Article

Marine science in Aotearoa New Zealand: a community-sourced over-the-horizon perspective

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As natural and social environments continue to change, socioeconomic systems need to anticipate change and adequately react. Science, in general, is a critical component of the anticipation. Marine science, as a scientific research field that seeks to understand a significant proportion of our planet, is no exception. Here we provide an outlook on the future of marine science – how it is perceived by society and done by people – in Aotearoa New Zealand. This was informed by a group of early, mid, and late career marine scientists, industry representatives, Indigenous coastal guardians, high school students and ocean users who sought to envision what marine science could look in the near future. Based on a workshop session, we provide ten recommendations to stakeholders, managers, funders, and scientists to bring marine science closer with society's expectations and needs. Marine science needs to adapt practices to respond to an increasing demand for providing both expert knowledge and public information, as well as addressing precarious working conditions and rising expectations to build a fairer, more inclusive, and just science system. Here we examine ways to involve a wide range of present and future actors to increase engagement, collaboration, diversity, impact and ultimately safeguard the worthiness of this research field in a fast-changing society.

Introduction

Aotearoa New Zealand (AoNZ) is a maritime nation – it sits upon the submerged continent of Zealandia and has one of the largest ratios of exclusive economic zone (EEZ) to population (Stevens and O'Callaghan, 2015). Its marine and coastal environments are of great ecological, cultural, and economic value (MacDiarmid et al., 2013). Despite this, the marine environment of AoNZ is under pressure, from direct human activities and anthropogenic climate change. At the same time, the landscape is shifting: there is growing economic and climate-related interest in the ocean for renewable energy, rare elements and minerals, aquaculture, bioproducts, and carbon capture, potentially opening up new research, funding, and employment opportunities. A future strategy for marine science must reflect this changing focus while ensuring that curiosity-driven and public-good research remains supported. While key research priorities have been identified to guide effective conservation, policy, and management in the face of current and emerging pressures (Jarvis and Young, 2019), the future of marine science should be envisioned more holistically to encapsulate

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Box 1. Positionality and approach

The recommendations of this perspective stem from a workshop held at NIWA (Earth Sciences New Zealand since July 2025) Wellington, New Zealand, on developing early career science views on what Aotearoa's marine science might look like in the horizon of 2050. The workshop discussed ideas related to four main themes: (i) the changing nature of marine science especially in a climate context, (ii) what a scientist might look like in the future, (iii) society's relationship with marine science and (iv) the rapidly evolving data, knowledge, and technology setting. In this way, we integrated our collective views on the future of marine science in AoNZ as a diverse group of individuals either working in marine science or with an interest in its future.

We represented a mix of career stages, spanning from high school students to senior scientists, with 71% identifying as early career researchers. In total, 18 authors contributed to this perspective piece. The author team was composed of 50% women/females, 50% men/males. The authors came from a range of institutes including the University of Otago, Victoria University of Wellington, The University of Auckland, The University of Waikato, Dragonfly Science as well as Earth Sciences New Zealand and senior science students from two high schools in Wellington. Ten authors were studying, either for a PhD (n=3), Masters and Undergraduate degree (n=3), or a high school diploma (n=4). The authors represent seven nationalities, with four people identifying Māori, and one person Pasifika, and some came from different disciplinary backgrounds, with the most frequently mentioned being physical oceanography, marine ecology and environmental social science.

