

An underwater photograph showing a dense field of yellow-green seaweed with many small blue fish swimming around it. The scene is brightly lit, suggesting a shallow depth. The background shows a clear blue sky and a rocky coastline above the water surface.

Aotearoa New Zealand's Seaweed Sector Framework

October 2022

National
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Ko ngā moana
whakauka

Sustainable Seas National Science Challenge project: Building a sustainable seaweed sector for Aotearoa New Zealand

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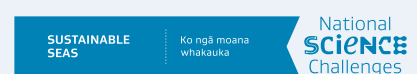
Cover image: Darryl Torkler

About Sustainable Seas Challenge

Our vision is for Aotearoa New Zealand to have healthy marine ecosystems that provide value for all New Zealanders. We have 60+ research projects that bring together around 250 scientists, social scientists, economists, and experts in mātauranga Māori and policy from across Aotearoa New Zealand. We are one of 11 National Science Challenges, funded by Ministry of Business, Innovation & Employment.

For more information on this project, visit:

www.sustainableseaschallenge.co.nz/our-research/building-a-seaweed-economy



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Contents



Contents	1	Supply chain priorities	13
Executive summary	3	Wholesale / Retail.....	13
Introduction	4	Process / Manufacture.....	13
Background	4	Hatcheries.....	14
Purpose	4	Knowledge	14
Current state	5	Supporting priorities	15
Seaweed globally	5	Regulation	15
The seaweed sector in New Zealand	5	Leadership.....	15
Barriers to growth	5	Workforce.....	16
Ecosystem Based Management	6	Brand/IP.....	16
2032 seaweed sector vision	8	Te Tiriti	16
Priority markets & value pathways	9	Environment	17
Competitive advantage.....	9	Business models & investment	18
Sector strategy	9	Sector development risks	19
Value proposition	9		
Priority markets.....	9		
Health & beauty.....	10		
Human food.....	10		
Animal feed supplements	11		
Biostimulants.....	11		
Ecosystem services.....	12		



Executive summary

The global value of seaweed aquaculture in 2019 was estimated at US\$14 billion with a growth rate of 7% per year on average over the last decade. A December 2020 Blue Economy report identified seaweed as a priority **opportunity** for New Zealand due to the under-developed state of the industry, the large number of local species, the potential for beneficial environmental, social and cultural impact, and opportunities to develop high-value products over time are highly aligned with restorative economies.

Barriers to growth for the New Zealand seaweed sector include investment, knowledge, regulation, leadership, and markets. The **purpose** of this Seaweed Sector Framework is to guide the development of a thriving, high-value seaweed sector that provides meaningful economic, environmental, social, and cultural benefits.

When this framework was tested with sector participants, the resounding feedback was the urgent need to enable new marine based seaweed aquaculture, particularly to open a pathway for commercially focussed research/trials.

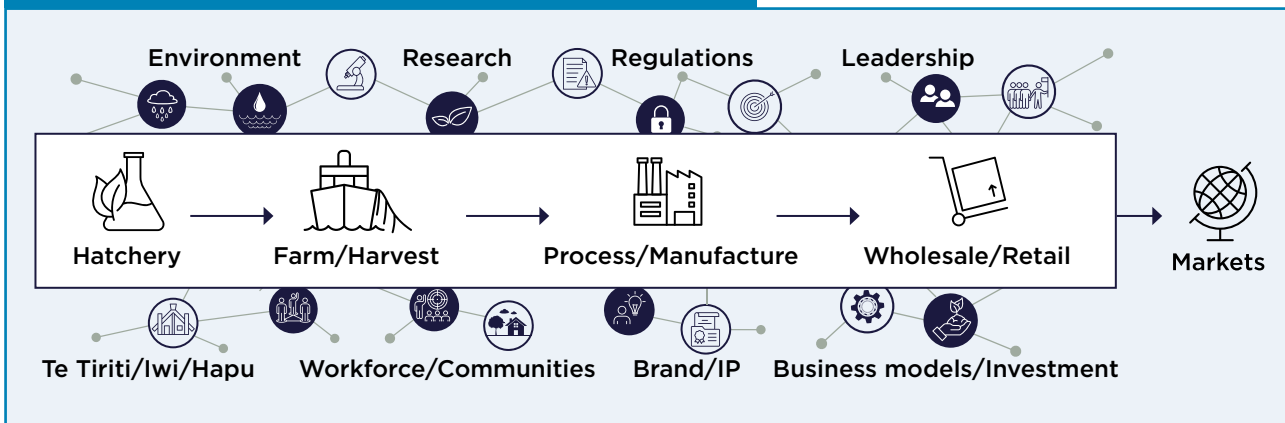
The call is for a framework which can accept some level of uncertainty of effects and adaptively manage as our experience and understanding develops. The pathway needs to include both marine farm consenting and access to wild seaweed for aquaculture broodstock.

This **framework** consists of layered outputs starting with this summary that can be used to navigate to graphics, lift outs, and detailed research reports. It incorporates principles of Ecosystem Based Management alongside Te Ao Māori. The main intended audiences include sector leaders and kaitiaki, participants, funders, researchers and regulators.

The 2032 seaweed sector **vision** is that:

Seaweed contributes significantly to New Zealand's economy and supports thriving ecosystems, communities, and culture.

The **building blocks** for achieving this vision are:



New Zealand's **competitive** advantage lies in high-value products for niche markets via:

Technology-led value extraction from New Zealand seaweed species via brands with high social and environmental licence.

Introduction

A pragmatic, phased **strategy** for New Zealand seaweed producers is to focus on unmet demand in existing markets, while progressively developing higher value products where technology, scale, investment, and intellectual property permit.

Priority **markets** for New Zealand seaweed product and services include health & beauty; human food; animal feed supplements, biostimulants, and ecosystem services and restorative economies. Each market has product pathways to higher value, and

some have significant unmet demand due to current seaweed supply chain constraints. Priority local seaweed species for supply vary according to the market being targeted.

Significant constraints to the seaweed sector's development and **responses** have been identified for the supply chain and supporting building blocks. Lift outs provide more detail on immediate and medium term **priorities** for sector regulation, knowledge, and leadership.

