Extending Open Ocean Aquaculture in the Eastern Bay of Plenty

Initial Opportunity Assessment

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Opotiki Harbour Transformation Project, Work Stream 15: Supporting Innovation; Task 4.1 Extending Open Ocean Aquaculture

30 June, 2017
EXECUTIVE SUMMARY

This report makes an evidence based initial opportunity assessment for three species considered for culture in the Whakatohea Eastern Bay of Plenty open ocean marine farm: Pacific oysters, Tio, (*Crassostrea gigas*), Flat oysters, Tio para, (*Ostrea chilensis*), and Geoduck, Hohehohe, (*Panopea zelandica*). In addition, it recommends initial opportunity assessments be made for the open ocean aquaculture of two species: scallops, Pure, (*Pectin novaezealandiae*) and crayfish, Koura, puerulii (*Jasus edwardsii*).

The context for the innovation assessment is the Whakatohea Maori Trust Board (WMTB) strategic plan which outlines a value proposition with mixed commercial and social elements. The assessment is framed in terms of the species, the technology, and recommendations for an innovation cluster. This approach to development of an aquaculture precinct adjacent to the proposed port is an avenue to harvest the opportunities in a manner consistent with the WMTB vision.

The Pacific oyster species deserves serious immediate consideration for commercialisation in the Whakatohea marine space. The opportunity is for innovation that extends existing know how to transfer species and culture practice from inshore to offshore water space to tap the commercial potential of high value export markets.

The physical infrastructure necessary stands ready for commercial deployment. Value creation and distribution networks are complemented by the Whakatohea proximity to air and sea freight hubs.

The attributes of the production context of Eastern Bay of Plenty waters provide the opportunity to tap into branding opportunities around safe, environmentally friendly production.

Substantial and growing export markets exist where consistency of quality and supply capacity have the potential to be well rewarded. Domestic and export markets feature supply shortfalls through disease incursion. The key challenge to the implementation of the Whakatohea aquaculture strategy is building a resilient value creation process that enables reliable delivery of high quality, consistent supply to high end international markets.

The key commercial risk lies in the biological domain in the form of disease risk. However, there is a comprehensive national biosecurity regime in place. The recent Pacific oyster herpes OsHV-1 disease incursion in Australasian waters offers experience, on-farm mitigation strategies, and evidence that a large proportion of affected farmers view the commercial risk as manageable. The Cawthron Institute selective breeding program selecting for resistance to OsHV-1 has proven to be very effective against the disease: normality is returning to the industry. The international literature shows genetic work to promote disease resistance and shorter culture times to be an effective value adding strategy to mitigate the effects of *Bonamia ostreae* parasite.

Innovation that effectively mitigates disease risk is an important means of building competitive advantage for the Whakatohea open ocean aquaculture project. This proposition underscores the importance of strategic alliances with universities and research institutes in the development of hatchery and research capacity in any proposed Opotiki Aquaculture Precinct.

Given the above, indicative commercial modelling shows a positive investment outlook. Indicative discounted cashflow models show positive investment signals. Open ocean marine farm space devoted to the culture of Pacific Oysters has the potential to generate, on a per hectare basis, twice the output, and direct and indirect economic development effects afforded by mussel cultivation.
This does not constitute a recommendation to supplant mussel culture with oyster production. Rather it should be read as an indication of the commercial and economic development potential that can be achieved through inclusion of the Pacific oyster species in a multi-species open ocean culture mix. Further, the open ocean developments are not meant to replace inshore activity, rather to compliment and extend it. In the future it may be that inshore and offshore become one integrated culture system.

The assessment of this work is that further research activity to define commercial proof of concept of the culture of Pacific Oysters in Eastern Bay of Plenty waters be undertaken with a view to informing full business plan development.

Applied across the anticipated culture species, investigations need to be undertaken as to the configuration of the “hard” and “soft” infrastructure that constitute the most effective means of meeting commercial goals as well as the wider Whakatohea social and economic development vision.

The Flat oyster species presents a parallel opportunity to any Pacific oyster culture. The comments above also apply to the potential for the culture of flat oysters’ species. However, demonstration of the organisms’ biological and commercial potential in Bay of Plenty waters is required. Given restriction on the movement of organisms as a quarantine measure to combat spread of the *Bonamia ostreae*, the performance spat from diverse locations around the country needs to be evaluated. The next step on the path of this species to commercialisation is a project to demonstrate biological proof of concept in Whakatohea waters.

The geoduck species should be considered as a future opportunity. It represents a "new" indigenous aquaculture species. Its production systems are in the infancy of development in in open ocean conditions. Product performance in substantial, diverse high value export markets is unknown. The next steps toward commercialisation of this species is to support current research activities by Cawthron Institute and its international research partners to development of suitable habitat mimics that can be deployed to the Set and Forget System and subsequent iterations under development.

The importance of a port in close proximity to the effective use of the adjacent offshore marine farm space should not be underestimated. The culture of shellfish species in high energy conditions requires multiple farm visits in a culture rotation, in often uncertain and changeable conditions.

Research, hatchery, and abundant hygienic sea water supply and cluster support facilities are key elements in the value creation aquaculture precinct. Applied across the anticipated culture species, investigations need to be undertaken as to the precinct configuration of the “hard” and “soft” infrastructure that constitute the most effective means of meeting commercial goals as well as the wider Whakatohea social and economic development vision.

Fostering on-going innovation will be a paramount consideration. There is mixed evidence in innovation literature as to optimal size of enterprise as to where innovation occurs best. Promotion of social wellbeing includes consideration of the nature of the enterprises that are associated with the marine space. The optimal mix of corporate and family business small to medium enterprise that meets Whakatohea vision requirements needs to be considered. Where networks of artisanal family business are present the need for active facilitation of a collaborative cluster needs to be considered. There are examples from the development of new aquaculture technologies in NZ where networks of individual nascent enterprises have failed through lack of active collaborative facilitation.
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Disclaimer:

Whilst every effort has been made to ensure the integrity of the data collected and its application to the assessment of species for the extension of marine farming in the Eastern Bay of Plenty, the author does not give any warranty as to the accuracy, completeness, currency or reliability of the information made available in this report and expressly disclaims (to the maximum extent permitted by law) all liability for any damage or loss resulting from the use of, or reliance on the information, tables and charts provided through them.

Revenues and production potential presented in this report should be considered in the context of the purpose in the report. The context is that of an initial opportunity assessment. Revenues, production technologies, production potential, and cost assessment data have been reported with the intention of illustrating and signalling the production potential and suitability of the species described in the report for development as open ocean aquaculture species in the Eastern Bay of Plenty. They do not constitute a recommendation for decision makers to proceed to commercialisation without first undertaking due diligence in terms of and biological and commercial proof of concept.

Any decision that is made after using the information contained in this report must be solely based on the decision makers own evaluation of all the information available to them, their circumstances, and objectives.
1.0 INTRODUCTION

1.1 Purpose and Scope

Priority One, on behalf the Opotiki Harbour Transformation Project, requires an initial assessment of new open ocean aquaculture opportunities in the Eastern Bay of Plenty. This is part of developing a strategy for innovation-related activity that can drive use of the proposed new Opotiki Harbour.

The purpose of this work is to provide initial information about, and analysis of, the technical and commercial feasibility of aquaculture of new species in the Eastern Sea Farms marine space. Specifically, it will cover three species shortlisted through consultation with stakeholders: Flat oysters, Pacific oysters, and Geoduck.

The assessment may also extend to other species if potential opportunities emerge that are assessed as being as better potential than those above.

The project will apply knowledge of existing industry and technical issues to identify likely potential pathways to, and issues around, developing new commercial enterprise based on these species. It is anticipated the project will be mainly desk research and modelling supported by some interviews with key stakeholders/experts as required, also preparation of presentation and report document. As this is a scoping study, the project will not be expected to deliver specific estimates based on a technical investigation of the water space.

This initial assessment of the three recommended species’ open ocean aquaculture potential will be reported in terms of: markets and customers -prices, quantities NZ and international supply; the nature of supply chains, distribution networks and channels; production systems; key technical issues; indicative commercial/economic analysis (investment, operations); and recommended next steps.

1.2 Open Ocean Aquaculture and the Eastern Bay Of Plenty

The Whakatohea Maori Trust Board (WMTB) Strategic Plan\(^1\) sets the strategic context for this report. It discusses stewardship over the 3,800 ha consented marine farm space, located five nautical miles distant offshore from the mouth of the Waioeka River at Opotiki \(^2\). Through the Eastern Sea Farms commercial entity this marine farm has allocated 330 “longlines” of a total allowable 1000 lines permitted by the current consent to the culture of greenshell mussels by Sanfords, new entities, and Whakatohea Mussels Opotiki Ltd. In the balance of the consented space, effectively some 670 lines of similar dimensions to those already placed have been allocated to other species: Pacific oysters, flat oysters, scallops, geoduck, and algae species, to serve other initiatives which include the development of a nutraceutical industry, brands, shellfish processing, and finfish farming.

Appendix One contains details of the WMTB strategic plan and its vision for Whakatohea Aquaculture:

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\(^1\) WMTB Version 6: (Cawthron Institute, 5/1/2017)
\(^2\) Notice Mariners, Whakatohea Mussels Opotiki (2014)
"Ko te kai hoki i Waiaua": To be the food bowl that feeds the world.