The first authors (FT and LK) led the design, implementation, and analysis of the workshop findings and drafted preliminary recommendations based on the outcomes. The paper was then written by the first authors, alongside three other co-authors (CS, GO, PR). FT, LK, CS, and GO identify as tangata tiriti, from European and Australian origin, and PR identify as tangata whenua (Ngāpuhi), currently working in marine science, with focuses on interdisciplinary and transdisciplinary marine science (LK and GO), and natural sciences (FT, CS, PR). The ten recommendations presented in this piece were discussed with all co-authors and they had the opportunity to amend the statements. After gaining consensus, the full paper was sent to all co-authors to review and contribute to. However, as the paper was written by five authors, this may have affected the positions, values, and findings of this piece. Although the workshop invitations were sent to diverse institutes with an aim to attain diversity in gender, cultural backgrounds, and different viewpoints (as assumed based on the participants' disciplinary background), we acknowledge that there was more representation from natural sciences and academic institutions compared to policy, social sciences, and industry viewpoints. Further, there was a high representation of participants originating from outside of AoNZ, which partly reflects the international landscape of marine science in AoNZ. This could have affected or enhanced the diversity of views, values, and beliefs represented in this paper.

society's values and aspirations to stay relevant in a fast-changing world. While scientific priorities are increasingly well defined, more subjective questions – such as What do we want the ocean for? – remain open and addressing them requires the insights and methodologies of the social sciences. This is particularly relevant at the time of writing as a Science System Advisory Group (SSAG, 2025) formed by the Ministry of Business, Innovation and Employment in March 2024, advises the Government on improving the science, innovation, and technology system, considering its structure, performance, and sector-wide challenges.

While the nation has high trust in science and scientists – as observed during the COVID-19 pandemic (Goldfinch et al., 2021) – it does not value science strongly in real terms and funds its research and development sector modestly. For example, total research and development expenditure was 1.41% the value of gross domestic product in 2019, one of the lowest of other small, advanced economy countries (MBIE, 2021; Small Advanced Economies Institute, n.d.). This resource challenge is even more difficult for environmental sciences like marine science as the pathway to economic or political benefit is often difficult to predict and demonstrate (Parliamentary Commissioner for the Environment, 2019). One potential fix is to better communicate to citizens why research in marine science is required, who is doing it, and who it is for.

Here, we provide a perspective on the future of marine science based upon a collaborative workshop involving participants from diverse backgrounds within the marine science community (see Positionality and approach statement, Box 1). We aim to bring a holistic and inclusive perspective on the future of marine science. Forward looking perspectives in the form of so-called "horizon scans" or roadmaps typically take a reasonably short-term view and rarely stray into the human dimension of the researchers doing the work and the nature of that work. We promote a "Marine Futurism" perspective which focuses on a longer, but still tangible, timeline and has a strong element of who, how, and why the research is being developed. It is speculative but valuable in this time of change to promote thinking beyond the status quo.

We aim to provide guidance for the field towards a more just and equitable marine research culture for the future of marine science, focussing on four aspects of scientific research: 1) scientists are people, 2) cultural competency in marine science, 3) society and decision making, and 4) data, knowledge, and technology. The goal of this exercise is not to scrutinise the technical aspect of marine science, but to develop new ideas, provide the coming generation of knowledge creators with food for thought, and synthesize

this kaupapa.

Challenges

A number of challenges will affect the field of marine science in Aotearoa New Zealand over the coming years and decades. These suggest a continuation of the status quo is a very unlikely outcome.

Viable career path — Academic professional pathways are increasingly precarious, predominantly affecting early careers (Heidt, 2023), but also current staff (Taylor and Sutton, 2023). Additionally, the prevailing competitive research culture is fuelling a mental-health crisis in science (Hall, 2023). As a result, the scientific pathway currently appears as "high skill, high competition, low reward", unappealing to less-privileged people and ultimately perpetuates the lack of diversity (Graves et al., 2022). The status quo will not prove attractive to the diverse potential future cohort. There is a need to make research a fairer, more diverse, and just system, and advocacy should come from the research community, but it is unlikely to have impact unless there are more resources available (Rayne et al., 2023).

