Moana Project Impact Mapping & Monitoring Framework

By Malene Felsing

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Document History

Versions

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0.0	July 2021	Initial document created	Norm Henry, Keith Hilligan, Brett Beamsley, Joao Souza, Jonathan Gardner, Maui Hudson, Julie Jakoboski
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This report describes the outcomes from a series of investment logic workshops involving members from the Moana Project Strategic Stakeholder Advisory Group and Moana Project Research Team Leads. The workshops were facilitated by Jim McMahon from Caravel Consulting, and indicators reviewed by the Moana Project Management team and Governance Group.

Contents

Summary

This report presents a framework for monitoring the impacts of the Moana Project, an $11.5 million ocean project funded by the NZ Ministry for Business, Innovation and Employment's (MBIE's) Endeavour Fund. Led by MetService, this multi-agency and -disciplinary project aims to vastly improve understanding of coastal ocean circulation, connectivity and marine heatwaves to provide information that supports sustainable growth of New Zealand's blue economy.

Although formal, separate reporting of impacts is not required, MBIE encourages research organisations to apply a 'results-chain' framework for thinking about research impacts. This framework distinguishes between research activities and outputs (under project control) and the outcomes resulting in impacts (outside project control). Recognising that impacts vary, MBIE recommends they are viewed within the New Zealand Treasury Living Standards Framework, which looks at current and future wellbeing in terms of multiple categories relating to natural, social, human, and financial and physical capital.

Monitoring research impacts is recognised to be difficult as impacts can take a long time to manifest, are somewhat dependent on chance, require multiple organisations and individuals to eventuate and are difficult to quantify. Traditionally, bibliometrics (citations in science papers) have been used to quantify research impacts, but it is increasingly recognised that it is desirable to measure impacts beyond the science community. Internationally, this had led to governments across the world requiring research organisations to assess impacts through a combination of bibliometrics and other measures such as economic (e.g. cost-benefit analysis) and case studies.

As end-users of the research, stakeholders are integral to impact manifestation. On the Moana Project, stakeholder input has been formalised through a Strategic Stakeholder Advisory Group through which stakeholders are informed of project progress and involved with shaping outputs.

To finalise expected impacts from the project and determine how best to monitor them, investment logic mapping was used to define impacts expected by stakeholders. The investment logic mapping involved an external facilitator guiding project stakeholders and research leads through a series of workshops in April and May 2021 defining project impacts and methods for monitoring these. The outcome of the workshops is a benefits map, outlining anticipated project benefits and key performance indicators to monitor to verify that the impacts materialise.

International literature recommends that monitoring is carefully targeted to not place too onerous a burden on research organisations. From the investment logic map, key performance indicators selected for monitoring are presented. These indicators include outputs, outcomes and impacts spanning across environmental, social/cultural and economic benefits, and incorporate bibliometrics, case studies and surveys. The indicators will be monitored and reported by the Moana Project Management Team to MetService and MBIE in 2024 and 2026.

1. Introduction

The Moana Project is an $11 million ocean project funded by the NZ Ministry for Business, Innovation and Employment's (MBIE's) Endeavour Fund. The project aims to vastly improve understanding of coastal ocean circulation, connectivity, and marine heatwaves to provide information that supports sustainable growth of the seafood industry, science research efforts, iwi initiatives and how we manage our marine environments. Moana is a five-year project, which started in October 2018.

The Endeavour Fund focuses on science excellence and impact, supporting 'research, science or technology, or related activities that have high potential to positively transform New Zealand's economic, environmental, and social outcomes, and give effect to the Vision Mātauranga policy' (MBIE, 2021).

The Moana Project is a complex programme of work, to be delivered by more than 50 researchers over 14 organisations. To ensure effective delivery, the project is grouped into four separate workstreams (Figure 1):

- Te Tiro Moana - Eyes on the Ocean – smart and sustained nation-wide ocean observing.
- Ngā Ripo o te Moana - Whirlpools of the Ocean – developing New Zealand's first nation-wide, open access ocean models.
- He Hono Moana – the Ocean Connections – connectivity of kaimoana species.
- He Papa Moana – the Ocean Foundation – creating a cross-cultural ocean knowledge platform to support iwi interests.

Each of these four workstreams contributes to a number of outputs beyond the publication of science papers (Figure 2).

The New Zealand Government has for a while been focusing on improving the understanding of the potential and measured impacts of research (MBIE, 2015). To this end, funding applications are required to provide impact statements outlining the benefits that a project is forecasted to bring about. Although there is no contractual obligation for the Moana Project to map or monitor impacts beyond what is required in routine annual and end-of-project reporting, MBIE (2019) recommends that 'public investments have a clear line of sight to eventual impact'.

This report presents a benefits map and monitoring framework for the Moana Project. It summarises recent thinking in the field of research impact assessment (Section 2), outlines the stakeholder engagement used in the project (Section 3), and presents impacts forecasted for the project in previous work and the findings from a series of Investment Logic Mapping workshops held with project stakeholders and staff (Section 4). Based on this, it presents recommendations for monitoring project impact (Section 5). References to literature cited are provided in Section 6.