Background

The Aotearoa New Zealand Seaweed Sector Framework project is part of the broader Blue Economy workstream of the Sustainable Seas National Science Challenge. The Blue Economy workstream seeks to *“transform Aotearoa New Zealand's ability to enhance our marine economy, and to improve decision-making and the health of our seas through ecosystem-based management.”*

Seaweed was identified as a priority blue economy opportunity in a December 2020 EnviroStrat Report due to the:

- » Relatively undeveloped state of the industry.
- » Significant, growing demand for seaweed-based products.

- » Large number (900 plus) of native and endemic species.
- » Potential for low environmental impact &/or benefits.
- » Opportunity to develop high-value products over time.

A research opportunity identified from the EnviroStrat Report was to frame up a future vision and value proposition for Aotearoa New Zealand's emerging seaweed sector. Additionally, New Zealand's large ocean estate and global brand as 'clean & green' means it is well placed to leverage the image in overseas markets.

Purpose

The **purpose** of the Aotearoa New Zealand Seaweed Sector Framework is to:

Guide the development of a thriving, high-value seaweed sector that provides meaningful economic, environmental, social, and cultural benefits to local communities and broader impacts nationally.

New Zealand's seaweed sector is growing rapidly, but without any strategic or structural context. We have an opportunity with the Seaweed Framework to determine and prioritise how the sector can develop in the coming years. Responsibility for

implementing the framework lies with current and future seaweed sector participants and stakeholders, and government. It is intended to be adaptive and incorporates principles of Ecosystem Based Management alongside Te Ao Māori.

The **main audiences** for this Seaweed Sector Framework are:

- » **Leaders and kaitiaki:** Iwi, the Crown, sector groups and pioneers.
- » **Supply chain participants:** hatchery staff, farmers, processors, wholesalers/retailers.
- » **Communities**
- » **Legislators and regulators:** central and local government.
- » **Researchers:** public and private.
- » **Public and private investors.**

The Seaweed Sector Framework comprises layered **outputs:**

- » **Summary:** forward focused sector vision, components, high-level priorities, and risks.
- » **Graphics:** illustrative insights on important topics.
- » **Lift outs:** summaries of priorities for specific audience groups.
- » **Reports:** detailed research that underpins the framework.

Current state



Seaweed globally

There are three types of seaweeds or macroalgae: green, red, and brown, all of which are farmed or harvested in some manner. Red seaweeds (52%) and brown seaweeds (47%) make up most of the global supply. 85% of farmed seaweed is used for human consumption, either directly or as a food ingredient. The balance (15%) is used for a range of markets including livestock feed supplements, biostimulants, extracts and a range of other uses.

Within seaweed food-products, China and Japan are the largest importers representing more than 71% of the global market. Lower value products dominate volume, but higher value pockets exist and are growing in segments such as food, supplements, and cosmetics where health benefits

and environmental credentials are valued in certain markets.

Seaweed makes up almost a third of global aquaculture production volume. Global value of seaweed aquaculture in 2019 was estimated at over US\$14 billion with a growth rate of 7% per year on average over the last decade. Seaweed aquaculture production volume has tripled over the last 20 years and now accounts for 97% of total global production (over 34 million tonnes was aquaculture and just over 1 million tonnes was wild harvest in 2019). Asia dominates seaweed aquaculture (97% in 2019); China (58%), Indonesia (29%), South Korea (5%) and the Philippines (4%) are the top producers.

The Seaweed Sector in New Zealand

New Zealand has an emerging seaweed sector operating at a small scale with pockets of product innovation. There are almost no data on the scale of the seaweed sector apart from the wild harvest of bladder kelp, *Macrocystis pyrifera*, which is managed by the quota management system under the Fisheries Act.

Market demand for most seaweed products in New Zealand is immature by comparison with international markets. The majority of New Zealand harvested seaweed is used to produce products for the agricultural and horticultural markets (mainly soil biostimulants and animal feed supplements). The domestic market for seaweed as food for

human consumption is relatively small and undeveloped. Other small volume markets for New Zealand seaweed today include seaweed extracts used in health products, beauty products, and as ingredients to other products. Small scale export of some of these products occurs today.

The seaweed sector is constrained by an underdeveloped local supply chain. Small volumes are harvested from mussel lines (as by-catch or deliberately caught), and from limited wild harvest and beach-cast collection. This supply is supplemented by some imported raw stabilised product that is processed in New Zealand.

Barriers to growth

The most significant barriers to growth for the New Zealand seaweed sector today include:



Investment: risk capital is needed to support early movers that reduce risk for others, sector relevant research and development, and to develop sector infrastructure.



Knowledge: significant practical knowledge gaps exist on farming New Zealand species, developing value-add products, and understanding environmental impacts.



Regulation: the current regulatory framework is not fit for purpose.

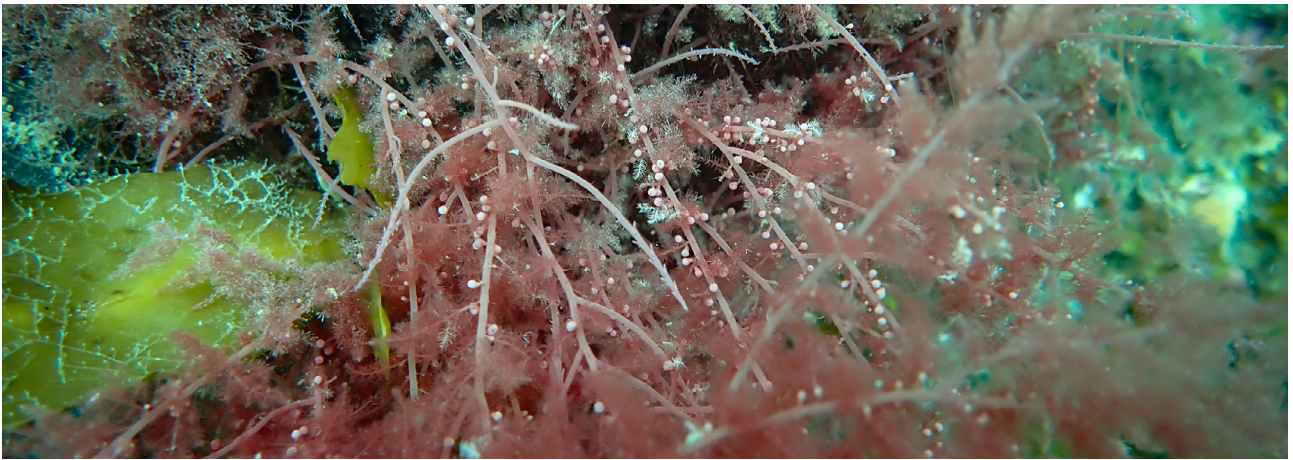


Leadership: there hasn't (until very recently) been a sector body or common vision to lead the sector.



