Great Barrier Reef Foundation

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REEF TRUST

GBR Decision Support System Scoping

Project Report

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Executive Summary

Scope

In 2020, the Great Barrier Reef Foundation (GBRF) engaged Aurecon to conduct an independent, wide-ranging analysis of the decision support landscape across the Great Barrier Reef (GBR) and its catchments, to inform recommendations for the development and prototyping of a fit-for-purpose GBR-wide decision-support system (DSS). The project was commissioned on behalf of the Reef Trust Partnership (RTP) and partners of the Reef Integrated Monitoring and Reporting Program (RIMReP), as recommendations will inform the program of work to be funded by the RTP to realise its Investment Strategy objectives, and potentially through other mechanisms such as RIMReP to realise its management guidance objectives. The analysis scope is “GBR-wide” which encompasses the scope of the Reef 2050 Long-term Sustainability Plan (Reef 2050 Plan), therefore the GBR and its catchments.

Approach

The project scope included the following activities:

- Mapping of programs subject to investment or funding across the Great Barrier Reef (GBR) and its catchments, and subsequent review of relevant documents describing investments, activities, decisions, actions and responsible parties within each program;
- Individual interviews with executives, senior-managers, advisors and subject-matter experts that make and / or contribute towards decision making across regulatory agencies, Federal and State Government departments, scientific institutions, industry bodies and non-governmental organisations;
- Survey issued to individuals at the Great Barrier Reef Marine Park Authority (GBRMPA) responsible for making and / or contributing to GBR management decisions;
- Group interviews with those responsible for developing or using tools, models and systems used to inform, support and / or make decisions on the GBR and its catchments;
- Desktop review of the state-of-the art in decision-support tools, models and systems used in similar contexts to the GBR and its catchments;
- Workshops to agree the opportunity statement and potential options for investing in the development and implementation of fit-for-purpose decision-support systems (DSSs); and
- Development of recommendations by the project team.

A project Steering Committee comprising representatives from the Great Barrier Reef Foundation (GBRF), GBRMPA and Australian Institute of Marine Science (AIMS) were consulted on a weekly basis to ensure the project scope evolved with ongoing input into the relevancy of preliminary findings. Other briefings and engagements with GBR stakeholders were also performed throughout the scope, including with the GBRF, GBRMPA, Reef Integrated Monitoring and Reporting Program (RIMReP) interim Operations Group (iOG) and RIMReP interim Executive Group (iEG).

As the purpose of this analysis was to scope a “GBR-wide” decision-support system (DSS) in the context of the Reef 2050 Plan, the Project team, in agreement with the project Steering Committee, explored decisions, decision making and DSSs that could be seen as contributing towards the achievement of the Reef 2050 Plan. This included engagement with the broad GBR community of decision-makers, right-holders, contributors, and stakeholders involved in these decisions and supporting DSSs at strategic, tactical and operational levels. The analysis aimed to identify needs, opportunities, barriers and transformations required to advance a “GBR-wide” DSS that addressed the entire value chain from monitoring data to modelling, decision making, evaluation and reporting. The analysis was therefore a ‘mile-wide, inch-deep’ review, with select ‘deep dives’ performed to gain further evidence and confirmation of specific findings to inform recommendations. Any review of specific historical or current decisions was conducted expressly to enable broad characterisation of decision-making practices and experiences, to comprehend the conditions for

uptake of DSSs. The analysis does not present findings on the outcomes of specific historical decisions or the merits or otherwise of the decision-making approaches used to make them.

Finally, it should be noted that this scope has been executed as a strategic consulting project, aimed at providing strategic insights, strategic direction, and actionable next steps. These are based on industry and domain consulting approaches and the specific GBR and catchment consulting experiences of the authors. This project is not intended to be an academic or theoretical exercise, and this is reflected in the content and writing style of this report.

Findings

The analysis identified several **key findings for decision-makers**:

1) Current decision makers are mature, and decision making is effective given the existing processes, knowledge, and pressures;
2) There is strong, universal support for efforts to make knowledge more available, more efficiently accessible, more synthesised, more predictive (i.e., understanding of projected changes) and more management focused;
3) Increasing efforts to develop a management information system (MIS) is high priority, urgent, and critical to decision making, and to realising desired outcomes on the GBR and its catchments;
4) A single “GBR-wide” MIS is ambitious and required investment will likely extend beyond the diminishing point of returns;
5) A single "GBR-wide” decision-support system (DSS) is not feasible, not leading practice and not asked for by decision-makers, and this narrative should be changed;
6) Decision-support systems (DSSs) have utility in the GBR, and should be developed opportunistically in multiple high-value areas starting with tactical and mature decisions, or following investment in maturing people, processes, and / or knowledge management for less mature decisions;
7) The concept of a DSS should be clearly delineated from other system types and communicated widely to avoid mis-aligned expectations;
8) The primacy of decision processes (over systems) in driving quality decision making could be more widely understood, and offers early wins for GBR-wide decision-makers;
9) Considered investment could be made in increasing understanding of, and literacy in decision-making processes to enable more effective participation in decision making;
10) Decision-makers and knowledge providers focus disproportionally on increasing understanding (knowledge) of the systems that underpin the GBR and its catchments, instead of understanding the relative consequences and trade-offs associated with decision choices;
11) Governance across the GBR and catchment landscape has limited formal application of decision quality-based assurance frameworks; and
12) A preliminary examination of the GBR-wide decision framework and decision quality from the perspectives of Traditional Owners reveals strong aspirations, strong support, and the investment required to achieve aspirations.

Recommendations

Twenty (20) recommendations were identified for consideration by the RTP and RIMReP partners, to 1) advance the development and prototyping of information systems and decision-support systems (DSSs) for the GBR and its catchments, and 2) to advance decision quality more broadly. These recommendations follow the path of three strategic horizons presented below, and designated as 1) no regrets activities, 2) foundational activities or 3) development activities, and, as 1) high priority, 2) medium priority and 3) low priority activities. Some recommendations in earlier strategic horizons lay the foundations for the achievement of later strategic horizons.

- **Horizon 1: Enhanced utilisation of available knowledge through management information systems (MISs).**

  Rec. 1) Reinforce current efforts to improve existing MISs and DSSs with consideration of highest-value areas and attention to point of diminishing returns *(no regrets, high priority)*;

  Rec. 2) Develop and socialise a high-level technology strategy, including capture of key decision literacy components, followed by a coherent strategic planning process *(no regrets, high priority)*;

  Rec. 3) Establish technical governance for system research, development and operations *(no regrets, medium priority)*;

  Rec. 4) Leverage the significant existing investment in RRAP MISs to make predictive knowledge (i.e., projections and forecasts) more widely available and more integrated with GBR-wide decision processes *(no regrets, medium priority)*;

  Rec. 5) Leverage and build on existing investments in socio-cultural, socio-economic and management-focused knowledge generation and synthesis, to improve decision quality GBR-wide *(no regrets, medium priority)*;

  Rec. 12) Conduct a current state baseline and gap analysis focused on Traditional Owners within the GBR-wide decision landscape *(foundational, high priority)*;

  Rec. 15) Generate an initial and high-level decision framework for the GBR Marine Park Area *(developmental, medium priority)*.

- **Horizon 2: Enhanced decision-making outcomes through matured decision processes and knowledge access.**

  Rec. 6) Leverage existing investment in quality decision making processes from RRAP and other programs to increase decision literacy and build capacity for quality decision making GBR-wide *(no regrets, medium priority)*;

  Rec. 7) Investment in and development of knowledge generation and information systems should improve the ability of decision-makers to evaluate decision choices across uncertainty ranges *(no regrets, low priority)*;

  Rec. 8) For mature, high-value sub-programs, develop a “Management Operating System” (MOS) and map associated decision-processes, focussed on tactical decisions *(foundational, high priority)*;

  Rec. 9) Focus and fund efforts to increase decision literacy across the GBR and its catchments *(foundational, high priority)*;

  Rec. 13) Assist with operationalising Strong Peoples - Strong Country by integrating with evolving GBR decision frameworks *(foundational, high priority)*;

  Rec. 14) Develop standardised, fit-for-purpose, qualitative and quantitative structured decision-making (SDM) processes *(developmental, high priority)*;

- **Horizon 3: Enhanced decision-making outcomes through application of fit-for-purpose decision-support systems (DSSs).**

  Rec. 10) Develop DSSs where the opportunity presents during MOS and decision process mapping, and following investment to mature people, process, and knowledge management *(foundational, medium priority)*;

  Rec. 11) Apply open architecture DSSs opportunistically enabling subsequent customisation for specific decision problems (*foundational, medium priority)*;

  Rec. 16) Focus efforts to increase decision literacy amongst senior decision-makers through greater opportunities to participate in mature structured decision-making processes *(developmental, medium priority)*;

  Rec. 17) Develop and implement decision assurance frameworks through existing governance structures *(developmental, low priority)*;

Rec. 18) Generate an initial and high-level decision framework for GBR catchments *(developmental, low priority)*;

Rec. 19) Continuously improve systems for better integration, higher decision quality, better capabilities and incorporation of emerging technology *(developmental, low priority)*.

In addition, the recommendations contribute to a fourth strategic horizon, which is included as an aspirational or "stretch" goal. Enabling this 4th strategic horizon is not intended to be the focus of the preceding three strategic horizons. Rather, it is intended to stimulate longer-term strategic thought regarding possibilities enabled by a future where decision quality GBR-wide is significantly advanced, including being supported by fit-for-purpose DSSs:

- **Horizon 4: Optimised allocation of resources GBR-wide given uncertain futures.**

  Rec. 20) Inform the next iteration of the Reef 2050 Plan framework with a comprehensive "GBR-wide" decision framework *(developmental, medium priority)*.

Acknowledgements

The authors acknowledge the Bindal, Wulgurukaba, Noongar and Wurundjeri people as the Traditional Owners of the land and sea where this work took place. We pay our respects to their Elders past, present and emerging and we acknowledge their continuing spiritual connection to their land and sea.

The authors thank all those whom we spoke with and collaborated with to complete this project, and the significant previous works upon which these findings were built. Most individuals graciously provided their time and input without compensation for which we are extremely appreciative.

The authors are grateful for the opportunity to contribute to the important work being performed by the RTP and RIMReP partners, and hope that the findings and recommendations from this project will make a meaningful contribution to realising desired outcomes on the GBR and its catchments in accordance with the Reef 2050 Plan. Further, the authors hope that these findings and recommendations serve their purpose in the ongoing history of interaction between the peoples, ecosystems and landscapes of the Great Barrier Reef and its catchments.

1 Introduction

1.1 Project background

The Great Barrier Reef (GBR) is the world's largest living structure, an ecosystem home to a wealth of marine biodiversity unmatched anywhere in the world, a global icon so exceptional that it has been inscribed on the United Nations (UN) World Heritage List since 1981 in recognition of its Outstanding Universal Value.

In its 2014 GBR Outlook Report, the Great Barrier Reef Marine Park Authority (GBRMPA) identified deterioration in key habitats, species, and ecosystem processes from the cumulative effects of declining water quality from land-based runoff, marine pests, and cyclones. In its most recent 2019 Outlook Report, GBRMPA identified the most serious threats to the GBR's long term health are those associated with climate change, land-based run-off, coastal development and some aspects of direct use (including the remaining impacts of fishing).

In 2018, the Great Barrier Reef Foundation (GBRF) and the then Australian Department of the Environment and Energy (DOEE) entered into the 6-year Reef Trust Partnership (the RTP) under which the GBRF agrees to undertake a range of activities for the benefit of the Great Barrier Reef World Heritage Area (GBRWHA). The principal objective of the RTP is to achieve significant, measurable improvement in the health of the Great Barrier Reef (GBR) during the term of the RTP. Activities under the RTP include the Integrated Monitoring and Reporting (IMR) Component, the purpose of which is:

- to support the implementation of the Reef 2050 Integrated Monitoring and Reporting Program (RIMReP), including eReefs and the Paddock to Reef (P2R) monitoring and reporting programs, and
- to improve health monitoring and reporting of the GBRWHA to ensure that monitoring and reporting to UNESCO is scientifically robust and investment outcomes are measurable.

In 2019, RIMReP completed a stocktake of existing programs, identified monitoring needs, and provided recommendations for establishing a Reef Knowledge System. These recommendations are presented in the RIMReP Program Design Report, Business Analyst Report and Implementation Roadmap Report under the 'Guide' component of the Program Design and RIMReP vision, which aims to enable resilience-based management of the GBR and its catchments. While there is a sound foundation to build from, a step-change in the depth, breadth, rigour, coordination, and availability of data that Reef Managers depend upon every day will be needed. As described in the RTP Investment Strategy and Annual Work Plan 2019-2020, the IMR Component is planning to support this by investing approximately $4.4 million (not including co-investment) to support the early stage development and prototyping of a "GBR-wide" decision support and forecasting system.

1.1.1 "GBR-wide" decision making and forecasting platform

Decisions pertaining to the GBR are highly varied and subject to significant complexity and uncertainty, associated with 1) understanding of the ecosystem, 2) understanding of the associated socio-economic and cultural system, and 3) ability to characterise and predict the potential future outlook across these dimensions given local and global forces and threats. Further complicating matters is the broader context in which these decisions need to be made, i.e., multiple and often competing interests, multiple interacting governance structures at community scales through to government scales, and breadth of perspectives on the value of the GBR across local and global scales.

The RTP and RIMReP partners believe a transparent and risk-based approach to decision making on the GBR and its catchments is beneficial, founded on available evidence and models that enable forecasting and scenario planning. It is assumed that a coordinated decision-support system (DSS) will greatly increase the value that can be extracted from existing monitoring and modelling programs. It is proposed that this approach could be used more systematically to target management actions, policy decisions and investments, across the full range of GBR activities.

Currently there is a significant time lag between the acquisition of some data and its availability to inform management or policy decisions. In a rapidly changing climate with a predicted increase in frequency and intensity of high impact events (including bleaching, cyclones and floods), adaptive management will greatly benefit from greater, more timely and more consistent use of monitoring and especially modelling data to inform more proactive decision making.

The strategic objective of the RTP is not to develop an all-encompassing, integrated model for decision making, as 'one size fits all' approaches have historically failed to meet expectations. Instead it is to support the development and implementation of a flexible decision-making environment that recognises the value of diversity in monitoring and model data, consolidates existing systems, streamlines the flow of information, and builds on the foundational work of RIMReP to address decision support needs for Marine Park management, including those identified in GBRMPA's Blueprint for Resilience.

1.1.2 Project scope

The purpose of this project is to conduct, within the remit of the Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan), an independent, wide-ranging analysis of the decision support landscape across the GBR and its catchments, including review of the state-of-the-art in terms of knowledge and systems, and to recommend options for the development and prototyping of a fit-for-purpose DSS for the GBR and its catchments. **The project specified "GBR-wide" as the scope extent, and this term is taken to cover the scope of the Reef 2050 Plan** (the term "GBR-wide" throughout this report is used in this context, as opposed to "GBR" which refers to the extents of the GBR Marine Park Area)**.** The scope is focused on identifying and assessing the enabling conditions for decision-support systems (DSSs), and as such, reviews a sub-set of decision making GBR-wide to achieve that purpose; it is not a comprehensive review or assessment of GBR-wide decision making. The recommendations will inform the program of work to be funded by the RTP to realise its Investment Strategy objectives, and potentially through other mechanisms such as RIMReP to realise its management guidance objectives.

The desired outcomes of the Project are:

1) to establish line-of-sight on the current state of decision support and decision making pertaining to the GBR and its catchments that contributes to the achievement of Reef 2050 Plan objectives, including the dissemination and use of knowledge (i.e., information, data and model outputs) and the application of decision support processes, decision-support tools and decision support expertise;
2) to establish line-of-sight on state-of-the-art DSSs used in contexts similar to the GBR and its catchments, and, on decision support frameworks, processes, models, systems and tools with potential or actual utility in informing decisions on the GBR and its catchments;
3) to establish line-of-sight on the current and potential future needs of GBR and catchment managers and decision makers with respect to decision support, and the gaps between the current state, their immediate needs, and their aspirational needs; and
4) to identify and recommend options to the RTP and RIMReP partners to progress development and prototyping of a fit-for-purpose DSS in alignment with Investment Strategy objectives, RIMReP management guidance objectives, and, potential development pathways given the strategies of complementary GBR programs including the Reef Restoration and Adaptation Program (RRAP) and Crown-of-Thorns Starfish (COTS) Control Program.

The project involved engagement with the broad Reef community to identify key hurdles, step changes and transformations required to help achieve the ultimate objective of an adaptive system. Realising the full value and co-benefits of integrating observation and modelling will require the strategy to address the entire value chain from monitoring data to modelling, decision making, evaluation, and reporting.

1.2 Methodology overview

A high-level summary of the 3-stage methodology for this project is presented below. More detailed descriptions are presented in Section 4 and Appendix B.

1.2.1 Stage 0 – Project establishment and stakeholder engagement planning

Stage 0 involved project planning activities to inform the work breakdown for Stages 1 and 2, and, detailed stakeholder engagement planning. The first step was establishment of the project Steering Committee[1], which consisted of Cedric Robillot (GBRF), Christian Roth (GBRF), Dylan Horne (GBRMPA) and Ken Anthony (AIMS). Subsequent activities primarily focussed on eliciting Steering Committee input on the plan for stakeholder engagement, understanding their experiences with, and attitudes towards decision frameworks and decision-support systems, and generating the list of relevant documentation for review.

1.2.2 Stage 1 – Establish current state baseline and gap analysis

Stage 1 was focussed on establishing a structured synthesis of the current state landscape of decision making across the GBR and its catchments. Activities were organised and executed by the Project team across multiple parallel workstreams:

- Mapping of programs subject to investment or funding across the Great Barrier Reef (GBR) and its catchments, and subsequent review of relevant documents describing investments, activities, decisions, actions and responsible parties within each program;
- Individual interviews with executives, senior-managers, advisors and subject-matter experts that make and / or contribute towards decision making across regulatory agencies, Federal and State Government departments, scientific institutions, industry bodies and non-governmental organisations;
- Survey issued to individuals at the Great Barrier Reef Marine Park Authority (GBRMPA) responsible for making and / or contributing to GBR management decisions;
- Group interviews with those responsible for developing or using tools, models and systems used to inform, support and / or make decisions on the GBR and its catchments;
- Desktop review of the state-of-the art in decision-support tools, models and systems used in similar contexts to the GBR and its catchments;

Weekly updates on progress were shared and discussed with the project Steering Committee. A preliminary insights workshop was held on Friday 21st August 2020 where the Project team shared early findings and insights with the project Steering Committee with the aim of getting endorsement of the approach to date and path forward for the remainder of the current state assessment. Various other briefings and engagements with GBR stakeholders were performed throughout the scope.

1.2.3 Stage 2 – Strategic options development and recommendations

Whilst Stage 1 comprised the majority of the project scope, that is, to establish the current state and undertake a gap analysis, Stage 2 was focussed on the identification and development of recommendations for the RTP and RIMReP partners to progress development and implementation of fit-for-purpose DSSs for the GBR and its catchments, and, advancing quality decision making more broadly. The development of recommendations was informed by the following activities:

- Review of current state findings from Stage 1 with the project Steering Committee over the course of 2 workshops (held on Friday 21st August 2020 and Thursday 24th September 2020).
- Facilitated session during the 2nd workshop (24th September 2020) to agree the opportunity statement for the IMR component of the RTP in investing in the development and implementation of fit-for-purpose DSSs, identifying relevant key success criteria, and identifying a long-list of potential options for consideration in realising the opportunity.

Development of recommendations based on the Stage 1 current state and gap analysis, and the opportunity framing and options identification processes.

[1] Over the course of the project, Cedric Robillot (GBRF) left the Steering Committee owing to a change in his role at the GBRF, and David Wachenfeld (GBRMPA), Jessica Hoey (GBRMPA) and Genevieve Williams (GBRMPA) all joined the Steering Committee owing to a change in their roles at GBRMPA.

2 Decision-making overview

2.1 What is a decision?

While there are numerous definitions for what constitutes a 'decision' in the English language, as presented in Table 1, published scientific and management literature assume the concept of a decision is self-evident. All definitions have at their core the concepts of choices, resolutions and actions as central to decisions and decision making.

In an organisational or program context, decisions occur whenever there are choices available to an organisation or individual in attempting to solve a problem or realise a desired outcome. Most private and public organisations have stated objectives and face choices about where to allocate resources to achieve those objectives and desired outcomes. Whenever choices exist, decision-makers need to reconcile the resources available versus those required to enact those choices, the consequences and trade-offs of those choices, and any uncertainty in the ultimate outcomes realised from each choice, all within available timeframes for making a decision.

Table 1. Alternative definitions of 'decision'

Definition	Source
"a choice that you make about something after thinking about several possibilities"	Cambridge Dictionary
"a conclusion or resolution reached after consideration"	Oxford Dictionary
"a determination arrived at after consideration"	Merriam-Webster Dictionary
"the making of a choice between alternative courses of action"	(Eilon, 1969)

There is a significant volume of published effort in decision science and operations research describing the science of *decision making*, much of which is focussed on the processes that lead to effective decisions and the prerequisite conditions for effective decisions. Peter Drucker, described as 'the founder of modern management' has stated two complementary definitions:

- "'effective decisions result from a systematic process, with clearly defined elements, that is handled in a distinct sequence of steps"[2], and
- "a decision has not been made until people know:
  - the name of the person accountable for carrying it out,
  - the deadline,
  - the names of the people who will be affected by the decision and therefore have to know about, understand and approve it – or at least not be strongly opposed to it, and
  - the names of the people who have to be informed of the decision even if they are not directly affected by it"3

In the context of this review of decision making across the GBR and its catchments, specifically in the context of decisions as the preceding step to strategic, tactical or operational management actions, we are using the definition of a 'decision' as:

Decision - *"the point at which a decision-maker makes a choice between 2 or more alternatives, and results in resources being allocated to action the chosen alternative".*

[2] Drucker, P. (1967). 'The Effective Decision', *Harvard Business Review.*
[3] Drucker, P. (2006). *The Effective Executive,* New York, NY, HarperCollins.