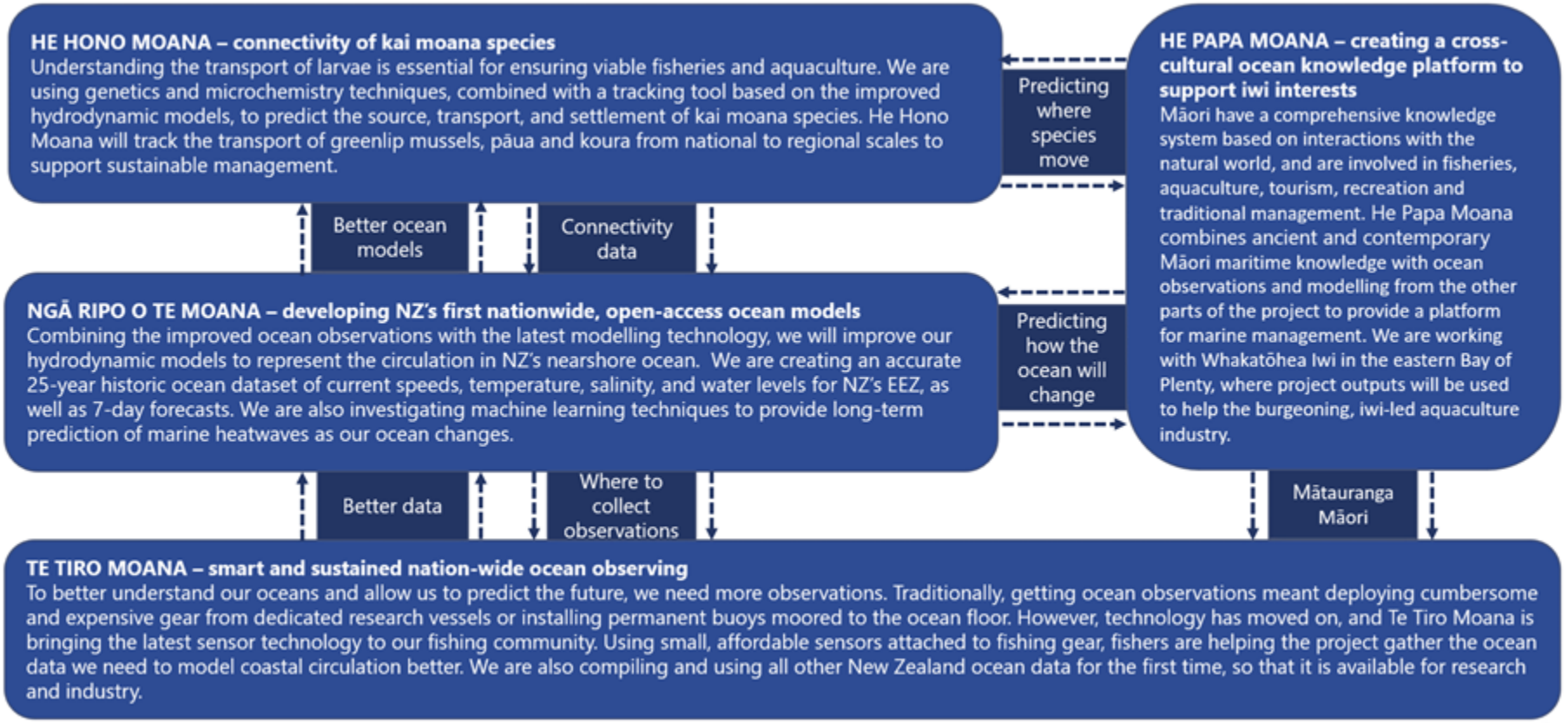

Figure 1: Overview of the four research teams of the Moana Project. Dotted arrows show how the knowledge created in the different teams interconnects.

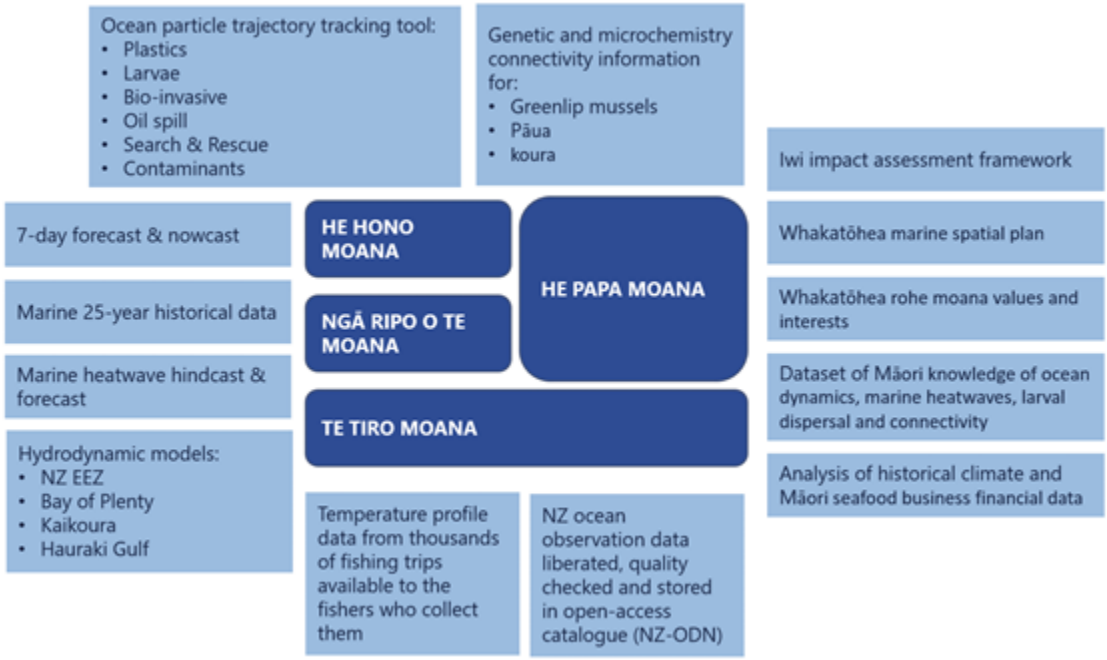

Figure 2: Outputs from the Moana Project grouped around the teams that produce them.

2. Defining and measuring research impacts

2.1 MBIE guidelines

MBIE (2019) defines research impact as 'a change to the economy, society or environment, beyond contribution to knowledge and skills in research organisations'. Whilst no established framework exists for monitoring research impacts in New Zealand, MBIE encourages research agencies to apply a 'results-chain' framework (Figure 3) for thinking about research impacts.

Implicit in the results-chain framework is the recognition that a research project can control inputs, activities and outputs, but that outcomes and impacts arising from research relies on external factors and agencies which the project can influence but not control.

Measuring the impacts of scientific research is recognised to be difficult (e.g. Smith, 2001; Guthrie et al., 2013; Bornmann, 2016; Thelwall, 2020). MBIE (2019) acknowledges that several factors complicate measuring research impacts, including:

- The long time lag between research taking place and impacts occurring.
- The complicated impact pathways which may involve several research organisations.
- Missing or ambiguous data.
- Factors beyond researchers' control.
- Difficulties quantifying the magnitude and value of impacts.