"Kia rangatira ai ngā Uri o Te Whakatōhea." To grow and invest in the well-being of our people.

They key principle taken from this document setting the context for this initial opportunity assessment, is that the Whakatohea value proposition contains both commercial and social elements. Accordingly, the assumption is made that the “opportunity” refers to the opportunity to be the food bowl of the world and to invest resources and returns from commercial ventures in the wellbeing of the Whakatohea people. Commercial considerations while important are not the ultimate objective. The vision is longer term and has social dimensions. Assessment of the opportunities to extend open ocean aquaculture in the Eastern Bay of Plenty in this report are made with that consideration mind.

Figure 1 is drawn from the WMTB Strategic Plan. It identifies priorities and characterises risk and reward for the commercial ventures that will serve those ends:

Figure 1: WMTB Pipeline and Priority Assessment

Source: WMTB Strategic Plan

Items 3 – 5 are considered in this report. Offshore engineering and the “Set and Forget” production system are discussed in Section 2.0 as the backbone of oyster production. Setting Pacific and Flat oysters offshore are the key focus of the report.

1.3 Methods

The work brief called for a desktop study complemented by interviews. The greater portion of the commentary in this report on the NZ aquaculture markets and value chains relies on information sourced from the Coriolis Report. Complimentary information is sourced from
Aquaculture NZ and The New Seafood Industry Council – SEAFIC. Information relating to open ocean production technology relies on one recent source in the published academic literature (Goseberg et al., 2017)\(^3\). The other document that is the source of information is a private report to commercial clients that has not been released for public access (Heasman et al., 2009)\(^4\). Other sources are cited in the text of the report.

Four interviews were conducted in the commercial, technical, and biological areas:

- Mr. Kevin Heasman, Cawthron Institute: Open Ocean Aquaculture (OOA) technical expert.
- Professor Andrew Jeffs, The University of Auckland: shellfish biologist and aquaculture expert.
- Mr. Gary Hooper, Chief Executive, Aquaculture New Zealand: commercial expert.
- Mr. Jim Barrett, Stewart Island Oysters, entrepreneur and oyster culture innovator.

### 1.4 Report Outline

This report is organised as follows:

Section 2.0, Open Ocean Shellfish Aquaculture Methods, addresses the production technology applicable to shellfish culture in open ocean conditions. It relies heavily on one source from the international literature that allows access to information contained in reports otherwise not in the public domain.

Section 3.0, The NZ Seafood Value-Added System presents an assessment of the NZ seafood value-added process, which is then extended to encompass the potential contribution of Whakatohea open ocean aquaculture in the Bay of Plenty.

Section 4.0, Markets, is devoted to discussion of NZ seafood markets, with reference to markets for three species: Pacific oysters, flat oysters, geoduck.

Section 5.0, Core species, contains a discussion of the issues relevant for innovation that enables their commercial production in Eastern Bay of Plenty offshore conditions.

Section 6.0, Commercial and Investment, considers available information for formulation of a preliminary investment assessment. Without full production and cost information this section develops an indicative assessment based in recent published sources.

Section 7.0, Additional Species for Consideration, makes a case for consideration of two further high value species for open ocean aquaculture in the Eastern Bay of Plenty: scallops, and crayfish.

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Section 8.0, assesses the opportunities afforded by each species and considers “next steps” for each of three core species under consideration. Each offers differing profiles of risk and reward. That discussion is framed in terms of activity around biological and commercial proof of concept, and business case development.

Appendices include: The Whakatohea Maori Trust Board Strategic Plan for Aquaculture; Coriolis SWOT analysis for the New Zealand Aquaculture sector; and summary sheets for each of the primary species in the scope of work.

2.0 OPEN OCEAN SHELLFISH AQUACULTURE METHODS

This section describes three aspects of Open Ocean Shellfish culture methods:

- A brief description of international research on open ocean aquaculture,
- The development path to the structure and components of the New Zealand submersible “Set and Forget” shellfish production system for high energy marine conditions, and,
- Extension of the New Zealand mussel longline system to oyster species’ culture in open ocean environments.

In the context of this report the term, “Open ocean aquaculture” refers to the culture of marine organisms in high energy coastal and oceanic conditions. The seminal NZ work on the subject is a report prepared by the Cawthron Institute (Heasman et al., 2009) which describes the longline culture of five species in high energy conditions in Hawke Bay and The Eastern Bay of Plenty. The authoritative work in the international literature is: Goseberg et al., (2017). Because Heasman et al., (2009) has not been released for public consumption – it is a private client report - Goseberg et al., (2017) has been adopted as the leading source for this description of methods. Mr Heasman is a co-author of that paper.

The environmental and societal challenges of land-based and near-shore aquaculture have promoted efforts to development of technologies for harsh, high energetic environments further offshore.

In the USA, the University of New Hampshire has undertaken research into the technological aspects of OOA farming. It included submersible cages and longlines, surface feeding systems and real time environmental telemetry. The grow-out potential of shellfish species with relevant to this project include blue mussels (*Mytilus edulis*), and sea scallops (*Placopecten magellanicus*), (Goseberg et al., 2017).

In German waters, multi-use aspects of aquaculture were explored at the wind farm “Veja Mate” where structures were attached to existing offshore wind energy foundations. Technological components such as mounting forces and scour tendencies of two different structures (cylindrical and spherical) were investigated by means of hydraulic scale modelling. The structures were constructed to existing standards and exposed to realistic offshore wave conditions. (Goseberg et al., 2017).

In Goseberg et al., (2017), Mr. Heasman provides a description of a research project to explore shellfish culture on high energy conditions in NZ:
“In 2003 consents for the offshore aquaculture space were lodged and the process of obtaining this space started. There were numerous reasons for the departure from the sheltered waters including user conflict and a desire to increase farm size. The proposed farms were in waters ranging from 6 to 20 km off the coast in water depths ranging from 35 to 80 m.

In 2005, the first experimental ropes were installed into the open ocean waters of Hawkes Bay. The first open ocean structure was based on the traditional mussel backbone but it was influenced by the systems used in the Coromandel in the North-Eastern corner of the New Zealand North Island. The Coromandel generally has higher energy than that of other culture sites such as the Marlborough Sounds.”

Goseberg et al., (Section 3.2.1:2017)

Figure 3 describes the structure of a surface longline developed for NZ mussel farms which formed the basis for open ocean development.

“A traditional inshore New Zealand mussel longline consists of: a mooring; chain; warp; bridal; backbone; bridal; warp; chain and mooring). The early moorings were Danforth type anchors. These were overtaken in preference by concrete shaped moorings of up to 10 metric tons (22,200 lb.) in mass. Where possible concrete mooring is being superseded by screw anchors when new ropes are being installed and the substrate is suitable.”

Goseberg et al., (Section 3.2.1:2017)

The dimensions of components of the NZ Mussel Longline are:

“The chain is a heavy-duty chain of 6 m (20 ft.) to 15 m (50 ft.) in length. A synthetic rope of 27 mm (>1 in.) to 36 mm (1½ in.) called a warp is attached to the chain and rises to the bridal. The warp is generally three times the depth of the water. The bridal splits into two, each split attaching to a header rope on the opposite edges of the float line, respectively. This section of the mussel longline holding the buoys or floats is called the backbone.”

Goseberg et al., (Section 3.2.1:2017)

![Cross-section of a surface longline marine farm](image)

**Figure 2: NZ Mussel Longline Cross Section**

Source: New Zealand Marine Farmers’ Association cited in Goseberg et al., (Fig. 3.1:2017)
“Since this backbone has a header rope on each side of the float to support the production line it is referred to as a “double backbone”. The backbone extends to the opposite bridal and so on. The buoys are 1.3 m across (~4 ft. 3 in.) and spaced appropriately to support the mass of growing mussels on the backbone. Typically, the backbone ranges from 100 m (328 ft.) to 200 m (656 ft.) long. A mussel longline (production rope) is hung from the backbone. It is attached on one side, descends to 10 or 15 m, loops up to the opposite side of the backbone and crosses the gap between the buoys and the descends again. Each loop being approximately 50 cm (20 in.) to 70 cm (28 in.) apart along the backbone. In this way, between 3000 m (9842 ft.) and 4000 m (13,123 ft.) of mussel long line is hung from a 100 m backbone.

The longline hanging from the backbone can produce between 6.5 kg (14 lb. 5 oz.) to 13 kg (28 lb. 10 oz.) per meter (or 4 lb. 12 oz. per ft. to 9 lb. 8 oz. per ft.) depending on site and situation. The time period to produce this would range from 12 to 20 months, again depending on site and location.”

Goseberg et al., (Section 3.2.1:2017)

The move to offshore, high energy conditions led to refinement of the double backbone configuration:

“As the industry changed from inshore to more exposed sites the backbones were cut down to a single header rope (single backbone) i.e. there is no bridal and the warp joined directly to the backbone (Fig. 3.2) and the production longline is draped in loops along the single header rope or backbone. The backbone is submerged and has approximately 66% of the floatation attached directly to it. Additional floatation is positioned on the surface with strops extending from the surface floats to the backbone. The length of the strop dictates the depth of the backbone.”

