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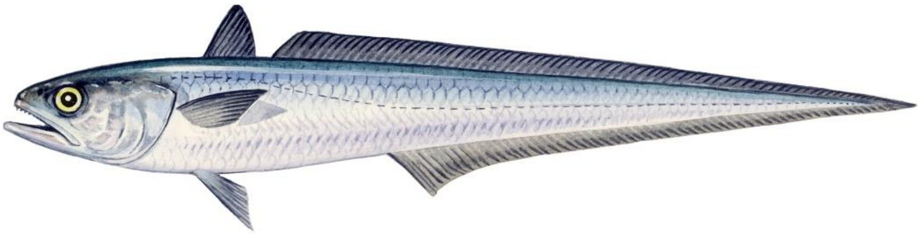
ADAPTATION PATHWAYS FOR THE SEAFOOD SECTOR: HOKI FISHERY



ADAPTATION PATHWAYS FOR THE SEAFOOD SECTOR: HOKI FISHERY

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Prepared for The Aotearoa Circle

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EXECUTIVE SUMMARY

Climate change and the seafood sector

Climate change is increasingly impacting food production, enterprises and communities in Aotearoa New Zealand. Being primarily based in coastal or marine environments, the commercial fisheries and aquaculture sector is particularly exposed to climate change and extreme events. National and global policies and consumer behaviour in response to climate change will also affect the social and economic operating space. Consequently, The Aotearoa Circle is formulating the Seafood Adaptation Strategy (SAS), guided by an implementation group (IG). To contribute to the strategy, Cawthron Institute (Cawthron), the National Institute of Water and Atmospheric Research (NIWA) and GNS Science were funded to conduct a project, Adaptation Pathways for the Seafood Sector, in March to September 2023, with one primary goal: using case studies of the snapper fishery, hoki fishery and salmon aquaculture, develop an adaptation pathways approach with the SAS IG. This report summarises the process and adaptation pathways for the hoki fishery.

Adaptation pathways

Adaptation pathways are a novel planning approach that proactively formulate a series of decision points to implement a suite of strategies designed to address emerging climate risks and opportunities, while maintaining flexibility to respond to unexpected future change. They represent a shift in climate adaptation science from a problem-oriented focus to one that is decision-oriented, thereby enabling stakeholders to assess and implement alternative strategy options within rapidly changing and complex systems. Adaptation pathways approaches are varied and can be adapted to different contexts, but to date they have not been applied to the fisheries or aquaculture sector in Aotearoa New Zealand.

Pathways for the hoki fishery

An adaptation pathways planning workshop for the hoki fishery was held with 24 decision-makers, industry stakeholders, regulators and scientists on 17–18 May 2023. Its objective was ‘to identify adaptation pathways for the industry that will achieve climate-resilient development despite future uncertainty’. Preparation for the workshop involved the collation of knowledge on climate impacts on hoki, and the SAS IG and other experts providing knowledge on industry trends, market forecasts and policy settings. The workshop process was designed to generate social learning, knowledge co-production and systems thinking, and encourage partnerships, leadership, collaboration and action.

A suite of adaptation strategies was formulated in two categories: incremental no regrets strategies carrying minimal risk, and transformational strategies that would be triggered at key decision points. These were sequenced into pathways that included timelines and actions, and named stakeholders responsible for their implementation. The pathways were collated into a summary infographic and more detailed tables.

Climate impacts on hoki

Current knowledge of climate impacts on hoki is limited and is complicated by interactions between multiple environmental factors in the ocean, and lack of biological information on critical aspects of the species' life history. There are no clear ecological tipping points that could inform future adaptation pathways decision-making. However, continued warming sea temperatures across the species' range in southern Aotearoa New Zealand and the subantarctic may affect ocean circulation and the mixed layer depth, and thus nutrient cycles. In turn, this will affect the availability and distribution of prey and, ultimately, adult hoki. Climate change may also influence survival of early life history stages and hence future recruitment to the fishery. Some warmer-water species may enter the fishery, such as alfonsino, squid and Ray's bream. Despite a significant knowledge gap about hoki stock structure, projections indicate that currently the population is healthy and the fishery is sustainable.

Drivers, vision and future scenarios

Together with markets and economics, climate change and fishery dynamics were considered the most important drivers of change for the industry. Major issues included the impacts of climate change on hoki food sources, juvenile recruitment and adults; fuel costs and fuel efficiency, and the availability of alternatives; and public concern about bottom-trawling. Participants created a vision for the fishery for 2050, summarised below:

- An abundance of fish (hoki catch > 100,000 tonnes)
- Higher market value for hoki
- Larger and more efficient carbon-neutral vessels
- Adaptive and agile policy and management
- Reduction of bycatch and lower environmental impacts
- Improved public perception and social licence to operate for the fishery
- Improved recruitment and retention of workforce through better working conditions
- Improved stock modelling and understanding of climate change signals.

Participants then explored possible futures based on uncertainties inherent in the primary drivers of change. Four future scenarios revealed potentially adaptive and maladaptive outcomes for the hoki fishery. Next, participants collated adaptation strategies and sequenced them into pathways.

Adaptation strategies and pathways

Six pathways were identified to achieve the vision (see infographic on page iv). Three were no regrets strategies to be implemented immediately:

1. Innovative fuel efficiency measures
2. Innovative value-adding
3. Diversification of target species and adaptation of vessels and crew.

Innovative fuel efficiency measures could reach a decision point where diesel costs are prohibitive, after which the pathway would become more transformational, with the potential for introducing a fleet that would fish and refuel at sea. Diversification of target species is already underway in the industry, but if a decision point occurs where current fishing becomes uneconomic, the fleet would have to shift to alternative enterprises such as offshore aquaculture or transporting seaweed used for carbon sequestration in a low-carbon economy.

Three immediate pathways were potentially transformational, and required initial steps by 2030:

1. Hoki climate research programme
2. Revised research funding
3. Adaptive legislation and management.

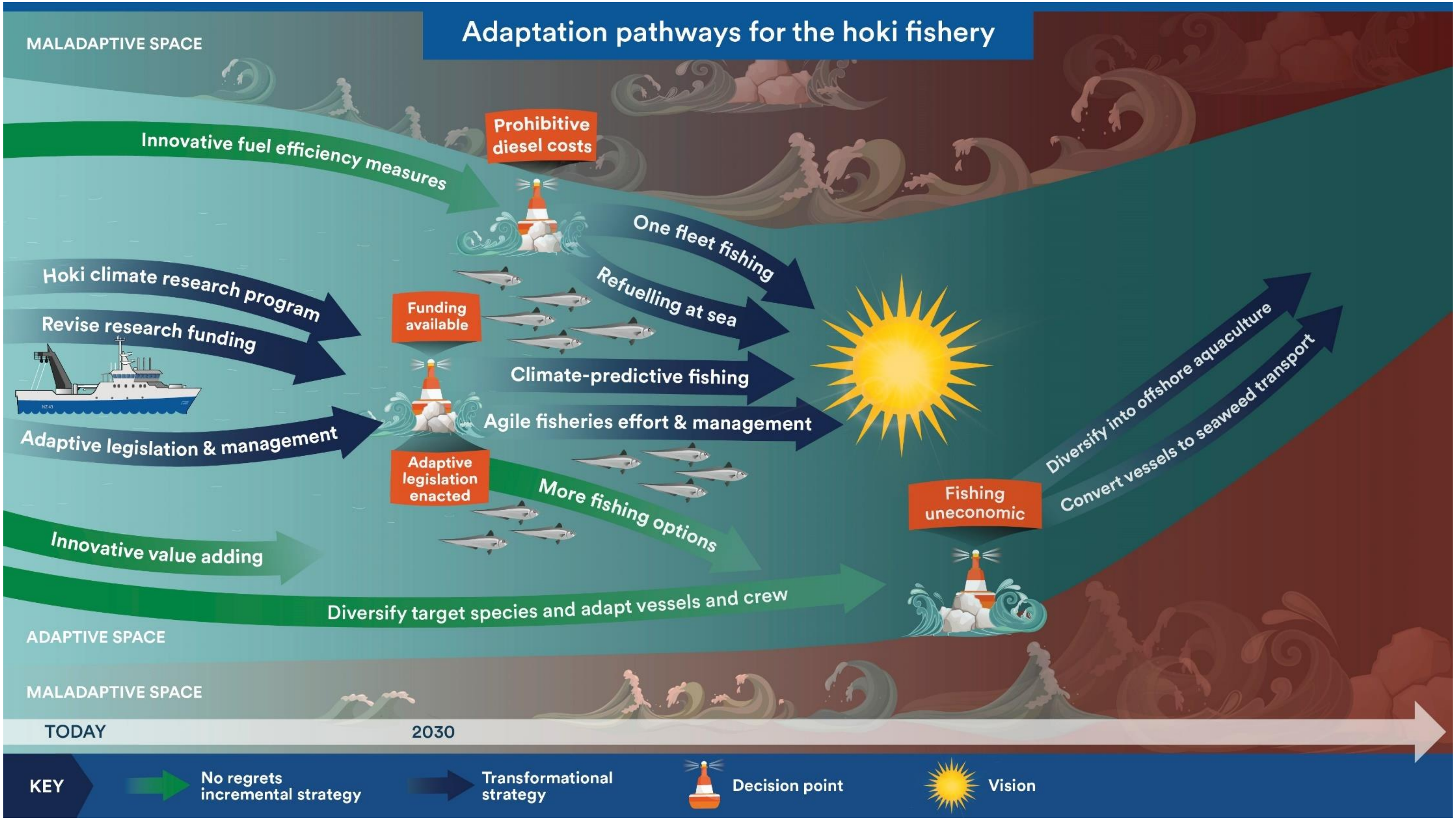
However, the future of these pathways depends on a decision point likely to emerge in the near future, where funding either does or does not become available and adaptive legislation is either introduced or not. If positive changes do come about, the industry would be able to continue these pathways, practising climate-predictive fishing and more adaptive fishing effort and management, providing more options to diversify target species and ultimately reaching the 2050 vision.

Evaluation and next steps

An online questionnaire survey was sent to participants after the snapper, hoki and salmon workshops to assess the degree to which the processes had achieved their intended outcomes. Overall, the respondents agreed that positive outcomes had been achieved. The highest scores were for enhanced social networks, trust and knowledge integration, followed by the creation of new partnerships and the realisation that issues are connected. Although still positive, emerging leadership, innovation and the likelihood that the workshops would lead to tangible action in the industry were weaker outcomes. Specific suggestions about how the process could be improved were:

- Involve a broader spectrum of stakeholder and partner representatives across the industry
- Include local government
- Target participation by emerging leaders in each industry
- Ensure that the strategies and pathways are communicated with key decision-makers
- Turn planning into implementation action.

The next steps involve designing an implementation plan for the pathways, identifying cross-cutting strategies for seafood sector adaptation, and determining how to embed iterative adaptation pathways practice within hoki fishery planning and management structures.


Adaptation pathways for the hoki fishery
MALADAPTIVE SPACE
Innovative fuel efficiency measures
Prohibitive diesel costs
One fleet fishing
Refuelling at sea
Hoki climate research program
Revise research funding
Funding available
Climate-predictive fishing
Agile fisheries effort & management
Adaptive legislation & management
Adaptive legislation enacted
More fishing options
Innovative value adding
Diversify target species and adapt vessels and crew
Fishing uneconomic
Diversify into offshore aquaculture
Convert vessels to seaweed transport
ADAPTIVE SPACE
MALADAPTIVE SPACE
TODAY
2030
KEY
No regrets incremental strategy
Transformational strategy
Decision point
Vision

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1. INTRODUCTION

1.1. Climate change and the seafood sector

Climate change is increasingly impacting food production, enterprises and communities in Aotearoa New Zealand. Being primarily based in coastal or marine environments, the commercial fisheries and aquaculture sector is particularly exposed to climate change and extreme events. This is exemplified by the salmon mortalities at aquaculture sites in the Marlborough Sounds in summer 2022, which were due at least in part to a marine heatwave (Gee 2022). National and global policies and consumer behaviour in response to climate change will also affect the sector's social and economic operating space. Transformation of enterprises and industries may be necessary if food production is to be maintained under future uncertainty and unprecedented, rapid environmental and economic change. Consequently, The Aotearoa Circle is formulating the Seafood Adaptation Strategy (SAS), guided by an implementation group (IG).

1.2. Adaptation pathways

Adaptation pathways are a novel planning approach that proactively formulate a series of decision points to implement a suite of strategies designed to address emerging climate risks and opportunities, while maintaining flexibility to respond to unexpected future change. They represent a shift in climate adaptation science from a problem-oriented focus (i.e. estimating impacts and vulnerabilities) to one that is decision-oriented. This enables stakeholders to assess and implement alternative options within rapidly changing and complex systems (Wise et al. 2014).

There are three foundational tenets to this approach. First, climate change impacts cannot be considered in isolation, but instead are intertwined with, and influenced by, the wider social, economic and environmental system. Responses to climate change will also alter the system. Second, to avoid 'maladaptation' (i.e. actions that impact adversely on, or increase the vulnerability of, the system or other sectors and social groups; Barnett and O'Neill 2010) and maintain flexibility, adaptation strategies should aim to yield benefits under any future conditions of change, and therefore be 'no regrets' (Hallegatte 2009). Third, planning should design a mix of strategies that address immediate risks ('incremental' strategies), plus interventions that may be necessary to shift to entirely new or novel system states ('transformational' strategies) because the current status quo becomes maladaptive.

Because adaptation activities cross numerous jurisdictional and social boundaries and levels, the process of designing and implementing adaptation pathways requires multi-stakeholder engagement. By integrating the varied knowledge of these stakeholders, adaptation pathways planning can build robust and innovative thinking about complex systems and the future (Werners et al. 2021). The process also strengthens social networks, leadership and trust, which are foundations of adaptive capacity (Butler et al. 2015, 2016).