Decolonisation — In marine science, as with many areas of research, there is a movement away from imperialism practices and towards recognising the role of Indigenous Knowledge in achieving ocean stewardship (Parsons and Taylor, 2021). In Aotearoa New Zealand, the resurgence of pūtaiao, as a way to conduct research that is grounded in kaupapa Māori, ultimately aims at restoring Indigenous research sovereignty (Moko-Painting et al. 2023, Moko-Painting and McAllister, 2023), and restore the place of Mātauranga Māori alongside scientific knowledge (Stevens et al., 2021). Such an approach rightfully shakes the modern science point of view but also implies important changes in scientists' training, workload, and engagement expectation. Given the direct implications for research funding of recognising Mātauranga Māori alongside science (Kaiser and Saunders, 2021; Tollefson, 2023), it is essential that institutions actively continue supporting and developing cultural competency and connection-building in the marine science sector.

Technology — Advances in computational power and the proliferation of externally sourced data are transforming marine science. Enhanced simulations and emerging tools such as machine learning are expanding research capabilities, while satellite and robotic data—often funded internationally and shared via open data policies—are reshaping how science is conducted. However, this shift may reduce national capacity for in situ data collection. To maintain a balanced and resilient research ecosystem, strategic investment is needed to complement technological innovation with sustained support for local and ethical data-gathering capabilities.

Recommendations and discussion

We propose ten recommendations grounded in inclusivity, ethical responsibility, and collaboration (Figure 1). Instead of focusing on the technical aspects of changing technologies, digitisation, and improving marine observation methodologies, the horizon scan brought forward ten recommendations focusing on the need for a just and effective research culture, increased focus on interdisciplinary approaches, and putting researchers and collaborative efforts at the centre of the marine research system (Figures 1, 2).

Scientists are people

1. Recognise the role of values-based research. Examples of values percolating in scientists' professional life are increasing; for example, scientists personally getting involved in climate action, through public warnings, climate strikes or in organisation like Scientist Rebellion (Racimo et al., 2022; Ripple et al., 2022) or by endorsing feminist, anti-colonialist, and inclusive practices (Raman, 2023). Yet, there is still resistance to recognising societal values in research, often by believing that merit itself will continue to make science relevant as it did in the past (Abbot et al., 2023). However, such approaches not only neglect the role of history and privileges but also fail to recognise the positive role of diversity (Thorp, 2023). Practicing values-based research can only increase societal buy-in, by providing diversity of role-models, and ultimately increase the relevancy of research to current societal issues as well as renew the appeal of the scientific pathway. Scientists need to better acknowledge their humanity, and associate values to their work as it matters who does science (Thorp, 2023).

2. Enable and value personal connections between marine scientists (current and future) with mana whenua representatives (at iwi, hapū and/or whānau level). The establishment of Customary Protected Areas through article two of Te Tiriti provides a good foundation for research relationships between tangata whenua and marine scientists. Tangata whenua will always have challenges to their kaitiakitanga of their marine space going forward. In order to make regulatory changes to fisheries management in Customary Protected Areas, research has to be conducted to support tangata tiaki and the aspirations they have for their fishery.

3. Foster a kind and collaborative approach to marine science.

In a world where individual accolades often overshadow collective achievements, it's time we reframe our priorities and better acknowledge the breadth of actors contributing to scientific research. Kindness should be prioritised over competitiveness (Powell, 2018), particularly in the realm of research and problem-solving. Cultivating a collaborative environment necessitates not just encouraging but actively rewarding generosity (Schumann et al., 2023), while also consistently acknowledging and crediting all contributors. To achieve this, a fundamental shift in how research is valued and measured becomes imperative. For example, Allen (2025) suggests adopting a 'G+ index' measuring impact about generosity, giving and other 'good things' in academia. It's about reshaping the mindset around the evaluation of research, emphasizing the collective input and the broader impact rather than conforming to traditional, individual-centric metrics (Kindness in Science, n.d.).

