summarises the trends in international aquaculture with respect to exploiting more exposed farm locations with a focus on the costs of infrastructure options and the drivers associated with the economic viability of such investments. This section largely focuses on the Norwegian experience (but should be interpreted as the same for other parts of the world) for several reasons:

- Most innovation is occurring in the Norwegian salmon farming industry. This is because of the ownership structure of the industry, and the proactive regulatory framework that has been adopted to support offshore innovation.
- The scale of the industry in Norway.
- The current challenges associated with traditional net pen farming in this region (e.g. sea lice issues and lack of inshore farming space – these issues apply across the Northern Hemisphere and in South America).
- Norway's salmon farming experience largely reflects that of the rest of the world.

Industry Structure

Ownership of much of the Northern Hemisphere salmon farming industry is based in Norway. Innovations in farming technologies are highly transferrable. Management control and technical expertise is more accessible in Norway because the head office functions are located in this region.

Norwegian Industry Scale

The industry in Norway is significantly larger than other regions of the world (see table below). The scale of the industry means that there is a large service sector, and this enhances and supports innovation.

Approximate production of (marine) salmonids from main salmon and trout producing countries.

Country	Marine Salmonid Production (2018, tonnes)
Norway	1,100,000
Chile	843,000
Scotland	155,000
Canada	123,000
Faroe Islands	77,000
Australia	48,000
USA	23,000

Iceland	19,000
Ireland	14,000
New Zealand	10,000

Regulatory Support

The Government of Norway has developed a supportive regulatory framework to encourage innovation. Licenses have been granted that require the holder to invest in innovative technologies (innovation licences are granted for open ocean aquaculture and must be based on the implementation of new technology). These licenses are issued with a very low cost and allow the holder additional productive capacity.

Production Challenges

Fish health status has deteriorated, and survival rates have declined in the salmon industry in Norway (where the vast majority of production occurs) as well as other key salmon producing countries like Scotland and Canada. The main driver of poorer fish health is sea lice either directly from the sea lice themselves, or as a result of multiple treatments using chemical and physical removal methods when treating the fish. There is also concern that, especially with respect to sea lice, that farms are negatively impacting wild stocks. Sea lice from farms 'infect' wild salmon and reduce their survival.

The New Zealand Context

In New Zealand there is no sea lice issue with farmed salmon in the coastal environment. This is because sea lice occur in lower abundances, and because chinook salmon are naturally resistant to sea lice.

Sea lice is therefore not a reason to prevent growth here. The main issues preventing growth in New Zealand are seabed impacts being perceived as higher than ideal, negative visual impacts on areas with high or outstanding natural character, and competition for coastal space with other users (e.g. recreational, fisheries etc.).

Shifting to OOA in New Zealand would likely offer a significant health premium for fish (lower temperature farming, less health issues (unrelated to sea lice)) and therefore better survival, faster growth and lower food conversion rates.

Sea lice control has become a major regulatory requirement. The regulator has responded by reducing the growth rate of the industry (i.e. cutting production and / or not allowing increases in production) until sea lice control and fish health status are improved. This has resulted in a stagnation in the growth of production in Norway. Prices for salmon have increased on the back of increasing demand and flat production. Profitability in the sector is high and farmers want to take advantage of the higher prices and increase production.

Production Objectives

Norway has a strong desire to increase the production of salmon in their EEZ. A total production of 5 million tonnes per year by 2050 has been suggested. This is a four-fold increase from the current levels.

In Scotland there is also a strong desire for growth; the industry has developed a plan to double the value of the aquaculture sector from 2016 levels by 2030. Industry, regulators and other stakeholders all recognise that to achieve these levels of production there will need to be new technological solutions to address environmental, fish health and social challenges associated with salmon farming.

1.4.2 Cost Trends

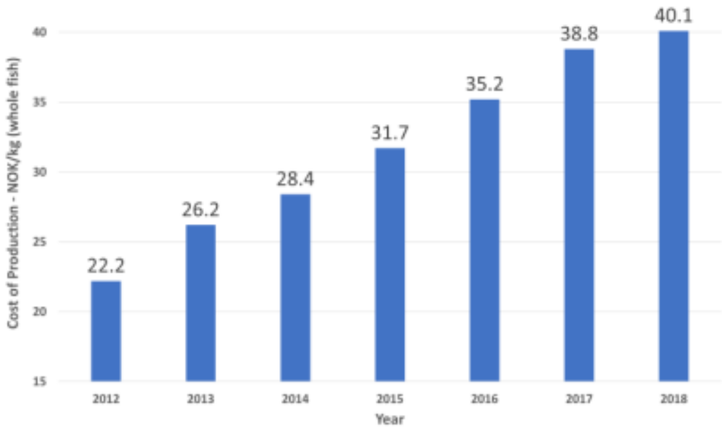

Figure 3. Norwegian Cost of Production Trend 2012 to 2018.

The cost of growing salmon in Norway has increased significantly over the last 7 or 8 years (see Figure 3). This is due to changes in exchange rates and to more challenging farming conditions – particularly fish health challenges related to sea lice control.

Since 2012 the exchange rate has changed from approximately 6NOK:1US$ to 8NOK:1US$. This is 33% depreciation in the Norwegian currency. This would affect some input costs – especially feed ingredients.

As feed contributes approximately 50%-65% of the production cost it is reasonable to assume that about 5NOK of the increased cost of production can be attributed to currency changes. The rest of the cost increase (approximately 14NOK/kg) can be attributed to genuine cost increases associated with the farming process. These have come primarily from farmers attempts to either directly control sea lice numbers on their stock to ensure regulatory compliance or from mortality associated with fish health treatments. Also associated with the sea lice control issue is the early harvest of fish at sub-optimal sizes. If sea lice numbers are too high operators will sometimes elect to harvest fish early. This means that there is less biomass harvested from the farm than planned and this increases the cost of production as fixed costs (especially capital) are not diluted by the anticipated volume of harvest biomass.

Despite these cost challenges, profits in salmon farming are increasing internationally as there has been very limited supply growth, while demand is increasing for the product. So, farmers have been able to increase the sales price by more than costs have increased.

It is the increasing cost of production associated with traditional net pens that has created the opportunity to invest in more expensive farming solutions (e.g. OOA) that will address fish health challenges, improve survival and allow savings in 'per unit' costs (as there will be less units to be managed).

OOA is seen as a way to farm in areas where there are less fish and fewer sea lice, and therefore improved fish health. This is not yet proven but is one of the key assumptions behind the transition to open ocean farming in Norway.

1.4.3 Innovating for Growth

The current industry model is to grow juvenile fish in land based freshwater facilities to an average transfer weight of 80 to 150g and then to move the fish to traditional net pens. Currently most farms are in the sheltered coastal ribbon. Sites have a reasonable to high amount of protection from wave action by being placed in the lee of islands or headlands from the prevailing wind direction or by being placed in sheltered fjords or bays. This has proven to be a very effective way to grow salmon to market size with a small environmental footprint and, especially in recent years, very good economic returns.

However, these areas are limited and there have been increasing issues with fish health and with interactions with wild salmonids (as discussed in 1.4.1) that are preventing significant additional increases in production using this model. To increase production, farming companies have a range of options:

1. Move to more exposed and energetic sites that are expected to allow the environment to more effectively absorb the additional nutrients from the farm system, allow more fish to be reared in a single location (economies of scale) and avoid sea lice (and therefore improve fish health) by being established away from salmon migratory routes.

2. Invest in land-based systems to grow fish to a larger transfer size. If larger smolt are transferred to sea this will reduce the time at sea and reduce the exposure of the fish to fish health challenges that have emerged. More importantly, from a production point of view, it will allow existing marine farms to produce more biomass per year. The current farming cycle is approximately 18 to 22 months followed by a 2-month fallow period. If the growing time is reduced to 10 to 14 months with a 2-month fallow period, then the annual production[8] from existing locations will be increased by up to 33%.
3. Invest in land-based systems to grow fish to market size. The technology to do this is not yet proven to be economic. Despite this, there is a massive investment currently underway (in Norway and the United States in particular) in 100% land-based production recirculation aquaculture systems (RAS) by new entrants and by incumbent farming companies (see 4.2.1).
4. Increase the productive capacity of existing farms in the coastal ribbon. By moving to semi-closed farming systems for part or all of the production cycle it may be possible to grow fish in a protected environment, eliminate sea lice issues that are prevalent in the Northern Atlantic and improve fish health by requiring less interventions and by improving the water quality of the system. This will lead to increased survival and reduced feed requirements. Additionally, the majority of the solid waste (faeces, waste feed, net biofouling material) could be removed from the water and disposed of on-land as fertiliser or utilised for energy production in anaerobic digesters.

[8] The annual site productive capacity can be determined by the biomass of fish harvested divided by 2 years.

2 Financial Model & Scenario Analysis

2.1 Key Findings

2.1.1 Operation Size

To calculate the cost of developing an OOA farm, a series of assumptions was agreed with NZTE and MPI (Appendix One contains the full set of assumptions):

- Each consent application, and subsequent development, will be undertaken to grow 10,000t of Chinook Salmon.
- The OOA farms developed will be completely independent of each other and will not rely on any existing aquaculture infrastructure that is privately owned.

Given the industry is non-existent in New Zealand at the moment (in the open ocean) the cost information has been calculated based on comparable local market data and comparable operations internationally. However, it is noted that OOA is a relatively new idea and market data is very difficult to find. As such, the input assumptions have required professional judgement in many instances.

2.1.2 Cost of Development

For each 10,000t consent application, NZ$187.5m of capex (in real dollars) is required, which includes:

- $2.5m on consenting;
- $25m hatchery;
- $160m open ocean operation (including processing infrastructure).

2.1.3 Return on Investment

The base case assumptions suggest an Internal Rate of Return of 12% and a payback period of 17 years (17 years to recover the capital outlay). This assumes all operational equipment needs to be purchased (including the hatchery) and no economies of scale. Given the concentrated aquaculture industry in New Zealand, it is likely that an investor would have existing operations and would benefit from economies of scale. Scenario analysis suggests that the IRR could increase to 19% however this is perceived as an aggressive scenario. The most apparent commercial risk is the time delay between applying for a consent and receiving a return. Based on the assumptions applied, it would take 9 years before any revenue would be generated and 11 years before breaking even, which could be delayed further if there were unforeseen setbacks.

2.1.4 Industry View

Analysis has been undertaken to understand the potential value of the OOA industry. Assuming 11 consent applications (for 10,000t each) between 2020 and 2040, gross production is expected to reach 110,000t of salmon which equates to $3.4b nominal ($2.0b real) of annual sales by 2049.

2.2 Capital Costs

2.2.1 Overview

The capital costs associated with the development and maintenance of an OOA operations include:

- Consenting – site identification, specification and consent application
- Hatchery development – land, RAS and buildings and plant
- OOA – On-water assets and processing facilities

Based on a 10,000t operation, the capital cost totals circa $188m (real dollars) which is spent over the first nine years of the development phase. As shown below, this cost is predominantly in relation to the OOA assets totalling $160m (real). The cost split is displayed below:

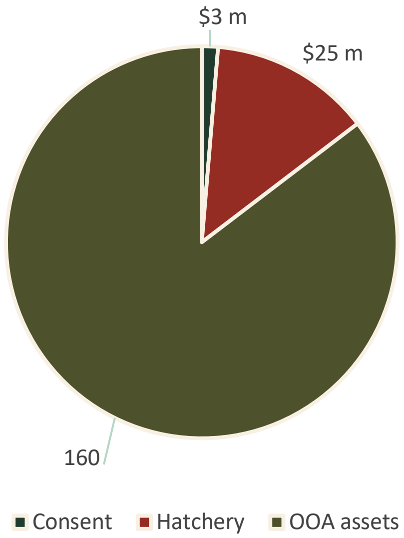

Figure 4. Upfront capital cost for 10,000t operation ($ real)

2.2.2 Consenting

The first step for the development of an open ocean aquaculture operation is obtaining resource consents. This will typically involve three steps:

1. Identifying the site location and undertaking a preliminary assessment
2. Resource consent application
3. Developing design specifications and associated costings

The assumed cost and timeframe associated with a successful consent application is provided in the table below:

Consent application		
Item	**Years 1 - 5**	**Years 6+**
Total cost of consent application	$2.5m	$2.0m
Number of years to gain consent	4 years	2 years

Source: Aquaculture Direct Limited and agreed with project team & NZTE/MPI

Assumptions relating to the table above:

- Each consent will last 20 years at which point a new consent application will be made and granted.
- The cost and timeframe to obtain a consent will reduce from year 6 and beyond. This assumption was agreed with the project team on the basis that the government will be encouraged to support the industry and will change consenting processes to encourage investment by the private sector.

2.2.3 Hatchery

Once the consent is obtained, the development of the hatchery will be initiated. As agreed with NZTE, it is assumed that the hatchery developed will utilise RAS technology and will have the production capacity of 2.6m smolts per annum which are required for the production of 10,000t of salmon assuming a survival rate of 85%. The assumed cost and timeframe associated with the development of the hatchery is provided in the table below:

Hatchery development	
Item	**Total**
Total cost to build hatchery	$25m
Number of years to build the hatchery	2 years

Source: Aquaculture Direct Limited.

Assumptions relating to the table above:

- The smolts will be grown to 130 grams in size and that this will take 12 months.
- For the first 2 years of production, the hatchery will operate at half capacity while the systems and processes are being tested. It is not realistic for the hatchery to operate at full capacity immediately.
- There is a new hatchery built for each 10,000t consent application. In reality, in a concentrated industry, the hatchery would likely be expanded to approximately 40,000t before building a new hatchery on a new site. However, this would depend on the location of the hatchery and the open ocean sites and biosecurity zooming considerations.

2.2.4 Open Ocean Assets

In parallel to building the hatchery, the OOA assets would also be developed including the open ocean cages, support vessels and processing infrastructure. The OOA assets are developed over 5 years which ensures that the operation is at full scale (10,000t) when the hatchery is producing sufficient smolts. The assumed cost associated with the development of the open ocean assets is provided in the table below:

OOA assets		
Item	**Standard specification**	**High specification**
Cage and net fabrication	$41m	$45m
Ancillary cage equipment	$1m	$1m
Feed barge	$40m	$44m
Wellboats	$20m	$22m
Net cleaning vessels	$12m	$13m
Service vessels	$20m	$22m
On-shore feed control centre	$6m	$7m
Processing plant	$20m	$22m

Total cost	**$160m**	**$176m**

Source: Aquaculture Direct Limited

Assumptions relating to the table above:

- The standard specification option is based on current technology that is used in the industry. The high specification option represents the technological advances that are currently being explored in the industry which will likely result in more reliable and robust equipment in exposed environment conditions. Given the uncertainty surrounding technological advances, it has been assumed that this cost will be 10% higher than standard.

The cost of building and operating in the open ocean is very much unknown. As such, we have provided scenario analysis to show the impact of fluctuations in these costs.

2.3 Operating Costs

2.3.1 Overview

The operating costs associated with the open ocean hatchery include the following:

- Hatchery – Feed, power and broodstock
- Open ocean farming – Transport on-water, farming and insurance
- Administration – Sales and marketing,
- Processing – Transportation on-land, removing gills and guts

Additional processing costs may then be incurred to transition the salmon into high-value products such as smoked salmon. When producing 10,000t per annum, the operating cost is $124m per annum which is split as follows:

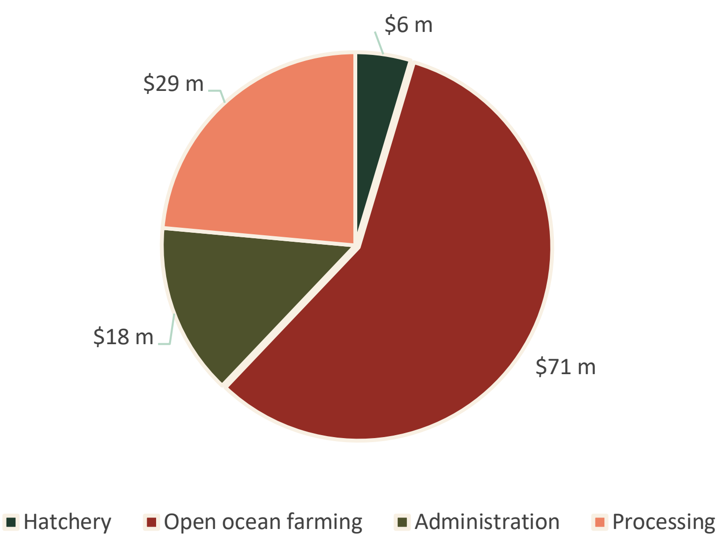

Figure 5. Annual operating cost for 10,000t ($ real)

2.3.2 Hatchery

When the hatchery is built and available to use (2 years after obtaining the consent), the hatchery will be put into operation at half capacity for two years. This will result in the production of 1.3m smolts per annum. The hatchery will then increase to full capacity of 2.6m smolts per annum.

The key operating metrics of the hatchery are summarised in the table below:

Hatchery operations	
Item	**Total**
Operating cost per annum	$2.20 per unit of smolt
Annual production at full capacity	2.6m smolts
Number of years at 50% capacity	2 years
Number of years smolts stay in hatchery	1 year

Source: Aquaculture Direct Limited

Assumptions relating to the table above:

- After the 12-month period in the hatchery, the smolts are assumed to be approximately 130 grams in size and therefore suitable for transitioning into the open ocean.

2.3.3 Open Ocean Operating Cost

After smolts have been in the hatchery for 1 year, they are transported and maintained in the open ocean for 2 years. Given the large scale and distance of the cages to land, operating in the open ocean can be expensive. The key operating metrics of the OOA operation are summarised in the table below:

OOA operations	
Item	**Total**
Farming cost including insurance	$7,124 per gross tonne
Years salmon stay in the open ocean	2 years

Source: Aquaculture Direct Limited.

Assumptions relating to the table above:

- The cost of $7,124 per gross tonne has been calculated based on a total cost of operating (including smolts) of approximately $78 million for 10,000t per annum. Given we are assuming that the smolts are grown internally rather than sourcing from a 3rd party, there is a slight saving.
- The farming cost includes transportation to and from the open ocean ages.
- The operating costs is untested in New Zealand therefore this is very difficult to predict. As such, we have considered the OOA operating cost in the scenario analysis.

2.3.4 Administration and Processing

After 2 years in the open ocean, the salmon are retrieved, processed and sold. The facilities required for processing are built as part of the OOA asset development phase. Throughout the OOA farming and processing phases, a management and sales and marketing cost is incurred. In addition, cost is incurred for processing, from whole salmon to gilled and gutted. The table below outlines these costs which are based on existing operations in New Zealand:

Admin, processing and sales	

Item	Total
Sales and marketing	$712 per gross tonne p.a.
Management	$1,069 per gross tonne p.a.
Transport and processing cost	$2,920 per gross tonne
Weight lost during processing	10% of gross weight

Source: Aquaculture Direct Limited

Assumptions relating to the table above:

- The sales and market and management cost are calculated based on 10% and 15% of the farming cost respectively.
- The transport and processing cost and weight lost during processing assumes salmon being gilled and gutted.

2.3.5 Sales and Product Mix

NZTE has assumed that the OOA operation will sell the salmon from the factory. As such, the product mix and price reflect the wholesale price that would be achieved ex-factory. The two primary categories for selling are gilled and gutted and smoked. Whilst smoked is a much higher price per kilogram, the processing cost and weight lost during the smoking process results in a small net gain. Current industry participants have suggested that the current mix between gilled and gutted and smoked is approximately 70% and 30% respectively, and that the cost and price received will vary depending on end use. The table below outlines the assumptions applied to calculate the revenue generated:

Assumptions Related to Product mix and sales				
Item	**Allocation**	**Sales price per kilogram ($)**	**Processing cost per kilogram ($)**	**Lost weight**
Smoked salmon	30%	50	12	45%
Gilled and gutted	70%	17	0	0%

Source: Aquaculture Direct Limited.

Assumptions relating to the table above:

- After allowing for the weight lost from processing and based on the allocation of 30% to smoked salmon and the balance sold as gilled and gutted, the price achieved per gross kilogram (before processing) is $20 (exclusive of GST) in real dollars.
- The prices above reflect prices observable in today's market. Over time, industry participants are predicting that the global demand for aquaculture products such as salmon will continue to be in excess of supply and as a result, the price should increase. The base case assumption is that the price will increase with inflation however this is considered conservative. The scenario analysis considers price growth over-and-above inflation.

2.4 Return on Investment

2.4.1 Cash Flow Forecast

To understand the cash flows and return on investment metrics, we have developed a 30-year forecast based on one consent application. The full set of financial statements for the base case can be seen in Appendix 2, however the table below provides a summary:

Cash flow forecast									
Item	**Year 1 & 2**	**Year 3 & 4**	**Year 5 & 6**	**Year 7 & 8**	**Year 9 & 10**	**Year 11 & 12**	**Year 13 & 14**	**Year 15 & 16**	**Year 17 & 18**
Capex	(1)	(1)	(97)	(73)	(38)	-	-	-	-
Revenue	-	-	-	-	215	447	465	483	503
Operating expenses	-	-	-	(58)	(228)	(349)	(363)	(378)	(393)
Tax	-	0	0	17	8	(23)	(24)	(25)	(26)
Working capital	-	-	-	5	(2)	(7)	(0)	(0)	(0)
Free cash flow	**(1)**	**(1)**	**(97)**	**(109)**	**(44)**	**68**	**77**	**80**	**83**

Source: DRAFT NZTE OOA model V0.03.

Notes relating to the table above:

- Between year 1 and year 9, $210m (inflation adjusted) of capital expenditure is required to pay for the consent, hatchery and OOA assets.
- From year 9 onwards the operation begins to generate revenue however the first two years of operations are at 50% capacity.
- From year 11 onwards, the OOA operation generates 10,000t of salmon (gross) and the profitability is achieved from this point onwards.

2.4.2 Internal Rate of Return

To calculate the return and compare scenarios, the Internal Rate of Return (**IRR**) has been calculated. Based on the various assumptions applied (see Appendix One for a full list of assumptions) the IRR is **12%** for the base case. The IRR has been calculated based on one 10,000t operation that does not benefit from economies of scale or leveraging off existing infrastructure. In reality, parties that are most likely to invest in OOA are existing operators and it is probable that some economies of scale would be achieved or that consent applications are for more than 10,000 tonnes which would reduce the consent cost per unit of production.

2.5 Scenario Analysis

2.5.1 Scenarios Considered

To understand the impact of changes to assumptions which are inheritably very unpredictable in this industry, the following scenarios have been considered:

- Scenario 1: Sales price growth of 1% per annum over years 1-10 (in addition to inflation).
- Scenario 2: 50% of sales is smoked salmon and the remaining 50% is gilled and gutted.
- Scenario 3: Consent timeframe after year 6 is 4 years.
- Scenario 4: 5% lower capital and operating costs for OOA.
- Scenario 5: 10% lower capital and operating costs for OOA.

- Scenario 6: Combination of Scenario 1, 2 and 5 (note: this is considered aggressive).