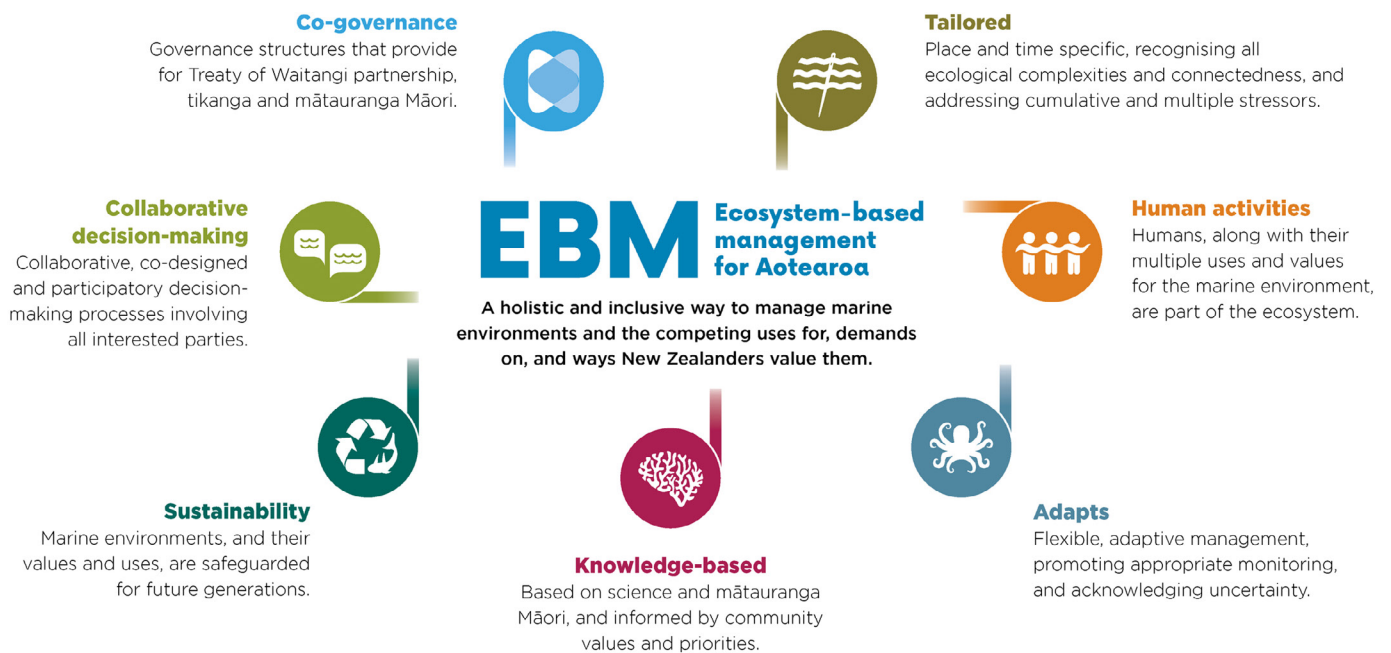
Markets: increased supply and scale is required alongside pathways to higher value in order to realise market opportunities.

Ecosystem Based Management



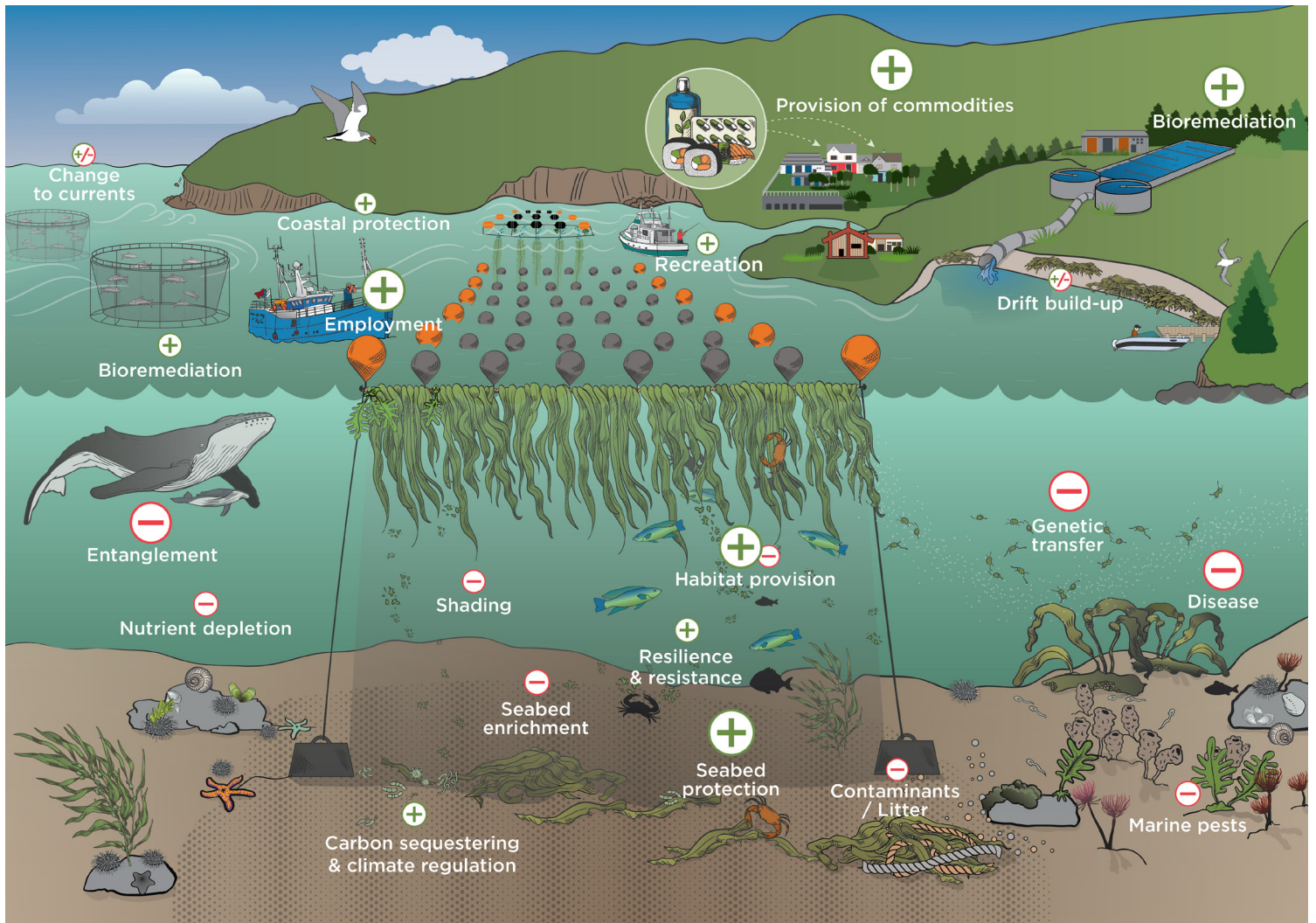
Sustainable Seas defines Ecosystem Based Management (EBM) as:

