National SCIENCE Challenges

SUSTAINABLE SEAS

Ko ngā moana whakauka

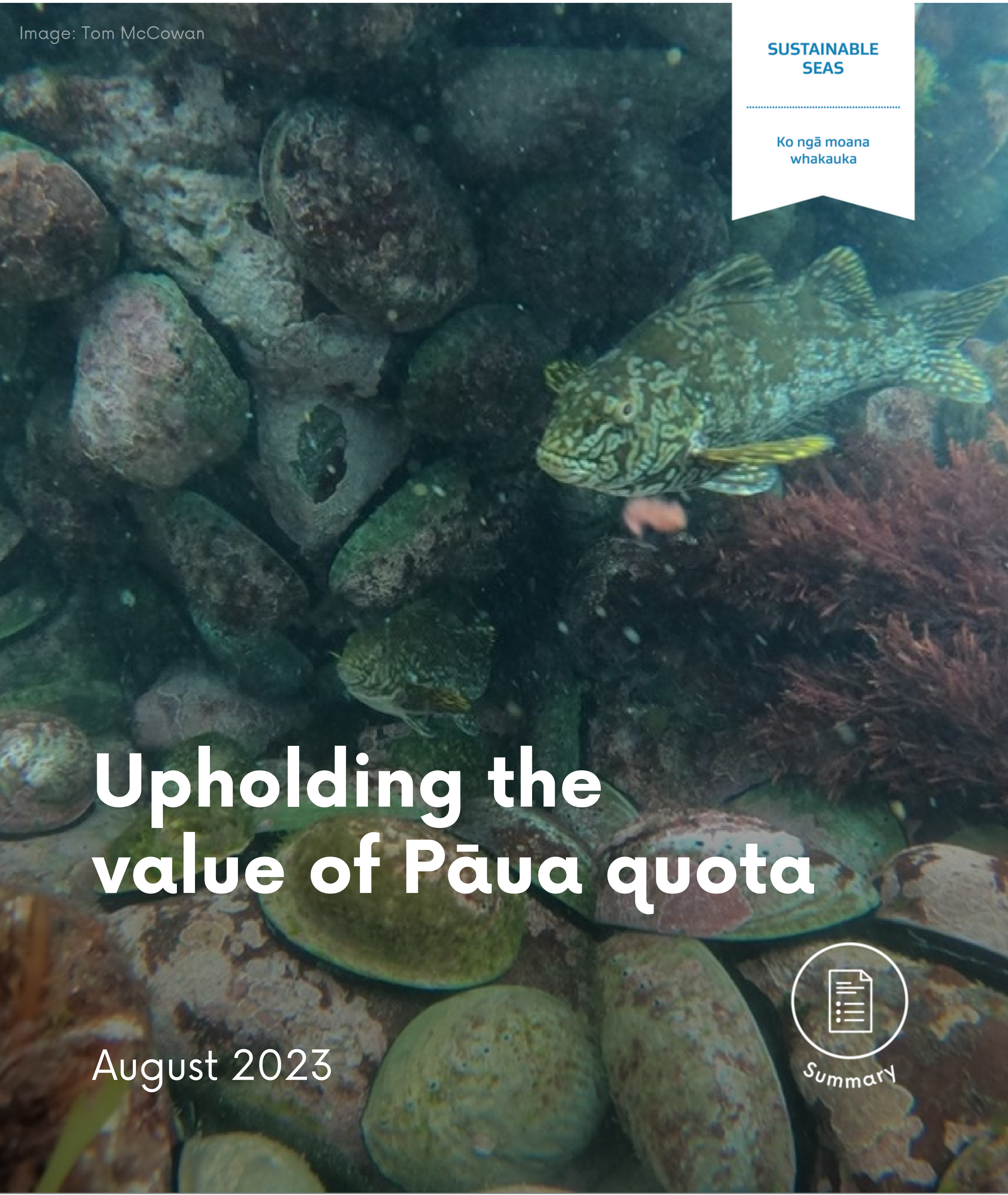
Image: Tom McCowan

Upholding the value of Pāua quota

August 2023

Summary

To uphold value, pāua fisheries must be supported to be more resilient to environmental change

Most New Zealanders have an affinity with the coast and ocean. However, societal, cultural, ecological, economic, and well-being needs met through the ocean (including seafood security) are increasingly at risk from environmental change. Neither fisheries management, fishing sectors (commercial, customary, or recreational), nor seafood business investors and lenders, systematically account for any 'value change' related to environmental change — either as risks or opportunities.

This document summarises three reports on the findings of the ***Sustainable Seas Science Challenge, Risk and Uncertainty Project 3.3: Upholding the value of Pāua Quota***. This summary:

- describes the pāua fishery PAU2
- outlines environmental threats
- discusses legal and financial considerations
- introduces The Pāua Quota Valuation Bio-Economic Model
- recommends future actions.

Improved understanding of environmental change, risks, and opportunities is needed

To uphold long-term pāua fishery values (cultural, economic, and societal), the value of commercial pāua quota, and the ecological role that pāua play in the marine environment, pāua fisheries must be supported to be more resilient to environmental change.

The current shift to ecosystem-based fisheries management requires improved understanding of environmental variability and change, as well as understanding the associated risks and opportunities. With better understanding, fishery sectors can account for these changes, evolve where required, and collaboratively invest in appropriate response strategies (eg, reducing land-based sediment input into the marine environment). These strategies must be developed by knowing the relative risks, uncertainties, costs, and any opportunities that may be created from such change.

