Port Underwood, Marlborough Sounds Museel Farm near Horahora Kakahu, New Zealand
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Central New Zealand Aquaculture Foodscape

Aquaculture diversification for resilience

LOCATION: New Zealand

SYNOPSIS

Central New Zealand is one of the largest shellfish producers in the world. In addition to supplying global markets, seafood has played a central role in the culture and foodways of indigenous communities for centuries. Yet, the Central New Zealand Aquaculture foodscape has limited space to expand operations in near-shore areas, constraining the opportunity for growth in this highly sustainable food source, and is also vulnerable to environmental and economic shocks because of its focus on a relatively small number of species.

Open-water and near-shore restorative aquaculture provide an opportunity to increase the productivity and resilience of the foodscape by adding a seaweed sector to diversify production. But despite strong potential for diversified aquaculture within the foodscape, there is still need to develop both the markets for diversified products and the infrastructure needed for this approach to be effective at scale. In the case of seaweed, barriers to human consumption likely need to be addressed more broadly, including public perceptions around food safety and the viability of seaweed as a dietary staple.

In terms of infrastructure development, emergent programs already highlight the potential for regional partnerships to catalyze sector-wide development, such as Seaweed for Europe.[20] These programs provide a valuable analogue for collaboration on shared challenges and offer learnings in the development of markets and technology, in this foodscape, in New Zealand more broadly, and across other marine foodscapes and regions.

DESCRIPTION OF FOODSCAPE

Mariculture – aquaculture in marine environments – in the Central New Zealand Aquaculture foodscape (FIGURE 1) takes place in three ecoregional provinces that span the main islands (northeastern, central, and southern New Zealand) and a range of sheltered and exposed, subtropical, temperate, and subarctic environments.[21]

CENTRAL NEW ZEALAND

FIGURE 1. Map of Central New Zealand Aquaculture Foodscape.

Aquaculture production has averaged 107,097 tons per annum from 2010 to 2020, with production comprised of a total of four shellfish and finfish species valued at more than $800 million. Approximately three-quarters of the country's mussel production (green-lipped mussel, *Perna canaliculus*) and two-thirds of fin-fish production (King salmon, *Oncorhynchus tshawytscha*) occurs in this foodscape. Currently, more than 600 farmers make up the green-lipped mussel industry, many of which farm an area less than 10 ha in size, often as small as 3 ha.

Kaimoana (seafood, in Māori) has always been an important source of protein and cultural and spiritual connection for coastal Māori. Māori traditionally carried out aquaculture activities, and the Waitangi Tribunal resolved that Māori have a customary interest in this activity; this is a finding that formed the basis for an allocation of 20% of new marine farming space to Māori a 2004 settlement.

Green-lipped mussel farm (*Perna canaliculus*), marine farming in Admiralty Bay, Marlborough Sounds, New Zealand.
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The cultural importance of *kaimoana* has grown as the availability of the other main traditional protein source, birds, has been restricted by law and scarcity. An estimated 40% of the marine farming industry is now owned by Māori.

CHALLENGES

Access to nearshore mussel farming sites has become limited in important growing areas such as the Marlborough Sounds. This is due to multiple factors, such as physical limitations on space, the need to work within the limits of regional ecological carrying capacity, and the need to ensure negative environmental impacts do not occur.

Social expectations also affect the support that is given to a sector or company, influencing the potential for aquaculture to occur and under what circumstances (e.g., types of farming, proximity to shore, license requirements). The type of farming (finfish versus shellfish), the quality of an individual's contact with an aquaculture operator, the potential for cultural impacts, and perception about the fairness of how economic benefits are distributed have been identified as influential in public acceptability of the aquaculture industry.[22]

At the same time, the health of ocean environments and impacts from land-based nutrient and sediment inputs, which must be managed by industry aquaculture operations, continue to be persistent issues in coastal and marine areas.[23]

The lack of diversity of products within Central New Zealand's Aquaculture foodscape exposes food producers here to a range of biophysical (e.g., climate change), market (e.g., fluctuations in price and demand), and social (e.g., changing social preferences) risks.[24,25] The foodscape's essential vulnerability was recently exposed under COVID-19 when foreign markets for mussels became limited, leading to an estimated 20% decrease in mussel prices, challenging the profitability of many farming operations.

