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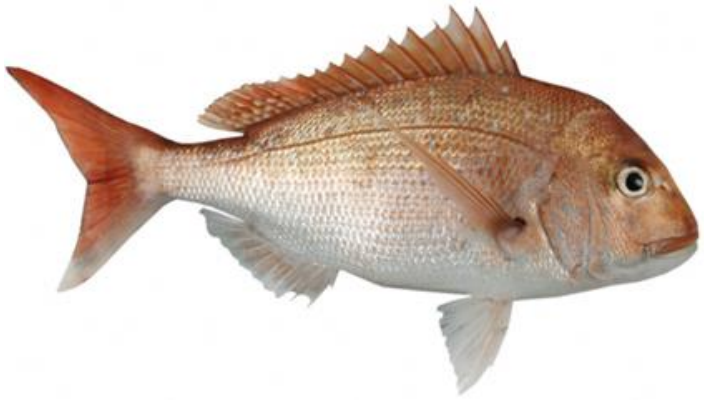
ADAPTATION PATHWAYS FOR THE SEAFOOD SECTOR: SNAPPER FISHERY



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ADAPTATION PATHWAYS FOR THE SEAFOOD SECTOR: SNAPPER 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 snapper 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 snapper fishery

An adaptation pathways planning workshop was held with decision-makers, industry stakeholders and regulators for the snapper fishery on 9–10 May 2023, with the objective ‘to develop 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 snapper, and the SAS IG and other experts providing knowledge on industry trends, market forecasts and policy settings. These were prepared as posters, other printed materials and slide presentations to be used in the workshops. The workshop process was designed to generate social learning, knowledge co-production and systems thinking.

A suite of adaptation strategies was formulated covering three categories: incremental no regrets strategies carrying minimal risk, medium-term no regrets strategies, and transformational strategies that would be triggered by key decision points. These were sequenced by participants 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 snapper

Current knowledge of climate impacts on snapper is limited, and is complicated by interactions between potentially negative and positive effects of warming temperatures and acidification on growth, survival and recruitment. However, ongoing sedimentation of coastal zones is likely to be exacerbated by climate change due to increased run-off, which will further impact spawning and juvenile life stages. There are no clear ecological tipping points that could inform future adaptation pathways decision-making.

Drivers, vision and future scenarios

Together with climate change, policy and regulation were considered the most important driver of change for the fishery. Major issues included declining investment in science and management, lags between stock assessments and policy response, balancing multiple stakeholders' values and objectives, and the need to establish ecosystem-based management that integrated catchment and marine ecosystems, or ki uta ki tai. Other major drivers were the sector's dependency on diesel fuel, changes in global policies towards carbon emissions, and rapidly rising fuel costs influencing profitability; declining social licence to operate and increasing consumer concern about fisheries practice; the opportunity for technology to inform management; the re-evaluation of fisheries and oceans to include te ao Māori perspectives; the declining capacity of crew and personnel; and unsustainable financing models for small fishery businesses.

Participants created a vision for the fishery for 2040, summarised below:

- Ecosystem-based management that embraces a full range of value systems and stressors
- Nimble temporal and spatial management, working with all sectors of the fishery
- Enhanced profitability for firms and fishers to pay increasing costs
- Maximising the total value of the catch
- Certainty for investment into the fishery
- Improved social licence to operate
- Novel technology to increase productivity
- More frequent stock assessments
- Abundant snapper stocks.

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 snapper fishery. Next, participants collated adaptation strategies and sequenced them into pathways.

Adaptation strategies and pathways

Eleven pathways were identified to achieve the vision (see infographic on page v). While some strategies did not address climate change specifically, they all bolstered the industry's

capacity to prepare for, and cope with, future change and uncertainty. Five were no regrets strategies to be implemented immediately:

1. Climate-specific research plan and priorities
2. Monitoring and management
3. Agile management system
4. Climate 'shock event' response planning
5. Climate innovation.

A further two were no regrets strategies to be implemented in the medium term: ecosystem-based management, and integrated ki uta ki tai (mountains-to-sea) monitoring and management. These would be supported and informed by the outcomes of the climate-specific research plan, monitoring and management, and agile management system pathways.

Four were potentially transformational, and required preparatory steps by 2030:

1. Stock enhancement
2. Alternative blue economy opportunities
3. Value-adding and waste minimisation
4. Alternative fuels research and development.

For stock enhancement and alternative blue economy opportunities, a key decision point triggering their implementation would be a decline in snapper stocks, or when the fishery was no longer financially viable. For value-adding and waste minimisation, the trigger would be global consumer changes and aversion to carbon-intensive transport. For alternative fuels, it would be prohibitive diesel costs and / or alternative fuels becoming available, and changes in markets or government drivers. In all four cases, the decision points would result in major changes to the snapper fishery that would be necessary to achieve the 2040 vision, or diversify beyond the vision.

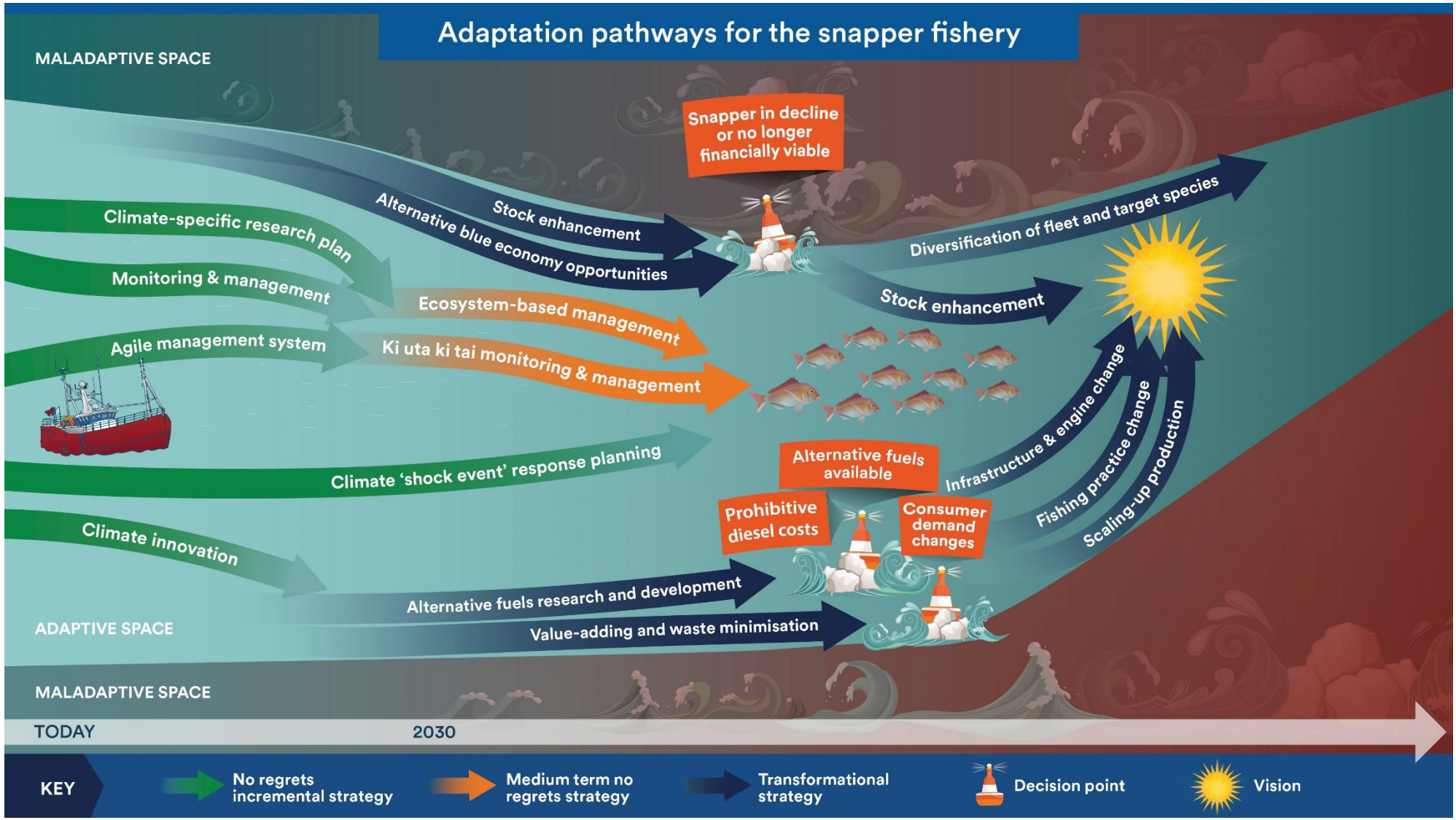
Evaluation and next steps

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 will be to design an implementation plan for the pathways, and to identify the cross-cutting strategies for seafood sector adaptation. How iterative adaptation pathways practice can be embedded within snapper fishery planning and management structures should also be determined.


Adaptation pathways for the snapper fishery
MALADAPTIVE SPACE
Snapper in decline or no longer financially viable
Stock enhancement
Alternative blue economy opportunities
Diversification of fleet and target species
Climate-specific research plan
Monitoring & management
Agile management system
Ecosystem-based management
Ki uta ki tai monitoring & management
Stock enhancement
Climate 'shock event' response planning
Alternative fuels available
Infrastructure & engine change
Fishing practice change
Scaling-up production
Prohibitive diesel costs
Consumer demand changes
Climate innovation
Alternative fuels research and development
Value-adding and waste minimisation
ADAPTIVE SPACE
MALADAPTIVE SPACE
TODAY
2030
KEY
No regrets incremental strategy
Medium term no regrets 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 predominantly 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 and responses 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.

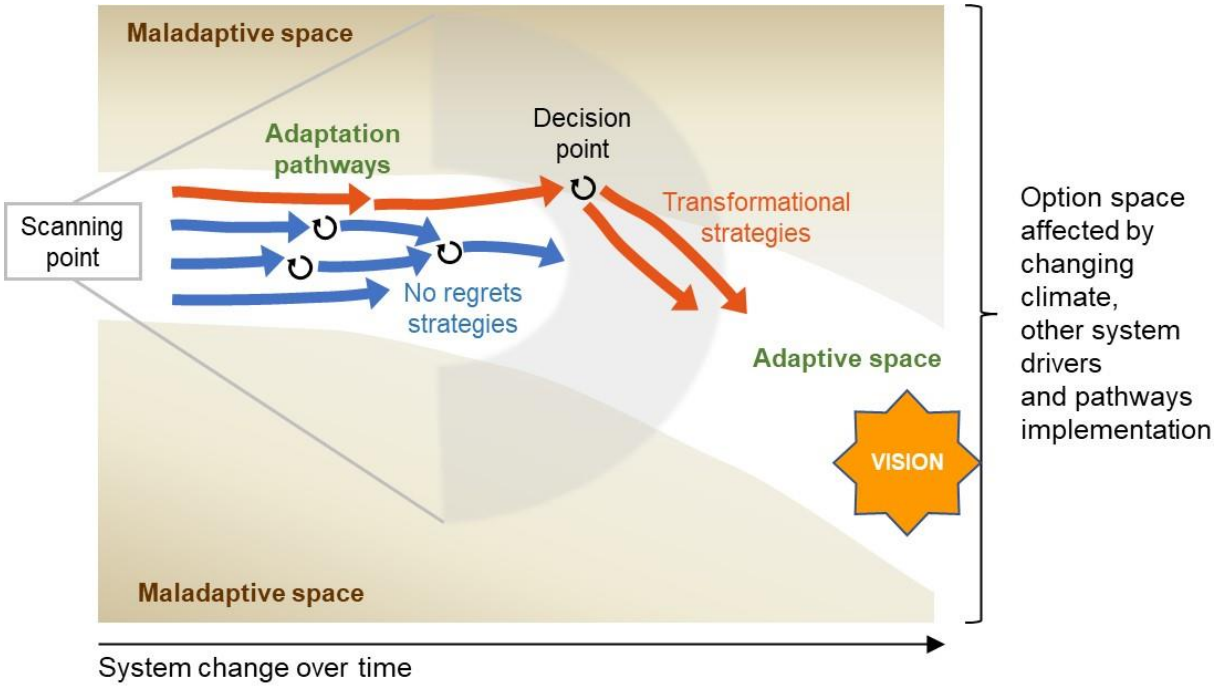

Figure 1. Adaptation pathways 'roadmaps' illustrate suites of strategies and related decision points, relative to the changing option space and a stakeholder-defined future vision for the system (adapted from Wise et al. 2014). Each pathway's process is a 'scanning point' that is repeated iteratively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