The key metrics of each scenario are shown in the table below:

Scenario analysis				
Item	**Upfront capex**	**Internal Rate of Return**	**Payback period**	**Revenue per kg**
Base case	$210m	12%	17 years	$20
Scenario 1	$210m	16%	15 years	$22
Scenario 2	$210m	14%	16 years	$22
Scenario 3	$210m	12%	17 years	$20
Scenario 4	$201m	13%	16 years	$20
Scenario 5	$192m	14%	15 years	$20
Scenario 6	$192m	19%	14 years	$22

Source: Aquaculture Direct Limited

Notes relating to the table above:

- The upfront capex amount varies between $192m and $210m
- Sales price growth (Scenario 1) has the most material impact, increasing the IRR from 12% to 16%. As noted above, industry experts are expecting some price growth therefore this is not considered overly aggressive.
- Increasing the proportion of sales of high value outputs from 30% to 50% results in a 2% increase in the IRR and one year reduction in the pay-back period.
- Scenario 6 is considered aggressive as this combines the reduction in capital and operating costs, sales price growth and increased proportion of sales to high value products. If these assumptions are adopted, the IRR increases from 12% to 19% and the payback period reduces from 17 years to 14 years.

The payback period has been calculated based on cash inflow/outflow after tax.

2.6 Industry View

2.6.1 Overview

Various targets have been set in New Zealand in respect of growing the aquaculture industry. As such, analysis has been undertaken to consider the potential volume of salmon that could be generated by OOA and the financial impact that would have on the industry.

2.6.2 Findings

To understand the potential impact, it has been assumed by NZTE for the purposes of the financial and economic modelling that one consent application will be initiated every 2nd year from 2020 to 2040 (inclusive) resulting in 11 consent applications. Each consent application will result in the development of an OOA operation capable of delivering 10,000t of salmon per annum. The outcome of this is:

- In the year ended 30 June 2049, gross production is expected to reach 110,000t of salmon which equates to $3.4b nominal ($2.0b real) of sales annually.

- The forecast EBITDA of the industry in the year ending 30 June 2049 is $758m nominal ($435m real).
- To achieve an industry of this size would require capital expenditure of $2.9b nominal ($2.1b real).

The chart below displays the growth in sales and production volumes over time:

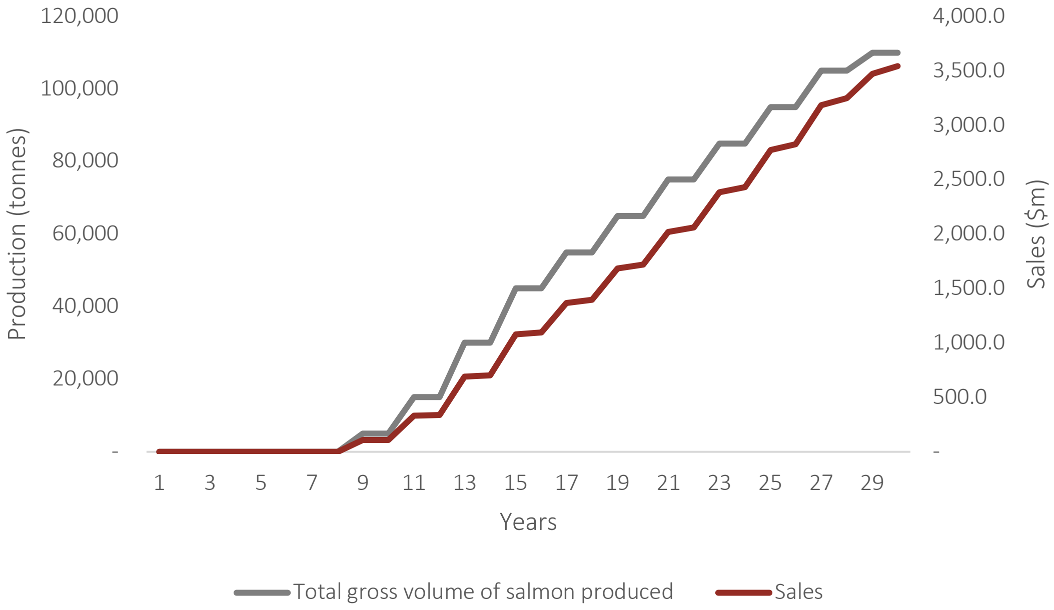

Figure 6. Industry production and sales - 30-year forecast.

3 Economic Impact Assessment

This section summarises the outcomes of an economic assessment of establishing an open ocean aquaculture industry in New Zealand. Crucially, the assessment focuses on establishing the industry using a 'greenfield approach' so all the required infrastructure needs to be procured. The assessment uses several different tools, including:

- Economic impact assessment (**EIA**), and
- Cost benefit analysis (**CBA**).

Both tools are linked to a Monte Carlo Simulation (**MCS**) that randomly adjusts key input parameters showing the anticipated distribution of outcomes. A positive outcome from using the two approaches is that a rich and multi-dimensional picture of the potential economic outcomes is presented. Perhaps the most important aspects include:

1. The CBA sheds light on relationship between costs and benefits,
2. The EIA illustrates how the new activity will flow through the economy, generating Value Added[9] (**VA**) and jobs.

Crucially, the economic impacts (VA) should not be seen as benefits. Value Added includes items like salaries and wages. A salary/wage is a gain to the worker but a cost to the company. Further, the initial capital investment (e.g. constructing a building) generates economic activity and so it delivers a VA impact. But this capital investment is a cost because a resource is used, and an opportunity cost is incurred[10]. Refer to Appendix B of the Economic Report for a full breakdown of the limitations, caveats, and the key assumptions that have underpinned this analysis.

3.1 Results

This section summarises the results of the assessment and the outcomes of a sensitivity analysis. The Monte Carlo Simulation is also discussed. The CBA is dealt with first before the EIA results are presented.

Several different discount rates are used to translate future cash flows (positive and negatives) into present values. Selecting a discount rate is very important because it has a large impact on the results. A high discount rate reduces the 'value' of cashflow (and benefits/costs) that occur in the future. This means that more weight is placed on the short term. Discounted Cash Flow analysis (**DCF**) is used to translate future costs and benefits into a single value, i.e. how much is the future costs/benefits worth today. A discount rate of 6% is used (together with 4% and 8% to show the range)[11]. The results for a zero-discount rate is also included as a benchmark.

3.1.1 Costs and Benefits

The analysis timeframe covers 30 years with the first 10-year period covering the set-up and initial investment in hatchery cycles. This means that most of the benefits are only expected after the first decade.

Cost Benefit Analysis Results Summary.

Discount Rates

[9] Value Added is similar to GDP but excludes some taxes.

[10] The funding cannot be used for another purpose.

[11] This is the 'default' discount rate used by the Treasury. Source: https://treasury.govt.nz/information-and-services/state-sector-leadership/guidance/financial-reporting-policies-and-guidance/discount-rates

		0%	4%	6%	8%	10%
Benefits	*Exports ($'m)*	27,434	11,850	**8,008**	5,510	3,856
	Employment ($'m)	1,120	509	**355**	252	183
	***SUB-TOTAL** ($'m)*	28,554	12,359	**8,363**	5,762	4,039
Costs	*Capex ($'m)*	2,160	1,250	**976**	775	625
	Opex ($'m)	22,856	10,308	**7,145**	5,054	3,645
	***SUB-TOTAL** ($m)*	25,017	11,557	**8,121**	5,829	4,270
Costs-Benefits	***NET POSITION ($'m)***	3,538	802	**242**	(68)	(231)
	CBR	1.1	1.07	**1.03**	0.99	0.95
	BENEFIT/LOSS PER YEAR ($'m)	118	26.7	**8.1**	(2.3)	(7.7)

Based on the base assumptions, the OOA industry will deliver a positive net position under low discount rates (up to 6%) with the net benefit position being $242m (at 6%[12]) over 30 years. This is equal to an annual gain of $8.1m. The export revenue (a benefit to New Zealand) is substantial, with a present value of $8bn (at 6%). The value of the employment benefit (after allowing for opportunity costs and transfer) is estimated at $355m over 30 years. The present value of the costs, both capex and opex, is estimated at $8.1bn with the opex component accounting for 88% of the costs. **Overall, establishing the OOA industry is expected to deliver benefits outweighing the costs, returning a Cost Benefit Ratio (CBR) of 1.03.** Figure 7 shows the cumulative position of establishing the OOA. Overall, a net positive position will be reached after 24 years. The breakeven position (not shown in the graph) is reached in year 15.

[12] 6% is the default rate put forward by NZ Treasury.

Figure 7. Cumulative position (benefits less costs).

Using different discount rates puts different 'weights' on future values relative to one expected in the shorter term. Without any discounting (0%), establishing the OOA industry will deliver benefits of $3.5bn and return a CBR of 1.1. Conversely, using a high discount rate (+8%) returns negative metrics with the net position lower than $0, i.e. the costs outweigh the benefits. Importantly, these observations are a by-product of the long industry set-up/establishment timeframe where during the first decade, the benefits are low.[13]

Looking past the long lead time (after the consent processes) and adjusting the evaluation timeframe to focus only on the actual activity (so, developing the hatcheries and establishing the OOA operation) presents the OOA in more favourable light. This is because the future benefits are discounted less[14], returning a CBR of 1.1, a net position of $1.7bn; an annual equivalent of +$56.1m.

Importantly, the assessment considered the overall OOA operation, but it is worthwhile to look at a single operation (producing 10,000t). **A single operation will return positive outcomes with a CBR of 1.1 (over 30 years and at 6%). The net position is estimated at $146m with an annual equivalent of $4.8m.** The full Economic Report (Appendix B) provides more detail about the results. Compared to the industry level analysis, a single (10,000t) operation is less sensitive to the discount rate and under a 10% rate, the operation is only marginally unfavourable. The present value of the net benefit is -$390,000. As mentioned, the analysis does not consider the potential environmental costs or other externalities. But, based on the analysis, the environmental costs and externalities would need to be greater than the annual values for the CBR to fall below one. For the overall industry this is around $8.1m over the assessment period and $4.9m for the single operation. But the discounting understates these values. Once operational, the annual values are over $650m[15] for a full OOA industry and $64m for a single operation.

3.1.2 Sensitivities

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[13] Only a small component of the spending is benefits associated with the labour market effects of the consenting spending.

[14] In this instance, the values are discounted to year 10. If the discounting is applied to year 0, then the total net position is $626m with a CBR of 1.1.

[15] No discounting, single year once operating at capacity and including renewal costs (conservative position).

The CBA suggests that establishing the OOA will deliver positive gains to New Zealand. In light of the unknowns, it is important to at least understand how sensitive the outcomes are to changes. A Monte Carlo Simulation was used to identify the spread of outcomes (of the CBR) if the key variables were changed. Figure 8 shows the distribution of the outcomes.

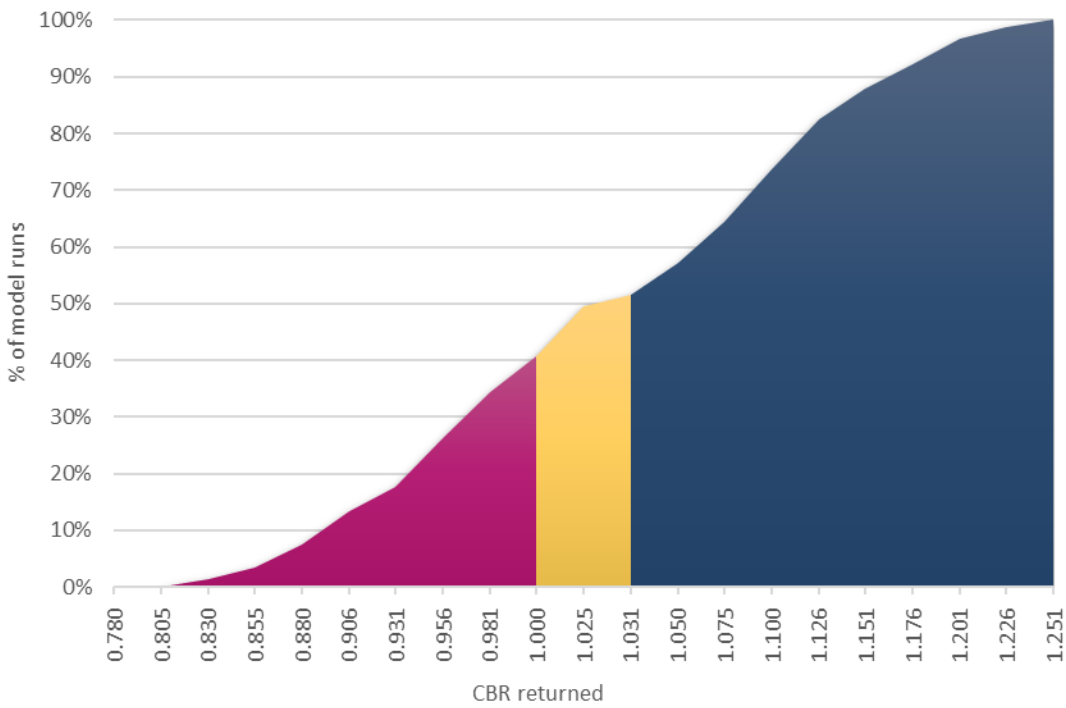

Figure 8. Distribution of outcomes (MCS).

Three key points are evident from the MCS:

- The CBR is robust with to the outcomes (CBR) remaining positive (>1) in 59% of the model runs.
- Forty-three per cent of the runs return a CBR that is higher than the base case.
- Seventeen per cent of the runs return a CBR lower than the base case but still above one i.e. the benefits outweigh the costs.

The MCS changes multiple settings and run the model for all the settings (adjustments) combined. While this provides insight into the overall robustness of the results, it does not assist in identifying how sensitive the results are to changing individual items. The table below summarises the outcomes of the sensitivity analysis using 6% discount rate for the industry level assessment.

Sensitivity analysis – Results (NPV at 6%).

Adjustment	Results			% Change from base	
	Net Position	CBR	Annual Value	Net Position	CBR
Increase consenting timeframe (x2)	(112)	0.980	(4)	-146.3%	-4.8%
Increase capex associated with hatcheries (+20%)	188	1.023	6	-22.1%	-0.7%
Increase capex associated with OOA (+20%)	(75)	0.991	(3)	-131.2%	-3.8%
Increase opex of hatcheries (+20%)	179	1.022	6	-26.1%	-0.8%

Reduce price (-10%)	(559)	0.931	(19)	-331.1%	-9.6%
Increase fish processing cost (+20%)	106	1.013	4	-56.1%	-1.6%
Increase years to build OOA (+20%)	149	1.018	5	-38.3%	-1.1%
Increase fish feeding costs (OOA + 20%)	(512)	0.94	(17)	-311.5%	-8.5%
Lower volume (-20%)	76	1.01	3	-68.5%	-2.0%
Adjust product mix (100% Bulk)	111	1.015	4	-54.2%	-1.4%
Adjust product mix (100% Smoked)	548	1.056	18	126.6%	2.5%
Adjust product mix (50%:50%)	329	1.038	11	36.2%	0.8%

The sensitivity analysis shows the downside situation (i.e. pessimistic) for the different settings, apart from changing the product mix. The resulting movements are in the anticipated direction. The sensitivity analysis suggests that the critical areas are:

- The consenting timeframes – this has a large effect on the CBR and the net position. The reason for this sensitivity is because any postponement during the early stages, delays exports taking place and therefore when benefits manifest.
- Increasing the capex associated with the OOA – such an increase drops the CBR below 1. This is because the capex covers several years, and the values are substantial.
- The price of the product that is achieved for the export products is critical. The analysis suggests that if the prices fall by more than 3%, then a CBR of less than 1 will be returned.

The effectiveness of the farming processes is important because fish-feed is an important input cost. Increasing the feed cost (+20%) lowers the CBA to less than 1. Feed costs are used as a proxy for the effectiveness of the salmon farming and feed-conversion. The analysis revealed that the other settings (excluding the product mix adjustments) all return lower net benefits, and the CBR is also slightly (<2%) lower than the base case. Changing the product mix toward higher value product (smoked salmon) leads to an increase in the CBR (to 1.056) and lifts the net gains to $548m. If all of the produce is exported in bulk format, then the CBR will fall 1.4% and the net benefit will be almost half ($11m). **But, importantly, the CBR remains above 1, so the benefits outweigh the costs.** This points to a need to work towards a high value product, but volumes must be maintained. **The sensitivity analysis suggests that the OOA industry is likely to return a positive outcome to New Zealand, but this positive outcome is not guaranteed and there are risks.**

3.1.3 Economic Impacts

The second part of the analysis estimated the economic impacts that establishing an OOA industry could unlock. This includes both the construction and one-off activity as well as ongoing activity. The economic impacts are estimated using a multi-regional Input-Output model with 15 regions and 106 sectors. The model reflects the supply chain effects[16].

The VA impacts arise as the additional (new) activity takes place, and then ripples through the economy. We estimate different impact types:

- '**Direct and indirect impacts'** – when a visitor (or business) spends (new) money in the local economy, then the economy responds by firstly increasing (or decreasing) activities supplying the goods and services, needed to address that initial demand. This is the direct effect. All firms supplying the businesses responding to the initial spending, adjust their outputs, stimulating

[16] Sometimes referred to as multiplier effects; we do not use multiplier to estimate the impacts as this can misrepresent the impacts.

further rounds of impacts, and so forth. Further (flow on) rounds of activity are needed to meet the extra demand and these rounds are called the indirect impacts.

- The **induced impacts**: As businesses respond to the economic change (the direct and indirect impacts explained above), they use additional workers (by increasing staffing hours, employing more people or working overtime). This leads to a lift in salary and wage payments to households; i.e. more salaries and wages paid to workers in return for their labour. Businesses also take additional profits as operating surpluses increase – this is partially returned to households through dividends paid to business owners or investors. As households spend their returns or earnings, another round of effects is created (i.e. household spending). These are termed induced impacts.
- The '**total impact'** reflects the sum of the direct, indirect and induced impacts

Only the total impacts are reported using 4%, 6% and 8% discount rates.

	Discount rate	Construction and set-up	Operational
		$m	**$m**
Total	4.0%	1,058	8,930
(Direct, indirect and induced)	**6.0%**	**827**	**6,048**
	8.0%	657	4,171

The VA impacts are expected to range between $657m and $1.1bn for the construction and set-up activity (including the consenting process). The mid-point is $827m and the range reflects the different discount rates. As expected, the impacts associated with the ongoing (operational) activity will be substantially larger. This is despite the operational activity only ramping up and reaching scale towards the end of the assessment period. The ongoing impacts (present value) are estimated at between $4.1bn and $8.9bn. Regionally, the impacts are concentrated in the areas that will host the OOA (and the hatcheries). In reality, these spatial patterns and distributions will change as regional distribution becomes clearer. The regional distributions (and temporal effects) are influenced by the scenario design. Nevertheless, it provides a useful indication of the regional impacts. The table below shows the regional distribution of impacts throughout New Zealand and differentiates between the VA impacts associated with the establishment phase, and the ongoing activity.

Regional VA Impacts (Total)

Region		**Construction and set-up**		**Ongoing activity**	
		$m	%	$m	%
1	Northland Region	7	0.9%	107	1.8%
2	Auckland Region	233	28.2%	845	14.0%
3	Waikato Region	20	2.4%	162	2.7%
4	Bay of Plenty Region	10	1.2%	126	2.1%
5	Gisborne Region	2	0.2%	20	0.3%
6	Hawke's Bay Region	5	0.6%	42	0.7%

7	Taranaki Region	19	2.2%	58	1.0%
8	Manawatu-Wanganui Region	8	1.0%	38	0.6%
9	Wellington Region	113	13.6%	334	5.5%
10	Nelson-Tasman-Marlborough Region	126	15.2%	1,847	30.5%
11	West Coast Region	3	0.3%	24	0.4%
12	Canterbury Region	26	3.1%	323	5.3%
13	Otago Region	150	18.1%	1,268	21.0%
14	Southland Region	105	12.7%	853	14.1%
15	Area Outside Region	0	0.0%	2	0.0%
	SUM	**827**	**100.0%**	**6,048**	**100.0%**

The regions hosting the OOA operations and the hatcheries, capture large shares of the construction impacts as well as the impacts arising from the ongoing activity. Auckland and Wellington (regions) both capture sizable shares of the establishment impacts. This is because we have assumed that the professional services procured for the consenting will be procured from these regions. In the case of the ongoing activity, Auckland receives 14% of the VA impacts. As New Zealand's largest economic hub, it is the centre of gravity with many goods and services delivered to the rest of New Zealand 'flowing through' Auckland.

The three host regions will see most of the ongoing impacts, with the top of the South Island capturing 30% of the VA impacts, Central South Island (Otago used as a proxy) capturing 21% and Southland accounting for 14%. As mentioned, the share of the VA impact felt in these three regions is a function of the development timing. Changing the sequence will move the VA felt in each region. The other regions through New Zealand share the balance, with on average $100m of VA felt in each region (excluding Auckland, Wellington and Area Outside Region). This share remains broadly stable regardless of where the actual operations are developed first. The OOA-operations will generate a substantial level of new activity throughout the economy. In turn, this require labour (workers) to complete the work[17]. Using existing relationships between economic output and employment, the number of jobs associated with the estimated level of activity is estimated. The employment uses 'Modified Employee Counts' (MECs) as the metric of employment. Figure 9 and Figure 10 illustrate the employment impacts of the two phases separately. At the peak of the construction phase, the OOA will support over 3,900 MECs throughout NZ. The construction and set-up phase span several decades, ramping up from year five, with intermittent peaks every two/three years. It then tapers off after 2040. In contrast, the jobs supported by

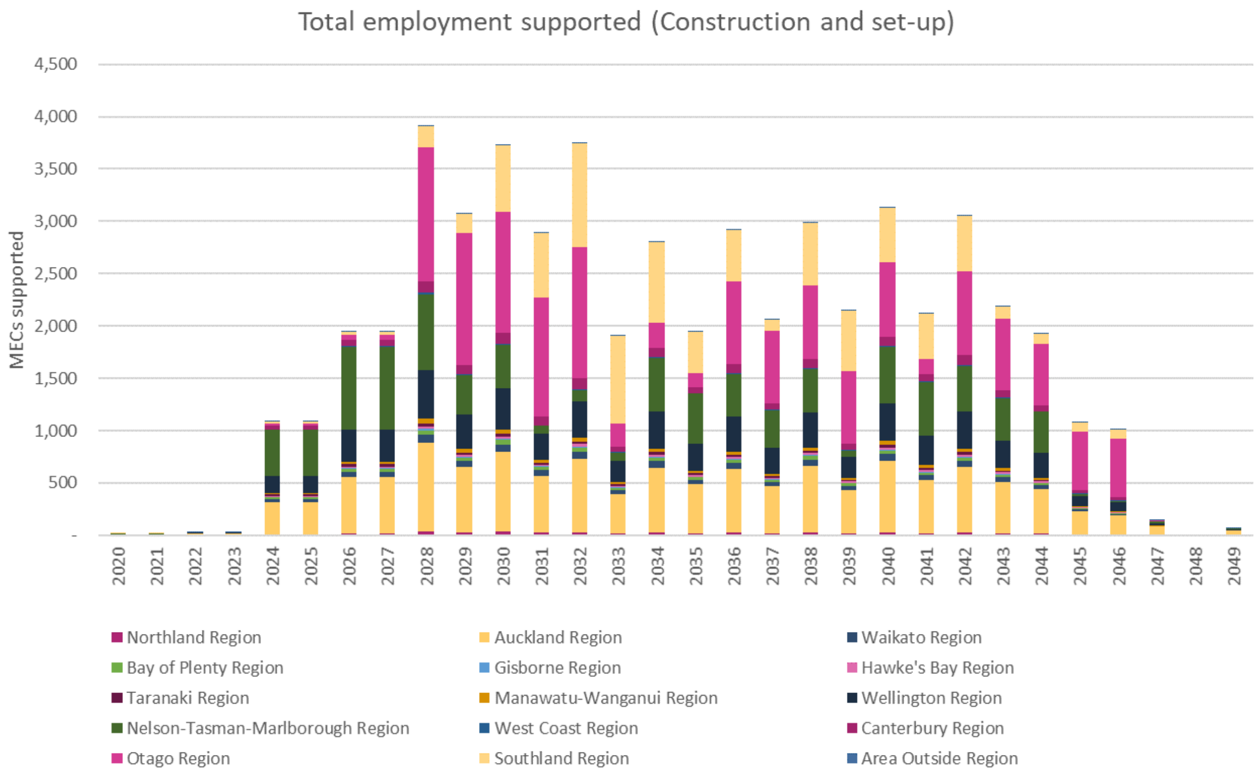

Figure 9. Employment Impacts – Construction and set-up

the ongoing activity, start in the second decade, increasing to 58,300 once operating at full capacity[18]. The scale of activity is significant and so are the employment impacts. Compared against the current (2018) employment base for the host regions, the OOA industry will generate work to sustain between 12% and 20% of local workers.