“The surface floats will provide 30–40% of the floatation and also give some indication of the load the backbone is bearing and when additional floatation will be required. The backbone is installed loose enough so that a hook can be lowered from a vessel to snag the backbone and the resultant apex of the snagged backbone brought to the surface. The spacing between the droppers may be increased when compared to the inshore systems and may be as much as 1 m (3 ft. 3 in.) apart. By submerging the ropes, this system provides some protection from the wave energy experienced in open ocean situations, however, the surface floats still transfer energy to the backbone which can result in production losses and increased maintenance. In addition, there is an issue arising from the additional requirement in flotation as a result of mussel growth, i.e. once the farm has a large number of backbones on it the management of floatation will increase.”

Goseberg et al., (Section 3.2.1:2017)

Figure 3 describes the structure and components of the NZ submerged longline system.

The most recent published development of the longline culture system for open ocean conditions is the “Set and Forget” system (Figure 4):
“The next generation system that is currently being developed and tested is the “Set and Forget” (S&F) system. This system, developed by the Cawthron Institute (www.cawthron.org.nz) in conjunction with an open ocean farming operation and Government funding (MBIE and Kiwinet), is a fully submersible double backbone system which will be deployed and recovered from the surface.

Goseberg et al., (Section 3.2.1:2017)

![Cross-section of a sub-surface longline marine farm](image)

Figure 3: Cross section of the sub-surface longline production system for open ocean conditions.

Source: New Zealand Marine Farmers Association cited in Goseberg et al., (Fig. 3.2:2017)

“...The S&F system has a similar configuration to the surface double backbone but where the bridal meets the backbone, there is a mooring directly below it (screw anchor. There are additional intermediate anchors spaced every 35 m along the backbone. These intermediate moorings are threaded through a mechanism in the S&F buoy. There are also single S&F attachment mechanisms on each warp with a surface float. The idea is to fully seed the longline on the backbone. The backbone is then floated with sufficient buoys to support the intended harvest mass. Once seeded the backbone is pushed below the surface to the desired depth and the S&F mechanism engaged. The mechanisms on the warps are tightened to ensure the backbone does not collapse towards the center. The mussels can then be left until they are due to be harvested. No intermediate floatation is required. At harvest the mechanisms are released using a surface driven unit (physically not electronically) and the backbone rises to the surface to be harvested.”

Goseberg et al., (Section 3.2.1:2017)

Oyster farming has also been tested at offshore sites. As was the case with development of the “Set and Forget” system, the production methods have involved transfer of contemporary inshore production methods (oyster purses or bags) to offshore application:
“Pacific oysters (*Crassostrea gigas*) have been held in purses or oyster bags. The bags are configured one below the other in a “ladder” configuration. There are 20 bags in a ladder spaced approximately 50 cm (20 in.) apart with 50–100 oysters in each bag depending on bag size and oyster’s size. Some work is required in the design of the bags to reduce the maintenance of the present ladder system. Baffles have been introduced into the bags/purses to avoid the oysters being clumped into one corner of the unit. Oysters have to be at a minimum depth below the surface to avoid being “rumbled” by the wave energy which restricts shell growth.”

Goseberg et al., (Section 3.2.2:2017)

Figure 4: The “Set and Forget submersible shellfish production system for open ocean conditions.

Source: New Zealand Marine Farmers Association cited in Goseberg et al., (Fig. 3.3:2017)

“The level of floatation has to be managed to reduce excessive energy transfer to the culture units. Oysters have shown growth rates comparable with inshore waters in North Island. The Flat oyster *Tiostrea chilensis* will be tested in the same ladder system in the near future on the open ocean farm. Early indicators are that flat oysters will grow in this system if they are away from direct wave energy.”

Goseberg et al., (Section 3.2.2:2017)

Figure 5 describes the ladder configuration for suspension from backbone elements for oyster species culture in open ocean conditions.
The move to offshore marine aquaculture has been motivated by environmental and spatial (the social license problem) conflicts.

This is an international phenomenon: it is the subject of a small but growing international literature.

Open ocean shellfish culture methods result from developments based in the transfer of species and methods from inshore conditions.

Those methods extend to oyster species’ production. Technical and biological proof of concept has been achieved for Pacific oysters (Crassostrea gigas) in conditions consistent with those experienced in the Eastern Bay of Plenty.

The advantages of the “ladder” in the context of the Set and Forget system lie in the potential for the development of complimentary physical and knowledge systems that are cost and labour minimizing. They bag (and purse) system has been widely used in inshore systems: offshore moves have a sound basis in culture practice to build on. The ladders can be deployed efficiently from bins or bags of suitable dimensions at sea in deck and crane operations and similarly on shore. The ladder system allows considerable scope for connection with shore based activities. Oyster culture will require three interventions between deployment and harvesting, with Pacific oysters requiring exposure to energetic surface conditions prior to harvest (Pers. comm. K. Heasman).
3.0 THE SEAFOOD VALUE-ADDING SYSTEM

The key challenge to the implementation of the Whakatohea aquaculture strategy is building a resilient value creation process that enables consistent delivery of high quality supply to high end international markets (pers comm, G. Hooper).

3.1 The NZ Seafood Value Added System

The New Zealand Seafood value-added chain is short and relatively uncomplicated, perhaps due to the perishable nature of the product. Aquaculture production is integrated with wild capture product at the processing and wholesaling stages. From there land, air and sea freight convey production to domestic and international markets. In the domestic market distributors and wholesalers are the conduit for products to supermarkets, fishmongers and foodservice enterprises.

In international markets a combination of secondary processors and wholesales channel product to supermarkets and fishmongers, foodservice enterprises, and an industrial category which encompasses further processing and wholesaling, e.g. house-brands, canners, and fishmeal production (Coriolis, 2013).

The Whakatohea aquaculture location in the Eastern Bay of Plenty provides proximity via land transport to elements of the NZ seafood value chain. A sea freight terminal is located in Tauranga, and the Tauranga Airport provides a connection to international flights air freight at Mangere International Airport in Auckland.

Figure 1 describes the NZ Seafood value chain:

Figure 6: NZ Seafood value chain.
3.2 The Eastern Bay of Plenty Value-added System

Because of its sheer size at 3,800 ha, the offshore marine aquaculture space in the Eastern Bay of Plenty is worthy of an addition to Figure 6.

Figure 7 expands Figure 1 to locate the Whakatohea open ocean aquaculture in the system.

A management stance centred ongoing innovation and the mixed pure commercial and social elements of the Whakatohea value proposition is reflected in a specification of the production elements of the value creation system.

The water space alone is not sufficient. A local port to enable timely and consistent access to the water space is a prime consideration. Within that port infrastructure, it is necessary to create an aquaculture precinct. Along with a proximate area to support offshore culture operations, hatchery and modest research facilities are necessary to resolve the necessity for ongoing selective breeding and juvenile production to support production operations within the constraints of national regulations around the movement of oyster organisms and materials. To
service these needs a substantial, durable and hygienic binary seawater supply system needs to be incorporated in engineering works in the port development.

The nature of the mix of enterprises that is designed to harvest and add-value to the Whakatohea marine space should be the subject of conscious deliberation. The New Zealand aquaculture industry has become concentrated into a small number of enterprises. While this presents advantages, it may not be the optimal approach to meet the mixed commercial and social goals of the Whakatohea value proposition.

There is mixed evidence in innovation literature as to optimal size of enterprise as to where innovation occurs best. Promotion of social wellbeing includes consideration of the nature of the enterprises that are associated with the marine space. What is the optimal mix of corporate and family business small to medium enterprise that meets Whakatohea needs?

Where networks of artisanal family business are present the need for active facilitation of collaboration needs to be considered. There are examples from the development of new aquaculture technologies in NZ where networks of individual nascent enterprises have failed through lack of active collaborative facilitation\(^6\).

The complete value chain, beginning at Opotiki, adds value to spat progressively, first in onshore facilities (selectively bred for disease resistance, growth rates, and processor consumer favoured attributes) then conveyance to the water space for growth to maturity. Harvest, then processing, in some instances refrigeration, create value before product joins the distribution elements of the value system into domestic and export markets.

Supply chains into international markets are well understood. The Coriolis Report describes the competencies of the NZ exporters and effects due to the concentration of the NZ Seafood industry. Figure 8 describes the Australian oyster supply chain.

In 2014 NZ oyster imports to Australia accounted for 7% of consumption. The Australian industry currently suffers from extensive disease outbreaks in key locations, a long-term effect that creates supply shortfalls that could be filled by NZ production.

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4.0 MARKETS

4.1 NZ AQUACULTURE MARKETS

The Coriolis Report (2013) makes the following observations about the aquaculture sector of the New Zealand seafood industry. They constitute the commercial context for the expansion of open ocean aquaculture in the Eastern Bay of Plenty:

- Production is dominated by three species: mussels, salmon and Pacific oysters.
- The aquaculture sector is more concentrated than the wild catch sector: five companies account for approximately 75% of production. These five companies feature a mix of ownership: private, Maori, offshore, and publicly listed.
- The NZ aquaculture sector lags international developments in terms of aquaculture as a proportion of seafood production – globally 55%, locally 21%.
- NZ has the tenth longest coastline internationally: only a fraction of that is farmed.
- NZ has access to an enviable set of natural sources through isolated location in the South Pacific 2100 km from Australia.
Branding NZ seafood in certification programmes offer huge opportunities.