2.2 Decision hierarchy classification: strategic, tactical and operational decisions

Decisions are often classified in scientific and especially management literature as being either strategic, tactical or operational in nature. The following definitions have been applied during this review:

Strategic - strategic decisions are major choices of actions and influence whole of or a major part of an organisation or program. Strategic decision problems are generally unstructured in nature, with typically no standard procedure or method in place to make decisions (i.e., bespoke), and inputs are often complex and undefined. They are typically infrequent, have a wide scope and are typically forward looking across a long-term time horizon (5-yearly or longer for GBR).
Tactical – tactical decisions are decisions and plans that concern the more detailed implementation of the strategy, usually with a medium-term impact on an organisation or program. They are typically semi-structured in nature, with some form of structured process potentially applicable, though with inputs and procedures not well defined. They are sometimes repeated over a moderate frequency with a medium-term time horizon (annual, quarterly or monthly for GBR).
Operational – operational decisions relate to the day-to-day operations of an organisation or program and generally have a short-term time horizon. They are often highly structured in nature, routine and repetitive with typically a standard response or solution arising from the decision, therefore often supported by standard decision-making procedures. They are typically undertaken at lower levels of management, are frequent (daily, weekly, or fortnightly for GBR) and have a narrow scope.

The exact delineation between the three classifications can differ based on the context in which decisions are being made, including who makes decisions, the complexity of the decision and how often the decision is made. In addition, the three classifications are typically nested, i.e., operational decisions typically exist within the frame used to inform tactical decisions, which in turn are typically made within the frame used to inform strategic decisions.

In the context of the GBR and its catchments, strategic decisions have been classified as those which deal with development of 5-year strategies and plans and establishing long-term goals and policies. Tactical decisions are classified as those which deal with annual, quarterly, and monthly plans, and responses to irregular events. Operational decisions are classified as those which deal with resource allocation to tasks and choices made in executing tasks, typically on a daily or weekly frequency. For example, in the context of recreational fishing compliance monitoring as part of the Joint Field Management Program, resource allocation as part of the 5-year business strategy process is classed as a strategic decision. Annual and monthly resource allocation decisions (part of the annual business planning and monthly planning processes respectively) are classed as tactical decisions. Operational decisions include the ‘on park’ decisions each day and week that result in fines / notices and patrol data generation.

2.3 Why are effective decisions important?

As described in Section 2.1, decisions occur whenever there are choices available to an individual or organisation in attempting to realise a desired outcome. Most private and public organisations have stated objectives and face choices about where to allocate resources to achieve those objectives and desired outcomes. Whenever choices exist, decision-makers need to reconcile the resources available versus those required to enact those choices, the consequences and trade-offs of those choices, and any uncertainty in the ultimate outcomes realised from those choices, all within available timeframes for making a decision.

The concept of effective decision making emanates from operations research and decision science, which comprise a suite of processes and tools used to inform managerial decision making. By focusing on decisions as the fulcrum between the potential solutions to problems and the action taken to solve them, operations research and decision science provide approaches for characterising complex problems, and for identifying, assessing and committing to solutions to those problems. For this reason, analytical processes

and tools from operations research and decision science are used extensively to inform decision making in complex public and private decision settings. The science underpinning operations research and decision analysis is well-documented in business and academic literature[4,5,6,7,8,9,10,11,12,13,14,15,16,17,18], as is the application of these approaches in the contexts of environmental management and nature conservation[19,20,21,22,23].

In the context of the GBR (and for coral reefs globally), successfully responding to the threats posed by climate change, coastal development, land-based runoff and direct use, and associated events that have resulted in deterioration in key habitats, species and ecosystem processes[24] is both critical and urgent. Within this context, finite resources need to be deployed effectively through targeted management actions by multiple partners to achieve complementary though sometimes conflicting objectives of maintaining the GBR's outstanding universal value and preserving broader social, cultural, and economic values.

Further, GBRMPA use a resilience-based management approach to guide management actions. Central to effective resilience-based management is effective decision making that ensures finite resources are focussed on the right choices in responding to these threats and events[25],[26].

2.4 Aspiring to making quality decisions

The Society of Decision Professionals, the largest global professional body for decision support practitioners, defines decision quality as:

> **Decision quality – the extent to which a decision has addressed the 6 requirements of good decision making**"[27]

Quality decision making, by extension, is the pursuit and realisation of effectiveness, efficiency, transparency, and defensibility in decision making. Quality decision making not only involves the use of tools and approaches from operations research and decision science to arrive at the 'best' choices, but also emphasises engagement with appropriate stakeholders (and if relevant, rights-holders) through the decision-making process to ensure alignment and achieving commitment to action (often a stumbling block in highly complex or contentious decisions or decisions involving large investments). Making quality decisions therefore emphasises the application of the appropriate processes and involvement of the appropriate

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people, in addition to knowledge needs and characterisation of uncertainty, to increase confidence in achieving desired outcomes from decision making.

All high-quality decisions meet 6 requirements, regardless of the outcome of the decision:

Requirements of High-Quality Decisions –

- A well-defined decision **frame***,
- Feasible and diverse **alternatives (i.e., options)**,
- Relevant and reliable **information**,
- Clear **understanding of the consequences and trade-offs** of alternatives,
- Robust logical **analysis**, and
- A commitment to **action**.

* In decision making, the decision frame describes perspectives or maps used by decision-makers or decision support practitioners to guide application of relevant decision-processes. As the name suggests, a frame establishes the problem to be solved or opportunity to be realised, and associated boundaries and constraints of the process.

In the context of the GBR and its catchments, the challenges that impact decision-making discussed in Section 1.1.1 make assessing choices and ultimate decision-making difficult, and, potentially time-consuming. An aspiration towards quality decision making, with a focus on the use of appropriate decision processes and the involvement of the right people in those processes, additional to the stated focus on improving systems, will likely increase the utility of existing knowledge pertaining to the GBR and its catchments, and, guide future knowledge acquisition and generation activities (e.g., modelling and forecasting). Conversely, a lack of decision quality often leads to failed strategies, wasted investment, recycling of decisions, and wasted time and effort on retroactive reviews of failed decisions. These consequences that too significant given the urgency of the challenges facing the GBR.

2.4.1 Importance of relevant people in decision-making

As discussed in Section 2.4, the importance of stakeholder engagement in decision-making is paramount, as input from and alignment amongst relevant people, using the right processes and tools, with access to right knowledge, is necessary for quality decisions. A key enabler is ensuring relevant stakeholders are adequately prepared and able to contribute to and engage in relevant decision support and decision-making activities to enable commitment to action. There is strong evidence throughout operations research and management-science literature that stakeholder engagement and participation is key to decision-making success.

The extent of stakeholder engagement and participation that has highest utility is typically dependent on the nature of the decision, across strategic, tactical and operational classifications. Learnings from leading practice in industry suggest that strategic decisions, owing to their unstructured and infrequent nature, typically benefit from and require more extensive involvement of executive leadership, a broad range of organisational subject matter experts (SMEs) and wider stakeholders in decision making. This is largely due to greater levels of uncertainty in the ultimate consequences of choices and typically large investment values and time-horizons commensurate with the frequency of these decisions. Tactical decisions, owing to their greater level of structure, greater frequency, shorter time-horizons and relatively smaller range of differences in consequences from available choices (compared to strategic decisions) typically benefit from a relatively smaller level of involvement from stakeholders (including rights-holders, subject matter experts, and other groups consulted or involved in decision making). Operational decisions, owing to their largely narrow scope and frequency, rarely require involvement of anyone beyond the decision-maker.

Figure 1 depicts the useful level (utility) of participation and engagement of various individuals and groups for quality decision making across strategic, tactical and operational decisions, based on leading practice in industry. Darker shades of green indicate greater utility with that set of individuals and groups and therefore where greatest value lies in pursuit of quality decisions).

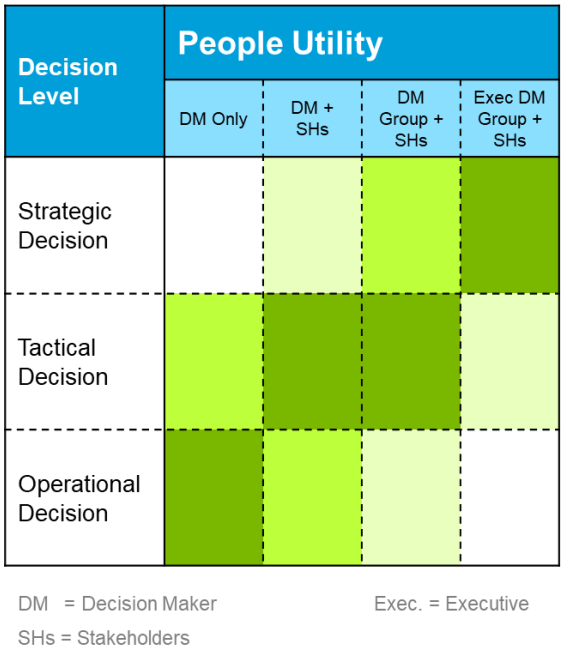


Figure 1. Leading practice involvement of stakeholders in decision making across strategic, tactical and operational decisions (darker shades of green indicate greater utility and therefore where greatest value lies in pursuit of quality decisions).

Importance of considering rights-holders in complex socio-cultural, environmental and economic asset management

The importance of considering rights-holders among stakeholder groups in human development contexts is useful for understanding decision quality on complex socio-cultural, environmental and economic assets such as the GBR and its catchments. The distinction between "stakeholders" and "rights-holders" can be found in the Human Rights-Based Approach (HRBA) to development (and the decision-making within it) that is listed as "Principle One" in the United Nations Universal Values on the 2030 Agenda[28]. A 'stakeholder' might be considered anyone who can claim a 'stake' in a process, while rights-holders might be considered those for whom the realization of their human rights is inextricably linked to their customary and socially defined rights to the assets. In particular, the principle stipulates that "development cooperation contributes to the development of the capacities…of 'rights-holders' to claim their rights". This highlights the importance of understanding power dynamics among groups of decision-makers, because if current and/or historical power inequities have resulted in lower capacity for any stakeholder or right-holder group, decision quality from their perspective may be lower than for other stakeholders.

On the GBR and its catchments Traditional Owners are considered the rights-holders as defined by Australian Law. As such, considering the power dynamics among Traditional Owners, stakeholders and decision-makers (noting some of these designations are unlikely to be mutually exclusive), historical power inequalities, and relative capacity, is essential to fully understand decision quality on the Great Barrier Reef and its catchments.

Importance of relevant governance and assurance frameworks in decision-making

Delegation within organisational or program governance frameworks typically entail three elements: authority, responsibility, and accountability, and is typically achieved through 1) assignment of tasks and duties, 2) granting of authority and 3) creating responsibility and accountability.

In the context of decision making, the relationship between accountability and responsibility is important to enable effective and efficient decisions. Accountability and responsibility are two types of authority. In leading practice organisations, *accountability* for decisions ultimately sits with the most senior person tasked with delivering the benefits from the outcomes of related decisions, while *responsibility* for decisions sits with the

[28] UNSDG Human Rights Working Group (2003) *The Human Rights Based Approach to Development Cooperation - Towards a Common Understanding Among UN Agencies*, United Nations, 2003.

appropriate individual within that person's branch, section, unit or function. Effective delegation of *authority* ensures the appropriate level of participation and engagement in decision-making to enable efficient decisions (e.g., separation by decision level - strategic, tactical, or operational). Where delegation of *authority* is not appropriate, it can lead to situations where either the extent to which people are involved in decision making, the extent to which knowledge is generated and synthesised, and / or the extent of analysis performed, is incommensurate with the value to decision making.

Appropriate decision-making governance can be supported by appropriate assurance of decisions. Leading practice organisations utilise decision assurance frameworks to support appropriate delegations of *authority* for decision making. These can take various forms, including steering committees, decision review boards, and assurance reviews by experts in decision support, and ideally should assess decision-making according to the 6 requirements for quality decision making. These elements maximise the chances that decisions made about the asset are high quality.

2.4.2 Importance of relevant processes in decision-making

As discussed in Section 2.1, there is a significant volume of published effort in decision science and operations research describing the science of decision making, much of which is focussed on the processes that lead to effective decisions. The application of relevant processes for decision-making is critically important to making quality decisions, as processes are widely acknowledged as providing the framework to guide knowledge acquisition and involvement of the right people at the right time to inform decision making.

Decision processes are defined as *the methods by which decisions are framed, choices are identified, developed, and logically analysed for their consequences and trade-offs, and result in commitments to action.*

The utility of relevant processes is typically dependent on the nature of the decision, across strategic, tactical, and operational classifications. There are different categories of processes used in decision-making:

Ad-hoc - primarily judgement-based approach to decision-making (typically used when decisions are required for a specific purpose at a precise moment with the goal of ensuring an instant and adequate result). In the GBR and its catchments, an example is Reef Joint Field Management Program (RJFMP) incident response.

Routine methods -primarily a simple, sequential approach to decision-making (typically used when decisions are made frequently, when there is little uncertainty and involves use of standard procedures). In the GBR and its catchments, an example is the GBRMPA permit application guideline.

Decision rules - primarily a conditional, formulaic approach to decision-making (typically used when observations can be mapped to relevant actions). In the GBR and its catchments, an example is the COTS control on-water decision tree.

Decision guidance - primarily recommendations / directions of a list of potential activities to inform decision-making (typically used in contexts where multiple decisions with similar but not identical characteristics are made, and involves proving actionable recommendations / directions based on an understanding of the context to inform decision making). In the GBR and its catchments, an example is the Reef 2050 policy guideline and the multitude of Marine Park policies currently in place.

Structured decision making - primarily an organised approach to identifying, evaluating, and selecting options to inform decision-making (typically used to help individuals and groups navigate through tough multidimensional choices characterised by uncertain science, disparate information, diverse stakeholders and difficult trade-offs). Decision analysis approaches such as Multi-Criteria Decision Analysis (and more specific types such as the Analytical Hierarchy Process) and Multi-Objective Decision Analysis typically use structured decision-making as an overarching framework to inform the analysis; similarly cost-benefit analyses for large-scale public-sector infrastructure investments and private-sector capital investments in complex asset industries are typically guided by structured decision-making frameworks. In the GBR and

its catchments, example applications include the RIMReP Monitoring Activity Trade-Off Analysis and the RRAP Concept-Feasibility Phase Cost-Benefit Analysis.

Learnings from leading practice in industry[29] suggest that strategic decisions, owing to their unstructured and infrequent nature, typically benefit from, as a minimum, decision guidance to inform decision making. When the different consequences of potential choices are significant, with commensurate potential impact and buy-in required from stakeholders, then structured decision-making is widely used as a guiding process for making decisions. Tactical decisions, owing to their greater level of structure, greater frequency, shorter time-horizons and relatively smaller range of differences in consequences from available choices (compared to strategic decisions), are typically subject to a range of different decision processes dependent on the individual context. For slightly more structured decisions (compared to strategic decisions), decision guidance can often be sufficient, with decision-makers free to select the appropriate approaches from within the guidance to inform decision making. For even more structured decisions, decision-making can often be codified into decision rules, assuming choices are known and pre-conditions that cause choices to be superior are understood. Operational decisions, owing to their largely narrow scope and frequency, rarely require more guidance than that provided by decision rules, with routine methods often sufficient.

Figure 2 depicts the useful application (utility) of decision-making processes for quality decision making across strategic, tactical and operational decisions, based on leading practice in industry (darker shades of green indicate greater utility and therefore where greatest value lies in pursuit of quality decisions).

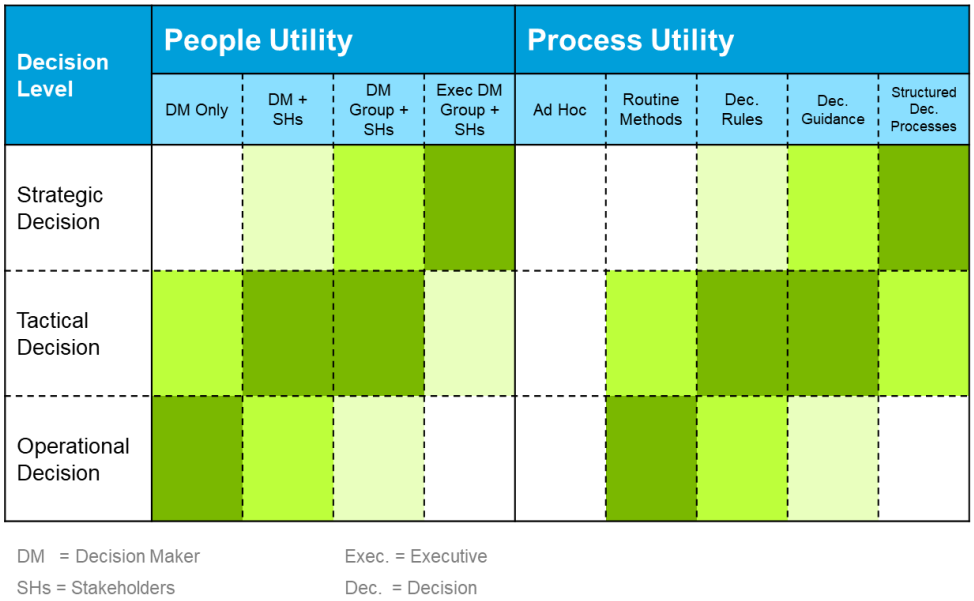


Figure 2. Leading practice relevance of decision-making processes across strategic, tactical and operational decisions, shown together with people lens from Figure 1 (darker shades of green indicate greater utility and therefore where greatest value lies in pursuit of quality decisions).

2.4.3 Importance of relevant knowledge in decision making and the relevance of information systems

Knowledge underpins the quality of all decisions. Knowledge is a prerequisite for a decision maker to be able to characterise consequences and trade-offs associated with alternative choices, irrespective of the logical analysis used to compare them, to inform decisions and generate commitment to action. Relevant decision processes guide what knowledge is required and desired by decision-makers, while the involvement of stakeholders in the decision-making process can also inform specific knowledge requirements.

[29] Public and private sector agencies and organisations in the defence, water, pharmaceutical and energy and resources industries globally are leaders in the application of quality decision making frameworks to inform management decisions. The Raiffa-Howard award for Organisational Decision Quality, awarded by the Society for Decision Professionals (the largest global professional body for decision-support practitioners), has been awarded 3 / 4 years to organisations in these sectors. Use of the term 'leading practice' uses practices in these organisations and sectors as a benchmark.

Whilst it is important that relevant knowledge is available, access to relevant knowledge that is synthesised for use in decision making (for example through scientific models) may be more important, depending on the classification of the decision (strategic, tactical or operational). Broadly, the more complex the decision and the more uncertain the consequences of alternative choices, the greater the utility in having access to synthesised knowledge that informs the relevant decision-making process.

Systems can play a useful role in making knowledge available, accessible, and synthesised to the extent required to support relevant decision-making processes. Such computerised systems can greatly contribute towards making decisions more efficiently and effectively, depending on the subject decisions and relevant supporting decision-making process. The relevance of information systems such as management information systems (MISs) and decision-support systems (DSSs) in decision making are discussed in detail in Section 3.

2.5 Decision frameworks for management decisions

The concept of decision frameworks emanates from operations research and decision science, which comprise a suite of processes and tools used to inform managerial decision making. By focusing on decisions as the fulcrum between the potential solutions to problems and the action taken to solve them, operations research and decision science provide approaches for characterising complex problems, and for identifying, assessing and committing to solutions to those problems. For this reason, analytical processes and tools from operations research and decision science (e.g., framing approaches, influence diagrams, strategy tables, multi-criteria analysis, cost-benefit analysis, value-of-information analysis) are used extensively in complex asset-intensive industries to inform decision making in programs and assets. **The concept of decision frameworks has been applied in this review as foundational conceptual framework to guide this current state assessment.**

A decision framework characterises the interaction between relevant people, processes and systems to inform decision making pertaining to a complex asset. Decision frameworks describe the elements that work together to drive the requirements of quality decision making as described in Section 2.4, most pertinently effectiveness, efficiency, transparency and defensibility. Figure 3 depicts a visualisation of a decision framework based on leading practice in asset-intensive industries (supported by operations research and decision science literature)[30], with definitions presented in Table 2.