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[17] This assumes that there is sufficient capacity in the local market i.e. there are workers available. In reality, business will use technology and other means to address capacity constraints where labour is not available. Further, including productivity change will lower the employment effects presented. The drop could be down to 43,000 if labour productivity grows at 1% per annum for the next 30 years.

[18] An MEC includes employee counts as well as working proprietors.

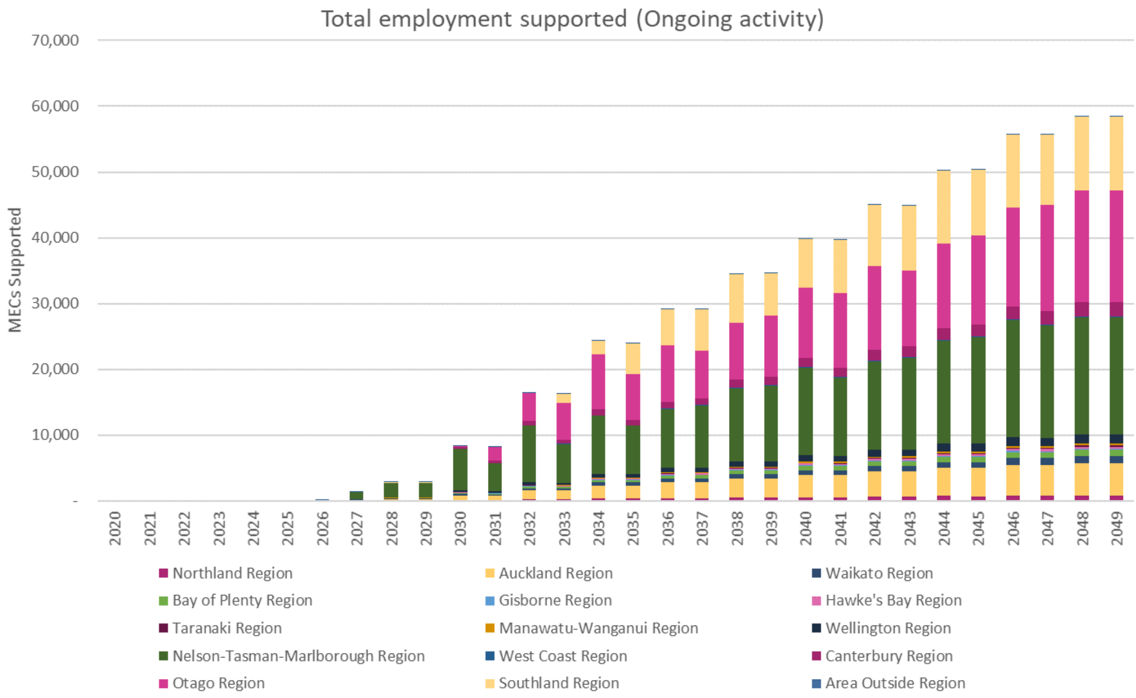

Figure 10. Employment Impacts - Ongoing.

3.1.4 Income Effects

Establishing a new industry in New Zealand will deliver a range of economic benefits. It will also impact on communities throughout New Zealand. These impacts will be in the form of jobs (salaries and wages) and household income. The social implications of lifting household income are reasonably well known i.e. alleviating poverty and providing households with opportunities that would not be available otherwise. As part of the assessment, the type of work that would be supported across NZ was identified by using occupations as metric. The total income distributed to households (workers) was also estimated.

Based on the current occupation profile, service and operations jobs will account for 61% of the jobs supported by the OOA project. The balance (39%) will be associated with management and technical jobs (see Appendix 2 of the full Economic Report (Appendix B) for the classification). Importantly, these figures relate to jobs supported in the entire economy, i.e. including all the flow-on effects so it is not the employment structure of the OOA operations itself.

Adding new activity to the economy, like the OOA, stimulates flow on effects and businesses employ staff to undertake the necessary work. In return, businesses pay salaries and wages. The scale of remuneration across the economy is substantial, increasing to over $815m once fully operational (in that year). During set-up and construction, the income returned to households will peak at $76m (2032).

A key point to emphasise is that the largest portion of the income effects are associated with the ongoing activities. Figure 11 shows the relativity and it highlights the importance on the ongoing effects. While the construction and set-up impacts are one-offs (until the different components have been delivered), they continue to add to the overall income distributed, but the size is comparatively small. Regardless, the $-value is sizable.

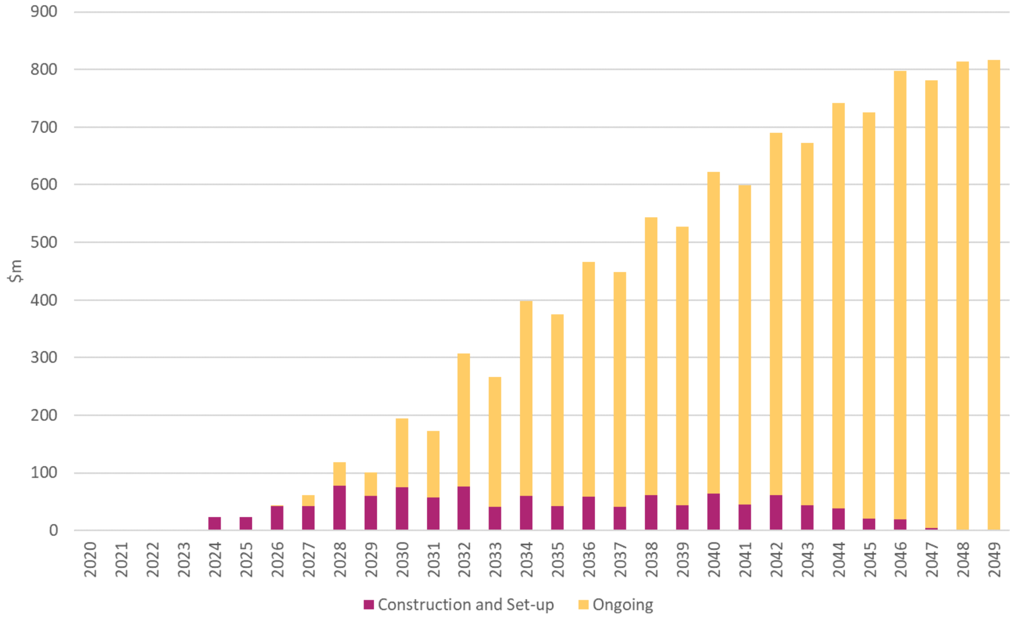

Figure 11. Income returned ($'m).

3.1.5 Economic Summary

Globally, the demand for protein will continue to grow and tapping into this market will also need environmentally sustainably ways to supply the markets. Open Ocean Aquaculture is one option. This assessment, based on the financial projection of how an OOA industry might develop, shows that it will generate large benefits that outweigh the costs. The analysis suggests that the CBR is relatively robust but that it is sensitive to shifts in prices, capex and some important input costs. Prices are linked to global commodity cycles, but it might be possible to reduce exposure to volatility by focusing on high-value product. But maintaining volumes will be important. Establishing an OOA industry throughout New Zealand will have large impacts across the country. The impacts will have a local impact with close connections to the regions where it is developed.

4 OOA Functional Requirements

4.1 Biological Specifications

For the purpose of this business case NZTE is focused primarily on Chinook (King) Salmon offshore aquaculture potential in New Zealand. However, some consideration has also been given to the potential for other species that may also perform well in open ocean conditions.

4.1.1 Chinook Salmon

Chinook, or King Salmon (*Oncorhynchus tshawytscha*) is a high value species produced in relatively small volumes globally (0.7% of world's farmed salmon supply), mainly in New Zealand, United States (Alaska), and Canada. Chinook is the only species of salmon farmed in New Zealand (The first sea-cage salmon farm was established in 1983 in Stewart Island's Big Glory Bay[19], and has been farmed in the Marlborough Sounds since the 1970's) and competes more directly in markets with Atlantic salmon compared to other internationally farmed salmon species and is available year-round.

New Zealand's largest producer NZ King Salmon Ltd provides over 50% of the world's supply[20] and achieves a 5-15% premium in international markets.

New Zealand Chinook Salmon achieved export earnings of $72.2m in the 2018/19 financial year[21], approximately 17% of the total across all farmed seafood products produced domestically ($433.2m)[22].

Figure 12. Chinook salmon (Oncorhynchus tshawytscha).

New Zealand has been somewhat successful in farming this species partly due to appropriate water environmental conditions in some areas of the country (particularly in the Marlborough Sounds and in Southland), and the low frequency of disease and pests (e.g. sea lice) that affect this species overseas. However, changing environmental conditions (e.g. increasing water temperature and increased nutrient loads) threaten the viability of this operation in coastal waters.

Percentage production by company in New Zealand.

Akaroa Salmon NZ Ltd	3.5%
Anatoki Salmon	0.1%
High Country Salmon	1.2%
Mt Cook Alpine Salmon Ltd	9.2%
The New Zealand King Salmon Co Ltd	61.8%
Salmon Smolt NZ (smolts only)	0.1%
Sanford (Bluff) Ltd	24.1%
Total	**100%**

Farming Chinook Salmon in New Zealand

Optimal salmon farming conditions include oxygen saturated cold water (<18°C) within a deep (30m< depth) strong flow environment (>10cm/s) to ensure left over feed and waste is flushed effectively. Fish

[19] http://www.salmon.org.nz/new-zealand-salmon-farming/history/

[20] https://www.kingsalmon.co.nz/our-salmon/our-king-salmon/

[21] https://www.aquaculture.org.nz/wp-content/uploads/2019/12/October-2019.pdf

[22] New Zealand's largest Chinook Salmon producer, NZ King Salmon produces approximately 8,300t per annum from 17 surface hectares of farm space.

farming sites should be selected away from sensitive biogenic habitats, and areas of high natural or aesthetic value.

Chinook salmon live an anadromous lifestyle, meaning they live in both fresh and sea water at different stages of their life cycle. These salmon are born in freshwater, spend the majority of their life at sea, returning to freshwater to spawn. Historically the freshwater cycle for salmon farming in New Zealand has not been a hindrance to the growth of the industry. Chinook salmon are relatively straightforward to farm in freshwater and the waters themselves are devoid of most salmon pathogens, lowering the cost of treatment for diseases.

The bulk of New Zealand's Chinook salmon production occurs in oceanic sea cages in the Marlborough Sounds, Stewart Island and Akaroa[23]. Typically, the sea cages are up to 17m deep, providing enhanced growth conditions that enable the fish to migrate to deeper sections to escape surface related stress and higher water temperatures. Stocking density rates may be as low as 2% fish and 98% sea water.

These nearshore areas are chosen for their proximity to production facilities, isolation, water quality and flow. There are relatively few coastal locations around the country that meet the criteria for salmon farming operations.

Chinook salmon is a relatively versatile species, suitable for inshore farming and a viable candidate for open ocean aquaculture. Although untested with Chinook, the offshore conditions (e.g. deep water, cold, and high flush rates) in some areas around the South Island are seen as appropriate for salmon farming.

NZ King Salmon Ltd.'s 'Blue Endeavour' application to farm Chinook in the Cook Strait, 7kms north of Cape Lambert, Marlborough, is New Zealand's first proposed OOA farming operation. If consent is granted, it is hoped that this first farm would produce up to 4000t per 18-month cycle, followed by a second and presumably subsequent farms at the same site and within the same consent. New Zealand's largest salmon producer has also lodged applications to monitor open ocean conditions off the east coast of the South Island as part of early stage investigations into future sites for open ocean salmon farming over the next 10 years.

Figure 13. Main Chinook Salmon marine farming regions, New Zealand. Source: Salmon Farmer's Association.

4.1.2 Other Species Considerations

Aquaculture production of finfish species other than salmon is common in other parts of the world, but this type of farming is relatively novel in New Zealand. It is not yet a reality due to the uncertainty around the access to farming space, the potential size of markets, and access to juveniles and breeding programmes.

This assessment reviews and ranks the relative attributes of Kingfish (*Seriola lalandi*), Hāpuku (*Polyprion oxygeneios*), Snapper (*Pagrus auratus*), and Trevally (*Pseudocaranx dentex*) for Open Ocean farming as these species have established research and breeding programmes in New Zealand. An additional species, Butterfish (*Odax pullus*), has been added for comparison but does not yet have an established breeding programme. Other coastal New Zealand finfish species like Tarakihi (*Nemadactylus*

[23] http://www.salmon.org.nz/new-zealand-salmon-farming/ocean-farming/

macropterus) and Parore (*Girella tricuspidata*) may have some potential for aquaculture but have been the subject of limited aquaculture-related research and are not assessed here. As there is not currently any large-scale farming of finfish other than salmon in New Zealand, this assessment uses international data on production and potential export value, but in some cases, data are lacking so qualitative estimates are provided.

In all cases, achieving a relatively large scale of production will be essential to long-term success of farming alternative finfish species, offsetting the costs of market development and access, export, and increasing commercial robustness. This assessment ranks alternative finfish species for open ocean farming potential assuming enough farming space is made available for a 5,000t industry on a 10-year horizon and an additional 5,000t on a 20-year horizon. A stocking density of 15 kg per m3 is assumed as best practice for all species.

All indications are that production methods and therefore CAPEX and operational costs are likely to be similar for the finfish species that were assessed here (these included: kingfish, Hāpuku, trevally, snapper, butterfish, rainbow trout). Based on international data for similar species and in some cases published New Zealand data, each species was assigned a range for predicted Food Conversion Ratio (**FCR**). The FCRs that will be achieved will, however, depend on the water temperatures in the growing environments, husbandry, and mortalities. A summary of the strengths, weaknesses, opportunities and unique challenges of each species assessed is also provided in the table below. See Appendix C for the full Economic Report for full breakdown of native species considerations.

4.1.3 Market Potential

The NZ domestic market for fresh fish is relatively small, so the production of an additional 5,000 – 10,000t of finfish other than salmon through aquaculture will likely require access to international markets to ensure economic resilience. Many of these international markets are supplied by their own aquaculture production of finfish, with species of Grouper, Cobia, Seabream and Yellowtail particularly popular in the Asia-Pacific region[24]. Access to these markets for fresh product will incur high export costs (airfreight) and require a premium price point in those markets to offset shipping costs. Our closest market, Australia, has a 10-year head start on the breeding and aquaculture production of Yellowtail Kingfish through a company called *Clean Seas*. There are likely to be significant learnings from the *Clean Seas* business model, as they have steadily increased exports to North America, Asia and Europe through development of a high-quality snap-frozen product called “Sensory Fresh”. For the New Zealand domestic market, a marketing campaign to increase consumption of aquaculture grown New Zealand finfish would be critical.

[24] http://www.fao.org/figis/servlet/TabSelector

Summary of strengths, weaknesses, opportunities and unique barriers to commercialisation.

Species	Strengths	Weaknesses	Opportunities	Unique barriers to commercialisation
Hāpuku	Unique to NZ, fast growing, good FCR, breeding programme at F2 generation, well regarded in NZ market	Diseases, variable supply of juveniles, virtually unknown in international markets	International market development, could be suitable in NZ waters marginal for salmon, potential for RAS to increase size at transfer to open ocean, good provenance story	Diseases, supply of juveniles
Australasian Yellowtail Kingfish	Existing farming model and established markets in Australia, fast growing, well regarded in NZ market, good FCR	Disease issues, similar species produced in Japan	International market development, could be suitable in warmer NZ waters, potential for RAS to increase size at transfer to open ocean	Competition from existing Australian aquaculture production, diseases and concerns from coastal recreational fishers
Trevally	Fast growing, sought after for sashimi	No domestic market, no experience of farming in NZ, unknown potential for disease, no FCR data.	International market development, could be suitable in warmer NZ waters, potential for RAS to increase size at transfer to open ocean	Still in the early stages of research, breeding programme only recently established
Snapper	Existing farming model in Japan, potentially fewer disease issues	Slower growing, export as live product expensive, lower price point	Japanese have double growth rates and survival through breeding programmes, could be suitable in warmer NZ waters	Still in the early stages of research, NZ breeding programme only recently established
Butterfish	Unique to NZ, herbivorous, high in Omega-3 and iodine	Research in early stages, no experience of farming in NZ, no FCR data, difficult to maintain product quality after harvest,	International market development, potentially good provenance story, could command premium pricing, could be suitable in NZ waters marginal for salmon	Still in the early stages of research, breeding programme only recently established, needs to be gutted immediately to reduce tainting of flesh

Ranked alternative native finfish species for open ocean aquaculture compared to Chinook (King) salmon.

Rank	Species	International equivalents	International Aquaculture Production (t)	Farm Gate HoG Price per kg ($NZ)	Estimated Market Price per kg ($NZ)	FCR range	Size at Harvest (kg)	Time to harvest (months)	Temperature Limits	Parasite / Disease transfer from wild populations[25]	Smolt / juvenile supply issues
1	Chinook / Pacific (King) Salmon	Chinook Atlantic Salmon Trout	30,000[5] 2,250,000[26] 250,000[5]	13.50	24	1.7-2	4-5	24	<18	Fewer	No
2	Hāpuku	Grouper / wreckfish species (Asia - Epinephelus spp.)	147,218[27]	?	15.30[28]	1.4-2	3-4	24	<19-20	Yes	Yes
2	Australasian Yellowtail Kingfish	Australia, Europe, USA, Japanese Yellowtail	3,500[29], 990[10,] 816[10,] 139,200[30]	13.50[31]	?	1.2-1.8	3-4	24	>15	Yes	No
3	Trevally	White Trevally (Asia)	4,400[32]	?	13.00[11]	1.8-2	2-3	24	>15	Yes	No
4	Snapper	Silver seabream (Japan)	62,700[33]	?	9.30[12]	1.7-2.2[34]	2	24-36	>15	Yes, possibly fewer	No
5	Butterfish	Unknown	6,500,000[35]	?	13-15?	?	1.5-2	24-36	<21?	Yes, possibly fewer	Yes

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[25] See appended report by Dr Ben Diggles
[26] https://www.conxemar.com/sites/conxemar/files/7._ragnar_nystoyl_0.pdf
[27] FAO - Fisheries and Aquaculture Information and Statistics Branch - 14/01/2020; Groupers nei; http://www.fao.org/figis/servlet/TabSelector
[28] https://www.tridge.com/intelligences/grouper - China average price - US$10/kg
[29] CleanSeas annual report 2019- https://wcsecure.weblink.com.au/pdf/CSS/02164873.pdf
[30] FAO - Fisheries and Aquaculture Information and Statistics Branch - 14/01/2020; http://www.fao.org/figis/servlet/TabSelector
[31] CleanSeas annual report 2019- https://wcsecure.weblink.com.au/pdf/CSS/02164873.pdf

[32] FAO - Fisheries and Aquaculture Information and Statistics Branch - 14/01/2020; white trevally, Asia, export and value http://www.fao.org/figis/servlet/TabSelector

[33] FAO - Fisheries and Aquaculture Information and Statistics Branch - 14/01/2020; silver seabream, Japan, export and value; http://www.fao.org/figis/servlet/TabSelector
[34] http://www.macalister-elliott.com/mep-project/improvement-feed-conversion-ratios-fcrs-of-seabream-for-a-private-fish-farming-company-turkey-2/
[35] FAO - http://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/1253488/

4.1.4 Water Temperature

Although this assessment has ranked finfish species as potential aquaculture candidates, water temperatures will be as significant determinant of which species will be appropriate for open ocean farming around New Zealand. In waters less than 19-20°C, Hāpuku will be best suited to cage production, while waters warmer than 15°C for most of the year, will suit Kingfish, Trevally, and Snapper farming. As such, Hāpuku and Kingfish were ranked second equal as the first is suited to cooler waters and the second to warmer growing areas.

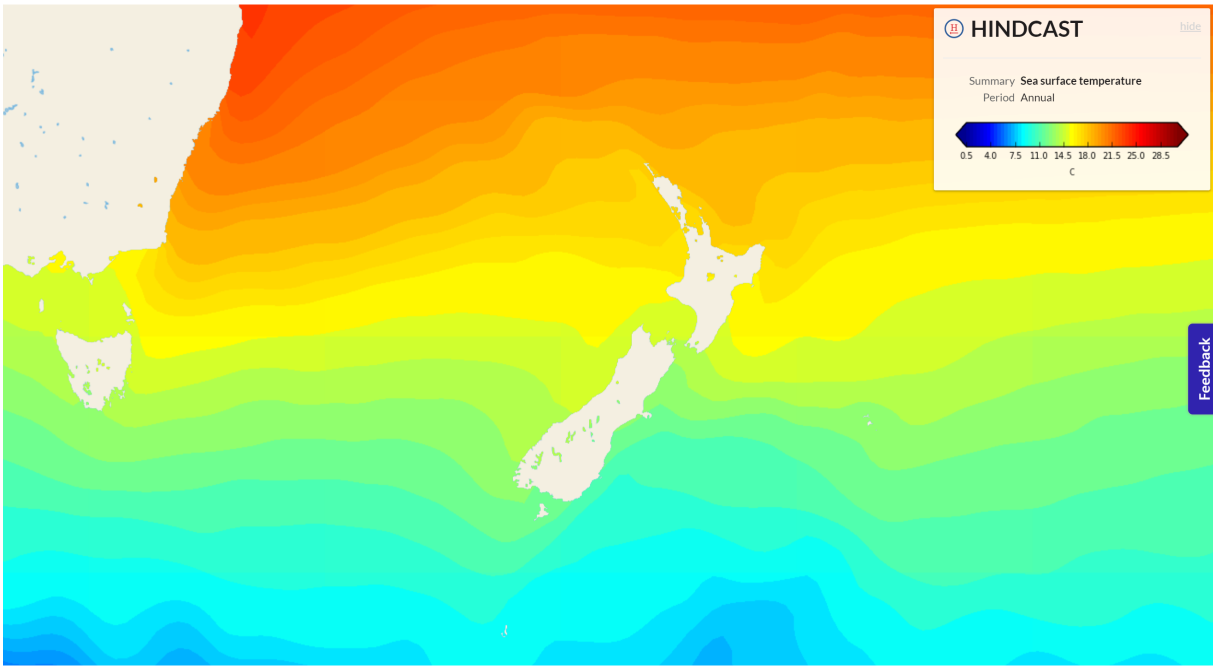

Figure 14. Annual Sea Surface Temperature (SST) map of New Zealand waters.