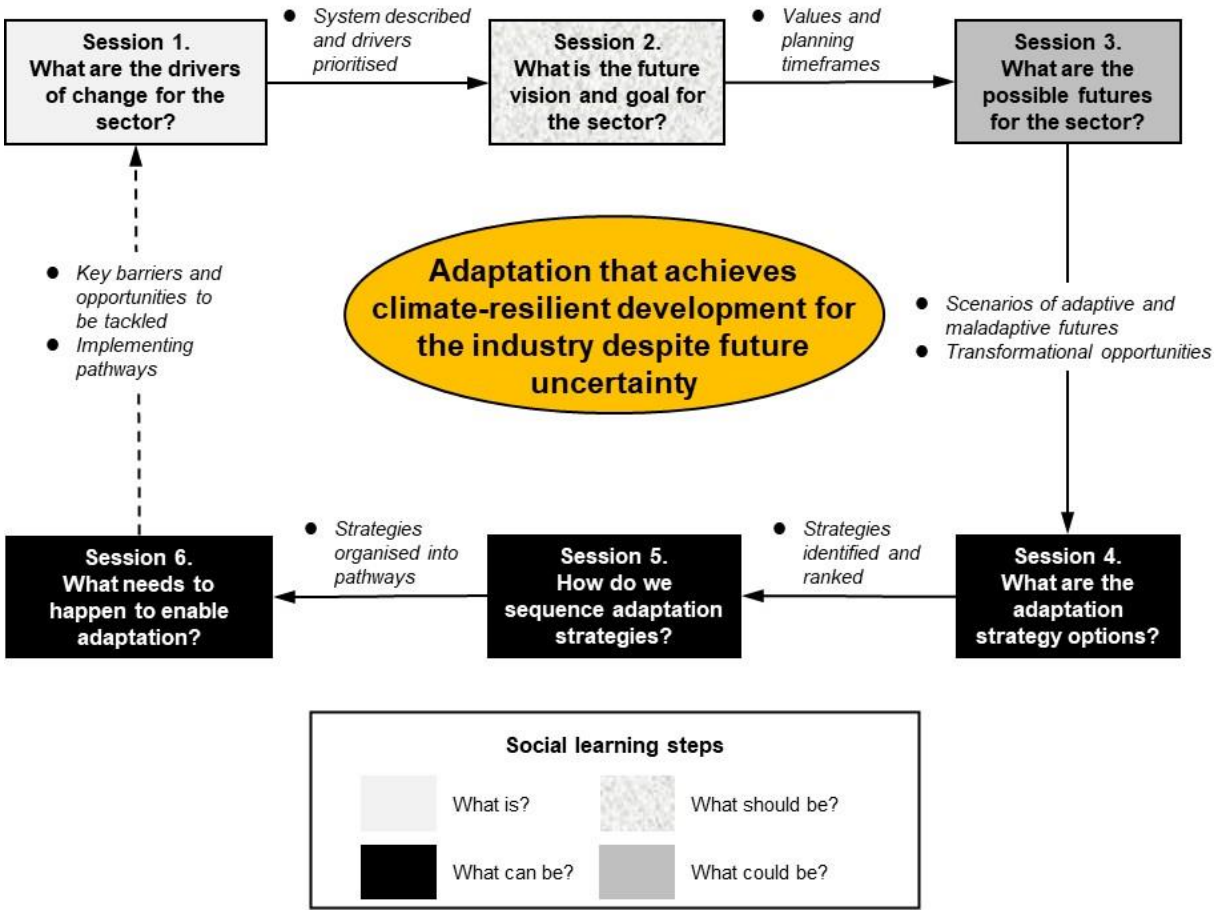

Figure 3. Phase 3 workshop process, adapting Brown and Lambert's (2012) decision-into-practice social learning steps into six sessions concerning adaptation in the seafood industry of interest.

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 options 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.

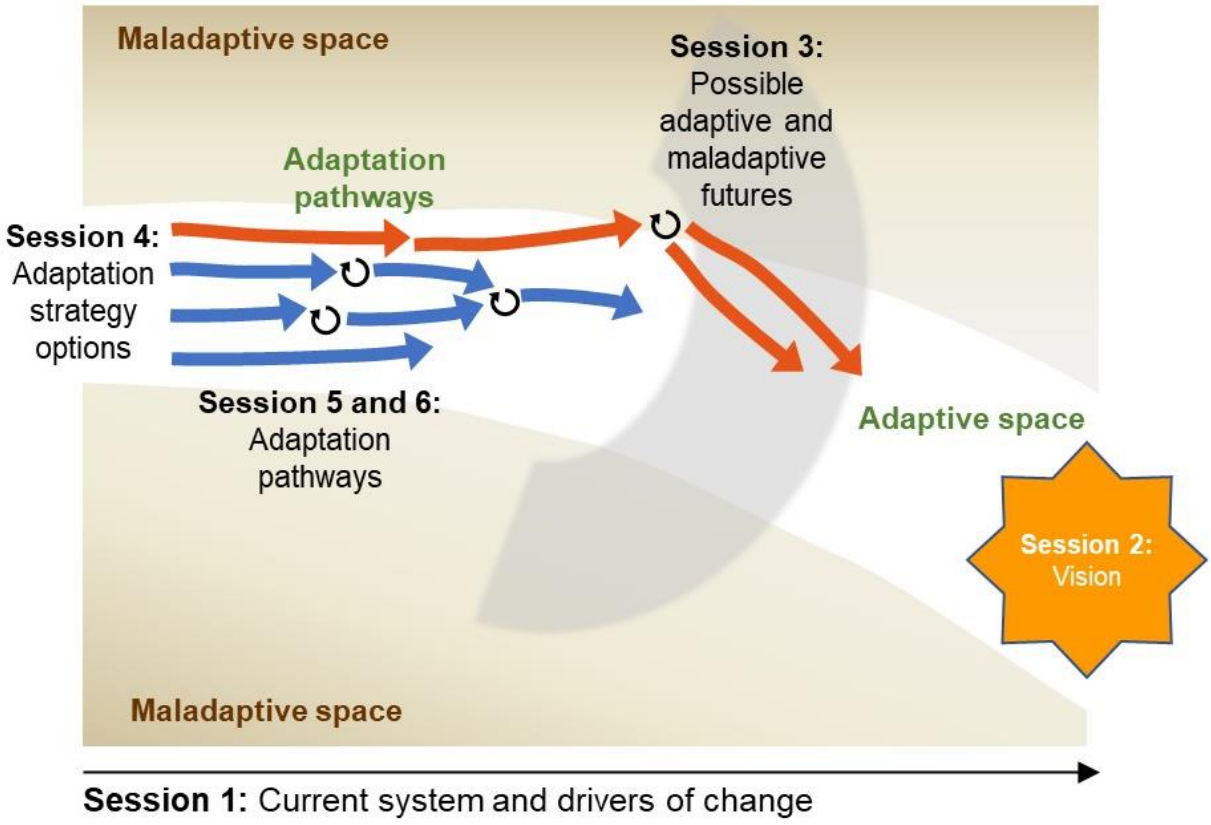

Figure 4. The Phase 3 workshop sessions superimposed on the Figure 1 adaptation pathways schematic.

3. SNAPPER FISHERY WORKSHOP

3.1. Workshop participants

The Phase 3 snapper fishery workshop was held at the Sanford Seafood School in Auckland on 9–10 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-three people participated (Figure 5), including nine representatives from industry and government, six members of the research team and eight 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 resources from Phase 2 were printed and placed around the room and on the tables.

Figure 5. Snapper 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 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 sector?

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

John Willmer (SAS IG and Seafood New Zealand) presented the characteristics, management and status of the snapper fishery. In summary, the fishery consists of a varied and complex mix of commercial, customary and recreational interests using trawl, seine and hook and line. The snapper fishery is one of the largest and most valuable coastal fisheries in Aotearoa New Zealand, with a total commercial catch of 6,714 tonnes in 2021/22. Snapper (tāmure, *Pagrus auratus*) are found most commonly around the North Island and the top of the South Island (Figure 6). The fishery is the largest recreational fishery in Aotearoa New Zealand, with harvests accounting for more than 40% of the total catch, but accurate data are not available. Snapper also form important fisheries for customary purposes, but the annual catch is not known.

Catches are managed through the Quota Management System using total allowable catch (TAC) and total allowable commercial catch (TACC) in five zones (Figure 6). Stocks are healthy and increasing, but an ageing fleet of commercial vessels, combined with the increasing cost of diesel fuel, is eroding the economic viability of many fishery businesses.

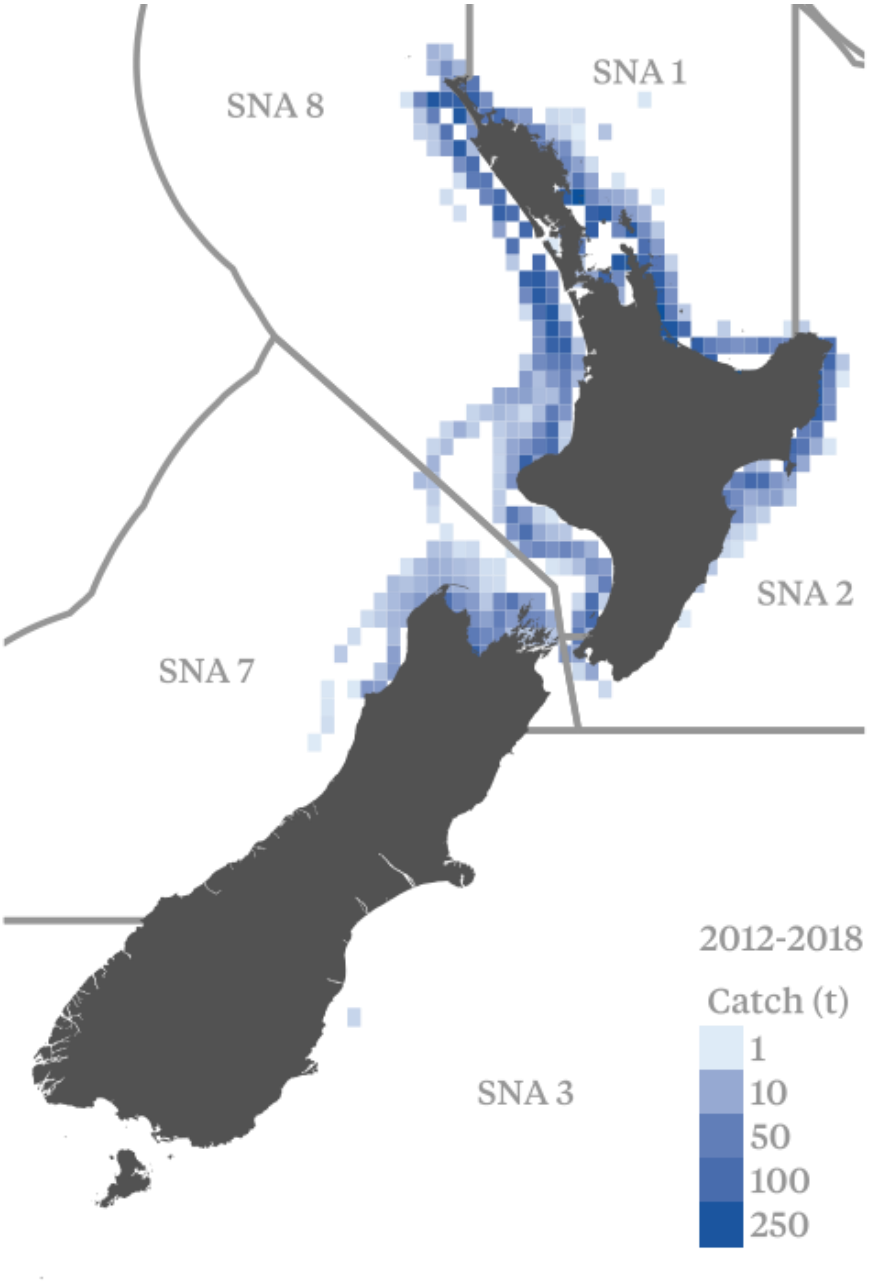

Figure 6. The five snapper fishery zones and spatial distribution of catches in 2012–18. Source: Snapper : Welcome to OpenSeas.