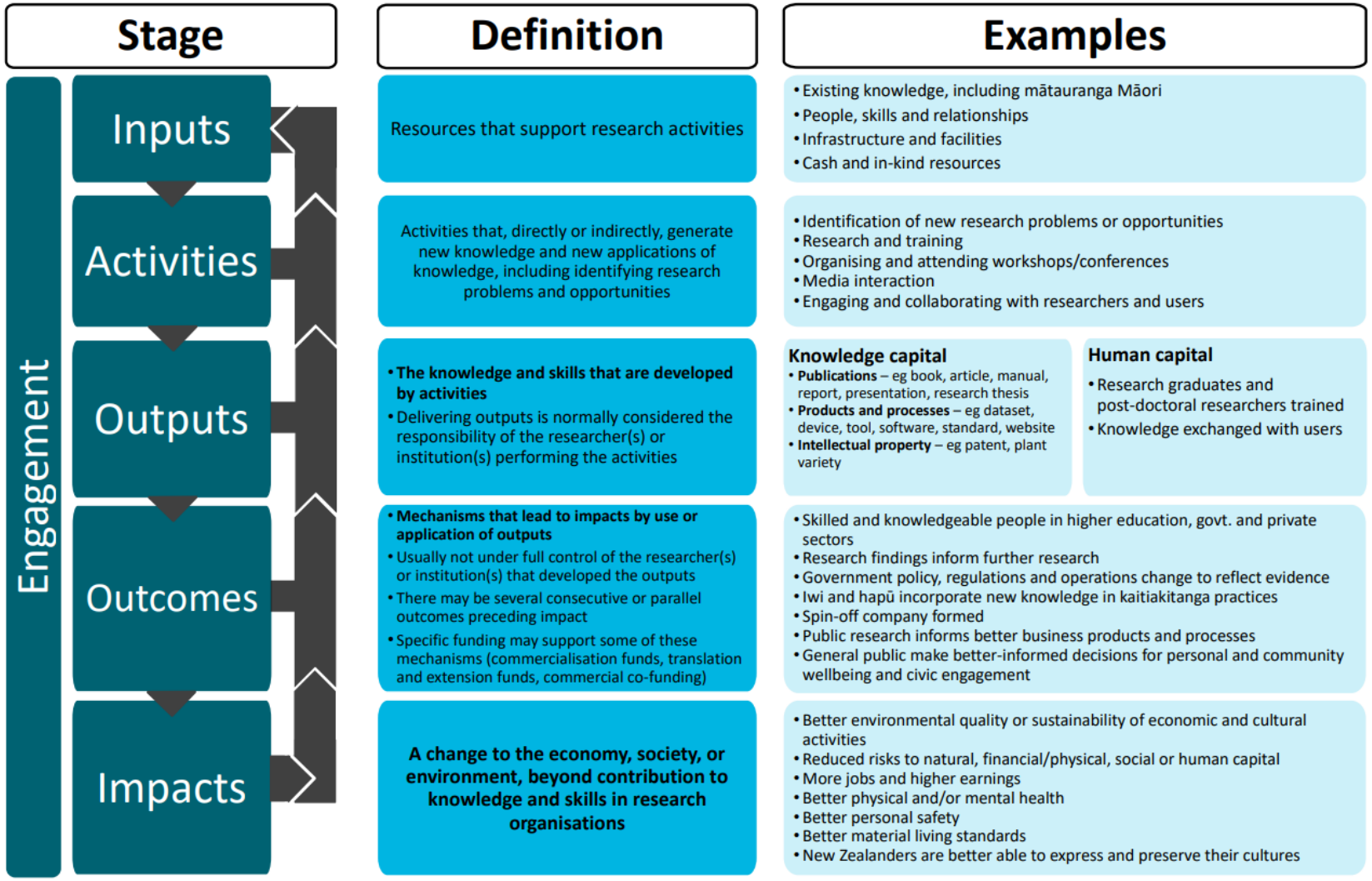

Figure 3: The results-chain framework for research impact, including definitions and examples. From MBIE (2019).

MBIE (2019) recommends that impacts are viewed according to the New Zealand Treasury Living Standards Framework (NZ Treasury, 2018). This framework (Figure 4) looks at current and future wellbeing in terms of twelve categories relating to four types of capital (natural, social, human, and financial and physical).

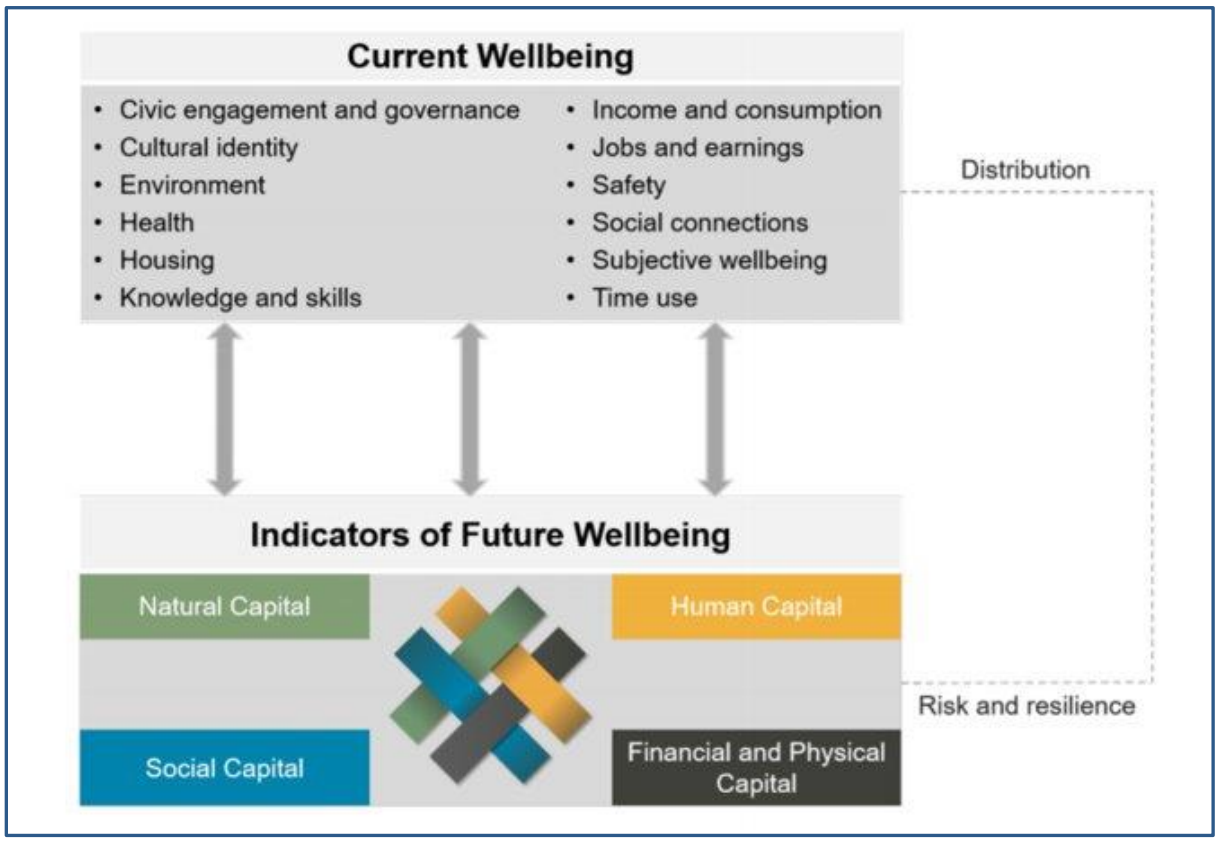

Figure 4: The Living Standards Framework (New Zealand Treasury, 2018).

Supplementing the Living Standards Framework is Vision Mātauranga (MORST, 2007), which includes requirements for research impacts to be viewed in terms of Taiao – sustainability through iwi and hapū relationships with land and sea, and Hauora/Oranga – improved health and social wellbeing.

The Moana Project potentially impacts a number of the categories in the Living Standards Framework. The Project directly increases ocean knowledge and skills, and through the Whakatōhea Moana Plan potentially strengthens cultural identity and relationships with the sea for Whakatōhea iwi. The improvements in ocean forecasts help improve safety at sea and will potentially increase jobs and earnings through aiding fishing and aquaculture operations to gain efficiencies and enhance planning. Additionally, accurate open-access ocean models and marine heatwave forecasts will likely improve the ability of New Zealand government agencies, fishers, and iwi to protect the marine environment. In terms of Treasury's four capitals, the Moana Project mainly contributes to human capital by increasing knowledge and understanding of New Zealand's oceans and by increasing the skill and education levels of the students and postdoctoral fellows on the project. Through the He Papa Moana workstream, the project also potentially increases social capital and iwi social wellbeing for

Whakatōhea and other coastal iwi who can use the Moana Plan and Iwi Impact Assessment Framework as blueprints for documenting and safeguarding their coastal interests.

2.2 Methods for monitoring research impact

MBIE (2019) recommends that researchers and research organisations use the results-chain framework to plan for, increase and articulate research impact, and suggests the following methods for measuring impacts:

- **Cost benefit analysis or econometric studies** for applied research targeting a particular economic sector.
- **Indicator framework approaches** for measuring contribution to delivery of health, education or social services.
- **Case studies** to describe research impacts in an accessible and engaging way.
- **Citation analysis** of research publications, patents and public documents to document knowledge flows from basic research.

Citation analysis is the traditional academic way to measure science impact. Using metrics like h-index, i-index and citation counts, the dissemination and usefulness of science knowledge to other researchers can be tracked and scored (e.g. Moed, 2005). Whilst useful, such measures have a time lag because the process of obtaining funding, doing the science and publishing the results takes a minimum of two years, and often the full impact of research publications can take five or more years to manifest in citations (Chavda & Patel, 2016).

To generate societal impact, research uptake should extend beyond academia, and recent New Zealand research recommends separating knowledge stocks (the act of doing research and publishing it in science journals) from knowledge flows (making the research available to end-users via methods other than science journals) when assessing research impacts (Duncan et al., 2020).