Source: MetOcean.

4.1.5 Selective Breeding Native Species

Selective breeding is key to ensuring optimal production efficiency in all farming systems. Of critical importance to the success of aquaculture production for these finfish species will be the continued development of breeding programmes and land-based hatcheries and on-growing facilities. Although, breeding programmes have been established for the four of the five species assessed, mainly through research programmes at NIWA and Plant & Food Research, these programmes are in varying stages of development in terms of generations in captivity.

Internationally, there is a growing movement in salmon production to on-grow juvenile fish to larger sizes before moving them to grow-out pens in the ocean. For open ocean farming of other finfish species in New Zealand, there are likely to be significant benefits in terms of survival, feed, servicing and maintenance costs, from utilizing land-based RAS to on-grow juveniles to larger sizes before they are introduced into higher energy open ocean farming systems. RAS do, however, require significant capital investment; for example, a recent on-growing facility for salmon in Australia cost AUD$43 million[36]. A shortage of hatcheries and the ability to continuously provide high-quality juvenile fish has been a limitation for finfish production in many growing areas around the world[37], so any development of an alternative finfish industry will require significant investment to up-scale breeding programmes, hatcheries, and nursery facilities.

[36] https://www.aquanet.com/blog/huon-aquaculture-accelerates-salmon-production-189

[37] https://www.bernaqua.com/marine-finfish-hatchery-technology-sustainable-intensification-with-precision-management-as-a-solution-for-high-reliability-productivity-and-quality-of-fingerling/

One challenge faced by aquaculture around the globe has been managing selective breeding of native species for domestication and reducing the risk of effects if they are re-introduced to their native range. Breeding for fast-growing, aquaculture resilient animals means that if they escape, they may have a competitive advantage against native stocks, which may mean the loss or dilution of wild-type populations. In some species, this risk is managed through triploid stock or only farming one sex, but there has been significant push-back from recreational and commercial harvesters in many countries when selectively breed stocks are introduced back to the native range. The risk of pushback is increased if farmed populations also require treatments for diseases or parasites. These challenges will require careful management by both industry and government to ensure the risk to investments in farming these native species is not adversely affected.

Figure 15. (Left to right, top to bottom). Kingfish (Seriola lalandi), Hāpuku (Polyprion oxygeneios), Snapper (Pagrus auratus), Trevally (Pseudocaranx dentex), Butterfish (Odax pullus).

4.1.6 Rainbow Trout

Special consideration has also been given to another non-native species, Rainbow Trout (*Oncorhynchus mykiss*), which also has OOA potential in New Zealand. Currently the aquaculture of Rainbow Trout is restricted by the Conservation Act (1987) and the Fisheries Act (1996). Given the non-native status and the significant regulatory changes required to enable Rainbow Trout OOA we have separated this into a standalone section.

Rainbow Trout are farmed extensively overseas both in sea pens and in land-based farms (ponds, flow through and reticulated aquaculture systems (**RAS**). They are known to be fast growing (4-6kg in 2-3 years) with excellent Feed Conversion Ratios (**FCRs**) (0.9 – 1.3) are very hardy and an excellent product, fresh, frozen and smoked. In Denmark fish in RAS grow to over 3 kg in approximately 12 months, but these are selectively bred stock with excellent growth performance characteristics. The species is fast growing, hardy and has excellent flesh quality. Fish are sold in a variety of sizes from portion size fish (500g) up to 3kg. Both saltwater and freshwater rearing is commercially undertaken, and significant markets exist in Europe and the US. Saltwater trout are usually of a larger size (>2kg) and also have less issues relating to flesh taint which is a common problem for freshwater reared fish.

Figure 16. Rainbow Trout (Oncorhynchus mykiss).

Rainbow trout were introduced successfully in New Zealand over 120 years ago and are now resident in many lakes and river systems throughout New Zealand. The farming of trout for food in New Zealand is currently prohibited under the Conservation Act (1987) and Fisheries Act (1996). This prohibition is something of an anachronism with other similar countries all farming trout including Australia, Chile, USA, South Africa and most of Europe. Historically both salmon and trout farming were considered in the 1970's and more recently in 2012, but trout farming is still prohibited. To enable the development of trout aquaculture a law change would be necessary to remove the prohibition on trout farming and the sale of trout. To develop an industry would require using the current wild population as a seed stock without compromising national biosecurity for aquaculture. Several populations exist that could be utilised to start the farming process. The initial rearing of juvenile fish would need to be land based and in freshwater. Various options could be explored in terms of suitability but include flow through farms, cages and RAS systems. The key to which are used would be determined by water requirements, site suitability and proximity to the main ocean pen rearing activity. Fish would be reared to approximately 100g prior to sea transfer and vaccination would protect the production from any current known disease issues. For production in the North Island the combined salinity and temperature issues would potentially be a barrier to production. Salinity issues could be managed with infrastructure development of the sea pens, the temperature issues in the Eastern Bay of Plenty, however, would restrict growing time to about 8 months of the year. To overcome the temperature issues genetic selection for higher temperature tolerance could be an option for future research.

In conclusion the aquaculture production of trout in New Zealand offers an opportunity to expand the finfish production in New Zealand beyond Chinook salmon. Rainbow trout offer a product with excellent flesh quality and consumers are already familiar with the product. Rainbow trout have significantly better FCR performance than Chinook salmon and dietary costs are cheaper for the same size animal. An expansion of finfish production in New Zealand would also offer the opportunity to develop extruded food production in New Zealand rather than reliance on importing food. Currently the production levels are too low to make economic sense. However, if production volumes could be expanded beyond the 30,000-tonne level a feed production plant would be economically viable in New Zealand.

4.1.7 Family Programmes & Genetics

Family Breeding Programmes (**FBP**) have been used by salmon farming companies in New Zealand for over 20 years. Improvement in growth rate has been notable and continues. The family programme IP and associated brood stock is owned by the current salmon farming companies.

One issue that will confront new entrants into OOA will be access to brood stock salmon and the associated benefits of existing programmes. It is assumed that existing farmers and their family programmes will be utilised where these companies become involved in OOA. For new entrants and new hatchery owners there will likely be issues around access to all female ova, brood stock and the benefits from existing family programmes. The original stocks of adult salmon for the development of the commercial industry were collected from wild run salmon in the Rangitata River and this could possibly be done again (with the approval of Fish & Game). This will not however provide access to the all-female stocks or the benefits of the family programme. The best access to family programmes and all female progeny is likely to be through JV arrangements with existing salmon farmers.

4.2 Infrastructure Requirements

4.2.1 Hatcheries (Freshwater Facilities)

Because of the small nature of the New Zealand salmon industry and the relative abundance of clean growing water, salmon hatcheries in New Zealand have traditionally been based on flow-through technology. These largely comprise of elongated raceways with water entry through screens at one end and discharging back into the receiving water at the other end. The system is simple, effective and inexpensive; however, it does not allow for the efficient use of water nor the innovations required for modern salmon farming.

The critical issue facing the New Zealand chinook salmon industry (and any other finfish farming sector) is that these existing hatcheries have limited scope for expansion, use outdated technology and have little capacity for growth. No new salmon hatcheries have been built in New Zealand for over 20 years and increased competition for large volumes of clean water makes site selection difficult. New Zealand's total current production is 5.9m smolts, whilst hatchery capacity is 6.3m smolt pa (the table below lists the

To achieve an additional 50,000 tonnes of salmon for the proposed open ocean industry, we estimate that an additional 13m smolt pa are required.

commercial salmon hatcheries in New Zealand and gives their current production capacity and future constraints). To achieve greater capacity using the present flow through systems would require identifying new large fresh water sources and obtaining new resource consents, which will be difficult. With significant additional production expected through the creation of a new open ocean salmon farming industry, one or more new salmon hatcheries (likely distributed regionally) will be required to meet the anticipated demand.

Current hatchery capacity constraints and future capability. Excludes several small private hatcheries with negligible volumes.

Company	Current Total Hatchery Capacity	Future Plans/Constraints
NZ King Salmon Ltd	3.5 million smolts (130-150g each)	At, or near, maximum.
Mt Cook Alpine Salmon	600,000 smolts (80-100g each)	Capacity for increase to 800,000 smolt (200,000 increase)
Sanford Ltd	1.2 million smolts (30g each)	At maximum
Salmon Smolt NZ Ltd	600,000 smolts (50-100g)	Capacity for increase to 800,000 smolt (200,000 increase)
Total	5,900,000 smolt	6,300,000 smolt

Reticulated Aquaculture Systems (RAS)

The principal differences between flow-through hatchery systems and RAS hatchery systems is the control and manipulation of the smolt growing environment. Globally, salmon smolts are grown "in house" by vertically integrated salmon farming companies (we assume that a similar approach would be applied to an OOA industry in New Zealand given the current composition of the sector). The price of salmon smolts varies from country to country, much as the technology for growing salmon smolts varies from species to species.

The advent of controlled smolt production in RAS hatcheries has (and still is) leading to many innovative improvements in the way smolts are managed. Improvements in hatchery technology that relate to improved salmon performance can include:

- Broodstock manipulation (with photoperiod and temperature control)
- Egg development (water temperature management)
- Smolt growth rate, size and smoltification (water temperature, photoperiod control and feed)

All these possibilities result in greater flexibility for salmon farmers and can result in performance improvements in seawater. Improved performance in seawater is particularly important for farmers in Europe, Australia and Chile where because of pathogenic risks (sea lice etc), where the seawater stage of the growth cycle is considered risky (due to salmon deaths and/or the cost of treatments). In short, the less time spent in seawater the better. New Zealand does not currently have sea lice or GDAS so this relatively is less important.

4.2.2 Nurseries (Land Based Seawater Facilities)

Land-based seawater hatcheries are not commonplace in salmon farming overseas. There may be some rationale to promoting the seawater transfer to a land-based seawater nursery if a sea cage farmer requires large smolt, the freshwater hatchery is some distance from the coast and smolt could be transferred to a well-boat by hydraulic pump. There is little known about the effects of tanker transport on large chinook salmon smolt, however there are distinct advantages in locating salmon smolt production close to the seawater infrastructure.

The benefits / risks associated with stocking larger smolts has been identified as a matter requiring further investigation. By growing smolts to a larger size in nurseries it may be possible to:

- Reduce growth time.
- Increase growth rates.
- Reduce sea cage risks.
- Allow for more efficient sea cage usage.
- Improve survival and smolt yield (not proven with chinook salmon).

4.2.3 Live Fish Transport Machinery

Overseas comparison shows that large smolts can be successfully transported and that the increase in transport costs is a minor cost consideration. Locating hatcheries close to sea cage operations is an advantage, especially as smolt size increases.

On land live transport is by converted tanker. This technology is well used and currently available. Tankers can be shared between companies and are a standard piece of hatchery equipment.

Smolt transport at sea has traditionally been undertaken by driving the smolt tankers onto delivery barges. This works well for inshore farms however with the advent of exposed site farms and the increase in size of sea cages, the trend has been to use multipurpose wellboats. It is assumed that wellboats will be an essential part of an OOA venture.

4.2.4 Ports / Landing Facilities

Given the assumption that wellboats for transferring stock and providing a supply of salmon feed will be essential for OOA, port facilities will require a working depth minimum of 4 metres. Figure 17 shows the location of those ports which would provide adequate facilities for OOA. The location of container terminals would be essential for feed ingredients should this be required in the future and also the export

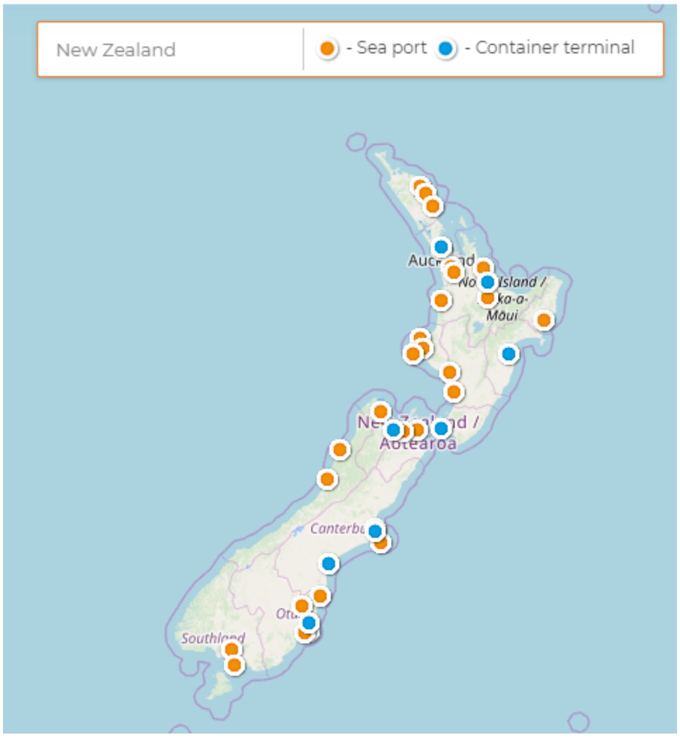

Figure 17. Sea port facilities & container terminals suitable for OOA around New Zealand.

of products from OOA. A breakdown of the port facilities that are capable of wellboat access is given in the table below. This breakdown does not assess the current state / condition of these port facilities and the associated infrastructure.

Relevant New Zealand ports for wellboat access.

Port	Depth[38]	Species
Lyttelton Port	Channel: 9.4 – 10m Cargo Pier: 9.4 – 10m	Salmon
Port Otago - Dunedin **Operates two wharf systems – Port Chalmers and Dunedin; both within Otago Harbour.**	Channel – Port Chalmers 13.5m Channel – Dunedin 8m Cargo Pier – Port Chalmers 11.5-13.9m Dunedin 6.1-8.3m	Salmon
Ports of Auckland	Channel: 9.4 – 10m Cargo Pier: 7.1 - 9.1m	Finfish
Port of Tauranga	Channel: 9.4 – 10m Cargo Pier: 9.4 – 10m	Finfish
CentrePort - Wellington	Channel: 11-12.2m Cargo Pier: 7.1 - 9.1m	Finfish
Port of Akaroa	Channel 12.5-13.7m Cargo Pier 3.4-4.6m	Salmon
Southport - Bluff	Channel 7.1-9.1m Cargo Pier 9.4-10m	Salmon
Port Marlborough	Channel 12.5-13.7m Cargo Pier 7.1-9.1m	Salmon
Port Nelson	Channel 6.4m-7.6m Cargo Pier 7.1-9.1m	Salmon
PrimePort - Timaru	Channel 9.4-10m Cargo Pier 9.4-10m	Salmon
Port Whangarei	Channel 6.4-7.6 Cargo Pier 7.1-9.1m	Fin Fish

[38] Depth data from www.searates.com

OOA / Marine Farming Support Services Required at Port Facilities.

Port Facility	**Requirements**
Commercial Wharf	Secure all weather wharf and 24 hour/7 day a week access.
Storage/Maintenance area	Large food storage area, net repairs and associated farming equipment Net loft Mortality disposal site Fuel storage. Potable water Sewage pump outs
Plastic fabrication	Large level area to allow the assembly of offshore cages and other farm infrastructure with access to port.
Vessel Servicing/ Maintenance	Boat building facilities Boat haul out area Dry dock areas suitable for anti-fouling vessels and general maintenance Cranes
Vessels	Range of well-boats, harvest vessels and service vessels

4.2.5 Processing Facilities

All of the port facilities listed in the table above have at some stage been fish landing and processing ports. Processing facilities for OOA will be the same as for existing salmon and finfish processing operations.

Existing processors convert entire wet fish into a range of different products, these include:

- Head on, gut in (whole fish – unprocessed).
- Head on, gut out.
- Head on, gilled and gutted.
- Head off, filleted.
- Head off, filleted, smoked.

These processing options and costs have been built into the financial model.

4.2.6 Feeding Technology – Nutrient & Delivery Methods

The purpose of this section is to discuss any important differences and difficulties in managing feed and nutrition in New Zealand offshore finfish farming, when compared to traditional inshore farming. Chinook (King) salmon are the primary consideration, but conclusions apply to most farmed finfish species.

Feed Mill Considerations

To be viable, a modern aquaculture feed mill generally requires a capacity of at least 100,000 tonnes production per annum. The construction of such a facility requires an investment in the order of NZ$70m. A mill of this size could support around 60,000 tonnes of fish production, depending on the FCR achieved. Such an investment might be justified before the New Zealand industry achieves this scale (initially a mill could also export feed from New Zealand for example), but the likelihood of attracting an investment will increase as these production volumes are approached.

The ideal location for a mill will have ready access to energy and services, staff and trades people, and transport routes. Direct delivery of feed from factory to farm by ship is becoming more common (and is arguably more important for offshore developments), making a waterfront location with access to a wharf particularly desirable.

Feed Delivery and Control

Modern farms employ two key systems, the Feed Delivery System and the Feeding Monitoring System, described below.

- Feed Delivery System

This is the system used to deliver feed from the storage location (typically a barge) to the fish pens. By far the most common system used on modern farms is the pneumatic feeder. In this system, feed is 'dosed' into a pipe containing moving air. The moving air then transports the feed to the fish pens and a spreading device scatters the feed across the surface of the water in the pen.

Pneumatic delivery cannot be easily applied to submerged cages. However, water-borne delivery of feed has been developed and works well. In this process many components of the feed delivery system remain the same, except the air blowers are replaced with water pumps and the pipes transport feed pellets suspended in water rather than air. Water-borne feed transport has been shown to be very gentle and also uses less energy than traditional pneumatic blowers. As such, there is interest in applying it to existing inshore farms, not just offshore developments.

- Feeding Monitoring System

When feeding fish, it is necessary to monitor their consumption to prevent excess feed being delivered and wasted. It is also necessary to ensure sufficient feed is given and fish are not underfed. The feed monitoring system is used to regulate the feed delivery system, either by human or automatic intervention. All the technologies used to monitor and control feeding from remote locations can be applied to offshore farm locations.

4.2.7 Nutritional Considerations

Background Concepts

- Feed is typically the highest single cost (60-65%[39]) in a finfish farm
- The speed the fish grow is also of great economic value
- Feed Conversion Rate (**FCR**) = kilograms of feed needed to produce a kilogram of fish. Higher numbers are less efficient.
- Specific Growth Rate (**SGR**) = Rate of growth as percentage bodyweight per day
- Ration (**R**) = Feed Intake as percentage bodyweight per day
- SGR and FCR respond to Ration according to the graph below. There is an optimum amount to feed and both under-feeding and over-feeding produce worse economic results[40].

[39] Generally greater than 55%, but in a medium range 60-65% depending on species being farmed (e.g. Atlantic Salmon are currently more efficient food converters than Chinook Salmon). However, all salmon diets currently used have been based on Atlantic Salmon nutritional requirements. If a salmon feed is developed for Chinook salmon, then one would expect improved food conversion ratios and reduced costs.

[40] There is no standard for FCR and SGR, this varies from farm to farm and hatchery to hatchery depending on fish size, feed quality and feed management. As a general rule, FCR 1.5 to 1.7: 1 and specific growth rate 0.5% to 0.6% per day depending on the size of the fish.

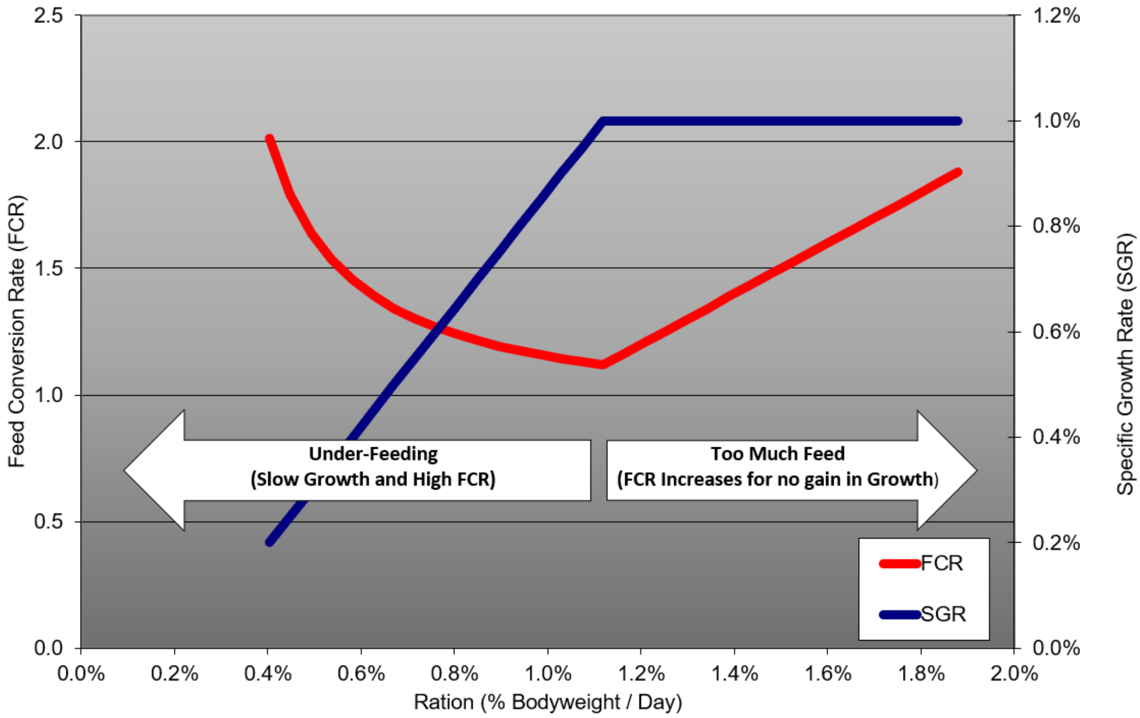

Figure 18. The effect of ration (feed amount) on growth rate and feed conversion rate.

Diets for Offshore Farms

It is anticipated that diet formulation and physical properties will not need to change for offshore farms. Diets for inshore farms produce good biological results and perform well in feed delivery systems; there is no reason to expect the basic nutritional requirements of fish will be fundamentally different in offshore farms.

Offshore Feeding Considerations

- Missed feeding opportunities can occur on inshore farms due to equipment failures and occasionally, extreme weather events. Typically, a day or less of feeding opportunity is lost (it is likely that the days lost / growth losses through adverse weather would be less than the losses incurred during high summer water temperatures in enclosed bays).
- When it is not possible to feed, growth is lost and FCR increases. Fish cannot fully recover these growths and FCR losses and losses accumulate over the life of the fish.
- Increased current speeds at offshore locations could potentially increase FCR. Any increase in FCR from increased swimming speeds could be offset by better growing conditions offshore (especially temperature and oxygen conditions).

4.2.8 Vessels

As OOA is developed the types of service vessels changes to include larger feed and smolt delivery vessels, these are commonly known as wellboats. It is expected that smaller service vessels used on existing inshore marine farms will also be applicable to the OOA context.