Our research explored how to better factor the key environmental risks of climate change and sedimentation (exacerbated by climate change) on the fishery into estimates of business risk to pāua quota owners and fishers. The project considered risks to pāua populations and growth, and to the coastal infrastructure essential for accessing the fishery and underlying pāua catch. These risks were developed into a ***Pāua Quota Valuation Bio-Economic Model*** for the Wairarapa coast commercial pāua fishery (PAU2).

New risk modelling can help embed climate change into business decision-making

At its heart, embedding climate change into business decision making requires new approaches to risk modelling. Businesses now need to measure and report on what were once considered externalities, and not captured or reported on. These 'externalities' are often referred to as non-financial risks. Increasingly, advocacy groups and wider society are expecting this reporting, legal frameworks are requiring it, corporate governance organisations are recommending it, and premium markets are specifying it. For these reasons, we've provided an overview of the legal and policy context for the pāua fishery and the effect of recent sustainability of businesses and transparency of disclosures on access to capital and the costs of capital (for more detail, see Craig *et al.*, 2023, Short *et al.*, 2023).

The research team included science, business, policy, and finance experts

This project brought together an interdisciplinary team from the biophysical and social sciences as well as from seafood business, marine policy, and banking and finance analytics to:

- develop a shared understanding of environmentally driven risks, uncertainties, and opportunities facing wild pāua as well as the commercial New Zealand pāua fishery and associated shore-based infrastructure economics, amongst Māori pāua quota owners, science, the Government, and the banking sector
- use these understandings to develop a model of business risks and uncertainties facing the commercial pāua wild harvest sector (fishery and infrastructure) that could be used by customary and commercial fishers and pāua businesses and investors.

The research findings will be of value to customary and recreational fisheries management, for ecosystem-based fisheries management planning, investment climate risk analysis and guidance, seafood sector transparency, and in informing future work — including strategic responses to address environmental risks such as collaborative marine environment monitoring. Beyond the pāua sector, the process and risk model developed can be developed and applied to other fisheries.

PAU2 – The Wairarapa coast commercial pāua fishery was ideal for the study

Although the wider PAU2 fishery is from Taranaki to the East Cape, the commercial fishery is only from Turakirae Head (Western side of Palliser Bay) to Castle Point (the Wairarapa area) (Figure 1). PAU2 was chosen for this study given:

- The total allowable commercial catch (TACC) is unchanged since 1986 at 121.88MT per annum, so the fishery is stable.
- Large parts of the quota management area (QMA) are closed to commercial fishing, providing good comparative opportunities of fished versus unfished areas.
- The East Coast/Poverty Bay and Taranaki Region's pāua are well known for smaller size at maturity; this is assumed to be because of warmer temperatures in these areas.
- The Poverty Bay/East Coast to Wairarapa has experienced extreme storm and marine heatwave events.
- The PAU2 Association is progressive and has good relationships with iwi in the area.
- The temperature gradient reflects the latitudinal gradient.

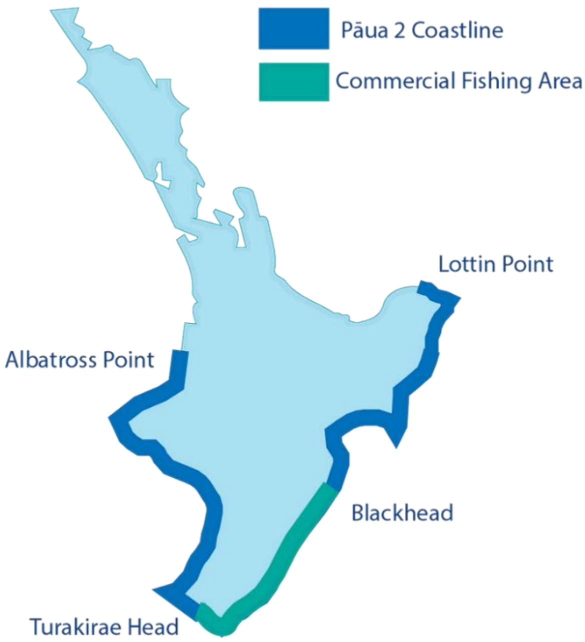

Figure 1 The PAU2 Fishery Area. Source: Terra Moana

The PAU2 total allowable commercial catch has been stable at 121MT since its QMS establishment in 1986. PAU2 is unique amongst other pāua fisheries that have had many management measures. This stability is largely because:

- the total allowable commercial catch was initially set correctly
- the catch per unit effort (CPUE), the most powerful indicator of fishery performance, has remained stable since 1986.

Iwi/Māori nationally own 71.9% of quota in PAU2 with Moana New Zealand holding 53.9% of that.

The PAU2 geographic location means it may be particularly subject to the effects of warming water (Figure 1). Evidence from the marine heatwaves forecasting component of the Moana Project shows that the PAU2 fishery was subject to recent marine heatwaves (the 2021/22 MHW). Much of the PAU2 coastline is close to extensive land uses (eg, plantation forestry and dryland farming) that potentially promote higher rates of sedimentation. See McCowan *et al.* (2023), Craig *et al*. (2023), and Short *et al*. (2023) for PAU2 management, industry, and reporting information.

Environmental risk factors exacerbated by climate change

The environment risks that pāua face were reviewed by the project and reported in McCowan *et al.* (2023). Many of the environmental risks are likely to be exacerbated by climate change (e.g., sediments, salinity and storms affecting habitats). Suggestions for research and possible management adaptations for pāua in the face of climate change are given in Cummings *et al.* (2021). Risks to land-based infrastructure are detailed in the section on 'Impacts of Natural Hazards on Key Infrastructure in the PAU2 Fishery' (McCowan *et al*., 2023). A simplified catalogue of the known risk factors that could come into play in valuing pāua quota is presented below (Table 1).