To demonstrate knowledge flows to end-users and the general public, complementary techniques like altmetrics and webometrics are increasingly used. These measure the downloading of articles or data, and the referencing of science publications in blogs, news articles, Wikipedia, GitHub, grey literature, etc., and mentions in, or sharing of, social media like Facebook, Twitter, Reddit and LinkedIn (Thelwall, 2020). Because such spread is much faster than that through traditional peer-reviewed journals, it provides another lens for viewing scientific and societal interest in, and uptake of, research.

In addition to this, seeking to measure the impacts of science beyond the scientific community, countries like the UK, Norway, the Netherlands and Sweden have introduced a requirement for researchers to demonstrate impact through case studies (Ravenscroft et al., 2017; Reed et al., 2021). An example of a template for an impact case study from the UK's Research Excellence Framework (Research Excellence Framework, 2021) is provided in Appendix A. When assessing such case studies, panellists are instructed to score the described impacts in terms of 'reach' and 'significance' (Research Excellence Framework, 2021). In general, it is recognised that case studies provide powerful narratives but are expensive, and are often well combined with surveys, which are more cost-effective and allow a wider range of stakeholder feedback (Adam et al., 2018).

In Australia, a mixture of methods is used to assess research impact. Citation analysis is the preferred method of the Australian Research Council (Bornmann, 2016), whereas Australia's Rural Research and Development Corporations (which includes aquaculture and fisheries research) require research impacts to be assessed using cost-benefit analysis for market benefits and through descriptive narratives of non-market benefits (RDC, 2018).

In Canada, Research Impact Canada (http://researchimpact.ca/) is a university network dedicated to maximising the public good impact of academic research. Universities part of the network share impact case stories and can access tools for impact maximising and monitoring, like the Knowledge Engagement tool developed by the University of Calgary (Al-Hashmy, 2021). This tool helps researchers score the impact of their projects in terms of reciprocity, reach, access and partnerships. The tool scores impact higher for projects that include training (e.g. PhD students), community and collaborator partnerships, community-based research, and ongoing openly accessible data and outputs. The scores are accompanied by a more detailed 'portrait', which allows researchers to add case study information to paint a more detailed picture of impact, including lessons learned.

As illustrated in the above, and supported by MBIE guidelines and current literature (e.g. National Research Council, 2014; Adam et al., 2018; Research Excellence Framework, 2021), the impacts of research are best measured using a variety of complementary methods aimed at different stages of the results-chain. The UK's Research Excellence Framework recognises this, and in the government assessment of research organisations award scores for 'outputs' (academic publications as well as other products like software, art, performances, etc. - worth 60% of the overall evaluation), 'impact' (as evidenced by case studies, worth 25% of the overall evaluation), and the 'research environment' (including vitality and sustainability, worth 15% of the overall evaluation) (Research Excellence Framework, 2021).

3. Project stakeholder engagement

As end-users of the research, stakeholders are an integral part of impacts. The Moana Project involves a number of formal and informal collaborators that represent end-users of project outputs. These include Whakatōhea Iwi, universities, crown research institutes like NIWA, government agencies like MPI, EPA, DOC, MfE and Regional and District Councils, and fishing and aquaculture industry bodies like Moana NZ, the Inshore Fisheries Group, the Deepwater Group, the Pāua and Rock Lobster Industry Councils, and the Marine Farming Association.

To ensure that impacts from the Moana Project are realised, the project formalises stakeholder engagement through a Strategic Stakeholder Advisory Group including members from the above and additional organisations (see Appendix B for a full list of Stakeholder Advisory Group members). The project stakeholders have met and agreed to terms of reference, according to which they are kept informed of project progress and are involved with shaping project outputs through targeted engagement around individual workstreams.

4. Moana Project impacts

4.1 Preliminary impact forecasts

To quantify intended impacts, Endeavour Project grant proposals are required to identify post-contract outcomes for three time horizons: two years, five years and ten years post project. The Moana post-project outcomes (technically a mixture of outcomes and impacts) are outlined in the Science Investment Contract between MetService and MBIE and reproduced in Table 1.

A more detailed description of potential outcomes and impacts from the Moana Project research was provided in the Moana Project Benefit Forecast submitted to MBIE in February 2021 (Felsing, 2021). For this, MBIE required research impacts to be categorised into environmental, economic and social/cultural benefits, with a further distinction between direct and indirect benefits. The resulting forecasted potential benefits are shown in Appendix C.

Table 1: Moana Project post-contract outcomes identified in the project proposal and Science Investment Contract.

Year	Outcome
2025	• ZebraTech sensors are on all NZ fishing vessels. Sensor data has improved ocean forecasting, resulting in operational efficiencies helping the seafood industry reach its $2.3B export target. • MetOceanTrack has improved biosecurity management, helping MPI and the aquaculture industry avert a serious aquaculture pest outbreak, saving the industry $ millions. MetOceanTrack is widely used by fisheries managers to understand connectivity. • Supported by Māori knowledge and scientific data, Whakatōhea Māori Trust Board manages 3800 ha of multitrophic aquaculture space, generating 150 regional jobs and $100M annual exports of a high-end product using local, indigenous branding. This, and an upskilled industry helps achieve the Bay of Plenty ($250M) and Government ($1B) aquaculture export targets.
2028	• The greeenshell mussel, kōura, pāua and deepwater (e.g. hoki) fisheries prosper as they use refined models to correlate catch and spawning data with circulation and temperature models and accurately predict stock abundance. • Moana-model outputs are widely used, and NZ is renowned for its evidence-based marine and fisheries management. • Whakatōhea has settled Treaty grievances and expanded aquaculture operations to 8000 ha, resulting in another 200 regional jobs and improved well-being. • MetOceanTrack is exported globally, supporting biosecurity, larval connectivity and fisheries management. The marine heatwave prediction system successfully forecasts intense heating in time for multiple aquaculture industries (greeenshell mussels, pāua, salmon) to mitigate, saving $100Ms.
2033	• Thousands of vessels globally provide temperature data from previously un-observed regions. Accurate ocean analysis and prediction have made the NZ fishing fleet the world's most efficient. NZ is an ocean technology leader. • Marine heatwaves occur frequently, but accurate forecasting systems help fisheries, aquaculture and ecosystem management mitigation and growth. • Whakatōhea is a thriving prosperous community skilled in ICT and marine sciences and an exemplar for other coastal iwi in an era of positive transformation.

4.2 Investment logic mapping

To further benefits definition from the initial proposal outline of Table 1, the Moana Project used investment logic mapping. This is a technique used to involve key stakeholders in decision-making around investments. It involves a series of structured workshops which aim to bring about an agreed

investment story that is supported by evidence (logic). The New Zealand Treasury recommends that investment logic mapping be carried out for any large project or programme, so that the results can be incorporated into the project or programme business case (Treasury NZ, 2021). The approach of involving stakeholders in definition of benefits and development of indicators to measure them is recognised internationally as helpful for ensuring the indicators selected for monitoring are robust and incorporate balanced perspectives (e.g. National Research Council, 2014; Adam et al., 2018, Al-Hashmy, 2021).

To maximise effectiveness, investment logic mapping should be done at the outset of a project, where it ideally is used as a first hurdle that helps organisations decide which projects are worth investing in. In the Moana Project, although formal investment logic mapping was not done before the project commenced, key stakeholders like Whakatōhea Māori Trust Board, Fisheries Inshore New Zealand, the Deepwater Group, Moana NZ, Aquaculture New Zealand and the Ministry for Primary Industries were involved in the project conception and provided support for authoring the grant application.