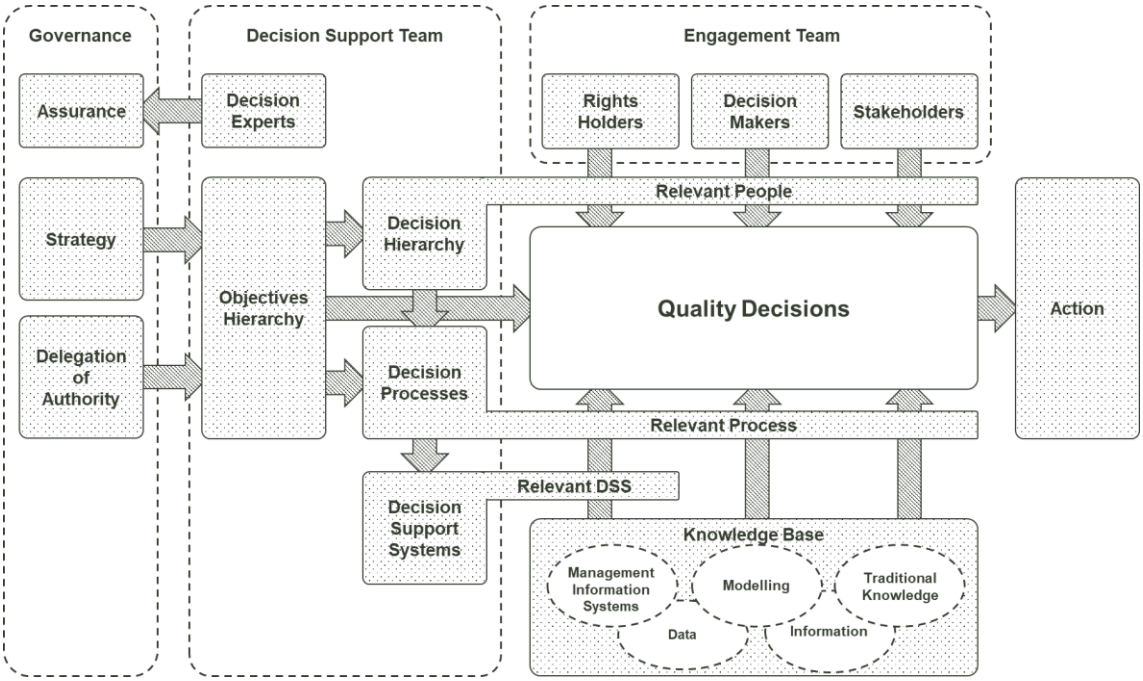


Figure 3. Visualisation of a typical decision framework describing the interaction between people, processes, systems and knowledge used to inform decision making in an organisational or program context.

[30] Sivapalan, M. and Bowen, J. (2020). Decision frameworks for restoration & adaptation investment – Applying lessons from asset-intensive industries to the Great Barrier Reef. *PLoS ONE*, 15(11).

Table 2. Definitions of the substituent elements of the decision framework described in Figure 3.

Element	Definition
Decision framework	The architecture of people, processes, knowledge and systems used to make decisions.
Objective hierarchy	The arrangement of organisational, program and / or project objectives into relevant hierarchical levels.
Decision hierarchy	The organisation of the decisions that need to be made, supported by who makes those decisions and how they relate to objectives, value drivers and boundaries across the decision landscape.
Delegation of authority	The agreed system of distributed accountability and responsibility to ensure the appropriate level of participation and engagement in decision making to enable quality decisions.
Assurance	In the context of decision making, assurance refers to an independent, objective assessment of decision quality.
Decision processes	The processes by which decisions are framed, choices are identified, developed and logically analysed for their consequences and trade-offs, and commitments to action are made, across the decision landscape.
Knowledge base	The data, modelling and information available pertaining to the asset, including understanding of provenance and uncertainty, used to inform decision making.
Management information system (MIS)*	The computerised system that gathers data from multiple sources and makes it available to users (including synthesis) to support quality decision making.
Decision-support system (DSS)*	The computerised system that gathers data from identified sources, synthesises it, and makes it available to users in accordance with specified decision processes to support quality decision making on specific semi-structured and unstructured decision problems
Quality decisions	Decisions are considered high quality if they meet the following 6 requirements, regardless of the outcome of the decision: (1) a well-defined frame, (2) feasible and diverse alternatives, (3) relevant and reliable information, (4) clear understanding of the consequences and trade-offs of alternatives, (5) robust logical analysis, and (6) a commitment to action.

**Note: MIS and DSS definitions are included here for completeness, the rationale behind these definitions in included in Section 3.*

2.5.1 Importance of objectives hierarchies

The establishment of a coherent objectives hierarchy is critical to the success of any organisation or program that would benefit from implementing a decision framework. The objectives hierarchy is typically derived directly from the strategy for the organisation or program. The decision hierarchy is a key element of a coherent decision framework for large, complex assets to characterise and organise problems and opportunities according to the potential value proposition of successful solutions and the complexity and uncertainty that impacts identification and selection of potential solutions.

Discussion of objectives hierarchies in the context of the GBR and its catchments is presented in Section 5.1.5.

3 Management information systems and decision-support systems overview

3.1 Introduction

This section provides an overview of information systems used to support decision making. As discussed in Section 2.4, quality decision making is enabled through use of relevant decision processes, the involvement of relevant people in those processes, and the use of relevant knowledge. Information systems, as purveyors of knowledge to those processes and people, also have a critical role. It should be noted that in the majority of decision contexts, processes, people and systems all exist to *support* a decision-maker in making a decision, as opposed to being designed to *make* / force decisions for / on the decision-maker. Discussion of systems and processes throughout this section and the remainder of this report should be considered in this context.

3.2 Management information systems vs decision-support systems

Management information systems (MISs) are defined as:

Management information system (MIS) – a *computerised system that gathers data from multiple sources and makes it available to users (including synthesis).*

As discussed in Section 2.4.3, MISs have utility in making relevant knowledge available and accessible to decision-makers as part of predefined decision processes to inform decision making.

Decision-support systems (DSSs) may make use of MISs, but they are distinct from them. A DSS is defined as:

Decision-support system (DSS) - *a computerised system that gathers data from identified sources, synthesises it, and makes it available to users in accordance with specified decision processes to support decision making on specific semi-structured and unstructured decision problems**.

* A structured decision problem is one in which data, process, and evaluation to be used are agreed, thereby making them repetitive and routine. Unstructured decision problems are those in which there is no agreement on relevant data, process, and evaluation to be used, and the decision-maker must provide judgment and insights into the problem definition & evaluation. Semi-structured decision problems are those in which there is partial agreement on data, process, and evaluation to be used.

When referencing both MISs and DSSs, there is often a need to clarify and define what both systems truly represent. Often these terms are erroneously used interchangeably, so this section aims to delve briefly into the histories of both systems, before clarifying the terms. Additionally, the qualification features required for a system to meet these definitions will be explored before a further introduction to both system characteristics and specific decision characteristics.

3.3 History of management information systems

The origins of MISs were in the early 1960's where they were developed and used as accounting and transaction recording systems. As computing hardware became more powerful, MISs continued to develop and provide more value and data storage capability for end users. Throughout the 1970's, with the introduction of the personal computer, MISs began to become commonplace in many organisations. With further advancements in technology in the 4 decades since, including enterprise and cloud computing, MISs have become essential tools in support of organisation decision making. An example of a commonplace MIS in organisations would be dashboards displaying a range of relevant organisational performance metrics to relevant decision-makers and stakeholders. In an environmental management context, the National Oceanic

and Atmospheric Administration (NOAA) through its Coral Reef Watch program has developed an MIS that is predicated on monitoring and predicting coral bleaching events worldwide.

3.4 History of decision-support systems

The first DSSs were derived from early computerised quantitative models created by researchers to assist in managerial decision making and planning[31] . As these models began to rise in popularity in the early 1970s, the term 'decision-support system' was first coined to describe these specific types of system. Over the ensuing decades, the definition and constituent components of a DSS were refined and codified, notably by MIS thought leader Ralph Sprague. Sprague provided the original framework upon which modern DSSs are based, outlining three prerequisite components for a DSS, namely a database, a model and a user interface[32]. DSSs have matured significantly since then, and a more detailed description is provided in Section 3.6. DSSs are used across many private and public applications and settings, including medicine, business, and environmental management. Nature-conservation practitioners and NGOs have used decision-support systems in various forms for decades, especially in terrestrial conservation contexts. Within the GBR and its catchments, the Reefonomics tool used by the GBRF to inform water quality investment is an example of a DSS applied within the environmental management context.

3.5 System definitions

As discussed in Sections 3.3 and 3.4, MISs and DSSs are used for multiple purposes across multiple organisations in multiple industries and contexts, including in the context of supporting decision making.

There is often mischaracterisation of MISs and DSSs. Because MISs can and are used to support decision making, they are sometime incorrectly identified as being DSSs. DSSs are sometimes incorrectly identified as computerised decision-*making* systems (as opposed to computerised decision-support systems), with unfounded perception that the 'system makes the decision.' Whilst there are some examples of computerised automated decision-making systems that are in use, these are largely in the context of enabling greater efficiency in small scale operational decisions where the computerised automated decision-making systems uses codified decision-rules to inform the decision-maker on preferred choices for very frequent decisions. There is also mischaracterisation of DSSs as the broader 'system' of decision making, which we have termed 'decision framework' in Section 2.5. DSS has a very specific definition as described above.

To clarify the oft-confused terminology and interpretations of systems relevant to decision making, a list of definitions aiming to illustrate the differences between these systems is presented in Table 3.

Table 3: Relevant definitions of systems used in the context of decision-making.

System	Definition
Database	A database is a collection of structured information (data), most commonly stored in an electronic format within a computer system. A database is often controlled by a database management system (DBMS). A common example of a database is an excel spreadsheet with raw data.
Management information system (MIS)	The computerised system that gathers data from multiple sources and makes it available to users (including synthesis) to support quality decision making.
Management information system (for Communication)	The computerised system that gathers data from multiple sources and makes it available to users (including synthesis) to support quality decision making. When used for a communication, the system visualizes key information in an easy to interpret format. Within the Great Barrier Reef decision landscape, the COTS dashboard developed by GBRMPA is a commonly used MIS for communication.

[31] Power, D., (2008). 'Decision support systems: A Historical Overview', *Handbook on Decision support systems: International Handbooks Information System.* Springer, Berlin, Heidelberg.
[32] Sprague, R.H., (1980). 'A framework for the development of decision support systems'. *MIS Quarterly*, 4(4): 1-26.

System	Definition
Management information system (for Insight)	The computerised system that gathers data from multiple sources and makes it available to users (including synthesis) to support quality decision making. When used for insight, the system is able to synthesise a range of data inputs to provide the user with a representation of a system (i.e., a model). Within the GBR, the CoCoNet and CONNIE ecosystem models are both considered an MIS for insight.
Decision-support system (DSS)	The computerised system that gathers data from identified sources, synthesises it, and makes it available to users in accordance with specified decision processes to support quality decision making on specific semi-structured and unstructured decision problems. An example of a DSS is the COTS management decision-support system developed by CSIRO.
Executive decision-support system (EDSS)	A specific type of MIS that facilitates and supports senior executive information and decision-making needs. EDSS' are focussed primarily on organisation-wide decisions that encompass a large scope and multiple sub-components. An example of such a system is Aurecon's Arena decision-support system.
"Management Operating System" (MOS)	The tools, meetings and behaviours used to manage a project, program or organisation's forecasting, planning, execution and reporting processes and people to translate goals into outcomes.
Automated decision-making system	Enable greater efficiency in small scale operational decisions where the computerised automated decision-making systems uses codified decision-rules to inform the decision-maker on preferred choices for very frequent decisions.
Decision framework	The architecture of people, processes, knowledge and systems used to make decisions.

3.6 System qualification

To inform the review of potential DSS candidates across the GBR and its catchments, and in other environmental management contexts, a framework was developed to inform the classification and assessment of each system. The classification framework is based upon a continuum that features a range of potential system types, starting with a common database through to an executive decision-support system (EDSS). The need to classify systems is important due to the ambiguous and often ill-defined use of 'decision-support system' and 'management information system' classifications used to describe different systems.

The classification of a candidate system allows for a deeper understanding of the current decision support landscape and enables further assessment in relation to decision process improvement. Listed in Table 5 are the definitions used for each of the qualification features, with the associated qualification matrix outlined in Figure 4.

Table 5: Decision System Qualification Features and their Corresponding Definitions

Feature	Definition
Graphical User Interface (GUI)	A point of interaction between a computer and humans; it includes any number of modalities of interaction (such as graphics, sound, position, movement, etc.) where data is transferred between the user and the computer system.
Database	A database is a collection of structured information (data), most commonly stored in an electronic format within a computer system.
Database Management System	A database system that interacts with end users, applications and the database itself to capture and analyse the data.
Database GUI	A graphical user interface that allows the user to visualise and interpret data, e.g., a dashboard indicating water temperature at various points on the GBR.

Feature	Definition
Model Base	A representation of a system that allows for investigation of the properties of the system and, in some cases, prediction of future outcomes.
Model Base Management System (MBMS)	A model base management system is one component of a generalized DSS architecture which provides for the creation, storage, manipulation and access of models.
Model Base GUI	A graphical user interface that provides the user with a synthesis of information to inform decision making, e.g., an ocean model indicating coral between ecosystems.
Decision GUI	A graphical user interface that allows the user a representation of choices pertaining to specific decisions.

	MIS (for organisation)	MIS (for communication)	MIS (for synthesis)	DSS	EDSS
Data Base					
DBMS					
Data GUI					
Model Base					
MBMS					
Model GUI					
Decision GUI					

Figure 4. MIS and DSS qualification matrix indicating how qualification features present within in a system reflect how the system is categorised

3.7 Relevance of information systems to decision making

As discussed in Section 2.4.3, MIS and DSS can play a useful role in making knowledge available and accessible, and synthesised to the extent required to support relevant decision-making processes and relevant decision-makers in making decisions. The utility and therefore selection of these systems is dependent on the nature of the decision according to the strategic, tactical and operations decision classification.

Strategic decisions, owing to their largely unstructured nature, complexity and potential magnitude of the consequences of action, would appear to be well served by DSSs. However, the lack of frequency of these decisions mean that any DSS for these decisions would likely not be utilised for decision making at sufficient frequency to justify investment, nor have sufficient structure to reuse the system without likely changes once the next occurrence of the decision comes around. MISs are more applicable in supporting strategic decisions, though given the relatively low time pressures on strategic decisions (rendering the efficiency advantages of MIS to be less valuable to the decision-maker than tactical decisions), bespoke information is often required due to the greater likelihood of unique options, and the significant stakeholder involvement and engagement typically required for such decisions. Therefore the most significant contributor towards quality decision making is likely to be from robust decision processes.

Tactical decisions are generally ideal for a DSS. They typically feature a degree of structure to the decision (e.g., known options, known value drivers), but with sufficient frequency in the decision-making event. Additionally, there is often sufficient complexity in the decision, uncertainty in potential consequences, and a sufficient comprehensive knowledge requirement that can benefit from the computational capability of a DSS to synthesise complexity and aid the decision maker. Though in many cases, depending on the decision being made and the processes being used to make it, an MIS which presents synthesised knowledge may have equivalent levels of utility.

For operational decisions, the benefit of an MIS is in enabling efficiency in accessing and interrogating data. Many of these decisions benefit from simple dashboards that are highly customisable, easy to access and present to decision-makers the information they need when they need to access it to inform their decisions.

Figure 5 depicts the typical utility of MISs and DSSs across strategic, tactical and operational decisions, based on leading practice in industry (darker shades of green indicate greater levels of utility based on observations in industry).

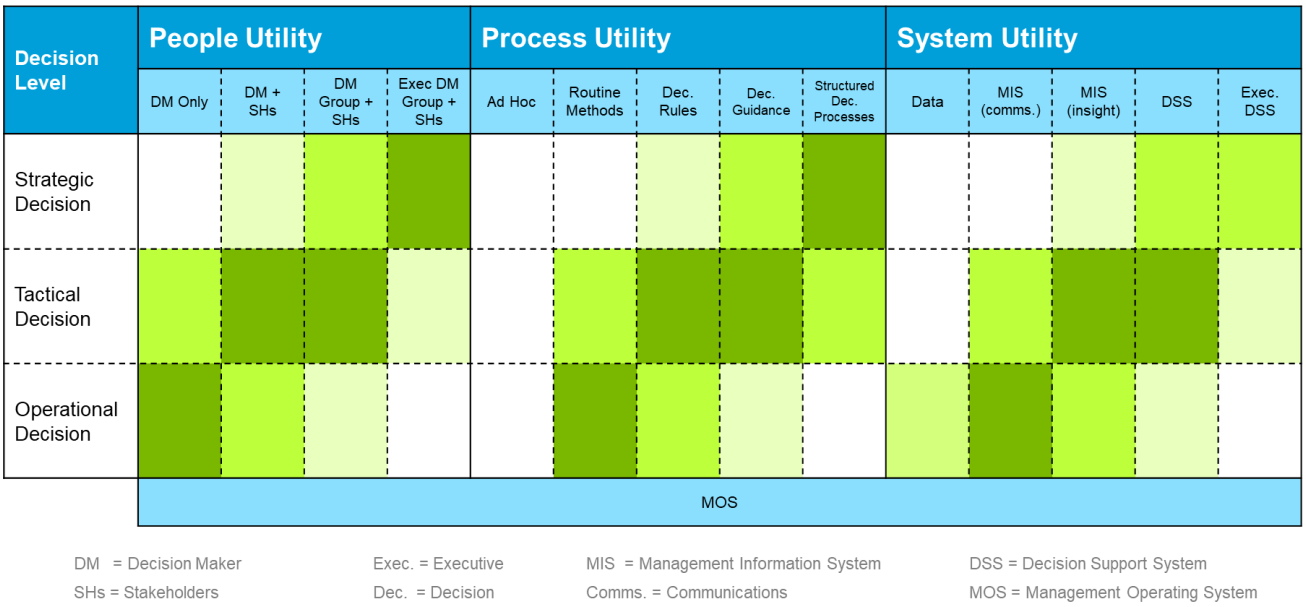


Figure 5. Leading practice utility of computerised systems to support decision making across strategic, tactical and operational decisions, shown together with people and processes lens from Figure 2 (darker shades of green indicate greater levels of utility and therefore where greatest value lies in pursuit of quality decisions).

4 Methodology of current state review

As discussed in Section 1.2, the following activities were undertaken in establishing a view of the current state pertaining to decision making and decision-support systems GBR-wide:

- Mapping of programs across the GBR that are subject to investment or ongoing funding, and subsequent review of relevant documents describing investments, activities, decisions, actions and responsible parties within each program;
- Individual interviews with executives, senior-managers, advisors and subject-matter experts that make and / or contribute towards decision making across Federal and State agencies, scientific institutions, advisory bodies, industry bodies and non-governmental organisations;
- Survey issued to a sub-set of individuals at GBRMPA responsible for making and / or contributing to reef management decisions;
- Desktop review of tools, models and systems used to inform, support and / or make decisions on the GBR, with accompanying group interviews with those responsible for developing or using them; and,
- Desktop review of decision-support tools, models and systems used in similar contexts to the GBR.

Each activity is discussed in more detail in Appendix B – Methodology - Detailed.

4.1 Analysis scope and boundaries

As the purpose of this analysis was in scoping a “GBR-wide” decision-support system in the context of the Reef 2050 Plan, the Project team, in agreement with the project Steering Committee, explored decisions, decision making and decision-support systems that could be seen as contributing towards the achievement of the Reef 2050 Plan. This included engaging with decision-makers, contributors and stakeholders who were involved in these decisions and decision-support systems. This included marine management decisions, coastal management decisions, and catchment management decisions, and, engagement with decision-makers, rights-holders, contributors and stakeholders at strategic, tactical and operational levels. The analysis was therefore a ‘mile wide, inch deep’ review, with select ‘deep dives’ performed to gain further evidence and confirmation of specific findings to inform insights and recommendations.

Any review of specific historical or current decisions was conducted only to enable broad characterisation of decision-making practices and experiences. In terms of the involvement of people, use of specific processes and use of knowledge and systems, it was done in the context of understanding the enabling conditions to maximise uptake and value gain from DSSs. The analysis does not present findings on the outcomes of specific historical decisions or the merits or otherwise of the decision-making approaches used to make them.

The project’s execution methodology is designed to aggregate findings in such a way as to assist GBR and catchment decision makers, whilst ensuring confidentiality of discussions. As such, findings are based on multiple data points, with uncertainties specifically articulated.

4.2 Methodology limitations

There are several key limitations to the methodology that should be considered while reading the results, the key findings and the recommendations for GBR decision support scoping:

- Due to the broad nature of this scope (“mile wide, inch deep”), the short time line for execution, and the preliminary nature of the work (scoping), the methodology used was fit-for-purpose; we make specific recommendations where more detailed work can be undertaken to improve the breadth, depth or resolution to the findings.
- Due to time constraints, engagement was only with Traditional Owner members of the RIMReP and RTP governance and programs. Key findings in this area have limited depth, so specific recommendations are made for a more comprehensive engagement.

- This scope has been executed as a strategic consulting project, aimed at providing strategic adjustment and strategic direction, providing actionable next steps, and based on industry and domain consulting experience and approaches; this project is not intended as an academic or theoretical exercise.

5 Results

5.1 Stakeholder interviews

5.1.1 Overview

The synthesis framework described in Section 2.5 and Section 3.6 has been used to organise the major findings from the stakeholder interviews, which are presented in Appendix G. Thirty-five (35) individual stakeholder interviews were conducted, with the interviewees listed in Appendix C. Results have been largely synthesised as enabling or impeding factors for the utility from and value proposition of DSSs, to inform recommendations for development and prototyping. Note that insights from interviews with system developers, owners and users are separate to this section, and are instead presented in Section 5.5.

5.1.2 General observations – GBR-wide decision-making landscape

To depict a synthesis of the GBR-wide decision-making landscape, using the framework presented in Figure 5, we have mapped the following broad stakeholder groups to the current and aspirational states across people, processes and systems, for the three decision classification levels (strategic, tactical and operational):

- GBRMPA;
- Other government agency executives and managers;
- Government executives;
- Industry representatives;
- Scientific, research and academic institutions; and
- Non-governmental organisations (NGOs).

The resulting map presented in Figure 6 characterises GBR-wide decision-making according to this framework, as well as a comparison to leading practice[33].