The Phase 1 analysis of climate change projections and potential impacts on snapper were then presented by Leigh Howarth (Cawthron) and Darren Parsons (NIWA), based on the species' life history, which depends on inshore habitats for spawning and juvenile recruitment (Figure 7). The initial assessment by Cummings et al. (2021) concluded that the species is 'moderately' vulnerable to climate stressors such as increasing temperature and acidification, and to the influence of other stressors, including sedimentation and declining water quality driven by land-use change and catchment run-off. Recent data have shown that coastal sedimentation is increasing in

many regions of Aotearoa New Zealand (Figure 8), and that the growing intensity of rainfall events due to climate change may further increase run-off.

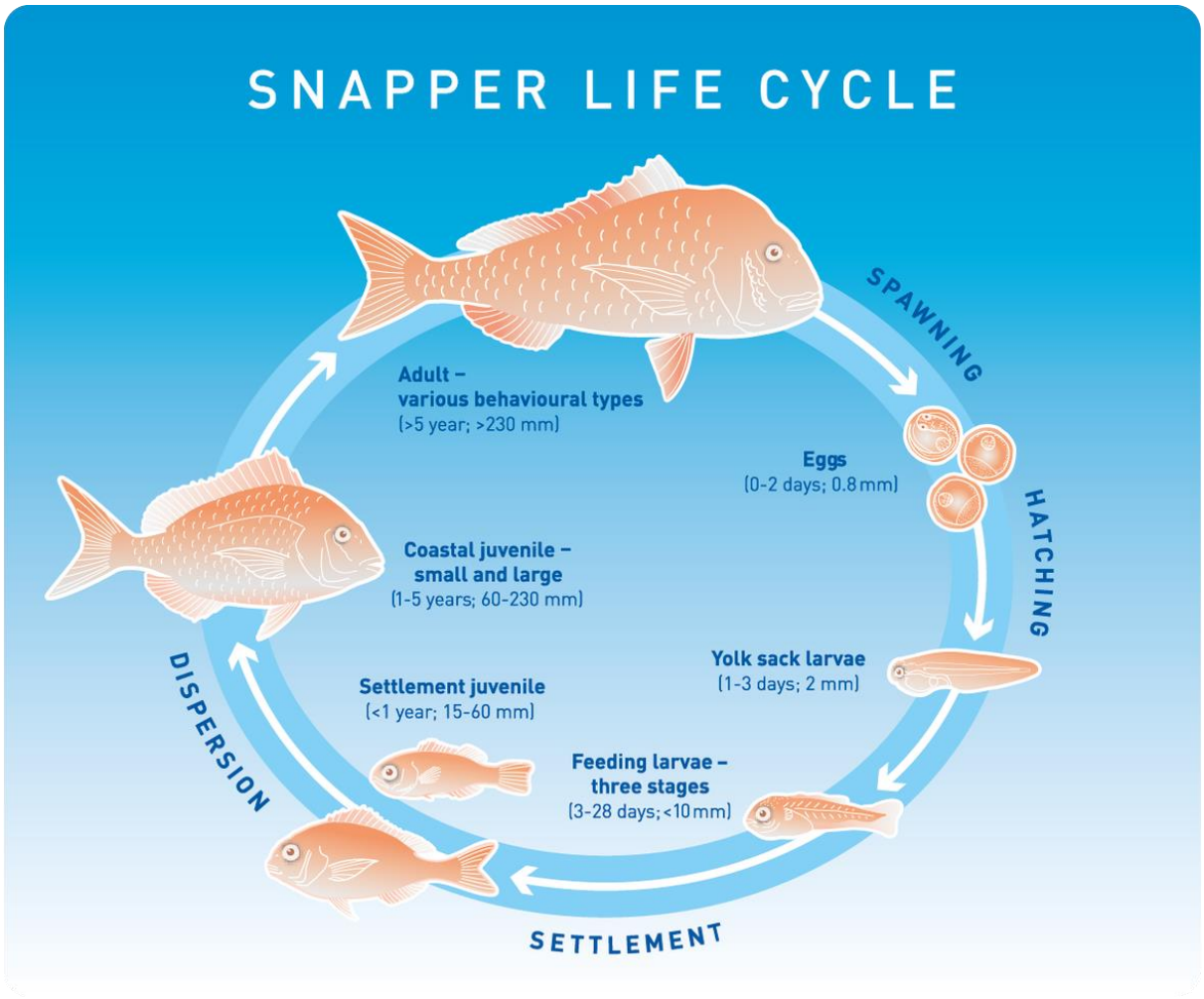

Figure 7. The life cycle of the snapper *Pagrus auratus*. Source: NIWA.

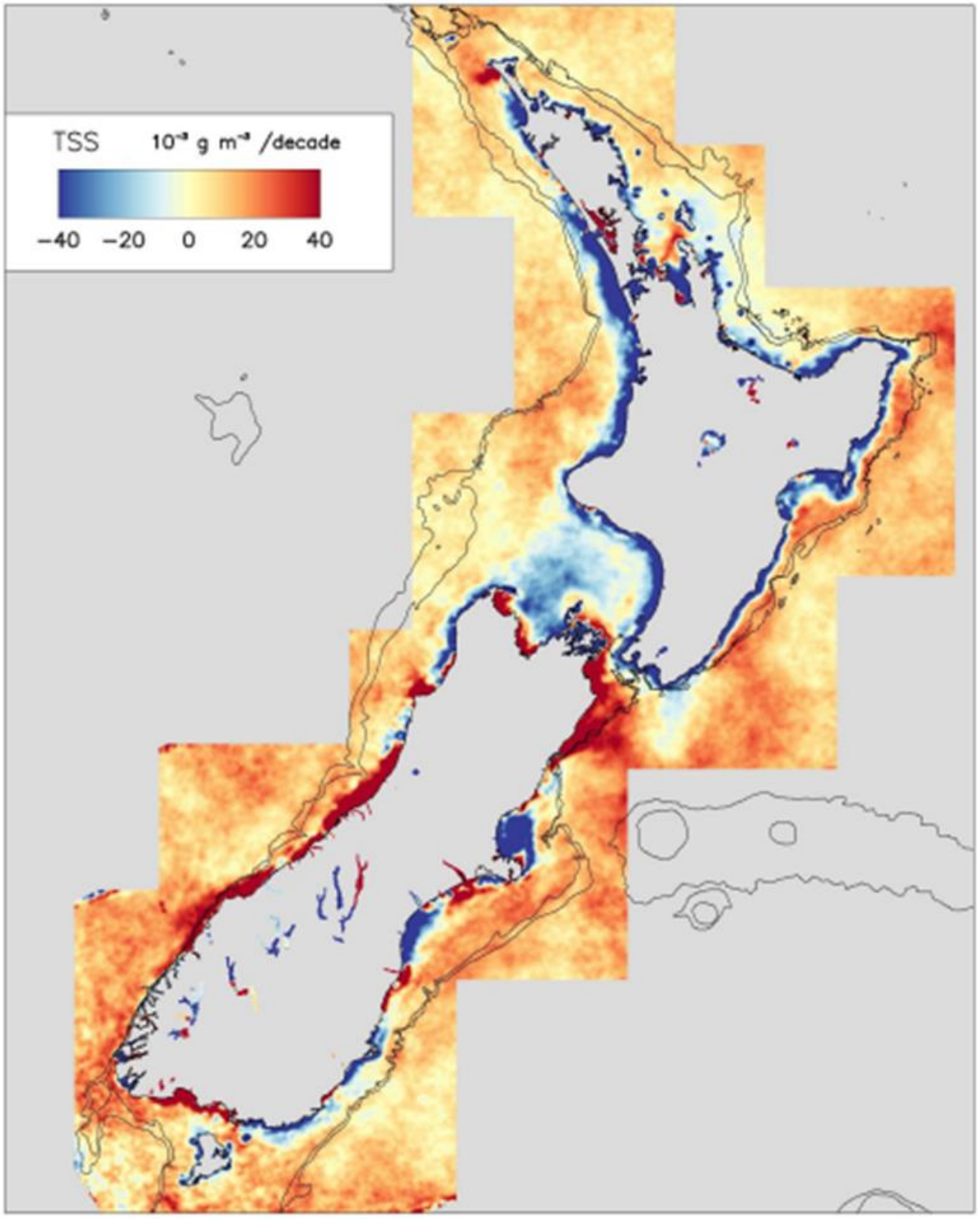

Figure 8. Spatial trends in monthly anomalies of total suspended solids (TSS) in 2002–21, where red indicates increasing trends and blue indicates decreasing trends. Source: MODIS-Aqua.

The Phase 1 collation of current knowledge revealed that there may be both positive and negative climate change effects on snapper (Figure 9):

Positive effects

- Increased growth rates and juvenile recruitment due to rising sea temperatures
- A southward shift in range due to warming seas, which may provide fishery opportunities in the South Island
- Increased survival of larval snapper due to acidification.

Negative effects

- Increased disease, physiological stress and reduced food supplies, as possibly exemplified by the occurrence of ‘skinny, milky flesh snapper’ during a marine heatwave in 2022–23
- New predator species and diseases
- Reduced larval performance and prey availability due to ocean acidification
- Changes in mixed layer depths, affecting ocean productivity
- Coastal erosion, affecting habitat, foraging and physiology
- Nearshore benthic (seafloor) habitat degradation due to run-off, sedimentation and invasive species, which impact key life stages
- Knock-on population effects from impacted earlier life stages.

Anticipating the direct influences of climate change on snapper is challenging due to a lack of comprehensive scientific knowledge and the combined effects of multiple cumulative stressors. Ecological tipping points were also unclear because of the many uncertainties. Due to the limitations of current monitoring data for the snapper fishery, it is difficult to detect trends. In addition, indirect effects from intensifying storms and rainfall events will likely exacerbate the ongoing influence of catchment and coastal erosion and riverine input into coastal zones, which will further impact spawning, juvenile life stages and habitats.

Storms are also likely to affect fishing conditions, and, along with sea-level rise, will impact coastal infrastructure (Figure 10).