The investment logic mapping was continued informally through discussions as the project Strategic Stakeholder Advisory Group was established and met in 2020 and was finalised in a series of workshops using external facilitator Jim McMahon in April and May 2021. The workshops involved key stakeholders from 16 organisations as well as project research team leads, who were asked to assess the expected outcomes from each research stream and identify the impacts they expected.

The outcome of investment logic mapping is a benefit map, which identifies and quantifies specific benefits that result from an investment of time, money and effort. Ideally, investment logic mapping requires benefits to be supported by one or two Key Performance Indicators (KPIs). KPIs are generally expressed in SMART (Specific, Measurable, Attributable, Realistic, Timebound) terms.

However, as outlined in Section 2, coming up with such measurable indicators for research is not straightforward and most practitioners and government agencies advise against reducing research impact measurements to a few, easy-to-document statistics (e.g. National Research Council, 2014; Adam et al., 2018; Rowlands, 2018; MBIE, 2019; Duncan et al., 2020; Research Excellence Framework, 2021). For the Moana Project, the investment logic mapping therefore supplemented explicit values with a series of statements around expected impacts.

The workshops resulted in a matrix of outputs and potential benefits the project could choose to monitor (Table 2, with more details provided in Appendix D), from which a monitoring framework was developed as outlined in the following section.

Table 2: Moana Project benefits map resulting from investment logic mapping workshops in April and May 2021. Table continues on following page.

MOANA PROJECT OUTCOMES	BENEFITS
TE TIRO MOANA	
• Novel, innovative technology allowing crowdsourcing of ocean observations, providing low cost, near real-time ocean observations across a greater extent of NZ's ocean. • Multi-disciplinary, collaborative research between industry, science and citizen groups.	Increased numbers of ocean observations gained at lower cost across a wider oceanographic area.
	Fishers using Mangōpare sensor data to increase efficiencies.
	NZ increased technical skills and reputation for cutting-edge ocean science as evidenced by demand for Mangōpare sensor overseas.
NGĀ RIPO O TE MOANA	
• Generation of ocean foundational knowledge • Greater predictability of extreme events and their effects. • Hind – and forecast models, providing fine-grained data for ocean heat, salinity, currents, surges, density, and knowledge of marine heatwave drivers. • Model data made available in the form of tools that better predict ocean conditions.	Increase in accuracy of NZ ROMS model, resulting in more accurate ocean temperature, sea level and current data becoming available.
	Maritime NZ better informed and equipped to respond to and prepare for disasters and extreme events (e.g. oil spill).
	Ocean knowledge advancing as science users downloading, using and benefitting from the Moana 25+ year hindcast.
	Commercial/citizen users benefitting from the Moana 25+ year hindcast and MetOceanTrack as made available on line.
	Marine farming industry using marine heatwave hindcast and forecasts to increase planning and efficiencies.
HE HONO MOANA	
• Connectivity information for mussel, pāua, koura stocks including larval origin, movement and settlement.	Future proofing mussel farming industry by determining and protecting source of Ninety Mile Beach mussel spat (supplying 80% of NZ mussel farming industry worth ~$400M).
	Accurate connectivity data helps Pāua Industry, iwi and government better manage pāua fishery post Kaikoura earthquake.

Table 2 continued.

MOANA PROJECT OUTCOMES	BENEFITS
HE PAPA MOANA	
• Blueprint for iwi marine plan. • Iwi impact assessment framework helping iwi estimate impacts from ocean changes. • Whakatōhea records and progresses values, interests and aspirations.	Whakatōhea values, interests and aspirations protected and enhanced by Moana Plan adopted by Regional Council and recommendations followed.
	Whakatōhea mussel farm using spat source and marine heatwave information to become more profitable and efficient.
	Other iwi applying the Moana Plan and Iwi Impact Assessment Framework methods, thereby enhancing their planning and self-determination.
OVERALL MOANA PROJECT	
• Improved ocean knowledge from the integration of Mātauranga Māori with traditional science, and blueprint for knowledge exchange. • Provision of scientists, data, research and models that inform or seed other research programmes.	NZ ocean science and social science capacity building: increased skills, data, information and knowledge in the form of postdocs, PhDs, MScs trained and progressing in their careers, scientific papers published, uptake of data and models in other NZ research.

5. Impact monitoring framework

Monitoring and reporting on impacts is resource intensive, and to not place undue burden on academic institutions, research impact assessment guidelines recommend selecting indicators carefully to ensure monitoring is affordable, cost-effective and efficient (Adam et al., 2018). Some of the indicators identified in the investment logic mapping (like the number of peer-reviewed publications and the number of spin-off projects) overlap with those used in MBIE annual reporting and are thus already being regularly monitored.

The timing of monitoring is important. If done during or close to the end of the project, impact assessment may not cover the full extent of impacts as these take time to manifest. However, monitoring at the end of the project is more likely to provide useful information that can influence organisational direction and decisions made by managers and researchers than monitoring after ten years when most benefits have materialised (RDC, 2018). For the Moana Project, it was decided that impact assessment horizons should be kept close to the end of the project – although it would be nice to measure the impacts of the Moana Project after five or ten years, it is unrealistic to plan for monitoring so far ahead that policies and funding agencies may have changed focus.

From the benefits map resulting from the investment logic mapping (Figure 2 and Appendix D), the Project Management team selected a subset of indicators to monitor. To ensure broad cross-project coverage and follow international, MBIE and Treasury guidelines, selected indicators include:

- at least one indicator from each of the four workstreams;
- items from all stages of the results-chain (i.e. outputs, outcomes and impacts);
- a mixture of environmental, economic, and social/cultural benefits; and
- some for monitoring at the end of the project (2024) and some for monitoring two years after project end (2026).

The resulting impact monitoring framework is shown in Table 3. The KPIs listed represent project goals in terms of measurable indicators but where case studies are used, these measurements will be accompanied by narratives describing impacts that cannot easily be quantified, including subjective assessments of impacts and unexpected outcomes. Case studies will follow the outline used in the UK's Research Excellence Framework (2021) (Appendix A), and findings will be targeted towards addressing the indicators and capitals outlined in Treasury's Living Standards Framework (Figure 3). To show the evolving of the thinking around impacts over time, they will also be compared to the forecasts made in the project proposal (Table 1).

Table 3: Moana Project impact monitoring framework. Continued on the following page.

RESULTS-CHAIN	IMPACT	KEY PERFORMANCE INDICATOR
Outputs	NZ ocean science and social science capacity building: increased skills, data, models, information and knowledge.	Bibliographic, webometrics: 15 peer-reviewed papers published by 2026. 30 citations in peer-reviewed literature. 15 online citations or mentions of papers.
		2024: 4 postdocs, 10 PhD students, 1 MSc finished
		2024: 200% increase in NZ ocean observations.
		2024: 10% reduction in bias and root mean square error for NZ national ROMS model compared to global simulation, available for research users nationwide.
		2024: At least one mussel source bed identified at Ninety Mile Beach from genetic analysis
Outcomes	NZ ocean science and social science capacity building: increased skills, data, models, information and knowledge.	2026: Survey showing 70% of Moana Project postdocs, PhDs, MSc employed in science, industry or government
		2024: Case study showing Mangōpare sensor used in three other countries. During the project, at least five invitations to speak at international science conferences, workshops, collaborations, seminars.
		2024 & 2026: Survey of model/data users and other collaborators showing ten spinoff research projects using Moana data. Case studies to determine impacts from these projects.
		2024: 100 downloads of hindcast dataset. Breakdown of what data was used for. Survey to establish whether data was useful. Case study to determine that 25 of these used for research creating benefits to NZ Inc.
	Maritime NZ better informed and equipped to respond to and prepare for disasters (e.g. oil spill).	2024: Forecast model taken up by Maritime NZ as primary guidance for search and rescue.
	Better tools for predicting ocean conditions and particle trajectories enhance NZ marine resource management and blue economy.	Case study showing 10 (2024) and 25 (2026) organisations / individuals leveraging Moana data through APIs or apps for marine business or management purposes.