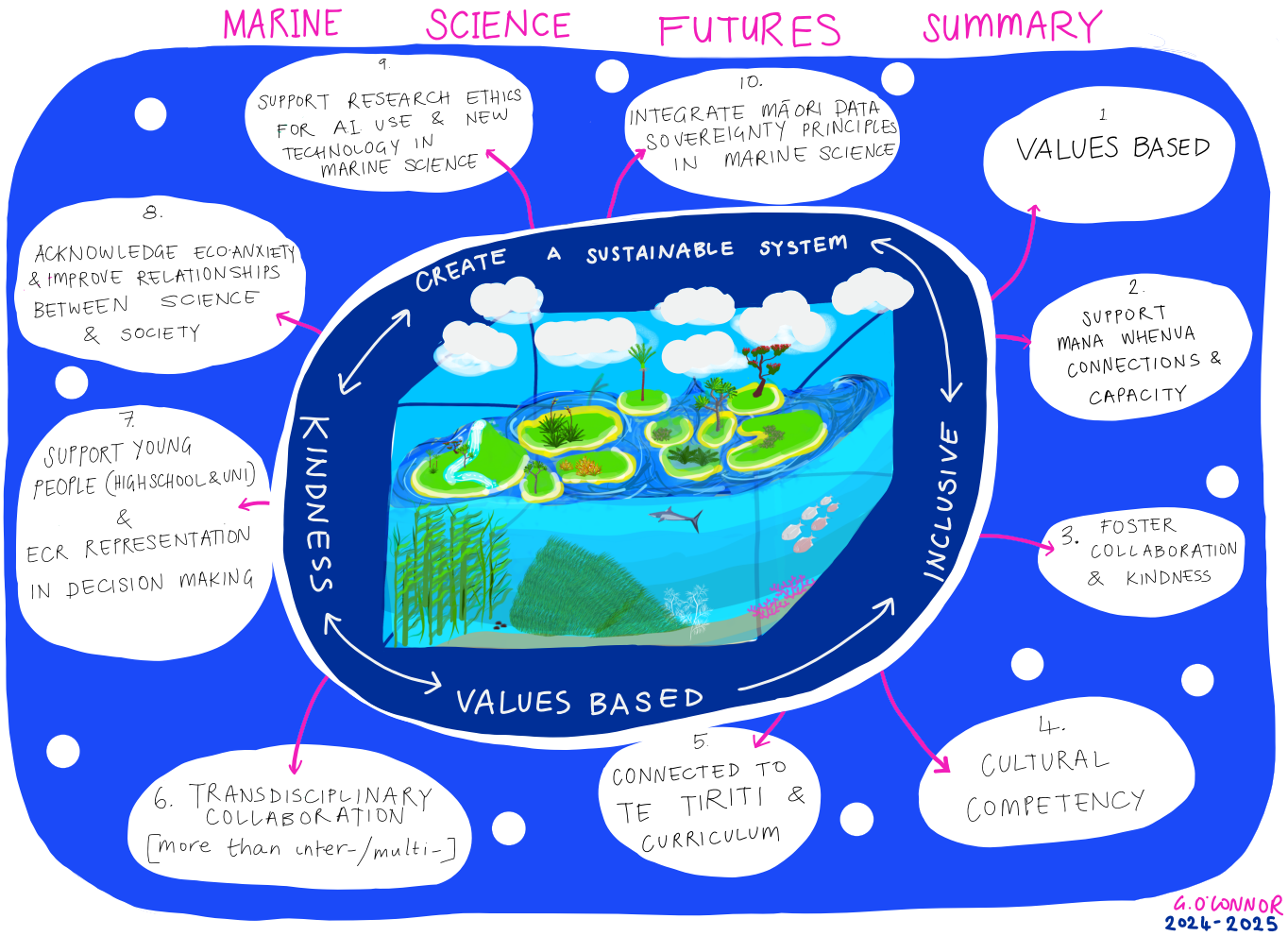

Figure 1: Ten recommendations for the future of marine science in Aotearoa New Zealand. (Diagram: O'Connor)