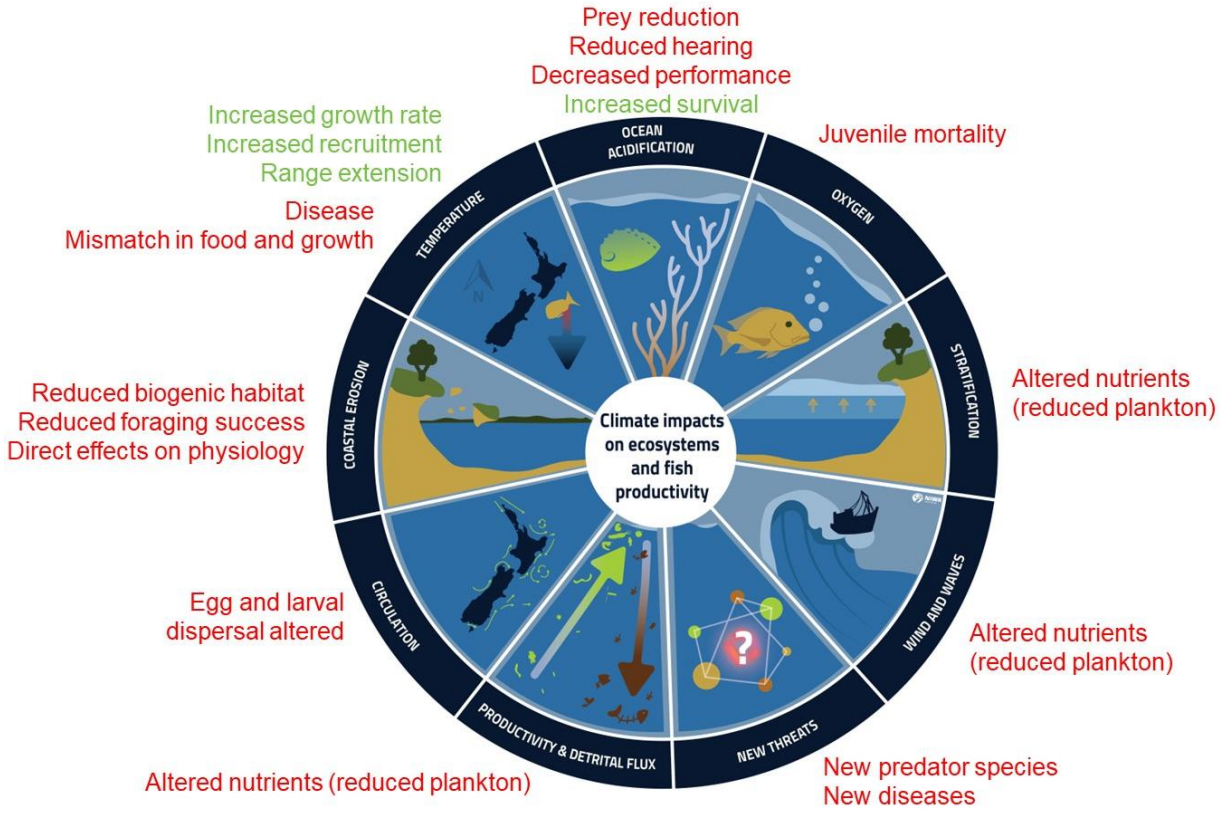

Figure 9. Summary of the Phase 1 analysis of potential positive (green) and negative (red) impacts of climate change variables on snapper (adapted from Cummings et al. 2021).

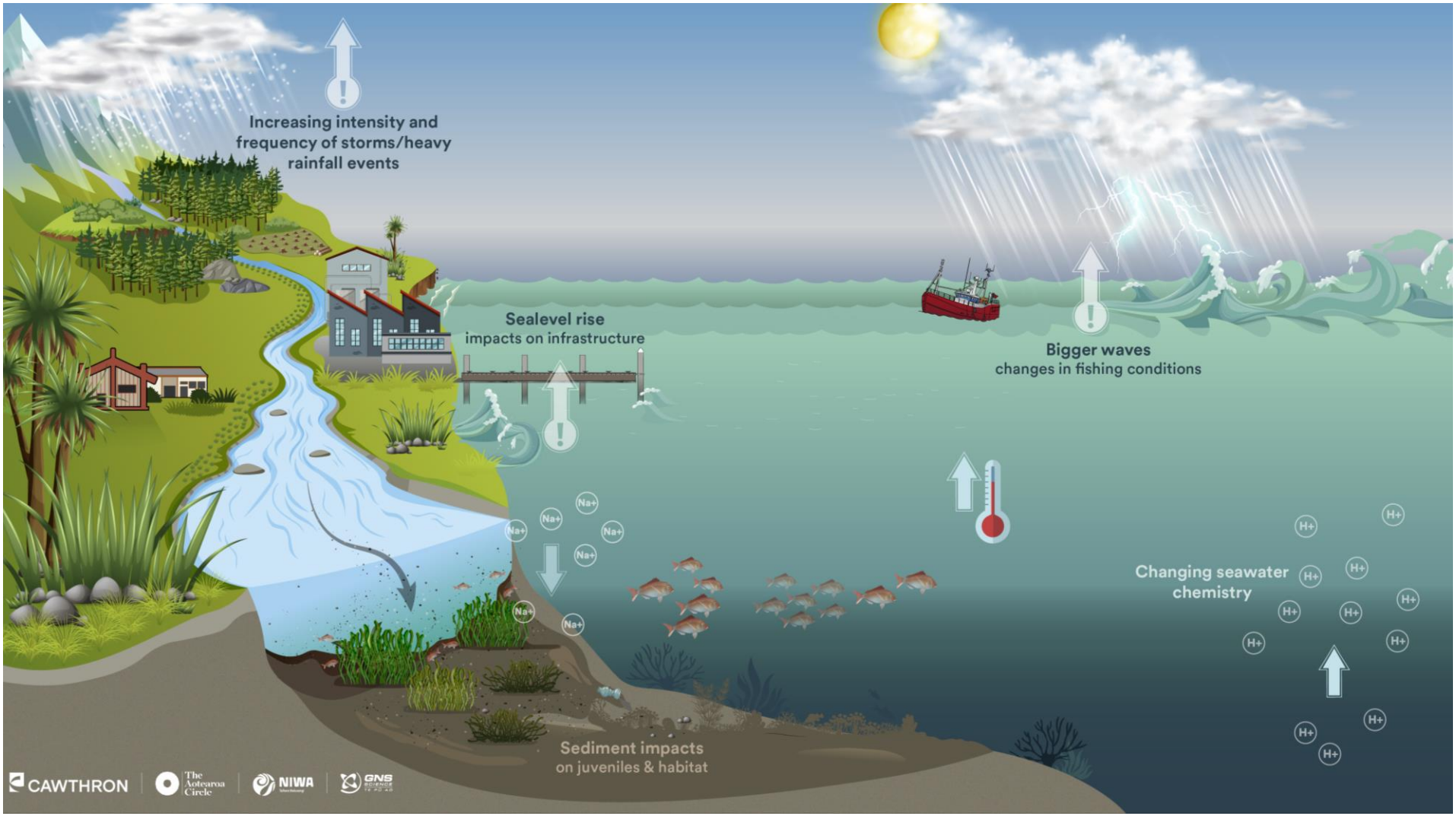

Figure 10. Summary of potential direct impacts of climate change on snapper, and on catchments and the fishing industry.

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 shrinking the gross margins of fishery businesses, and have 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. Growing investment in renewable energy technology to reduce greenhouse gas emissions may result in more competition with fisheries for inshore space – for example, through the construction of wind farms. 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 those vessels that can meet the operational demands of the fishery. Similar pressure is likely to bear on the supply chains upstream and downstream from fisheries.

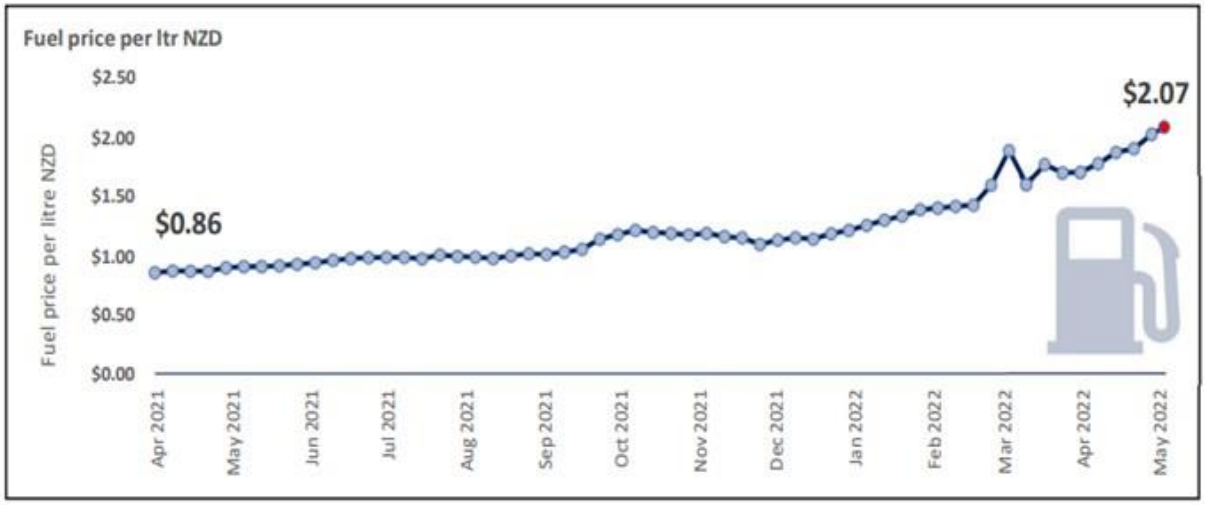

Figure 11. Changes in Aotearoa New Zealand fuel prices from April 2021 to May 2022. Source: Seafood New Zealand Inshore Council.

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

- Adjusting TAC and TACC annually in response to changing abundance or yields of stocks
- Enabling greater responsiveness using current fishery and stock data

- Using *New Zealand Gazette* notices to change input controls and spatial measures with more agility
- Amending the stock zones to allow shifts in fishing distribution and effort
- Scaling-out ecosystem-based management (EBM) to build resilience of habitats and species to climate change, particularly in terms of catchment run-off.

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

- Sustainable fuels
- Diversification of species targeted
- Traceability of products using block chain
- 100% use of fish carcasses
- Using artificial intelligence (AI) and machine learning to promote ‘smarter’ fishing methods
- Holistic ‘kono’ fisheries management
- Step-changing public opinion about fisheries to raise social licence to operate (SLO)
- EBM, from land to sea (ki uta ki tai)
- Genomic mapping of snapper stocks to improve management
- Ranching of juvenile snapper to overcome inshore habitat bottlenecks
- Sustainable financing models for smaller vessels and businesses.

Following these presentations, each group was asked to discuss what they considered to be the major drivers of change for the snapper 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. Policy and regulation scored highest, with 19 votes, followed by climate change with six (Table 1). Within the themes, the reduction in science and management investment was identified as the most important specific driver.

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

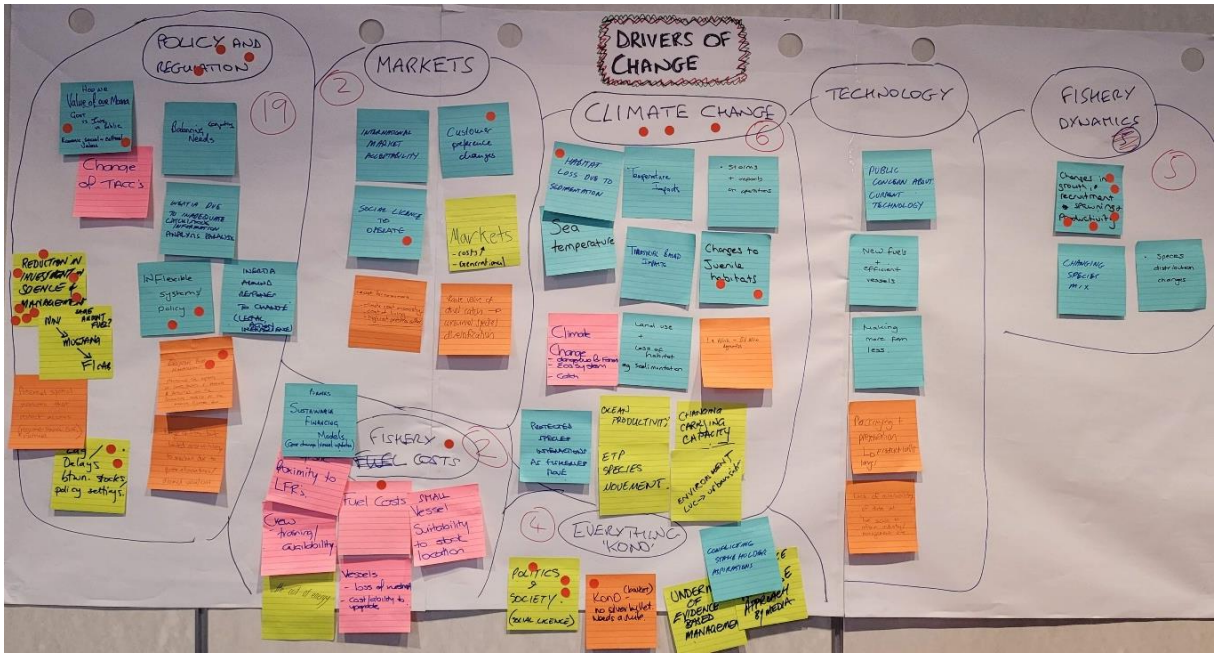

Figure 13. Sticky notes of individual drivers placed under driver themes in Session 1, and voting (red dot) stickers