Table 3 continued

RESULTS-CHAIN	IMPACT	KEY PERFORMANCE INDICATOR
Impacts	Whakatōhea mātauranga, values, interests and aspirations documented, protected and enhanced.	2024: Moana Plan adopted by Bay of Plenty Regional Council. 2026: At least two consents / planning initiatives incorporating plan recommendations. 2024 & 2026: Case studies to ascertain other impacts on Whakatōhea Maori Trust Board from the Moana Project.
	Novel, innovative technology allowing crowdsourcing of ocean observations helps fishing companies increase efficiencies and reduce bycatch.	2024: Survey showing at least two fishing companies actively using Moana Project data. Case study determining benefits to these companies.
	Source of Ninety Mile Beach mussel spat safeguarded, helping to future proof NZ mussel farming industry.	2024: Case study showing Te Oneroa-a-Tōhe Board, MPI, Marine Farming Association and Northland Regional Council are using the information about the location of source mussel beds provided by the project. 2026: Bibliography showing source bed safeguarded through legal mechanisms (e.g. fishery closure, mātaitai/taiāpure, other mechanism) by Te Oneroa-a-Tōhe Board, MPI, or Northland Regional Council.
	Pāua industry, iwi and government use accurate connectivity data to sustainably manage Kaikoura pāua fishery post-earthquake.	2024: Case study showing pāua connectivity data taken up and used by MPI, PIC, ECAN and/or Ngāi Tahu to manage pāua fishery.
	Marine farming industry uses marine heatwave forecast and hindcast data to increase operational efficiencies and future-proof industry.	2026: Case study showing two marine farming companies actively using Moana heatwave forecast or hindcast data, description of impacts.

The KPIs will be monitored and reported by MetOcean Solutions, the marine branch of MetService under which the Moana Project is managed. Wherever possible within the pre-set reporting format and word count, the 2024 KPIs will be incorporated into the final report to MBIE due March 2024. In addition, a separate project impact assessment report will be prepared for the MetService Board, the Moana Governance Group and MBIE. As the Governance Group dissolves at the end of the project, the 2026 impact assessments will be reported only to the MetService Board and MBIE.

It is important to note that the monitoring outlined in Table 3 is not the only evaluation of project impacts. Ongoing assessment of project impacts are provided in MBIE annual reporting as well as Moana Project stage gate reviews and internal work package delivery. To complement this ongoing assessment, the progress of the selected KPIs (Table 3) will be informally monitored every six months by the Moana Project Management Team as part of routine project progress reporting. This will ensure that if project impact realisation falls behind, remedial action can be taken.

Although complex and potentially difficult, the measurement and reporting of research impacts present an important step towards ensuring research investments provide benefits to New Zealand. The Moana Project is wide-reaching and diverse, involving more than 50 researchers from over 14 organisations. As a result, the indicators presented here by necessity do not fully account for all project impacts. Rather, they are intended to provide a broad range of evidence around the impacts that stakeholders feel are most important as expressed in the investment logic mapping workshops.

6. References

Adam, P.; Ovseiko, P.V.; Grant, J.; Graham. K.E.A.; Boukhris, O.F.; Dowd, A.; Balling, G.V.; Christensen, R.N.; Pollitt, A.; Taylor, M.; Sued, O.; Hinrichs-Krapels, S.; Solans-Domenech, M.; Chorzempa, H. (2018) ISRIA statement: ten-point guidelines for an effective process of research impact assessment. Health Research Policy and Systems 16 (8) DOI 10.1186/s12961-018-0281-5

Al-Hashmy, R. (2021) Knowledge Engagement team develops toolkit for researchers to measure impact. University of Calgary Newsletter (https://news.ucalgary.ca/news/knowledge-engagement-team-develops-toolkit-researchers-measure-impact).

Chavda, J.; Patel, A. (2016) Measuring research impact: bibliometrics, social media, altmetrics, and the BJGP. British Journal of General Practice 66 (642): e59–e61.

Duncan, R.; Robson-Williams, M.; Fam, D (2020) Assessing research impact potential: using the transdisciplinary Outcome Spaces Framework with New Zealand's National Science Challenges. Kōtiotio: New Zealand Journal of Social Sciences Online 15 (1): 217-235.

Felsing, M. (2021) Moana Project Benefit Forecast. Report prepared for the Ministry for Business, Innovation and Employment (MBIE). Raglan, 33pp.

Guthrie, S.; Wamae, W.; Diepeveen, S.; Wooding, S.; Grant, J. (2013) Measuring research: A guide to research evaluation frameworks and tools. Prepared for the Association of American Medical Colleges. 174pp.

MBIE (2015) National Statement of Science Investment 2015–2025. Ministry of Business, Innovation and Employment, Wellington. 65pp.

MBI) (2018) The impact of science: Discussion paper. Ministry of Business, Innovation and Employment, Wellington. 47pp.

MBIE (2019) The Impact of Research. Position paper. Ministry for Business, Innovation and Employment, Wellington. 27pp.

MBIE (2021) Endeavour Fund 2021 Investment Round Gazette Notice. Ministry of Business, Innovation and Employment, Wellington.

Moed, H.F. (2005) Citation analysis in research evaluation. Dordrecht, Springer. 348pp.

MORST (2007) Vision Mātauranga. Unlocking the Innovation Potential of Māori Knowledge, Resources and People. Ministry of Research, Science + Technology, Wellington. 25pp.

National Research Council (2014) Furthering America's Research Enterprise. R.F. Celeste, A. Griswold, and M.L. Straf (Eds.). Committee on Assessing the Value of Research in Advancing National Goals,

Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press. 200pp.

NZ Treasury (2018) Our People Our Country Our Future. Living Standards Framework: Background and Future Work. New Zealand Treasury, Wellington. 57pp.

RDC (2018) Cross-RDC Impact Assessment Program: Guidelines. Updated 2018. Australian Rural Research and Development Corporations, Canberra. 85pp.

Ravenscroft, J.; Liakata, M.; Clare, A.; Duma, D. (2017) Measuring scientific impact beyond academia: An assessment of existing impact metrics and proposed improvements. PLoS ONE 12(3): e0173152. https://doi.org/10.1371/journal.pone.0173152

Reed, M.S.; Ferré, M.; Martin-Ortega, J.; Blanche, R.; Lawford-Rolfe, R.; Dallimer, M.; Holden, J. (2021) Evaluating impact from research: A methodological framework. Research Policy 50 (4): 104147.

Research Excellence Framework (2021) Guidance on submissions. Research Excellence Framework (REF), United Kingdom. 121pp.

Rowlands, I. (2018) What are we measuring? Refocusing on some fundamentals in the age of desktop bibliometrics. FEMS Microbiology Letters 365 (8): fny059.

Smith, R. (2001) Measuring the social impact of research: Difficult but necessary. British Medical Journal 323 (7312): 528.

Thelwall, M. (2020) Measuring societal impacts of research with altmetrics? Common problems and mistakes. Journal of Economic Surveys. Doi: 10.1111/joes.12381

Treasury NZ (2021) website: https://www.treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/better-business-cases-bbc/bbc-methods-and-tools/investment-logic-mapping Accessed on 12 July 2021.