Table 1 Environmental change risks within scope of this project

Environmental Factor (in scope)		**Potential Impact**
Warming	Pāua	Susceptibility of juvenile and adult pāua to short term heat waves is unknown. The impact of prolonged heat waves on reproductive cycles is unknown.
Warming	Growth rate	Growth above 80mm slows once water temperature passes an estimated 21.5°C (Moana Project).
Warming/MHWs	Food sources impacted	Seaweeds are negatively impacted at higher temperatures
Sediments	Pāua	Impacts on pāua energy consumption are assumed as they physiologically cope with sedimentation (respiration etc). Uncertainty exists about impacts of prolonged suspended sediment events. The impact of suspended sediments on reproductive cycles is unknown.
Sediments	Pāua	The animal's substrate adherence capabilities are weakened. Juveniles and adults can be smothered by large-scale sedimentation events. Settlement sites are less available.
Sediments	Food sources and juvenile settlement sites	Seaweeds are negatively impacted by elevated suspended sediments and sediment deposits.
Salinity	Pāua	Instances of significant washups are assumed to be caused by prolonged exposure to reduced salinity seawater, resulting from elevated river flows and freshwater held against coastlines during storms.
Sea level rise	Pāua	Limited knowledge is available of how stressors impact pāua across their depth range.
Acidification	Pāua	Acidification is known to have significant impact on larval development, with higher proportions of abnormally developed larvae at pH 7.8 and below.

Storms	Habitat Impacts	Large storms could impact habitat structures (boulder movement, submerged logs), and disturb habitats (lost weed) as evidenced in Cyclone Gabrielle.
Storms	Infrastructure	Increasingly severe and frequent storms are disrupting normal operational road access for divers to the fishery in the form of slips, washouts, and other damage.
Storms	Operational	The increasing severity and frequency of storms reduce diver days in the water because storms increase turbidity and higher wave action is dangerous for diving.

Legal considerations — quota rights for pāua are unique

While pāua quota rights hold many commonly recognised attributes of other well understood rights such as property, they fundamentally differ because:

- the ability to diversify is through product processing
- access to raw materials is shared
- management decisions are largely out of quota owner control.

Details of the present management structure (rooted in the Quota Management System) and extended to future policy developments and potential management options are given in Craig *et al.* (2023)[1].

Financial considerations — global investors expect sustainability strategies and clear reporting

In December 2022 Aotearoa New Zealand joined 200 parties in adopting the Kunming Montreal Global Biodiversity Framework at the Convention on Biodiversity Conference of the Parties (COP15) meeting. Global environmental, social and governance drivers that affect all businesses (Figure 2) are particularly relevant to the New Zealand financial system. New Zealand's dependence on external funding is high for a developed economy, with offshore bank funding at around two thirds of New Zealand's net external liabilities, according to Reserve Bank data from May 2022.

[1] See sections by Stephen FitzHerbert and Tom McCowan & Storm Stanley

Global investors who fund the financial system expect the banks that they invest in to have developed clear sustainability strategies and to report transparently on their progress through regular disclosure statements aligned with market practice. The New Zealand mandatory Climate Disclosure reporting requirements, due to come into effect from 2024, align with investor expectations.

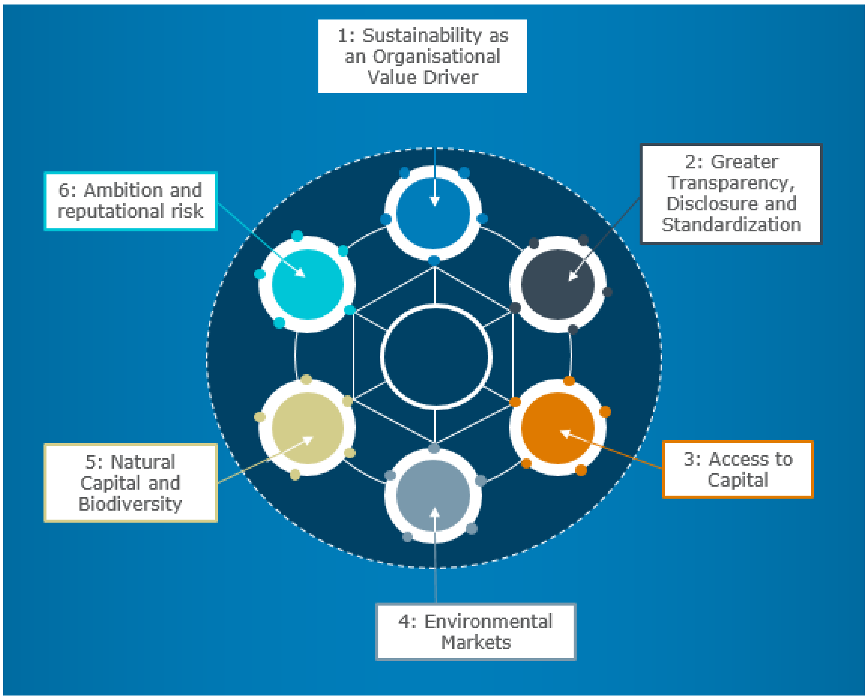

Figure 2 Global environmental, social, governance trends increasing focus, ANZ NZ

A growing number of banks, accounting for 40% of global banking assets, have committed to the Net Zero Banking Alliance (NZBA), including Australasian banks. Under the alliance, signatories will work to align their lending and investment portfolios with net zero emissions by 2050.