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

Driver of change theme (total votes)	Driver	Specific votes
Policy and regulation (19)	Valuing our moana: economic versus cultural versus social values	2
	Inflexible policy, regulation and management	2
	Lags between stock assessments and policy response	2
	Inertia around response to change	
	Change of TACCs	
	Balancing competing stakeholder needs	
	Inertia due to inadequate stock information	
	Reduction in science and management investment	8
	Spatial measures that may restrict fishery access	
	EBM and land-based impacts	2
	Shifting range of snapper but limited access due to quota	
Markets (2)	International market acceptability	
	Customer preference changes	1
	Declining SLO	1
	Intergenerational costs	
	Increasing costs for consumers due to climate change	
	Raised value of other catch, leading to diversification	
Climate change (6)	Coastal habitat loss due to sedimentation	1
	Temperature impacts	
	Storm impacts on operations	
	Changes to juvenile habitats	2
	La Niña / El Niño dynamics	
	Climate change dangerous for fishing vessels	
	Protected species interactions as fishery moves	
	Changing carrying capacity	
	Urbanisation and land-use change	
Fisheries costs (2)	Sustainable financing models	
	Logistic proximity to less favoured regions	
	Crew training and availability	
	Small vessel suitability to stock location	
	Loss of investment and ability to upgrade	
Whole of system kono (4)	Politics and society, SLO	3
	Kono – need for a basket of approaches	
	Undermining of evidence-based management	
	Prevalence of win–lose approach in the media	
	Conflicting stakeholder aspirations	
Technology	Public concern about current fishing technology	
	New fuels and efficient vessels	
	Making more from less	
	Packaging and preservation means products last longer	
	Need for real-time data to inform management	
Fishery dynamics (5)	Changes in growth, recruitment, spawning, productivity	5
	Changing species mix	
	Species distribution changes	

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

The aim of Session 2 was to enable stakeholders to define their vision for the snapper 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 2040 as their target year, and one group selected 2050. There were several similarities between the groups. For example, Team Kakariki and Relentless Positivity had the following visions:

Team Kakariki (2040)

- More frequent stock assessments driven by low-cost data acquisition
- Nimble management system, temporally and spatially, working with industry
- Novel technology to increase productivity (e.g. ranching of juveniles to overcome nursery habitat bottlenecks)
- Improved SLO to eat wild-caught fish
- EBM, embracing a full range of value systems and stressors: ki uta ki tai
- A just transition for intergenerational equity
- Fishing is a more certain investment.

Relentless Positivity (2050)

- Certainty provided for investors
- Abundant stocks
- Responsive management of all sectors
- Resilient ecosystems
- Holistic EBM
- Enhanced profitability for firms and fishers to pay increasing costs
- Happy Greens, iwi and recreational fishers.

Additional features of other visions were: ‘maximising the total value of the catch by utilising the entire catch’, ‘reducing political influence in decision-making’, ‘increased accountability’ and ‘more transparency in the supply chain’. In summary, the composite vision for the fishery included:

- EBM that embraces a full range of value systems and stressors
- Nimble temporal and spatial management, working with all sectors of the fishery
- Enhanced profitability for firms and fishers to pay increasing costs
- Maximising the total value of the catch
- Certainty for investment into the fishery
- Improved SLO

- Novel technology to increase productivity
- More frequent stock assessments
- Abundant snapper stocks.

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

The aim of Session 3 was to explore potential futures for the snapper fishery, based on the uncertainties around the two primary driver themes selected by participants in Session 1 – i.e. policy and regulation, and climate change. To begin the session, the facilitators drew the two driver themes as axes, ranging from 'good' to 'bad'. In the case of climate change, 'good' represented moderate climate change, since elevated sea-surface temperatures, acidification, weather events and sea-level rise are inevitable, but 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 snapper fishery (Figure 14):

- Scenario A, with moderate climate change and improved policy and regulation
- Scenario B, with extreme climate change and improved policy and regulation
- Scenario C, with extreme climate change and poor policy and regulation
- Scenario D, with moderate climate change and poor policy and regulation.

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 draw (Figure 15), focusing on the year 2040 to correspond with the timelines they had selected for their visions in Session 2. They each drew their scenario on flip-chart paper and gave it a descriptive title, before presenting it as a narrative.

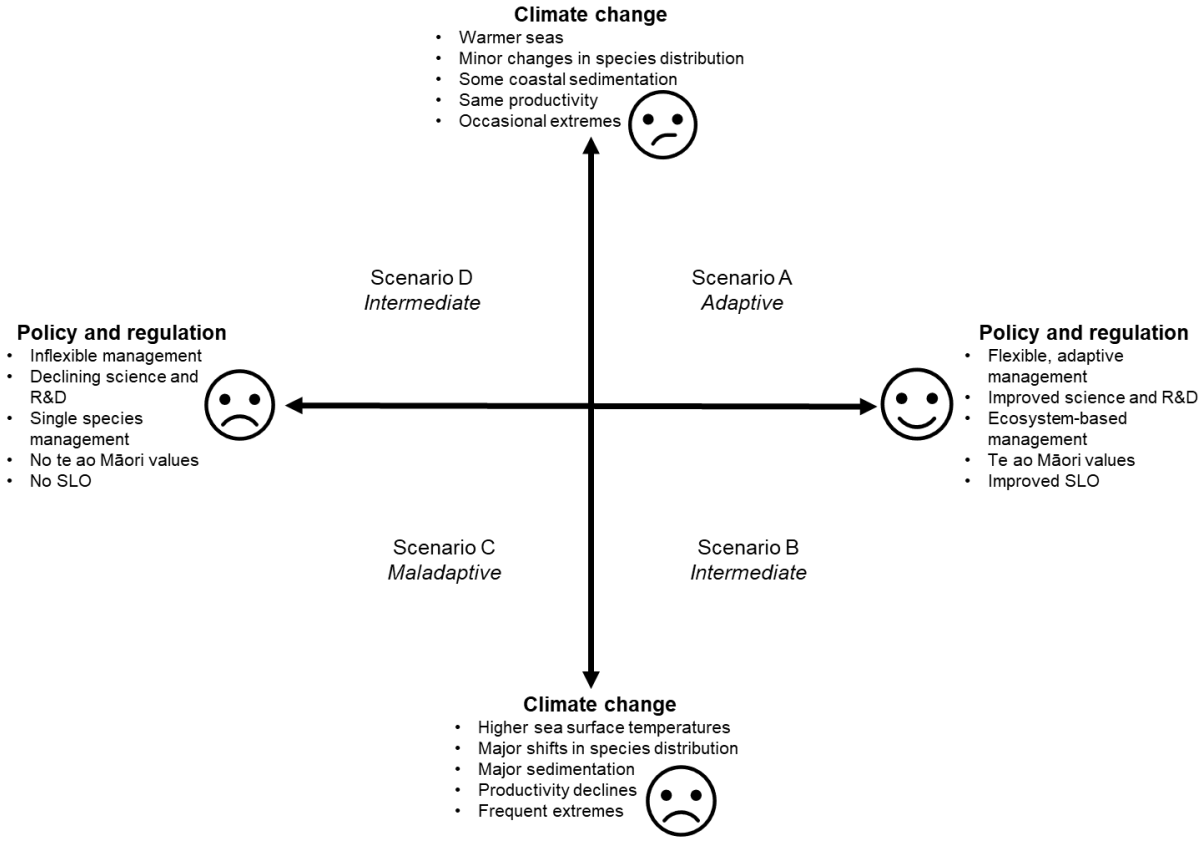

Figure 14. The matrix of scenarios derived from the primary driver themes identified by participants in Session 1, characterising different adaptive or maladaptive futures

Figure 15. Participants drawing future scenarios in Session 3.

Scenario A (adaptive future) was titled ‘Outrageously oarsome’ and explored the snapper fishery with moderate climate change and improved policy and regulation (Figure 16). This described a situation with committed investment in fisheries businesses by the banking sector; flexible and engaged policy and regulation; smart technological innovations, enabling more efficient fishery data management and integration; no-contact trawling; SLO and growing markets for wild-caught fish; and reduced land-based causes of coastal run-off through integrated ki uta ki tai ecosystem stewardship, and as a result, plentiful snapper stocks. As such, it reflected aspects of the visions produced in Session 2.

Scenario B (intermediate future) was titled ‘The world has gone to shit … but we handle it’ and depicted a situation with extreme climate change but improved policy and regulation (Figure 17). In this scenario, technology (e.g. Facebook-based catch reporting) enables the reflexive and adaptive management of marine heatwaves and their impacts on snapper stocks and the coastal environment. Improved regulation of catchments, including forestry, limits some run-off and nutrient enrichment.

Scenario C (maladaptive future), titled ‘No more tāmure’, was altered to ‘More Grinch’ to reflect a system with extreme climate change and poor policy and regulation (Figure 18). This represented a maladaptive system, where natural disasters impact the fishery and the broader economy, reducing confidence and investment in an ageing, fossil fuel–dependent fleet with high carbon emissions. Meanwhile, the lack of a common vision among stakeholders, continued public concern about fishery practices, and a top-down, inflexible approach by government limits the ability of the fishery to respond. This is exacerbated by poor investment in science, which limits monitoring of stocks.

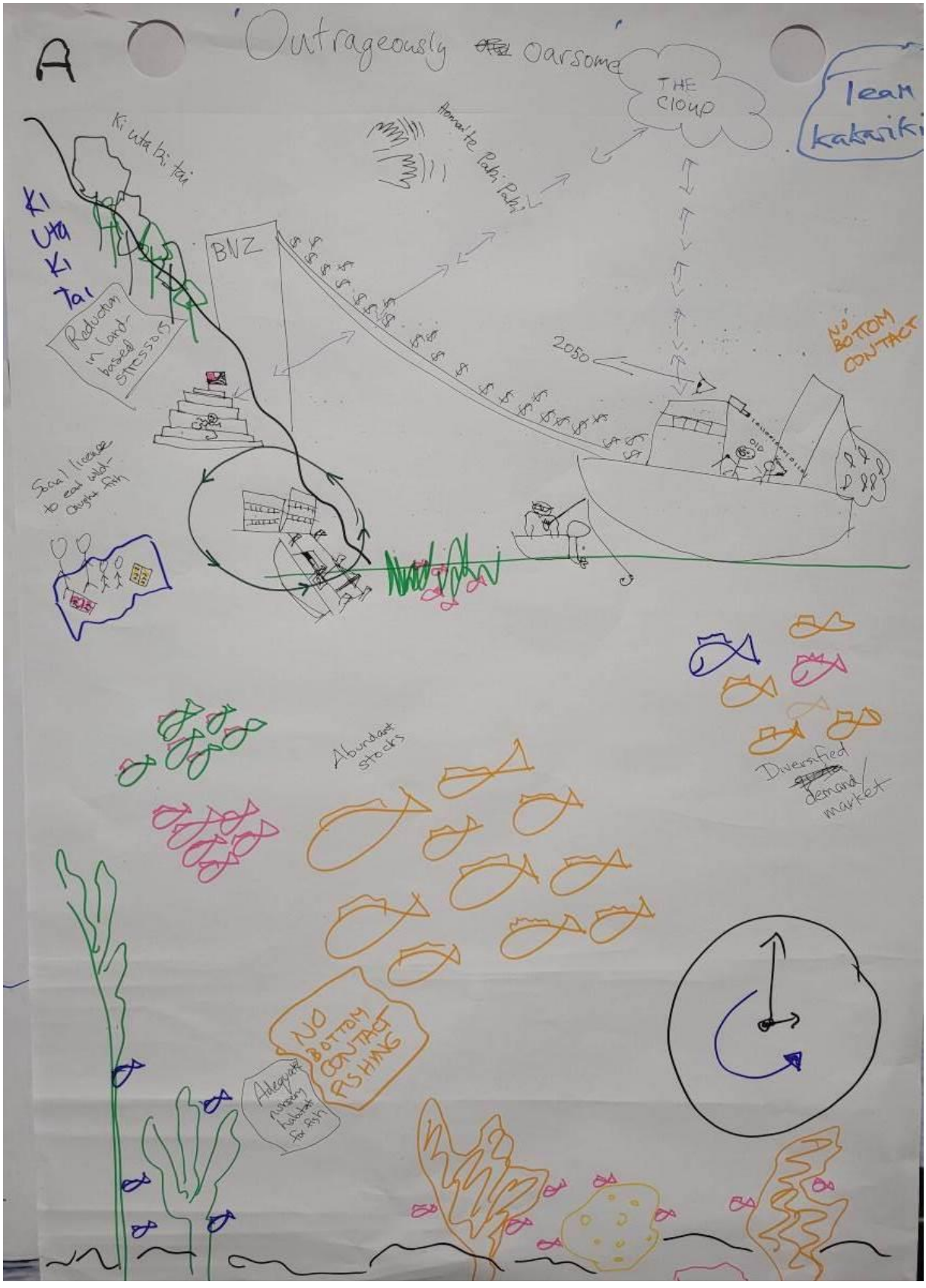

Figure 16. Scenario A, 'Outrageously oarsome', explored the snapper fishery in 2040 with moderate climate change and improved policy and regulation.