Wellboats

Wellboats are used overseas to transport, grade, treat and harvest fish; these vessels provide on-site feed storage facilities for up to 7 days. Key advantages of using wellboats include:

- By transporting fish in the specially built wellboat hull - rather than the traditional method of towing pens full of fish - the potential for disease transfer, and fish escapes is reduced, and the fish can be monitored on video screens. Instead of towing large liners full of freshwater, fish are transferred into the wellboat where they swim around for a few hours before they are returned back to a pen.

- They reduce the need for higher numbers of smaller, noisier vessels to be moving around the farms and in transport routes.
- They make the process of bathing fish far less stressful for the stock, as well as providing safer working conditions workers during adverse weather.
- By transporting all fish in an enclosed system that can be sterilised, the potential for disease transfer is significantly reduced.
- They provide another advantage over freshwater liners in that they can clean and reuse the same supply of water up to six times, enhancing water efficiency.

Figure 19. Ronja Huon. 75m long wellboat owned by Huon Aquaculture.

4.2.9 Exposed Ocean Technologies

Internationally, moving to more exposed areas with more robust traditional technology is occurring and has proven to be profitable. The additional capital cost is, relatively, minor. This additional cost can be offset by larger scale operations that provide some offset and allow for more automation and remote management that reduces operating costs on a per kilo of production basis. The capital cost per m^3 of volume can be lower than with existing traditional farms as the scale of farms can be larger in more energetic environments (due to a higher environmental assimilative capacity).

However, these systems do not offer a significant health benefit. Sea lice control and health concerns remain major concerns. These can be addressed with larger well boats and other treatment methods. These again benefit from the scale of the farm. For these reasons the economic performance of farms in more exposed locations has been good – despite the lack of a health benefit. There have also been challenges. In some cases, structural damage has occurred and has resulted in losses of stock to escapes and/or to mortality due to damage caused to the fish during storm events. Sea lice and gill health issues have been encountered.

Suitable locations are also challenging to find as they are still in the coastal ribbon – benefitting from some shelter from nearby land masses. This means that the number of sites available for development is smaller. There are 'existing' technologies that are proven and are being deployed and there are innovative technologies that are in the development/testing phase. The table below has a summary of the key different technologies that are under development or in use.

Submersible cages

Submersible cages are currently available but these tend to be smaller in volume and are not being pursued aggressively at this time. The concept is that during storm events cages can be submerged to avoid the highly damaging wave energy that is greatest at the surface. Different designs of these are used in the Mediterranean, in the Caribbean and in Hawaii. There are various types of cages – but in terms of size and scale they are too small to be effective for the cost-efficient rearing of salmon in offshore environments.

Semi-closed Systems

Various semi-closed systems are in development. In these systems the salmon would be separated from the sea by an impermeable barrier (GRP or strong fabric). These systems are not being developed for the offshore environment – rather they are being developed for the inshore environment and are outside the scope of this summary.

Utilisation, exposure capability and scale of different farming technologies as well as an estimate of the asset life (for depreciation purposes).

	Use	H_s Rating	Volume per Pen (m^3)	Volume per Farm (m^3)	Asset Life[41]
Typical Traditional Net Pen Systems[42]	Widespread	4	45,000	450,000	15
Improved Exposed Location Net Pen Systems[43]	Occasional	6	80,000	800,000	15
Havfarm	Not yet deployed	10	150,000	900,000	30
Ocean Farm 1	1 farming cycle in 1 system	Not declared	480,000	480,000	30
Smart Fish Farm	Not yet deployed	15.5	1,000,000	1,000,000	30

Existing Technologies

Farming systems are being deployed with more robust versions of existing cage and mooring systems. Examples of these are the Fortress cage system the Aqualine Midgard system, Gael Force SeaQurePen system and AKVA Groups Polarcirkel 630R. These cage systems are, fundamentally, an evolution from current technologies. They are designed to be placed in more exposed locations, not genuine offshore locations. A significant wave height of H_s 6.0[44] has been suggested for the Aqualine system. This envisages a maximum wave height of 12m. And it predicts that 1 in 100 waves will be 10m height. This is a very energetic system – but is still not a genuine open ocean environment. Farms in locations with an H_s 6.0 will benefit from some shelter from a land mass and/or will be located in areas where there are less frequent and less intense storms. Moving to genuine offshore environments the H_s would be higher

[41] There would be significant refurbishment costs are various points through the life cycle of these assets with some components being replaced much earlier than the total asset life)

[42] (10 pens, 140m circumference, 30m deep)

[43] (10 pens, 160m circumference, 40m deep)

[44] Significant wave height (Hs) is defined as the average height of the highest one-third waves in a wave spectrum. The height of the highest 1% of waves (H1/100) is approximately equal to 1.67 times Hs, and a theoretical maximum wave height (Hmax) is approximately equal to two times Hs.

and requires new technologies. There are two main types of systems that are currently being tested and developed in Norway.

Open Ocean Solutions

The Havfarm and the Smart Fish Farm concepts are designed to allow the exploitation of much more exposed locations. They also anticipate a health premium that will result in improved survival, reduced treatment cost and improved environmental and fish welfare outcomes. The Smart Fish Farm is designed to withstand an H_s of 15.5m. The concept is that this will allow the farms to be located away from the coastal ribbon and wild salmon migration routes and that this will eliminate the sea lice issue.

The Havfarm is designed to be used closer to the coastal ribbon (H_s 10.0m) and to either benefit from some modest shelter from nearby land masses or to have the ability to self-propel to a more sheltered location prior to the arrival of forecast storms. The health benefit will be generated by the steel sea lice skirts that will isolate the fish from the infective sea lice stages (that live near the surface). The overall cost benefit associated with genuine offshore technologies is not yet established. The capital cost per m^3 of pen volume will be much higher than existing systems – approximately 10x to 15x higher. The life of the assets would be longer – perhaps a depreciation rate of 30 years versus 15 years for existing structure technologies. This means that the depreciation cost of the farming assets would be approximately 4 to 6 times higher than with the existing technology. The assumption is that by moving to a genuine offshore environment that treatment costs associated with sea lice and other fish health interventions will be significantly lower (or zero). But this has not yet been established.

Further detail is available in the supplementary analysis (Appendix F) provided to this report.

New Zealand – A Special Case

In the New Zealand context, there may be a significant health benefit associated with moving to exposed locations using more robust traditional technologies that is not available in the Northern Hemisphere. In New Zealand, sea lice are not a concern. However high-water temperatures are a significant issue and limited farming locations prevent the use of site fallowing on a routine basis to improve fish health within the sheltered coastal ribbon.

By developing more exposed locations lower sea temperatures will be attained and this will give a major benefit to the health status of the stock. Additionally, if significant new space is allocated, there is the opportunity to re-organize how the existing sheltered sites are managed and to introduce between year class site fallowing practices that are standard practice in most farming regions in the world. Lower temperatures and fallowing will result in improved survival, reduced FCR and better fish health status. These will assist in offsetting the additional cost associated with the more robust exposed location farm structures.

4.3 Technological Horizons

4.3.1 Mobile aquaculture technologies

At least one research consortium is understood to be in the early stages of investigating the feasibility of mobile systems for rearing fin fish[45]. Such systems have the potential to deliver a number of benefits, including avoiding concentration of adverse environmental effects and providing resilience to climate-change related adverse weather and sea conditions. From a regulatory perspective, mobile facilities may avoid or minimise the need for resource consents (or marine consents in the EEZ) for occupation and installation of structures, though discharge consents would remain necessary. Because such systems could move between areas under the jurisdiction of different regional councils, and even between the CMA and the EEZ, inconsistencies between different legal and planning regimes would present particular

[45] The New Zealand Institute for Plant and Food Research Limited "Re-imagining aquaculture: inventing low-impact, offshore mobile technology that transforms finfish production" – refer https://www.mbie.govt.nz/assets/2019-endeavour-round-successful-projects.pdf.

challenges. It is unlikely that mobile aquaculture systems could be developed at present (at least at commercial scales) without some regulatory amendment, however. For example:

- Applications to be registered as a fish farmer under the FA96 must be accompanied by a copy of *"the appropriate resource consent … that applies to the area and premises specified in the application"*, which may not exist in the case of a fully mobile aquaculture system. As noted above, an operator who is neither a commercial fisher nor a registered fish farmer would appear to commit various offences under the FA96 if it possesses or harvests fish for the purposes of sale.
- Although not a barrier to mobile operations *per se*, such operations would fall outside both the 1992 Māori Fisheries Settlement and the Māori Commercial Aquaculture Claims Settlement Act 2004. As a result, no legal mechanism would exist by which iwi could share in the benefits of these activities in the way that they are entitled to do so with respect to commercial fishing and traditional aquaculture (within the coastal marine area, at least).

4.4 Legal Assessment of OOA

A detailed overview of the legal framework relating to open ocean aquaculture (OOA) is outside the scope of this business case but a brief review is set out below.

4.4.1 Overview

Section 12 of the Resource Management Act 1991 (the **RMA**) prohibits the installation and use of structures and occupation of space within the coastal marine area (**CMA**) except as expressly allowed by a national environmental standard, a rule in a regional coastal plan or a resource consent. Section 15 of the RMA imposes a similar prohibition on the discharge of contaminants into any water, including the waters of the CMA. The CMA is the foreshore, seabed, coastal water and air space above the water of the zone that stretches from the line of mean high-water springs to the 12 nautical mile outer limit of the territorial sea. The effect of this is that any fin fish farming operation established in the CMA will require a range of resource consents.

Beyond these high-level provisions, the RMA sets up a hierarchy of planning documents at national and regional levels. For aquaculture, the most important of these are the New Zealand Coastal Policy Statement and regional coastal plans (**RCP**s), which set out a number of policies, rules and matters to be taken into account by consent authorities in determining whether resource consent should be granted for any development. The relevant provisions of RCPs in regions where OOA is likely to be developed in the foreseeable future are summarised below.

Beyond the 12nm limit, the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (the EEZ Act) and regulations made under that Act, administered by the Environmental Protection Authority (the EPA), performs the equivalent function to the RMA and its suite of planning documents. The particular challenges presented by this regime are addressed in more detail below.

All fish farmers must be registered as such under the Fisheries Act 1996 (the FA96). Although this is a straight-forward bureaucratic process, it is significant, as the FA96 effectively makes it an offence to be in possession of fish for the purposes of sale unless one has the status of a commercial fisher (holding of a fishing permit) or registered fish farmer. The FA96 also sets out processes for assessing whether a proposed aquaculture development will have an "undue" adverse effect on commercial fishing, in which case the developer will need to provide an agreed or arbitrated level of compensation to affected fishers.

In addition to these legal regimes, any OOA operation will have to comply with a number of others, including the Maritime Transport Act 1994, Biosecurity Act 1993 and Animal Welfare Act 1999. These regimes impose regulatory requirements that are far from insignificant, though they will not be materially different for OOA, relative to traditional forms of aquaculture.

Finally, the Māori Commercial Aquaculture Claims Settlement Act 2004 imposes obligations on the Crown to provide iwi with assets equivalent to 20% of all space first consented for aquaculture activities in the CMA after the commencement of that Act. This establishes a mechanism by which iwi can share in the benefits of new aquaculture developments but leaves any active participation to be negotiated between iwi and other operators. The settlement framework does not extend into the EEZ or cover mobile aquaculture technologies, which may provide litigation risk. If the Crown took the view that the framework should be extended to include this area/technology before development could occur, these types of OOA could be delayed by some years. It could also provide Māori, who comprise a significant portion of NZ's aquaculture sector, with a greater incentive to participate and invest in the OOA industry.

4.4.2 Regional Coastal Plans

Appendix G (supplementary to this report) includes a high-level analysis of relevant provisions of the Regional Coastal Plans (RCPs) for regions in which OOA is most likely to be developed in the foreseeable future, namely: Northland, Auckland, Waikato, Bay of Plenty, Marlborough, Canterbury, Otago and Southland. It is clear from this that detailed or specific provisions for finfish farming are the exception, rather than the rule in relevant regions. In the small number of plans that do include such provisions, their application is limited to identified (generally inshore) zones, with activities outside those zones prohibited (i.e. no resource consent application can even be made without simultaneously applying for a privately-initiated change of the plan). OOA will therefore most likely be located in areas where the activity is – at best – discretionary and – at worst – prohibited. This presents a high level of uncertainty for an OOA proponent.

In all regions, resource consent applications for a large OOA development would be publicly notified and public hearing and appeals would almost inevitably result. These could add significantly to application time, costs and risk. For the purpose of this report, NZTE has assumed no cost associated with these aspects.

4.4.3 OOA in the Exclusive Economic Zone

As noted above, the jurisdiction of the RMA extends only to the outer limit of the CMA/territorial sea at 12nm. Beyond that OOA would be regulated primarily through the EEZ Act (and other legislation noted above). New Zealand's jurisdiction over the EEZ is conferred by the United Nations Laws of the Sea (UNCLOS) and is limited in ways that result in a regulatory 'lighter touch' than that which applies to the territorial sea.

To date, the EPA has not been presented with any applications for aquaculture activities in the EEZ, and regulations made under the EEZ Act reflect a focus on oil, gas and mineral extraction and activities such as dumping of dredged material. This is particularly problematic with respect to discharges associated with fish farming (e.g. of feed), as s.20G of the EEZ prohibits the dumping/discharge of any material in the EEZ unless regulations allow discharge of a particular material to be authorised by a marine consent and such a consent is obtained. In other words, unless regulations made under the EEZ Act expressly provide for consent to be sought in respect of fish feed and other material that may need to be discharged in relation to an OOA operation, no such consent may even be applied for, and discharge of the material would constitute an offence attracting a maximum fine of $300,000 for an individual and $10M for a company.

At present, the Exclusive Economic Zone and Continental Shelf (Environmental Effects—Discharge and Dumping) Regulations 2015 permit marine consent to be sought from the EPA (on a non-notified basis) for "dumping" of "fish waste, or organic material resulting from industrial fish processing operations" and "organic material of natural origin". Unless all discharges associated with an OOA operation in the EEZ could be brought within those categories, it appears that regulatory amendments would be required before any OOA could be considered within the EEZ.

The situation is a little more straight-forward with respect to structures for OOA in the EEZ, as there is no prohibition on seeking marine consents to permit these, though EPA consenting processes are notoriously time-consuming and expensive. One advantage of seeking to operate in the EEZ, rather than the CMA, is that marine scientific research[46], and the installation of structures used in such research, is a permitted

[46] "research (whether fundamental or applied) carried out for the purpose of increasing knowledge about the marine environment, marine resources, or living marine organisms", including any related scientific activity.

activity pursuant to the *Exclusive Economic Zone and Continental Shelf (Environmental Effects—Permitted Activities) Regulations 2013*, meaning that no consent is required.

Establishing a fin fish farm in traditional, inshore areas faces a very difficult resource consenting path, as the recent experience of New Zealand King Salmon demonstrates. From a regulatory perspective, OOA in the CMA will face just the same challenges, while it is debatable whether OOA in the EEZ, or through mobile technologies, is even possible within the current regulatory framework. Even aside from the likely need for time-consuming legislative/regulatory changes, the whole sector suffers from a lack of effective strategic and spatial planning, and national guidance.

4.5 Commercial Risk

4.5.1 Insurance & Bankability

The bankability and insurance of salmon farms goes hand in hand. Without insurance, banks will be reluctant to lend. For offshore farms each risk is evaluated on its own merits and there are several factors that affect the terms and conditions that insurers might offer and, indeed, even whether insurance will be available at all.

As a general rule (based on actuary analysis) the following risks (ranked in order of severity) are seen by insurers to be most risk prone:

- Equipment failure
- Disease/fish health
- Water quality deterioration
- Human error

The insurance market for caged fish is small, and even smaller for Open Ocean cover. Many insurance companies offering fish cover have limits on the insured value. Projects in untested areas such as open ocean salmon farming in New Zealand, especially of the size proposed in this report, may stretch the capacity of insurers beyond their limits. In this case there may be some requirement for Government assistance, especially in the first few years and until a risk history is established.

Discussions with UK based underwriters note that offshore farming and the insurance of farms is not a straightforward exercise, as there is no formal definition of what is considered to be onshore and what is offshore. Some locations and conditions that one farmer would consider "rough"; another might see reduced issues.

Matters that insurers must consider include whether it is felt that a site is abnormally exposed and if boat access is likely to be limited due to adverse sea conditions and extreme wave climate. Another issue relates to the speed of the current and although some sites would be considered an acceptable insurance risk from the perspective of anticipated wave climate, strong currents may be more of an issue to the fish.

When looking at an operation that is in a very exposed location, insurers will demand to see mooring specifications and get "chapter and verse" about who designed the mooring specifications and what this is based upon. In order to be comfortable, historical data on wave height and current speed for the site, recorded over a considerable time period, would also be required. Such data would give confidence to insurers that the insured really knew what they are likely to be up against and ensure that the design of a mooring is adequate for the specific location and environment.

Insurers also noted that it is unlikely that cover would be offered for stock at a new location until cages stocked with fish had been there for a period of time and the operation had proved itself. In addition, the aquaculture insurance market is currently experiencing challenging times, with the highest number of claims being experienced for several years. All risks would be carefully assessed.

Storm damage cover is only likely to be available if the applicant can prove that all the necessary research on the site conditions has been undertaken and that the mooring and cage design has been designed and constructed to cope with what might reasonably be expected. Offshore salmon farming will have some benefits for insurers. Water quality is better in the open ocean, so there is an incentive to move out from the nearshore areas to mitigate fish losses caused by algae blooms, poor water quality and pathogens /parasites

Salmon companies with a proven farm security and animal husbandry record, who plan to farm offshore and have an existing relationship with their insurers, will likely have an advantage in securing affordable insurance.

4.6 Biosecurity

4.6.1 Overview

This section provides a succinct overview of biosecurity-related issues associated with open ocean aquaculture of marine finfish in New Zealand. The objective of this summary is to review and update information on diseases of these marine finfish species, and to summarise the current available information on potential dispersal distances for these and other infectious agents which may be relevant to offshore farming of these species in New Zealand. See supplementary Appendix I for full breakdown of biosecurity risks.

4.6.2 Ranking of Biosecurity Risks for Different Fish Groups

Salmonids

Extensive salmon farming experience in Europe (Norway, Scotland, Ireland, Iceland), North America (Maine USA, Canada), South America (Chile) and Australia (Tasmania) has identified a range of disease threats which from time to time have caused significant disruption of the culture of salmonids (mainly Atlantic salmon, *Salmo salar*) in several overseas countries[47,48,49]. Refer to Appendix I for full breakdown of diseases.

Risk scores for infectious diseases of relevance to culture of salmonids (Oncorhynchus tshawytscha, O. nerka, O. mykiss, S. salar) in New Zealand.

Diseases of salmon	Risk estimation for disease in chinook salmon	Risk estimation for disease in Atlantic salmon	Risk estimation for disease in Sockeye salmon	Risk estimation for disease in rainbow trout
VIRUSES	15	21	15	**22**
BACTERIA	21	21	21	**21**
FUNGI	2	2	2	**2**
METAZOA	6	10	8	**10**
TOTAL RISK SCORE	**53**	**64**	**55**	**65**

When the qualitative risk estimations for the various diseases listed in the table above are compared between the various species of salmonids, it is evident that viral and bacterial disease agents generally

47 Diggles BK (2011). Environmental Assessment Report – Disease Risks. DigsFish Services Report DF11-02. Prepared for NZ King Salmon 5 August 2011.

48 Diggles BK (2016). Updated disease risk assessment report- relocation of salmon farms in Marlborough Sounds, New Zealand. DigsFish Services Report DF16-01. Prepared for NZ King Salmon 7 September 2016.

49 Diggles BK (2018). Distances to consider for farm management area planning in the Marlborough Sounds. DigsFish Services Report: DF 18-03, 4 August 2018. 17 pgs.

pose the greatest risk, while chinook salmon has the lowest disease risk profile (total risk score of 53). Sockeye salmon had the next lowest disease risk profile (total risk score = 55, due to their higher risk of infection by sea lice compared to chinook salmon), while Atlantic salmon (total risk score 64) and rainbow trout (total risk score 65) had much greater disease risk scores due to increased risk of infection by viral diseases, amoebic gill disease and metazoans such as sea lice and whirling disease.

Marine Finfish

A wide range of pathogens have been recorded in a wide range of marine fish species, especially in warm water aquaculture in Asia[50,51], but also in New Zealand[52]. Refer to Appendix I for full table.

Risk scores for infectious diseases of relevance to culture of kingfish (Seriola lalandi) and hāpuku (Polyprion oxygeneios) in New Zealand[53].

Diseases of kingfish	Risk estimation for disease in kingfish	Risk estimation for disease in hāpuku
VIRUSES	10	**10**
PROTOZOA	7	**8**
METAZOA	35	**22**
Monogenea	14	**6**
Digenea	4	**3**
Crustacea	5	**5**
Myxozoa	12	**8**
TOTAL RISK SCORE	**64**	**51**

When the qualitative risk estimations for the various diseases listed in the table above are compared between kingfish and hāpuku, it is evident that for kingfish, metazoan diseases pose the greatest disease risk, contributing 35 points towards a total risk score of 64 points. For hāpuku, metazoan diseases also contribute the highest risk, however due to the relatively limited knowledge of their disease status, it is difficult to accurately assess the relative disease risk for hāpuku, which may explain the relatively low total risk score of 51 points for this species.

4.6.3 Minimum Distances for Buffer Zones

Experience overseas has found that management arrangements that allow spatial separation of different year classes of fish into independent farm management areas separated by ideal buffer zones represents world's best biosecurity practice, as this allows integrated pathogen management as well as regular synchronised fallowing of each farming area. Planning in this manner is recommended in New Zealand

[50] Sheppard M (2004). A photographic guide to diseases of yellowtail (*Seriola*) fish. Sakana Veterinary Services Ltd. 60 pgs.

[51] Tak Seng L (2014). Parasites and diseases of warm water marine finfish in floating cage culture. Chee Khoon Printing Sdn Bhd, Malaysia. 87 pgs.

[52] Diggles BK, Hine PM, Handley S, Boustead NC (2002). A handbook of diseases of importance to aquaculture in New Zealand. NIWA Science and Technology Series No. 49, ISSN 1173-0382. 200 pages. http://docs.niwa.co.nz/library/public/NIWAsts49.pdf

[53] See Appendix I for full table, definitions for risk estimations and risk scoring method. A lower risk score indicates a lower disease risk

as it would provide added protection if / when biosecurity leaks allow exotic diseases to be introduced, and/or if/when new endemic diseases emerge. Regarding disease threats to industry development, viral and bacterial diseases have caused significant disruption of the culture of salmonid and non-salmonid fishes in several overseas countries.

Data from high intensity farming of salmonids in Chile suggest buffer zones of 10-15 km are required in order to effectively manage risks from outbreaks of viral diseases and also bacterial infections. For non-salmonid fishes, infection pressure from monogeneans may reduce to background levels between 8-18 km from the source farm. For sea lice, which can infect both salmonids and non-salmonid marine fishes, modelling has suggested that their infective stages can be transported large distances (90-100 km) by currents, however in these extreme cases the viability of the infective stages is greatly reduced. The distance at which sea lice infection pressure remains significantly higher depends on various factors, but appears to be over 8-12 km and less than 30-45 km from a source farm.