The alliance commitment complements the work New Zealand banks are doing to understand climate impacts across material sectors in New Zealand under the Climate Disclosure reporting requirements. A local approach is required to first identify material sectors, then to set Paris-aligned decarbonisation targets for these sectors. Banks must then engage with their lending clients to support them in their transition plans if the banks' financed emissions are to meet their commitments. Stakeholder's expectations are aligned on improved sustainability practices of businesses they engage with. To retain market access to our key export markets, the integrity of the supply chain will be paramount as food and fibre traceability becomes increasingly important.

Stakeholder expectations on businesses are also rapidly changing with a shift from shareholder primacy, where the purpose of the firm was to maximise shareholder returns, to one of stakeholder primacy, where businesses need to consider wider stakeholder values. Successful firms will ensure that they deliver satisfactory financial (and environmental and social) impact returns. This shift may seem to create a conflict with the profit maximisation mantra, but firms that embrace the need to align purpose and profits with the expectations of their stakeholders will ultimately maximise stakeholder outcomes.

Figure 3 describes the relationship between improving environmental monitoring, blue economy businesses, their corporate disclosure domestically, and how these feed into the international environmental disclosure frameworks. Having evidence-based response strategies reduces risk, and the evidence for both the state of the marine environment, and the efficacy of response strategies comes from having appropriate data and information. A range of new technologies is emerging to do this including measurement instruments designed for harsh marine conditions, and that can be placed on marine infrastructure, including vessels. Remote sensing is also emerging as important.

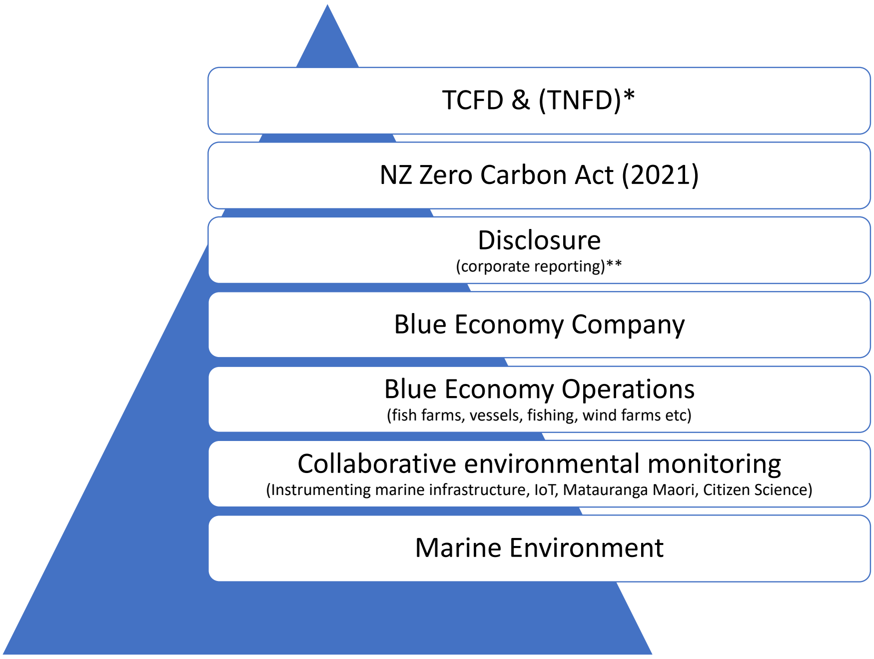

*Figure 3 Risk reduction pyramid. Source: Terra Moana Ltd. *TCFD = the Taskforce on Climate-related Financial Disclosures. New Zealand's mandatory climate related disclosure 'CRD' regime is aligned with the TCFD framework. The CRD regime applies to reporting periods starting 1 January 2024.; TNFD = Taskforce on Nature Disclosures. This material is summarised in depth in the Sustainable Seas Report* [*Sustainability Disclosures in the Blue Economy*]

ANZ has partnered with Terra Moana Ltd and the project working group, believing an initiative like *Upholding the value of pāua quota* as part of the Sustainable Seas National Science Challenge will help advance our understanding in identifying and assessing the risks of climate change and other environmental stressors on the pāua industry.

The Pāua Quota Valuation Bio-Economic Model [2]

This section introduces the Pāua Quota Valuation Bio-Economic Model, explains how it was developed and how it's structured, gives information on its limitations and transferability, and suggests how different groups could use the model.

Finance and business risk modelling estimates probability and impact

Risk modelling attempts to estimate the probability of an event occurring and the impact of the event should it occur. For example, insurance costs are derived from complex risk modelling that attempts to price the risk event by charging premiums that adequately compensate for the occurrence of future losses that the insurance company will pay out on. In a business setting the more uncertain future revenue streams are, the lower the value ascribed to them. The value of an asset reflects the sum of the expected cashflows adjusted for the expected inherent risk.