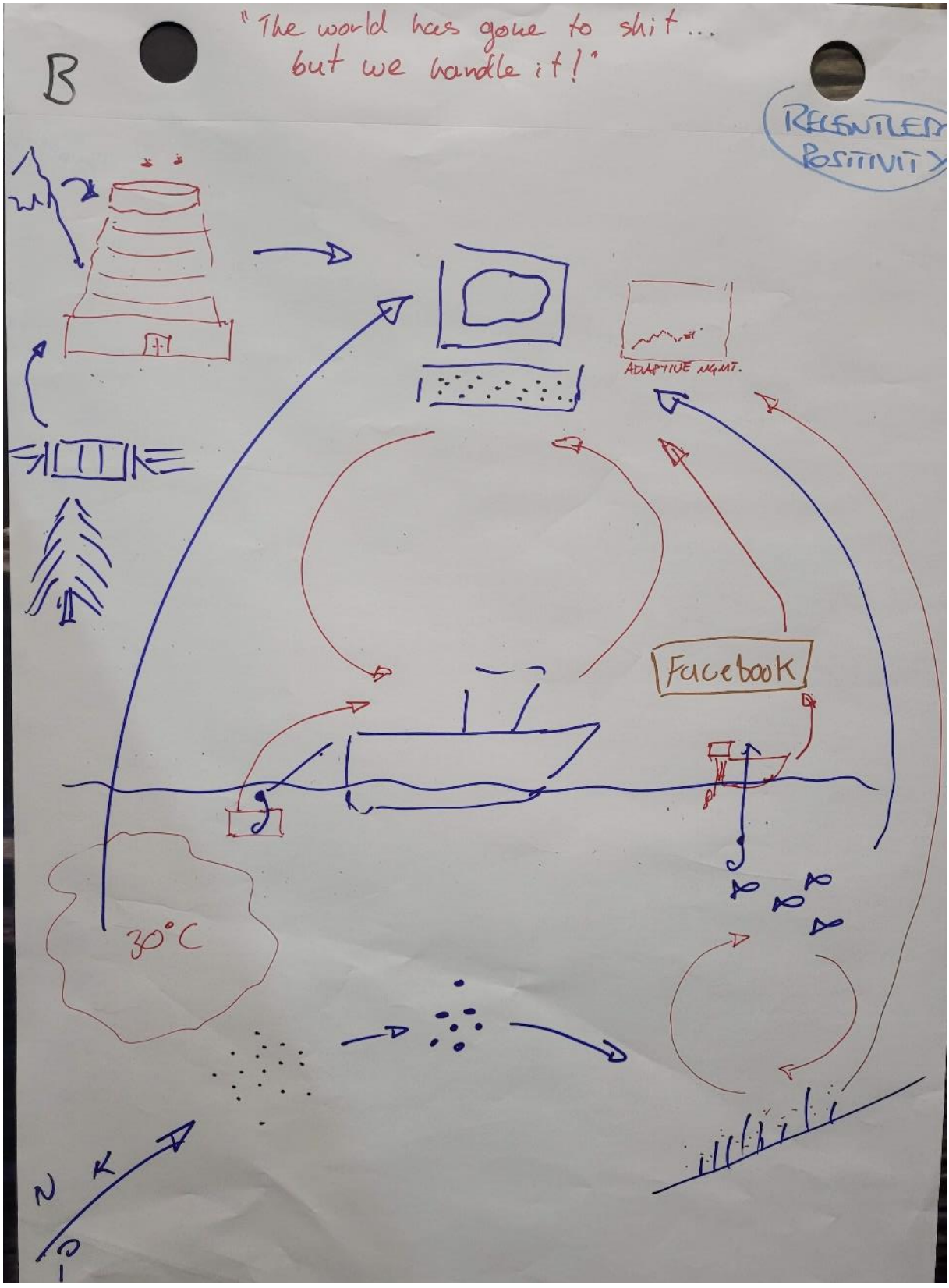

Figure 17. Scenario B, 'The world has gone to shit … but we handle it', explored the snapper fishery in 2040 with extreme climate change but improved policy and regulation.

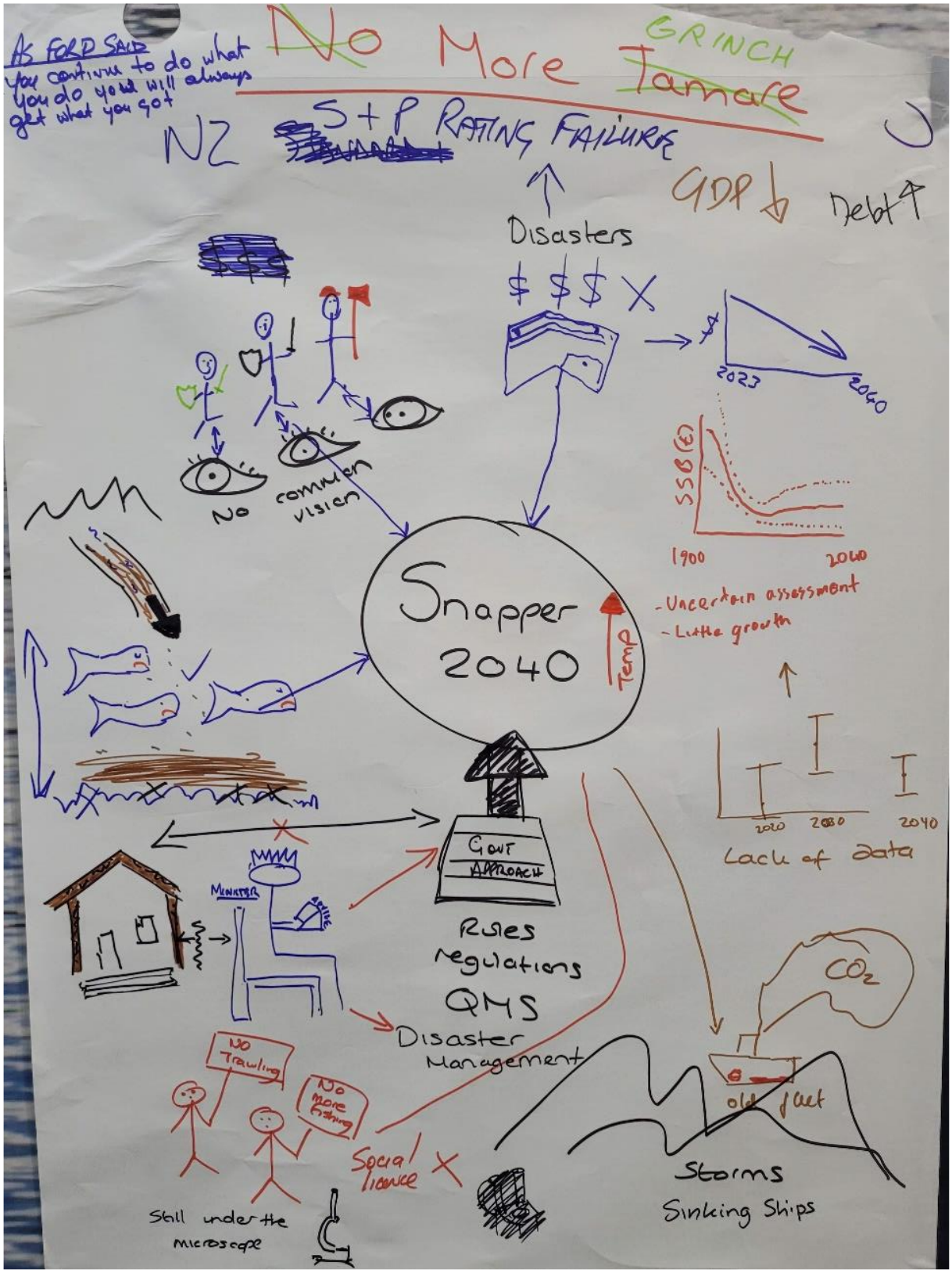

Figure 18. Scenario C, 'No more tāmure / More Grinch', explored the snapper fishery in 2040 with extreme climate change and poor policy and regulation.

Scenario D (intermediate future), titled ‘Warmly unregulated’, represented a situation considered to be the status quo – i.e. if no changes were made to the current system, with moderate climate change but disjointed and poor policy and regulation (Figure 19). The fishery would be overexploited, and catchment and land management would continue to have run-off and water quality impacts on coastal zones, and hence affect juvenile recruitment. The public would continue to criticise the sector for its fishery practices, undermining markets and economic viability. Climate effects, including weather extremes and rising marine temperatures, would affect stocks and the ability of the fleet to operate, and the fleet would still be dependent on fossil fuels and have high carbon emissions.