As such, adaptation pathways practice is being developed as an alternative to reactive responses to climate and global change, which are largely retrospective and do not consider opportunities for innovation or transformation. Adaptation pathways thinking is versatile, and can be applied to many different situations, including planning community development, enterprises and infrastructure, or to different administrative units (e.g. government regions) or biophysical units (e.g. catchments). However, there is no blueprint for the approach, and variations of the methodology are evolving to suit different decision-making contexts (Werners et al. 2021; Cradock-Henry et al. 2023).

Outputs from pathways planning exercises are typically ‘roadmaps’ that illustrate suites of strategies and their sequencing or adjustment over time as the option space changes (Figure 1). The pathways of strategies aim to maintain the system within the ‘adaptive space’ and avoid the ‘maladaptive space’, and are often guided by an aspirational, stakeholder-driven future vision for the system. Strategies may be implemented immediately or at a later date. They may be incremental and no regrets, or more risky and transformational. Key decision points can be identified where one strategy needs to be substituted by another, or a transformational strategy must be implemented in response to potential maladaptation and where there is a need for a radical realignment of the system to achieve the vision.

Importantly, to maintain flexibility the pathways process should be repeated iteratively at intervals over time. Each iteration is a ‘scanning point’ that examines the future to anticipate any unexpected change, and reviews the effectiveness and relevance of the strategies implemented or planned at the prior scanning point. Consequently, monitoring, evaluation and learning are essential to assess the progress of pathways and to revise strategies if necessary. In addition, monitoring is critical to judge the proximity of key decision points.

In Aotearoa New Zealand, adaptation pathways have been applied to agricultural planning (e.g. Cradock-Henry et al. 2020) and urban planning (e.g. Lawrence et al. 2019). It also forms the basis of the Ministry for the Environment’s guidance to councils on adapting to rising sea levels (Ministry for the Environment 2017). However, the approach has not yet been tested with, or adapted to, the aquaculture or fisheries sector, either within Aotearoa New Zealand or internationally.

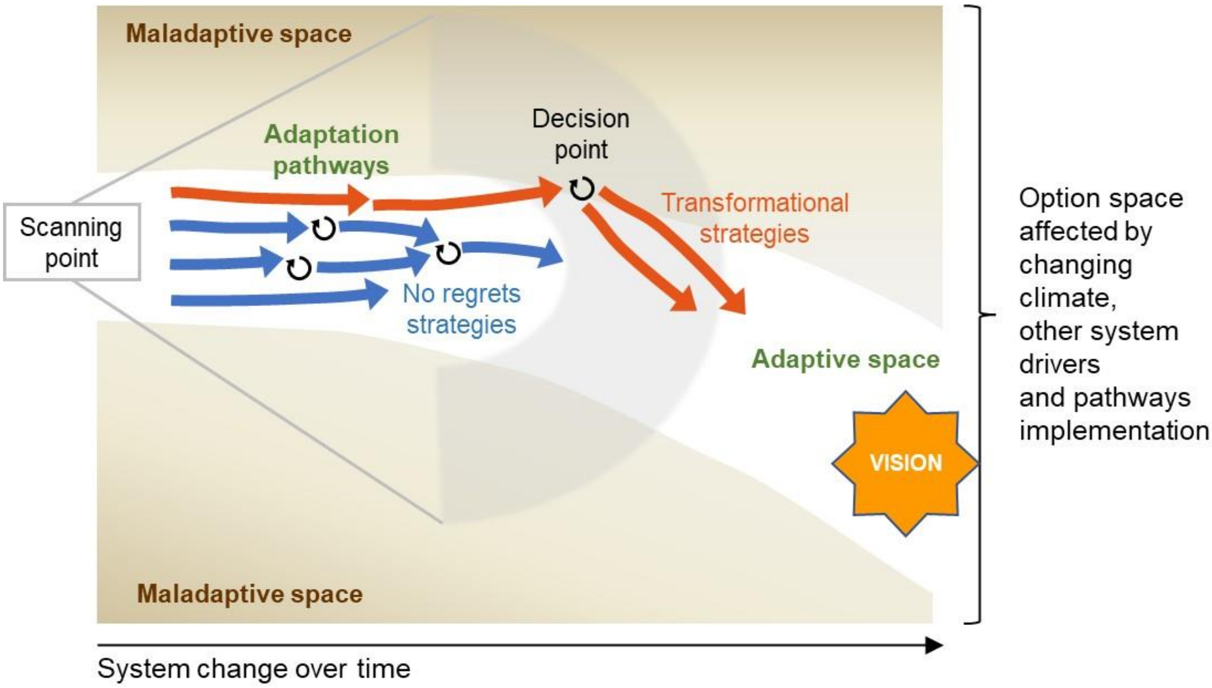

Figure 1. Adaptation pathways ‘roadmaps’ illustrate suites of strategies and related decision points, relative to the changing option space and a stakeholder-defined future vision for the system (adapted from Wise et al. 2014). Each pathways process is a ‘scanning point’ that is repeated iteratively through time.

2. ADAPTATION PATHWAYS PROJECT DESIGN

2.1. Project goals

Between September 2022 and February 2023, the SAS IG designed the Adaptation Pathways for the Seafood Sector project, which would contribute to the delivery of The Aotearoa Circle's SAS. Running from March to September 2023, the project had one primary goal: using case studies, develop an adaptation pathways approach with the SAS IG. The project also aimed to build the capacity of the SAS IG members to scale-out the approach across the seafood and aquaculture sector, and to identify cross-cutting strategies that could be promoted by the SAS IG as potentially transformational.

2.2. Project activities

To cover a range of climate and industry contexts, the SAS IG selected three case studies: the inshore snapper fishery, the deepwater hoki fishery and salmon aquaculture. A research team of 15 scientists – including planners, economists, climate and oceanographic modellers, fishery and marine ecologists, pathologists and geneticists – was formed from Cawthron Institute (Cawthron), the National Institute of Water and Atmospheric Research (NIWA) and GNS Science. The project involved five phases:

Phase 1: Climate change data and gap analysis

This phase collated the current state of knowledge of climate impacts on the species concerned. For snapper and hoki, this built on vulnerability assessments previously conducted by NIWA (Cummings et al. 2021). To inform decision points for adaptation pathways, the analyses identified thresholds and tipping points where the species will be significantly affected by changing environmental conditions, both negative and positive, plus potential opportunities presented by changes in species distributions due to warming sea temperatures. Uncertainties and data gaps were also identified.

Phase 2: Workshop preparation

The second phase prepared the materials required for the case study pathways planning workshops (see Phase 3), including slide presentations, infographics and posters. The SAS IG identified key decision-makers in each case study, including fishing companies, fishery operators, feed suppliers (for salmon aquaculture), national government regulators and non-government organisations, and invited them to the workshops. For each workshop, industry and government experts were asked to prepare presentations on the current state of the sector, regulation and management; future projections for policy, inputs and markets; and potential blue-sky thinking about potentially transformational technologies and opportunities.

Phase 3: Adaptation pathways planning workshops

A single 1½-day workshop was held for each case study. Workshops were facilitated by the Cawthron, NIWA, GNS Science and SAS IG team. Each workshop built a preliminary portfolio of adaptation strategies, identified key decision points and drew pathways maps to illustrate this information.

Phase 4: Synthesis and drafting workshop outputs

This phase collated the findings from each workshop into a report and draft adaptation pathways to be disseminated to participants (this document in the case of the hoki study). In addition, the approach will be captured in guidelines with tools to aid the scaling-out of future planning by SAS IG members and the iterative revisiting of the pathways for snapper, hoki and salmon in due course.

Phase 5: Scaling-out, common priorities, learnings and next steps

In the final phase, the preliminary adaptation pathways will be refined, and a plan for their implementation designed. Based on learnings from the process, the SAS IG will consider how to improve and scale-out the approach across other fishery and aquaculture industries involved in The Aotearoa Circle. Common cross-cutting adaptation strategies will be identified; if addressed, these could generate transformational change across the sector.

2.3. Phase 3 adaptation pathways planning workshop process

The Phase 3 adaptation pathways planning workshops were the main project activity, bringing together the Phase 1 and Phase 2 outputs into a learning process involving key decision-makers and stakeholders for each case study. The Theory of Change for the workshops was that by designing the process to stimulate social learning, knowledge production and systems thinking, intangible outcomes would immediately emerge: trust, coordination, leadership, enhanced social networks and innovative thinking. As a result, more tangible outcomes would be generated: incremental 'no regrets' and transformational strategies formed into adaptation pathways that include key decision points, and ensuing collective action to implement the pathways (Figure 2).

Figure 2. The intended Theory of Change of the Phase 3 workshops.

To encourage social learning, knowledge co-production and systems thinking, the workshops were designed around Brown and Lambert's (2012) decision-into-practice learning steps. These address in sequence the following questions: What is? What should be? What could be? What can be? Application of these steps has been shown to build adaptive capacity and catalyse adaptation action among decision-makers (e.g. Butler et al. 2015, 2016). In this case, the system concerned is the seafood sector case study, and the objective is achieving climate-resilient development for the industry despite future climate and global uncertainty. The four learning steps were translated into six sessions, which were posed as questions related to drivers of change for the current system, stakeholders' aspirational vision for the future, possible alternative futures, adaptation strategy options, their sequencing to form pathways and steps necessary to enable adaptation (Figure 3). Importantly, this process forms an iterative cycle, whereby the implementation of pathways from Session 6 (Figure 3) will influence the system of concern, and at intervals it will have to be repeated to maintain adaptive decision-making as the future unfolds.

This workshop process can also be interpreted in terms of the adaptation pathways schematic shown in Figure 1. Session 1 describes the current system and examines drivers of change; Session 2 establishes the stakeholders' vision for the system; Session 3 explores possible system futures relative to the adaptive and maladaptive space, depending on shifts in drivers of change; Session 4 identifies currently available adaptation strategy options; and Sessions 5 and 6 map these into pathways and decision points, and considers enabling actions (Figure 4). As such, this case study workshop represents the first scanning point of an ongoing, repeated process over successive time periods.

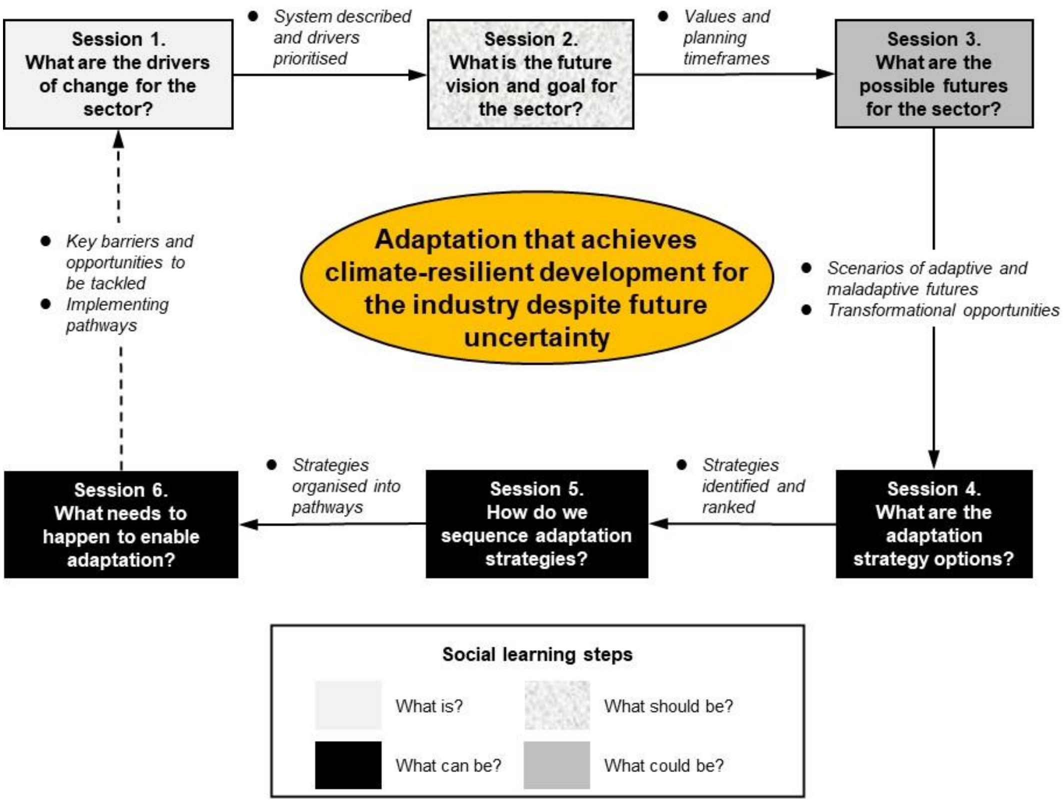

Figure 3. Phase 3 workshop process, adapting Brown and Lambert's (2012) decision-into-practice social learning steps into six sessions concerning adaptation in the seafood industry of interest.

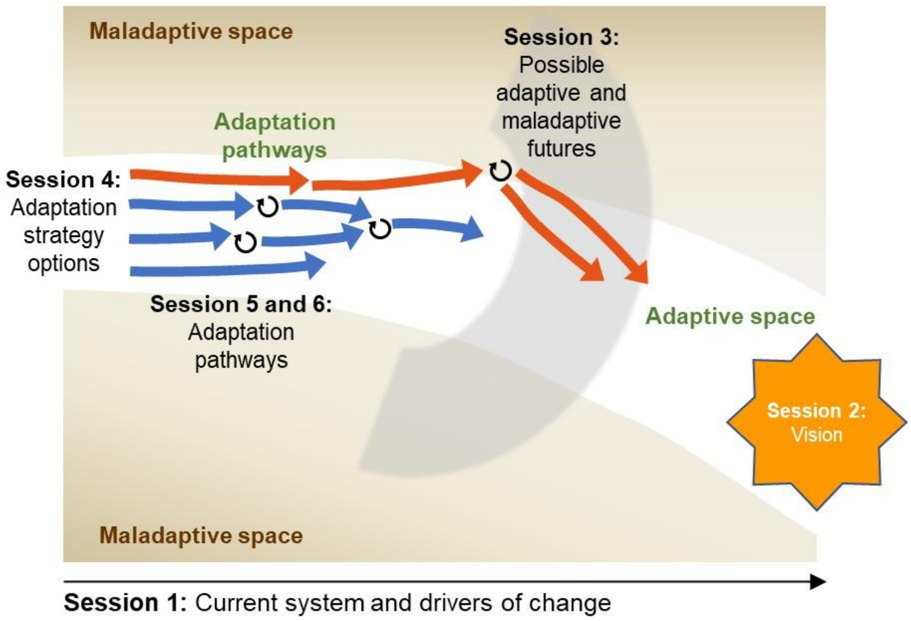

Figure 4. The Phase 3 workshop sessions superimposed on the Figure 1 adaptation pathways schematic.