Severe and plausible scenarios need to be considered

Risk models can help us understand the change in value of an asset, for example quota values, under different scenarios. These scenarios can be adjusted to reflect potential 'what-if' scenarios that can be helpful in business planning and strategy development. In the financial sector, the Reserve Bank of New Zealand (RBNZ) defines scenario testing as '*a tool that subjects financial institutions to severe*

[2] Christine Smith (ex-ANZ Bank New Zealand Limited Securitisation (retired)), Dean Spicer (ANZ Bank New Zealand Limited) and Tony Craig (Terra Moana Limited).

but plausible scenarios (and sensitivities) that are deliberately chosen for their potential to threaten the viability of their business model', which in our project includes the risk to changes in the monetary value of quota. Where data is lacking, appropriate qualitative assessments can be beneficial in providing insights into the operations risk exposure that can help inform business planning, strategy and risk management practices.

The RBNZ guidance[3] for financial institutions highlights the use of scenario testing to model risks proportionate to an entity's size, business mix, and complexity. For smaller firms, simplified scenarios may be appropriate. The guidance also acknowledges that climate risk scenario testing is:

- a developing area that's likely to evolve and become more sophisticated over time
- an important starting point in assessing climate related risks.

The level of complexity involved and the change that lies ahead for risk modellers is covered in a report from McKinsey & Company: '*Using model risk management to address climate analytics: It's a process not a task, Climate models create significant risk and complexity. Model risk managers need a tailored approach to ensure they are fit for purpose'*[4].

The McKinsey report notes: *'Climate change creates physical and transition risks that are complex, uncertain, and playing out in real time. To gauge the potential impacts on clients and portfolios, as well as the effects of mitigation measures, banks require new models, new documentation, and new model risk management (MRM) capabilities. With few precedents in hand, none of this is easy'.*

More detailed data will improve the model

We hope the model we've developed will help as a starting point, but we acknowledge the inherent limitations given the lack of detailed data, ie location and time data, factors of climate change that may affect the pāua fishery and the ecosystem that supports it, along with the challenges in modelling climate-related risks relative to traditional risk modelling highlighted in the RBNZ guidance.

These challenges include:

- the non-linear nature of climate-related risks and '*the potential for irreversible changes in climate, leading to impacts that are not easily mitigated or reversed*' (Reserve Bank of New Zealand)
- the ability for climate-related risks to impact multiple lines of business at the same time, with the potential for financial stability impacts
- uncertainty over time frames in which climate-related risks will materialise
- the unprecedented nature of climate-change, meaning that traditional risk assessment models that rely on historical data have the potential to systematically underestimate the impacts of climate change.

The model was developed in four stages

We developed the model in the following stages.

1. **Establishing a baseline**. The first stage was understanding pāua biology and lifecycle, the industry, and the environmental risks to establish baseline knowledge about the Wairarapa Coast commercial pāua fishery PAU2 (McCowan et al 2023). Workshops highlighted that pāua recruitment success and growth and mortality rates are impacted by environmental stressors,

[3] 2022.03.02 Guidance - Climate-related risks (rbnz.govt.nz)

[4] Using model risk management to address climate analytics: It's a process, not a task Climate models create significant risks and complexity. Model risk managers need a tailored approach to ensure they are fit for purpose. This article is a collaborative effort by Abhishek Anand, Isaam Hanif, Hans Helbekkmo, Mark Levonian, Pan Liu, Shyamal Patel, and Christophe Rougeaux, representing views from McKinsey's Risk & Resilience Practice.

but that effects are known to differ in different areas. A model to run scenarios for smaller regions with similar characteristics and biomass within the PAU2 fishery area would be more useful than attempting to model the biomass for the whole of PAU2.

2. **Modelling the biomass**. With the assistance of Phillip Neubauer at Dragonfly Data Science we next developed a much-simplified version of some of the methodology in the pāua stock assessment model[5]. This helped us derive an initial population for PAU2 and then allow changes over a 20-year period with various scenarios that impacted on recruitment success, growth transition, natural mortality ('instantaneous mortality') and fishing mortality.
3. **Calculating the value of quota**. The traditional methodology was used but with the annual commercial catch projected by the model used as the annual catch entitlement. This approach creates added transparency in calculating projected harvestable biomass within the allocated TAC and adjustments to the discount rate[6] in relation to other climate risks.
4. **Building and presenting the model**. The base case (current situation in PAU2) was presented to the Shellfish Working Group and Project Advisory Group for feedback. Input was sought on the environmental stress scenarios and consequential impacts to model. These groups felt that there was no clear evidence of the long-term impacts of environmental stressors on pāua or the time horizon over which they could be expected to occur, except for the relationship between temperature and pāua maximum size attained. For this reason, we decided to base scenarios on several different hypotheses and allow them to be easily amended or supplemented in the future, if data becomes available which supports the relationships between actual environmental change and impacts.

The model is simple and structured around spreadsheet software

Our model is simple, transparent, and uses standard business spreadsheet software that can be run by non-subject matter experts (see Figure 7 in Short et al. (2023)). The model was built in Excel and consists of forty (40) worksheets. Two of the worksheets take input by users to create and select scenarios and sub-zones. The remainder of the worksheets perform calculations, aggregate and graph results, or contain information.

A detailed explanation of the model is set out in Short et al (2023) and in Appendix 1 of the manual. However, in summary:

- The model allows for up to 31 different PAU2 fishery sub-zones from which users can select.
- The length categories (70 mm to 170 mm in 2 mm increments) are hard-coded into the model.
- Users determine the percentage of the population contained in each sub-zone.
- Users can create their own scenarios related to recruitment success, instantaneous mortality, growth transition, fishing mortality, and valuation factors over time.
- Each sub-zone has its own calculation sheet, which calculates annual recruitment success; growth; distribution by length buckets; pāua weight; recreational, customary, and illegal catch by numbers and tonnage; commercial catch by numbers and tonnage; instantaneous mortality; and opening and closing balance numbers of pāua each year under the current scenario.