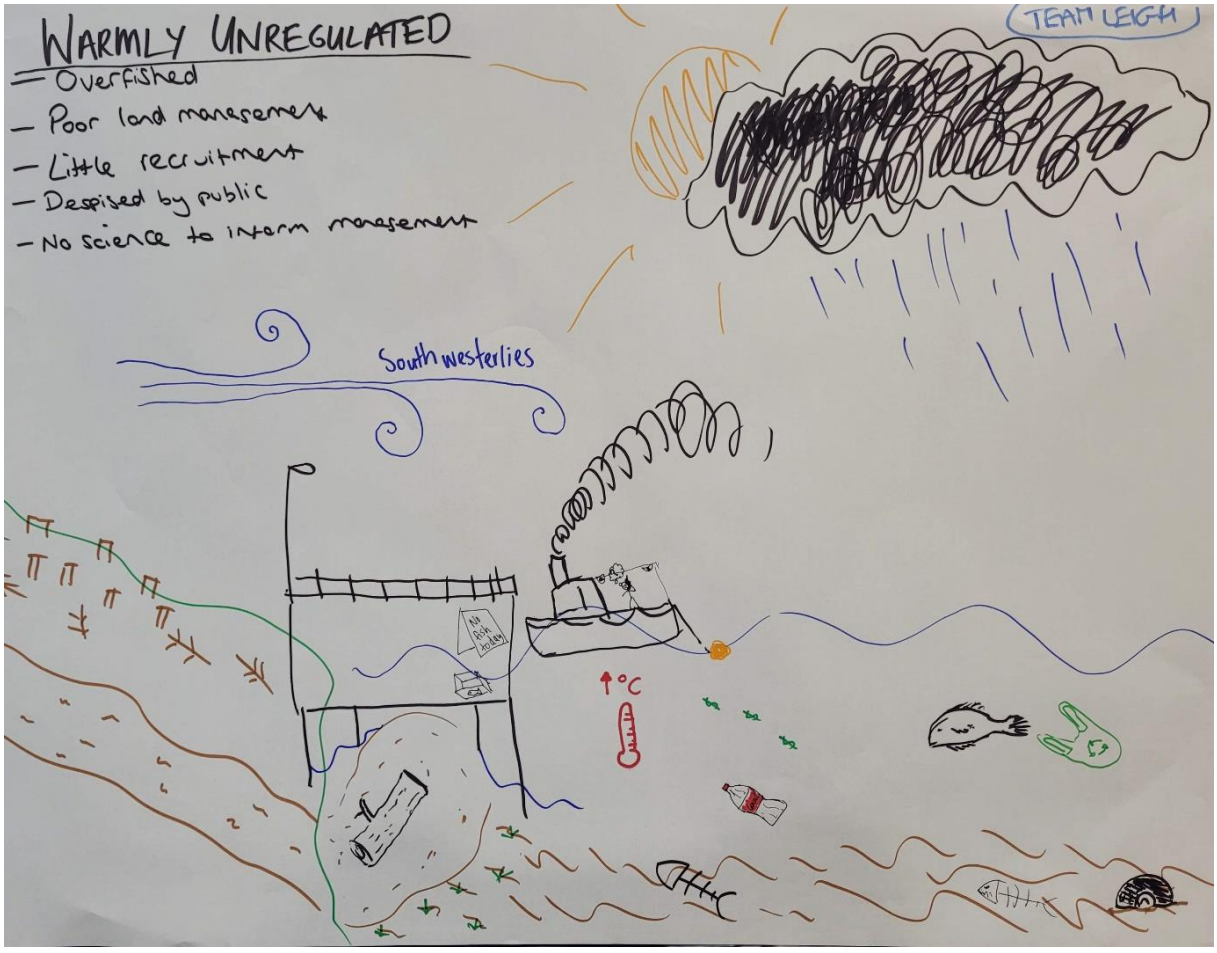

Figure 19. Scenario D, ‘Warmly unregulated’, explored the snapper fishery in 2040 with moderate climate change and poor policy and regulation.

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 snapper fishery developed by Cummings et al.

(2021) through a process involving experts and stakeholders were presented as follows:

- Modify stock assessments to incorporate climate change factors
- Reassess stock boundaries and quota management areas (e.g. via the Fisheries Act 1996, industry voluntary measures, more frequent monitoring)
- Undertake monitoring to inform the fishery and its management (e.g. juveniles, gonad state, disease, predators, competitors)
- Identify and measure differences in stock responses (e.g. size at maturity, population age structure)
- Expand efforts to reduce coastal erosion, sedimentation and land-based pollution and improve water quality, alleviating potential for sediment inputs and coastal acidification.

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). These were placed on a 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 and 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 (Figure 21). The following morning, this was presented back to the groups for feedback and discussion.

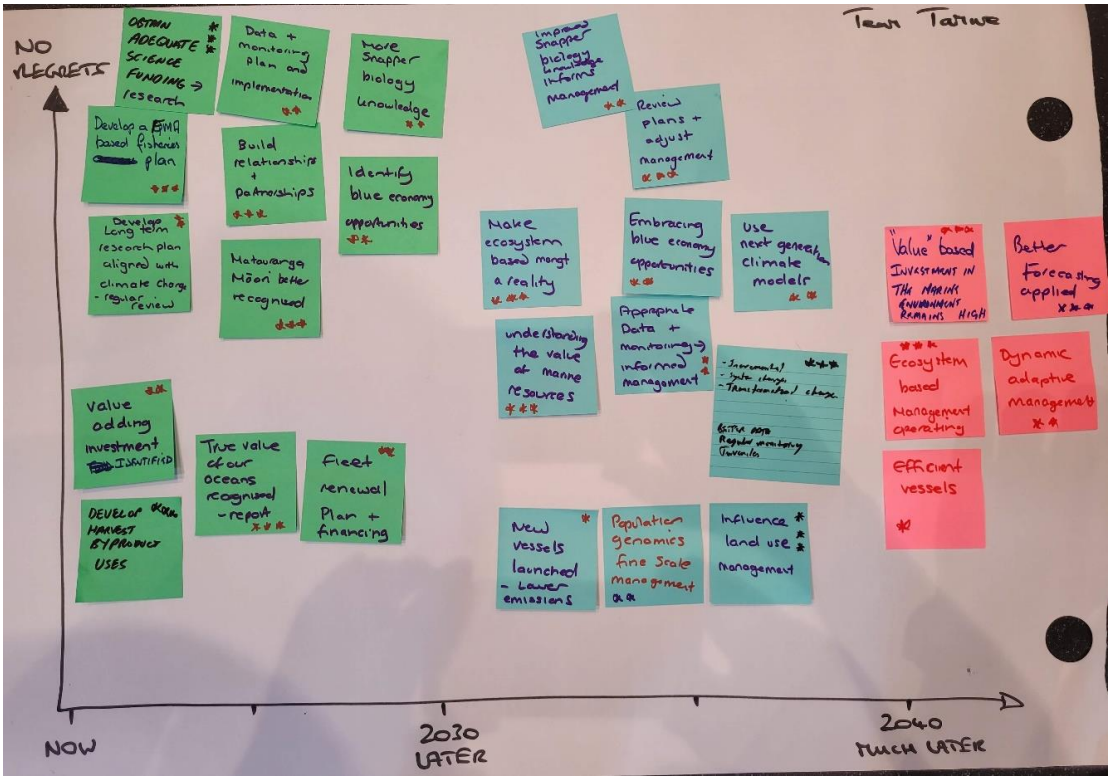

Figure 20. Adaptation options differentiated by time and risk in Session 4.

Figure 21. The groups' adaptation options collated into themes, differentiated by time and risk.

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 three categories: no regrets and incremental, medium-term no regrets, and transformational. Participants were divided into three groups, and each was assigned one of the categories and given all of 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 (Figure 22). Where possible, they were also asked to identify decision points where one set of strategies would shift to another.

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. Figure 23 synthesises the final set of 11 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, 3 and 4.

Figure 22. Participants organising adaptation strategies into pathways of actions and stakeholders responsible.

Eleven pathways were identified to achieve the vision. While some strategies did not address climate change specifically, they all bolstered the industry's capacity to prepare for, and cope with, future change and uncertainty. Five were no regrets strategies to be implemented immediately (Table 2):

- Climate-specific research plan and priorities
- Monitoring and management
- Agile management system
- Climate 'shock event' response planning
- Climate innovation.

A further two pathways were no regrets strategies to be implemented in the medium term: ecosystem-based management, and integrated ki uta ki tai (mountains-to-sea) monitoring and management (Table 3). These would be supported and informed by the outcomes of the climate-specific research plan, monitoring and management, and agile management system pathways.

Four pathways were potentially transformational, and required preparatory steps by 2030 (Table 4):

- Stock enhancement
- Alternative blue economy opportunities
- Value-adding and waste minimisation
- Alternative fuels research and development.

For stock enhancement and alternative blue economy opportunities, a key decision point triggering their implementation would be a decline in snapper stocks, or when the fishery was no longer financially viable. For value-adding and waste minimisation, the trigger would be global consumer changes and aversion to carbon-intensive transport. For alternative fuels, it would be prohibitive diesel costs and / or alternative fuels becoming available, and changes in markets or government drivers. In all four cases, the decision points would result in major changes to the snapper fishery that would be necessary to achieve the 2040 vision, or diversify beyond the vision.

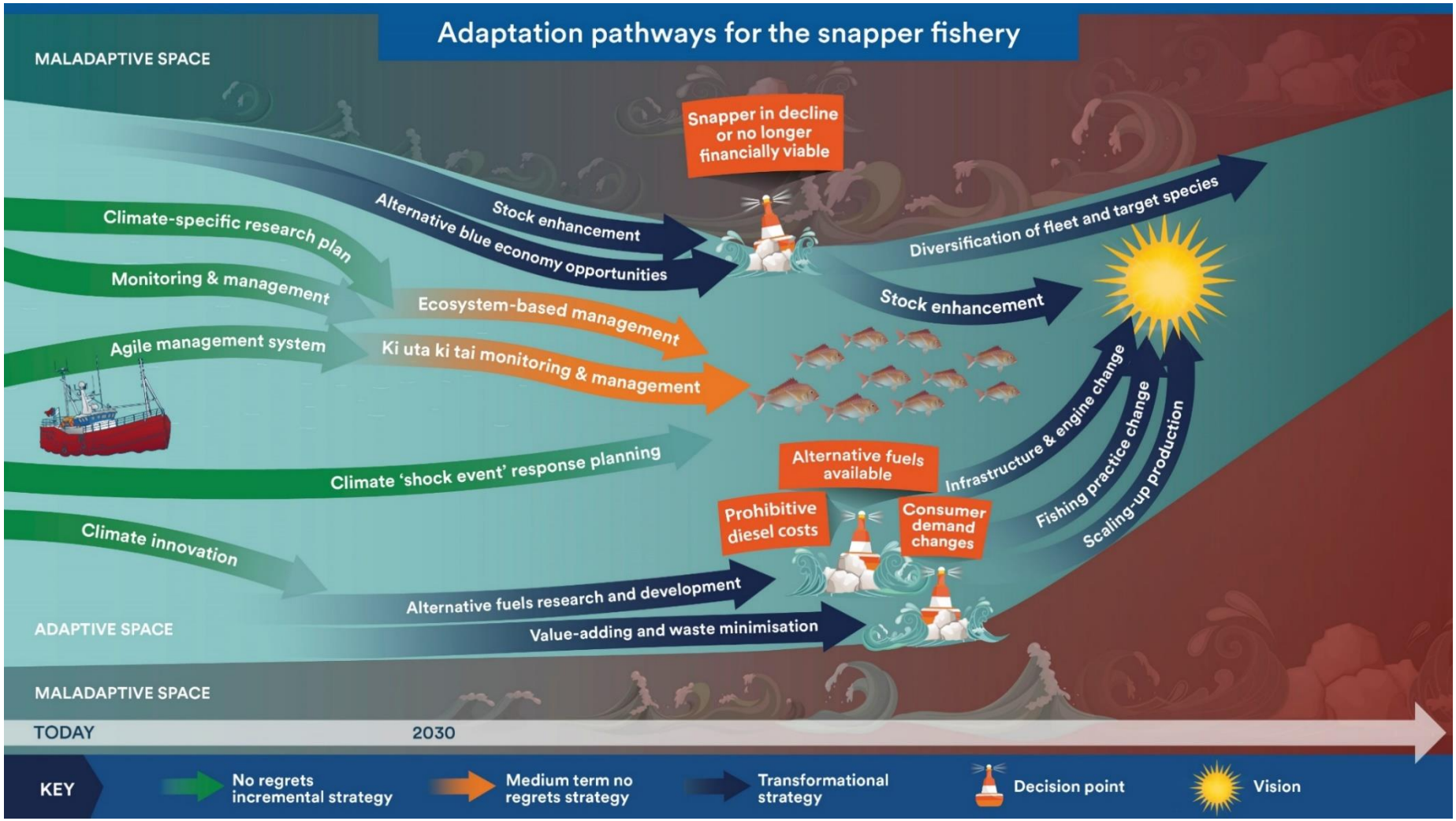

Figure 23. Synthesis of the 11 adaptation strategy pathways for the snapper fishery identified in Session 5, organised into their categories of no regrets and incremental, medium term, and transformational, and showing timelines and key decision points. Details of each pathway are given in Tables 2, 3 and 4.

Table 2. Details of the five no regrets incremental strategies and their pathways in terms of the actions and decision-makers involved, and approximate time frames for the snapper fishery to achieve the 2040 vision.