Appendix A: UK Research Excellence Framework 2021 case study template

Modified (deleting internal references) from Research Excellence Framework (2021).

Title of case study
1. Summary of the impact (indicative maximum 100 words) This section should briefly state what specific impact is being described in the case study
2. Underpinning research (indicative maximum 500 words) This section should outline the key research insights or findings that underpinned the impact, and provide details of what research was undertaken, when, and by whom. This research may be a body of work produced over a number of years or may be the output(s) of a particular project. References to specific research outputs that embody the research described in this section, and evidence of its quality, should be provided in the next section (section B3). Details of the following should be provided in this section: • The nature of the research insights or findings which relate to the impact claimed in the case study. • An outline of what the underpinning research produced by the submitted unit was (this may relate to one or more research outputs, projects or programmes). • Any relevant key contextual information about this area of research.
3. References to the research (indicative maximum of six references) This section should provide references to key outputs from the research described in the previous section, and evidence about the quality of the research. Underpinning research outputs may include the full range of output types and are not limited to printed academic work. All forms of output cited as underpinning research will be considered equitably, with no one type of output being preferred over others. Include the following details for each cited output: • author(s) • title • year of publication • type of output and other relevant details required to identify the output (for example, DOI, journal title and issue) • details to enable the panel to gain access to the output, Evidence of the quality of the research must also be provided in this section.
4. Details of the impact (indicative maximum 750 words). The 'Panel criteria', Annex A, Table 1 provides an illustrative list of evidence that could be provided. This section should provide a narrative, with supporting evidence, to explain: • how the research underpinned (made a distinct and material contribution to) the impact; • the nature and extent of the impact. The following should be provided:

- A clear explanation of the process or means through which the research led to, underpinned or made a contribution to the impact (for example, how it was disseminated, how it came to influence users or beneficiaries, or how it came to be exploited, taken up or applied).
- Where the submitted unit's research was part of a wider body of research that contributed to the impact (for example, where there has been research collaboration with other institutions), the case study should specify the particular contribution of the submitted unit's research and acknowledge other key research contributions.
- Details of the beneficiaries – who or what community, constituency or organisation has benefitted, been affected or impacted on.
- Details of the nature of the impact – how they have benefitted, been affected or impacted on.
- Evidence or indicators of the extent of the impact described, as appropriate to the case being made.
- Dates of when these impacts occurred.

5. Sources to corroborate the impact (indicative maximum of ten references)

This section should list sources external to the submitting HEI that could, if requested by panels, provide corroboration of specific claims made in the case study. Sources provided in this section should not be a substitute for providing clear evidence of impact in Section B4; the information in this section will be used for audit purposes only. This section should list sufficient sources that could corroborate key claims made about the impact of the unit's research. These could include, as appropriate to the case study, the following external sources of corroboration (stating which claim each source provides corroboration for):

- Reports, reviews, web links or other documented sources of information in the public domain.
- Confidential reports or documents.
- Individual users/beneficiaries who could be contacted by the REF team to corroborate claims.
- Factual statements already provided to the HEI by key users/beneficiaries, that corroborate specific claims made in the case study.

Appendix B: Moana Project Strategic Stakeholder Advisory Group members

Where several staff members are involved with the project, the key contact is listed.

Organisation	Name and position
Fisheries NZ, MPI	Richard Ford, Fisheries Science Manager. Chair.
Whakatōhea Māori Trust Board	Te Kahautu Maxwell, Board member
Aquaculture New Zealand	Dave Taylor, Technical Director
Open Ocean Whakatōhea Mussels	Ashleigh Anderson
Fisheries Inshore NZ Ltd	John Willmer, Fisheries Manager
Deepwater Group Ltd	Richard Wells, Fisheries Specialist
FINNZ	Dan Martin, Head of Technology
Moana NZ	Nathan Reid, Quota and Resource Manager
Marine Farming Association	Kevin Oldham, Chair R&D Committee
Ōpōtiki District Council	Aileen Lawrie, CEO
Pāua Industry Council	Tom McCowan, Scientist
Royal NZ Navy	Nicholas Francesco, LT METOC, Joint Force HQ
Ministry for the Environment	Pierre Tellier, Senior Analyst Strategy & Stewardship
Department of Conservation	Monique Ladds, Senior Policy Advisor
Te Ohu Kai Moana	Te Taiawatea Moko-Mead
NZ Rock Lobster Industry Council	Daryl Sykes, Chief Operating Officer
Terra Moana	Tony Craig, Partner
Sanford	Anna Kleinmans, Aquaculture Technical Advisor
Pelco Ltd	Denham Cook, Science Representative
Waikato Regional Council	Chris Staite, Senior Policy Advisor
Auckland Council	Coral Grant, Scientist
Bay of Plenty Regional Council	Stacey Faire, Senior Planner
Northland Regional Council	Richard Griffiths, Resource Scientist
Environment Canterbury	Jane Doogue, Senior Planner
Te Oneroa-a-Tōhe Board	Sheila Tailor
Our Seas Our Future	Noel Jhinku
EPA	Tim Roser, Senior Advisor Land & Oceans
NZ Coastguard	Ray Burge,
Maritime NZ	Mike Hill, Manager Rescue Co-ordination Centre

Appendix C: Moana Project benefit forecast February 2021

Table C1: Potential economic benefits from the Moana Project. From Felsing (2021).

Direct economic benefits
Whakatōhea mussel farm increasing production supported by improved mussel connectivity data (providing certainty around spat collection) and better marine weather information (warning of marine heatwaves). This will lead to economic gains and employment, helping the farm expand to 3800 ha, generating 150 regional jobs and $100M annual exports of a high-end product using local, indigenous branding.
Deepwater hoki fishery thriving and meeting catch limits even in years of marine heatwaves, averting $13M losses of previous marine heatwave years as fishing companies correlate hoki presence/absence data with hindcast and nowcast data to find isotherms where hoki congregate.
The future of NZ's thriving mussel industry (worth $350M) safeguarded as national spat sources identified and protected through actions of MPI, EPA, MFE, DOC, Iwi organisations, and Regional Councils.
The mussel aquaculture industry is spat-limited. If further sources of spat could be found through Moana Project connectivity studies, the industry could grow an additional $50M per annum.
Marine heatwave hind- and forecasts help aquaculture industry plan for sustainable future, relocating temperature-sensitive stock (mussels, salmon) from areas of high probability of marine heatwaves to areas where water is likely to remain cooler.
Pāua source populations supporting the Kaikoura fishery identified, enabling industry to keep fishing 45 tonnes/annum sustainably.
Operational efficiencies realised as fishers use sensor, now- and forecast data to target the isotherms where fished species congregate.
Increase in quality-checked ocean observations collated in open-access archive allows step-change in knowledge and understanding around NZ's oceans, leading to thriving marine industries and better government and industry decision-making.
Indirect economic benefits
Outcomes from observation optimisation work outlines where future ocean observations should be focused to maximise the value per unit effort, thus saving NZ research organisations $ millions by targeting the effort where it is most needed to help us understand our oceans.

Table C2: Potential environmental benefits from the Moana Project. From Felsing (2021).