Mussel farmers and industry associations that represent them have become increasingly interested in integrating seaweed farming into existing mussel leases. Seaweed aquaculture represents an opportunity for the industry to diversify the production portfolio, supplement incomes, increase their resilience to future change, and enhance the provision of ecosystem services from aquaculture operations.

With a concerted focus on overcoming barriers to seaweed aquaculture production and markets, the Central New Zealand foodscape could support profitable and sustainable, diverse aquaculture operations, including seaweed farming.

SOLUTIONS

The Government of New Zealand has outlined a vision to become a "globally recognized world leader in sustainable and innovative aquaculture across the value chain"[26] and has a stated goal of expanding to a $1 billion industry by 2025. The government also recognizes the specific opportunity for aquaculture to "be a more significant part of a lower emissions economy."

The first of four outcomes listed in the national government's aquaculture strategy is environmental sustainability, which suggests nature-based solutions, such as restorative aquaculture, will be foundational to improvements and expansions in the aquaculture industry.

The strategy further emphasizes the need for innovation, including the diversity of production and development of new production technologies to support sustainable aquaculture, such as seaweed farming and open ocean aquaculture.

Economic modeling has assessed the theoretical addition of seaweed farming of kelp, *Ecklonia radiata*, under two transition scenarios in the Marlborough Sound within the Central New Zealand foodscape (one of the most favored and high-density farming areas in New Zealand). One scenario focuses on a 5 ha mussel farm integrating seaweed in its farming operations alone, and the other focuses on a farm that integrates seaweed in its operations while being part of a cooperative that jointly owns the seaweed nursery and processing facilities.

In the first scenario, mussel farmers could increase income through integration of seaweeds, by an estimated $35,000 per year. If farming activities are vertically integrated, including a hatchery for production of seed through a cooperative approach as in scenario two, it is estimated that income would rise significantly, to $82,000 per year, a 133% increase over farming individually (FIGURE 2).

The environmental benefits associated with this vertical approach would also increase. As non-fed, extractive species, bivalves and seaweeds have the greatest current known potential for restorative aquaculture. These species groups can improve water quality at various scales because they remove nutrients, including nitrogen and phosphate.[27,28]

In fact, a global opportunity assessment for restorative aquaculture potential identified the three marine ecoregions surrounding the mainland coasts of the north and south islands as "high" opportunity areas to profitably generate positive environmental outcomes through seaweed and shellfish farming.[29]

Longer term, restorative aquaculture might also provide the opportunity to engage with greenhouse gas emissions reduction of farming operations and abatement strategies for other industries, such as through the use of seaweed for production of biofuels or biochar (to improve soil carbon sequestration). By integrating seaweed into farming operations, it is estimated a 5 ha mussel farm could reduce greenhouse gas emissions by 1.7 tonnes of CO_2 equivalents per year and absorb an additional 0.34 metric tonnes of nitrogen from coastal waterways.

Integrating seaweed and shellfish farming can also provide nature-based solutions to help address some of the environmental challenges now facing New Zealand waterways, including persistent eutrophication due to agricultural runoff and coastal development, as well as habitat declines of native kelp and mussel beds. Seaweed and shellfish filter water and cycle nutrients, which can contribute to reductions in excess anthropogenic nitrogen, phosphorous, and carbon.