[5] We understand that climate change stressor impacts upon the pāua populations are currently being integrated into the stock assessment model.

[6] The discount rate is the rate of return, which an investor expects to earn on an investment, taking into account its risks.

- The results for the sub-zones selected by users are aggregated in a valuation worksheet. The net present value of the discounted cash flows and capitalised value of the annual available catch entitlement are calculated based on the valuation assumptions in the current scenario. Two tables are produced: the impact on pāua numbers and weight of pāua caught both for customary, recreational, illegal fishing (CRIF) and commercial fishing and compares those with the expected CRIF tonnage and the TACC; and the projected internal rate of return (ROR) for an investment in pāua quota over a 10-year period and the capitalised value over a 20-year period.
- The model produces four types of graphs: comparing the TACC with the estimated commercial catch; the capitalised value and the estimated commercial catch each year in kilograms; the aggregate closing number of pāua, the number with the number of pāua available for fishing each year and the weighted average length of all pāua; and the weight of pāua available for fishing remaining after assumed CRIF, the estimated commercial catch and the estimated percentage of aggregate pāua that have reached the minimum legal size for fishing each year.

The model has limits, and can be applied more widely

Our model provides a methodology to run scenarios on business risks, rather than giving accurate projections of future stock numbers. Unlike the stock assessment model, which requires expert scientific input and management, our model can be used by quota owners, seafood business executives, and non-experts, and will be publicly accessible. The stock assessment model does not capture valuation data or perform valuations.

Reliance on the stock assessment model as a base does limit the ability to assess impacts or resilience strategies that include early life stages, as the minimum length used is 70mm (which is well beyond the size at which pāua settle to the seafloor. However, for pāua, we currently lack comprehensive data on thresholds of responses to different environmental variables, with the exception being the relationship between temperature and pāua growth (maximum size attained). Without specific information on relationships with stressors across life stages, we applied a method common to risk assessment of unknown impacts of known or unknown events, running scenarios based on a number of hypotheses and magnitudes of impact (eg 15 % decrease in growth rate). Quantitative data was insufficient to factor into the model hazard risks to terrestrial infrastructure as these risks are location specific.

The model can be used in other areas and for other species that may respond differently to environmental change. The model can also be used as is for assessing risk to pāua quota in other areas as it is built around the pāua stock assessment model. For other species, a simplification of that species' stock assessment model could be written in and the length categories hard coded into the model would need to be changed.

Different groups can use the model

As the research to date suggests, pāua stocks are unlikely to benefit from climate change. This fact drives the need for careful risk analysis and targeted mitigation strategies. The model has been built to enable such risk analysis across sixteen climate and environment-driven scenarios to the best extent possible at this point. Indicative value change is provided for combinations of climate driven risks at various scales, and in the absence of more exact information about pāua individual, fishery, and coastal ecosystem responses to environmental change. To illustrate the model outputs, Short et al (2023) provides an example scenario (Scenario 13). Under Scenario 13, the mortality rate increases by 200 per cent and the recruitment rate reduces by 20 per cent in year two in the selected sub-zones. This scenario mimics a hypothetical impact on instantaneous mortality and recruitment success from environmental stressors such as marine heatwaves, severe storms, increased sedimentation or a combination of multiple stressors.

New research is essential to provide this information which would improve the ability to model scenarios directly related to specific environmental changes. Fisheries New Zealand is currently researching climate change risks to commercial fisheries at the broader scale, but pāua specific physiological and ecological research is needed.

In the meantime, the model can provide value to the following users:

Pāua quota owners

Pāua quota owners need to begin to assess the potential downstream impacts of differing climate change scenarios on the resource. This is both the right thing to do to inform business investment and management and is becoming increasingly important for the finance sector and for future sustainable financing opportunities. The ability to model the effects of likely change in abundance, size ranges, productivity and harvestability, as well as overlaying the infrastructure and accessibility challenges informs strategic policy setting, fisheries management, and operational business decision making. The increasingly volatile, uncertain, complex, and ambiguous world quota owners must operate in to uphold value under climate change increasingly demands a more hands-on approach to understand the ongoing dynamics of the fishery, the ecosystem that supports it, and pāua needs. Model scenarios could be used to determine changes in recruitment, growth, and mortality that would have high impacts on business risk and be used to design experiments and data collection.

Pāua divers

Pāua divers will benefit from using the model to better understand what is happening in and across the fishery, year on year, over the long term and, in some cases within a year,. For example, during or post a year's catch, a scenario could be run using that year's observed recruitment running for future years. Being modelled across a range of potential scenarios enables better planning, at the area or paddock level, of more efficient harvest operations. As knowledge improves, the model will be able to be used to identify the most likely scenarios that will produce optimal operational models. These will likely need to be mobile, agile, and responsive to short term setbacks (weather events), and long-term change, as climate change unfolds.

Investors

Investors will benefit from significantly improved understanding and reduced uncertainty about climate change risks in their financing of pāua commercial fisheries. To date, the finance sector has largely relied on information from and the understanding of the borrower (quota owner or diver), to know about long-term fishery outlook. This tool will allow the finance sector to do its own analysis.

Investors (both providers of debt and equity) could use this new tool to test their own assumptions about the potential impact of climate change on their exposure to the sector through investment in the sector and other parties that rely on the sector. While the value of the tool is currently limited because users have to come up with their own assumptions, it could be more valuable in the future if data were to become available on the actual impact of climate change and consequent risks.