Direct environmental benefits
Improved, more sustainable fisheries management as MPI uses Moana hindcast data to elucidate effects of changing ocean weather (temperatures and currents) on important fisheries stocks and incorporate the best possible data into stock management.
Reduction in bycatch as fishers use forecast and nowcast data to target the ocean isotherms where fished species congregate.
Easier, more sustainable aquaculture planning benefitting aquaculture operators, EPA, DOC, and Regional Councils as MetOceanTrack tool used to predict the dispersal of solid waste from aquaculture operations.
Improved biosecurity management as Biosecurity NZ uses MetOceanTrack to determine spread of invasive species that threaten NZ biodiversity, fisheries, and aquaculture operations.
Improved models and particle tracking feeds into national and regional planning, highlighting connectivity e.g. between populations of threatened species or Marine Protected Areas, leading to better protection of vulnerable species and habitats.
Indirect environmental benefits
Moana Project models, hindcast data and particle tracking tool used by NZ researchers for projects including predicting sedimentation transport pathways in Hawke's Bay, regional fish stock management, determining risk of eutrophication, ship routing, defence and Search and Rescue. The model and data used is helping improve marine resource management and research across NZ.
Improved understanding of the drivers of marine heatwaves (gained through machine learning) allows prediction of future trends, thus providing early warning of how NZ's oceans will change over the coming years. This will help sustainable marine management by government agencies like DOC, MPI, MFE and EPA.
Moana Project enhancement of OpenDrift open-source particle tracking model source code helps users internationally and within NZ to better track particles (larvae, contaminants, plastics, oil), leading to improved resource and emergency waste management.

Table C3: Potential social and economic benefits from the Moana Project. From Felsing (2021).

Direct social and cultural benefits
Whakatōhea iwi values and aspirations recognised and safeguarded through adoption of Moana Plan into Bay of Plenty statutory plans (including Regional Coastal Plan), leading to protection of sites of cultural and social significance.
Iwi Impact Assessment Framework helps Whakatōhea and other iwi determine the consequences of marine heatwaves and ocean changes to their interests, aiding self-determination and control over planning for the future.
Hundreds of thousands of Kiwis benefitting from improved ocean forecasts through Moana forecasts being displayed on MetService's free weather forecasting websites WeatherMap and SwellMap, leading to safer ocean recreation.
Improved hydrodynamic models and forecasts leading to lives saved at sea as NZ's Maritime Rescue Coordination Centre uses MetOceanTrack and Moana models when searching for vessels or personnel lost at sea.
One MSc, 10 PhDs trained, and four postdoctoral fellowships completed, significantly increasing NZ's ocean science ability (25% of these are Māori), leading to increased knowledge generation and local expertise to benefit NZ in years to come.
Indirect social and cultural benefits
Improved storm surge prediction from using Moana model forecasts helping Regional Councils warn coastal residents in flood-prone areas, thus increasing safety and reducing damage.
World-leading crowd-sourcing of ocean observations increases NZ's reputation as leading oceanography innovation.
Whakatōhea marine spatial plan provides example of a process and format for recording iwi value and aspirations which other coastal iwi can draw from to produce their own.

Appendix D: Moana Project benefit map

Moana Project benefits map resulting from investment logic mapping workshops in April and May 2021.

MOANA PROJECT OUTCOMES	BENEFITS	MEASURE TYPE	MEASURE DESCRIPTION/ INDICATOR
TE TIRO MOANA			
• Novel, innovative technology allowing crowdsourcing of ocean observations • Low cost, near real-time ocean observations across a greater extent of NZ's EEZ • Multi-disciplinary, collaborative research between industry, science and citizen groups	Increased numbers of ocean observations gained at lower cost across a wider oceanographic area	Case study	2024: % increase in number of observations gathered.
		Case study	2024: fishers' use of the data and the benefits derived.
	NZ increased technical skills and reputation for cutting-edge ocean science.	Case study	2024: demand for sensor – number of exports, number of international conferences invited to speak at.
NGĀ RIPO O TE MOANA			
• Generation of ocean foundational knowledge • Greater predictability of extreme events and their effects • Hind – and forecast models of marine heatwave drivers • Fine-grained data for ocean heat, salinity, currents, surges, density, etc. • Availability of tools that better predict ocean conditions. Which may increase the possibility of catching the right sort of fish, while reducing bycatch and environment impact.	Maritime NZ better informed and equipped to respond to and prepare for disasters and extreme events (e.g. oil spill)	Case study	2024: uptake of Moana Backbone model and incorporation into standard processes by Maritime NZ. Survey of Maritime NZ to assess usefulness of model.
	Ocean knowledge advancement: science users benefitting from the Moana 25+ year hindcast	Bibliographic + case study	2024: # people who have accessed hindcast dataset, # of acknowledgements of use of data in science publications, survey to determine how much benefit users derived from hindcast.
	Commercial/citizen users benefitting from the Moana 25+ year hindcast and MetOceanTrack as made available on MetOceanView	Case study	2024: % improvement in model accuracy.
		Case study	2024 and 2026: # subscribed to MetOceanView Hindcast[2] and MetOceanTrack apps, survey to determine benefits derived.
	Better informed marine farming and resource management planning	Case study - economic	2026: uptake, use and benefits of marine heatwave and regular hindcast and forecasts by marine farming industry.

MOANA PROJECT OUTCOMES	BENEFITS	MEASURE TYPE	MEASURE DESCRIPTION/ INDICATOR
HE HONO MOANA			
• Specific knowledge of sources of mussel, pāua, koura stocks • Connectivity information for mussel, pāua, koura larvae to track origin, movement and settlement • Correlations between climate change / natural disasters (e.g. Kaikoura earthquake) and finfish / shellfish stocks	Future proofing mussel farming industry by identifying and protecting source of Ninety Mile Beach mussel spat (supplying 80% of NZ mussel farming industry worth ~$400M).	Case study - economic	2024 and 2026: Potential % of mussel farming industry saved (in $). Gains from reducing the risk of reliance on a single known source of spat.
	Accurate, quantitative data to identify and manage larvae restoration, restocking, reseeding activities	Case study	2024: Pāua Industry and MPI: use of connectivity data to prepare, anticipate and sustainably manage long-term impacts of Kaikoura earthquake.
HE PAPA MOANA			
• Improved ocean knowledge from the integration of Mātauranga Māori with traditional science. • Cross-cultural knowledge exchange means people value, seek out and incorporate different worldviews to create more holistic knowledge base. Value of exchange in itself. • Blueprint for iwi marine plans. • Iwi impact assessment framework helping iwi estimating impacts from ocean changes. • Whakatōhea distillation of sites of significance and aspiration – bringing iwi together and documenting.	Whakatōhea values, interests and aspirations protected and enhanced.	Case study / survey	2024 and 2026: is Whakatōhea satisfied? Was Moana Plan incorporated into the Bay of Plenty Regional Coastal Plan? Are Plan recommendations followed?
	Whakatōhea mussel farm using spat source and marine heatwave information to become more profitable and efficient	Case study - economic	2024 and 2026: impact of improved knowledge on Whakatōhea mussel farm management, profits and efficiencies.
	Other iwi pick up and apply the Moana Plan and Iwi Impact Assessment Framework	Bibliographic	2026: Instances where the frameworks are used by other iwi, monitored through references / acknowledgements or direct contact from iwi asking for advice / further information / assistance.
OVERALL MOANA PROJECT			
• Provision of scientists/data/research/models that inform or seed other research programmes.	NZ ocean science and social science capacity building: increased skills, data, information and knowledge	Bibliographic	2026: # research citations in influential publications.
		Case study	2024: Number of PhDs, MScs, MAs completed.
		Case study	2026: Career path of postdocs, PhDs, MSc and MA
		Case study	2024 and 2026: details of spin-off projects arising from or using Moana Project research/data/models.