a holistic and inclusive way to manage marine environments and the competing uses for, demands on, and ways New Zealanders value them.



EBM is informed by a range of knowledge sources. Development of a sustainable seaweed industry incorporating EBM principles means including the community, co-governance (if this is a priority for tangata whenua either now or in the future),

and appropriate science. Collaborative decision making and adaptability in regional approaches and business models is likely to be required depending on the aspirations of each community.



Development of Aotearoa New Zealand's seaweed sector will require a shift towards aquaculture to allow an increase in yields without placing pressure on wild seaweed populations. This diagram shows the possible negative environmental effects and ecosystem services associated with seaweed aquaculture in subtidal environments. The likely nature and degree of effect is indicated by large '-' or '+' symbols. Graphic by Revell Design.

To develop a sustainable seaweed sector within an EBM framework, considerations include:

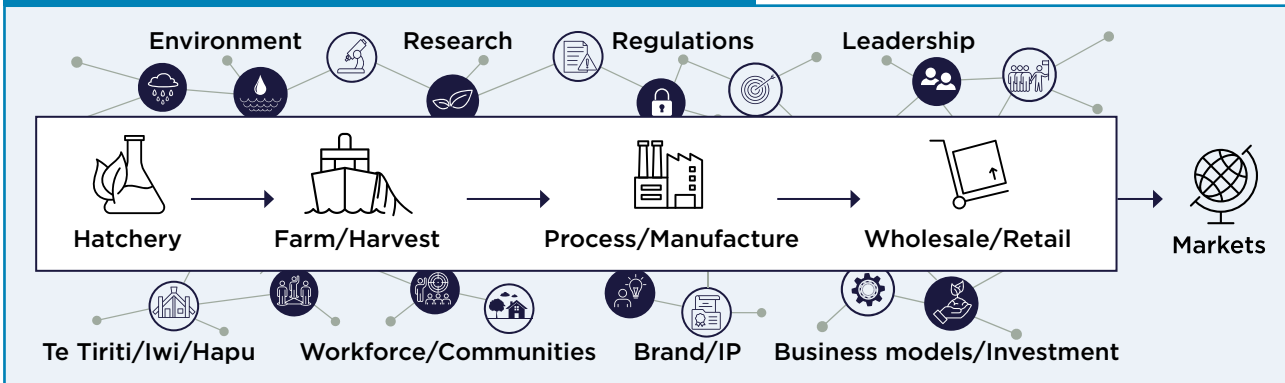
- » **Co-governance:** does genuine partnership exist? How could it be established and underpinned by te tiriti principles?
- » **Collaborative decision making:** who needs to be at the table? How will decisions be made?
- » **Knowledge based:** what are the knowledge systems being used? What is missing, and how might those gaps be filled? What do we need to know as seaweed aquaculture develops?
- » **Sustainable:** how can the environment and human communities benefit and how can undesirable impacts be avoided or mitigated?
- » **Adaptable:** how can the seaweed sector develop, grow, and respond to new information or changing conditions?
- » **Tailored:** What are the requirements specific to this community, environment type, species, or time?

2032 seaweed sector vision

The 2032 seaweed sector **vision** is that:

Seaweed contributes significantly to New Zealand's economy and supports thriving ecosystems, communities, and culture.

The **building blocks** for achieving this vision are:



Individual building blocks are interdependent. All building blocks are needed to achieve the vision, collectively.

Building block	Aspirational success
Markets	Proven markets exist for New Zealand seaweed products that value and pay a premium for our high quality and sustainable products.
Wholesale / Retail	Seaweed producers can access enough high-quality, sustainable seaweed at a reasonable price to meet market demand.
Process / Manufacture	Seaweed processors and manufacturers economically process seaweed to extract maximum value from the raw product using innovation and technology.
Farm / Harvest	Seaweed farmers and harvesters, working alongside kaitiaki, have the space, knowledge and equipment to operate profitably with wider benefits.
Hatcheries	Seaweed hatcheries produce sufficient high-quality product at a reasonable price to meet the needs of all seaweed farmers.
Research	Seaweed research provides practical knowledge for local species, and pathways to higher value products and services. This includes data framework and approach for data collection, and data sharing.
Regulations	Seaweed regulations support sector innovation, collaboration, and value while enhancing environmental, social, cultural, and economic values. Regulations are tailored to specific species as required and these regulations enable and support seaweed blue economy.
Leadership	Seaweed sector leadership provides a trusted sector voice to influence externally, and cooperate internally, to achieve a common sector vision. It also provides a voice and opportunities to communities seeking to participate in sector.
Workforce / Communities	Trained workers are available to meet sector needs and they feel valued within their communities. Ensure positive local environmental, social, cultural impacts from new seaweed businesses in the areas in which they operate.
Brand / IP	New Zealand seaweed brands are protected and recognised locally and internationally as leaders in quality and sustainability.
Te Tiriti / Treaty of Waitangi Iwi / Hapu	The Crown and Māori are partners in the development of New Zealand's seaweed sector, with whanau, hapu and iwi as active participants. Iwi / hapu are involved from the outset of new seaweed businesses, ensuring positive local environmental, social, and cultural impacts from new businesses.
Environment	The New Zealand seaweed sector actively enhances ecosystem health, EBM principles, community well-being and cultural enhancement. It provides circular economy, climate, water quality and biodiversity benefits.
Business Models/ Investment	Successful seaweed business models and funding options align with the sector vision and provide proven pathways to enter the industry. Strategically aligned investment blending public, private, philanthropic capital to catalyse the emerging sector.