With regard to people, many of the discussions with stakeholders indicated the existence of mature and experienced networks of decision-makers who routinely negotiated complex inter-related objectives and participated together in decision making. Mapping decision-makers against leading practice showed strong alignment to leading practice, with a greater preference for collective decision making and a preference for strong levels of alignment to be achieved before decisions were made. Thus compared to leading practice, involvement of people in decision making across the GBR and its catchments is considered sophisticated and skewed conservatively. This can be seen in the symbols for each stakeholder group appearing to the right of dark-green areas for each decision level (strategic, tactical and operational). It is observed that this is likely due to the complex, inter-connected decision-making environment, with a relatively small community of decision-makers and participants in decision-making processes and multiple strong inter-personal relationships.

With regard to processes, these appear to be inconsistently mature, and inconsistently applied. Many processes were observed to be mature, appropriate for the decision context, and reported to be applied consistently. Other processes were observed to be immature in structure, ad-hoc, or perceived as overly complex or overly involved. Others were observed to be useful and applied successfully for the relevant decision level and context, though leading practices would suggest that more efficient or effective decision

[33] Public and private sector agencies and organisations in the defence, water, pharmaceutical and energy and resources industries globally are leaders in the application of quality decision making frameworks to inform management decisions. The Raiffa-Howard award for Organisational Decision Quality, awarded by the Society for Decision Professionals (the largest global professional body for decision-support practitioners), has been awarded 3 / 4 years to organisations in these sectors. Use of the term 'leading practice' uses practices in these organisations and sectors as a benchmark.

processes could be iterated (e.g., evolving from decision guidance to decision rules, or establishing more structured processes where decision guidance is currently used).

With regard to systems, aspirations for the use of systems appear to be appropriate though ambitious given the current state. The aspirations of many GBR and catchment managers for systems are largely for management information systems (MIS) to make knowledge available and accessible to support tactical and operational decisions. There are no strong aspirations amongst GBR and catchment managers for DSSs, which matches industry practice. Aspirations for DSSs are shared by science and academic stakeholders for supporting decisions at tactical and operational levels (which is not leading practice), and executive stakeholders for supporting decisions at strategic levels (matching leading practices). It should be noted that the aspirations of some science / academic stakeholders are for MISs, though there has been mischaracterisation of these aspirations as being for DSSs, through a lack of understanding of the distinction between the two. The current state of systems is largely as databases, with some development of MISs to serve specific purposes (typically related to the dissemination and communication of modelling outputs), and limited existence of DSSs. Given the current state of systems GBR-wide, aspirations amongst some towards a single GBR-wide MIS or DSS appear ambitious.

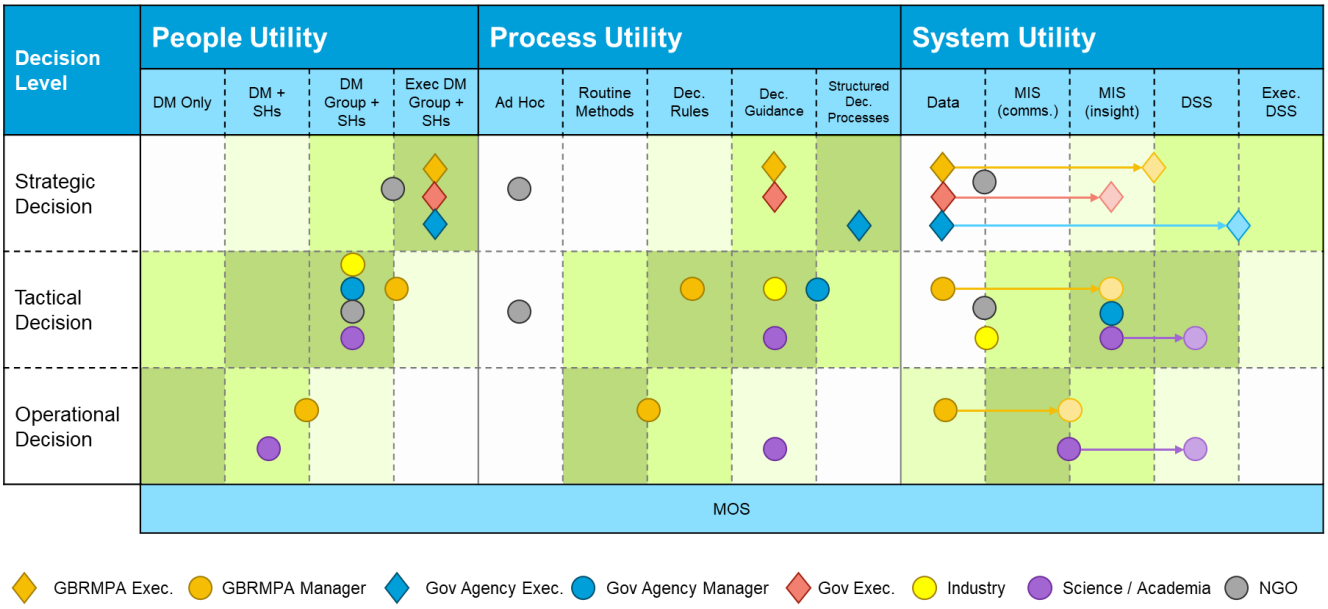


Figure 6. Current and future-state aspirations for systems that support decision making, and current state use of processes and involvement of people for decisions across strategic, tactical and operational decisions; DM = decision maker, SH = stakeholder, Exec = executive, Dec = decision, Struct = structured, MIS = management information system, comms = communication, DSS = decision-support system.

5.1.3 General observations – Influence of legacy experiences on attitudes towards decision making and 'decision-support systems'

There is inconsistent understanding of core concepts pertaining to quality decision making (as defined in Section 2.4), and legacy issues arising from decision-maker experiences with, and perception of, the use of decision-support systems. Specifically:

- Conflation of *decision guidance* (list of potential activities to be selected from to inform decision making) with *structured decision making* (an organised approach to identifying, evaluating and selecting options to inform decision making);
- Conflation of *decision-making systems* (computerised decision-support systems that automate decision making – typically used for operational decisions), *decision-support systems* (computerised systems that gather data from identified sources, synthesise it, and make it available to users in accordance with specified decision processes to support decision making), *decision processes* (processes by which decisions are framed, choices are identified, developed and logically analysed for their consequences and trade-offs, and commitments to action are made) and *decision frameworks* (the architecture of people, processes, knowledge and knowledge systems used to make decisions.);

- Mischaracterisation of *management information systems* (computerised system that gathers data from multiple sources and makes it available to users (including synthesis) to support quality decision making) and *decision-support systems*;
- Misunderstanding and subsequent concern from decision-makers that decision-support systems will automate the act of decision making;
- Varied positive and negative experiences and perceptions of the merits and challenges associated with the use of decision-support systems in previous decisions (e.g., use of Marxan for the Representative Areas Project for zoning the GBR Marine Park);
- Perception of decision making being largely dictated by regulatory requirements, reducing the perceived optionality that can be considered by decision makers that would support use of a structured decision-making approach;
- Perception of senior decision makers having an aversion to uncertainty, leading to obfuscation of uncertainty in knowledge, options, values, consequences and trade-offs used in the decision-making processes;
- Perception of senior decision makers having an aversion to decision-making approaches that, through their objective, data-driven approach, would be perceived as constraining their ultimate decision-making power;
- Perception that decision-making processes, are generally inclusive and appropriate, but sometimes seen as rushed, resulting in sub-optimal engagement, and sometimes leading to sudden and last-minute alterations to outputs without adequate finalisation of alignment among stakeholders and rights-holders;
- There are high expectations amongst some of what a decision-support system will be and can do, partially driven by expectations established by the RIMReP program, and, discussions and funding on decision support for the RRAP program; and
- A sense that ‘decision-support systems’ have been sold as being able to do more than has been demonstrated, leading to expectations management issues.

In the context of the opportunity for use of, and benefit from, DSSs, these issues mean that decisions pertaining to the development and prototyping of DSSs need to carefully consider appropriate use cases accompanied by stakeholder engagement and communication of what the DSS is and isn’t, the processes it would be used to support, and benefits .

5.1.4 General observations – Individuals and relationships in the GBR

Broadly speaking, it was observed that the vast majority of stakeholders interviewed had significant long term involvement within the GBR and its catchments, with significant experience in their respective domains and relatively long tenures in their organisations, and in some cases their current roles. Most stakeholders were highly credentialed (possessing post-graduate qualifications) and almost all expressed their passion in delivering successful outcomes on the GBR and its catchments. Strong histories, working relationships and connections between individuals were explicitly discussed in many interviews, as was familiarity with the various GBR programs, and their histories despite varying degrees of involvement. Whilst the GBR funding, management and scientific community is well-connected, a wide range of differing opinions were expressed on most topics pertaining to decision making. However, it was observed that there would be very consistent perspectives amongst some participants on certain topics pertaining to decision making despite different levels of familiarity.

In the context of the opportunity for use of and benefit from DSSs, the close connections within the GBR community have the potential to create positive momentum and decision-maker buy-in from successful early experiences of end users from DSSs. Though conversely, there is the potential for significant risk if end user experiences and ultimate outcomes from use of DSSs are viewed as underdelivering on the promise.

5.1.5 General observations – Convergent and divergent objectives of GBR and catchment managers, scientists, and funders

Generally, it was observed that objectives across the GBR and its catchments are variously complementary and variously competing, as with many complex assets. However, unlike most complex assets that have sole points of accountability and coherent structures for investment decision making, the GBR and its catchments have multiple points of accountability and complex structures for investment decision making. The environmental, ecological and socio-economic complexity of the GBR and its catchments, as well as their political and regulatory history ensures that it is difficult to determine whether this arrangement is the most effective. However, there was general agreement that progress is being, and should continue to be, made towards a more integrated understanding of objectives GBR-wide, with accompanying investment decision making shifting as much as possible (given the complexities) towards greater integration between decision making on the GBR and decision making on its catchments.

Within this context, it was observed that while the programs of the GBR are all explicitly or implicitly intended to deliver progress towards the objectives of Reef 2050, the objectives of the contributing organisations and agencies are not always in full alignment with the objectives of these programs. While this is expected and typical in large multi-stakeholder asset contexts, this can play out in the various lenses that individuals from various organisations and agencies apply to the problems that need to be solved and the decisions that are made. For example, a recurring theme throughout the interviews was the perception that there is a significant amount of scientific effort performed attempting to better characterise various aspects of the bio-physical GBR system, in particular those for which there is relatively less knowledge, without direct characterisation of how improved understanding would be used to realise improved outcomes on the GBR through relevant management actions.

Developing decision support processes and systems offers an opportunity for GBR and catchment decision makers. It can help focus the science, collection of data and generation of knowledge on the objectives of Reef 2050 and key problems that may impact achievement of those objectives. It can help resolve relevant uncertainties that impact on management choices. Lastly, it can help optimise efforts between increasing understanding of relevant aspects of the GBR system, including bio-physical and other domains, and efforts to help discern between options and make the right choices that benefit the GBR, its catchments and society.

5.2 Surveys

As outlined in Section 4, the responses provided from the GBRMPA Reef Managers' survey have been synthesized and presented in Section 5.2.1, and in Appendix H. Note at the time of writing, 10 of the 16 individuals surveyed had provided responses.

5.2.1 Decision making: knowledge and knowledge systems

Responses from survey participants indicate that currently data is largely available for decisions across strategic, tactical and operational decisions, but that it is not widely accessible nor synthesised for comms (e.g., through dashboards) or for insight (e.g., through accessible model outputs). This is slightly more pronounced for strategic and tactical decisions than for operational decisions. Survey responses indicate participants desire a greater level of access to information that is synthesised for communications (e.g., through dashboards) for strategic, tactical and operational decisions, and, desire access to information that is synthesised for insight (e.g., through accessible model outputs) for operational decisions.

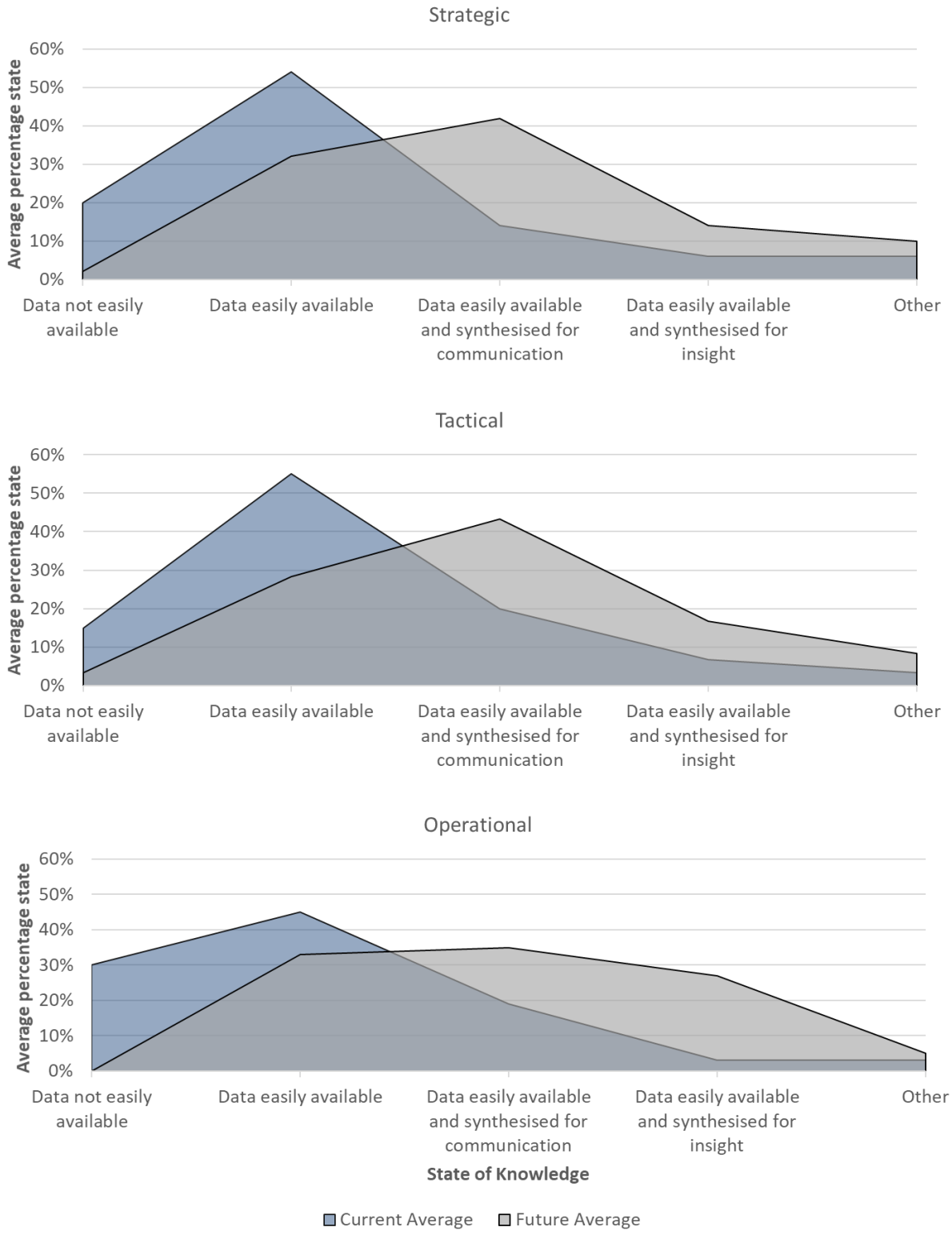


Figure 7. State of Knowledge to Support Decision-making – Current vs Future.

5.2.2 Decision making: current use of systems

The Reef Management System (RMS), Reef Explorer and Native Title Vision systems were the most common systems identified by respondents as being used to support decision making. Eye on The Reef is

the only other system to have been mentioned more than once.

Figure 8 Word-cloud indicating the most commonly mentioned systems used to inform decision making, in response to the question: Decision Systems

5.2.3 Decision making: desired knowledge needs

Multiple respondents identified the need for more socio-economic, social science and traditional owner-related data to inform decision making. Uncertainty in modelling, reef visitation data, islands and species data and cumulative impacts were also identified. Specific responses are listed below in Figure 9.

"Confidence rating in modelling is not always apparent"	*"Collective Reef visitation, across all sectors and use at a site level scale. Exposure to drivers of coral decline"*	*"Good metadata. More social science data"*
"There is a substantial amount of knowledge that we don't have. Reef scale environmental data. Traditional Owner sensitivities. Cumulative impacts. Research into the risk, impacts and benefits of activities to the Marine Park values, in particular emerging technologies and activities."	*"The list is endless - use levels, cumulative impacts, cultural impacts, information "I should know about" of a specific location"*	*"Resource requirements - what it takes, operationally, to effect strategic objectives"*
"Location and state of Indigenous Heritage. Capacity and track record of delivery by Indigenous organisations. Hot spots of most risk - tourism pressure, research pressure, non-compliance and environmental risk. Cultural protocols and contacts for non-TUMRA organisations. Aspirations of each Traditional Owner group"	*"Data about social and Traditional Owner impacts, risks and sensitivities. Cumulative impact modelling and data to inform decisions"*	*"Much of the island-based and species-based knowledge is not available in any form of dashboard to inform decision making. Generally speaking, this data has to be interrogated beforehand to assist in decision-making"*

Figure 9. Responses indicated knowledge needs of Reef Managers to inform decision making

5.3 Desktop document review

As discussed in Section 4 and Appendix B, a desktop review was performed of relevant documents pertaining to GBR entities and programs for the purposes of identifying the spectrum of decisions being made across the GBR. Figure 10 shows the number of documents which had % content levels pertaining to strategic, tactical and operational decisions. For example, there were 25 documents which had approximately 75% or more of its content (and by extension, decisions) of a strategic nature, compared with 8 which had approximately 75% of more of its content focussed on content of a tactical nature (and by extension, decisions). A more detailed breakdown can be found in Appendix F.

	No. of Documents Reviewed		
	Strategic	Tactical	Operational
Content >75%	**25**	**8**	**0**
Content >50%	**39**	**20**	**1**
Content >25%	**44**	**29**	**6**
Content >10%	**58**	**59**	**21**

Figure 10. Number of documents reviewed, characterised by percentage content pertaining to each decision classification (strategic, tactical, operational)

Figure 11 shows (1) the average distribution of decisions reported through reviewed GBR documentation, and (2) the relative proportion of documents that were strategic, tactical and operational in focus. The chart shows that strategic decisions accounted for more than half of the decisions reported in the documents followed by tactical decisions (34%) and operational decisions (15%), and, the majority of documents reviewed.

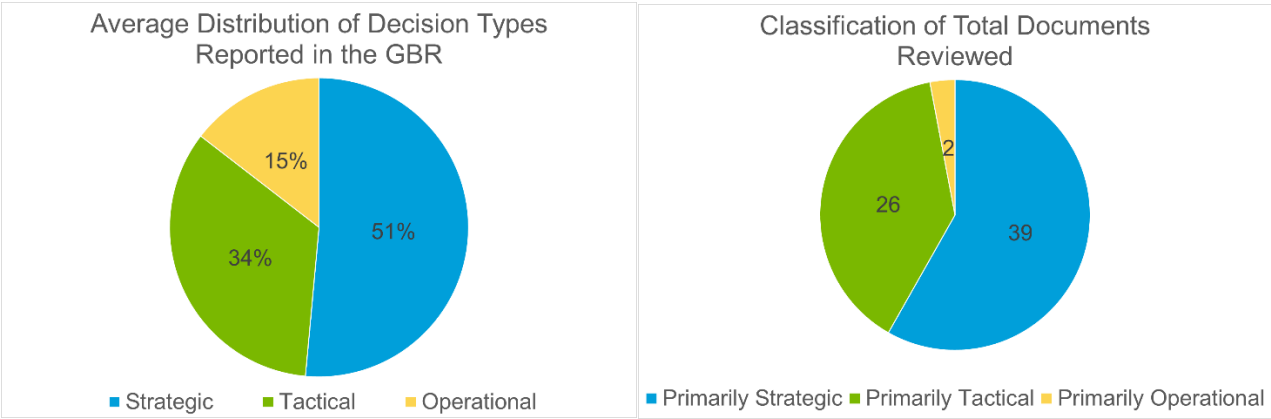


Figure 11. Chart to show average distribution of decision types reported in the GBR

5.3.1 Documented decision processes

An exercise was carried out to review a sample of three documented decision-making processes to assess for the occurrence of each of the 6 elements of quality decision making (as outlined in Section 2.4) in the decision-making process. The documented decision-making processes that were reviewed were:

- Reef line harvest strategy 2020-2025
- GBRMPA Permit Assessment Guidelines
- Representative Areas Program (RAP): Zoning of the Great Barrier Reef

The purpose of the review was not to assess how well these decision processes fulfilled the 6 elements of quality decision making, but simply to review for the presence of these elements in the decision-making processes outlined in the documents. The review concluded that all three decision-making processes included, to some degree, all 6 elements of quality decision making, however the level of complexity demonstrated for each of the 6 elements in the decision-making processes, did vary between the decisions. A table of the review can be found in Appendix L.