The greatest impediments to growth lie in the interplay between the social license concept and the NZ regulatory circumstance.

Most shellfish consumed internationally are locally sourced. Demand for shellfish products often has its basis in local cultural traditions.

Globally 12% of mussel production crosses border, for oysters 1%.

Excepting China, global production of oysters is not growing.

Markets are concentrated: a small number of markets account for the greatest proportion of NZ aquaculture exports: Australia, Japan, USA, Korea, Hong Kong and Spain.

Commercial competitors lie principally in Southern Hemisphere nations located in similar latitudes.

High levels of biosecurity protection in Australia and Japan benefit NZ firms owing to the NZ production circumstance and national biosecurity stance.

Appendix One contains the Coriolis SWOT analysis for the NZ Aquaculture sector. That analysis identifies opportunities in:

✓ Consumer perceptions of the health implications of seafood.
✓ Growing middle classes is in China and SE Asia,
✓ Progressive removal of trade barriers via trade agreements,
✓ Improved access to Australia through phyto-sanitary barriers,
✓ Increased industry cooperation,
✓ Land based production, and,
✓ New species and methods.

The context that creates those opportunities for the aquaculture sector lie in:

✓ Low levels of the NZ Exclusive Economic Zone water space currently
✓ host aquaculture ventures.
✓ The greater proportion of existing water space is devoted to the production of low value species.

Challenges to strategies to harness those opportunities lie in:

✓ Space conflicts, and,
✓ Regulatory burdens and costs.

4.2 Key differentiation strategies for Whakatohea Aquaculture

Key strategies for product differentiation lie in:

• Certification systems,
• Reference to location specific factors,
• First peoples, basis of production, supply chains,
• “Terroir” and artisanal approaches to production and brand, and,
• Co-location in other value chains e.g. wine or local horticultural produce.
4.3 Pacific Oyster Exports

In 2016 Pacific oysters were exported in these product forms with proportion by percentage of volume:

- Chilled Halfshell (2%),
- Frozen Halfshell (72%),
- Live Chilled (25%),
- Smoked, Dried, Salted or in Brine (1%).

Figure 9 shows frozen half shell exports to key markets:

Figure 9: Pacific Oyster Frozen Half Shell Exports to February 2017.

Source: Aquaculture NZ

Summary statistics for Pacific oyster exports sourced from Aquaculture NZ indicate December 2016 year to date exports of the order of 1.9m dozen with an FOB value of NZ$22.1m.

4.4 Flat Oyster Exports

An emergent Flat Oyster Industry began exporting in recent years. The following product forms are evident in Seafood Industry Council export data (YTD Feb 2017) classified as “Oysters Dredge Farmed” (proportion by value in brackets):

- Chilled half shell (5%)
- Frozen Half Shell (71%)
- Frozen whole (2%)
- Live (24%)

Prominent export destinations include (proportion by value in brackets):

- Australia (66%)
- Hong Kong (10%)
- French Polynesia (6%)
- Other (18%)

Year to date for February 2017 FOB: $934,000 (SEAFIC, February 2017)
5.0 CORE SPECIES: KEY INNOVATION ISSUES

Section 5.0 is devoted to the core species specified in the report scope. Three species are considered; Pacific oysters (*Crassostrea gigas*), Flat oysters (*Ostrea chilensis*), and Geoduck (*Panopea zelandica*). The focus is on the issues relevant to biological, technological, and process innovation that enables their commercial production in Eastern Bay of Plenty open ocean aquaculture conditions.

A number of issues are common across the species under consideration. Table 1 describes those issues and presents potential avenues for mitigation.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access includes weather issues and effective time on farm</td>
<td>Port development. Onshore tasks to alleviate limited access</td>
</tr>
<tr>
<td>General marine operational issues</td>
<td>On the job (OTJ), farm lay out and orientation</td>
</tr>
<tr>
<td>Vessel development</td>
<td>OTJ, operational feedback</td>
</tr>
<tr>
<td>Fouling &amp; predators</td>
<td>Location specific environmental fact of life, farm management work around.</td>
</tr>
<tr>
<td>Water column temperatures</td>
<td>Impacts growth rates: organism selection, selective breeding</td>
</tr>
<tr>
<td>Food availability</td>
<td>Farm layout and orientation, culture densities</td>
</tr>
<tr>
<td>Aglal blooms</td>
<td>Work around, environmental monitoring, remote sensing</td>
</tr>
<tr>
<td>Organism health, disease, parasites.</td>
<td>Monitoring, remote sensing, quarantine, on-farm practices, genetic improvement, shorter culture duration. (see commentary below).</td>
</tr>
<tr>
<td>Seasonality, in year and ENSO</td>
<td>Farm layout and orientation, culture densities</td>
</tr>
<tr>
<td>Skilled labour availability</td>
<td>Training and education</td>
</tr>
</tbody>
</table>

Table 1: Common issues across oyster species

5.1 Disease

Two diseases with considerable commercial consequence are factors that should be paid close attention in assessing the opportunity fields associated with open ocean culture of oyster species in NZ. Innovation that focuses on these diseases provides the mitigation and adaptive responses for any other similar sources of risk to oyster culture.

The diseases are the Pacific oyster herpes OsHV-1 disease, and *Bonamia ostreae* in flat oyster culture.

In one leading assessment of future directions for the NZ seafood industry, disease risk was a key factor in steering recommendations for future species’ culture development in NZ waters away from oyster species. However, where industry circumstances feature a dearth of potential new high value species, and water space use devoted predominantly to low value species, consideration of disease mitigation strategies for oyster species becomes

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The diseases Pacific oyster herpes OsHV-1, and *Bonamia ostreae* in flat oyster culture present serious challenges to the commercial feasibility of open ocean oyster culture in New Zealand.

7 The Coriolis Report,( 2013)
paramount. Indeed, this is an avenue to build competitive advantage over oyster culture value creation in export markets that have been similarly afflicted.

The Pacific oyster herpes OsHV-1 disease manifested itself since 2010 in an outbreak in NZ waters that caused widespread mortality to oyster stocks with flow on effects for the commercial viability of farms. The Cawthron Institute selective breeding program selecting for resistance to OsHV-1 has proven to be very effective against the disease: normality is returning to the industry. It is possible to mitigate the effects.

The corresponding threat to Flat oyster culture is the *Bonamia ostreae* organism.

> “*Bonamia ostreae* is a parasite that can be fatal for flat oysters. This is a parasitic Rhizaria in the phylum *Haplosporidia* that can cause lethal infections in shellfish, particularly the European flat oyster, *Ostrea edulis*. Infection in oysters rarely results in clinical signs of disease and often the only indication of the infection is increased mortality⁸.

In May 2017, the parasite was detected in Stewart island waters:

> “*Bonamia ostreae* has been in New Zealand since 2015 in the Marlborough Sounds and Nelson. In May 2017, the Ministry for Primary Industries (MPI) detected the parasite on 2 flat oyster farms on Stewart Island. This was the first time it had been found in another area of New Zealand.

On 12 June 2017, MPI delivered a Notice of Direction to flat oyster farmers in Big Glory Bay in Stewart Island and Marlborough requiring the removal of all flat oyster stocks. We are currently moving with urgency to remove all flat oyster stocks from marine farms in Big Glory Bay on Stewart Island and in Marlborough. This work has involved close cooperation with affected farmers and the wider community in Southland. MPI has also put in place movement controls legally restricting movements of some shellfish species, including their spat, into and out of Nelson, Marlborough Sounds, and Stewart Island. It also legally restricts movements of farm equipment and vessels to limit further spread”.⁹

A recent study¹⁰ reviewed the international literature on genetic improvement for disease resistance in oyster species. In all the studies reviewed, resistance was a heritable trait. Significant response to selection to improve disease resistance was observed in all studies after two to four generations of selection for a range of diseases and species at risk including OsHV-1 in *Crassostrea gigas*, and related organisms *Haplosporidium nelsoni* and *Roseovarius crassostrea*.

The use of selectively bred hatchery spat as a disease mitigation strategy features in international jurisdictions such as the USA and the EU. For example, one US source offers disease resistant diploid and triploid spat at between US$13.50 -17.00 per 1,000 for 5-10mm size organisms¹¹.

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⁸ [http://www.gov.scot/Topics/marine/Fish-Shellfish/18610/diseases/notifiableDisease/Bonamiaostreae](http://www.gov.scot/Topics/marine/Fish-Shellfish/18610/diseases/notifiableDisease/Bonamiaostreae)


¹¹ University of Maryland Center for Environmental Science Horn Point Oyster Hatchery
A study by the Cawthron Institute\textsuperscript{12} describes on farm preventative reaction and response:

“Amongst the preventive strategies explored in the interview, adopting a collective risk management plan and varying the sources of spat (juvenile oyster) were the two most effective approaches. On-farm biosecurity measures were ranked third in terms of perceived effectiveness but were the most likely to be applied of all proposed measures. The discrepancy between perceived effectiveness and an inclination for uptake suggested limitations in the potential feasibility of some preventive strategies. In contrast, ranking of effectiveness and practicality of control strategies were more consistent. Stopping movements of stock and gear and zoning of farming areas by OsHV-1 status received the most support. “

(Castinel et al., 2015: i)

In terms of farmer willingness to deal with disease risk:

“Following POMS\textsuperscript{13}, most affected farmers and more than half of unaffected farmers changed their approach to growing oysters, by modifying their husbandry techniques or adopting a different operational strategy. When asked about taking business risk in the near future, the group was clearly divided: 41% were not ready to take any risk whilst the rest of the respondents were considering changes such as diversifying species, investing in hatchery spat and in new, more versatile infrastructure, or a mix of these initiatives. In terms of biosecurity readiness, the majority were confident that their business was as prepared as it could be to overcome disease challenges.”