3. HOKI FISHERY WORKSHOP

3.1. Workshop participants

The Phase 3 hoki fishery workshop was held at the Sanford Seafood School in Auckland on 17– 18 May 2023. The agenda is provided in Appendix 1. The workshop started at 10am on Day 1 and concluded at 1pm on Day 2. A dinner was arranged for all participants on the evening of Day 1 to encourage networking and enable further discussion. Twenty-four people participated (Figure 5), including five members of the research team and seven SAS IG members (see Appendix 2). The workshop was facilitated by James Butler (Cawthron), Nick Cradock-Henry (GNS Science) and Jodie Kuntzsch (SAS IG and The Aotearoa Circle), supported by the SAS IG members present. Posters and other useful materials from Phase 2 were printed and placed around the room and on the tables.

Figure 5. Hoki workshop participants.

3.2. Introductions

The workshop began with participants introducing themselves, followed by brief presentations about The Aotearoa Circle. An introduction was also given about the project, and the workshop's objective: to develop adaptation pathways for the industry that will achieve climate-resilient development despite future uncertainty.

To comply with the Cawthron's Human Research Ethics Policy, verbal consent was sought from participants for their involvement in the workshop and recording of the outputs for potential publications; all agreed. Participants were subsequently divided into four groups of 4–5 people, ensuring that stakeholders were mixed in each group to encourage a diversity of knowledge exchange and learning. SAS IG members were distributed among the groups to aid facilitation.

3.3. Session 1: What are the drivers of change for the industry?

The aim of Session 1 was to describe the hoki fishery and the drivers of change for the industry, defined as ‘any natural or human-induced factor that directly or indirectly causes a change in the system of interest’ (Millennium Ecosystem Assessment 2005).

Aaron Irving (Deepwater Council) presented the characteristics, management and status of the hoki fishery, which is one of Aotearoa New Zealand’s most commercially important deepwater fisheries. Hoki (*Macruronus novaezelandiae*) are widely distributed throughout Aotearoa New Zealand waters in depths of 10 m to more than 900 m but occur primarily at depths of 200–800 m round the South Island and in subantarctic waters. The fishery operates in four main regions around the South Island: on the Chatham Rise, Campbell Plateau, along the West Coast and in the Cook Strait (Figure 6). The catch in 2021–22 was 91,664 tonnes, with an export value of NZ$213 million, equivalent to 33% of Aotearoa New Zealand’s deepwater exports and making it the country’s most important fishery.

Hoki is managed by Fisheries New Zealand using the Quota Management System (QMS). The majority of quota ownership is represented by the Deepwater Council, a non-profit organisation promoting quota owners’ interests and working in partnership with the government to ensure deepwater fisheries are sustainable and well managed, including through voluntary measures.

The hoki fishery was the first large white fish fishery to be certified by the Marine Stewardship Council in 2001, and has since been recertified three times, most recently in 2018. A reassessment is being prepared for 2024. However, bottom-trawling is the primary method, which interacts with the seafloor and affects benthic community structure and function. There have also been incidental captures of protected species such as New Zealand fur seals / kekeno, basking sharks and seabirds.

Hoki are managed as two separate stocks: eastern and western. Research and assessments are carried out on both stocks and catches are managed within separate catch limits under an overall total allowable commercial catch (TACC). However, hoki stock structure represents a significant knowledge gap. The current construct of one stock consisting of two sub-stocks and their assumed migration patterns (with juveniles from both the eastern and western stocks mixing on the Chatham Rise) is used as the base case in the stock assessment model, but is still not fully validated. Despite this uncertainty, catches have remained within TACC limits and are considered sustainable.

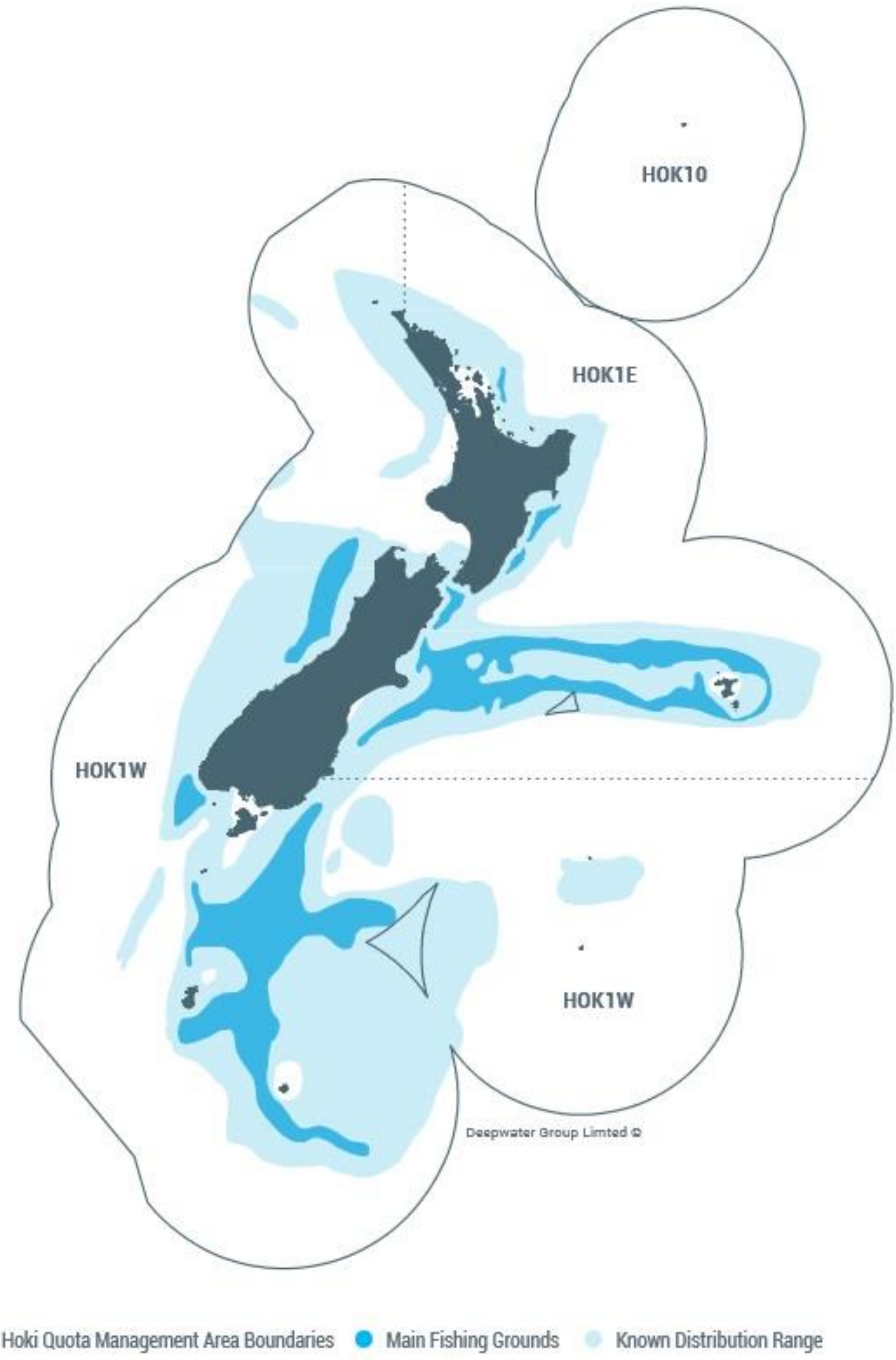

Figure 6. The spatial distribution of hoki and the primary fishing grounds. Source: deepwatergroup.org

The research team's Phase 1 analysis of climate change projections and potential impacts on hoki were then presented by Romain Chaput (Cawthron) and Richard O'Driscoll (NIWA), based on the species' life history (Figure 7). Hoki spawn in June–September, and the primary spawning areas are centred on Cook Strait and the Hokitika Canyon. Larvae inhabit surface waters and are found throughout the mixed layer, before migrating into deeper water at the end of their larval development, with the majority of juveniles congregating around the Chatham Rise. Adults then distribute themselves across the species' range.

Ocean temperatures have been rising across much of the species' range, with the greatest changes occurring off the country's west coast and around Cook Strait (Figure 8). These are likely to continue, with impacts on the mixed layer depth, but complicated by growing variations in the El Niño / La Niña cycle. However, there is little understanding of how these changes will affect hoki early life stages and ocean productivity in general.

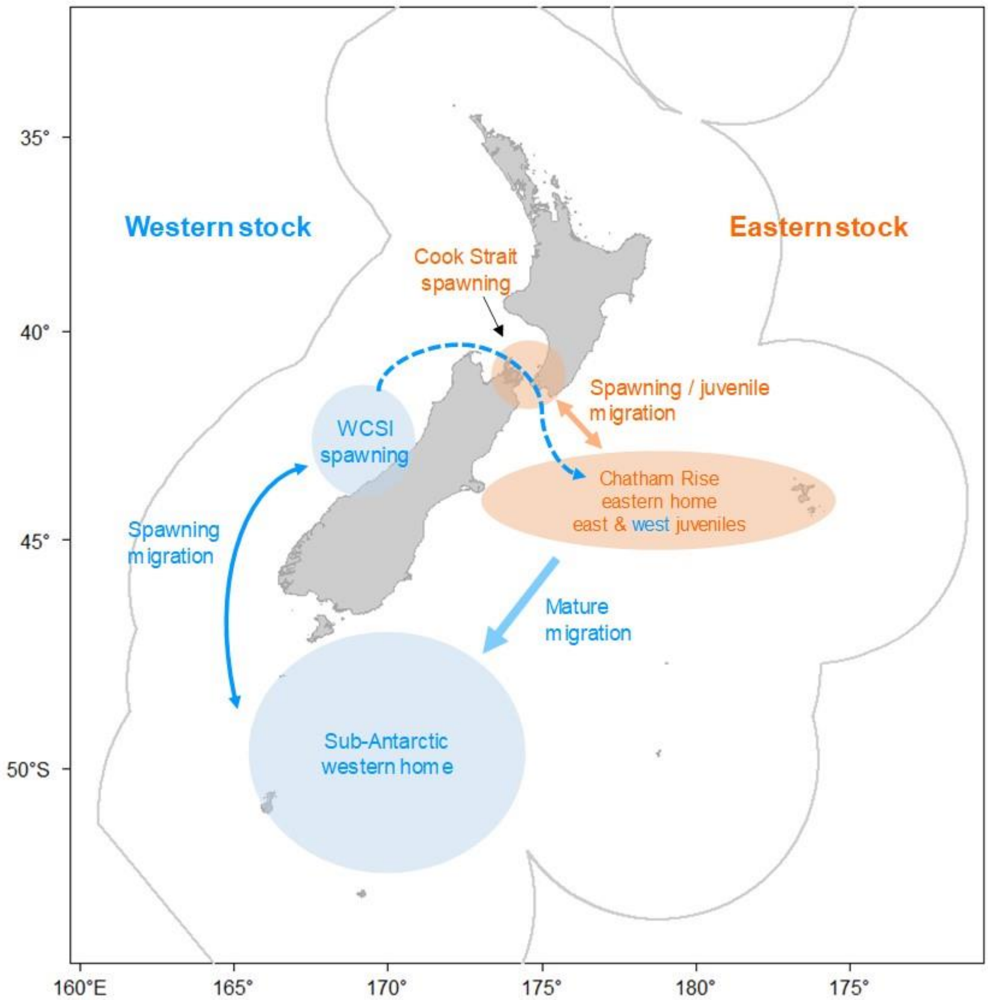

Figure 7. The stock structure and migrations of hoki (*Macruronus novaezelandiae*). Source: Fisheries New Zealand and NIWA.