Cultural competency in Marine Science

4. Leverage resources to build cultural competency in the marine science workforce.

Only about 35% of Māori and 56% of non-Māori agree there is sufficient support for staff who want to build their Māori cultural competency across the New Zealand Research, Science and Innovation (RSI) workforce (MBIE, 2022). Strengthening this support is essential for fostering respectful and effective partnerships with Māori communities. At the same time, the RSI workforce is highly international, and while this diversity is a strength, it also underscores the need to ensure that international researchers are equipped to engage meaningfully with the cultural context of Aotearoa New Zealand. Initiatives like the Marine Science degree programme from the University of Otago includes a third year field course that is marae based working with Tangata Tiaki (local customary fisheries managers/guardians) that enables graduates with elementary cultural competency (Hepburn et al., 2019). Students from this course have gone on to post-graduate studies working in Customary Protected Areas and employment in research, iwi, local and central government.

5. Embed Te Tiriti principles and obligation in the marine science curriculum.

Tertiary institutions have various statements about Te Tiriti within the governance sphere, some have memorandums of understanding with local Iwi, however how this translates down into curriculum varies between institutions. Article two of Te Tiriti o Waitangi provides a great platform for a working relationship between Tangata Tiaki and researchers based in and around Customary Protected Areas. The Otago Customary Protected Areas field course is a good example of how students can be enabled by incorporating Te Tiriti o Waitangi into the curriculum (Hepburn et al., 2019). Employers have commented that this course is a point of difference when looking at potential graduates. For some students it will be the first time they have visited a marae, which is somewhat surprising in 2025.

Society and decision making

6. Encourage collaboration among marine scientists, communicators, artists, and communities to strengthen outreach using diverse methods.

Fostering inter and transdisciplinary collaboration will enhance marine scientific outreach by promoting

greater interactions among marine scientists, science communicators, journalists, artists, and communities (Woodall et al., 2021). Innovative and audience-targeted communication methods, such as science comics, serious games, design challenges, and unique educational events, should be further explored to engage a broader audience, emphasizing active community involvement in marine scientific research (Heras et al., 2021).

7. Support Pre-(high school, university) and Early-Career representation in future decision making.

Stakeholders of scientific research need to be redefined as all citizens of Aotearoa New Zealand, not only those in managerial positions. This involves a truly transdisciplinary approach (Tress et al., 2005) to collaborative research where the communities that benefit from the research are involved in the research design and process from the beginning. Young people should also be considered as accomplished participants and stakeholders of marine science research (O'Connor, 2025) where, given access to good information and experiences of research, they have much to contribute. Young people's participation in research can benefit their families, through a distribution of new knowledge that trickles outward within their households (Lawson et al., 2019; Ojala and Lakew, 2017), and communities (O'Connor, 2025). Within the workshop that has informed this paper, the youngest members from local high schools had the most to contribute in "big picture" thinking as they were determining their futures while witnessing anthropogenic climate change up close. Young people freely expressed their opinions and synthesised information in ways that created respect amongst the marine research community that attended the workshop. Their voices are valid and necessary as we make decisions that will directly influence the future that they will be experiencing.

8. Acknowledge eco-anxiety and support scientist-public interactions to alleviate its negative effects on people.

Ecological crises induced by anthropogenic climate change are provoking strong emotional responses - often termed "eco-anxiety" – to both environmental researchers and the general public (Jones and Lucas, 2023; Kurth and Pihkala, 2022). Although eco-anxiety can be particularly prone in children and young people due to beliefs of inadequate responses from governments (Hickman et al., 2021), environmental research might have a role to play in alleviating the effects of eco-anxiety by creating discussions about environmental issues as well as bringing information, solutions and hope. In fact, involving the general public in motivational and actionable message can reduce eco-anxiety (Wang et al., 2023). Allowing more interactions between environmental scientists and the general public not only increases the dissemination of up-to-date information but also might play a positive role in mitigating eco-anxiety.