Seaweed farming can create a localized effect in buffering pH and increasing acidification,[30] and spillover of mussel larvae from aquaculture can supplement wild mussel populations that may have declined.[31] In association with farming infrastructure these species also provide habitat for a range of other wildlife, especially fish and invertebrates, which come to these areas for feed or shelter, including shelter for recruitment.[32,33] Diversifying the species farmed, and engaging specifically with farming of seaweeds, provides a pathway for the New Zealand aquaculture industry to increase efficiencies in the use of current allocations of water; increase income at the farm scale, enhancing the socioeconomic value of the industry; plan for longer term impacts, such as climate change, and related shifts in biophysical parameters; reduce risk associated with diseases and pathogens (typically species-specific) as well as external shocks in trade (e.g., fluctuations in commodity price); and more confidently approach changing expectations in social license, governance, and marine planning.

Kelp (pictured here) provide an opportunity to diversify aquaculture activities and production. These species are used in a range of products, including food, and their farming can generate environmental benefits in surrounding seas.
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Agricultural landscapes can impact coastal aquaculture through farming practices, South Island, New Zealand
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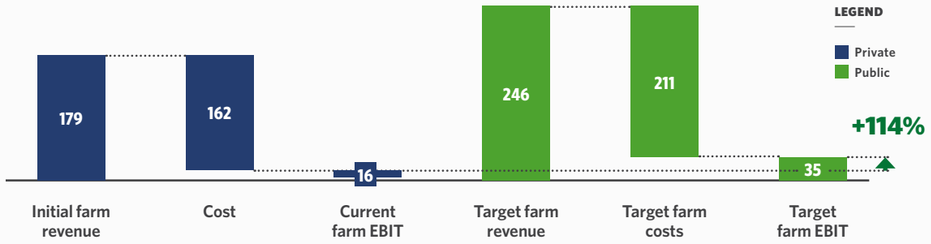
AGGREGATION OF ARCHETYPES TO THE FOODSCAPE LEVEL

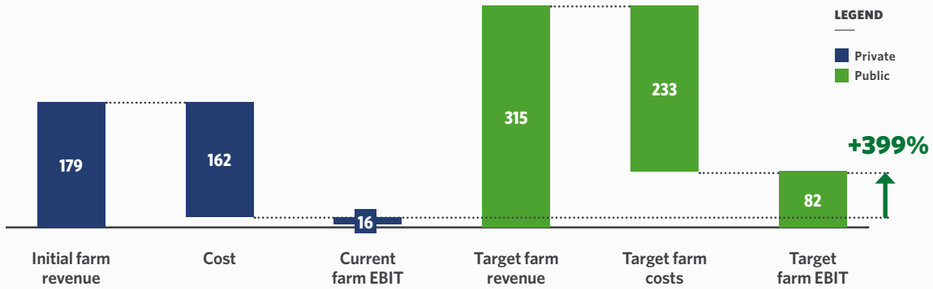
Foodscape economic impact
(thousand USD/year)

5 ha mussel farm ····▸ 5 ha mussel and seaweed farm



Economic impact per farm as part of cooperative
(thousand USD/year)

5 ha mussel farm ····▸ 5 ha mussel and seaweed farm as part of a cooperative hub



Nitrogen/Phosphorus absorption target farm
(tons of N – P/year)

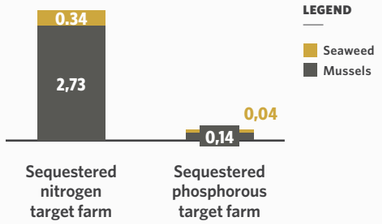


FIGURE 2. Summary of economic analysis of nature-based solutions in the Central New Zealand Aquaculture foodscape. The diagram describes the costs and benefits associated with two transitions in the integration of seaweed with mussel farming, a 5-ha mussel farm integrating operation alone, and a farm integrating as part of a cooperative (jointly owns the seaweed nursery and processing facilities). The waterfall diagrams summarize current farm costs and benefits, future farm costs and benefits, public costs and benefits, and total net benefits associated with the two scenarios. Estimated impacts on nutrient absorption apply to both scenarios. See Supplementary Material for a description of methods.[1]

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