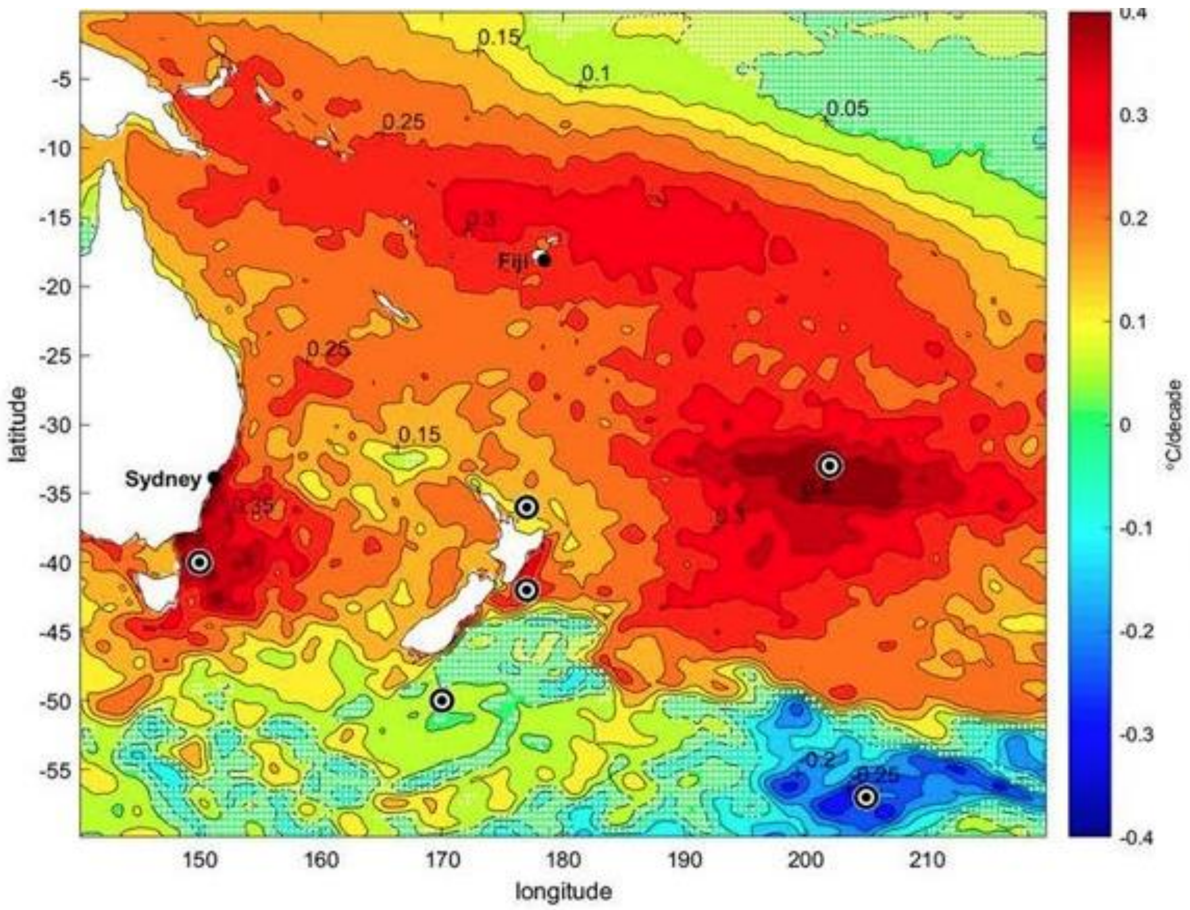

Figure 8. Changes in sea temperature around New Zealand in 1981–2017 (°C per decade). Source: E. Behrens, NIWA.

Although an initial assessment by Cummings et al. (2021) summarised that hoki has a 'low' vulnerability to climate change, confidence in this conclusion was limited because of the multiple environmental variables that may affect the species and limited understanding of how climate change may influence its ecology, particularly that of the poorly studied early life stages. The Phase 1 collation of current knowledge came to a similar conclusion. Good annual monitoring and assessment processes are in place for both juveniles and adults, and forecasts suggest that the stock is currently healthy.

Key impacts for the species and fishery are likely to be on egg, larval and juvenile survival, and hence recruitment, prey availability, natural mortality and the emergence of new diseases (Figure 9). Other changes may be southward shifts in stock distribution, and hence more distant and variable fishing grounds, and changing species assemblages. For example, as ocean temperatures rise, it is possible that warm-water species such as alfonsino, squid and Ray's bream may become more abundant in the hoki fishery area and could contribute to the catch, resulting in less targeted fishing and higher rates of bycatch. The most likely areas where impacts will be observed are the west coast and the south of the South Island. Ecological tipping points were also unclear because of the many knowledge gaps.

In terms of fishing activities, the intensity of storms will increase, affecting fishing conditions for vessels and crew. Sea-level rise will also impact coastal infrastructure (Figure 10).

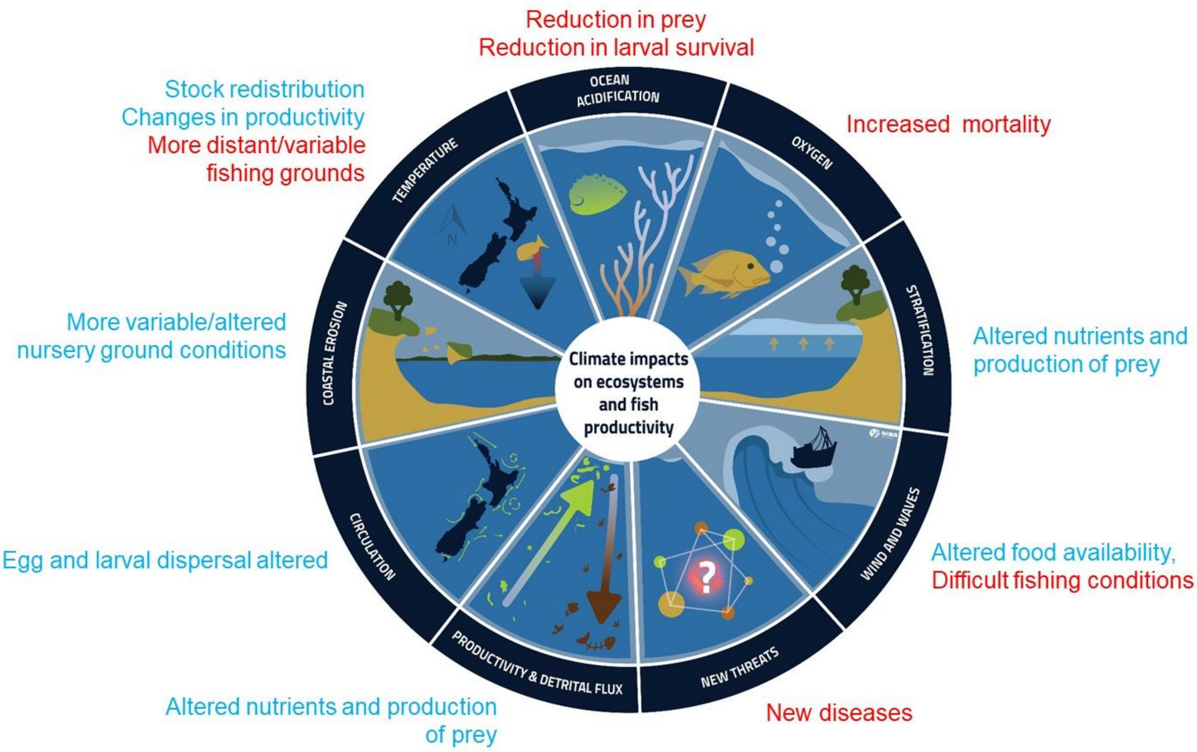

Figure 9. Summary of the Phase 1 analysis of potential changes (blue) and negative (red) impacts of climate change variables on hoki (adapted from Cummings et al. 2021).

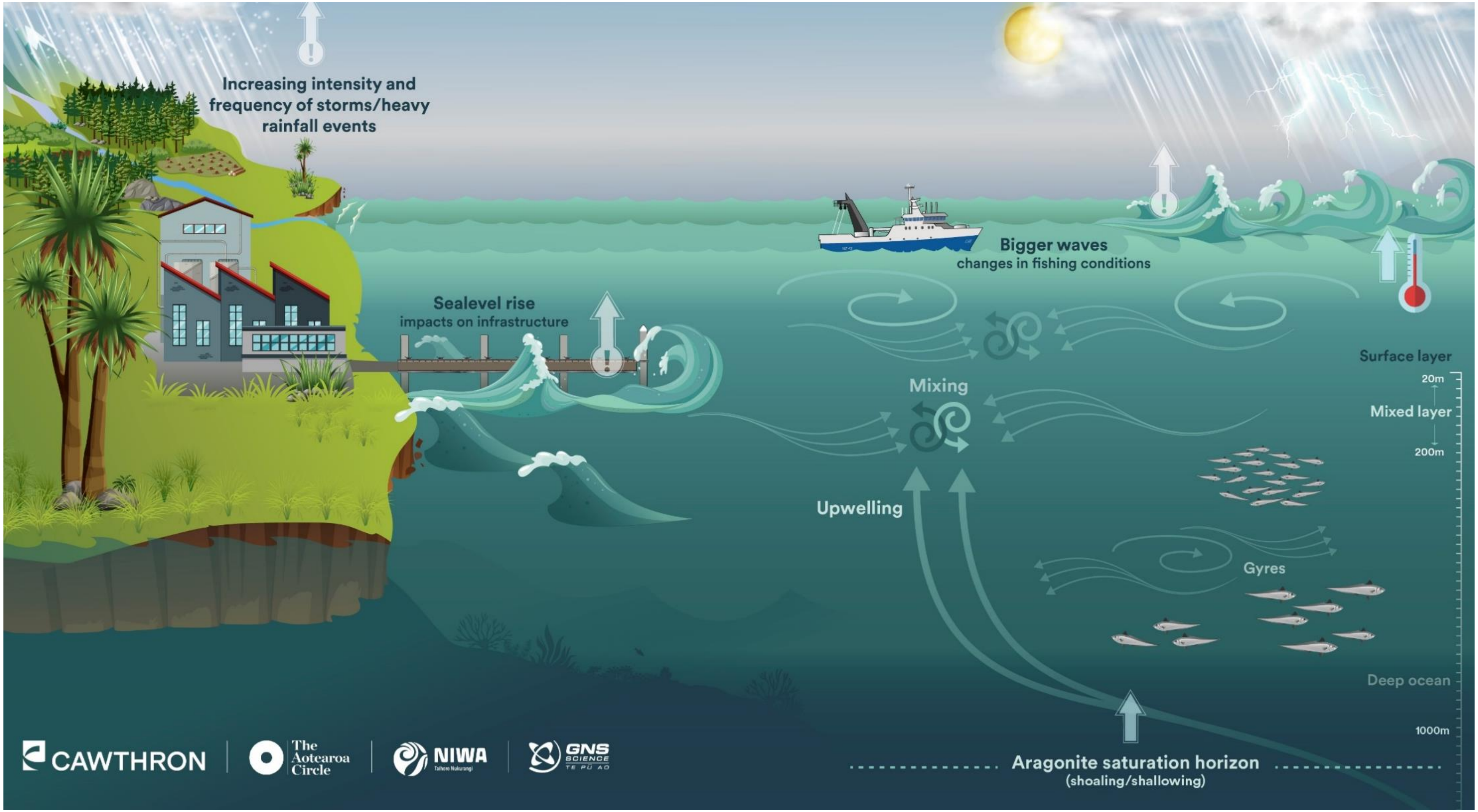

Figure 10. Summary of potential direct impacts of climate change on hoki and the fishing industry.

Peter Longdill (SAS IG and Sanford) then presented the current status of markets for fisheries in Aotearoa New Zealand, and potential future projections for businesses based on global trends, including greenhouse gas emissions reduction policies. Notable drivers were growing climate consciousness among consumers and demand for sustainably sourced seafood. Rising prices of diesel fuel are already pressuring the gross margins of fishery businesses, and have at least doubled in the period April 2021 to May 2022 (Figure 11). Emissions trading schemes and carbon taxes are projected to further increase the cost of carbon-based fuels and transport. In parallel, there is likely to be greater pressure on fisheries to reduce their emissions footprint, and yet currently there is no feasible alternative to diesel as the primary fuel for vessels. Similar pressure is likely to bear on the supply chains upstream and downstream from fisheries.

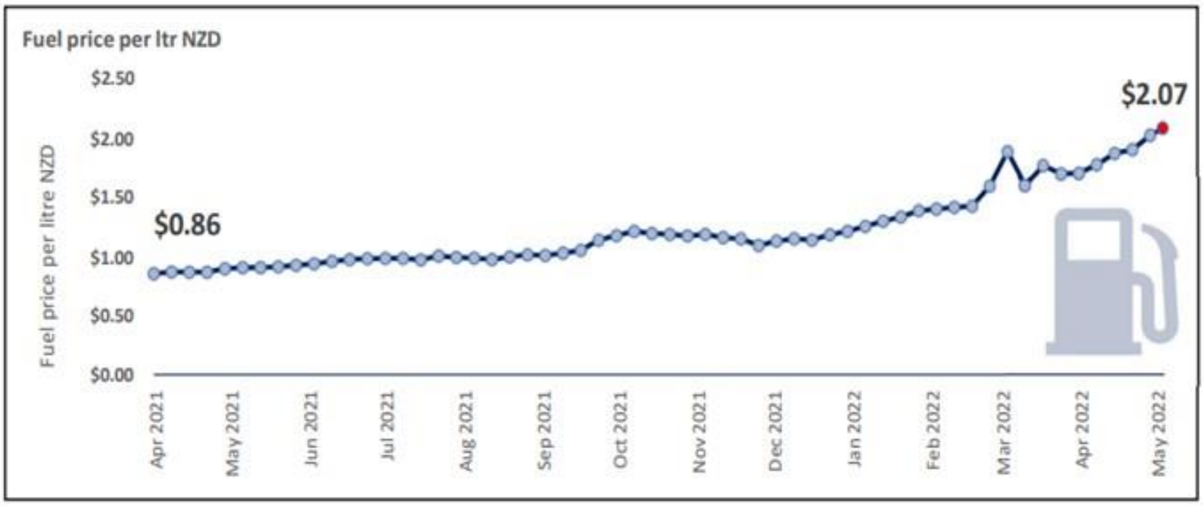

Figure 11. Changes in Aotearoa New Zealand fuel prices from April 2021 to May 2022. Source: Seafood New Zealand Inshore Council.

Andy Biggerstaff (Fisheries New Zealand) then presented the current policy and regulatory framework for the hoki fishery. As well as explaining the TACC, he highlighted options for adopting more flexible management measures that might enable greater reflexivity in response to fluctuating climate conditions. For example:

- The National Fisheries Plan for Deepwater and Middle-depth Fisheries, originally delivered in 2010, will be updated and may provide an avenue for implementing adaptation pathways strategies
- The Deepwater Council's non-regulatory Hoki Management Areas and Hoki Seasonal Spawn Areas are examples of voluntary industry measures to reduce catches on sensitive areas; such arrangements enable more agile management

- The Fishery Industry Transformation Plan is currently being drafted, and includes objectives on strengthening environmental performance, improving profitability, and supporting people and communities
- Te Mana o te Taiao, the New Zealand Biodiversity Strategy, has objectives specifically referring to reducing impacts of marine fisheries, and promotes the implementation of ecosystem-based management (EBM).