Data, knowledge, and technology

9. Support research ethics for the use of AI and new technologies in marine science. A possible future is one where global datasets and globally operating sensor systems, in conjunction with modelling and analysis tools, such as AI, provide a quantitative knowledge framework that can then be interrogated with science questions. Science will of course exist beyond this, where questions and assessment of analysis by such approaches falls outside what is known or presently possible. Regardless, this points to part of the job of a scientist as being to evaluate the worth of the abundant information for the question at hand. It's essential to advocate for robust research ethics governing the utilization of AI and emerging technologies within the domain of marine science. Potential risks include issues with data bias and quality, transparency and accountability, ownership and access to data, potential harm to marine ecosystems from increasing use of autonomous measuring systems (Coghlan and Parker, 2023), as well as unintended consequences that could adversely affect local communities, Indigenous groups, or the broader socio-economic landscape. These consequences may include job displacement, changes in fishing practices, or altering traditional knowledge systems. Addressing these ethical challenges involves developing clear ethical guidelines, ensuring transparency in AI systems, considering the broader impact on ecosystems and communities, and involving various stakeholders in decision-making processes to navigate the ethical use of AI in marine science responsibly (McGovern et al., 2022). Equally important is recognising that a wealth of data and knowledge already exists, and that future progress may depend as much on reinterpreting this existing information. Technology can support this progress, but it must be balanced with context-specific application of what we already know.

10. Integrate Māori data sovereignty principles in marine science. Māori understand the environment – and related environmental data – a living tāonga, which is of strategic value to Māori (Lovett et al., 2018; Te Mana Raraunga Māori Data Sovereignty Network, n.d.). Given the tight relationships between the marine environment and Māori (Stevens et al., 2021), marine science is inherently collecting, storing, and sharing data that are tāonga – what marine science has in the past overlooked. Practices honouring Māori data sovereignty are not only an obligation induced by Te Tiriti but are also an international responsibility induced by the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). Practices like increasing partnership between marine scientists and Te Mana Raraunga Māori Data Sovereignty Network (n.d.) appear crucial. In particular, when dealing with fisheries data that is both sensitive and potentially profitable in the wrong hands, protocols need to be followed around how this data is presented and published by researchers.

Concluding remarks

In our swiftly changing world, various pressures are exerting influence on social-ecological systems, urging research to adapt to respond to societal needs (Rayne et al., 2023). Without proactive measures and a change in direction, we risk cultivating a research culture ill-equipped to tackle evolving and pressing global challenges. Embracing diverse and inclusive approaches within marine science is