Strategy	TODAY Action 1	2025 Action 2	2030 Action 3	2035 Action 4
Climate-specific research plan and priorities **links to 'Ecosystem-based management' and 'Ki uta ki tai monitoring and management' in Table 3*	• Determine scope of the climate-specific research needed; include government and scientists; led by industry • Determine climate-specific research priorities – what are the things we need to monitor / measure: ○ Stocks (managing a mixed fishery) ○ Ecosystem and habitat dependencies ○ Climate forecasting (e.g. impacts of La Niña / El Niño events) ○ Fisher / management responses (research informs fisher response, including innovation in fishing operations) ○ What are the tipping points and warning signs? • Why do we need to measure? • How can we measure? • Formulate climate-specific research plan and priorities	• Identify research delivery options • How will research be funded? • Deliver research outputs, as per research priorities		
Monitoring and management **links to 'Ecosystem-based management' and 'Ki uta ki tai monitoring and management' in Table 3*	• Industry identifies key performance indicators (economic and environmental) for management decisions • Feed this into research prioritisation (what, why and how monitoring and management will be implemented) • Review data needs to undertake monitoring: ○ What information do we get from trawl surveys? ○ How does this inform agile decision-making (or our understanding of stocks)? ○ Could that information be generated in a different way? ○ What level of certainty / risk is acceptable in the information informing decisions?	• Real-time monitoring of the environment • Juvenile monitoring, disease monitoring and gonad condition • Synthesis of data • Data identify gaps / issues, informing a work plan to guide better management decisions		

	○ What other information do we need (e.g. life cycle, environmental, ecosystem?) • Identify options for monitoring key performance indicators for management decisions, e.g. training AI cameras to collect data on stock sizes and health • Identify data-sharing opportunities across organisations (start now and build out as the understanding of information needs grows) – why, what, who, how? • Integrate catch data: ○ Innovate / consider alternative stock assessment surveys (FNZ, NIWA) ○ Combine trawl surveys and fisher, observer and e-book data		
Agile management system **links to 'Ecosystem-based management' and 'Ki uta ki tai monitoring and management' in Table 3*	• Define what agile fisheries management means – what would it be expected to do? • Gap analysis – can the current system deliver agile fisheries management? • Develop a plan to transition, if needed • Continue practice of developing voluntary measures in response to changes in stocks (e.g. localised measures) • Identify a process to capture fisher information to be considered in fisheries science and management decisions	• Economic key performance indicators for the fishery • Identify options for more agile decision-making in response to performance indicators • Sector-level arrangements (e.g. spatial measures, harvest control rules) • Fisher information (on the ground) informs stock assessment and management response *(*links to integrated catch data, above)* • Develop a system to identify voluntary	• How is the system working against key performance indicators? • Monitor and review

		measures responding to changes in stocks		
Climate 'shock event' response planning	• Define financial risks and costs analysis with inflation • Businesses develop business viability indicators (company level) • Planned responses to shock events (e.g. fishing less, fishing in alternative places, fishing in different ways [innovation – see below])	• Financial disaster safety net for fishers – business finance planning • Understand that support is available		

Climate innovation	• Needs analysis and identification of innovation opportunities (e.g. consider options to change gear to let out unwanted catch due to climate change impacting abundance / distributions, changing how gear operates for vessel efficiencies)
	• Establish a baseline for fuel use (e.g. fuel used per kg of catch):
	  ○ Record-keeping of fuel use per nm travelled
	  ○ What innovation is needed to minimise fuel burn (e.g. cameras in the net will mean fishers will know when bag is full and can stop fishing)
	• Marine engineers present solutions to boat builders on possible alternatives to reduce fuel burn and alternative catch methods
		• Based on the needs analysis, scope and price innovation opportunities identified
		• Identify fisher transition plans if needed
		• Identify funding avenues
		• Forecasts of wind, wave temperature, mean wave height, heat waves
		• Finding use for new / alternative catch – engage with licensed fish receivers (LFRs) regarding new market opportunities (for bycatch, new fish in area, catching something else)
			• Website with solutions / contractors as a resource for fishers who haven't yet innovated	• Real-time environmental monitoring
				• Alternative fuel use

Table 3. Details of the two medium-term no regrets strategies and their pathways in terms of the actions and decision-makers involved, and approximate time frames for the snapper fishery to achieve the 2040 vision.

Strategy	TODAY Action 1 (*who?*)	2025 Action 2 (*who?*)	2030 Action 3 (*who?*)	2035 Action 4
Ecosystem-based management	• Agreed understanding of how ecosystem supports fisheries resilience and identified priorities for implementation – linked to research priorities (*independent working group*) • Identify what work has already been undertaken by Sustainable Seas National Science Challenge and what outputs are relevant to a climate adaptation plan for snapper / inshore fisheries	• Identify gaps and opportunities / priorities to progress EBM • Identify opportunities to support ecosystem resilience, restoration and enhancement programmes (e.g. shellfish, habitat, seagrass and seaweed restoration)	• Share experience and learning and publicise (*stakeholders and iwi*)	
Ki uta ki tai monitoring and management	• Protect snapper and protein production (*stakeholders, scientists, communities*) • Undertake monitoring: trawl surveys, land run-off and environmental data (*research organisations*)	• Develop a plan for a localised snapper case study (*stakeholders, scientists, communities, iwi, government*) • Holistic re-evaluation of oceans		

Table 4. Details of the four transformational strategies and their pathways in terms of the actions and decision-makers involved, key decision points and approximate time frames for the snapper fishery.

	2025	?	?	?
Strategy	**Action 1 (*who?*)**	***DECISION POINT***	**Action 2 (*who?*)**	**Action 3 (*who?*)**
Stock enhancement	• Feasibility study and risk assessment	*Snapper in decline or no longer financially viable*	• Acquire funding for stock enhancement (*research–industry collaboration*)	• Feasibility study and survival rates of stocked fish (*research–industry collaboration*)
Alternative blue economy opportunities	• Identify blue economy opportunities (*Crown Research Institutes and fishers*)	*Snapper in decline or no longer financially viable*	• Change fishery target to alternative species (*industry and government*) • Multi-use platform vessels to diversify fleet • Fishery vessels become research platforms	• Fish, seaweed and shellfish aquaculture • Boutique alternative wild-caught fish
Value-adding and waste minimisation	• Maximum utilisation of by-products for maximum value (*Plant & Food Research*) • Consider waste management options, e.g. regional rendering plant (*industry and Crown Research Institutes*)	*Global consumer changes and aversion to carbon-intensive transport*	• Scaling up production to match consumer changes (*industry*) • Fishing practice change (*fishers*)	• Source raw origin material for lab- or cell-based culture or similar
Alternative fuels research and development	• Fuel use data collected in other actions also relates to this • Fuel change research (*global science*)	*Prohibitive diesel costs and / or alternative fuels become available, changes in markets or government drivers*	• Choose suitable maritime fuel (*International Maritime Organization, free market*) • Consider alternative lower-carbon distribution methods	• Infrastructure and vessel energy system change (engine) change

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. Issues raised by participants were:

- The need for a shift in mindsets towards future opportunities, and a will to do so
- The need to rethink the value of moana
- Consideration of transfers in costs and values – for example, through a 'polluter pays' scheme for land-based pollution and run-off into coastal zones
- A lack of evidence and / or awareness about the issues experienced by the snapper fishery
- The need for an agreed strategy for the snapper fishery, with clearly defined success targets
- The need for access to appropriate financial instruments to enable the implementation of adaptation pathways
- A lack of trust among stakeholders in the fishery
- Entrenched views among stakeholders
- No space to take risks
- Stakeholders' limited capacity to engage and inform one another
- A lack of agility within the system to respond
- High levels of complexity and uncertainty
- Significant knowledge gaps
- Disconnections between the components of the ecosystems (i.e. inshore, ocean, catchments).

Many of these represented systemic barriers to action – for example, inherent mistrust among stakeholders and entrenched views. However, the workshop process may have enabled steps to be taken towards addressing these and other issues, such as the need for an agreed strategy 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 below).

4. WORKSHOP EVALUATION

An online questionnaire survey was sent to participants 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.

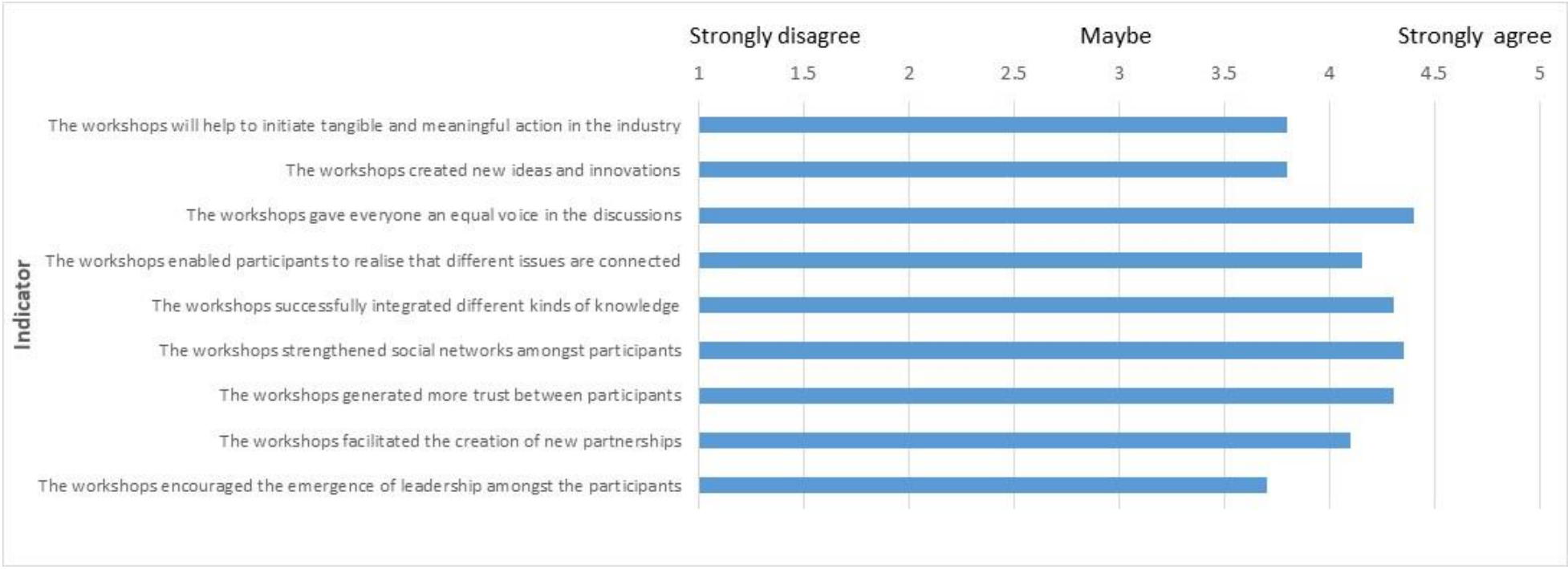

Figure 24. Average scores given by 20 respondents who attended the snapper, hoki and salmon workshops

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 targeting 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 snapper 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 snapper 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

Session	Time	Activities	Outputs
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
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	Dave Moore	Leigh
2	Willie Parata	Terra Moana
3	Jim Missen	Te Ohu Kaimoana
4	Rebecca Alexander	Ashton Fish Ltd.
5	Jane McWhinnie	Sanford
6	Laws Lawson	Fisheries Inshore
7	Tony Craig	Terra Moana
8	John Taunton-Clark	Fisheries NZ Inshore Fisheries North
9	Bruce Hartill	Fisheries NZ Principal Scientist Stock Assessment
10	Leigh Howarth	Research team - Cawthron Institute
11	Carolyn Lundquist	Research team - NIWA
12	Nick Cradock-Henry	Research team - GNS Science
13	Erik Behrens	Research team - NIWA
14	Darren Parsons	Research team - NIWA
15	James Butler	Research team - Cawthron Institute
16	Jodie Kuntzsch	SAS IG - Aotearoa Circle
17	John Willmer	SAS IG - Seafood New Zealand
18	Peter Longdill	SAS IG - Sanford
19	Vonda Cummings	SAS IG and research team - NIWA
20	Jane Symonds	SAS IG and research team - Cawthron Institute
21	Charles Heaphy	SAS IG - Sealord Group Ltd.
22	Michelle Cherrington	SAS IG - Moana New Zealand
23	Megan Linwood	SAS IG - Ministry for Primary Industries

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- 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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