In the final segment of Session 1, a discussion was held about blue-sky thinking and potentially transformational innovations for the hoki fishery. The following ideas were discussed:

- Revisit biological research using technological advances and alternative data collection at lower cost (e.g. autonomous drones, satellite imagery, fishery vessels as data platforms)
- Ring-fence sector New Zealand Emissions Trading Scheme levy payments for the purposes of climate adaptation and innovation in the fishery
- Investigate alternative fuels for vessels
- Use eDNA tools for monitoring
- Brand ‘New Zealand’ as a country that practises sustainable fishing
- Adopt remote-control gear technology, which could publicise trawling and promote social licence to operate (SLO)
- Improve understanding of biological capital
- Ensure 100% utilisation of carcasses and value-adding (e.g. hoki collagen, hoki soda)
- Improve data use, integrating existing fishery and stock data.

Following these presentations, each group was asked to discuss what they considered to be the major drivers of change for the hoki fishery into the future (Figure 12). Participants were asked to write drivers on sticky notes. These were then placed on a wall under seven themes: policy and regulation, markets, climate change, technology, fishery dynamics, fishery costs, and kono or the wider system (Figure 13). Participants were asked to vote for the two specific drivers or themes that they considered most influential. Climate change scored highest, with 13 votes, followed by fishery dynamics and fishery costs, which both had eight votes (Table 1). Among these themes, the impacts of climate change on hoki food sources, juvenile recruitment and adults, rising fuel costs, fuel efficiency and the availability of alternatives were identified as the most important specific drivers. Public concern about bottom-trawling was also identified as a specific issue under policy and regulation.

Figure 12. Participants discussing drivers of change in Session 1.

Figure 13. Sticky notes of individual drivers placed under driver themes in Session 1, and voting (red dot) stickers.

Table 1. Drivers of change for the hoki fishery identified under each theme, and participants' votes.

Driver of change theme (total votes)	**Driver**	**Specific votes**
Policy and regulation (5)	Bottom-trawling concerns among the public	4
	Management of bycatch	
	Ineffective policies and lagged response	
	No long-term commitment to data gathering by government	
	Reduced TACCs	
	Social licence to operate declining	
	Fisheries management responsiveness	
	EBM versus ecosystem-based fisheries management	1
	Cost of EBM	
Markets (4)	Market instability	
	Competition with subsidised fisheries	
	Changing customer preferences and market responses	
	Product diversification	
	Increasing resilience through better use of raw products	2
	Competition for international markets	
	Traceability granularity of fish to market	
	Price realisation	
	Value of fish	
	Changing customer expectation	
	Human population growth and increasing demand for fish protein	
Climate change (13)	Severe weather events	
	Impacts on food sources, juvenile recruitment and adults	8
	Emerging aquatic diseases	
	Predator–prey disconnect	
	Growing ocean temperature variability	
	Economic impacts on returns to fishery	
	Increasing acidification	
	Changing (shallowing) aragonite saturation depth	
Fisheries costs (8)	Lack of skilled crew	1
	Monitoring costs	
	Rising fuel costs, fuel efficiency and availability of alternatives	4
	Increased costs of energy and production	2
	Coastal infrastructure	
	Health and safety costs	
	Pressure on fish prices and competition from alternative species	
	No access to capital investment	
Whole of system 'kono' (1)	Misleading advocacy and uninformed opinion	
	Community and social acceptance of fishery	1
	Lack of collaboration and sharing of data	
	Increasing public environmental awareness	
	Changing public trends and attitudes	
	Lacklustre leadership	
	Cost of living increases	

Driver of change theme (total votes)	Driver	Specific votes
Technology (1)	Improved collection, analysis and breadth of data	
	Access to available tested technology (i.e. cost and fitness)	
	Mitigation and innovation for bottom-trawling	
	Sourcing innovative products from fish	
	Biotechnology delays due to ethical concerns	
	Technology infrastructure	
Fishery dynamics (8)	Distribution and abundance of threatened and protected species	
	Recruitment	
	Lack of data on climate change impacts on fish behaviour	
	Availability and distribution of prey	
	Understanding stock dynamics	
	Ocean productivity	
	Increasing catch of non-target species	
	Research costs and need for holistic science	
	Competing industries (e.g. demand for seaweed and ocean space)	

3.4. Session 2: What is the future vision for the industry?

The aim of Session 2 was to enable stakeholders to define their vision for the hoki fishery, and to select a time frame in which this was to be achieved. Each group chose to write a set of statements describing their vision. Three groups chose 2050 as their target year, and one group selected 2040. There were similarities between the groups. For example, the two groups named ‘Table one’ and ‘Ikoh 1’ had the following visions:

Table one (2050)

- An abundance of fish (hoki catch > 100,000 tonnes per annum)
- Hoki is a higher-value commodity
- Increased predictive capability for stocks
- Reduction of bycatch and lower environmental impact
- Cheaper, more efficient and lower carbon–footprint capture vessels / technology
- Recognition of seafood as ‘blue meat’
- A healthy marine environment
- Adaptive enabling policy framework.

Ikoh 1 (2040)

- Larger and greener, modern carbon-neutral boats
- Predictable costs of fishing
- More good news stories
- Increased catch

- Reduced carbon dioxide
- Using climate change signals to model stock dynamics
- Increased agility of management.

Additional features of other groups' visions were: 'improved SLO driven by minimising impact on non-target species' and 'increased recruitment and retention of workers through better training, pay and safety'. A synthesis of the primary features of all visions was:

- An abundance of fish (hoki catch > 100,000 tonnes per annum)
- Higher market value for hoki
- Larger and more efficient carbon-neutral vessels
- Adaptive and agile policy and management
- Reduction of bycatch and lower environmental impacts
- Improved public perception and SLO of the fishery
- Improved recruitment and retention of workforce through better working conditions
- Improved stock modelling and understanding of climate change signals.

3.5. Session 3: What are the possible futures for the industry?

The aim of Session 3 was to explore potential futures for the hoki fishery, based on the uncertainties around the primary driver themes selected by participants in Session 1 – i.e. climate change and fishery dynamics (which were combined due to the overlaps in issues such as recruitment), and markets and economics (incorporating fisheries costs, economics and markets). To begin the session, the facilitators drew the driver themes as axes, ranging from 'good' to 'bad'. In the case of climate change and fishery dynamics, 'good' represented moderate climate change, where elevated sea-surface temperatures, acidification and extreme events will continue, although not to the same extent as for the 'bad' extreme. The details of each driver were informed by the information presented in Session 1. This created four potential future scenarios for the hoki fishery (Figure 14):

- Scenario A, with moderate climate change and stable fishery dynamics, and improved economics and markets
- Scenario B, with extreme climate change and altered fishery dynamics, but improved economics and markets
- Scenario C, with extreme climate change and altered fishery dynamics, plus poor economics and markets
- Scenario D, with moderate climate change and fishery dynamics, and poor economics and markets.

Scenario A represented the adaptive space in Figure 1, Scenarios B and D were intermediate futures between the adaptive and maladaptive spaces, and Scenario C represented the maladaptive space.

Each group was allocated one scenario to describe, focusing on the year 2050 to correspond with the timelines they had selected for their visions in Session 2. They each described their scenario on flip-chart paper and gave it a title, before presenting it as a narrative.

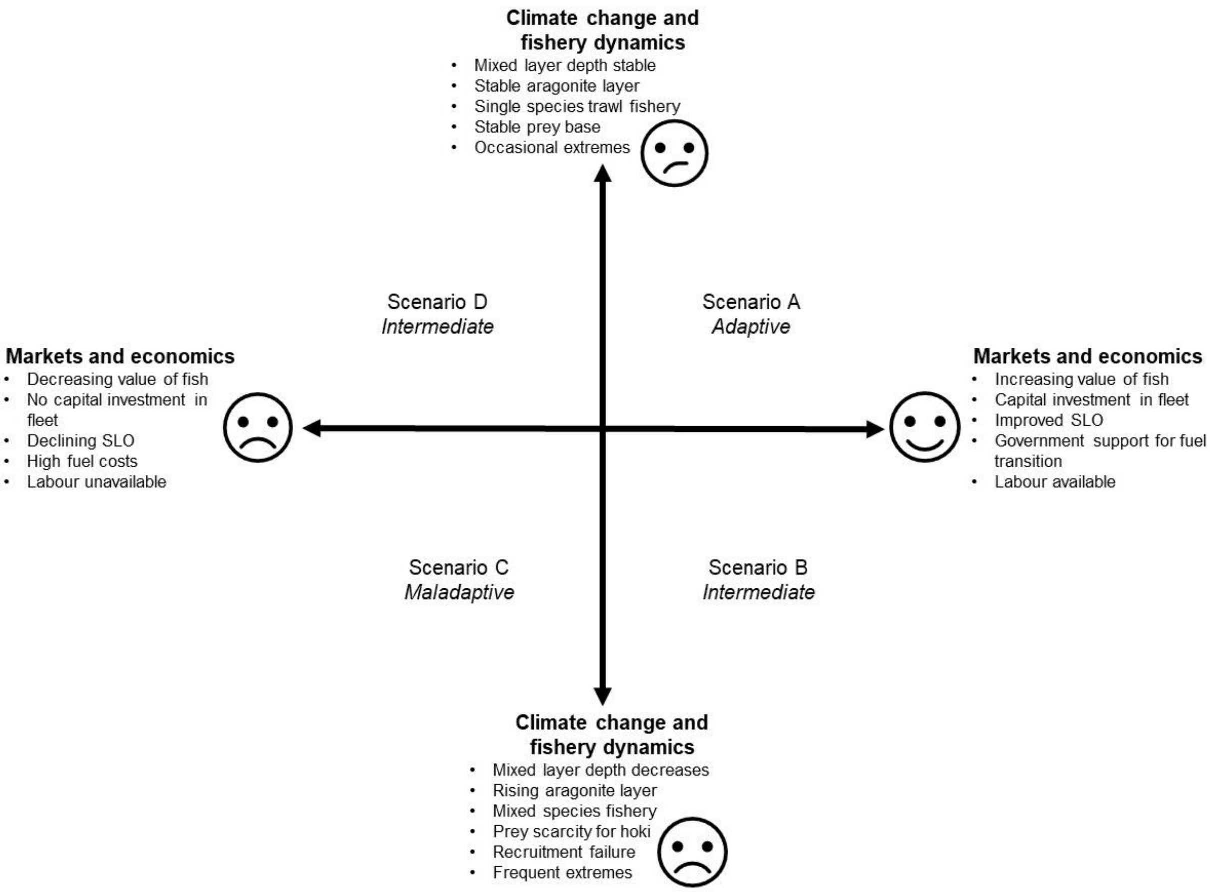

Figure 14. The matrix of scenarios derived from the primary driver themes identified by participants in Session 1, characterising different adaptive or maladaptive futures

Scenario A (adaptive space) explored the hoki fishery with moderate climate change, stable fishery dynamics, and improved economics and markets (Figure 15). This described a situation with consistent and healthy hoki stocks producing a 100,000 tonne fishery, from which 100% value is obtained. As a result, government and community see the value of the fishery and people seek to join the workforce. At the same time, the government provides an enabling policy framework in partnership with the industry that results in unprecedented amounts of research and monitoring, and no shortage of technical equipment for understanding ocean health and hoki recruitment. Carbon neutrality of the fleet is achieved ('the flashest boats in the world'), and stress on aquatic habitats is reduced due to the increased profitability driving more environmentally friendly technology. As such, this scenario reflected aspects of the visions produced in Session 2, and hence was named '2050 vision update'.

Scenario B (intermediate future), titled 'Positive market, negative climate', depicted a situation with extreme climate change and altered fishery dynamics, but improved economics and markets (Figure 16). In this scenario, the positive market results in higher values of fish, more money to invest and increased SLO as consumers increase their purchasing of hoki and participation in the fishery. The better market provides room to innovate and also provides bargaining support. However, the extreme climate change makes any investment vulnerable and less resilient. There is a chance of stock reduction and a higher risk of regulatory precautionary closures. The changes in climate increase the risk of overfishing and the possibility of a mismatch between management and stock distribution, which in turn increases monitoring costs.