The literature therefore suggests the minimum width of an ideal on-water buffer zone ("as the fish swims", not "as the crow flies") to ensure true independence of marine finfish farming management areas in New Zealand would be somewhere around 15 km. However, if sea lice outbreaks became problematic in New Zealand in the future, the width of an ideal buffer zone may need to be increased to between 18 and 45 km, with the actual minimum distance depending on detailed modelling.

The greater isolation from the coast, together with increased water depths, will inherently provide offshore aquaculture protection against many diseases of concern (by dilution and disruption of multi-host parasite lifecycles). Nevertheless, biosecurity planning for offshore aquaculture in New Zealand should emphasise prevention through use of vaccination for microbial diseases, and to reduce reliance on chemical treatments, seacage barrier/submerged cage technology combined with integrated pathogen management should be adopted to reduce impacts of parasitic infections from sea lice and monogeneans. Provision of appropriate buffer zones between farming areas is a critical biosecurity management consideration, given that new endemic diseases could emerge in finfish aquaculture in New Zealand at some time in the future, as well as the ever present, but unquantifiable, risk of biosecurity leaks that could allow exotic disease incursions to occur[54,55,56].

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[54] Diggles BK (2011). Environmental Assessment Report – Disease Risks. DigsFish Services Report DF11-02. Prepared for NZ King Salmon 5 August 2011.

[55] Diggles BK (2016). Updated disease risk assessment report- relocation of salmon farms in Marlborough Sounds, New Zealand. DigsFish Services Report DF16-01. Prepared for NZ King Salmon 7 September 2016.

[56] Diggles BK (2018). Distances to consider for farm management area planning in the Marlborough Sounds. DigsFish Services Report: DF 18-03, 4 August 2018. 17 pgs.

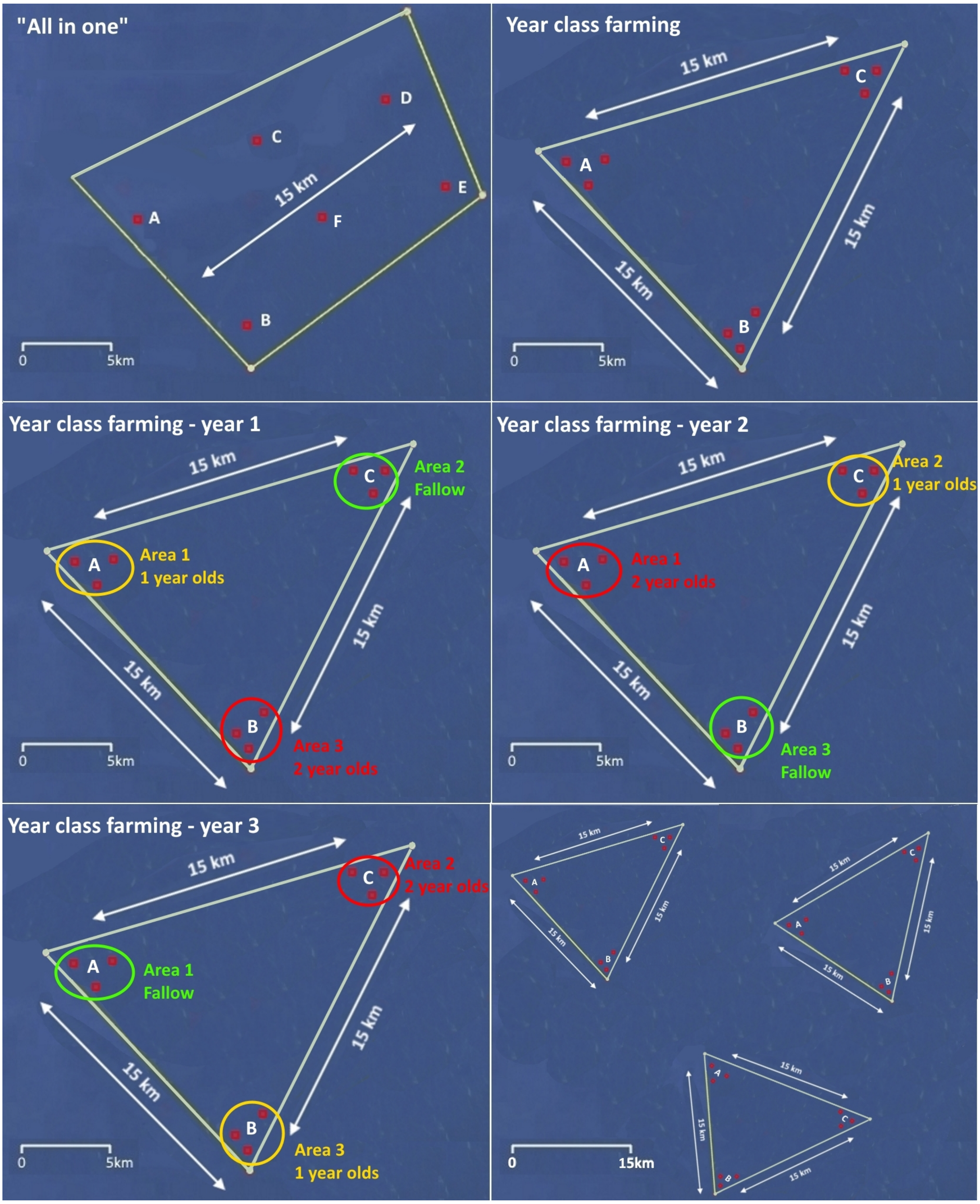

Figure 20. Diagrams showing relative biosecurity risk

Notes to above figure:

The diagrams show the difference between the least biosecure "all in one" farming model (upper left), compared to a year class model (upper right) which has the same number of active cages within a similar area, but separates fish into different year classes with ideal (15 km) buffer zones between year classes. This design allows integrated management of the various year classes and regular fallowing (middle 3 diagrams). Different companies can farm in the same geographic region if each farm area is also separated by ideal buffer zones (lower right).

4.6.4 Differences in Biosecurity Risk between Chinook and Atlantic Salmon

When the qualitative risk estimations for the disease agents of salmonids are compared between chinook and Atlantic salmon, it becomes apparent that chinook salmon has the lowest disease risk profile (total risk score of 53), due mainly to their resistance to amoebic gill disease (AGD), sea lice infections. In contrast, Atlantic salmon are well known to be highly susceptible to many viruses, particularly the OIE listed ISAV, and also are affected by both sea lice and AGD (see supplementary Appendix I). Given the high risk score for diseases of Atlantic Salmon, the introduction of new Atlantic Salmon genetic stock from overseas is not recommended, due to the inherent risk of importing several exotic diseases.

4.6.5 Use of Treatments for Farmed Finfish

While the treatment of farmed finfish is commonplace in the industry overseas, this practice is not undertaken in New Zealand, because of our largely pathogen-free marine environment. Nevertheless, this section covers off the primary considerations when it comes to treating for disease in farmed finfish, and how this relates to OOA.

Treatments of diseases of seacage farmed fish is a controversial subject, due to issues related to development of microbial resistance to antibiotics[57] and parasitic (sea lice) resistance to drugs such as delousing agents[58]. Indeed, widespread use of vaccination against major viral and bacterial disease agents has resulted in massive reductions in antibiotic use and massive increases in production in several major salmon farming regions including Norway, Scotland and North America. In Norway, for example, development of effective vaccines led to an approximate 99.8% decrease in antibiotic use (compared to 1987[59]) and increased production now exceeding 1 million tonnes of salmon per year, while using <0.17 grams of antibiotics per tonne of production. In contrast, in Chile antibiotic use has increased in recent years and in 2016 the salmon farming industry used around 0.53 kg of antibiotics per ton of harvested salmon[60].

The appropriate model for New Zealand to adapt is the Norwegian / Scottish / North American model, hence pathogen management strategies for open ocean finfish aquaculture should strongly emphasise development of vaccines to combat viral or bacterial disease issues that may arise in New Zealand waters.

One key aspect to be considered with respect to treatment of finfish farmed in offshore cages is that their greater isolation from the coast, together with the deeper water depths at which the cages are anchored, will inherently provide greater protection against many diseases of concern. This is because of the better water quality offshore, together with the fact that the larger populations of wild fishes in shallower inshore areas act as reservoirs of infection and vectors for disease introduction into seacages[61,62]. Because of this, offshore location of seacages is likely to reduce the risk of outbreaks of many viral, bacterial, protozoan and metazoan disease agents.

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[57] Sitjá-Bobadilla A, Oidtmann B (2017). Chapter 5 – Integrated Pathogen Management Strategies in Fish Farming. In: Jeney G (ed), Fish Diseases Prevention and Control Strategies, Academic Press, pp. 119-144.

[58] Aaen SM, Helgesen KO, Bakke MJ, Kaur K, Horsberg TE (2015). Drug resistance in sea lice: a threat to salmonid aquaculture. *Trends in Parasitology* 31: 72-81.

[59] Sitjá-Bobadilla A, Oidtmann B (2017). Chapter 5 – Integrated Pathogen Management Strategies in Fish Farming. In: Jeney G (ed), Fish Diseases Prevention and Control Strategies, Academic Press, pp. 119-144.

[60] Miranda CD, Godoy FA, Lee MR (2018) Current status of the use of antibiotics and the antimicrobial resistance in the Chilean salmon farms. *Frontiers in Microbiology* 9: 1284.

[61] Dempster T, Uglem I, Sanchez-Jerez P, Fernandez-Jover D, Bayle-Sempere J, Nilsen R, Bjørn PA (2009). Coastal salmon farms attract large and persistent aggregations of wild fish: an ecosystem effect. *Marine Ecology Progress Series* 384: 1-14.

[62] Uglem I, Dempster T, Bjørn PA, Sanchez-Jerez P, Økland F (2009). High connectivity of salmon farms revealed by aggregation, residence and repeated movements of wild fish among farms. *Marine Ecology Progress Series* 384: 251-260.

Furthermore, it has been proven that moving seacages to deeper water can provide up to tenfold reduction in risk of infection by some important and problematic parasites such as blood flukes and sea lice[63].

4.7 Impacts & Stakeholders

A detailed overview of the environmental and stakeholder impacts relating to OOA is outside the scope of this business case. A brief review of the main considerations is set out below[64], however, due to the uncertainties and risks associated with the unquantified impacts of fish farming activity in the open ocean are unknown, we recommend further investigation and analysis of the cost implications for stakeholders to provide a more complete analysis for stakeholders and potential investors.

4.7.1 Environmental Considerations

OOA requires scale in order to be economic. However, it is equally important that farming activity at scale is balanced with suitable approaches to managing the environmental impact. The approach to developing environmental management strategies for open ocean farming can be divided into four core areas:

1. Identifying locations that will minimise the interaction / overlap with maritime navigation, fishing activity, significant natural environments and conservation areas, and fauna such as marine mammals and seabirds.
2. Applying recognised standards that determine the operating parameters for marine farms.
3. Consistent monitoring of environmental conditions against the agreed standards.
4. Including accommodating consent conditions that enable swift action to take place when required.

Seabed Impacts

The dynamic hydrological conditions found in offshore environments are expected to provide for better waste dispersal capabilities than many of the inshore locations currently used for fish farming, providing a distinct advantage for limiting / mitigating seabed effects. Although the production increases expected through OOA will be significant (significant feed inputs are required), there is a lot of uncertainty around the extent of the impacts this could have on the deepwater benthic environment (the extent of the impact may depend on the type of species present on the sea floor, and the water current speed at various depths, among other factors). A summary of the potential issues and their effect on the seabed for an OOA finfish farm is given below[65].

[63] Kirchhoff NT, Rough KM, Nowak BF (2011). Moving cages further offshore: Effects on southern bluefin tuna, *T. maccoyii*, parasites, health and performance. *PLoS ONE* 6(8): e23705. doi:10.1371/journal.pone.0023705

[64] These considerations incorporate many of the details included in the recently submitted NZ King Salmon OOA Application.

[65] Sourced from NZ King Salmon OOA application. Assessment of Environmental Effects report.

Potential issues and their effect on the seabed.

Activity	Implication	Consequences
Mooring Installation	Destruction and smothering of habitats and benthic organisms	The installation of each screw anchor is likely to result in the displacement of epifaunal and infaunal taxa in areas immediate to anchor sites. There will be small-scale resuspension and settlement of fine particulates, which will likely occur over a relatively short time frame (hours) with minimal impact due to the high currents that will rapidly disperse the sediment. Recovery of organisms will take place immediately after disturbance, but for sensitive or slow-growing taxa, recovery back to existing state could take up to several years in affected areas.
Presence of Structures	Biodeposition changes the composition of benthic communities.	Colonisation of the anchor warps by hydroids and/bryozoans may occur. Some drop-off of these organisms to the seabed is expected from the pen structures. This may result in the colonisation of the seabed by these taxa. The difference in the light environment between the pen depths and the seabed depth is likely to limit the ability of algae to colonise the seabed. The effect will persist for the farm duration but recovery to community will occur in a moderate timeframe if the farm is removed.
	Shading by marine structures reduce food availability.	Shading can block sunlight from reaching the seabed, potentially causing a reduction in food availability for some organisms. Although this can lead to mortality of photosynthetic organisms at shallower sites, this is unlikely to occur at deeper sites as there are few / no photosynthetic taxa living there.
Farm Operations	High nutrient loading.	Possible increase in algal abundance due to increased nitrogen and phosphorus availability. Very unlikely to be an issue at sites with limited light penetration to seabed already inhibiting algal growth, and breakdown processes in the water column.
	Elevated predation on benthic organisations.	Biodeposition of both fouling organisms and feed / faeces may encourage aggregation of scavenging and / or predatory organisms. This could cause potential displacement of prey species.
	Alteration to epifaunal communities.	Depending on the level of deposition, communities may have an enhanced food supply effect, through to eventual displacement. Population level effects may also occur through sub-lethal effects such as reduced reproductive success or larval settlement and recruitment. *The tolerance of ecologically important and/or sensitive habitats (horse mussels and brachiopods) to farm-related enrichment is not well known. The dispersal of farm waste into the far field from highly dispersive sites is not well understood.*

Activity	Implication	Consequences
	Depletion of oxygen near to the seabed.	At excessive enrichment levels, where organic matter accumulates on the seabed, respiration from the breakdown of organic matter can lower oxygen levels. This can cause stress to biological communities.
	Alteration to infaunal communities.	Increased particulate organic matter from uneaten feed and faeces provides an additional food source and changes in sediment conditions for infaunal communities. A gradient will be present, where the effect will decrease with increasing distance from the farm to the edge of the depositional footprint. Recovery of most taxa will be on the order of several months, but for more sensitive or slow-recruiting taxa, infaunal communities would be on the order of years following the removal of the farm. *The dispersal of farm waste into the far field at highly dispersive sites is not well understood.*
	Accumulation of contaminants.	Metals and other contaminants from feed/substances used on farm can deposit on the seafloor. These compounds can accumulate in the sediments to levels that can cause toxic, sublethal effects on biota (e.g. zinc from feed and copper from antifouling). Toxic concentrations unlikely at dispersive sites, but elevated concentrations may persist in sediments for the duration of a farm, and for several years after farm has been removed. *The fate of therapeutants and toxic effects from contaminants are not well understood.*

Water Column

A summary of the issues and their potential effect on the water column for an OOA finfish farm is given below.

Issues and their potential effect on the water column.

Issue	Potential Effect
Nutrient Loading	Increased concentrations of dissolved nutrients (e.g. nitrogen, phosphorus) can enhance phytoplankton growth beyond background environmental levels. Phytoplankton blooms can be toxic, and may contribute to a reduction in oxygen concentrations, creating stress for the fish.
Artificial Lighting	Although likely to be highly localised, artificial lighting may attract phototaxic organisms, leading to changes in the vertical migration patterns and benthic settlement of planktonic organisms.
Low Oxygen Levels	High concentrations of fish can lead to highly localised reductions in oxygen saturation. Deep water with high flush rates can be used to mitigate the severity of low oxygen conditions.

Marine Mammals and Seabirds

Aquaculture may impact marine mammals through an overlap between the farming operations and the migration routes and / or habitat use for that species. It is anticipated that the primary effects of an OOA activity taking place in New Zealand would include potential habitat displacement (including exclusion from feeding areas) and entanglement risk. Other secondary impacts may include high underwater noise (generated from vessels), trophic flow on effects (arising from additional nutrient availability), and artificial light.

Although it is likely impossible to eliminate the risk of large floating structures typically used for finfish farming, the overall risk profile for farms is low. However, the severity of the consequences of an event occurring (e.g. entanglement) should warrant forethought and the development of appropriate mitigations. Current inshore marine farms are required to have a Marine Mammal Management Plan (**MMMP**) prior to starting operations. A MMMP provides suggested best management practices for the operation of ocean farms that may help reduce the risk of a negative interaction with marine mammals and limit the potential consequences. This measure is also recommended for any OOA developments in New Zealand.

An in-depth analysis of risks / impacts to seabirds posed by OOA is beyond the scope of this report, however, we have included a summary of the considerations that should be included when choosing a location for an open ocean farm. It should be noted that a site-specific analysis of seabird presence is required for any consenting processes in order to meaningfully determine the potential impacts of an OOA operation to seabirds.

Seabirds can be affected by 'feed-added' fish farms in the following ways[66]:

- Habitat exclusion
    - Enclosed farms will prevent seabirds from foraging in the enclosed area. However, it may not exclude diving birds (e.g. penguins) from feeding underneath a farm. The space occupied by an OOA farm is likely to comprise a very small proportion of the overall foraging area of many seabirds, therefore the anticipated impacts will be negligible.

[66] Sourced from Appendix H (Contract Report No. 4594) of the NZ King Salmon Application for Resource Consent for an Open Ocean Salmon Farm.

- Smothering of benthos
  - The smothering of the benthic environment may change the availability of prey species to seabirds – particularly those that feed on or near to the seafloor (e.g. penguins). OOA farms located in deeper water (100m<) may eliminate this issue since most seabird's maximum foraging depth is relatively shallow.
- Changes in abundances of prey
  - Fish farms are likely to attract wild fish through the fish feed availability (although pellet loss is generally low in New Zealand (0.3% of feed supplied[67])), biofouling on cage structures, and submerged lighting. The extent to which fish are attracted to marine farms is difficult to predict, however, it is assumed that if aggregations occur with some regularity, it is likely fish-eating seabirds will also be attracted. The attraction of prey species to OOA farms may have a positive impact on seabird species through enhancement of food availability.
- Provision of roosts
  - Seabirds may use OOA farm infrastructure for roosts (roost provision is generally considered a positive effect). However, roost provision may serve to enable seabirds to remain onsite for longer, and therefore increase their exposure to other farm-related risks (e.g. entanglement, collision etc).
- Disturbance
  - Farming activity has the potential to disturb seabird behaviours such as foraging or breeding. Disturbance issues arising from OOA farms are expected to be minimal. This is because farms are likely to comprise a very small proportion of seabird foraging grounds, and open ocean farms will not be located near breeding colonies.
- Ingestion of foreign objects
  - Foreign objects (predominantly plastics) are known to be consumed by seabirds that may mistake the item as prey. Plastic waste consumption can be lethal, and may have sub-lethal effects. Small plastic waste items from fish farm operations are likely to comprise only a small proportion of the overall volume of anthropogenic debris, however it still poses a risk (level of risk is unknown).
- Collision with marine farm structures.
  - The risk of collision with marine farm structures could potentially affect any seabird species. Seabirds typically collide with artificial structures / vessels during foraging; this risk is generally higher in the commercial fishing industry. However, the level of risk is affected by the following factors:
    - The amount of lighting (and brightness / intensity) required to ensure visibility of a farm at night to vessels.
    - The what extent seabird species are attracted to light.
    - The foraging nature of the seabird species (whether it forages at night or day).
    - The extent to which the marine farm acts as a source of food for seabird populations.
    - The size, height, and visibility of the farm structure.
- Entanglement.
  - Drowning by entanglement has the greatest potential significance for seabirds out of these possible effects from OOA farms. Entanglement can occur in the fish holding nets,

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[67] Figure quoted from a NIWA study into feed loss at NZ King Salmon farms. Sourced from Appendix H (Contract Report No. 4594) of the NZ King Salmon Application for Resource Consent for an Open Ocean Salmon Farm.

the underwater predator fence / net, and in the above water bird net. The design of the farm infrastructure (type and number of nets) therefore has the potential to significantly alter the risk level. The size of the impact is dependent on the location of the farm, the susceptibility of the species in question (i.e. to what extent are they attracted to the farm), and the population status.

4.7.2 Stakeholder Impacts

Commercial Fishing

The impact of OOA on commercial fishing interests will be highly dependent on the location of the farm(s). Overlap with prime fishing grounds will likely mean that an offshore aquaculture operation won't go ahead. Fisheries New Zealand (**FNZ**)[68] assesses the effects of a proposed marine farm on fishing through the Undue Adverse Effects (**UAE**) test. FNZ cannot consider effects on the enjoyment of fishing or whether a marine farm would affect views while fishing. This means that the UAE test is limited to the effects on the practicalities of catching, taking and harvesting fish. The outcome of the UAE test is called an aquaculture decision. The aquaculture decision determines whether the permit for marine farming is confirmed, thereby allowing the farm to go ahead. A proposed marine farm cannot be developed if it would have undue adverse effects on recreational, customary, or commercial fishing (unless the applicants makes an aquaculture agreement with quota holders). When assessing effects under the UAE test, the following matters are considered:

- the location of the proposed farm in relation to fishing areas
- the likely effect of the proposed marine farm on fishing, including the proportion of any fishery that would be affected;
- how much the proposed farm would exclude fishing;
- whether an affected species could be fished in other areas;
- how much the proposed marine farm would increase the cost of fishing;
- the cumulative effect on fishing of any authorised aquaculture.[69]

Shipping & Navigation

Maritime NZ ensures international obligations are met through a specific approval process for aids to navigation. Under section 200(7) of the Maritime Transport Act 1994 (**MTA**), no person may erect, place, alter or remove a 'navigational aid' without the approval of the Director of Maritime NZ (the Director). This applies irrespective of the owner. In some parts of New Zealand, the MTA section 200(7) power to approve aids to navigation has been delegated to named harbourmasters in relation to aids to navigation for marine farms. Section 200(2) of the MTA provides that the operator of any marine farm is responsible for providing and maintaining aids to navigation for the facility. An OOA operation is likely to affect at least three different types of vessel transit routes by virtue of its location, as well as the associated movements of relevant vessels (e.g. wellboats). These include:

- Inshore coastal routes
- Coastal transit routes
- Offshore transit routes

The risks to navigation are likely to be the risks or hazards to marine craft and vessels, associated maritime activity (e.g. commercial fishing), and the hazards to farm staff from vessels operating in close proximity. Although there will always be some degree of risk, the overall risk level are expected to be

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[68] Fisheries New Zealand (FNZ) is a division of Ministry for Primary Industries (MPI).