Priority markets & value pathways

Competitive advantage

To build a high value sustainable sector, New Zealand producers need to develop high-value products for niche markets with a competitive advantage that can be maintained.

Competitive advantage for New Zealand seaweed products

Technology-led value extraction from New Zealand seaweed species via brands with high social and environmental licence.

Sector strategy

A pragmatic, phased strategy for New Zealand seaweed product producers is to focus on unmet demand in existing markets ('**activate**'), while progressively developing higher value products where technology, scale, funding, and intellectual property permit this ('**transition**'). The transition phase to higher value can be accelerated by investment to develop the seaweed supply chain and support sector growth.

Using a cascading processing approach, it is possible to produce products for multiple markets at once, and to extract maximum value from seaweed. This is evidenced where **innovative New Zealand seaweed product producers are leveraging the material, scale, and revenue from lower value products, to concurrently develop higher value products. EBM and community/iwi engagement should be at the core of the sector as it emerges.**

Value proposition

These elements can be combined into unique seaweed **value proposition(s)** for New Zealand:

- » Endemic &/or native New Zealand species.
- » Scientifically proven product and service benefits.
- » Authentic brands with high social and environmental licence.
- » Mātauranga Māori, Māori names, stories, knowledge, and culture.
- » Intellectual property protection (names, brands, processing, and compounds).
- » Restorative ocean farming methods and Southern Pacific Ocean water quality.
- » Trusted food safety and production standards.
- » Premium ingredients that build on New Zealand story/brand.

Priority markets

The table below summarises priority market opportunities for New Zealand seaweed producers based on previous research and sector stakeholder input¹.

Market	Fit Potential advantage for New Zealand	Profit Expected profit margins at maturity	Scale Revenue potential for New Zealand	Readiness Proven market viability and demand
Health & Beauty	High	High	Low	Low
Human Food	High	Med	Low	Low
Animal Feed Supplements	High	Med	High	Med
Biostimulants	High	Low	High	High
Ecosystem Services and restorative economies	Med	Low	Med	Low

¹ Bradly et al 2021, Stocktake and Characterisation of New Zealand's Seaweed Sector

Health & beauty

Seaweed extracts for use in beauty, nutraceutical, or pharmaceutical products may emerge as a significant opportunity in time for New Zealand. Premium products such as Crème De La Mer

demonstrate the potential from significant investment in research, processing, intellectual property, and marketing. However, this type of success takes time and is not easily replicated.

Lower value	Medium value	Higher value
» Non-IP protected active ingredients	» IP protected active ingredients » Beauty products » Nutraceutical products	» Pharmaceutical products

Priority New Zealand seaweed species for health and beauty include:



Karengo (*Pyropia & Porphyra*) - antioxidant and anti-inflammatory bioactivities, health promoting amino acids and peptides, and enzymes that can lower blood pressure.



Fucoids (*Durvillaea & Marginariella*) - fucans with anticoagulant, anti-inflammatory, and anti-viral effects; alginates for hydrogels; and fucoidan with anti-cancer effects.



Asparagopsis - not well studied but used in acne treatment.



Kelps (*Ecklonia, Lessonia, & Macrocystis*) - fucoidan and carotenoids with anti-tumour, anti-viral, and anti-inflammatory properties; vitamins and mineral micronutrients.

Human food

Seaweed consumption in New Zealand is in its infancy compared to markets in Asia, Europe, and North America. Most of the product consumed here is imported from low-cost Asian suppliers as heavily

processed pre-packaged snacks and sushi wrap. Traditional high-end export markets such as Japan have high quality requirements and barriers to entry.

Lower value	Medium value	Higher value
» Commodity food ingredient (e.g., agar)	» Branded condiments (e.g., seasonings) » Processed food (e.g., seaweed infused pasta)	» Fresh chilled product (e.g., restaurant menus) » Premium processed food with health benefits

Priority New Zealand seaweed species for food include:



Sea lettuce (*Ulva species*) - fresh in salads or soups or dried as a food wrap.



Karengo (*Porphyra/Pyropia*) - boiled fresh or dried as alternative to Japanese nori.



Wakame (*Undaria pinnatifida*) - fresh in soups, smoked, or dried as a seasoning.



Bladder kelp (*Macrocystis pyrifera*) - roasted as chips or dried as a seasoning.

Animal feed supplements

Seaweed is a small but fast-growing part of the global livestock feed and supplement market. New Zealand seaweed-based feed supplements exist for cattle, horses, pigs, goats, poultry, and bees. There

is existing unmet demand due to seaweed supply constraints, and a lot of interest in the potential for seaweed to help reduce methane emissions and urinary nitrogen from livestock.

Lower value	Medium value	Higher value
» Processed seaweed feed with anecdotal benefits	» Feed supplements with research backed animal health and productivity benefits	» Feed supplements with research backed animal health, productivity, and environmental benefits

Priority New Zealand seaweed species for animal feed include:



Sea lettuce (*Ulva species*) - trace elements, vitamins and immunity benefits via ulvans.



Bladder kelp (*Macrocystis pyrifera*) - rich in iodine and aids mineral absorption.



Common Kelp (*Ecklonia radiata*) - range of animal health and productivity benefits.



Asparagopsis - reduction in livestock methane emissions.



Wakame (*Undaria pinnatifida*) - immune response, digestion and weight gain benefits.

Biostimulants

Many seaweed biostimulant products exist overseas and in New Zealand. These are applied to soils or sprayed on foliage to promote soil health and plant productivity. Seaweed-based products have significant nutrient/trace element and environmental benefits over synthetic fertilisers.

These are sometimes blended with other material to achieve target NPK ratios (Nitrogen, Phosphorous, Potassium). There is unmet domestic and export demand for these products due to seaweed supply constraints. Organic status contributes to higher sales prices.

Lower value	Medium value	Higher value
» Dried product with anecdotal benefits	» Liquid product » Research backed formulations	» Research backed formulations with organic certification

Priority New Zealand seaweed species for biostimulants include:



Common Kelp (*Ecklonia radiata*) - proven soil health and plant productivity benefits.



Bladder kelp (*Macrocystis pyrifera*) - fast growth suits high volume seaweed supply.



Wakame (*Undaria pinnatifida*) - proven soil health and plant productivity benefits.