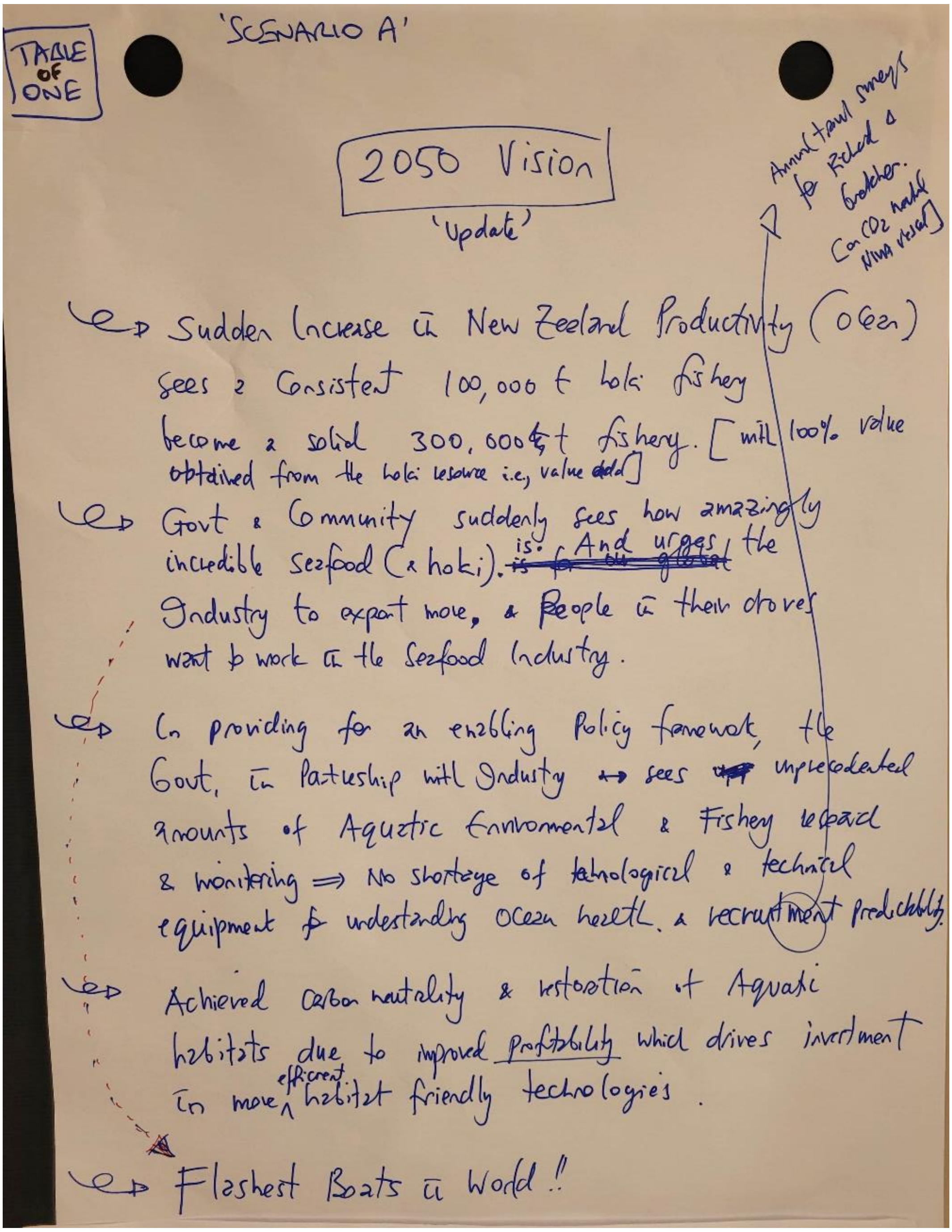

Figure 15. Scenario A, '2050 vision update', explored the hoki fishery in 2050 with moderate climate change, stable fishery dynamics, and improved economics and markets.

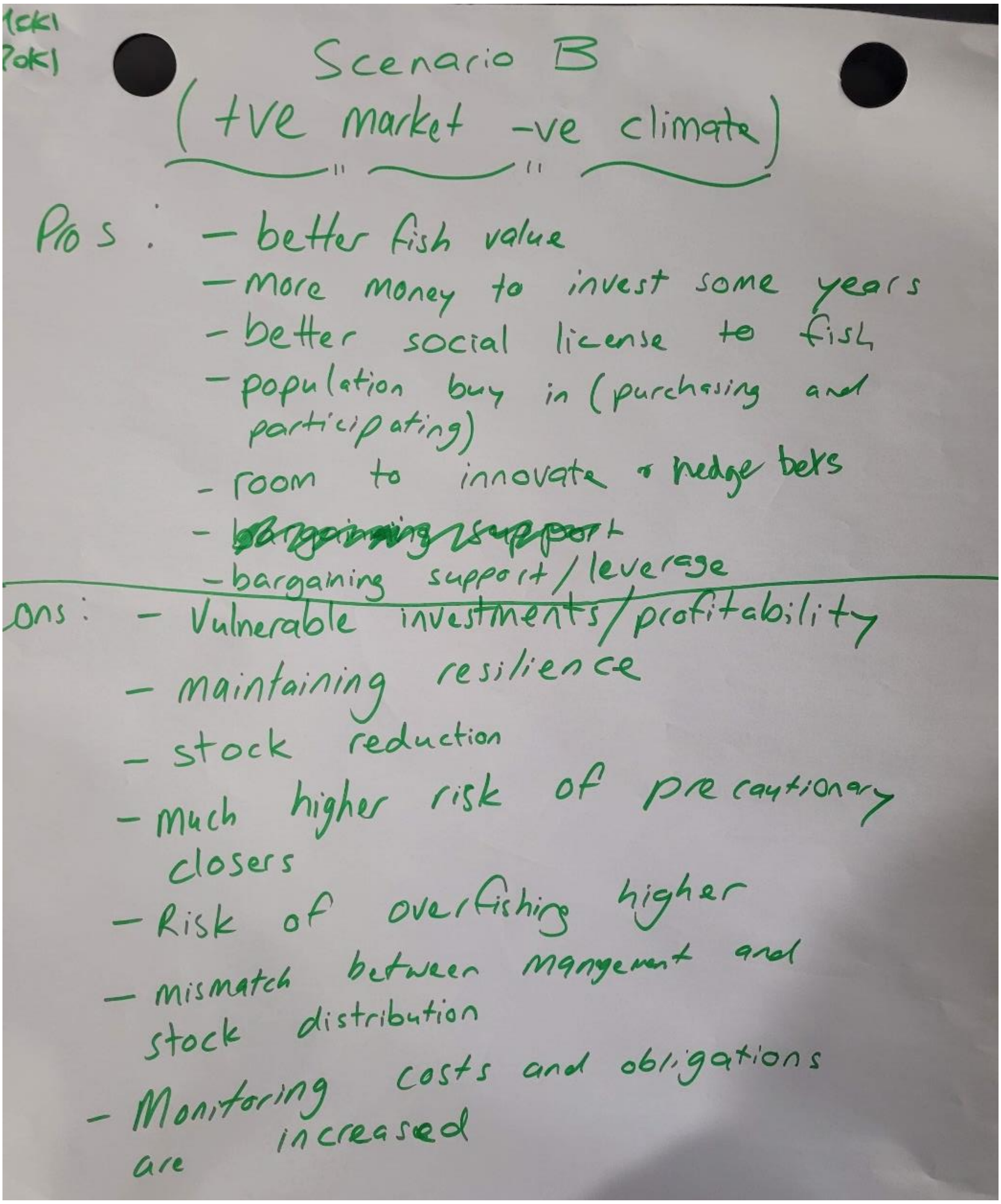

Figure 16. Scenario B, ‘Positive market, negative climate’, depicted a situation with extreme climate change and altered fishery dynamics, but improved economics and markets.

Scenario C (maladaptive space), titled ‘Worst case’, reflected a system with extreme climate change and altered fishery dynamics, plus poor economics and markets (Figure 17). This scenario would result in a reduction in the fleet as a result of an inability to respond quickly to the need to improve vessels, and increased costs per net shot, leading to a constrained catch. Spawning aggregations would be targeted, resulting in a long-term impact on stocks. The need for high grading and 'premium-isation' will ultimately be unsustainable, forcing a dependency on alternative species of potentially lower value. Government support would be required for infrastructure, but this would be influenced by foreign interference.

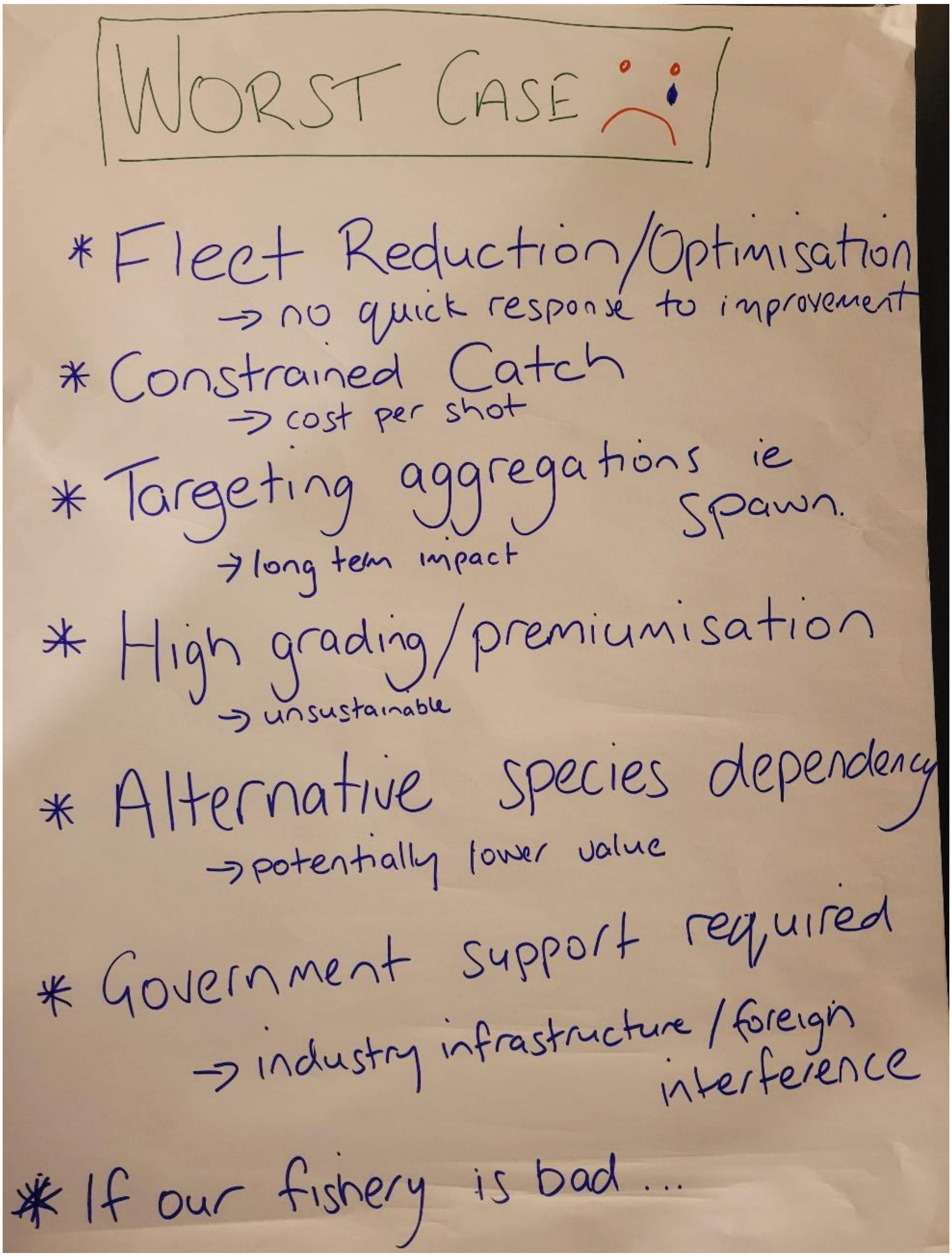

Figure 17. Scenario C, 'Worst case', reflected a system with extreme climate change and altered fishery dynamics, plus poor economics and markets.

Scenario D (intermediate future), titled 'Status quo', represented a situation with moderate climate change and fishery dynamics, but poor economics and markets (Figure 18). There is low investment in infrastructure, and the workforce remains poorly skilled and is subject to high health and safety risks, leading to high staff turnover. There is no product development, and the fishery faces competition with low-cost producers. Data collection is less well managed, and the fishery is volume-driven, making it less sustainable and consequently reducing its SLO. The fishery is vulnerable to environmental events, and there is pressure to switch from hoki to other species of higher value, which in turn increases pressure on those fisheries.

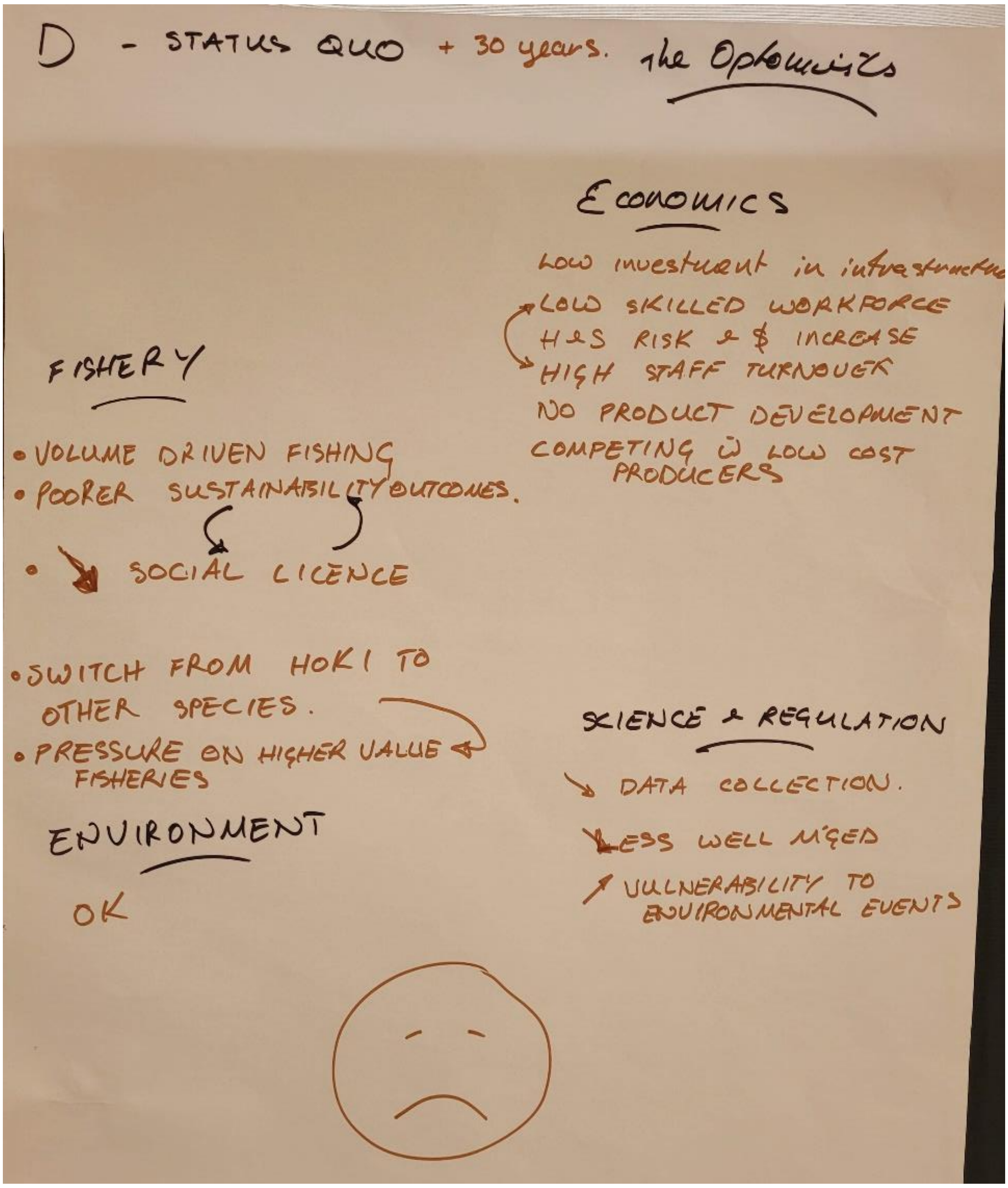

Figure 18. Scenario D, 'Status quo', represented a situation with moderate climate change and fishery dynamics, but poor economics and markets.