5.3.2 Terms of reference decision guidelines

An exercise was carried out to review a sample of terms of reference, charters and constitutions for a range of decision-making bodies within the GBR and its catchment. The purpose of the exercise was to identify whether these documents explicitly outlined any guidelines for the provision and application of decision quality and assurance in the decision-making processes both for the group and the broader programs of work the groups were involved in. The documents that were reviewed were:

- Reef line fishery working group
- Sustainable Fisheries Expert Panel
- Cape York NRM Constitution
- North Queensland Dry Tropics NRM Constitution
- Fitzroy Basin NRM Constitution
- Burnett Mary NRM Constitution
- GBRMPA Board Charter
- RIMReP Executive Committee Terms of Reference
- RIMReP Steering Committee Terms of Reference

The review concluded that the only document that made any reference to the provision of decision quality and assurance in the decision-making processes of the group and its broader program of work was the GBRMPA Board Charter. The references to decision making outlined in the charter were at a very high level, for example ‘board decision making is informed by an understanding of risk and how risk is managed’, and did not go into a level of detail around the processes that could be followed to ensure decision quality and assurance. A table of the review can be found in Appendix M.

5.4 Identify opportunities for DSS’s by investment patterns

An analysis of investment in major programs and initiatives is an additional approach to defining potential value from investment in DSS, as the value of the associated decisions is in part determined by the quantum of funding the actions from those decisions are subject to. Information on Australian and Queensland government funding commitments in the GBR and its catchments, primarily those that fall within the auspices of the Reef 2050 Plan, were extracted from publicly available sources. Disaggregating these investments at tactical and operational decision levels yields insights as to where there may be the greatest cost and / or value from decisions being made, and where investment into DSSs may provide a better return on investment.

The results of mapping funding through operational programs to target areas of action on the GBR and its catchments from FY21 to FY25 indicates that at the level of the Australian Government, the roughly $650m being invested under the auspices of the Reef 2050 Plan comprises several major programs being delivered at the tactical level (IMOS $110M, JFMP $210M, WQ in the RTP $201M and RTP RRAP $100M). Given the utility of DSSs are generally highest at the level of tactical decisions (as discussed in Section 3.6), high-priority opportunities for DSSs are likely to exist in these large programs (noting that several of these – e.g., RRAP and RTP WQ - have existing efforts to develop DSSs). Whilst there is lower utility from DSSs at the operational level, given the majority of investment GBR-wide is in the operational management of reef and fisheries assets, programs focussed on reef and fisheries management may be high-value targets for DSSs. The existence of DSSs in these areas would likely also benefit strategic decision making, in conjunction with relevant decision processes for these decisions.

Mapping of investment flows beyond the tactical and operational levels to specific areas of action and then through to outcomes was not attempted due to the absence of a more formalised objectives hierarchy or program logic in the Reef 2050 Plan, and due to lack of publicly available information that coherently links program budgets to indicators (as proxies for outcomes). In future iterations of the Reef 2050 Plan, it would be useful to develop a program logic and associated objectives hierarchy to be able to implement structured decision making more effectively, in particular in relation to strategic decision making.

5.5 Desktop systems review

5.5.1 Overview

As discussed in Section 4 and Appendix B, a desktop review of relevant models and information systems in the GBR and in similar contexts was performed, followed by subsequent interview with GBR system developers and users. The full list of systems reviewed is presented in Appendix J.

Figure 12 depicts the candidate systems reviewed and their level of application in which the systems are utilised. Each concentric circle within the figure represents the level to which a system is applied (i.e., Great Barrier Reef, Coral Reefs, Environmental Management and General). For example, the COTS DSS is applied specifically within the Great Barrier Reef, whereas GoldSIM simulation software is applied across a broad range of settings and is more general. Most systems reviewed where from within the GBR domain to ensure findings where relevant to the GBR decision landscape.

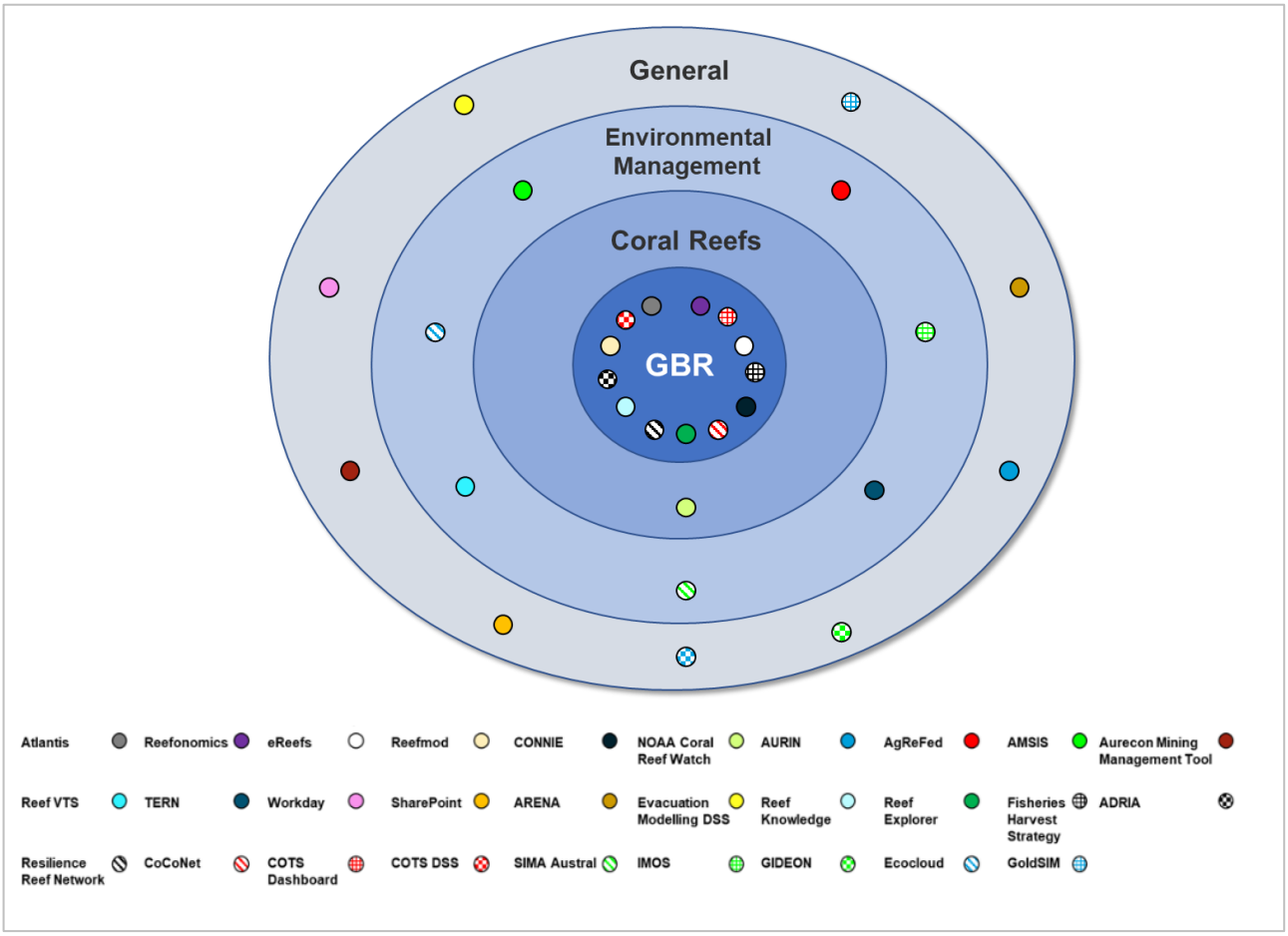


Figure 12. Summary of Potential Candidate MISs and DSSs reviewed, according to their application

5.5.2 System mapping

Figure 13 highlights the classifications of GBR associated systems against the framework definitions for MISs and DSSs. The majority of systems currently in use or development in the GBR fall into the MIS category, almost equally split between MIS for comms and MIS for insight. Two systems are considered DSS – the COTS DSS developed by CSIRO for the JFMP and the Reefonomics tool used by the GBRF for water quality investment planning. Interestingly, many of the MISs for insight appear to be used for strategic decisions and not for tactical decisions – this likely represents a significant opportunity to enable higher quality decisions. They also appear to be used as part of decision guidance-based processes – this is consistent with what was found through the stakeholder interviews. There appears to be a lack of available

systems with synthesised knowledge for operational and tactical decisions, again consistent with stakeholder interviews and the survey of GBRMPA Reef Managers.

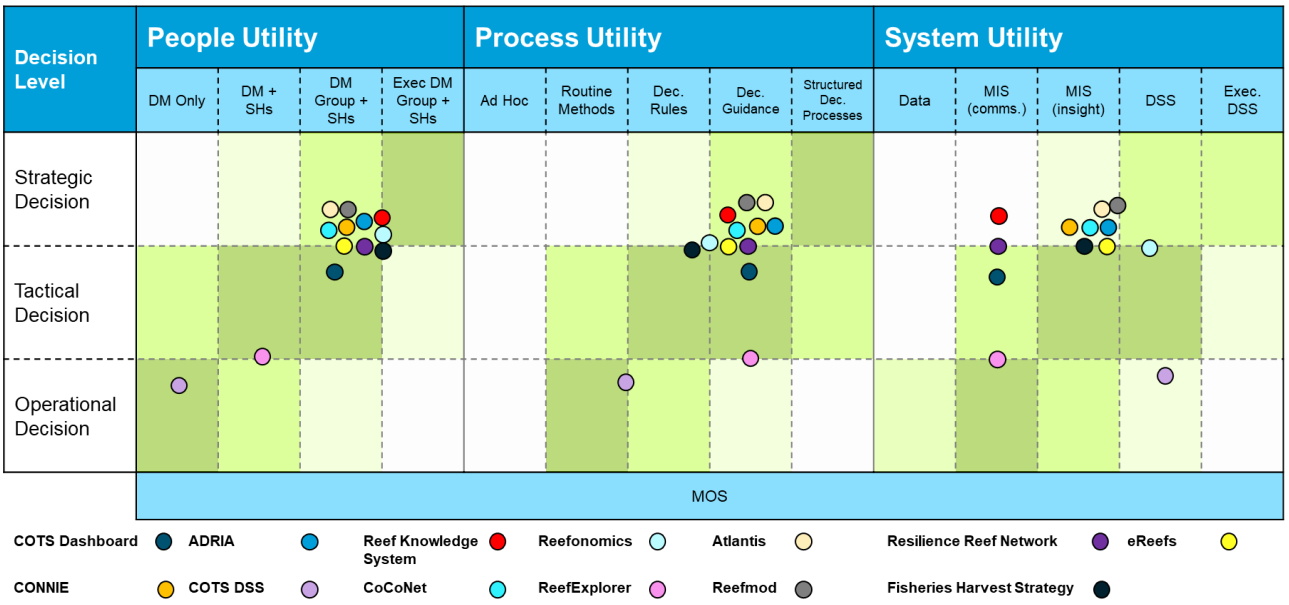


Figure 13. Mapping of GBR systems and supporting decision processes and decision-maker involvement

Figure 14 highlights the classifications of a sample of non-GBR associated systems against the framework definitions for MISs and DSSs. Most systems reviewed are either MISs for comms (i.e., dashboards) with two EDSSs also reviewed.

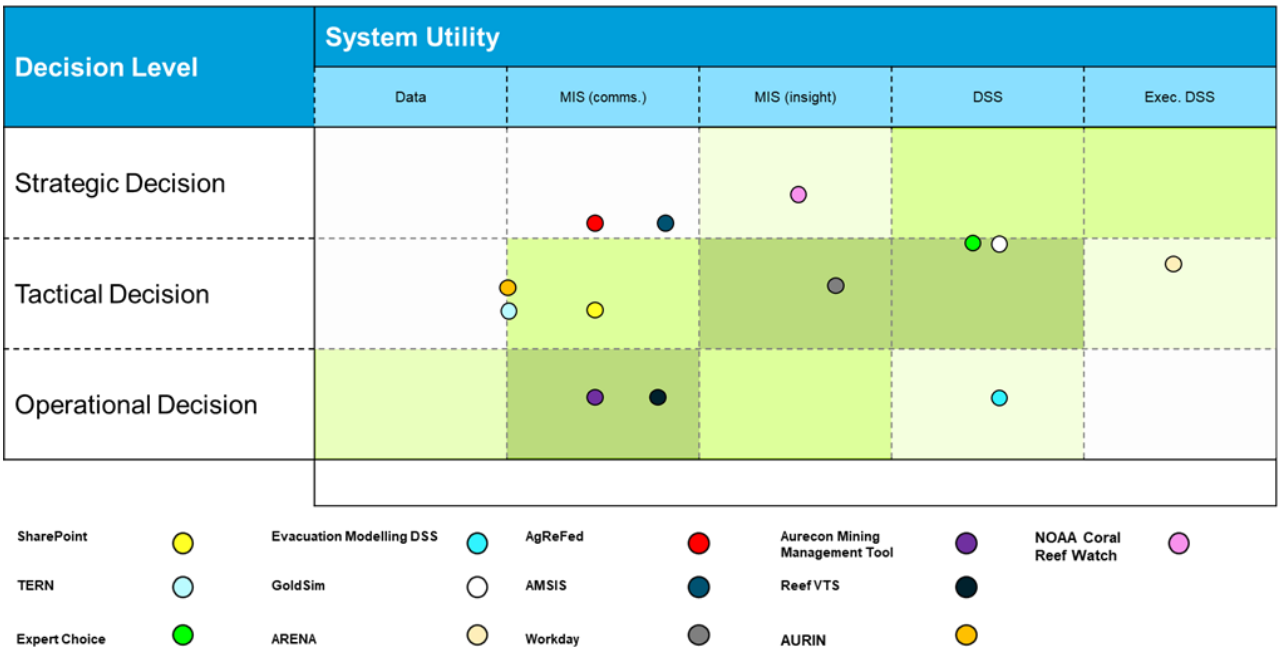


Figure 14. System Utility Mapping within GBR & Outside of the GBR Landscape

Figure 15 depicts each reviewed system against each program that it supports. eReefs and e-Atlas are the most widely used MISs, while the COTS control program is the greatest user of GBR MISs and DSSs.

	Programs									
Systems	COTS Control Program	Joint Field Management Program	QLD Reef Water Quality Program	Reef Restoration and Adaption Program	QLD Sustainable Fisheries Programs	Marine Monitoring Program (GBRMPA)	Long Term Monitoring Program (AIMS)	Paddock to Reef	Integrated Marine Observing System	QLD Fisheries Monitoring and Research Plan
E-Atlas	✓	✓			✓	✓	✓		✓	✓
eReefs	✓		✓	✓	✓	✓	✓	✓		
Eye on the Reef Dashboard	✓	✓								
ReefMod	✓			✓						
ADRIA				✓						
Atlantis					✓					✓
Reef Explorer		✓								
Resilience Reef Network		✓				✓	✓			
Fisheries Harvest Strategies					✓					✓
CoCoNet	✓			✓						
CONNIE	✓				✓					
COTS Contrpl Program Dashboard	✓									
COTS Operational Management DSS	✓									
Reefonomics			✓					✓		
Reef Knowledge Portal						✓	✓			

Figure 15. GBR systems mapped to use in GBR programs

5.5.3 System review – classification examples

Provided in Table 4 are a range of system types and their corresponding system classifications.

Table 4. List of Common Examples for Each System Category

Database	MIS (Comms)	MIS (Insight)	DSS	EDSS
Ecocloud	COTS Dashboard	CONNIE	Reefonomics	ARENA
	Reef Explorer	CoCoNet	COTS DSS	Workday
	Reef Knowledge	eReefs		
	Eye on the Reef	NOAA Coral Reef Watch		

5.6 Case Studies

Several case studies were made into specific systems in order to gain insights for potential DSSs for application in the GBR and its catchments. These case-studies were conducted within the decision framework presented in this document, are summarised below, with details in Appendix K.

Reef line Fishery Harvest Strategy:

Description:

The 5-year Reef line harvest strategy was one of two harvest strategies implemented in 2020 (the other being the Spanner crab harvest strategy), in response to the Queensland Sustainable Fisheries Strategy (implemented in 2017) target to have *'implemented harvest strategies for all Queensland fisheries, which set clear targets for fishery performance, triggers for action and clear decision rules for the actions that will be taken'*.

Reef line Fishery Harvest Strategy:

Decision Process:	Ad Hoc	Routine Methods	Decision Rules	Decision Guidance	Struct. Dec. Making
			■	■	

System Qualification: MIS for Insight	Data Base	DBMS	Data GUI	Model Base	MBMS	Model GUI	Dec. GUI
	■	■		■	■		

Key insights for GBR DSS:

- Pre-determined decision rules, outlined in the harvest strategy and approved by the Minister of Fisheries, enable a delegation of authority for changes in fishing quotas to be set by fishery managers without the need for an approval process, therefore improving the efficiency of the decision-making process.
- Harvest strategies use a multitude of datasets to inform their stock assessment models and would benefit from a centralised knowledge database to collect all information relevant to decision-making process - GBRMPA
- Codifying decision rules outlined in harvest strategies would enable development of a DSS capable of determining annual fishing quotas for different species, sectors and fisheries.
- Implementing a structured decision-making process for the development of the 5 yearly harvest strategies would enable more robust objectives, performance indicators, management responses and decision rules to be identified and developed.

COTS Operational Management DSS:

Description:

The first on-water COTS management decision framework was implemented in 2018, as part of the expanded COTS Control Program (increasing from 1-2 vessels to 6 vessels), to enable COTS control vessel operators to make decisions on which reefs to visit and the appropriate COTS management actions at each reef. The simplified decision tree framework has formed the basis of a digital COTS Control Centre DSS (also developed by NESP5 COTS IPM Research Program) that, when implemented, will provide COTS control vessel operators with management decisions.

Decision Process:	Ad Hoc	Routine Methods	Decision Rules	Decision Guidance	Struct. Dec. Making
			■		

System Qualification: DSS	Data Base	DBMS	Data GUI	Model Base	MBMS	Model GUI	Dec. GUI
	■	■		■	■	■	■

Key insights for GBR DSS:

- The decision framework underpinning the DSS has been developed through application of an integrated pest management framework and first tested as a manual version by COTS control vessel operators to refine and optimise the decision rules before codifying.
- Pre-determined, optimised and codified decision rules enable efficient and consistent operational decisions to be made, using an organised and centralised database – EoTR.
- Decisions at the GBR and Regional scale i.e., which reefs to include in the control program, are currently selected by program managers through annual workshop processes and data reviews, however could benefit from similar codifying of processes, as per the operational DSS.
- Research into efficacy of management interventions currently informed by modelling provided by CoCoNet and ReefMod.

Reefonomics:

Description:

The Reefonomics DSS is an updated version of the 'investment pathways tool', developed in 2018 by the RTP to help inform on the optimal course of action for prioritising its $201m investment in water quality improvement strategies as part of the Queensland Reef Water Quality Program. Users can create different scenarios to provide an estimate of cost and prediction of water quality improvement for implementing a range of different on-ground management actions.

Decision Process:	Ad Hoc		Routine Methods	Decision Rules	Decision Guidance		Struct. Dec. Making
				■	■		
System Qualification: **DSS**	Data Base	DBMS	Data GUI	Model Base	MBMS	Model GUI	Dec. GUI
	■	■		■	■	■	■

Key insights for GBR DSS:

- An engaging and simple to use graphical user interface enables a multitude of stakeholders to operate and benefit from the insights of this DSS.
- A centralised information portal ensures data can be quality controlled and managed.
- A structured-decision-making process is still necessary for the user to undertake, to prioritise what is important to them in terms of management outcome, particularly in cases where funding is limited.

ARENA:

Description:

ARENA is an open architecture decision-support tool developed to aid in complex decision-making scenarios. The tool is predominately used for infrastructure and resources development in both the public and private sector. ARENA provides an opportunity for decision makers to assess concept feasibility and business cases at an early stage in a project's lifecycle.

Decision Process:	Ad Hoc		Routine Methods	Decision Rules	Decision Guidance		Struct. Dec. Making
					■		■
System Qualification: **DSS**	Data Base	DBMS	Data GUI	Model Base	MBMS	Model GUI	Dec. GUI
	■	■	■	■	■	■	■

Key insights for GBR DSS:

- An EDSS of this nature with an easy to navigate GUI is a relatively simple process and can demonstrate the potential of decision support at the early stages of a project. The system is typically a low investment, high value proposition for a project.
- The tool works best in conjunction with good processes and can help with advancing the application of a DSS and Structured Decision Making processes
- The need to quantify uncertainty investment provides further clues to the development of a GBR - wide decision-support system.

Expert Choice:

Description:

Expert Choice's decision-making software is a multi-criteria decision analysis tool that aims to align strategic objectives with the decision-making process. The tool is particularly useful when there are multiple stakeholders involved in the decision-making process.

Decision Process:	Ad Hoc	Routine Methods	Decision Rules	Decision Guidance	Struct. Dec. Making

System Qualification:	Data Base	DBMS	Data GUI	Model Base	MBMS	Model GUI	Dec. GUI
DSS							

Key insights for GBR DSS:

- The use of software such as ExpertChoice is valuable where a portfolio problem is present. In respect to the GBR landscape, such a system may have utility for decisions where a portfolio management approach is required
- Additionally, in a context where a large number of stakeholders are involved in the decision-making process application of this system is appropriate.

5.7 Drafting a "Management Operating System" (MOS) for recreational fishing compliance management

During the course of several conversations with GBRMPA managers, the project team established a very preliminary "Management Operating System" (MOS) for the recreational fishing compliance management component of the Joint Field Management Program (JFMP). The intent of this exercise is not to establish a comprehensive view of the people, process, systems and knowledge inherent in the recreational fishing compliance management area, but instead to indicate the utility of MOS to characterise decision frameworks in detail as a foundational activity for advancing decision process understanding in the context of the GBR or its catchments. Conceptually, after a current state MOS is mapped, subsequent discussions can be held to define a future state MOS that incorporates areas of improvement, including the application of MISs or DSSs and any other relevant element of a robust decision framework (as described in Section 2.5).