[69] Refer section 186G Fisheries Act 1996: Fisheries New Zealand (2018) *Growing and Harvesting: The Undue Adverse effects test*. Retrieved form https://www.mpi.govt.nz/growing-and-harvesting/aquaculture/setting-up-a-marine-farm/undue-adverse-effects-test/

low for an OOA operation (depending on the location) provided a site-specific risk management plan is developed, as well as the implementation of appropriate measures to mitigate risk, these may include:

- Navigational markers.
- Orientation of the farm parallel to vessel traffic flow.
- Ensure visibility of the farm (e.g. using lighting system).
- Locating the farm outside of primary transport routes.
- Ensuring regular maintenance of farming structures and navigation aids.

Tourism

There are relatively few tourism operations that occur in the open ocean environment. A site-specific analysis on the impact of OOA on tourism activities will be required for any resource consent application. This section provides a high-level overview of the potential tourism activities and the potential impact that OOA could have:

Tourism Activity	Potential Impact
Cruises / Cruise ships	OOA may pose a navigational hazard to the movement of cruise ships in the open ocean environment. The risk to cruise ships is likely to be highest in primary shipping channels and around major ports, which are unlikely to be chosen as locations for OOA regardless. The overall risk posed to cruise ships is expected to be low provided the farm(s) applies the appropriate mitigation measures as described in the section above.
Wildlife Watching	OOA could affect wildlife watching tourism through several ways; generally, these effects are viewed negatively. The potential impacts are outlined below: • Displacement of wildlife (e.g. whales / seabirds) from traditional habitat – potentially to areas inaccessible to tourism operators. • Impact the natural character (e.g. visual) of the oceanic environment, therefore reducing the enjoyment factor for tourists. • Through attracting prey species, some wildlife may be attracted to new areas. Although this could be viewed positively if tourism ventures are enhanced by greater exposure to wildlife. • Wildlife is disturbed by marine farming activities, resulting in unnatural behavioural changes that reduce the 'wildness' of the tourism experience.
SCUBA Diving	Most SCUBA diving tourism operations are located in sheltered coastal waters around the mainland or on outer islands. This is due to two main factors: 1. The best dive sites are generally located in relatively shallow, biodiverse coastal areas. 2. It is more time and cost effective for dive operators to operate near to shore. Nevertheless, some SCUBA diving takes place in open ocean 'blue water' environments[70]; generally, this type of diving is undertaken to observe pelagic species.

[70] Mid-water conditions where the bottom is out of sight of the diver and there may be no fixed visual reference.

	OOA is expected to have minimal impact on SCUBA tourism, simply by virtue of being located further out to sea marine farming activities will avoid most dive operators. The effect of OOA on open ocean diving is likely to be inherently linked to some of the aforementioned impacts to marine mammals in 4.7.1, however the extent to which diving activities may be affected is unknown.
Sport Fishing	Sport fishing operators utilise the open ocean environment around New Zealand. These charter fishing vessels target primarily pelagic and / or deep-water demersal species, requiring operators to travel beyond the shallow coastal zones to access the fishing grounds. The impact of OOA on sport fishing activities is unknown. Given the proportion of potential fish habitat, or a total fishery, that may be occupied by a fish farm, the likelihood of sport fishing charters being significantly impacted (e.g. prevented from accessing fishing grounds) is low (i.e. no material impact on their ability to catch fish). OOA farms may pose a navigational hazard to sport fishing vessel operators (the types of general navigation hazards / impacts are detailed in the section above), however, provided that appropriate navigational aids are provided, it is unlikely that a structure will pose any significant issue to this user group.

General Public / Recreational Users

The regulatory situation for sea cage farming has become complex and led to limited inshore water space consented for salmon farming activity in New Zealand. Aquaculture requires public water space in which to operate and there are increasing competing interests for the use of water space especially within the inshore areas. Increasing population pressures in areas considered of low use and value when farms were originally consent in 1970's have attracted more attention at renewal, due to land subdivision and the building of holiday homes in areas not previously populated. The land use has changed, as have the number of users and their values attached to these areas. This phenomenon when linked with increasing summer temperatures in the Marlborough Sounds has contributed to greater interest in transitioning to open ocean aquaculture.

The impact of OOA on recreational users of the marine environment is anticipated to be low, both within the 12nm limit and beyond. Areas that will be suitable for fish farming are likely to be located away from zones where there is high public use of the marine environment. The location of open ocean farms away from the nearshore environment is driven, in no small part, by the high competition with the public for access to coastal marine resources.

The recreational user group most likely to be impacted by an OOA operation will be amateur fishers who utilise private vessels to access open ocean fishing grounds. The level of impact will be strongly tied to the location and productivity of fishing grounds. Given the anticipated distance from shore for OOA activities, any recreational fishing grounds that far out will have to outperform (i.e. be more productive) than any nearshore fisheries in order to attract recreational fishers. In any case, if productive fisheries do exist that far out, it is likely that there will be greater competition with commercial fishing operations rather than recreational.

It should be noted that in general, coastal / nearshore marine farms are well-regarded by the fishing community for their productivity, often supporting significant numbers of fish that are targeted by recreational fishers. This is particularly evident around the marine farms in the Coromandel. It is uncertain whether OOA will enhance recreational fishing success in the same manner as the existing coastal farming industry, and further investigation is required.

Limits on public access to open ocean farming would only be to the extent necessary for the safe and efficient operation of the farm(s). The placement of farming structures in the open ocean will still allow for safe access around the operation. Given the extent of open ocean environment around New Zealand, the exclusive occupation zone of a farm (or multiple) will be insignificant. The consenting process for any proposed OOA enterprise will require the applicant to demonstrate that they have considered the potential impact of an operation on the public (e.g. exclusion of recreational fishers), and that the impact will be minimal.

4.7.3 Māori Aquaculture Interests

A number of iwi, particularly those in regions where traditional, inshore aquaculture is well-established, have indicated an interest in exploring offshore opportunities. Te Ohu Kaimoana Trustee Limited (trustee of the Māori Commercial Aquaculture Trust) and Fisheries New Zealand have initiated some engagement with iwi on what those opportunities might look like, and what challenges come with them. Key among these is the fact that offshore aquaculture is, and will be, a capital-intensive undertaking. Even when the activity occurs within the coastal marine area and is subject to the Māori Commercial Aquaculture Claims Settlement Act 2004 – so that iwi in the relevant region receive some settlement assets in respect of it – settlement entitlements alone are unlikely to put iwi in a position where they can participate in the commercial undertaking in a significant way.

The existing mussel farm offshore from Ōpotiki demonstrates this challenge. Although iwi in the region received assets equivalent to the value of 20% of the resource consents under which the farm operates, the value of those entitlements is dwarfed by the recent announcement of almost $80M in Government funding for infrastructure to support the farm. Open ocean finfish farming will have different infrastructure needs, but the example highlights the way in which the level of investment required far outstrips that generally available to iwi.

For open ocean aquaculture in the EEZ (or through non-traditional mobile technologies), the challenge to iwi participation is even more stark. Without the assistance of settlement entitlements, iwi aspirations to participate in developments may well be limited by their capacity to invest in capital intensive and somewhat untested ventures.

4.8 Climate Change Considerations

An in-depth analysis of the risks and impacts of climate change on a hypothetical OOA operation is beyond the scope of this report, however, this section provides a high level overview of the key considerations for potential investors who may look to establish finfish farms in the open ocean around New Zealand.

Climate change presents a significant threat to New Zealand aquaculture; however, it is difficult to predict the severity and type of potential impacts both for inshore and open ocean aquaculture. Future climate projections are generally at a coarse scale (e.g. global), and often reflect long-term global or regional averages[71] (Figure 21 shows sea surface temperature trends around New Zealand over the last ~40 years). Although analysis of global trends can be useful, these resolutions may not capture the complexity of finer-scale zones where aquaculture activities are located, and subsequently do not accurately represent the specific environmental variabilities that the culture stock are subjected to. Therefore, it is important that finer-scale data is collected in order to make well-informed aquaculture management and planning decisions.

Some of the potential effects of climate change that affect the aquaculture sector include:

- Increased seawater temperature, leading to:
    - Toxic algae blooms
    - Lower oxygen concentrations
    - Elevated microbial activity

[71] Falconer, L., Hjøllo, S. S., Telfer, T. C., McAdam, B. J., Hermansen, Ø., & Ytteborg, E. (2020). *The importance of calibrating climate change projections to local conditions at aquaculture sites.* Aquaculture, 514, 734487.

    - Direct mortality of cold-water tolerant species (e.g. salmon).
    - Increased stratification of the water column
- Increased ocean acidity (lower p.H).
- Changing distributions / prevalence of pests and diseases.
- Reduced availability of lower-trophic fish species that are used to create fish feed for higher value species.

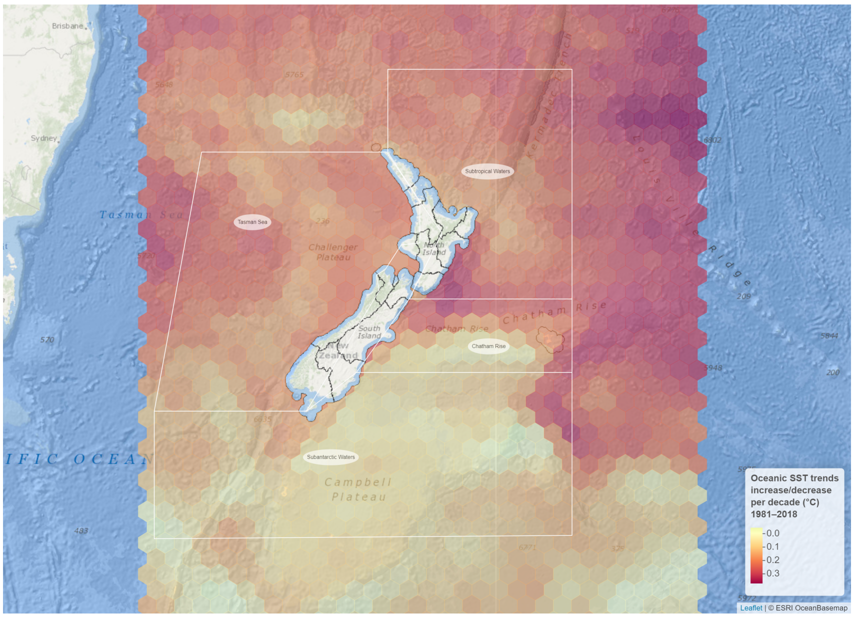

Figure 21. Oceanic sea surface temperature trends around New Zealand (1981 - 2018).

Source: Stats NZ.

New Zealand's largest salmon producer, NZ King Salmon Ltd already undertakes environmental monitoring at each of its ocean-based farms, providing high resolution data specific to each farming operation. The NZ King Salmon Annual Report (2019[72]) notes that *"three of the last five summers have seen record high water temperatures. While last summer wasn't quite as hot as the all-time record of the year before, the effects of the summer carried on well into April, impacting the survival of our salmon"* (see Figure 22).

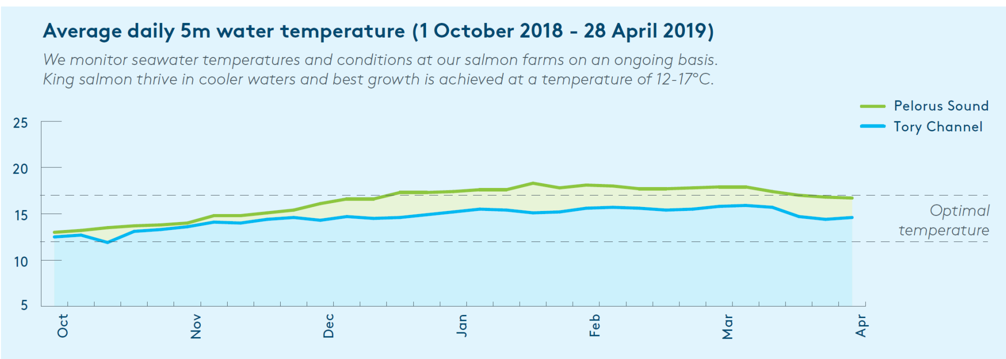

Figure 22. Surface seawater temperature records at Marlborough Sounds salmon farms (2018-2019).

Source: NZKS Annual Report 2019.

[72] https://www.kingsalmon.co.nz/investors/announcements/nzk-annual-report-2019/

The significance of climate change to the existing inshore salmon farming industry cannot be understated. The integration of climate change-centric management approaches and measures (e.g. moving farms away from warmer inshore areas) is becoming increasingly common in the sector. This is reflected to an extent by the recent NZ King Salmon consent application to farm salmon in the colder waters of Cook Strait; this application enables the company to adapt to the effects of climate change which it has already experienced, and insulate itself from future issues arising from warmer coastal water temperatures.

The movement of fish farming offshore is seen as a realistic, proactive and practical measure for the industry to address the challenges associated with climate change, alongside other responses such as a single year class production model to enhance stock resilience during the summer period, and improved biosecurity management. Although the open ocean environment is generally considered more stable, and therefore at lower risk to climate change effects, close monitoring of the sea conditions around future OOA operations will be crucial in order to better understand how changes in the oceans will impact the future of fish production.

> **"The five Goals being focused on are: decent work and economic growth, *climate action*, good health and well-being, responsible consumption and production, and life below water."**
>
> – NZ King Salmon Annual Report 2019.

5 Conclusions

Farmed salmon offers a very compelling environmental and human health story by comparison with other farming systems in New Zealand. Farmed salmon has a very low carbon footprint, low water use and low 'land use' from input of raw materials compared to all other animal farming systems. Farmed salmon are a very healthy choice for consumers offering significant health benefits over other animal protein sources. These two factors mean that there is and will continue to be a growing demand for farmed raised salmon for the foreseeable future. Moving offshore is essential for the growth of the industry as this enables the capitalisation of the natural ocean environment. RAS systems are unlikely to be an effective solution in New Zealand as the cost of the systems will be high, and one of the offsetting costs is by locating these systems close to the market to reduce costs and time associated with moving fish to the end customer. Growing fish in OOA systems is likely to have a big payback in terms of fish health benefits (mostly associated with lower temperature rearing), as well as creating greater scale. This type of approach would allow New Zealand to continue to claim more 'natural' farming rather than very high density on-land RAS systems, providing an advantage on international markets.

Technologies being investigated include semi-closed systems to increase production in the existing sheltered coastal ribbon, land-based systems using RAS technology and offshore systems that can exploit much more energetic open ocean locations. For offshore technologies there are two main categories. The first is more robust 'existing' net pen technology that can withstand greater wave action (up to H_s 6.0m). This type of system requires some shelter from genuine open ocean conditions and is still exposed to the same fish health challenges that farms in more sheltered locations experience. However, the capital cost is not excessive compared to existing technologies and the farmer benefits from economies of scale because each site is larger.

The capital cost of the new technologies that can operate in more exposed locations is much higher. For these to be successful they must offer a 'health benefit' that will offset the additional capital and operating costs associated with moving offshore. The economic performance of these new technologies is not yet established. In parallel to the development of offshore technologies is the development of on land RAS production systems and coastal ribbon semi-closed systems. These systems may be used to reduce the production time in existing farms and/or to grow fish through to harvest size.

Semi-closed systems will have lower capital costs than offshore systems and RAS systems. They will have higher operating costs (especially energy costs and waste treatment costs) than traditional cage systems. But they will offer a significant health benefit for the fish that may off-set these costs. The future for salmon farming is bright. Consumer demand for the product is high and the environmental case is strong. Farming systems need to change to accommodate the increasing demand as the existing coastal ribbon is at or near capacity. It is likely that there will be a mix of the traditional (existing) farming systems, more exposed systems using more robust existing technology, genuine offshore farming technologies, semi-closed farming systems and RAS systems. At this stage what will emerge as the dominant production technology for the next 20 years is not clear. Over the next 5 years there will be significant progress made in all these different systems and much more robust information to determine what the shape of the industry will be.

New Zealand's competitive advantage is its natural marine environment. New Zealand is far away from the large salmon markets – so RAS systems will be less attractive proposition in this region (unless it is to support more traditional farming systems by reducing the 'at sea' growing time). To take advantage of the marine environment, developing offshore technologies with more robust existing technology and with genuine offshore technology will be important and should get significant focus. This focus should address the technologies that are best suited in the New Zealand context and the regulatory framework to support the industry in these new farming areas.

Financial Summary

To calculate the cost of developing an OOA farm, we have assumed that each consent application, and subsequent development, will be undertaken to grow 10,000t of Chinook Salmon. It is assumed that the OOA farms developed will be completely independent of each other and will not rely on any existing aquaculture infrastructure that is privately owned.

Each 10,000t operation requires approximately $188m of capex (real) to set-up and the annual operating cost when fully operational equates to $124m (real) excluding additional processing costs from transitioning into high value products. The annual revenue from such an operation is estimated to be $181m (real) per annum when fully established / 11 years after the consent application is initiated. The base case assumptions that were considered conservative resulted in an IRR of 12% and a payback period of 17 years. When more aggressive assumptions were applied (such as increased sale price growth and lower cost assumptions) the IRR increased to 19% with a pay-back period of 14 years.

The investment metrics and analysis, despite being at a high level, does suggest that open ocean aquaculture is a commercial opportunity that the private sector may be interested in. It is likely that the biggest commercial hurdle is the time it takes to set-up an open ocean operation. From the date of first investment it is estimated that it will take approximately 9 years before any revenue is generated and that is dependent on various assumptions that are highly unpredictable. As such, the risk profile associated with such an investment is very high.

The financial analysis undertaken considered the performance of one consent application and the performance of multiple consent applications (which generated a view of the potential industry). The key metrics associated with each of these scenarios are provided below.

Financial Summary

<table>
<tr><th colspan="9">1 FARM</th></tr>
<tr><th rowspan="2">Supply chain stage</th><th rowspan="2">Production volume (tonnes/smolts)</th><th rowspan="2">Revenue, NZ$m p.a. at a fully operational mode</th><th rowspan="2">Total direct investment required (NZ$m)</th><th colspan="2">Jobs created, FTEs</th><th rowspan="2">Value of jobs created, NZ$m</th><th rowspan="2">Contribution to GDP, NZ$m</th><th rowspan="2">Potential exports, NZ$m</th></tr>
<tr><th>High skill</th><th>Low skill</th></tr>
<tr><td>Hatchery/nursery</td><td>2.6m smolts</td><td></td><td></td><td rowspan="3">39% of jobs</td><td rowspan="3">61% of jobs</td><td rowspan="3">Construction: $73m
Ongoing: $604m
(Income returned,
PV at 6%)</td><td rowspan="3">Construction: $827m
Ongoing: $6bn
(PV@6%)</td><td rowspan="3"></td></tr>
<tr><td>OOA farm</td><td>10,000t</td><td></td><td></td></tr>
<tr><td>Processing</td><td>9,000t</td><td>$181m (real)</td><td>$188m (real) capex</td></tr>
<tr><td rowspan="5">Total</td><td rowspan="5">N.A.</td><td rowspan="5">$181m (real)</td><td rowspan="5">$188m (real) capex</td><td colspan="2">Construction:</td><td rowspan="5">$604m</td><td rowspan="5"></td><td rowspan="5">98%-100% of revenue</td></tr>
<tr><td>410</td><td>2,160</td></tr>
<tr><td colspan="2">Ongoing</td></tr>
<tr><td>640</td><td>3,375</td></tr>
<tr><td colspan="2">Per year (at max, total employment across economy).</td></tr>
<tr><th colspan="9">MULTIPLE FARMS</th></tr>
<tr><th rowspan="2">Supply chain stage</th><th rowspan="2">Production volume (tonnes/smolts)</th><th rowspan="2">Revenue, NZ$m p.a. at a fully operational mode</th><th rowspan="2">Total direct investment required (NZ$m)</th><th colspan="2">Jobs created, FTEs</th><th rowspan="2">Value of jobs created, NZ$m</th><th rowspan="2">Contribution to GDP, NZ$m</th><th rowspan="2">Potential exports, NZ$m</th></tr>
<tr><th>High skill</th><th>Low skill</th></tr>
<tr><td>Hatchery/nursery</td><td>28.6m smolts</td><td></td><td></td><td rowspan="2">39% of jobs</td><td rowspan="2">61% of jobs</td><td rowspan="2">Construction: $512m</td><td rowspan="2">Construction: $827m</td><td rowspan="2"></td></tr>
<tr><td>OOA farm</td><td>110,000t</td><td></td><td></td></tr>
</table>

<table>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td>Processing</td><td>99,000t</td><td>$1,994m (real)</td><td>$2,068m (real)
capex</td><td></td><td></td><td>Ongoing: $3.0m
(Income returned,
PV at 6%)</td><td>Ongoing: $6bn
(PV@6%)</td><td></td></tr>
<tr><td rowspan="5">Total</td><td rowspan="5">N.A.</td><td rowspan="5">$1,994m (real)</td><td rowspan="5">$2,068m (real)
capex</td><td colspan="2">Construction:</td><td rowspan="5">$815m
(at max)</td><td rowspan="5">$6.8bn
(PV@6%)</td><td rowspan="5">98%-100% of revenue</td></tr>
<tr><td>1,520</td><td>2,380</td></tr>
<tr><td colspan="2">Ongoing</td></tr>
<tr><td>22,765</td><td>36,600</td></tr>
<tr><td colspan="2">Per year (at max, total employment across economy).</td></tr>
</table>

Economic Summary

Using the base assumptions, the OOA industry will deliver a positive net position under low discount rates (up to 6%[73]) with the net benefit position being $242m over 30 years. This is equal to an annual gain of $8.1m. The export revenue is substantial, with a present value of $8bn. The value of the employment benefit is estimated at $355m over 30 years. The Present Value of the costs (both capex and opex), is estimated at $8.1bn with the opex component accounting for 88% of the costs. Overall, establishing the OOA industry is expected to deliver benefits outweighing the costs, returning a Cost Benefit Ratio (CBR) of 1.03.

At the peak of the construction phase, the OOA will support over 3,900 jobs throughout NZ. The construction and set-up phase span several decades, ramping up from year five, with intermittent peaks every two/three years. It then tapers off after 2040. In contrast, the jobs supported by the ongoing activity, start in the second decade, increasing to 58,300 once operating at full capacity.

Overall Conclusions:

- There is a severe shortage of salmon smolt and other finfish production facilities (lack of hatcheries for all species in general) in New Zealand; an increase to 264m smolt per annum is required to meet each additional 10,000t of production.
- Much of the equipment used for OOA is not currently made or available in New Zealand.
- There is no barrier applying feed delivery systems to offshore farms.
- The technology used for growing smolts in New Zealand is old and inefficient (not state of the art). New (RAS) technology is available and widely used in the salmon farming industry overseas and would be suitable in the New Zealand context.
- There are limited locations in New Zealand's marine environment to establish new salmon farms, however Southland and Cook Strait are the most promising locations for future salmon OOA. The Ports of Bluff, Nelson and Picton are well suited to establishing a salmon farming and processing base to service OOA farms.
- The allocation of water space for salmon farming in the open ocean environment is an urgent requirement / pre-requisite/dependency.
- OOA, if developed in New Zealand, and particularly for salmon, in the South Island, would be profitable and of substantive regional economic benefit to the country.