(Castinel et al., 2015:i)

Two considerations emerge. First, the report highlights mitigation strategies that can be taken on farm, complemented by national biosecurity procedures that farmers considered effective in mitigating their commercial risk. Second, only a minority of farmers were not prepared to continuing farming in the face of disease risk.

Along with selective breeding for enhanced growth in local conditions, and organism quarantine processes to limit exposure, this disease mitigation strategy reinforces the mandate for inclusion of research and hatchery in any aquaculture precinct considered for Whakatohea aquaculture.

5.2 Pacific Oysters Culture Issues

Pacific oysters are currently cultured in the region in Ohiwa Harbour in mesh bags and trays. The key innovation task is to transfer the species to the offshore environment.


\textsuperscript{13} Pacific Oyster Mortality Syndrome, the Australian term for the disease.
The culture technologies are referred to in section 2.0 Open Ocean Shellfish Aquaculture Methods. Figures 4 and 5 depicting the Set and Forget System, and the suspended ladder configurations respectively provide the physical infrastructure.

5.2 Flat Oyster Culture Issues

As well as addressing the disease issues described in Section 5.1, innovation to support Whakatohea culture of flat oysters off shore needs to address fundamental biological issues along with the same offshore production issues discussed in the context of Pacific Oysters. While flat oyster species have been documented in northern locations such as the Manukau Harbour\(^\text{14}\), to date commercial flat oyster culture in New Zealand has occurred only in waters featuring cooler water column temperatures: Tasman Bay/Marlborough and Stewart Island.

![Image credit: Kiwaoysters.com](Image credit: Kiwaoysters.com)

Figure 10 describes the seafloor water column temperature profile of the Whakatohea offshore farm site in the Eastern Bay of Plenty. The red line are maxima, the blue minima.

![Figure 10 Monthly near seafloor temperatures; Eastern Sea Farms Site.](Image credit: Sea-Ex.com)

\(^{14}\) See the considerable contribution to the literature attributable to Professor Andrew Jeffs, The University of Auckland.
Figure 11 describes the seafloor water column temperature profile of a site in Tasman Bay.

Comparison of Figures 11 and 12 shows that an extended period from January to May in which Bay of Plenty maximum temperature exceed those of Tasman Bay. Resolution of the issue lies in sourcing spat from northern variants of the species. Figure 13 describes spat collection sites in New Zealand that have been the subject of brooding and settlement studies of *Ostrea chilensis*\(^{15}\). There may be growth rate effects in which northern variants grow faster in northern waters than their southern counterparts\(^{16}\).

![Tasman Bay Monthly near seafloor temperatures](image)

**Figure 12: Tasman Bay Monthly near seafloor temperatures**

Source: Brown et al., 2010\(^ {17}\)

![Spat collection sites](image)

**Figure 13: Spat collection sites reported in Brown et al., 2010**

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\(^{15}\) Pers comm, Professor Andrew Jeffs, Mr. Jim Barritt.

\(^{16}\) Professor Andrew Jeffs.

The innovation challenge for flat oyster culture in the Eastern Bay of Plenty is therefore threefold. First, there are biological issues around commercial culture of the species in warmer northern waters. Second, an appropriate response to the disease issues. Lastly operational deployment of the set and forget system adapted to ladder basket culture methods. Part of the innovation response lies at sea, but an important component lies in the design and implementation of a harbour with aquaculture precinct for Opotiki that includes hatchery and research capacity.

5.3 Geoduck (Hohehohe): culture and potential markets

The progress of the species geoduck (*Panopea zelandica*) to commercial production is in its infancy. It has been selected as a priority species in the Cawthron Institute’s Cultured Shellfish Programme.

The world’s first geoduck fishery was created in 1970, As of 2011, these sold for US$330/kg live, in China That high market value lead to an $80-million plus industry in the US Alaska, Washington, and Oregon states. The Canadian province of British Columbia also exports the shellfish. Product from those locations has been the subject of import bans into China for safety reasons based in the presence of elevated levels of paralytic shellfish poisoning, a biotoxin that shellfish can accumulate, and in the case of one shipment. Those bans may signal an opportunity for product in sourced New Zealand’s clean waters.

There was wild harvest of geoduck in NZ waters in the late 20th Century. This species lives 20-40cm buried in the sand. It can be found around the North, South and Stewart islands and occurs mainly in shallow waters (5–25 metres) in sand and mud off sandy ocean beaches. Another geoduck species (*Panopea smithae*) is found in deeper New Zealand waters.

In a 2012 assessment, G.S. Gislason & Associates Ltd18 make the following points:

> “Current total production is about 6,000 tonnes annually - 600 to 800 tonnes from culture, the remainder from the wild fishery. 90% or more of BC production is exported with 95% of the exports going to Hong Kong and China - Vancouver is the distribution hub for both BC and US product as the city has better air connections to Hong Kong and Mainland China than West Coast US locations.

The clear majority, more than 95%, is live sales - prices for live geoduck, like all live or fresh seafood, is supply-sensitive since one cannot inventory the product for very long. Current exports from North America are dominated by Vancouver-area businesses with close connections, often family connections, to Asian importers -

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the result is an opaqueness to the marketing function and a lack of formal marketing and promotion.

Hong Kong is a tariff free zone whereas Mainland China has a 28.82% tariff on geoduck. Hong Kong is a trans-shipment point for much of the geoduck destined to China. Major end user applications are hot pot and quick fry meals (sushi/sashimi is only 10% but growing) - over 90% is consumed in foodservice/restaurants. Geoduck competes with other high-end seafood such as Australian lobster and abalone. Colour (the whiter the better), and size (~1 kg preferred) are the most important product attributes. BC product is sold ungraded by the primary producer to the processor who grades the product into about four categories. Wild product generally is crunchier, hardier & has less shrinkage than culture product.

Culture product is whiter/has higher share of the #1 Grades, more uniform in size and has thinner shell/higher recovery - culture product gets 10% higher price on average than wild due to the better grade mix. Peak demand months are winter, December through early February before and during Chinese New Year.

Large price increases, in real inflation adjusted terms, occurred over 1990 to 1994 due to a number of factors. Wild supply is likely to decline by 3-5% over next 10 years, culture supply from Washington State likely will remain flat (due to lack of good growing areas and regulatory constraints related to opposition to geoduck culture on intertidal lands), geoduck culture potential from China is an unknown - but could take root as scallop culture did 30 years ago.”

(G.S. Gislason & Associates Ltd, 2012:iii)

In anticipation of increased world supply those authors note:

“...The market is short of product, and has been for 10 years. Supply growth from traditional sources is constrained, and therefore there is market opportunity for new sources of supply. There is potential to expand the market for geoduck to the relatively untapped North China and Interior China regions.

New supply would have some negative effect on the overall price, but the actual price impact would depend critically on the size of the supply increase, any new marketing efforts (the product essentially is not marketed now), the strategic behaviour of industry, and, how orderly the new supply was introduced (e.g., a steady increase in annual production would disrupt the market and market pricing much less than a sudden large increase in production).”

(G.S. Gislason & Associates Ltd, 2012:iii)
This positive commercial assessment of the market and value creation process motivates an assessment that should the biological and technical innovation challenges of NZ culture be successful the commercial prospects are sound. It has also been banned for heavy metal accumulation in the skin of the geoduck based on samples from one particular farm. The US west coast is considered as 1 region by China so a single import banning incident can have implications for the whole fishery of the west coast. Further, the NZ free trade agreement with China may promote tariff-free access, A significant advantage.

Biological proof concept of culture rearing has been achieved. The species lends itself to both intertidal and longline culture. Development of habitat mimics for longline culture to be attached to the Set and Forget System in the same manner as oyster basket ladders are the subject of a current Cawthron Institute research project. However, No NZ product currently in markets, acceptance of product attributes of indigenous wild NZ product unknown: size, taste colour, texture.

6.0 COMMERCIAL AND INVESTMENT

A full scale bioeconomic modelling assessment of culture of the species is beyond the scope of this report. The scope does call for however some indicative assessments of the commercial potential of those species. An indicative assessment has been compiled based on diverse and approximate sources. Caution is advised in their use: a full business case of open ocean oyster production in Eastern Bay of Plenty conditions should be developed to confirm their validity.

Bioeconomic modelling of the production and commercial potential of these species requires information on biological growth rates, stocking densities, effective production outcomes, prices, and fixed and variable costs. Without that information, the discounted cash flow modelling that generates investment assessment statistics such as net present value (NPV) and internal rate of return (IRR) is not possible. Further, it may prove unreliable to transfer production potential, cots and revenues reliably from other locations.

Given those caveats, this analysis relies on secondary sources to give indicative assessments of the commercial and economic development potential of the oyster species considered for this initial opportunity assessment.

From export statistics (Aquaculture NZ and SEAFIC data) weighted average FOB prices per piece for Pacific oysters and Flat oysters are NZ$ 0.92 and $1.18 respectively.