Ecosystem services and restorative economies

The ecosystem benefits of seaweed grown in coastal waters are generally well understood in terms of biodiversity and biomass. The nutrient removal benefits are also well studied, particularly for point source pollution remediation on-land. Other benefits exist in areas such as ocean acidification, deoxygenation, and coastal protection. More recently, there has been considerable interest

in the role of seaweeds in carbon dioxide removal and sequestration. Noting varying examples of payments for these ecosystem services from seaweed are still rare internationally. The use of seaweed in restorative economies can enable thriving marine ecosystems whilst providing social, cultural and economic benefits to iwi and local communities.

Lower value	Medium value	Higher value
» Non-IP protected active ingredients	» IP protected active ingredients » Beauty products » Nutraceutical products	» Pharmaceutical products

Priority New Zealand seaweed species for ecosystem services include:



Sea lettuce (*Ulva species*) – point source pollution nutrient removal on land.



Bladder kelp (*Macrocystis pyrifera*) – fast growth suits high nutrient/carbon uptake.



Common Kelp (*Ecklonia radiata*) – predominant coastal species around North Island.

Supply chain priorities



Wholesale / Retail

There are a wide range of wholesale and retail participants in the New Zealand seaweed sector. It is also where the most innovation is present with firms pioneering new products and establishing new

domestic / export markets. However, the limited volume and unreliable supply of New Zealand seaweed at a reasonable cost is a major constraint to growth.

Constraint	Response
Constrained domestic seaweed supply	Investment to unlock growth constraints on earlier stages of the supply chain, particularly in hatcheries and farming.
Domestic perceptions of seaweed products	Research on benefits of New Zealand seaweed species / product types that can be used in marketing by wholesalers / retailers.
Limited brand protection for New Zealand seaweed species	Industry led coordination and protection of “our names” for priority New Zealand seaweed species /products.
Cost of research / testing export markets	Grant support for seaweed export market research, supply chain market access, and trials with the results publicly available to other sector participants.

Process / Manufacture

Transporting and/or stabilising fresh seaweed presents significant cost challenges due to the weight of fresh product, and the time/energy requirements for drying seaweed. Most

New Zealand processors use low technology fermentation, but some are investing to extract more value through ‘cascading’ processing steps and new products from ‘waste’.

Constraint	Response
Time and/or cost to stabilise fresh seaweed	Research into low-cost seaweed drying methods that support large volumes all year round, ideally using sustainable energy sources.
Limited understanding of high-value seaweed extracts	Market driven research to identify highest value extracts possible with New Zealand species.
Limited processing knowledge for high-value extracts	Research into cost-effective processing techniques to obtain higher value extracts from New Zealand species.
Investment cost to establish processing facilities	Grant support for establishing new shared processing facilities that will be accessible to multiple seaweed suppliers.

Farm / Harvest

Commercial seaweed aquaculture in New Zealand is in its infancy, and the potential for significant growth from wild harvest and beach cast seaweed is heavily constrained. Current permit holders eligible

to farm seaweed are reluctant to invest due to the commercial uncertainty and risk. Consenting new farm space is a slow, costly, and risky process.

Constraint	Response
Cost and time to obtain consents / permits for seaweed farming	Improved coordination between central and local government on how to apply National Environmental Standards for seaweed. Government funded aquaculture R&D lines in different regions that are consented for priority seaweed species, and available for lease at low cost for commercial seaweed farming trials.
Lack of seaweed farming operational knowledge for priority New Zealand species	Government funded research on seaweed farming techniques for priority New Zealand species with productivity and cost objectives. Each species will have different farming requirements.
Limited access to seaweed farming knowledge	Funded development and maintenance of seaweed species “hatchery and farming handbooks” intended for commercial use. Knowledge required is different for each species.

Constraint	Response
Prohibitive cost of seaweed farming trials disadvantages smaller participants	Remove high co-funding requirements on Government grants for smaller participants in exchange for providing public access to farming trial results (public access can be time delayed for 1-2 years to provide “1 st mover” advantage).
Public licence / support for establishment of seaweed farming	Public communications from central and local government on support for the seaweed sector, reasons why, along with expected regional/local impacts for communities.

Hatcheries

New Zealand does not have any commercial seaweed hatcheries, and this is a fundamental infrastructure constraint to establishing large scale seaweed farming in New Zealand. Investment will

not occur at scale in commercial seaweed farms without a reliable supply of juvenile seaweed. Current aquaculture production of seaweed occurs at small scale in research hatcheries.

Constraint	Response
Lack of hatchery knowledge for priority New Zealand species	Government funded research on hatchery techniques for priority New Zealand species with productivity and cost objectives.
Limited access to hatchery research on priority species ('locked up' by entities)	Public accessibility requirement for Government funded seaweed hatchery research. Funded development and maintenance of seaweed species “hatchery and farming handbooks” intended for commercial use.
Prohibitive cost of research hatcheries for commercial trials	“Reasonable cost” access to research laboratories for early commercial trials via Government subsidy of academic costs.
Regulatory restrictions on hatcheries.	Reform regulations that prevent sale of seaweed from a research hatchery, and that make it hard to establish commercial hatcheries.
Control of hatchery supply / genetic brood stock	New seaweed sector ‘seed bank’ of commercially attractive, regional strains for priority seaweed species. Reasonable cost access to commercial seaweed strains for all New Zealand seaweed researchers &/or farmers.

Knowledge

Practical and underpinning knowledge for producing New Zealand seaweeds and products is limited as well as established processes for access and benefit sharing with Māori. Without investment to build our knowledge base, the seaweed sector will fail to

realise its full potential and meet the expectations of Māori. International knowledge and experience should be adapted as appropriate to help establish the New Zealand sector.

Constraint	Response
Absence of a sector research strategy	Prepare a sector research strategy collaboratively between researchers, sector participants, government and Māori organisations to identify knowledge gaps, interdependencies for unlocking the sector, and prioritise research.
Limited research funding	Collaboration to ensure that research effort is co-ordinated and investment to close key knowledge gaps.
Predict and confirm the value proposition	Conduct bioeconomic modelling to identify sensitivities, inform research priorities and confirm the value proposition for different seaweed value chains.
Lack of established processes for access and benefit sharing with Māori	Co-design processes and frameworks for research, commercialization of mātauranga and seaweed/rimurimu.
Absence of community stakes	Absence of regulatory mechanisms for ensuring local community stakes and participatory governance.
Non implementation of EBM	Incomplete knowledge of effects and impacts on marine environment from seaweed aquaculture

Supporting priorities



Regulation

The seaweed sector is currently regulated under a complex mix of policy and regulations that were developed to manage a wide variety of activities. The regulatory framework is not-fit-for

purpose and needs updating to unlock sector potential and ensure sector development within an EBM framework, including co-governance and community participation.