3.6. Session 4: What are the adaptation strategy options?

This session began with a review of the blue-sky thinking discussion and ideas presented in Session 1, which potentially represented transformational opportunities. In addition, adaptation options for the hoki fishery developed by Cummings et al. (2021) through a process involving experts and stakeholders were summarised as follows:

- Continue regular data collection, stock monitoring and stock assessments:
  - Ensure these are reactive to change
  - Make more use of mortality rate reference points.
- Promote precautionary management:
  - Continued protection of nursery grounds and refugia
  - Keep the stock structure intact by avoiding overfishing.
- Gain knowledge about hoki stocks:
  - Spawning locations and dynamics
  - Early life history.

Each of the four groups was then asked to list their suggested options, using different-coloured sticky notes for strategies that could be introduced ‘now’, those that could be introduced ‘later’ (around 2030) and those that could be introduced ‘much later’ (around 2050) (Figure 19). These were placed on flip-chart paper, with time drawn along the x-axis and risk along the y-axis, ranging from no regrets to higher risk (Figure 20). In this way, it was possible to rank adaptation strategies from immediate, incremental and low-risk options to medium-term or longer-term transformational but more risky options.

Once groups had completed and presented their options, the facilitators compiled the sticky notes into strategy themes and sorted them onto a larger piece of flip-chart paper using the same axes of time and risk. The following morning, this was presented back to the groups for feedback and discussion.

Figure 19. A group ranking adaptation options.

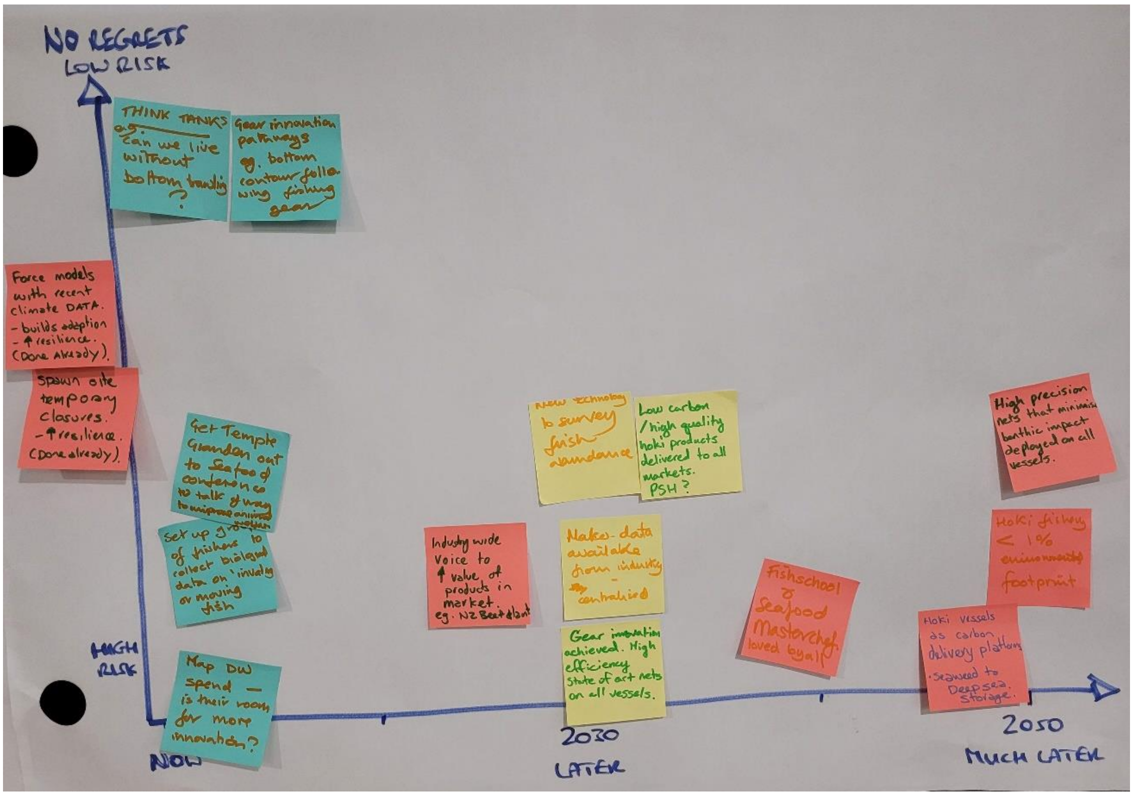

Figure 20. Adaptation options differentiated by time and risk in Session 4.

3.7. Session 5: How do we sequence adaptation pathways?

Day 2 began with Session 5, which aimed to sequence the adaptation strategies into pathways of actions and identify key decision points. The themes of strategies identified in Session 4 were sub-divided into two categories: no regrets and incremental, and transformational. Participants were divided into three groups, and each was assigned a collection of strategies and given all the sticky notes from Session 4 relating to that strategy. They were given fresh flip-chart paper with the same axes of time and risk, plus more sticky notes, and were asked to disaggregate the strategies into sequences of actions and name who would be responsible for implementing those actions (Figures 21 and 22). Where possible, they were also asked to identify decision points where one set of strategies would shift to another.

Figure 21. Participants organising adaptation strategies into pathways of actions and stakeholders responsible.

Figure 22. Presentation of a group's preliminary adaptation pathways to the workshop.

The first set of draft strategies and pathways was circulated to participants after the workshop, and then a subsequent SAS IG workshop was held on 1 September 2023 to consider feedback and further refine the pathways. Through this process, three strategies were considered to build adaptive capacity but were not directly relevant to climate change: building human capital, increasing iwi participation and building social licence to operate. Figure 23 synthesises the final set of six strategies and their pathways, based on the conceptual diagram shown in Figure 1. The details of each pathway in terms of the actions and decision-makers involved, key decision points and time frames are listed in Tables 2 and 3.

Six pathways were identified to achieve the vision. Three began with no regrets strategies to be implemented immediately (Table 2):

- Innovative fuel efficiency measures
- Innovative value-adding
- Diversify target species and adapt vessels and crew.

Innovative fuel efficiency measures could reach a decision point when diesel costs are prohibitive, after which the pathway would become more transformational, with the introduction of a fleet that would fish and refuel at sea. Diversifying target species is already underway in the industry, but if a decision point occurs where current fishing becomes uneconomic, the fleet would have to shift and transform into alternative enterprises such as offshore aquaculture, or transporting seaweed used for carbon sequestration in a low-carbon economy.

Three pathways were potentially transformational, and required initial steps by 2030 (Table 3):

- Hoki climate research programme
- Revised research funding
- Adaptive legislation and management.

However, whether these pathways continue depends upon a decision point likely to emerge in the near future, where funding either does or does not become available and adaptive legislation is either introduced or not. If positive changes do come about, the industry would be able to continue these pathways, practising climate-predictive fishing and more adaptive fishing effort and management, providing more options to diversify target species and ultimately reaching the 2050 vision.

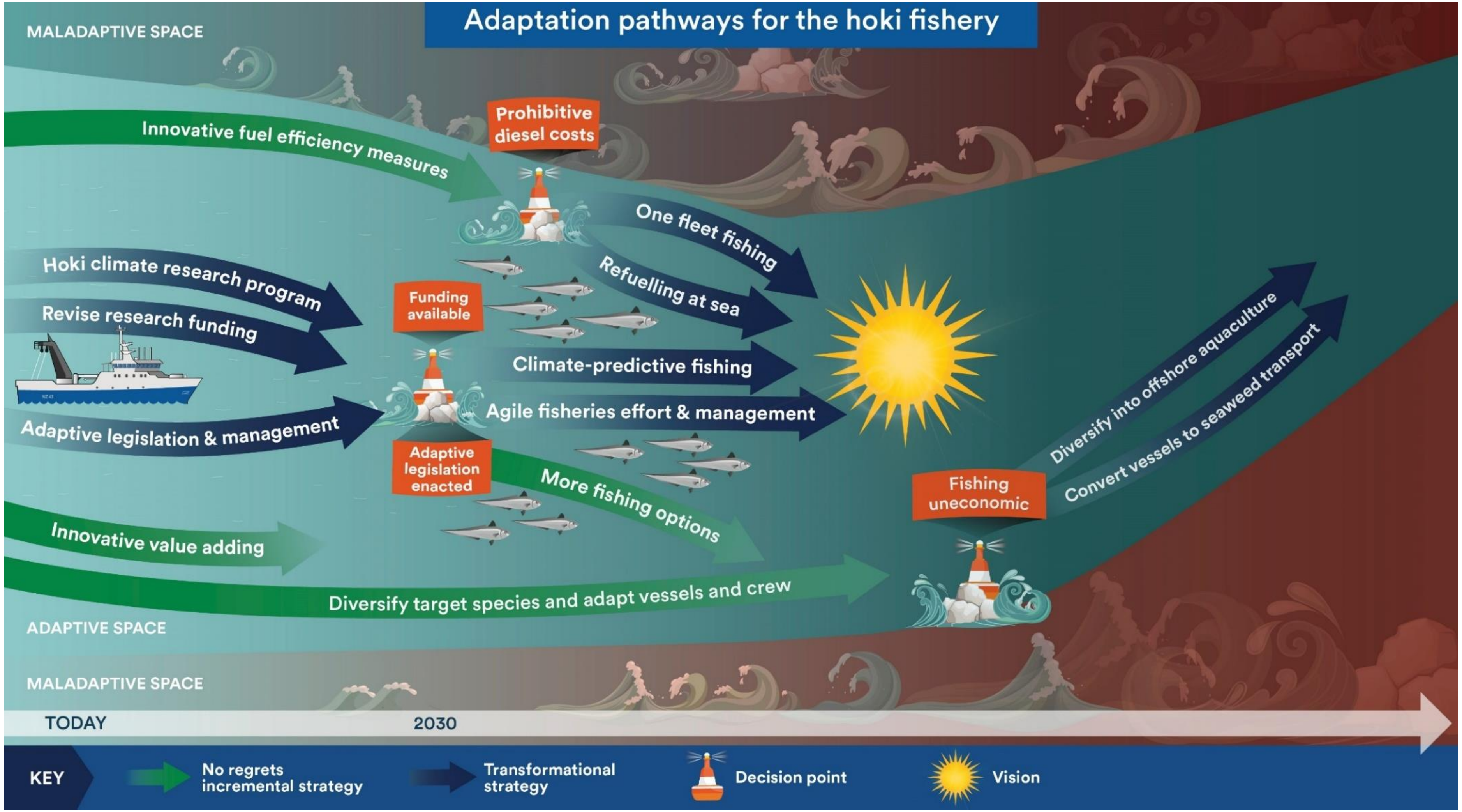

Figure 23. Synthesis of the six adaptation strategy pathways for the hoki fishery identified in Session 5 for the hoki fishery, organised into their categories of no regrets and incremental, and transformational, and showing timelines and key decision points. Details of each pathway are given in Tables 2 and 3.

Table 2. Details of the three no regrets incremental strategies and their pathways in terms of the actions and decision-makers involved, and approximate time frames for the hoki fishery to achieve the 2050 vision.

	TODAY	?	➡ ➡ ➡ ➡ ➡ ➡	➡ ➡ ➡ ➡ ➡ ➡
Strategy	**Action 1 (*who?*)**	***DECISION POINT***	**Action 3 (*who?*)**	**Action 3 (*who?*)**
Innovative fuel efficiency measures	• Re-evaluate fishing effort, reducing low-volume / high-effort fisheries (*industry and companies*) • Benchmark fuel efficiency and carbon footprint with international deepwater fisheries (*industry and companies*) • Engage with Fishery Industry Transformation Plan	*Prohibitive diesel costs*	• Implement technology to refuel at sea (*companies*) • Apply one-fleet fishing (*industry and companies*)	
Innovative value-adding	• Develop industry approach to increasing value of products and developing products (*industry and companies, government*) • Product development (*industry and companies, government*)		• Increase the market for new and improved products	
Diversify target species and adapt vessels and crew	• Research alternative target species and business options (*industry and companies, government*)	*Fishing is uneconomic*	• Hoki vessels converted to be delivery platforms for seaweed storage (*companies*) • Diversify into offshore mixed aquaculture (*industry and companies*)	• Ports developed for mixed use • Consolidation of processing plants to alternative uses • Close hoki fishery

Table 3. Details of the three transformational strategies and their pathways in terms of the actions and decision-makers involved, key decision points and approximate time frames for the hoki fishery to achieve the 2050 vision.

TODAY ?