Comiskey (2014) estimates the half shell farmgate price to be 67% of landed Melbourne prices ready to enter the supply chain through distribution processes. Assuming equivalence to NZ FOB prices, this yields equivalent ex Opotiki prices per piece half shell (packed, chilled) for Pacific and flat oysters of NZ$0.64 and $0.79 respectively (based in 2017 FOB prices).

In 2011 Woods Hole Oceanographic Institute produced a series of advisory papers that contain business planning for longline shellfish culture. They developed production based discounted cashflow models as part of their analysis.

19 Hauke L. Kite, Powell Marine Policy Center, Woods Hole Oceanographic Institution, Shelton, 7 February, 2011
They describe typical longline production costs as: structures (13%); Spat and expendables (22%); Vessel and crew (40%); Onshore and other (25%).

In that paper, A DCF model for a blue mussel venture of scale 20 longlines, each line producing between 8000 and 10,000 kg of wet product per year produced a table of farmgate price, NPV, IRR, and payback data. The method used in this report is to make the same underlying assumptions as to scale and timing of farm development and its production revenues. It also assumed that the cost structure associated with oyster culture is equivalent to that of mussel culture.

Extrapolating from that data for a similar scale NZ oyster operation using a form of multivariate analysis yields NPV point estimates of NZ$ 0.65m and NZ$0.96m for similar scale Pacific and Flat oyster ventures respectively.20

Wyatt (2013) 21 undertook a study to evaluate the economic development impacts of harbour development at Opotiki. Because Wyatt (2013) publishes the revenue assumptions and current export unit prices for oyster species are known, it is possible to use her outcomes to make inference as to contrasting indicative estimates of the economic development outcomes for the Opotiki – Whakatane region that may result from some portion of the Whakatohea consented marine farm being devoted to oyster culture.

Wyatt (2013) assumes a farm gate unit price of the order of $NZ 0.31 per piece (18 pieces per kg at $5.58 per kg) for mussels. Ex-Opotiki estimates for Pacific oyster production described above are of the order of NZ$0.60. For comparison, the per hectare contribution of output value added and direct and indirect employment under Pacific oyster production are likely to be approximately double that generated under mussel production.

Importantly, one of the key points in that report refers to the interdependence of a port facility and effective use of the adjacent offshore marine farm space:

“You can’t have one without the other”

(Wyatt, 2013:4)

20 The coefficients on the Payback and IRR variables were not statistically significant. Estimates for those parameters are not reported here.

21 Wyatt, S., 2013, Economic Impacts of Opotiki Harbour Development. Report to ToiEDA.
7.0 ADDITIONAL SPECIES RECOMMENDED FOR CONSIDERATION

Two high value species are recommended for consideration for inclusion in the mix of species to be farmed by Whakatohea aquaculture’s open ocean programme:

7.1 Scallops, (*Pectin novaeseelandiae*),

Globally the scallop aquaculture industry is now well established, with a reported annual production totalling over 1,200,000 metric tonnes from about 12 species. Many species of scallop are cultured and harvested all over the world. However, only few species, in particular the *Pecten* genus, dominate the world harvest. The Japanese are the leaders in scallop landings from natural fisheries and in culturing and manipulation of scallop. Other countries where commercial harvesting is important include Korea, USSR and Australia in the West Pacific, and Canada, the United States of America, Peru, Argentina and Chile in the East. Important landings also occur in the Atlantic rim countries such as Iceland, France, United Kingdom, and Norway. The University of New Hampshire research described in Section 2.0 experimented with scallops in an open ocean environment.

7.2 Crayfish; (*Jasus edwardsii*) Puerulus on growing

Puerulus are juvenile crayfish that emerge from the larval stages of the crayfish lifecycle in pelagic coastal waters. They settle on coastal substrate and are readily captured around the New Zealand

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22 http://www.fao.org/docrep/field/003/AB714E/AB714E01.htm
The photograph above shows a clutch taken from an experimental mussel longline during research in the first Cawthron OOA program. Protocols have been negotiated with quota owners that enable use of this resource.

There is a considerable industry in Indonesia collecting *Panulirus ornatus* puerulii that are exported to Vietnam for on-growing in cages for re-export to China. The live crayfish market in China is lucrative.

### 8.0 NEXT STEPS

#### 8.1 Pacific Oysters

The Pacific oyster species deserves serious immediate consideration for commercialisation in the Whakatohea marine space. The opportunity is for innovation that extends existing know how to transfer species and culture practice to tap the commercial potential of high value export markets.

The physical infrastructure necessary stands ready for commercial deployment. Value creation and distribution networks are complemented by the Whakatohea proximity to air and sea freight hubs.

The attributes of the production context of Eastern Bay of Plenty waters provide the opportunity to tap into branding opportunities around safe, environmentally friendly production.

Substantial and growing export markets exist where consistency of quality and supply capacity have the potential to be well rewarded. Domestic and export markets feature supply shortfalls through disease incursion.

The key commercial risk lies in the biological domain in the form of disease risk. However, there is a comprehensive national biosecurity regime in place. Recent experience of disease incursion in Australasian waters offers experience on-farm mitigation strategies, and evidence that most affected farmers view the commercial risk as manageable. The Cawthron Institute selective breeding program selecting for resistance to OsHV-1 has proven to be very effective against the disease: normality is returning to the industry. The international literature shows genetic work to promote disease resistance and shorter culture times to be an effective value adding strategy.

Innovation that effectively mitigates disease risk is an important means of building competitive advantage for the Whakatohea open ocean aquaculture project.

Given the above, indicative commercial modelling shows a positive investment outlook.

Open ocean marine farm space devoted the culture of Pacific Oysters has the potential to generate, on a per hectare basis, twice the output, and direct and indirect economic development effects afforded by mussel cultivation.

This does not constitute a recommendation to supplant mussel culture with oyster production. Rather it should be read as an indication of the commercial and economic development potential that can be achieved through inclusion of the Pacific oyster species in a multi-species open ocean culture mix.

The assessment of this work is that further research activity to define commercial proof of concept of the culture of Pacific Oysters in Eastern Bay of Plenty waters is undertaken with a view to informing full business plan development.
Applied across the anticipated culture species, investigations need to be undertaken as to the configuration of the “hard” and “soft” infrastructure that constitute the most effective means of meeting commercial goals as well as the wider Whakatohea social and economic development vision.

8.2 Flat Oysters

The species presents a parallel opportunity to any Pacific oyster culture. The general comments in the section above also apply to the potential for the culture of flat oysters’ species. However, demonstration of the organisms’ biological and commercial potential in Bay of Plenty waters. Given restriction on the movement of organisms as a quarantine measure to combat spread of the *Bonamia ostreae*, the performance spat from diverse locations around the country needs to be evaluated. The present fluid situation with the flat oyster and *Bonamia* will result in strengthened risk mitigation in NZ. There are strategies in place following events like the *catenatum* event in early 2000s.

The next step on the path of this species to commercialisation is a project to demonstrate biological proof of concept in Whakatohea waters.

8.3 Geoduck

The geoduck species should be considered as a future opportunity. It represents a "new" indigenous aquaculture species. Its production systems are in the infancy of development in open ocean conditions. Product performance in substantial, diverse high value export markets is unknown.

The next steps toward commercialisation of this species is to support current research activities by Cawthron Institute and its international research partners to development suitable habitat mimics that can be deployed to the Set and Forget System and subsequent iterations under development.
Whakatōhea Strategic Plan

Vision:
"Ko te kai hoki i Waiaua"
*To be the food bowl that feeds the world*

"Kia rangatira ai ngā Uri o Te Whakatōhea."
*To grow and invest in the well-being of our people*

Our five-year **Goals**:

<table>
<thead>
<tr>
<th>Goals</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grow sustainable seafood</td>
<td>1. Grow Greenshell mussels</td>
</tr>
<tr>
<td>Enhance the value of seafood</td>
<td>2. Grow other seafood</td>
</tr>
<tr>
<td>Work with our environment</td>
<td>3. Innovate and identify new AQ opportunities</td>
</tr>
<tr>
<td>Uplift all of our people</td>
<td>4. Commercialise</td>
</tr>
<tr>
<td></td>
<td>5. Understand environmental systems</td>
</tr>
<tr>
<td></td>
<td>6. Educate and train people</td>
</tr>
</tbody>
</table>

**Lenses:**
through which we view decisions to set our priorities and to focus on the right things for our future generations to thrive

**Meet Māori values**
- De-risk commercial ventures
- Invest in people and infrastructure
Whakatohea Maori Trust Board

Eastern Sea Farms

Whakatohea Mussels Opotiki Limited (shareholder) 300 lines by 2022

Sanford 10+ lines leased

Possible new entities 20+ lines leased

Other initiatives
- Multi-species (oysters, gooduck, seaweed)
- Nutraceutical research
- Brands
- Processing shellfish
- Fish farming
KURA KI UTA, KURA KI TAI
Developing Whakatohea Aquaculture Research Programme

WHAKATOHEA AQUATIC PRODUCTION
Ko te kai hoki i Waiawa
LAND • SURF • DEEP SEA

Building Capacity
Aquaculture and environmental training for all ages. Teaching and training youth for the future; upskilling school leavers; identifying opportunities for adults; ie: skills development.