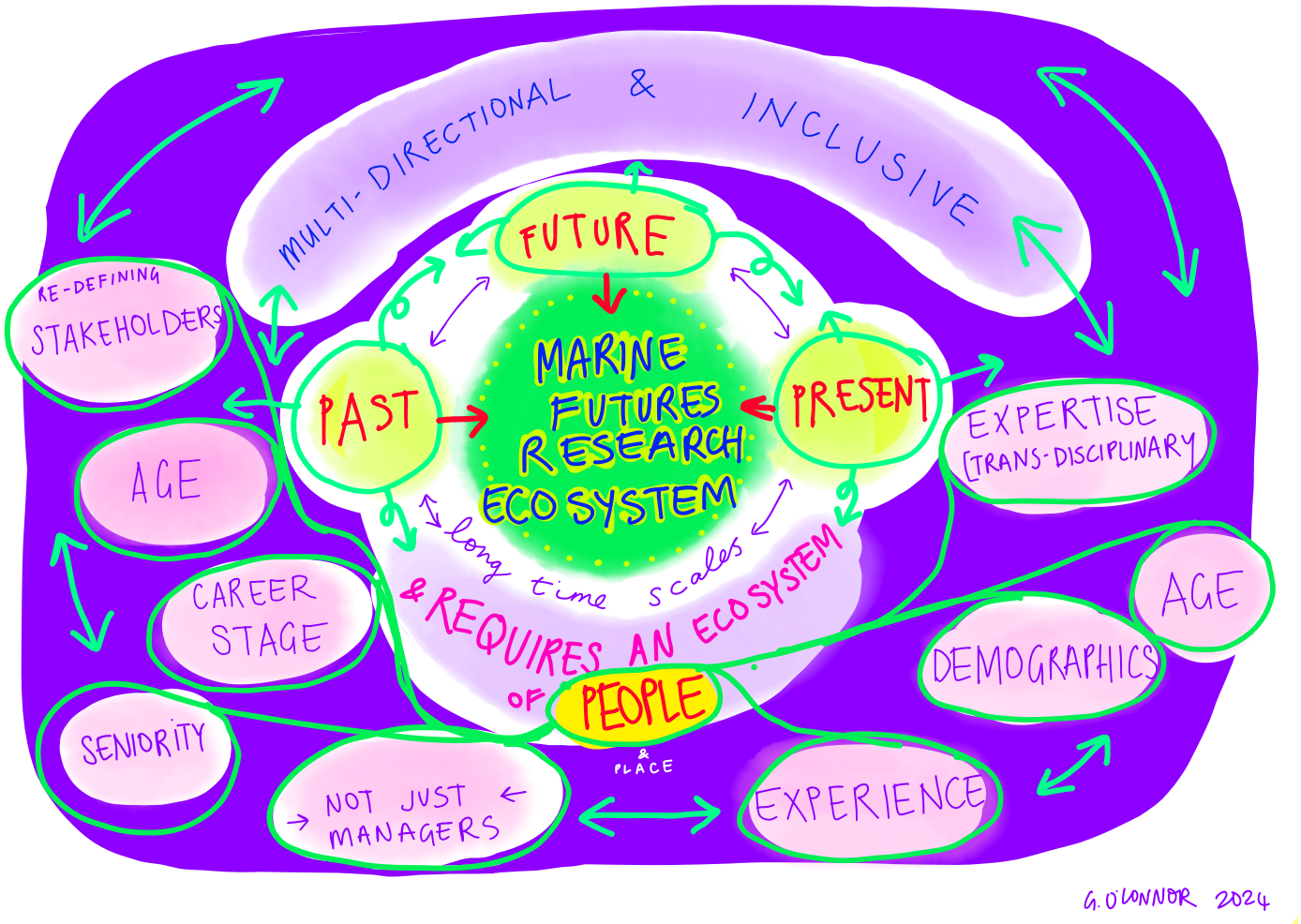

Figure 2: Towards building a more inclusive marine science research system in Aotearoa New Zealand, embracing the diversity of people. (Diagram: O'Connor)

pivotal in addressing the multifaceted challenges that lie ahead for our ocean, and the way we study it. While Aotearoa New Zealand presents a unique cultural and scientific landscape, the recommendations presented here are intricately connected to broader global agendas, such as the UN Sustainable Development Goals (SDGs) and the UN Ocean Decade (e.g. Claudet et al. (2020)), advocating for a change in the way marine science is done and placed in the context of the broader societal challenges (Franke et al., 2022).

Since the 2023 workshop, the landscape of scientific research has continued to evolve both internationally and nationally. These changes are such that, in 2025, the United States has experienced a rollback of diversity and inclusion guidelines in federal science agencies, raising concerns about equitable participation in research and innovation. In addition, the US has seen a reduction in climate and environmental research funding. In Aotearoa New Zealand, the Government has initiated a major reform of the science, innovation, and technology system—the most significant in over 30 years. This used the SSAG (2025) review and resulted in the consolidation of Crown Research Institutes (CRIs) into new Public Research Organisations (PROs). These new organisations are expected to have a stronger emphasis on economic outcomes, with the hope of identifying new research opportunities and funding (Reti, 2025). How these shifts will affect science for the public good, cultural inclusion, and societal engagement, remain to be seen. However, in terms of future marine science, the ocean's central role in climate means the need to understand and predict ocean outcomes will remain a societal need. Ultimately, the success of actioning these recommendations hinges on effective collaboration, engaged leadership, mutual understanding, and a shared commitment to sustainability, innovation, value and cultural sensitivity within the realm of marine science.

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