[73] This is the 'default' discount rate used by the Treasury. Source: https://treasury.govt.nz/information-and-services/state-sector-leadership/guidance/financial-reporting-policies-and-guidance/discount-rates

Appendix 1: Financial modelling assumptions

Financial model assumptions			
Category	**Assumptions**	**Source**	**Commentary**
General			
OOA operation size	N/A	Agreed with NZTE	Assume each consent application will be for 10,000 tonnes of gross production p.a. For modelling purposes, it is assumed that each consent application is a separate operator.
OOA NZ industry	N/A	Agreed with NZTE	Assumed that the industry is segmented with various operators. In reality the industry is likely to be much more concentrated therefore efficiencies should be achieved.
Species	N/A	Agreed with NZTE	For modelling purposes, only salmon has been considered.
Goods and services tax	N/A		All figures in the model are GST exclusive
Finance			
Interest rate on cash at bank	2%	Modelling assumption	
Interest rate on term debt	5%	Modelling assumption	
Minimum cash required for working capital	$5m	Modelling assumption	

Percentage of capex financed with equity	70%	Agreed with NZTE	Given the long investment cycle it is believed that debt funding would be difficult to secure.
Inflation			
CPI	2%	The Treasury guidelines	
Working capital			
Months payables outstanding	1	Modelling assumption	Assumes payables are paid within one month of invoice
Months receivables outstanding	1	Modelling assumption	Assumes receivables are received within one month of invoice
Tax			
Corporate tax rate on profit	28%	Inland Revenue Department	
Terminal value			
EBITDA multiple for terminal value	9x	Average of 11x with 20% liquidity discount applied	As at 4 February 2020 - NZ King Salmon: 13x, Huon Aquaculture: 10x, Sanford: 9x
Consent option 1			
Number of standard applications initiated	1 in year 1	Agreed with NZTE	

Number of high tech applications initiated	Nil	Agreed with NZTE	High tech consents relate to consents utilising new technology that is expected to be developed over the next 10-15 years
Consent option 2			
Number of standard applications initiated	7 before 2033 (every second year)	Agreed with NZTE	
Number of high tech applications initiated	4 between 2035 and 2041 (every second year)	Agreed with NZTE	High tech consents relate to consents utilising new technology that is expected to be developed over the next 10-15 years
Total cost for application of consent			
Years 1-5	$2.5m	Aquaculture Direct	
Years 6+	$2.0m	Agreed with NZTE	Assumed reduction in consent cost based on government changes to consenting framework
Number of years to gain consent			
Years 1-5	4 years	Aquaculture Direct	
Years 6+	2 years	Agreed with NZTE	Assumed reduction in consent timeframe based on government changes to consenting framework
Hatchery			
Number of years to build hatchery capacity **for 10,000 tonne salmon farm**	2 years	Aquaculture Direct	When the consent is granted, the hatchery takes 2 years to build. In reality there is likely to be some planning underway prior to the consent being granted

Number of years smolt stay in hatchery	1 year	Aquaculture Direct	Assumed to stay for 1 year and grow to 130 grams
Number of ramp-up years at half capacity	2 years	Aquaculture Direct	Operate at half capacity for initial period while testing systems etc
Smolt			
Number of smolt required for 10,000 tonne p.a production	2,600,000	Aquaculture Direct	Assumes 85% mortality rate resulting in approximately 2,200,000 smolt going into the open ocean
Hatchery capex			
Land	$5m	Aquaculture Direct	Based on capacity for 2,600,000 smolt per annum
RAS	$10m	Aquaculture Direct	Based on capacity for 2,600,000 smolt per annum
Buildings and other plant	$10m	Aquaculture Direct	Based on capacity for 2,600,000 smolt per annum
Hatchery opex			
Power	$0.2 per unit of smolt	Aquaculture Direct	
Feed	$1.8 per unit of smolt	Aquaculture Direct	
Other	$0.1 per unit of smolt	Aquaculture Direct	
Broodstock	$0.1 per unit of smolt	Aquaculture Direct	

Open Ocean Aquaculture (OOA) operation			
Number of years to build OOA operation	5 years	Aquaculture Direct	Staged development from the date of the consent being granted to the end of the ramp-up phase
Number of years smolt stay in open ocean	2 years	Aquaculture Direct	
OOA capex			
Cage and net fabrication	$41.2m	Aquaculture Direct	Sufficient capacity to hold 20,000 tonnes of salmon - allows for 10,000 tonnes to be harvested p.a.
Ancillary cage equipment and spares	$1m	Aquaculture Direct	
Feedbarge	$40m	Aquaculture Direct	
Feeding system	$0m	Aquaculture Direct	
Wellboats	$20m	Aquaculture Direct	
Net cleaning vessels	$12m	Aquaculture Direct	
Service vessels	$20m	Aquaculture Direct	
On-shore feed control centre	$6m	Aquaculture Direct	

Processing plant	$20m	Aquaculture Direct	
OOA opex			
Farming	$7124 per gross tonne p.a.	Aquaculture Direct	
Administration and processing			
Sales and marketing	10% of farming cost	Aquaculture Direct	
Management	15% of farming cost	Aquaculture Direct	
Weight lost during processing	10%	Aquaculture Direct	
Transport and processing cost	$2,920 per gross tonne	Aquaculture Direct	
Sales			
Smoked salmon	30%	Aquaculture Direct	
Bulk, head on, gilled and gutted	70%	Aquaculture Direct	
Smoked salmon	$50 per kg	Aquaculture Direct	Based on price ex-factory

Bulk, head on, gilled and gutted	$17 per kg	Aquaculture Direct	Based on price ex-factory
Additional processing cost			
Smoked salmon	$12 per kg	Aquaculture Direct	
Bulk, head on, gilled and gutted	$0 per kg	Aquaculture Direct	
Weight lost from processing			
Smoked salmon	45%	Aquaculture Direct	
Bulk, head on, gilled and gutted	0%	Aquaculture Direct	
Scenarios			
Scenario 1 - Sales price growth	1% real price growth	Agreed with NZTE	Price growth applied from year 1 - 10
Scenario 2 - High value output	50/50 split	Agreed with NZTE	50% of output sold as smoked salmon, 50% of output sold as gilled and gutted
Scenario 3 - 4 year consent	4 year consent process	Agreed with NZTE	All consents take 4 years (does not reduce after year 5)
Scenario 4 - 5% less OOA cost	-5% OOA capex and opex	Agreed with NZTE	

Scenario 5 - 10% less OOA cost	-10% OOA capex and opex	Agreed with NZTE	
Scenario 6 - Aggressive			Combination of price growth, high value output and 10% less OOA capex and opex

Appendix 2: Financial statements – base case

Years 1 - 15

	Units	1-Jul-20 30-Jun-21	1-Jul-21 30-Jun-22	1-Jul-22 30-Jun-23	1-Jul-23 30-Jun-24	1-Jul-24 30-Jun-25	1-Jul-25 30-Jun-26	1-Jul-26 30-Jun-27	1-Jul-27 30-Jun-28	1-Jul-28 30-Jun-29	1-Jul-29 30-Jun-30	1-Jul-30 30-Jun-31	1-Jul-31 30-Jun-32	1-Jul-32 30-Jun-33	1-Jul-33 30-Jun-34	1-Jul-34 30-Jun-35
Total gross volume of salmon produced	Tonnes	-	-	-	-	-	-	-	-	5,000	5,000	10,000	10,000	10,000	10,000	10,000
Income statement																
Revenue																
Sales	$m	-	-	-	-	-	-	-	-	106.3	108.4	221.1	225.5	230.0	234.6	239.3
Expenses																
Hatchery	$m	-	-	-	-	-	-	(3.2)	(3.3)	(6.7)	(6.8)	(7.0)	(7.1)	(7.3)	(7.4)	(7.5)
OOA	$m	-	-	-	-	-	-	-	(40.9)	(41.7)	(85.1)	(86.9)	(88.6)	(90.4)	(92.2)	(94.0)
Admin	$m	-	-	-	-	-	-	-	(10.2)	(10.4)	(21.3)	(21.7)	(22.1)	(22.6)	(23.0)	(23.5)
Processing	$m	-	-	-	-	-	-	-	-	(17.1)	(17.5)	(35.6)	(36.3)	(37.0)	(37.8)	(38.5)
Other processing	$m	-	-	-	-	-	-	-	-	(10.4)	(10.6)	(21.7)	(22.2)	(22.6)	(23.1)	(23.5)
EBITDA	$m	**-**	**-**	**-**	**-**	**-**	**-**	**(3.2)**	**(54.4)**	**19.8**	**(33.0)**	**48.2**	**49.2**	**50.2**	**51.2**	**52.2**
Depreciation	$m	-	-	-	(0.1)	(0.1)	(1.2)	(1.2)	(1.2)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)
EBIT	$m	**-**	**-**	**-**	**(0.1)**	**(0.1)**	**(1.2)**	**(4.4)**	**(55.7)**	**11.8**	**(41.0)**	**40.2**	**41.2**	**42.2**	**43.2**	**44.2**
Interest on cash at bank	$m	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
Interest expense	$m	-	(0.3)	(0.3)	(0.3)	(0.3)	(1.0)	(1.8)	(2.6)	(5.8)	(6.0)	(7.7)	(6.0)	(3.8)	(1.5)	-
Net profit before tax	$m	-	(0.2)	(0.2)	(0.3)	(0.3)	(2.2)	(6.2)	(58.2)	6.1	(46.9)	32.6	35.3	38.4	41.8	44.5
Tax	$m	-	-	-	-	-	-	-	-	-	-	-	-	-	(11.2)	(12.5)
Net profit after tax	$m	-	(0.2)	(0.2)	(0.3)	(0.3)	(2.2)	(6.2)	(58.2)	6.1	(46.9)	32.6	35.3	38.4	30.6	32.0
Balance sheet																
Current Assets:																
Cash at bank	$m	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	13.3	53.2
Accounts receivable	$m	-	-	-	-	-	-	-	-	8.9	9.0	18.4	18.8	19.2	19.6	19.9
Total current assets	$m	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**13.9**	**14.0**	**23.4**	**23.8**	**24.2**	**32.8**	**73.2**
Current Liabilities:																
Accounts payable	$m	-	-	-	-	-	-	0.3	4.5	7.2	11.8	14.4	14.7	15.0	15.3	15.6
Total current liabilities	$m	**-**	**-**	**-**	**-**	**-**	**-**	**0.3**	**4.5**	**7.2**	**11.8**	**14.4**	**14.7**	**15.0**	**15.3**	**15.6**
Non Current Assets:																
Consent	$m	0.6	1.3	1.9	2.4	2.3	2.2	2.1	1.9	1.8	1.7	1.5	1.4	1.3	1.2	1.0
Hatchery	$m	-	-	-	-	13.5	26.2	25.1	24.1	23.0	21.9	20.8	19.7	18.6	17.5	16.4
OOA assets	$m	-	-	-	-	34.7	70.1	106.1	143.0	173.7	166.9	160.2	153.4	146.6	139.8	133.0
Total non-current assets	$m	**0.6**	**1.3**	**1.9**	**2.4**	**50.5**	**98.5**	**133.4**	**168.9**	**198.5**	**190.5**	**182.5**	**174.5**	**166.5**	**158.5**	**150.5**
Non Current Liabilities:																
Term loan	$m	5.2	5.5	5.9	6.3	21.0	36.7	52.2	115.9	119.2	153.7	119.8	76.6	30.2	-	-
Total non-current liabilities	$m	5.2	5.5	5.9	6.3	21.0	36.7	52.2	115.9	119.2	153.7	119.8	76.6	30.2	-	-
Owners Equity																
Paid in capital	$m	0.4	0.9	1.3	1.8	35.6	70.0	95.2	121.0	147.3	147.3	147.3	147.3	147.3	147.3	147.3
Retained earnings	$m	-	(0.2)	(0.3)	(0.7)	(1.0)	(3.2)	(9.4)	(67.5)	(61.4)	(108.3)	(75.6)	(40.3)	(1.9)	28.7	60.7
Total owners equity	$m	**0.4**	**0.7**	**1.0**	**1.1**	**34.5**	**66.8**	**85.9**	**53.5**	**85.9**	**39.0**	**71.7**	**107.0**	**145.4**	**176.0**	**208.0**
Equity plus liabilities	$m	5.6	6.3	6.9	7.4	55.5	103.5	138.4	173.9	212.3	204.5	205.9	198.3	190.6	191.3	223.6
Check		OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Cash flow statement																
EBITDA	$m	-	-	-	-	-	-	(3.2)	(54.4)	19.8	(33.0)	48.2	49.2	50.2	51.2	52.2
Change in working capital	$m	-	-	-	-	-	-	0.3	4.3	(6.2)	4.4	(6.8)	(0.1)	(0.1)	(0.1)	(0.1)
Cash flow from operations before inte	$m	**-**	**-**	**-**	**-**	**-**	**-**	**(3.0)**	**(50.2)**	**13.6**	**(28.6)**	**41.5**	**49.1**	**50.1**	**51.1**	**52.1**
Interest	$m	-	(0.2)	(0.2)	(0.2)	(0.2)	(0.9)	(1.7)	(2.5)	(5.7)	(5.9)	(7.6)	(5.9)	(3.7)	(1.4)	0.3
Tax	$m	-	-	-	-	-	-	-	-	-	-	-	-	-	(11.2)	(12.5)
Cash flow from operations	$m	**-**	**(0.2)**	**(0.2)**	**(0.2)**	**(0.2)**	**(0.9)**	**(4.7)**	**(52.7)**	**7.9**	**(34.5)**	**33.9**	**43.2**	**46.4**	**38.5**	**39.9**
Capex: Consent	$m	(0.6)	(0.6)	(0.7)	(0.7)	-	-	-	-	-	-	-	-	-	-	-
Capex: Hatchery	$m	-	-	-	-	(13.5)	(13.8)	-	-	-	-	-	-	-	-	-
Capex: OOA	$m	-	-	-	-	(34.7)	(35.4)	(36.1)	(36.8)	(37.5)	-	-	-	-	-	-
Free cash flow before financing	$m	**(0.6)**	**(0.8)**	**(0.8)**	**(0.9)**	**(48.4)**	**(50.1)**	**(40.8)**	**(89.5)**	**(29.6)**	**(34.5)**	**33.9**	**43.2**	**46.4**	**38.5**	**39.9**
Debt drawdown/(repayment)	$m	5.2	0.4	0.4	0.4	14.7	15.7	15.5	63.7	3.3	34.5	(33.9)	(43.2)	(46.4)	(30.2)	-
Equity	$m	0.4	0.4	0.5	0.5	33.7	34.4	25.3	25.8	26.3	-	-	-	-	-	-
Net cash flow	$m	**5.0**	**0.0**	**(0.0)**	**(0.0)**	**-**	**-**	**-**	**-**	**-**	**-**	**(0.0)**	**-**	**-**	**8.3**	**39.9**
Opening Cash Balance	$m	-	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	13.3
Movement	$m	5.0	0.0	(0.0)	(0.0)	-	-	-	-	-	-	(0.0)	-	-	8.3	39.9
Closing balance	$m	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**13.3**	**53.2**

Years 16 - 30

	Units	1-Jul-35 30-Jun-36	1-Jul-36 30-Jun-37	1-Jul-37 30-Jun-38	1-Jul-38 30-Jun-39	1-Jul-39 30-Jun-40	1-Jul-40 30-Jun-41	1-Jul-41 30-Jun-42	1-Jul-42 30-Jun-43	1-Jul-43 30-Jun-44	1-Jul-44 30-Jun-45	1-Jul-45 30-Jun-46	1-Jul-46 30-Jun-47	1-Jul-47 30-Jun-48	1-Jul-48 30-Jun-49	1-Jul-49 30-Jun-50
Total gross volume of salmon produced	Tonnes	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Income statement																
Revenue																
Sales	$m	244.1	249.0	254.0	259.1	264.3	269.5	274.9	280.4	286.1	291.8	297.6	303.6	309.7	315.9	322.2
Expenses																
Hatchery	$m	(7.7)	(7.9)	(8.0)	(8.2)	(8.3)	(8.5)	(8.7)	(8.8)	(9.0)	(9.2)	(9.4)	(9.6)	(9.8)	(10.0)	(10.2)
OOA	$m	(95.9)	(97.8)	(99.8)	(101.8)	(103.8)	(105.9)	(108.0)	(110.2)	(112.4)	(114.6)	(116.9)	(119.3)	(121.6)	(124.1)	(126.6)
Admin	$m	(24.0)	(24.5)	(24.9)	(25.4)	(26.0)	(26.5)	(27.0)	(27.5)	(28.1)	(28.7)	(29.2)	(29.8)	(30.4)	(31.0)	(31.6)
Processing	$m	(39.3)	(40.1)	(40.9)	(41.7)	(42.6)	(43.4)	(44.3)	(45.2)	(46.1)	(47.0)	(47.9)	(48.9)	(49.9)	(50.9)	(51.9)
Other processing	$m	(24.0)	(24.5)	(25.0)	(25.5)	(26.0)	(26.5)	(27.0)	(27.6)	(28.1)	(28.7)	(29.2)	(29.8)	(30.4)	(31.0)	(31.7)
EBITDA	$m	**53.3**	**54.3**	**55.4**	**56.5**	**57.6**	**58.8**	**60.0**	**61.2**	**62.4**	**63.7**	**64.9**	**66.2**	**67.6**	**68.9**	**70.3**
Depreciation	$m	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.0)	(8.9)
EBIT	$m	**45.3**	**46.3**	**47.4**	**48.5**	**49.6**	**50.8**	**52.0**	**53.2**	**54.4**	**55.6**	**56.9**	**58.2**	**59.5**	**60.9**	**61.4**
Interest on cash at bank	$m	1.1	1.9	2.7	3.6	4.5	5.5	6.4	7.4	8.5	9.5	10.6	11.7	12.9	14.1	15.3
Interest expense	$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Net profit before tax	$m	46.3	48.2	50.1	52.1	54.2	56.3	58.4	60.6	62.8	65.1	67.5	69.9	72.4	75.0	76.7
Tax	$m	(13.0)	(13.5)	(14.0)	(14.6)	(15.2)	(15.8)	(16.4)	(17.0)	(17.6)	(18.2)	(18.9)	(19.6)	(20.3)	(21.0)	(21.5)
Net profit after tax	$m	33.3	34.7	36.1	37.5	39.0	40.5	42.1	43.6	45.2	46.9	48.6	50.3	52.1	54.0	55.2
Balance sheet																
Current Assets:																
Cash at bank	$m	94.5	137.1	181.1	226.6	273.5	321.9	371.9	423.4	475.6	530.5	587.0	645.3	705.3	767.2	824.6
Accounts receivable	$m	20.3	20.8	21.2	21.6	22.0	22.5	22.9	23.4	23.8	24.3	24.8	25.3	25.8	26.3	26.8
Total current assets	$m	**114.8**	**157.9**	**202.3**	**248.2**	**295.5**	**344.4**	**394.8**	**446.8**	**499.5**	**554.8**	**611.8**	**670.6**	**731.1**	**793.5**	**851.4**
Current Liabilities:																
Accounts payable	$m	15.9	16.2	16.5	16.9	17.2	17.6	17.9	18.3	18.6	19.0	19.4	19.8	20.2	20.6	21.0
Total current liabilities	$m	**15.9**	**16.2**	**16.5**	**16.9**	**17.2**	**17.6**	**17.9**	**18.3**	**18.6**	**19.0**	**19.4**	**19.8**	**20.2**	**20.6**	**21.0**
Non Current Assets:																
Consent	$m	0.9	0.8	0.6	0.5	0.4	0.3	0.1	-	3.0	2.8	2.7	2.5	2.4	2.2	2.1
Hatchery	$m	15.3	14.2	13.1	12.0	10.9	9.8	8.7	7.7	6.6	5.5	4.4	3.3	2.2	1.1	21.3
OOA assets	$m	126.2	119.5	112.7	105.9	99.1	92.3	85.6	78.8	72.0	65.2	58.4	51.7	44.9	38.1	31.3
Total non-current assets	$m	**142.5**	**134.5**	**126.4**	**118.4**	**110.4**	**102.4**	**94.4**	**86.4**	**81.6**	**73.5**	**65.5**	**57.5**	**49.4**	**41.4**	**54.7**
Non Current Liabilities:																
Term loan	$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total non-current liabilities	$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Owners Equity																
Paid in capital	$m	147.3	147.3	147.3	147.3	147.3	147.3	147.3	147.3	149.5	149.5	149.5	149.5	149.5	149.5	165.0
Retained earnings	$m	94.1	128.8	164.9	202.4	241.4	282.0	324.0	367.7	412.9	459.8	508.4	558.7	610.9	664.9	720.1
Total owners equity	$m	**241.4**	**276.1**	**312.2**	**349.7**	**388.7**	**429.2**	**471.3**	**514.9**	**562.4**	**609.3**	**657.9**	**708.2**	**760.4**	**814.4**	**885.1**
Equity plus liabilities	$m	257.3	292.3	328.7	366.6	406.0	446.8	489.2	533.2	581.0	628.3	677.3	728.0	780.6	834.9	906.1
Check		OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Cash flow statement																
EBITDA	$m	53.3	54.3	55.4	56.5	57.6	58.8	60.0	61.2	62.4	63.7	64.9	66.2	67.6	68.9	70.3
Change in working capital	$m	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Cash flow from operations before int	$m	**53.2**	**54.2**	**55.3**	**56.4**	**57.6**	**58.7**	**59.9**	**61.1**	**62.3**	**63.5**	**64.8**	**66.1**	**67.4**	**68.8**	**70.2**
Interest	$m	1.1	1.9	2.7	3.6	4.5	5.5	6.4	7.4	8.5	9.5	10.6	11.7	12.9	14.1	15.3
Tax	$m	(13.0)	(13.5)	(14.0)	(14.6)	(15.2)	(15.8)	(16.4)	(17.0)	(17.6)	(18.2)	(18.9)	(19.6)	(20.3)	(21.0)	(21.5)
Cash flow from operations	$m	**41.3**	**42.6**	**44.0**	**45.4**	**46.9**	**48.4**	**50.0**	**51.5**	**53.2**	**54.8**	**56.5**	**58.3**	**60.1**	**61.9**	**64.0**
Capex: Consent	$m	-	-	-	-	-	-	-	-	(3.2)	-	-	-	-	-	-
Capex: Hatchery	$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(22.2)
Capex: OOA	$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Free cash flow before financing	$m	**41.3**	**42.6**	**44.0**	**45.4**	**46.9**	**48.4**	**50.0**	**51.5**	**50.0**	**54.8**	**56.5**	**58.3**	**60.1**	**61.9**	**41.8**
Debt drawdown/(repayment)	$m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equity	$m	-	-	-	-	-	-	-	-	2.2	-	-	-	-	-	15.5
Net cash flow	$m	**41.3**	**42.6**	**44.0**	**45.4**	**46.9**	**48.4**	**50.0**	**51.5**	**52.2**	**54.8**	**56.5**	**58.3**	**60.1**	**61.9**	**57.4**
Opening Cash Balance	$m	53.2	94.5	137.1	181.1	226.6	273.5	321.9	371.9	423.4	475.6	530.5	587.0	645.3	705.3	767.2
Movement	$m	41.3	42.6	44.0	45.4	46.9	48.4	50.0	51.5	52.2	54.8	56.5	58.3	60.1	61.9	57.4
Closing balance	$m	**94.5**	**137.1**	**181.1**	**226.6**	**273.5**	**321.9**	**371.9**	**423.4**	**475.6**	**530.5**	**587.0**	**645.3**	**705.3**	**767.2**	**824.6**