Currently, investors using their own assumptions could use the model in the following ways, as examples:

- Running different scenarios for a specific business (or all their impacted businesses) to assess likely impacts of climate change on a company's pāua related assets or income. For example, an investor could model some of the assumed impacts of higher sea surface temperatures resulting in slower and stunted growth to project future commercial catch for that borrower and quantify the impact on a borrower's assets or financial strength, if any.

- Running different scenarios for a value to quantify the potential impact of climate scenarios on the assets and income of a fishery or seafood business. For example, an investor might wish to model the impact of a scenario that showed smaller commercial catch but a higher price due to scarcity on a borrower's assets or income.
- Modelling the impact of a severe weather event that may impact one region. For example, an investor may wish to assess the potential loss of income from lower commercial catch to one region by modelling higher mortality rates for affected areas in that region.
- Assessing risks to the sector for aggregate exposure, by modelling the impact of different scenarios in different regions.

The model will need more detailed supporting information that includes commercial viability and the environmental, managerial, and policy implications that would underpin such viability. Potentially, such information could lead to conversations about designing and implementing innovative response strategies, such as building coastal ecosystem resilience.

For all these direct users of the model, even in the absence of exact attributive data, the modelled scenarios show the increasing risk of cumulative environmental stressors on pāua and the coastal ecosystems upon which they rely. Through bringing the financial implications into sharper focus, use of the model could underpin dialogue with landowners and regional councils and inform engagement in consenting processes and improve climate change mitigation and adaptation approaches. Making financial analysis information more visible, the model enables a sharper focus on the financial risks to the fishery, conversations between interested parties, and potentially a stronger coalition of the willing to address the climate change challenges facing the fishery and affecting value.

Discussion — an innovative, user-friendly starting point will improve with better data

Our aim was to create a 'PAU2 environmental related risk' bioeconomic model to allow stakeholders, including quota owners, investors, and financers, to assess the potential business implications of environmental risks (including climate change).

Our model has been developed as a starting point in the process of assessing climate and other environmental related risks. It's a tool that could be helpful in projecting future stock *trends* based on known data and assist with more active management of the fishery as well as an understanding of factors that mitigate or exacerbate climate impacts. By making the model readily available in a standard spreadsheet format and using simplified methodology, we hope we have provided a means of making a complex subject area more accessible and easily understood. A benefit of our modelling is likely to be increasing understanding of the environmental risks and impacts that pāua quota holders are increasingly exposed to. We suggest that this could help drive changes at the strategic, organisational, and operational management levels, and importantly, contribute to better informed business strategies.

The model is innovative in translating the fishery biomass stock assessment model, used for fishery management, into a financial value model. However, a key finding of the project was that, to use the model for predictive scenario purposes, better information is needed about the levels of environmental stressors and change that affect pāua. These data gaps need to be filled through establishing long-term laboratory-based experiments, along with methodical marine environment-based observation, measurement and mātauranga. In addition, investment in systematic data capture infrastructure is needed if impact measurement and modelling are to be developed to provide reliable and robust environmental impact measurement, climate change risk analysis, and resilience and mitigation business management analysis that can be presented in succinct information dashboards, and transparent environment social governance (ESG) reporting.

Questions and answers

Here are some questions and answers that arose during the project and the development of the model.

Can the banking and finance sector more directly contribute to improving fisheries and marine management?

Banking and finance can play a role in two areas:

1. By requiring risk assessments as part of lending criteria to the seafood sector, the sector can contribute to improving data collection.
2. By publicly expressing concerns, partnering in projects such as this, specifying such lending criteria as mentioned above, participating in the Aotearoa Circle and The Centre for Sustainable Finance, and by participating in any new collaborative initiatives to establish marine environmental monitoring and sustainable financing, the sector can play an important role.

Can Māori and iwi quota share owners influence better management, locally and across industry, recreational, and customary fisheries, and in marine management with local and central government?

WAI262 is yet to be settled, with the Crown currently working through its response in the work programme, Te Pae Tawhiti. At the heart of this claim is the assertion that Māori be able to control things Māori and in which tino rangatiratanga is restored over taonga. Should this longstanding claim be settled, the foreseen outcomes include greater customary influence over the protection of taonga species (ie pāua), which may include better resourcing of the ability to protect taonga species and their habitats including through practices and mātauranga associated with taonga. Māori/Iwi quota share owners also can play a role in directing the evolution of the stock assessment model to better understand environmental considerations.

Will our grandchildren be able to get a feed of pāua into the future?

The model provides a method to highlight risks to the sustainability of pāua as a food source. The model has already highlighted the need to better collect marine environmental information (including land-based stressor-pāua relationships).

Can the model help improve pāua management?

The model can be used to improve collaboration with quota share owners and the banking and finance sector, as it sharpens the focus on the risks to quota value from inaction, as well as the need to improve information. Being a financial analysis tool, developed with a bank, it brings the challenges of the fishery, such as the need to improve environmental information, to new audiences. This potentially opens the way to collaborative financing of data collection.

Project recommendations

Existing data, understanding, and expert opinion can be used to highlight probable impacts, and to inform changes necessary to improve management responsiveness. However, the needed research, data capture and data analysis that have been suggested throughout this report, aligned with a management framework that enables agile responses, is critical for resilience planning for the fishery, divers, and quota owners.

Such an approach, if implemented quickly, should ensure climate change impact assessment becomes the norm, provide confidence to the financial sector to support ongoing investment, and uphold the value of quota.