A preliminary draft MOS for recreational fishing compliance is shown below in Figure 16. It shows the cadence of activities across the categories 'forecast / review', 'plan', 'execute' and 'report'. Key decision points are represented as the endpoint of decision processes, e.g., there is a decision to allocate resources at the end of the 5-year business strategy process. Knowledge is created which is then passed to the next decision process, e.g., the 1-year targets review process. Mapping of the people, processes, systems and knowledge in any one decision area, such as recreational fishing compliance, shows where there are potential improvements that can be made to increase decision quality. In this example, early indications are of the potential for MIS or DSS application in the monthly translation of the intelligence database and other databases into the monthly planning process, as well as the linking of monthly patrol and compliance data back into the databases. As mentioned earlier, these findings are preliminary and serve only to demonstrate the potential efficacy of MOS mapping.

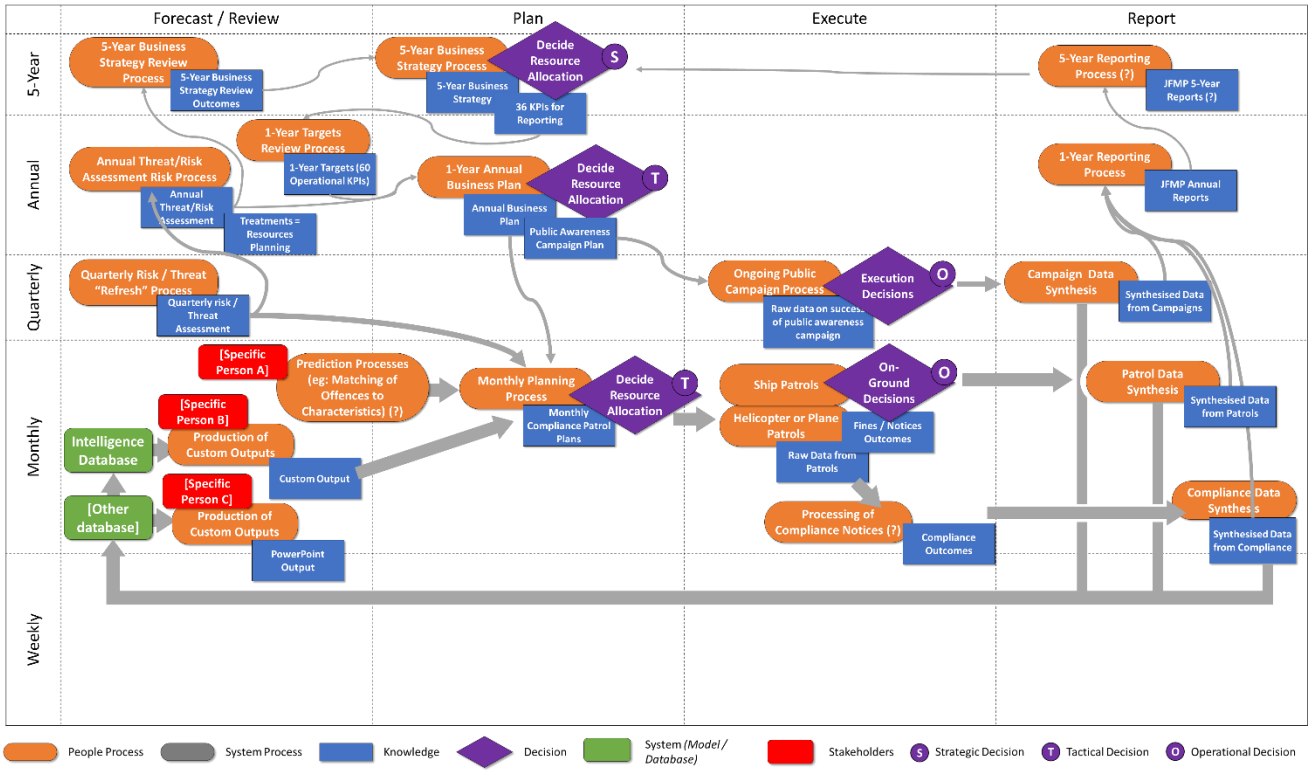


Figure 16. Preliminary draft "Management Operating System" (MOS) for recreational fishing section of the Joint Field Management Program (JFMP); showing cadence of activities

5.8 Investment in modelling & decision support in the Reef Restoration and Adaptation Program (RRAP)

This analysis was undertaken in parallel to a project performing foundational activities for the development of modelling and decision support (M&DS) for the $100m Research & Development (R&D) phase of the Reef Restoration and Adaptation Program (RRAP). Included in that scope was consideration of the development

of information systems (including DSSs) to support the program. Aurecon were also the lead consultant for this scope.

The foundational activities scope addressed the following aspects:

1) current state assessment of M&DS in RRAP,
2) identification of key decisions across the life of the program
3) mapping of knowledge needs, gaps and uncertainties relevant to key decisions
4) development of a decision framework for the program
5) gap analysis of current vs future M&DS needs
6) identification of potential model and information system infrastructure options to support program decision-making needs
7) Identification of critical work packs to progress development of required M&DS for RRAP.

While at the time of writing the RRAP M&DS scope is still ongoing, several relevant findings are known:

- RRAP is widely seen by GBR stakeholders as the likely home for innovation over the next 4 years, owing to the greenfield nature of the scope and the significant investment made in it ($100m).
- RRAP leadership are committed to making a significant investment in M&DS capability, including, in fit-for-purpose information system capability (including DSS) to inform RRAP R&D investment and prioritisation decisions and subsequent restoration and adaptation decisions in intervention deployment.
- In particular, RRAP requires and is investing in enhancements in predictive knowledge, ecosystem services and socio-economic and cultural knowledge, integration of environmental and ecological models, dissemination of synthesised knowledge, intervention optimisation sub-modelling and decision processes for structured decision making.

The first 18 months of the RRAP R&D phase, the majority of the focus for M&DS is in model enhancements and integration, predictive knowledge generation, and, development of structured decision-making processes for investment in R&D experiments, trials and ultimate restoration and adaptation intervention deployment prioritisation. These capabilities and advancements are highly likely to be pertinent to enhancing the capabilities and knowledge available to broader GBR decision-makers, and, to any development pathway for other GBR DSSs. Progress made in RRAP is likely to be a critical pre-cursor to advancements sought after and required in wider GBR decision-making contexts.

Development of any GBR DSSs, and, enhancement of GBR-wide decision making, should plan to leverage the advancements being planned in RRAP.

6 Key findings: The GBR-wide decision landscape and the place for DSS's

Based on the current state assessment, a number of key findings have been developed regarding the GBR-wide decision landscape. These are presented for RTP and RIMReP partners to consider as they advance the development and prototyping of DSSs for the GBR and its catchments, and, as they advance quality decision making more broadly.

The key findings are structured as a narrative to describe the GBR-wide decision-making landscape observed during this scope. As such they are often inter-related, overlap, or provide greater resolution to previous findings. It is encouraged that all findings are fully comprehended to ensure each individual finding is understood in its entirety. These key findings are the view of the authors, and to be interpreted in the context of the "mile-wide, inch-deep" nature of this analysis.

A reminder that the scope of this project specified "GBR-wide" as the scope extent, and this term is taken to cover the scope of the Reef 2050 Plan (the term "GBR-wide" is used in this context, as opposed to "GBR" which refers to the extents of the GBR Marine Park Area). The scope is focused on identifying and assessing the enabling conditions for decision-support systems (DSSs), and as such, reviews a sub-set of decision making GBR-wide to achieve that purpose; it is not a comprehensive review or assessment of GBR-wide decision making.

Key finding 1 – Current decision makers are mature, and decision making is effective given the existing processes, knowledge, and pressures

Current decision making across the GBR and its catchments is mature, with many engaged, collaborative and skilful decision-makers who make effective decisions given the existing processes, knowledge, uncertainty, time pressures and resource pressures, based on the following:

- Decision making for the GBR and its catchments has a long history, over which time it has matured, and for which the long tenure of many of the decision makers at strategic, tactical and operational levels has driven strong institutional memory, strong understanding of the complexities, and high collaboration with colleagues.
- Long tenure of decision makers, combined with their personal engagement / passion has resulted in a continuous push for highest quality decisions, and a parallel and justified individual and institutional pride in that pursuit.
- Decision processes and the knowledge that feed them are widely seen as highly uncertain, requiring of constant improvement, and subject to pressures of time and resources such that it impedes the achievement of optimum outcomes for the GBR and its catchments; however, they are seen as adequate processes and "best available" knowledge given the constraints, which is an indication of effectiveness.

Key finding 2 – There is strong, universal support for efforts to make knowledge more available, more efficiently accessible, more synthesised, more predictive (i.e., understanding of projected changes) and more management focused

Decisions have been made, and will continue to be made, with the best available knowledge, and there is wide-spread and strong support for efforts to make knowledge more available, more efficiently accessible, more synthesised, more predictive and more management focused, for the following reasons:

- Availability of knowledge (e.g., data, MIS) was found to be immature compared to leading practice, and immature compared to the mature nature of GBR decision-makers and decision processes.
- There were strong indications that knowledge pertaining to the GBR and its catchments was extensive (apart from several key areas), but often not particularly easy or timely to access; there were associated indications that improving access should be prioritised higher alongside any investment in generating more knowledge.
- There was a clear emphasis on the need to increase effort (management, developmental and scientific) in synthesising existing knowledge to enable higher quality decisions, and that that this should be prioritised higher alongside any investment in generating more knowledge.
- It was observed that there were many existing parallel and extensive efforts to identify and fill gaps in knowledge pertaining to the GBR and its catchments (their current state, management, and predicted state).
- Predictive knowledge was widely identified as a key gap in the GBR and catchment landscape, particularly in the acknowledgement of climate change as a major driver for changes to the GBR and its catchments.
- GBR asset managers widely reported that knowledge regarding the efficacy of their management actions was highly desired, but largely unavailable for various reasons including significant uncertainty, significant complexity, limited scientific investigation and limited available resourcing to pursue improvements to this situation.
- GBR managers widely reported that knowledge pertaining to the spatial distribution of human use was key missing knowledge.
- In order to increase efficacy of scientific effort towards addressing knowledge needs of managers, several areas were identified: (1) greater transparency in access to scientific knowledge (2) focusing scientific effort on reduction of uncertainty, and (3) enabling better translation of knowledge and knowledge insights between scientists and managers.

Key finding 3 – Increasing efforts to develop a MIS is high priority, urgent and critical to decision making, and to realising desired outcomes on the GBR and its catchments

The capability of a MIS is widely requested by GBR and catchment decision-makers and is foundational to achieving higher decision quality, so current efforts should be continued or increased, based on the following:

- There is strong support for efforts to make knowledge more efficiently available and accessible, more synthesised, more predictive and more management focused (see key finding 2). For example, the potential of the Reef Knowledge System currently in development by GBRMPA, to enable increased access to information, appears to be warmly received by Reef Managers.
- Best available information is critical to increase decision quality and therefore management success for the GBR and its catchments; managers have a strong desire to know that they have access to the best available information.
- Lack of time and resources are key constraints for decision quality on the GBR and its catchments, so accelerated development of MIS capability will assist GBR and catchment managers by accelerating access to knowledge thereby enabling greater efficiency in decision making.
- There are limited resources and time available for development of an MIS, and GBR and catchment managers are also subject to limited resources and time, so additional efforts to build an MIS should be focussed on assisting the most time-poor managers working on the most critical problems.

- The volume of available information will only increase, so accelerated development of an MIS will enable future information gathering efforts are focussed on filling key gaps and are ultimately captured within and disseminated through an MIS.
- Due to the existing limitations on the available time and resources of GBR and catchment managers, combined with emerging challenges that will likely increase those limitations (e.g., climate change, budgeting restrictions due to COVID-19), leveraging potential efficiencies is both urgent and necessary.

Key finding 4 – A single "GBR-wide" MIS is ambitious and required investment will likely extend beyond the diminishing point of returns

A single "GBR-wide" MIS that is the repository of all GBR-wide information is ambitious. It should be considered aspirational only as investment towards a single MIS will likely result in development effort and investment that extends beyond the returns from consolidation and centralisation, based on the following:

- The project team have little evidence from this analysis or from previous experience of an "asset, program or organisation-wide" MIS successfully created in an industry, company or organisation of the scale of many GBR institutions, or the scale of the GBR-wide context, except for several well-resourced and consolidated ones.
- There are a multitude of information sources, users and needs across the GBR and its catchments, and the volume of information being generated (for example, through analysis and synthesis) will likely only increase with increased technological and computational advances.
- Decision-making knowledge needs across the GBR and its catchments are diverse, specific, evolving and highly customised. While there are information needs that are consistent across multiple domains (e.g., reef condition information that informs both Marine Park compliance and COTS control location selection), it will be challenging to confidently identify and map all knowledge needs.
- The amount of knowledge generated GBR-wide in response to these needs, the multiple sources, complexity of collection, variety of themes, and their inter-relationships, would require significant effort in characterisation and consolidation as part of a single MIS. Given resource constraints, it is considered ambitious to attempt to undertake this effort, let alone for the purposes of developing a single "GBR-wide" MIS within the foreseeable future.

Key finding 5 – A single "GBR-wide" decision-support system (DSS) is not feasible, not leading practice and not asked for by decision-makers, and this narrative should be changed

The narrative of a single "GBR-wide" decision-support system should be changed, and the change communicated as soon as possible due to the following reasons:

- The project team have little evidence from this analysis or from previous experience of an "asset, program or organisation-wide" DSS successfully created in an industry, company or organisation of the scale of many GBR institutions, or the scale of the GBR-wide context, except for several well-resourced and consolidated ones.
- The number of decisions GBR-wide, and the complexity of their inter-relationships, means that even a sub-set of them will be far in excess of possible available resources to develop a "GBR-wide" DSS within the foreseeable future.
- The variety, inconsistency and non-codified nature of many of the processes used in decision making on the GBR and its catchments means that the utility of a DSS is not universally high under leading

practice across all of these processes; thus a “GBR-wide” DSS that covers all decision processes does not have high utility.

- The GBR-wide decision framework is minimally understood across current stakeholders; without it the structure of a hypothetical GBR-wide DSS would be elusive.
- GBR manager aspirations for systems are largely for MISs for tactical and operational decisions, not for a DSS, which aligns to leading practice; aspirations towards a DSS are shared among science / academic stakeholders for tactical and operational levels (not leading practice), and executive stakeholders for strategic levels (matching leading practice).
- A “GBR-wide DSS” narrative could cause a negative influence on efforts to advance the development of DSS’s, MISs and quality decision making and decision literacy more generally.

Key finding 6 – Decision-support systems (DSSs) have utility in the GBR, and should be developed opportunistically in multiple high-value areas starting with tactical and mature decisions, or following investment in maturing people, processes, and / or knowledge management for less mature decisions;

While there is high utility and strong aspirations for DSS’s in the GBR (i.e., the Marine Park), future efforts to develop DSS’s in the GBR would be best served by adhering to several principles regarding the focus, scale, and enabling conditions:

- DSS’s are highly unique to their decision areas, so efforts on the GBR should include multiple parallel and coherently unrelated DSS’s for several highest-value decision areas (this aligns with the elimination of the “GBR-wide” narrative).
- Efforts to develop DSS’s should identify highest-value decision areas, and target those opportunistically; “value” needs to be determined by investment planners.
- Leading practice utility of DSS’s is highest for tactical decisions, with some utility for limited strategic decisions, and limited utility for operational decisions, and the appetite of GBR stakeholders largely matches this perspective; development efforts should start with tactical decisions.
- Development of a DSS in any decision context is reliant on coherent understanding of the existing decision framework (i.e., people, processes, systems and knowledge base) and decision frame (i.e., problem / opportunity, objectives, boundaries, alternatives), with a mature understanding of these elements essential to developing and iterating a DSS that is useful and utilised by decision-makers.
- Where there are aspirations to develop a DSS where the decision framework is not well known or defined, preferential initial investment in people, processes and knowledge base (including an MIS) will clarify the utility and scope of a proposed DSS, and generate the support for its development and implementation.
- The timelines for development of a DSS, including the timeline for developing an understanding of the decision framework and decision frame, should be considered in planning.

Key finding 7 – The concept of a DSS should be clearly delineated from other system types and communicated widely to avoid mis-aligned expectations.

Clear communication of what a DSS is and what it is not, particularly in comparison to other relevant systems such as an MIS, would create the enabling conditions for achieving DSS development aspirations, for the following reasons:

- Current communication about what DSS's are, and the aspirations for developing them, is unclear; this appears to have contributed to variously accurate levels of understanding among GBR decision makers, rights-holders, and stakeholders.
- Conflation of concepts of DSS and MIS has led to unnecessary barriers to the implementation of MIS which is of high utility to most decision makers and for which there is strong appetite; these barriers are more often related to the perception of an MIS being a DSS.
- The negative reactions of many GBR and catchment decision makers towards DSS's is often legitimate given 1) the limited current utility of DSS's to strategic, tactical and operational decisions, 2) the variety of highly complex, mature and appropriate decision processes, and 3) the skilled nature of many decision makers.
- Visibly subsuming the scope and utility of DSS's within the scope and utility of processes, people and knowledge base (including MIS) will likely go some way to correct expectations about and reduce barriers to future development of DSS's.

Key finding 8 – The primacy of processes (over systems) in driving quality decision making could be more widely understood, and offers early wins for GBR-wide decision makers

Decision-making processes are inconsistently sophisticated, mature, and applied, and evidence of continuous process-improvement varies. Improvements in decision quality can be achieved through increased knowledge sharing on leading practices currently in use, and increased codification of existing processes. In several instances these are likely to be a more effective and lower cost lever than investment in DSSs. This is based on:

- Decisions are and will continue to be made by decision-makers in the time available for decision making, using an acceptable process familiar to the decision-maker, using the best available information.
- Decision-making guidance is the predominant type of decision-making process used to inform decisions, which offers flexibility to decision-makers on specific processes and sub-steps to undertake in making decisions, whilst still being defensible. This is appropriate given the breadth of decisions made across the GBR.
- For strategic decisions where decision-guidance is used, there is an opportunity to create more consistency in decision making through greater structure in the processes for such decisions, such as that provided through structured decision making. Increased consistency can enable accelerated development in decision-making capability of current and future decision-makers, enable stakeholders to participate more effectively through increased familiarity with the process and enable greater defensibility in the ultimate decisions.
- For tactical decisions where decision-guidance is used, there is an opportunity to increase efficiency of decision making through codification of decision-processes into decision-rules, which can greatly simplify decision making and increase the potential utility of application of a DSS to such decision problems.
- Process improvement is typically lower cost than system development, and potentially represents a greater return on investment for improving the quality of decision making than investment in DSSs.

Key finding 9 – Considered investment could be made in increasing understanding of and literacy in decision making processes to enable more effective participation in decision making

While current decision making across the GBR is sophisticated and mature, with many engaged, collaborative and skilful decision-makers, participants and stakeholders, formal knowledge and comprehension of decision-making processes is varied. Investment in education and increasing awareness could catalyse improvements in decision-making effectiveness and efficiency, and, potentially result in secondary benefits in generating alignment and progress given the highly complex and political context in which especially strategic decisions are made. This is based on:

- The involvement of decision-makers, subject matter experts, knowledge brokers and stakeholders in decision making across the GBR is sophisticated though skewed conservatively for more tactical and operational decisions (i.e., greater levels of involvement of subject matter experts, more senior decision-makers and / or stakeholders than would be expected). This appears to reflect the inherent complexity of the GBR-space and the desire to ensure engagement with the complex patchwork of agencies, organisations, subject-matter experts, and stakeholders to enable commitment to action to be achieved. A greater focus on decision processes, and more consistency in decision processes, could enable the same outcomes to be achieved with less onerous engagement and participation requirements.
- Currently, communication of the operational decision framework, which informs decision making, is limited. Education in decision-making concepts and processes and increasing literacy would enable an increased focus on decision processes to inform decision making, and could enable more effective participation and engagement. Broader understanding and familiarity could catalyse improvements in decision making related to aspects beyond decision-processes.
- More universal understanding of decision-making processes and practices could also enable better alignment of scientific effort to enable higher quality decisions.

Key finding 10 – Decision-makers and knowledge providers focus disproportionally on increasing understanding (knowledge) of the systems that underpin the GBR and its catchments, instead of understanding the relative consequences and trade-offs associated with decision choices;

The high levels of uncertainty of knowledge, values, options, consequences, trade-offs, decision frames and decision makers on the GBR and its catchments has led to a focus on understanding the system better, rather than industry leading practice which demands a focus on the trade-offs between decision choices:

- The GBR landscape was widely acknowledged to be highly complex, highly interconnected, with multiple levels of uncertainty within data, about how changes in one part of the asset affects other parts of the asset.
- The decision space with regards to objectives, stakeholders, values, and trade-offs was found to add significant additional uncertainty, which has fundamental effects on quality decision making requirements such as defensibility, transparency and consistency.
- Due to this uncertainty strategic decision-makers (including those tasked with investment decision making) have pushed strongly into efforts to better understand the system (more knowledge, more science).

- Industry best practice in scenarios of high, complex and interconnected uncertainties is to focus instead on examining decision choices (alternatives / options) across the range of uncertainty to ensure that the most robust choice is found (and under what range of uncertainties it remains the best option).
- There was little significant evidence found for a focus on option performance across uncertainty ranges as the focus for decision making; certainly not to the level of focus afforded to better understanding the system.
- It was found that high-level strategic decision makers wanted defensible knowledge base about the decision choices, however, this is widely mis-interpreted at lower levels in the decision hierarchy as wanting defensible knowledge base about the system; this distinction is critical to pursuing higher decision quality (particularly better commitment to action) in a highly uncertain decision space such as the GBR and its catchments.