Strategy	Action 1 (*who?*)	*DECISION POINT*	Action 2 (*who?*)	Action 3 (*who?*)
Hoki climate research programme	• Identify research and data priorities (*industry, research providers*) • Identify ecological tipping points (*industry, research providers*)	*Funding available*	• Results applied to inform fisheries management (*industry, companies, government*) • Climate-predictive fishing implemented (*industry, companies)*	
Revise research funding	• Scope alternative funding models (*industry, government*) • Lobby government to invest emissions trading scheme funds into the industry (*industry)*	*Funding available*	• Climate-predictive fishing implemented (*companies*)	
Adaptive legislation and management	• Advocate and collaborate across the sector (*industry, NGOs*) • Design prototype of alternative management system (*industry, NGOs*) • Amend legislation to improve marine spatial planning in all NZ jurisdictional waters (*government)* • Quota Management System amended to address boundary changes (*government)*	*Adaptive legislation enacted*	• Agile fisheries effort and management (*companies and government*) • More fishing options (*companies*)	

3.8. Session 6: What needs to happen to enable adaptation?

The final session was an open discussion about the barriers and enablers to implementing the adaptation pathways. Barriers to adaptation raised by participants were:

- A lack of capacity in the industry, resulting in continuation of the status quo
- A lack of leadership and collaboration (need to bring people along, allocate scarce resources and set realistic objectives)
- A lack of funding due to the necessity to recover costs
- Entrenched attitudes of 'us versus them'
- Patch protection and defence tactics
- Legal restrictions on cooperative efforts
- Mistrust among stakeholders
- Uncertainty (e.g. in the review rounds).

Enablers to adaptation were:

- Technology
- Different types of leadership in the Deepwater Council, and mutual trust
- A shared vision for the hoki fishery
- Investment in the future
- Transparency and understanding stakeholders' mutual interests
- Good enough information to make progress
- 'New Zealand-ness' and control over our own destiny
- New Zealand Inc.
- Global linkages
- Blue economy opportunities.

Despite the apparent systemic barriers to action (e.g. inherent patch protection among stakeholders), there appeared to be numerous enablers to counter them, such as different types of leadership in the Deepwater Council and transparency among stakeholders. The workshop process may have contributed positively to improving some issues, such as the shared vision for the fishery, which was considered by the Session 2 future visions. It also encouraged more collaboration and trust among those present (see Section 4).

4. WORKSHOP EVALUATION

An online questionnaire survey was sent to participants out after the snapper, hoki and salmon workshops to assess the degree to which the Theory of Change (see Figure 2) had been realised. A total of 20 respondents provided scores from 1 (strongly disagree) to 5 (strongly agree) for nine questions that reflected the intangible and tangible outcomes anticipated. Most respondents had attended multiple workshops, and hence the data were pooled to reflect their overall feedback about the process rather than outcomes from a specific case study.

Overall, the respondents agreed that the intended outcomes were evident. The highest scores were for social networks, trust and knowledge integration, followed by the creation of new partnerships and the realisation that issues are connected (Figure 24). Although still positive, the outcomes of leadership, innovation and the likelihood that the workshops would lead to tangible action in the industry were weaker. However, the highest-scoring individual indicator was that everyone in the workshop had an equal voice.

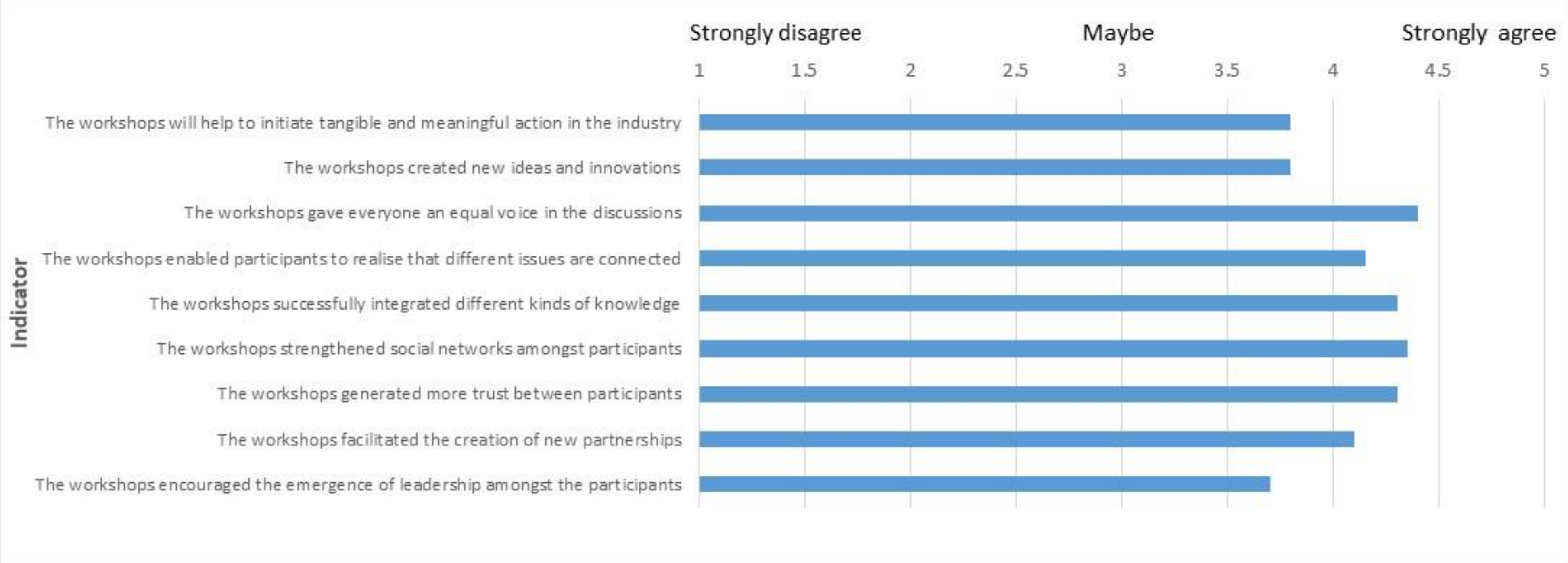

Figure 24. Average scores given by 20 respondents who attended the snapper, hoki and salmon workshops.

When participants were asked ‘What was the most valuable thing you gained from attending the workshop?’, there was clear evidence of learning, trust-building, collaboration and collective action. Responses included:

‘The idea that we have the tools to plan for an uncertain future in a positive way.’

‘Learning about the many drivers of the seafood industry beyond my usual realm of science.’

‘Probably increased sense of urgency in addressing climate change challenge.’

‘Discussions with a wide range of industry participants and stakeholders are always useful.’

‘Greater awareness of the variability (and diversity) of challenges and climate challenges within the various sector groupings.’

‘Provided both time and opportunity to step back and think about the impacts that will arise due to climate change.’

‘Understanding some of the ocean science and impacts on the fishery (water strata, nutrients, etc.).’

‘Hearing the views from across a wide range of perspectives, and seeing that everyone is grappling with the issues. The need to collaborate was widely recognised.’

‘Seeing the willingness of the participants to share their experience and table some great ideas.’

‘It was really great to see the industry representatives collaborating on future options that could support the sector in adapting.’

‘Looking at different scenarios broadened the thinking (and the options!), which was useful.’

‘Transparency within industry and openness to share challenges.’

‘I gained a better understanding of some of the discrete operational challenges that the fishing industry faces with respect to any potential change in fuel or operational characteristics to secure lower carbon impact. I also feel that there was more trust built between industry participants and at least one NGO.’

'I thought the workshop was well run and encouraged a lot of discussion across different areas of expertise. It was well worth the attending in terms of sharing thoughts and building relationships.'

In answer to the question 'Is there any other feedback you would like to provide?', some suggestions were given about how the process could be improved and the importance of implementation. Specific issues were:

- The need to involve a broader spectrum of stakeholder and partner representatives across the industry
- The need to include local government
- The importance of target participation by emerging leaders in each industry
- The importance of communicating the strategies and pathways with key decision-makers
- The necessity to turn planning into implementation action.

5. NEXT STEPS

This report summarises one case study workshop, and presents the results for the hoki fishery. As such, it has contributed to the project's primary goal: using case studies to develop an adaptation pathways approach with the SAS IG.

Next steps required to complete the project will be:

- Design of guidelines and tools to aid future planning by SAS IG members
- Consideration by the SAS IG of how to scale-out the approach across fisheries and aquaculture industries involved in The Aotearoa Circle
- Having completed the snapper, hoki and salmon aquaculture case studies, identification of cross-cutting adaptation strategies and pathways that, if addressed, could generate transformational change across the seafood sector.

Finally, the SAS IG should consider how the adaptation pathways process can be embedded within the current and future planning and management for each industry. As detailed in this report, adaptation pathways involve ongoing, iterative evaluation and review of strategy implementation, and scanning of emerging futures and impending decision points. Hence, this project represents only a first scanning point. How the approach can be mainstreamed into current hoki fishery planning and management structures to ensure subsequent iterations and revisions of the pathways presented here is yet to be determined.

6. APPENDICES

Appendix 1. Workshop agenda

Session	Time	Activities	Outputs
Day 1	0930	Tea and coffee on arrival	
Introductions	1000–1030	• Karakia, participant introductions, project introduction, workshop agenda, research ethics and verbal consent for photos, videos, etc. • Divide participants into mixed groups (4–5 per group). One SAS IG member per group	• Participant attendance recorded • Verbal consent

Session 1: What are the drivers of change for the sector?	1030–1200	• Explanation of activity
		• Presentations on:
		  ○ Sector
		  ○ Climate change projections and impacts (Phase 1 results)
		  ○ Market forces and forecasts, societal shifts
		  ○ Policy and regulation
		  ○ Innovations, opportunities and blue-sky thinking
		• Groups discuss and list drivers of change on sticky notes
		• Groups put sticky notes on whiteboard under driver themes
		• Facilitators review results
		• Participants use voting stickers to select top two drivers / themes
		• Facilitators total votes and review results
			• Sector drivers
			• Ranking of drivers of change

Session 2: What is the future vision for the sector?	1200–1300	• Explanation of activity • Groups draw / write their vision for the sector, including desired timeline (e.g. 2030, 2040, 2050) • One representative presents each group's vision • Visions stuck up on walls • Plenary discussion about commonalities and differences in visions and timelines	Visions and planning timelines for the sector
Lunch	1300–1345	Facilitators prepare whiteboard with scenario matrix for Session 3	Scenario matrix
Session 3: What are the possible futures for the sector?	1345–1515	• Explanation of activity • Groups draw one scenario each with title and narrative • Groups present their scenario and narrative, then put them on the wall	Scenario pictures and narratives

Session	Time	Activities	Outputs
Tea	1530–1545	Facilitators prepare adaptation strategy options matrix	Adaptation strategy options matrix
Session 4: What are the adaptation strategy options?	1545–1700	• Explanation of activity • Presentation of adaptation options, and Session 1 blue-sky thinking • Groups list options on sticky notes and sheets • Each option is classified by time frame and high risk / no regrets scale • Groups present back their options	Adaptation options classified by time frame and risk
Wrap-up and lead-in to Day 2	1700	After close, facilitators consolidate groups' adaptation strategies into one master copy with themes of strategies. Then divide up themes and relevant sticky notes onto pathways sheets, one for each group	Consolidated master copy of adaptation strategies and pathways sheets
Dinner	1830		
Day 2	0900–0915	Introduction to Day 2	
Session 5: How do we sequence adaptation pathways?	0915–1115	• Explanation of activity • Groups order sticky notes into pathways of actions and decision-makers, including decision points	Pathways maps for each group's strategies
Tea	1115–1130	Tea and coffee	
Session 6: What needs to happen to enable adaptation?	1130–1230	Plenary discussion of key barriers, enablers, needs and next steps	• List of barriers for SAS IG to address • Knowledge gaps • Next steps
Evaluation, wrap-up and close	1230–1300	• Plenary discussion on process and how it could be improved • Wrap-up • Karakia	List of improvements
Debrief (research team and SAS IG)	1330–1430	Group discussion and reflection on learnings and adjustments needed for next workshop	Adjustments for next workshop

Appendix 2. Workshop participants

No.	Name	Organisation/Role
1	Aaron Irving	Deepwater Council
2	Geoff Clark	Sealord Group Ltd.
3	Stew Reynolds	Sealord Group Ltd.
4	Darryn Shaw	Sanford
5	Kylie Grigg	Te Ohu Kaimoana
6	Te Hau White	Te Ohu Kaimoana
7	Dean Jurasovich	Sanford
8	Andy Biggerstaff	Fisheries NZ Deepwater
9	David Foster	Fisheries NZ Deepwater
10	Gretchen Skea	Deepwater Council Chair
11	Jack Fenaughty	Fishery consultant
12	Mary Livingston	Hoki fishery/ecology expert
13	Carolyn Lundquist	Research team - NIWA
14	Nick Cradock-Henry	Research team - GNS Science
15	Romain Chaput	Research team - Cawthron Institute
16	Richard O'Driscoll	Research team - NIWA
17	James Butler	Research team - Cawthron Institute
18	Jodie Kuntzsch	SAS IG - Aotearoa Circle
19	Bubba Cook	SAS IG - WWF
20	Peter Longdill	SAS IG - Sanford
21	Vonda Cummings	SAS IG and research team - NIWA
22	Charles Heaphy	SAS IG - Sealord Group Ltd.
23	Megan Linwood	SAS IG - Ministry for Primary Industries
24	Stuart Yorston	SAS IG - Sealord Group Ltd.

7. ACKNOWLEDGEMENTS

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- Jodie Kuntzsch, The Aotearoa Circle
- John Willmer, New Zealand Seafood Industry Council
- Peter Longdill, Sanford
- Vonda Cummings, NIWA
- Jane Symonds, Cawthron
- Charles Heaphy, Sealord Group Ltd
- Michelle Cherrington, Moana New Zealand
- Megan Linwood, Ministry for Primary Industries
- Ruth Cook, Ministry for Primary Industries
- Stuart Yorston, Sealord Group Ltd
- Dave Taylor, Aquaculture New Zealand
- Bubba Cook, WWF.

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