PRE SCHOOL • SCHOOL • TRADE TRAINING • ADULT EDUCATION • POST GRAD RESEARCH

Developing Opportunities
Investigating and growing aquatic species to broaden New Zealand’s Aquaculture industry.

GREEN MUSSEL SPAT • FLAT OYSTERS • PACIFIC OYSTERS • SEAWEED • SPONGES • SURF CLAMS • FISH

Enhancing Value
Identifying the value each species has to offer and how to produce each species efficiently; including quantifying the business risks, and the value in dollars and Mātauranga Māori.

Understanding Environment & Biology
Determining all the water properties that can help or hinder aquaculture goals; including researching where the water come from, what it brings and where it goes.

Creating New Environments
New structural and biological environments will be created on land and at sea. These will be suited to the location, robust, optimal for the species being grown and harvested, sustainable, easy to use and cost effective.

MATAURANGA MĀORI
WHAKATOHEA AQUACULTURE WORKING GROUP • IWI • HAPU
Māori values are our foundation.
<table>
<thead>
<tr>
<th>TASKS</th>
<th>WHAT DRIVES US</th>
<th>OUTCOMES</th>
<th>EXISTING CAPABILITY</th>
<th>CAPABILITY DEVELOPMENT</th>
<th>ACHIEVEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grow GSM</td>
<td>• Harvest GSM spat for sale or on-growing • Harvest GSM for domestic product. • Help meet BoP’s aquaculture goal of $250m by 2025. • Help meet NZ target of $1bn exports by 2025. • Explore actives in GSM for other applications</td>
<td>• Discover best GSM spat catching areas • Discover optimum growing areas for GSM production • Improve offshore growing systems • Improve GSM volume • Improve domestic and export markets • Identify new AQ space for GSM production</td>
<td>• Start GSM production in partnerships • Learn animal husbandry techniques • Brand GSM • Path to market • Development &amp; testing of GSM products • Partnership with Cawthron, Waikato University</td>
<td>• Biology and husbandry of GSM offshore • Best biosecurity practice • Grow GSM as sole trader • Commercialisation and marketing skills • Expand the brand • GSM breeding and genetics for future gain</td>
<td>• Secure spat catching rights • Best Management Practice on farm • Efficient grow out • Meet market need for GSM export volume and value • Realise economic value and opportunities</td>
</tr>
<tr>
<td>Grow other seafood</td>
<td>• Grow and harvest Pacific oysters for export • Grow and export flat oysters • Develop understanding of seaweed/algae production • Explore other added value species</td>
<td>• Export Pacific oysters • Trail flat oysters • Trial seaweed or algae • Product development / added value products • Lease more space</td>
<td>• Leadership position in seafood in BoP • Research partnerships to deliver spp diversity • Advancing technical capability • Unique understanding of marine AQ species</td>
<td>• International customers • Expand technical capability • Extend the research network • Algal technologies that enable larger biomass scale</td>
<td>• Viable Pacific oyster production business • Divestment of commercial production • Increase in national and international customers • Research delivers market-led new food products</td>
</tr>
<tr>
<td>Innovate and identify new AQ opportunities</td>
<td>Commercialise</td>
<td>Commercialise</td>
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<tr>
<td>• Identify bioactive compounds (from marine offshore resources) for supplements, nutra- and pharmaceuticals</td>
<td>• Access to and protection of aquaculture space</td>
<td>• Access to and protection of aquaculture space</td>
<td></td>
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<tr>
<td>• Land based aquaculture opportunities (algae, hatchery/ nursery)</td>
<td>• Streamlined monitoring and consenting processes</td>
<td>• Streamlined monitoring and consenting processes</td>
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<tr>
<td>• Research laboratories</td>
<td>• Novel compounds that can be extracted for markets</td>
<td>• Novel compounds that can be extracted for markets</td>
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<td></td>
<td>• Partner to build R&amp;D capability in bioactives</td>
<td>• Partner to build R&amp;D capability in bioactives</td>
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<td></td>
<td>• Commercial scale production</td>
<td>• Commercial scale production</td>
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<td></td>
<td>• Build infrastructure to support innovation</td>
<td>• Build infrastructure to support innovation</td>
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<td></td>
<td></td>
<td>• New offshore fish farming technologies</td>
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<td>• New offshore fish farming technologies</td>
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<td>• New science and technologies to enable improved space access and management for aquaculture</td>
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<td>• New science and technologies to enable improved space access and management for aquaculture</td>
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<td>• Tools and technologies for minimising biosecurity risk</td>
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<td>• Tools and technologies for minimising biosecurity risk</td>
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<td>• Improve consent processes and monitoring</td>
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<td>• Improve consent processes and monitoring</td>
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<td>• Aquaculture engineering</td>
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<td>• Aquaculture engineering</td>
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<td>• Bioeconomic modelling</td>
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<td>• Bioeconomic modelling</td>
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<td>• Co-culture methods</td>
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<td>• Co-culture methods</td>
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<td>• Leadership in enabling space for aquaculture</td>
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<td>• Leadership in enabling space for aquaculture</td>
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<td>• Build expertise in health monitoring, and diagnostics</td>
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<td>• Build expertise in health monitoring, and diagnostics</td>
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<td>• A+ certification</td>
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<td>• A+ certification</td>
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<td>• More space allocated</td>
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<td>• Healthy productive farms</td>
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<td>• Sustainable farming offshore</td>
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<td>• More space allocated</td>
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<td>• Healthy productive farms</td>
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<td></td>
<td></td>
<td></td>
<td>• Sustainable farming offshore</td>
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<tr>
<td>Understand environmental systems</td>
<td>• Need for fish farming trial offshore</td>
<td>farming technologies</td>
<td>• Collaborate with others to create the best team</td>
<td>• Use technology to assess the marine and coastal environments close to farms and other ecosystems</td>
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<tr>
<td>• Healthy, biosecure and productive farm environments</td>
<td>• Describe the aquatic environment, its health and interactions between diverse ecosystem components</td>
<td>• Understand impacts on the environment</td>
<td>• Enhance the environment where possible</td>
<td></td>
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</tr>
<tr>
<td>• Quality advice for sustainable management and economic development of coastal and marine farming opportunities</td>
<td>• Understand the aquatic environment’s value</td>
<td>• Use available assessment tools</td>
<td>• Restore environments and species where degraded and possible</td>
<td></td>
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</tr>
<tr>
<td>• Cost effective and efficient knowledge for farming in specific environments, high energy offshore areas</td>
<td>• Develop an environmental plan</td>
<td>• Deploy remote sensing buoys for monitoring real time</td>
<td>• Partner with Cawthron, Waikato University</td>
<td></td>
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</tr>
<tr>
<td>• Manage and utilise our resources better</td>
<td>• Make good decisions for best environmental management</td>
<td>• Communicate our environmental plan</td>
<td>• Long-term environmental planning</td>
<td></td>
<td></td>
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<tr>
<td>• Enhance the environment where possible</td>
<td></td>
<td></td>
<td>• Good working relationships with Councils</td>
<td></td>
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</tr>
<tr>
<td>• Restore environments and species where degraded and possible</td>
<td></td>
<td></td>
<td>• A widely accepted environmental plan</td>
<td></td>
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<tr>
<td>• Partner with Cawthron, Waikato University</td>
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<td>• Consents are reviewed and fit with the environmental plan</td>
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<td></td>
<td></td>
<td></td>
<td>• Healthier environments</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• More productive marine and coastal systems</td>
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<tr>
<td>Educate and train people</td>
<td>Education of all ages</td>
<td>Develop expertise</td>
<td>New ideas are supported</td>
<td>Attractive education learning for all</td>
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</tr>
<tr>
<td>We build knowledge, experience and a spirit for learning</td>
<td>Education of all ages</td>
<td>Develop expertise</td>
<td>New ideas are supported</td>
<td>Attractive education learning for all</td>
<td></td>
</tr>
<tr>
<td>We start with our young ones</td>
<td>Training to advance skills</td>
<td>Research ideas are identified and encouraged</td>
<td>Innovation is what drives us</td>
<td>We find outstanding scientific discoveries</td>
<td></td>
</tr>
<tr>
<td>We develop our youth</td>
<td>Create local jobs</td>
<td>Proof of concepts started</td>
<td>Ideas are funded</td>
<td>Build a development and learning platform</td>
<td></td>
</tr>
<tr>
<td>More young people going to University</td>
<td>Keep our whanau locally employed</td>
<td>Development and learning platform</td>
<td>Funding sources identified</td>
<td>Ideas lead to pilot scale projects</td>
<td></td>
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<tr>
<td>We upskill our adults</td>
<td></td>
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</tbody>
</table>
## FEASIBILITY of COMMERCIAL STUDIES

<table>
<thead>
<tr>
<th>Ideas and Discovery</th>
<th>Reduce Uncertainty</th>
<th>Local Application of Science</th>
<th>Feasibility of Commercial Gain</th>
<th>Launch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify areas in the region</td>
<td>Identify what is needed for proof of concept</td>
<td>Test in field</td>
<td>Partner interest and investment sought</td>
<td>Ready to sell, Partners highly desirable</td>
</tr>
<tr>
<td>Partnerships to share risk</td>
<td>Proof of concept</td>
<td>Investor interest or resources</td>
<td>Clear performance criteria known</td>
<td></td>
</tr>
</tbody>
</table>