Key finding 11 – Governance across the GBR and catchment landscape has limited formal application of decision quality-based assurance frameworks

It was found that while there are mature decision makers, decision processes, multiple decision-making governance groups and long histories of decision making, concepts of decision quality or decision assurance were not widely referenced or applied. This is based on:

- The review of Governance organisations and associated Terms of Reference showed no reference to decision assurance frameworks or decision quality.
- There was limited evidence for decisions being assessed on their application of the six characteristics of quality decisions.
- Decisions reviewed were largely made based on understanding of the system, rather than feasible and diverse alternatives (key finding 10), thus limiting decision quality.
- The involvement of stakeholders in decision making is skewed conservatively compared to other contexts, showing in part the complexity of the decisions (thus requiring more involvement of stakeholders), but also potentially showing the impact of attempting to increase decision quality through ensuring a wider group commits to action (broad consensus), rather than attention to other aspects of decision quality such as process or robust options identification.
- For strategic decisions, where decision quality and decision assurance have high utility, there was little evidence of quality decision making principles being recorded formally, which indicates that they may not be consciously applied.

Key finding 12 – A preliminary examination of the GBR-wide decision framework and decision quality from the perspectives of Traditional Owners reveals strong aspirations, strong support, and required investment to achieve aspirations.

Beginning to understand the perspective of Traditional Owners through the lens of decision frameworks (including quality decision making) has begun to inform an understanding of their perceptions of the current state of decision making across the GBR and its catchments, including:

- Traditional Owner decision makers have requirements for representation to include diverse and geographically dispersed groups.
- The objectives for Traditional Owners are maturing swiftly (e.g, through clear frameworks such as Strong peoples – Strong country, and aspirations to centralised governance), with ongoing and

additional investment in this area justified to bridge the gap to more established parts of the GBR-wide objectives-hierarchy.

- Involvement of Traditional Owners, as rights-holders and decision makers, in decision making is, and has been, limited in numbers, diversity and authority (due to historic and ongoing power imbalances), and this is widely recognised by rights-holders, stakeholders and decision makers across the GBR and its catchments.
- While many stakeholders across the GBR and its catchments are fairly stretched for time, Traditional Owners as rights-holders are particularly stretched for time, particularly in more recent times with long awaited funding and attention to Traditional Owner programs.
- Established decision processes within the GBR and its catchments are embedded within established power dynamics for which Traditional Owners have clear objectives to rebalance, requiring focused and widespread effort, including support from and collaboration with stakeholder groups.
- Tight timeframes and tight resource availability were acknowledged frequently as both a feature of a highly complex industry, but also limiting the perceived appropriateness of engagement with rights-holders, including implementing foundational approaches such as free, prior and informed consent (FPIC).
- The Traditional Owners' world view typically involves holistic thinking, meaning that Traditional Owner decision makers expect themselves to cover broadly any decision problem before being comfortable that a quality decision has been made; the effort required for this may not be adequately accounted for in current decision processes on the GBR and its catchments.
- Given the current levels of investment in the GBR and its catchments, the opportunity to identify, enact or influence the most efficient or effective decision processes that include Traditional Owners has greatly expanded; the "best approach" is not yet known, giving importance to prototyping decision processes in a co-developed, co-ordinated and coherent way that build institutional knowledge and expands personal and collective capability.

7 Objectives and the development of options for decision support on the GBR

7.1 Methodology of objective and options development

Stage 2 of this scoping project was focussed on two elements: (1) examining the current state assessment and its key findings, and (2) undertaking a structured process with the project Steering Committee to develop options for progressing DSSs for the GBR and its catchments. This methodology would result in developing **recommendations** for action.

The first step was a review of current state findings from Stage 1 with the project Steering Committee, comprising the following:

- Two (2) workshops (held on Friday 21st August 2020 and Thursday 24 September 2020);
- Review of the detailed and summary results from the work performed to date;
- Discussion of initial findings, including interpretation, likely perception of readers and implications; and
- Identification of any critical flaws or areas for improvement, combined with alignment on additional work to complete the scoping.

A facilitated session was run during the 2nd workshop (24 September 2020) to identify the aspirational future state and long-list options for DSS development, comprising the following:

- Agreement on the opportunity statement for the IMR component of the RTP when investing in the prototyping and development of a DSS;
- Identification of key success criteria for when the opportunity statement could be considered met;
- Identification of high-level priorities for areas of the GBR and catchments decision framework to take action; and,
- Identification of a long-list of options for potential consideration in seeking to achieve the opportunity.

Following the facilitated session, the project team developed preliminary recommendations based on the Stage 1 current state and gap analysis, and the opportunity framing and options identification processes. This involved:

- Drafting of a recommendations presentation structure for review with the project Steering Committee and the RIMReP interim Executive Group from (30th October 2020),
- Drafting of the preliminary recommendations, with review from the project Steering Committee,
- Finalisation of the recommendations in the Stage 2 report.

7.2 Objectives & priorities

During the workshops the following opportunity statement was framed:

Opportunity Statement - *"To develop and operationalise integrated systems that address the needs of strategic, tactical and operational decision makers GBR-wide. Including the critical elements:*

- *It must include a computerised system*
- *It should be operational in some form within 3 years (the end of the IMR program)*
- *There should be a staged approach to the build*
- *It should be aligned to RIMReP*

- *It should integrate existing and rationalise development of future management information systems and decision-support systems*
- *Maturing processes and people is implicit in development of the system".*

The desired outcomes from the subject of the opportunity statement are:

- Decisions are more effective, efficient, transparent and defensible;
- Investment in management actions GBR-wide is commensurate with the expected benefits;
- Decision support needs of Reef and catchment managers, key stakeholders and Traditional Owners are met;
- Systems are operational and highly-utilised, delivering efficiency gains and value commensurate with the investment;
- Investment in modelling and decision-support systems GBR-wide has been optimised;
- Scientific effort in decision making is targeted at management effectiveness (purpose-focused);
- Working to and demonstrating progress against a development roadmap, with key decision points guided by progress and user needs;
- Being ambitious, and, pragmatically focussed;
- Clearly communicating decision-making concepts and the utility of identified recommendations to decision-makers; and
- Leverages and builds on existing investments (e.g., RRAP).

7.3 Priorities and development of recommendations

As the key findings demonstrated, the goal of MISs, DSSs or quality decision making GBR-wide is ambitious given available resources, so priorities are useful to guide strategic planning. As such the decision framework was used to frame the scope as a system development, maintenance & management pathway, from ad-hoc to mature. By taking into account the current state of the decision framework, and the utility of the framework components across strategic, tactical and operational decisions, some preliminary priorities for action were established, as shown below in Figure 17.

A long list of options for development of DSSs and their enabling activities was developed using the decision framework elements and the priorities below as the major categories. However, a distinction was made between the options for strategic, tactical and operational levels in order to drive towards executable and meaningful recommendations.

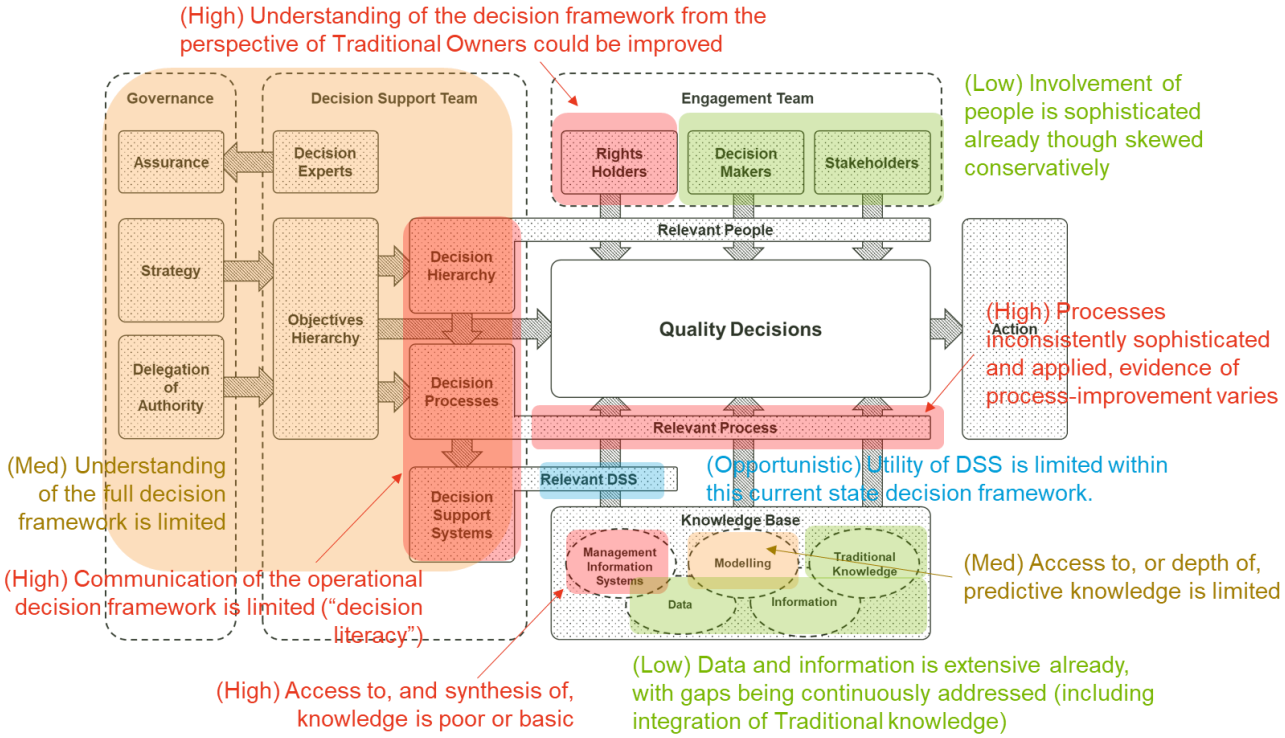


Figure 17. Preliminary priorities for action across the decision framework for the GBR and its catchments; framework elements are considered *low priority* when they are already mature or well developed, or gaps are being continuously addressed; framework elements are considered *high priority* when they are less developed but with high utility.

8 Recommendations

Based on the current state assessment, gap analysis, opportunity framing and options identification, a set of twenty (20) ***recommendations*** have been proposed, for the consideration of RTP and RIMReP partners, in advancing the development and prototyping of DSSs for the GBR and its catchments, and to advance quality decision making more broadly. The authors strongly encourage these recommendations be co-developed further with GBR stakeholders (including decision makers), rights-holders and decision-support practitioners, prior to commitment to implementation.

As discussed in Section 1.1.2, the project specified "GBR-wide" as the scope extent, and this term is taken to cover the scope of the Reef 2050 Plan**.** The scope is focused on identifying and assessing the enabling conditions for DSSs, and as such, reviews a sub-set of decision making GBR-wide to achieve that purpose; it is not a comprehensive review or assessment of GBR-wide decision making.

The recommendations have been structured as below:

- Activities categorised as *"no regrets"* (considered to be essential to decision quality and highly likely to deliver net-benefits for decision making on the GBR and its catchments), *"foundational"* (considered to be early, strategic steps necessary to unlock further development), or *"developmental"* (considered to be further maturation beyond foundational activities);
- Whether activities are *"high"*, *"medium"* or *"low"* priority for attention, based on the objectives and priorities framed in Section 7;
- Who the recommended option is likely to involve when actioned, defined as *"managers"* (the tactical and operational decision-makers and managers), *"executive"* (the executive-level decision-makers within regulatory bodies and government departments), or *"investors / funders"* (investment decision-makers within regulatory bodies, government departments and other funding or investment organisations), and other key stakeholders listed as required[34];
- An approximate timeline for the activity, represented over the lifetime of the Integrated Monitoring and Reporting program of the Reef Trust Partnership; and
- Where there are potential dependencies among recommendations, these are listed as *"pre-conditions"*.

These recommendations are the views of the authors and should be considered in the context of the "mile-wide, inch-deep" nature of this analysis.

8.1 Build decision-support systems on strong foundations

The recommendations are intended to lay out actionable and realistic steps that build towards enhancing decision-making outcomes through the benefits from fit-for-purpose DSSs. To achieve this goal, the recommendations follow the path of three strategic horizons:

- Horizon 1: Enhanced utilisation of available knowledge through management information systems (MISs)
- Horizon 2: Enhanced decision-making outcomes through matured decision processes and knowledge access
- Horizon 3: Enhanced decision-making outcomes through application of fit-for-purpose decision-support systems (DSSs)

In addition, the recommendations contribute to a fourth strategic horizon, which is included as an aspirational or "stretch" goal. Whilst the first three strategic horizons are relatively self-explanatory, the fourth horizon offers decision makers the ability to consider further optimisation in investment prioritisation on GBR management actions in an expected environment of greater uncertainty associated with the impacts on the Reef, it's catchments and its people from climate change, and, available funding and investment.

[34] In some specific contexts within a regulatory body, executives and investors may be the same people.

Enabling this 4th Horizon is not intended to be the focus of the preceding three horizons. It is intended to stimulate longer-term strategic thought about possibilities beyond a future where decision quality (as defined in Section 2.4) GBR-wide is significantly advanced, including being supported by fit-for-purpose DSSs:

- Horizon 4: Optimised allocation of resources GBR-wide given uncertain futures

All four strategic horizons and the distribution of recommendations across them are visualised in Figure 18. For details on the recommendations, see the descriptions in the section below.

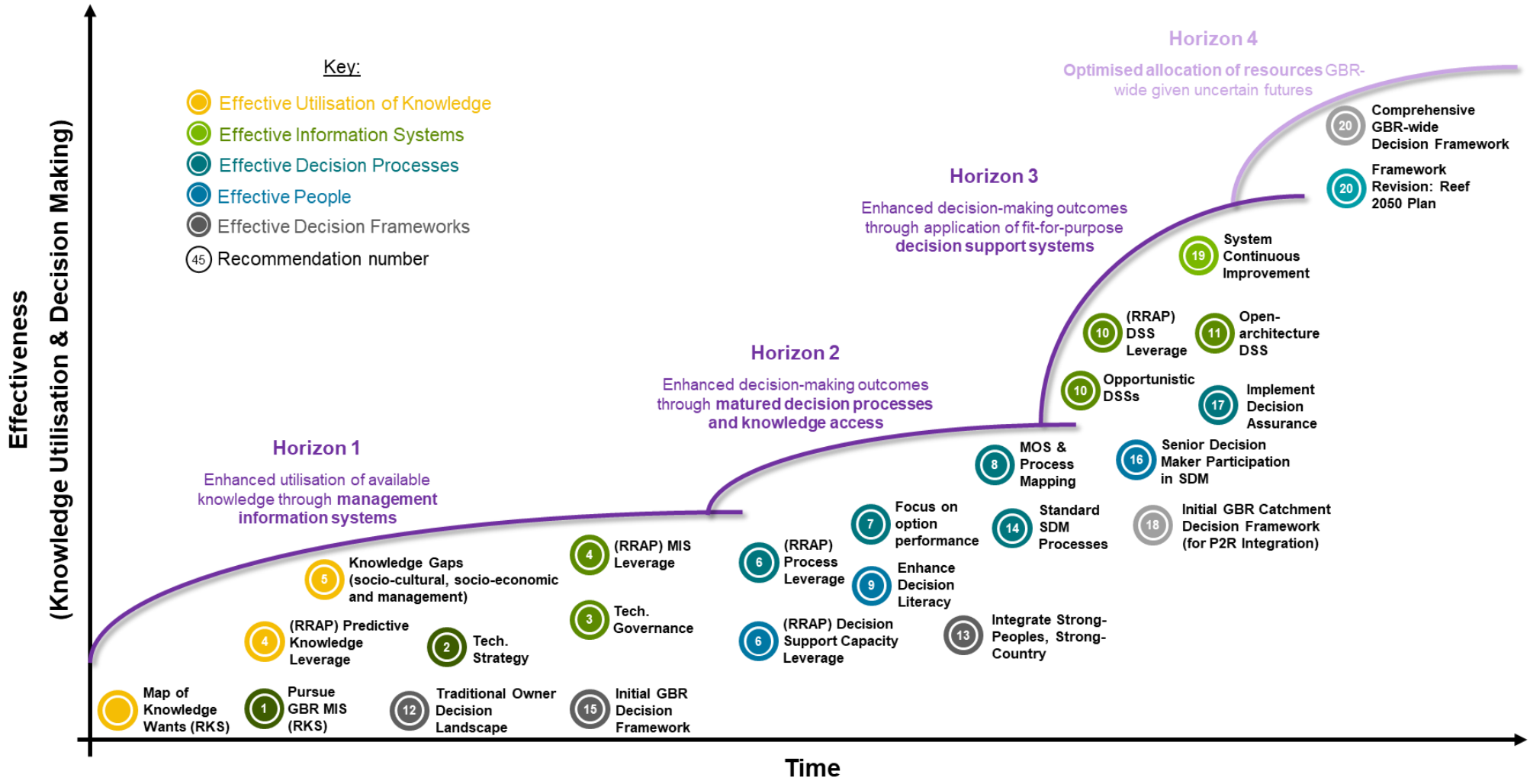


Figure 18. Four strategic horizons and associated recommendations to build towards enhancing decision-making outcomes through the benefits from fit-for-purpose decision-support systems, to be pursued over the remaining life of the current RTP term (numbers correspond to recommendations).

8.2 No regrets activities

Recommendation 1 – Reinforce current efforts to improve existing MISs and DSSs with consideration of highest-value areas and attention to point of diminishing returns

What: **No regrets**	*Priority:* **High**	*Horizon 1:* 
Who: **Executive, Managers**		
Pre-conditions: None		

Rationale:

The utility of a MIS is widely requested by GBR decision makers and is foundational to higher decision quality, so current efforts should be continued or increased, whilst prioritising those areas of highest value to decision making. As existing DSS efforts (e.g., RRAP, CoTS, Fisheries) have typically evolved in mature decision spaces and have achieved buy-in, these should also be supported.

- Given early development efforts of the Reef Knowledge System by GBRMPA, there is potential utility in investing in the development of an MIS that builds on these early efforts and addresses the knowledge needs of a subset of the GBR decision-making arena, namely those making decisions related to marine park management. Starting with an MIS here would 1) likely serve immediate needs and therefore be utilised, 2) generate time savings for time-poor managers, 3) demonstrate potential to other stakeholders, and 4) enable lessons learned to inform future development efforts to broaden scope of the system and / or inform development of alternative systems in other domains.
- Potential development efforts would need to consider 1) access to raw data, 2) presentation of information, 3) extent to which synthesis of information is required and presentation of synthesised information, 4) future build out of the system for future information sources / uses, and 5) integration with future concurrent and / future DSS development.
- The investment roadmap could involve consideration of timeframes for major upcoming decisions in the GBR and its catchments, and efforts could be made to pre-map these decisions and the timeframes required to utilise high quality decision processes.
- Investment in MISs and DSSs should be focussed on those applications with highest-value to decision makers, with initial options identified through this scope including:
  - Develop consolidated sets of accessible or synthesised knowledge (MIS) to support high-value operational decision processes (e.g., permits, compliance);
  - Initially focus on integrating the various management functions around corals, in order to demonstrate an integrated approach to knowledge communication and synthesis (MIS), MOS and decision processes, and, if the conditions are set, DSSs;
  - Develop consolidated sets of accessible or synthesised knowledge (MIS) for socio-cultural and socio-economic knowledge (e.g., human dimensions repository / dashboard, Eye on the Reef, etc);
  - Develop consolidated sets of accessible or synthesised knowledge (MIS) for predictive knowledge (i.e., understanding of how the ecosystem is likely to respond to projections of environmental condition);
  - [additional focus areas will emerge from execution of Recommendation 8].
- Once highest-value areas are identified, progressively invest as much as feasible up to point of diminishing returns.

- Continue to implement the recommendations from the RIMReP Business Analyst report regarding development of RIMReP MISs, these being:
  - Develop and formulate user personas, user journeys and high-level business processes (integrated with MOS development);
  - Fully define and develop the data strategy and framework;
  - Further refine and socialise the existing MIS;
  - The prototype MIS solution should adhere to better practices over time;
  - Build capacity and skills of the MIS management team to match business requirements; and
  - Build dashboards and define value drivers to continuously support KPIs for decision making.
- Invest in competency development for decision makers, managers and analysts to effectively utilise and interact with relevant MISs and DSSs.

Recommendation 2 – Develop and socialise a high-level technology strategy, including capture of key decision literacy components, followed by a coherent strategic planning process

What: **No regrets**	*Priority:* **High**	*Horizon 1:* 
Who: **Executive, Investors / Funders**		
Pre-conditions:		Recommendation 3 – Establish technical governance for system research, development and operations

Rationale:

A high-level technology strategy should be developed as soon as possible that articulates the preferred high-level pathway for decision support (including for knowledge, MIS, DSSs, processes and people). This high-level technology strategy should iterate and build on the RIMReP "Guide" development plan and the findings of this scoping project by March 2021 to inform IMR funding decisions for FY22. This would serve to communicate any changes in direction from perceived or actual current strategy, as well as serve to socialise key decision literacy components in the short term, such as definitions, conceptual models and key findings. This may include key findings and recommendations from the scoping study such as:

- The primacy of processes (over systems) in driving quality decision could be more widely understood and offers early wins for GBR-wide decision makers;
- The concept of a decision-support system (DSS) should be clearly delineated from other system types and communicated widely to avoid misalignment of expectations; and
- There is strong, universal support for efforts to make knowledge more available, more efficiently accessible, more synthesised, more predictive and more management focused.