Constraint	Response
Fisheries Act limits access to biomass for aquaculture research and product development	Amend the Fisheries Act to create new special permit purposes for 'aquaculture' (which enables a limited harvest of wild seaweed resources for land-based and marine aquaculture purposes), and for 'commercialisation trials' (which enables pathways to commercialisation) subject to conditions and policy.
Resource Management Act controls access to new or existing farm space	Simplify the aquaculture regime (and include seaweed) in the upcoming review of the Resource Management Act. Support the addition of seaweed to existing marine farm consents.
Onerous and costly food safety certification processes	Develop seaweed standards for ACVMS, functional food claims and dietary supplementary regulations. Develop seaweed specific certifications.
Land-based activities constrained by Freshwater Fish Farming regulations	Prioritise a review of the Fresh Water Fish Farming Regulations including explicit consideration for seaweed and macroalgae and potentially a separate land-based aquaculture regime.

Leadership

The seaweed sector is currently made up of a wide range of businesses, organisations and aspiring participants. All these groups have different needs and are sending different messages about the potential value and current barriers to the sector

achieving this value. Sector participants have joined together to address these issues and have recently launched the Aotearoa New Zealand Seaweed Association (ANZSA), to champion the needs of the sector.

Constraint	Response
Lack of a shared vision or priorities	A clear vision of the sector's aspirations, needs, and value proposition needs to be developed and shared by stakeholders
Current regulatory environment	Sector leadership communicates with central government about current regulatory environment and needed changes. Create a cross-agency 'one stop shop seaweed desk' with connections across MPI, MBIE, DOC, MFAT, regional councils.
Priority markets and opportunities not identified	Leadership needs to co-ordinate efforts to identify markets and opportunities. This could be a done in a pre-competitive exercise and information shared with the wider sector.
Limited information flow and networking among sector participants	Development of sector group with open information sharing and encouraging government-funded research to be open access or otherwise accessible.
Capacity / pathway for Māori organisations	Ensuring that there are pathways for Māori organisations to join in the sector. Ensuring the protection of taonga species and committing to Wai262 principles. Include co-governance and participatory governance.

Workforce

The existing aquaculture and supporting work force is experiencing staff shortages at all levels but particularly on farm workers in regional parts of New Zealand. Much of the skills required for seaweed farming are readily transferrable from the

wider aquaculture industry and other sectors (e.g. marketing and sales) but specific training is also needed, for example for hatchery production and processing.

Constraint	Response
Lack of trained staff across aquaculture sector	Develop and support engagement initiatives in schools and through career events to encourage young people/rangitahi to consider a career in the sector. Support workplace training and micro-credential courses to enable qualifications as well as recognition of prior learning as a credit towards qualification.
Seaweed sector specific training	ANZSA identifies specific sector needs. Te Pūkenga (NZ Institute of Skills and Technology) and NZ Universities to incorporate seaweed sector specific training into existing aquaculture qualifications.

Brand/IP

New Zealand has some award-winning seaweed businesses that have compelling product stories. However, it is unclear whether there is a viable supply chain for these products that adequately rewards farmers and growers to invest in seaweed farming. New Zealand does not have a clear unique

competitive advantage that differentiates our product(s) from those of overseas competitors and it is unknown whether NZ native species have unique properties that are marketable and can be sold at a premium.

Constraint	Response
Lack of an integrated supply chain	Establish clear market propositions for each part in the value chain so that aspiring stakeholders can choose whether to participate (e.g. long term grower supply agreements with specified standard requirements from processors and wholesalers).
Lack of unique selling proposition	Carry out extensive market analyses to scope overseas market potential for NZ seaweed products.

Te Tiriti

Current State | Constraint | Priority responses

Tiriti principles of **participation, protection and partnership** act as guideline for the sector to ensure Māori, iwi, and hapu can effectively participate and engage with the developing seaweed sector.

Principles of note include active protection, informed decision making and partnership.

Principle	Response
Active protection	Implement Wai262 best practice for research relevant to seaweed and its commercialisation.
Informed decision making	Mātauranga is incorporated in sector level decision making. Ensuring Māori have the information required to make decisions and including mātauranga and science in research projects and outputs which seek to develop the sector.
Partnership	Partnerships can be enabled through benefit sharing and kaitiakitanga frameworks. Following Māori tikanga and kawa.



Environment

Current State | Constraint | Priority responses

Current understanding/research on the environmental benefits or ecosystem services of natural seaweed beds are well known. Research is underway to understand environmental impacts of seaweed aquaculture farms. While the potential for seaweed aquaculture to supply ecosystem services beyond the provision of biomass is promoted as

a benefit of seaweed farming, the delivery and quantum of this is highly dependent on scale and context. Seaweed farming is considered to have a lower environmental risk than most other forms of aquaculture. Genetic interactions with wild populations, disease and marine pests, and wildlife entanglement pose the greatest environmental risk.

Constraint	Response
Site and scale specific nature of environmental benefits and effects	Spatial planning is required to identify suitable sites and scales which is the primary mitigation method to reduce environmental effects of aquaculture.
Quantifying the benefits of seaweed farming to the environment	Monitoring once experimental and pilot-scale farms have been established.
Biosecurity implications	Development of seaweed specific biosecurity management plans and processes
Risk of entanglement for wildlife	Development of wildlife management plans, ensuring farm design principles follow the best practices as identified by current aquaculture farms.



Business models & investment

Different business models can contribute to the development of a high-value and sustainable seaweed sector. Different models will coexist, and hybrids or variations of each are possible (e.g., a

not-for-profit Foundation operating alongside a for-profit entity or tikanga-led corporate businesses). Some basic business models for seaweed sector development are outlined below.