### Size of Opportunity Scale
- SMALL
- MEDIUM
- LARGE

### LEGEND
1. GSM spat catching
2. GSM adult harvesting
3. Offshore engineering: Sell and forget
4. Setting pacific oysters offshore
5. Setting flat oysters offshore
6. Grow seaweed for research
7. New farm space
8. Finfish consent
9. Trout farming

---

**Risk:** possibility that the opportunity will not be realized into a commercial gain or used otherwise
### 9.2 Coriolis Report SWOT Analysis for the NZ Seafood Sector

<table>
<thead>
<tr>
<th><strong>Strengths</strong></th>
<th><strong>Weaknesses</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean water and generally healthy aquatic environment</td>
<td>Small producer of mussels on a global scale; very small producer of other two species</td>
</tr>
<tr>
<td>Unsubsidised industry</td>
<td>Mussel and oysters have low value per hectare; salmon development limited by red tape (change in use and landuse consent difficult)</td>
</tr>
<tr>
<td>Strong food safety regulations</td>
<td>Reliance on biosecure markets and a handful of flat to declining others (e.g. USA)</td>
</tr>
<tr>
<td>Predictable supply</td>
<td>Constrained regulatory environment which is semi-constant changing</td>
</tr>
<tr>
<td>Concentrated resources in three key species</td>
<td>Relatively low government support for fledgling industry (e.g. vs. Norway loan guarantees in early days of salmon industry development)</td>
</tr>
<tr>
<td>Only country farming green lipped mussels (Perna canaliculus); other farm other green shelled (perna viridis, etc.) or blue mussels (mytilus sp.)</td>
<td>Competing users of coastal space</td>
</tr>
<tr>
<td>Limited presence of disease</td>
<td>No competitive advantage around feed production due to low scale</td>
</tr>
<tr>
<td>Unique access to some biosecure markets (particularly Australia &amp; Japan)</td>
<td>Disconnect between scientific research into new species and needs of industry; research appears to be constrained to primarily research native species</td>
</tr>
<tr>
<td>Parts of domestic industry protected from imports by biosecurity measures</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Opportunities</strong></th>
<th><strong>Issues/Threats/Risk</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer perceptions of health benefits of seafood</td>
<td>Low cost competitors in low wage/low regulation higher productivity warm waters</td>
</tr>
<tr>
<td>Growing middle class in China and SE Asia</td>
<td>- Chile</td>
</tr>
<tr>
<td>On-going removal of trade barriers and free trade agreements</td>
<td>- China (future)</td>
</tr>
<tr>
<td>Preferential access to Australia due to access through phyto-sanitary barriers</td>
<td>Beach, bach and boat (the 3 b's), NIMBY (not in my back yard) user population limiting industry activity</td>
</tr>
<tr>
<td>New species</td>
<td>Disease outbreaks (e.g. oysters recently)</td>
</tr>
<tr>
<td>Development of land based plants for use in aquaculture (e.g. soy)</td>
<td>Reliance on a small number (3) of species (risk if disease outbreak); no significant new species has emerged since 1976</td>
</tr>
<tr>
<td>Industry co-operation</td>
<td>Single variable special interest groups driving domestic regulatory agenda</td>
</tr>
</tbody>
</table>
### 9.3 Pacific Oysters Summary

**COMMENTARY:** Deserves serious immediate consideration. The opportunity for innovation that extends existing know how to transfer species & culture practice to tap the commercial potential of high value export markets.

<table>
<thead>
<tr>
<th>Pacific Oysters</th>
<th>Markets</th>
<th>Value added chain</th>
<th>Production systems</th>
<th>Technical / biological issues</th>
<th>Commercial / investment</th>
<th>Next steps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Well developed domestic and export markets: December 2016 YTD 1.9m doz, $22.1m FOB</td>
<td>1. Branding opportunity in location specific Natural NZ, certification, best practice schemes.</td>
<td>1. Longline suspended ladders of baskets, net bags, trays <a href="http://link.springer.com/chapter/10.1007/978-3-319-51159-7_3/fulltext.html">http://link.springer.com/chapter/10.1007/978-3-319-51159-7_3/fulltext.html</a></td>
<td>1. Water column temperatures: higher temperatures lead to faster growth but with high nutrition demand.</td>
<td>1. Positive outlook.</td>
<td>1. Workshop to review findings</td>
</tr>
<tr>
<td></td>
<td>2. Considerable scope for expansion</td>
<td>2. &quot;Terroir&quot;, boutique, artisanal potential</td>
<td>2. Integration of hatchery, farm, processing : local location hatchery</td>
<td>2. Availability of nutrition, underlying; proximity of other AMA</td>
<td>2. Consistent with &amp; meets requirements of prior commentary e.g. Coriolis Reports</td>
<td>2. Full business case development</td>
</tr>
<tr>
<td></td>
<td>3. Nutrition, healthily foods, nutraceutical market / segments</td>
<td>3. Co-location in other value chains e.g. wine</td>
<td>3. Small scale production to export already evident in flat oyster production in the South Island</td>
<td>3. Fouling: operations, food availability.</td>
<td>3. Low - moderate commercial risk if technical challenges can be resolved</td>
<td>3. Develop SIL project proposal for commercial proof of concept</td>
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<tr>
<td></td>
<td>6. Proximity to air/sea distribution hubs</td>
<td>6. Aquaculture precinct: facilitated cluster approach to local industry development.</td>
<td>6. Weather - access to farms especially at critical production activities</td>
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<td></td>
<td>7. Existing relationships at forward end of chain</td>
<td>7. Alternative development options between large integrated firms and artisanal cluster to tap innovation potential</td>
<td></td>
<td>7. Seasonality - in year &amp; ENSO cycle</td>
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<tr>
<td></td>
<td>9. Value added chains well characterised</td>
<td>9. Use Open ocean approach to resolve social license issues while resolving economic development contradictions inherent</td>
<td></td>
<td>9. Vessel, harvest, process innovation, lean approaches</td>
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</table>

### 9.4 Flat Oysters Summary

**COMMENTARY:** Parallel opportunity that requires demonstration of the organisms’ commercial potential in Bay of Plenty waters.

<table>
<thead>
<tr>
<th>Markets</th>
<th>Value added chain</th>
<th>Production systems</th>
<th>Technical / biological issues</th>
<th>Commercial / investment</th>
<th>Next steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat oysters</td>
<td>1. Emerging domestic and export markets: December 2016 YTD $1,200 doz, $0.89m FOB</td>
<td>1. Branding opportunity in location specific Natural NZ, certification, best practice schemes.</td>
<td>1. Water column temperatures: higher temperatures lead to faster growth but with high nutrition demand (interview)</td>
<td>1. Positive outlook.</td>
<td>1. Workshop to review findings</td>
</tr>
<tr>
<td></td>
<td>2. Considerable scope for expansion</td>
<td>2. Integration of hatchery, farm, processing: local location hatchery</td>
<td>2. Availability of nutrition, underlying: proximity of other AMA</td>
<td>2. Consistent with &amp; meets requirements of prior commentary e.g. Coriolis Reports</td>
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<td></td>
<td>5. Price elasticity of demand of the order of -1.13</td>
<td>5. Share / co-develop shore facilities &amp; common processing packing &amp; distribution processes with other Eastern Bay production</td>
<td>5. Maritime operational issues</td>
<td>5. Indicative long run longline operation production cost structure: longlines etc,13%; spat,expendables,22%;vessel &amp; crew,40%;onshore, other,25%.</td>
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</tr>
<tr>
<td></td>
<td>7. Existing relationships at forward end of chain</td>
<td>7. Alternative development options between large integrated firms and artisanal cluster to tap innovation potential</td>
<td>7. Seasonality - in year &amp; ENSO cycle</td>
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</tbody>
</table>
### Geoduck Summary

**MARKETS**

1. Well developed high value international markets
2. Average annual world production estimate: 5,800 tonnes
3. High end product: competes with lobsters etc
4. Market features supply shortfall.
5. 2010 international price approx NZ$550 per kg FOB
6. Conspicuous consumption: Chinese business meal markets
7. No NZ product currently in markets

**VALUE ADDED CHAIN**

1. With market acceptance, as for oysters
2. Branding opportunity in location specific Natural NZ
3. Co-location in other value chains e.g. wine
4. Consistent quality supply key criteria of value add
5. Consistent quality supply key criteria of value add
6. Proximity to air/sea distribution hubs
7. Existing relationships at forward end of chain
8. Diversity of channels to consumers

**PRODUCTION SYSTEMS**

1. Longline suspended arrays of production habitats: technology & operations well understood
2. Production / culture habitats mimic intertidal habitat
3. Production / culture habitats in design & trial phase.
4. Requires demonstration of biological, technical and commercial proof of concept.

**TECHNICAL / BIOLOGICAL ISSUES**

Species under examination in MBIE OOAv2 research program.
All aspects of specie's culture under review
High risk

**COMMERCIAL / INVESTMENT**

No production modelling undertaken

**NEXT STEPS**

1. Workshop to review findings
2. Maintain relationship with MBIE OOA2 project

**COMMENTARY: Future opportunity: "new" indigenous aquaculture species, production systems in infancy in open ocean conditions, with unknown product performance in substantial, diverse, high value export markets**