The following recommendations arise from the research:

Recommendations for pāua fishery

1. Invest in further research to increase certainty around the effects of changing environmental stressors on pāua fisheries. Research to date has detailed the effects of stressors (eg, temperature, sedimentation, and acidification) on some of the life stages of pāua. However, incomplete understanding remains, of such impacts across the pāua life cycle and, importantly, uncertainty about the effects of/response(s) to multiple or cumulative stressors (ie, increased temperature plus sediments) in the natural environment, particularly at larger fishery scales under forecasted climate change projections. More complete information could be collected by establishing:
    a. long-term pāua experiments (in the marine environment and laboratory) to better ascertain the impacts of environmental stressors
    b. a marine environmental baseline including habitat mapping in the PAU2 area.

2. Develop an understanding of how changing environmental stressors potentially influence outputs in the stock assessment process, as this is currently the driving mechanism for broad scale management responses. This is also essential to inform industry management considerations when endeavouring to translate research outputs into meaningful management decisions. At present there is a disjunct between much of the research of stressors on pāua biology, which is often conducted on reproduction, larvae and juvenile stages, and stock assessments, which emphasise older life stages. The life stages focussed on in this research were selected because these larvae or early juveniles stages are the most vulnerable to negative impacts.

3. Use the suite of tools available for the management of pāua fisheries at both government and industry levels. Generally, those tools conducted at the industry level (ie, PāuaMAC) can be implemented in short time frames and at finer scales than the central government level, potentially giving a greater scope for adaptive business risk management. At the fisher scale, the model could be used to direct catch for the next year. To make the best use of fine-scaled management, ongoing collection of fine scale fisheries data is required, as is formal affirmation of industry-level management techniques in Fisheries Plans.

Recommendations for a national enabling environment

Although not the subject of direct research in the project, given the users of this research are largely pāua quota owners and fishery financiers, project discussion included considerations of how to respond to these challenges including by fishery management. Discussion also included the transferability of the model and the findings of the project to other fisheries and marine businesses.

This section of recommendations relates to these discussions.

4. Develop credible and well-functioning environmental markets to enable timely and informative signals to be sent to businesses.

5. Build capability throughout those involved with the blue economy to understand how science, research, and improved marine environmental data underpins improving management and corporate disclosure, de-risks investments, and enables enduring financing.
6. Promote financing for marine management to improve data, information, and knowledge, including mātauranga. The pāua findings 1-3 above generated discussion within the project team and advisory group about how they could be funded. At present <10% of environment funding is spent on the marine environment (PCE 2022). Internationally, models for blue financing roundtables are being used to bring a range of interested parties together to contribute to marine management eg, The Organisation for Economic Cooperation and Development (OECD), the Asian Development Bank, and the Ocean Risk and Resilience Action Alliance and increasing blue economy and finance initiatives from leading countries such as the United Kingdom and Monaco.

Recommendations for PAU2 as an exemplar

Through project discussions, the Project Advisory Group considered how PAU2 could become an exemplar of a resilient fishery and a model for demonstrating kaitiakitanga and ecosystem-based management, where risks are fully assessed and factored into management. This consideration is partly because of the stability of the fishery, as the opportunity exists to act before the fishery is in trouble. To do so, the following steps should be considered. Not all of these steps are directly related to the project (those not-directly related steps are italicised).

- *Finalise the PAU2 Wairarapa Fisheries Plan (Draft December 2022) out for consultation:*
    - This does not include improving the marine environmental information base, nor improving information about the relationships between environmental conditions and pāua physiology.
- Improve the information base about the marine environment, including climate change and sedimentation, and their relationship with the pāua population:
    - Collaboratively finance marine environmental monitoring.
    - Establish citizen science and Mātauranga Māori marine environment and cultural health programmes.
    - Monitor habitat condition and change.
- Prepare for disasters:
    - The need for disaster preparedness was highlighted during the project, as Cyclones Hale and Gabrielle affected the ability of fishers to reach launch sites and, potentially, pāua recruitment, growth, and mortality through large amounts of sediment entering the marine environment.
    - Establish response preparedness plans for the fishery, and marine environment.
    - Enable post-event monitoring and analysis, and fishery operations and management adjustment as required.
- Innovate:
    - *Take up the lessons, new knowledge, science, and research from the Sustainable Seas Science Challenge into the management of the fishery.*
    - Improve the model through including better environmental monitoring and climate impact information, as mentioned above.
    - Improve the PAU2 Stock Assessment Model by including relationships between pāua population dynamics and environmental conditions.

Other reading

Cummings VJ, Lundquist CJ, Dunn MR, Francis M, Horn P, Law C, Pinkerton MH, Sutton P, Tracey D, Hansen L, Mielbrecht E (2021). Assessment of potential effects of climate-related changes in coastal and offshore waters on New Zealand's seafood sector New Zealand Aquatic Environment and Biodiversity Report No 261 Fisheries New Zealand.

Craig T, FitzHerbert S, McCowan T, Short K, Stanley S (2023) Part 2: Pāua Fisheries, Management and Legal Considerations

McCowan T, Cummings V, Hewitt J, Short K, Craig T (2023) Part 1: Environmental Risks Facing Pāua including Summarised Natural Hazard Risks to Pāua Operations.

Short K, Craig T, Smith C, Spicer D (2023) Part 3: Model Description, Financial Perspectives, and Pāua Quota Risks

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Our vision is for Aotearoa New Zealand to have healthy marine ecosystems that provide value for all New Zealanders We have 75 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 the Ministry of Business, Innovation & Employment

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