	Artisan	Non-Profit	Collective	Corporate
Description	Small scale business with unique attributes (e.g., brand, personality, networks) supplying premium product to a local market. Difficult to replicate as success is very context specific.	Broader purpose (e.g., environmental, social, cultural) and scale can vary along with structure (e.g., foundation or charitable trust). Operate where for-profit business can't or won't (i.e. not seeking financial returns).	Independent farmers / suppliers pool capital and collaborate to achieve scale and / or market access. Tribal partnerships and farmer co-operatives are common structures in NZ. It is important to develop business models that realise the potential for world-leading community involvement/stakes across all of these business types - as opportunity to secure community participation, co-governance, marketing advantages, investor interest etc.	Focused on shareholder profit but can include elements of a broader impact. Most common structures are large private or public companies.
Elements	<ul style="list-style-type: none"> » Authentic brand / social licence. » High quality focus (e.g., freshness). » Direct customer relationships. » Labour intensive / relatively lower technology investment. » Can be vertically integrated or a single part of the supply chain. 	<ul style="list-style-type: none"> » Purpose / impact driven. » May generate revenue and / or surplus but not seeking profit. » Social licence is key to the brand. » Raising capital can be challenging. » Can align with commercial entities. 	<ul style="list-style-type: none"> » Pooled capital for individually cost prohibitive activities such as: <ul style="list-style-type: none"> • Hatcheries • Vessels • Pre-processing • Processing » Sometimes shared marketing. 	<ul style="list-style-type: none"> » Profit driven decision making. » Operate high-value supply chain stages and control low-value stages. » Scale supports ongoing R&D. » Scalable and replicable structures.
Examples	<ul style="list-style-type: none"> » Natural Kelp NZ » Connemara Seaweed 	<ul style="list-style-type: none"> » Kelp Forest Foundation » Oceans 2050 	<ul style="list-style-type: none"> » GreenWave (hybrid non-profit) » Atlantic Sea Farms 	<ul style="list-style-type: none"> » Waikaitu » CH4 Global
Investment	Small scale investment normally required to establish the business. Typically comes from owner's own capital and/or commercial lending.	Often rely on philanthropy &/or government grants. Commercial partners can also help to fund.	Partnerships usually are self and /or debt funded. Cooperatives are self-funded in mature primary sector and struggle to self-fund in newer sectors.	Balance sheets often support self-funding or debt funding. Well placed to access government grants that require co-funding.
Other	Struggle to exist if corporate interests control hatchery and/or farming.	Sustainable funding is a challenge, especially in small markets like NZ.	If supported early, can provide critical shared assets to smaller participants.	Can also have significant impact focus.

Sector development risks



There are significant risks to achieving the sector’s vision that need to be managed through a

co-ordinated approach by the industry, government, stakeholders and researchers.

User group	Risk	Likelihood	Impact	Mitigation
Sector Wide	(Lack of) access to risk capital (Lack of) immediate short-term returns	High	High	<ul style="list-style-type: none"> » Increase government investment and support, particularly for infrastructure and smaller pioneers with limited capital that are advancing sector priorities. » Use collaborative approaches such as collectives and leverage government investment in early-stage development and commercialisation initiatives. » Collective investment enables investment in infrastructure and scaling.
	Risk of being drawn into commodity product cycle.	Low	Med	<ul style="list-style-type: none"> » Phased transition to develop high-value unique products for New Zealand with value chain captured in New Zealand.
	(Lack of) collaboration	Med	Med	<ul style="list-style-type: none"> » Sector leadership via the Aotearoa New Zealand Seaweed Association (ANZSA) that advocates for sector interests and fosters cross sector collaboration. » Government investment in sector priorities that will benefit broader sector development and not just individual companies.
Local Community / Regulators	Negative environmental effects	Low	Med	<ul style="list-style-type: none"> » Ensure ecosystem service benefits are measured and understood and enshrine EBM in sector vision/governance. » Spatial planning ensures farms are appropriately located and consideration is given to other users and local communities. » Establish national biosecurity standards for seaweed aquaculture. » Establish strong participatory governance.
Regulators	Regulatory hurdles and constraints are unable to be addressed	Med	High	<ul style="list-style-type: none"> » Collaboration between ANZSA, industry and regulators on regulatory priorities. » Prioritise and focus on key pieces of regulation that would enable sustainable sector development and access to overseas markets. » Ensure seaweed aquaculture is considered and included in marine spatial plans.
	Fragmented consenting authorities	Med	Med	<ul style="list-style-type: none"> » Establish national, co-ordinated approach to seaweed farm consenting. » Central government engagement with regional consenting authorities on streamlining consents, particularly for small scale seaweed farming trials.

User group	Risk	Likelihood	Impact	Mitigation
Seaweed Farmers	Difficulty accessing water space including competition with other species	Med	High	» Spatial allocation considers specific areas where seaweed farming should be prioritised and needs to be species specific.
	Pests and Pathogens	Med	Med	» Establish national biosecurity standards for seaweed aquaculture, active surveillance, and readiness and response plans.
	Low farm gate price	Med	High	» Support collective infrastructure for farmers (e.g. hatcheries, drying sheds) » Farmer collectives negotiating long term grower agreements with processors.
	Risk that production methods will be too difficult, unreliable, or expensive for profitable farming	Med	High	» Develop and/or adapt reliable and efficient farming methods for NZ production environments and commercial species (e.g. mussel infrastructure adaptation). » Government funded and publicly available R&D to improve efficiency of low value steps in supply chain (e.g., product stabilisation post-harvest). » Conditions for growth in coastal spatial planning, to help farmers understand spatial plans
Processors and Manufacturers	Imbalance between farm production, at-scale processing capacity, and market demand	Low	Med	» Regulatory processes provide confidence at the farm end of the value chain. » Government risk capital support for early seaweed farming pioneers.
Seaweed Wholesalers and Retailers	(Lack of) clear competitive advantage, and reputation overseas	Med	Med	» Sector focus on New Zealand's competitive advantage and value proposition. » Research to establish the uniqueness of NZ seaweeds and enable product claims.
	(Lack of) standards for seaweed products means quality is inconsistent	Low	Med	» Establish national standards for established products where markets require quality assurance (e.g. food).
Research	Research funding and effort is insufficient, duplicitous and untargeted	Med	Med	» Sector leadership provides ongoing direction and co-ordinates funding amongst stakeholders to support sector research strategy and maximises leverage. » Publicly funded mission led research maximises benefit to Aotearoa New Zealand.
	Mātauranga and Taonga species are not adequately respected	Low	Med	» Follow Wai 262 best practice guide for science partnerships with kaitiaki for research involving Taonga (http://www.rauikamangai.co.nz/).



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