A more coherent strategic planning process should be undertaken over a longer timeframe to develop a higher resolution technology strategy, ideally under the leadership of established technology governance (Recommendation 3). This would include:

- Detailed characterisation of case studies in decision support success or DSS success, to help define similar pathways to success for the future plan.
- Showcasing DS and DSS success within the technology strategy documentation and communicated outside it, to help generate momentum for further decision support, MIS and DSS development.

- Iteration of the high-level technology strategy using decision-making principles to drive a high-quality outcome with the most relevant stakeholders and rights-holders committing to action (ideally relevant stakeholders and rights-holders would include a representative user group, product owner and technology committee as per Recommendation 3).

Recommendation 3 – Establish technical governance for system research, development and operations

What: **No regrets**	*Priority:* **Medium**	*Horizon 1:* 
Who: **Executive, Investors / Funders**		
Pre-conditions: None.		

Rationale:

Scope and establish technical governance for systems within the GBR industry, including communication MISs (dashboards and portals), synthesis MISs (models), and decision-support systems (DSSs). Technology strategy (Recommendation 2) and the governance required to formulate it, and assure its execution, should be integrated with other GBR governance functions such as existing governance structures, program strategies, decision assurance, knowledge strategy and R&D strategy.

The key foundational elements for effective technology governance may include concepts such as:

- The formation of a representative user group to guide the development priorities of the technology in line with the utility it affords users; this may include immediate users, and other users that may access the technology in the future.
- The establishment of a Technology Committee to establish the Technology Strategy for the program; this group may include representatives from other GBR governance groups, independent experts, and representatives from the subject matter experts and information system owners used widely.
- The appointment of a Product Owner as the sole point of accountability for directing technology development according to their interpretation of user requirements (as set by the representative user group), and for executing on the Technology Strategy (as set by the Technology Committee); the Product Owner could be included in the Technology Committee.

The purpose of the technical governance is to:

- Accelerate the availability of operational systems to support decision makers and thus affect achievement of Reef 2050 objectives.
- Strategically manage the research and development pathways towards the release of updated operational systems.
- Strategically manage the potential integration of systems and assess these efforts for value prior to execution.
- To directly manage investment under the authority of the technical governance to ensure no duplicative investment.
- Ensure system development is undertaken in the context of broader decision-making conditions and needs.
- To provide the opportunity for investment decision-makers other than the RTP to interface with a representative governance body overseeing a consolidated plan.
- Given the extent of expenditure on systems, to allow rationalisation in line with the strategic planning.
- To ensure a legacy of technical governance beyond the life of the RTP.

It is recommended that the technical governance should avoid aspiring to command and control of systems research, development and operations. Ensuring a vibrant and competitive (and, if possible, open-source) technology ecosystem is increasingly being seen in the technology industry as having superior outcomes to centralised command and control.

Note that this recommendation is *not* related to decision assurance or decision governance, which is covered in Recommendation 17 – Develop and implement decision assurance frameworks through existing governance structures.

Recommendation 4 – Leverage the significant existing investment in RRAP MISs to make predictive knowledge (i.e., projections and forecasts) more widely available and more integrated with GBR-wide decision processes

What: **No regrets**	*Priority:* **Medium**	*Horizon 1:* 
Who: **Executive, Investors / Funders**		
Pre-conditions: Recommendation 2 – Develop and socialise a high-level technology strategy, including capture of key decision literacy components, followed by a coherent strategic planning process		Recommendation 3 – Establish technical governance for system research, development and operations Recommendation 6 – Leverage existing investment in quality decision making processes from RRAP and other programs to increase decision literacy and build capacity for quality decision making GBR-wide

Rationale:

The significant RRAP and other RTP investment in predictive knowledge capabilities, including in the MISs (models) to synthesise it, offer a unique opportunity to fulfill the appetite for predictive knowledge to enable proactive decision making GBR-wide. Planning, investment and the governance required to oversee it, if put in place (Recommendations 2 and 3) will ensure that this investment is leveraged for this GBR-wide purpose, as well as its original purpose in RRAP. It would also ensure the longevity of a coherent technology strategy beyond the life of RRAP. Some considerations for this recommendation include:

- Given the increasing importance of future trajectories to the health of the GBR and its peoples, it is important to maximise the potential for predictive capabilities and analyses to be available prior to key strategic reviews (e.g., Reef 2050 Plan review, 5-year Program strategy reviews, GBRMPA Outlook Report).
- RRAP is heavily focused on the production of a suite of “counter-factuals” which comprise possible future trajectories for key environmental and ecological conditions under various climate change scenarios; these may be available by mid-2021. These counter-factuals should be made easily available to non-RRAP decision makers and efforts made to integrate them with non-RRAP decision processes.
- RRAP and other RTP investments in converting existing models (e.g., e-Reefs or ReefMod) into more accessible MISs (e.g., with graphical user interfaces) for the purposes of RRAP can be extended to decision makers GBR-wide with considered effort (e.g., by providing portals from the Reef Knowledge System).
- Predictive modelling efforts in other programs (e.g., CoTS) can be integrated with both RRAP and other GBR-wide decision processes.

Recommendation 5 – Leverage and build upon existing investments in socio-cultural, socio-economic and management-focused knowledge generation and synthesis, to improve decision quality GBR-wide

What: **No regrets**	*Priority:* **Medium**	*Horizon 1:* 
Who: **Managers, Executive, Investors / Funders, Scientists**		
Pre-conditions: None.		

Rationale:

Significant current and potential investments in socio-cultural, socio-economic, management-focused and traditional knowledge capabilities offer a unique opportunity to fulfill the appetite for these types of knowledge to aid decision quality GBR-wide. These investments include through the RTP (SELTMP, Strong Peoples – Strong Country, CoTS innovation, Traditional Owners Program), RRAP, NESP and OGBR funding of "human dimensions" monitoring, GBRMPA investment in resilience-based management, and the GBRMPA science strategy. This effort can be leveraged by focusing on its application to improving decision quality in several ways:

- Utilise the investment opportunity to shift the focus of knowledge generation that supports decision making towards how options perform over ranges of uncertainty, and away from a dominant focus on system understanding (more details in Recommendation 7).
- A clear understanding of what decisions in the decision hierarchy are upcoming (i.e., what decisions will GBR or catchment managers need to make soon) would help to catalyse scientific effort towards knowledge generation and synthesis of knowledge to aid critical future decisions.
- Reinforce that where scientific effort is undertaken for management purposes, it should be directed by and heavily influenced by managers (and their needs); shift the cultural dynamic between managers and scientists from "here is some cool stuff to help you" to "what do you need?".
- Reinforce that communication of science to managers can be improved, including involving managers in formulating recommendations/insights from research.
- Reinforce that managers are time-poor but have a large appetite for effort (i.e., research) to be undertaken into their management outcomes / learning / improvement cycles.
- Reinforce the role of science should include discrete effort to synthesise knowledge to gain additional insights.

The investments in socio-cultural, socio-economic and management-focused knowledge generation described above, should be actively integrated with the work in the RRAP Modelling & Decision support (M&DS) sub-program to better translate predictive knowledge scenarios of bio-physical and ecological state (biophysical and ecological counter-factuals) into predictive knowledge scenarios of socio-cultural and economic values (socio-cultural and economic counter-factuals). If a comprehensive decision framework is to include future scenarios, the establishment of a range of socio-cultural and economic counter-factuals may become just as, if not more, important to decision makers than bio-physical and ecological counter-factuals.

Effort should be taken to leverage existing RIMReP efforts to engage Reef and catchment managers (in particular the Program leaders) to identify the objectives, indicators, metrics and data gaps required to be filled to complete a management-focused decision hierarchy. Understanding these hierarchies will help to establish more effective utilization of knowledge to assess options for quality decisions.

Recommendation 6 – Leverage existing investment in quality decision making processes from RRAP and other programs to increase decision literacy and build capacity for quality decision making GBR-wide

What: **No regrets**	*Priority:* **Medium**	*Horizon 2:* 
Who: **Executive**		
Pre-conditions: None.		

Rationale:

The significant RRAP investment in quality decision making, offers a unique opportunity to leverage these components to aid decision making GBR-wide. Effort should be made to capture and communicate stories of success, examples and guidance to aid GBR-wide decision literacy and build capacity of decision makers. These components include:

- Detailed decisions frameworks.
- Planning for and utilising best-practice decision processes.
- Having previously successfully utilised quality decision processes and methodologies (eg: structured decision making, cost-benefit analysis, value of information).
- Aspiring to maximum knowledge effectiveness.
- Improving decision literacy of key decision makers and stakeholders.
- Characterising and understanding the effect of uncertainty on option performance.
- The development of techniques, processes and tools, to optimise decision choices prior to their consideration in decision processes.
- Qualification or quantification of risks and opportunities associated with decision choices as part of structured decision-making processes.

In other areas of the GBR and its catchments, stories of decision-making success should also be leveraged as above. For example, the Resilient Reefs Network, recreational fisheries management strategies, and various other case studies presented in this report.

Recommendation 7 – Investment in and development of knowledge generation and information systems should improve the ability of decision makers to evaluate decision choices across uncertainty ranges

What: **No regrets**	*Priority:* **Low**	*Horizon 2:* 
Who: **Executive and Managers**		
Pre-conditions:		Recommendation 2 – Develop and socialise a high-level technology strategy, including capture of key decision literacy components, followed by a coherent strategic planning process

Rationale:

In strategic and tactical decision contexts in the GBR, there is likely to be benefit from a greater emphasis on understanding the relative performance of choices being considered, in terms of their consequences and trade-offs, and the uncertainties that impact this understanding.

The interconnected GBR ecological, socio-economic and cultural system is complex and subject to significant uncertainty in spite of the science that has been undertaken and the knowledge that is available. Leading practice in other highly complex decision contexts with high levels of uncertainty (e.g., environmental management, resource extraction, pharmaceuticals, infrastructure development) is to focus on examining decision choices (alternatives / options) across the range of uncertainty to ensure that the most robust choice is found (and under what range of uncertainties it remains the best choice).

Greater decision quality for the GBR and its catchments would entail a greater emphasis on knowledge generation and synthesis to inform relative understanding of choices within specific decision contexts and the relevant uncertainties that impact them, as opposed to knowledge generation focussed on enhancing understanding of the system (particularly the ecological system which is the focus of the majority of knowledge generation activities and scientific endeavour). In other words, a focus on understanding the performance of options may give better returns than additional research data on the system. Specifically, future investment in knowledge generation, information synthesis and information systems should be leveraged and guided towards:

- Enabling the assessment of options within a decision across a wider value set.
- Enabling a more sophisticated understanding and analysis of trade-offs among options.
- Enabling an increased focus in decision making on the performance of options across uncertainty ranges.
- Communicating these aspects to decision-makers to support their decision making.

This should be enabled by the application of appropriate decisions processes which require a focus on clear statement of objectives, conception of options and the use of options analysis and decision-support tools which are focussed on characterising the relative performance of options to inform decision making.

Efforts to increase system understanding could be more efficient and targeted once these elements and practices have been matured, and it is clear where uncertainties associated with system understanding compromise a decision-maker's ability to discern between options and make quality decisions (i.e., the uncertainty is too great to be able to decide between choices).

8.3 Foundational activities

Recommendation 8 – For mature, high-value sub-programs, develop a "Management Operating System" (MOS) and map associated decision-processes, focussed on tactical decisions

What: **Foundational**	*Priority:* **High**	*Horizon 2:* 
Who: **Managers**		
Pre-conditions: None.		

Rationale:

MIS and DSS scoping and development efforts can be greatly informed by the development of 'Management Operating System' (MOS) that map the interaction of people processes, decision processes and knowledge generation activities (an example is shown in Figure 16). MOSs enable visibility on frequency of strategic, tactical and operational decisions, the people processes (e.g., meetings) that

support them and the flows of knowledge that are required to inform or report on them. MOSs can be used to identify common knowledge needs across sub-programs, and, where a computerised MIS or DSS has utility in the lifecycle of a decision (e.g., the example provided in Figure 16). This could be either in helping consolidate and communicate multiple necessary knowledge streams required for a decision, or in identifying where people processes could be simplified by a relevant information system. Co-development of MOSs with decision-makers is helpful in creating the enabling conditions for a decision-maker to see value in and ultimately 'buy-in'' to the use of a MIS or DSS.

Subsequently, it is recommended that the decision processes used to make tactical decisions identified within the MOS are mapped. As discussed, decision guidance is the predominant form of decision process that is used across the GBR, and mapping of specific decision processes being used for tactical decisions is a key enabling activity for 1) identifying where decision guidance can be codified, 2) identifying where decision guidance processes can be codified into more structured decision-making processes or decision rules, and 3) identifying the specific opportunities for MIS or DSS in supporting those decision processes.

Mapping of the MOS and specific decision processes for tactical decisions unlocks multiple development pathways, e.g., implementation of MISs and development of DSSs for tactical decisions, decision process development for strategic decisions, access to MISs for operational decisions. Undertaking these activities across multiple complementary sub-programs will enable greater focus and efficiency in MIS and DSS development efforts, and, in decision process development efforts.

Process improvement is typically lower cost than system development, and potentially represents a greater return on investment for improving the quality of decision making than investment in DSSs.

Recommendation 9 – Focus and fund efforts to increase decision literacy across the GBR and its catchments

What: **Foundational**	*Priority:* **High**	*Horizon 2:* 
Who: **Executive**		
Pre-conditions:		Recommendation 8 – For mature, high-value sub-programs, develop a "Management Operating System" (MOS) and map associated decision-processes, focussed on tactical decisions

Rationale:

Efforts to improve decision quality, through greater utilisation of information systems (MISs and DSSs) and more defined decision processes, may be impeded or compromised due to varying degrees of decision literacy across the GBR and its catchments. More consistent and uniform understanding of key decision-making concepts (e.g., decision processes vs systems, management information systems vs decision-support systems, decision framing, etc) would increase the likelihood that efforts to increase decision quality are successful, and, improve the value proposition from investment in supporting information systems (MISs and DSSs). Specific activities that should be considered include:

- Education on relevant decision-making concepts, including the different types of decision processes and systems.
- Establishment, communication and use of clear definitions for key decision concepts.
- Understanding of decision frameworks.
- Knowledge capture and communication of exemplar applications of quality decision making approaches (e.g., case studies, methodologies, templates, and tools).
- Development of standardised approaches (see Recommendation 14).
- Establishing a multi-agency community of practice.

Recommendation 10 – Develop DSSs where the opportunity presents during MOS and decision process mapping, and following investment to mature people, process, and knowledge management

What: **Foundational**	*Priority:* **Medium**	*Horizon 3:* 
Who: **Executive, Investors / Funders**		
Pre-conditions: Recommendation 2 – Develop and socialise a high-level technology strategy, including capture of key decision literacy components, followed by a coherent strategic planning process		Recommendation 8 – For mature, high-value sub-programs, develop a "Management Operating System" (MOS) and map associated decision-processes, focussed on tactical decisions Recommendation 9 – Focus and fund efforts to increase decision literacy across the GBR

Rationale:

Following on from the generation of MOS and mapping of decision processes (Recommendation 8) additional opportunities for DSS development will emerge. These opportunities should be taken by:

- First investing in maturing the people, process and knowledge management within the opportunity space.
- This includes any potential development of MIS for communication or synthesis of knowledge for the decision makers.
- The codification of the decision framework for each DSS opportunity will lay the foundation for the development of DSS components.
- Iteration of the DSS alongside the iteration of the MOS and decision processes will ensure that continuous improvement of the entire decision framework (not just the DSS) drives towards higher decision quality.

It is noted that the above steps may be useful for supporting existing DSS continuous improvement efforts (eg: RRAP, CoTS, Fisheries). In addition, it is recommended that deep-dives into successful case studies be conducted to help define and motivate pathways to successful DSS implementation, and to higher quality decisions.

Recommendation 11 – Apply open architecture DSSs opportunistically enabling subsequent customisation for specific decision problems

What: **Foundational**	*Priority:* **Medium**	*Horizon 3:* 
Who: **Managers, Executive, Investors / Funders**		
Pre-conditions: Recommendation 2 – Develop and socialise a high-level technology strategy, including capture of key decision literacy components, followed by a coherent strategic planning process		Recommendation 8 – For mature, high-value sub-programs, develop a "Management Operating System" (MOS) and map associated decision-processes, focussed on tactical decisions Recommendation 10 – Develop DSSs where the opportunity presents during MOS and decision process mapping, and following investment to mature people, process, and knowledge management

Rationale:

There are several commercially available open-architecture decision-support tools available to support decision-makers across a broad range of contexts (see Appendix J). These tools are designed to work as part of broader decision processes, typically those prescribed in decision guidance or structured decision making. These processes typically require the use of a relatively finite set of analytical methods to guide final decision-makers (e.g., multi-criteria analysis, cost-benefit analysis), and these open-architecture tools typically perform these applications.

Executing Recommendation 8 will likely reveal where common decision processes are being used, and, the use of these analytical methods. These should be evaluated for potential application of relevant open architecture DSSs, as this could serve as useful test cases for the applicability of DSSs, and, inform future development activities for bespoke GBR DSSs. These open architecture DSSs should not be the first consideration because, even though they are open architecture, they still have a specific range of use cases. Each decision area should be considered for its own use case (Recommendation 10), with suitable areas identified for open architecture DSSs as a result of that process.

A major recurring issue with DSS development in analogous and other industries is that development can often be highly bespoke, applicable to very specific decisions, and sometimes developed based on the aspirations of the system designer, rather than the perspective of the decision-maker. A significant risk for investors in GBR DSSs is the creation of highly bespoke applications that are not useful beyond the particular context for which it was designed. Use of open-architecture decision-support tools in the short-term can help guide custom DSS development in alignment with what decision-makers are likely to engage with and use, and, focus effort on the relevant sub-models required to enable the open-architecture tools to be relevant. These tools can be replicated as part of bespoke DSSs once utility has been ascertained.

Recommendation 12 – Conduct a current state baseline and gap analysis focused on Traditional Owners within the GBR-wide decision landscape

What: **Foundational**	*Priority:* **High**	*Horizon 1:* 
Who: **Traditional Owners, Managers, Executive, Investors / Funders**		
Pre-conditions: None.		

Rationale:

It is recommended that a scoping exercise is conducted into the GBR decision framework from the perspectives of Traditional Owners. The methodology should be co-designed with Traditional Owners and other relevant GBR stakeholders to ensure the review is focused towards progressing the aims of Traditional Owner programs. If targeted efforts are to be made to increase decision quality in the GBR and its catchments, then a focus on high-grading processes and capability of people should involve high-demand groups such as Traditional Owners. This high demand provides an opportunity to begin to redress existing power differences, whilst building personal and group capability to make, and influence the making of, high quality decisions. We recommend a process involving:

- From the start, co-design of a detailed process for the analysis under the principles of free prior and informed consent (FPIC).
- Include a Traditional Owner in the team to develop and roll out the process, as well as establish a steering group or working group of Traditional Owners to oversee the process development and execution.
- Undertake several targeted case-studies of previous decisions, including document review, interviews and synthesis conversations.

- Synthesise the findings using the concepts of decision frameworks and decision quality; in order to establish a current state of decision quality from Traditional Owner perspectives, and to coherently map and communicate the extent of participation and power of Traditional Owners across the decision framework for GBR assets.
- Provide recommendations into subsequent processes to set objectives for an aspirational state and define options for progressing towards it.

Recommendation 13 – Assist with operationalising Strong Peoples - Strong Country by integrating with evolving GBR decision frameworks

What: **Foundational**	*Priority:* **High**	*Horizon 2:* 
Who: **Traditional Owners, Managers, Executive**		
Pre-conditions: Recommendation 12 – Conduct a current state baseline and gap analysis focused on Traditional Owners within the GBR-wide decision landscape		Recommendation 8 – For mature, high-value sub-programs, develop a "Management Operating System" (MOS) and map associated decision-processes, focussed on tactical decisions
Rationale: Following from distinct efforts to characterise the Traditional Owner perspective on the GBR and its catchments decision landscape (Recommendation 12), this understanding can be leveraged to identify areas where there is maximum value in operationalising Strong Peoples – Strong Country. This can be done by assessing the Traditional Owner current state baseline and gap analysis against the established MOSs and decision processes (Recommendation 8); this mapping will establish a set of "no regrets" actions, "foundational activities" and further developmental activities. The decision processes and systems can then be iterated to achieve higher quality decisions from the Traditional Owner perspective. This effort should involve integration with any activities related to decision-making assurance or governance (Recommendation 20). As with Recommendation 12, this should include a Traditional Owner in the team to develop and roll out the process, as well as establish a steering group or working group of Traditional Owners to oversee the process development and execution.		

8.4 Developmental activities

Recommendation 14 – Develop standardised, fit-for-purpose, qualitative and quantitative structured decision-making (SDM) processes

What: **Development**	*Priority:* **High**	*Horizon 2:* 
Who: **Executive**		
Pre-conditions: Recommendation 6 – Leverage existing investment in quality decision making processes from RRAP and other programs to increase decision literacy and build capacity for quality decision making GBR-wide		Recommendation 8 – For mature, high-value sub-programs, develop a "Management Operating System" (MOS) and map associated decision-processes, focussed on tactical decisions

Rationale:

Decision guidance is the predominant decision process used across the GBR. Aspiring towards quality decision making, especially for strategic decisions, will benefit from the use of more formal structured-decision-making processes. There are multiple variations of structured decision making, though all broadly align to the 6 requirements of quality decision making (outlined in Section 2.4). Within the GBR and its catchments, there are multiple examples of these variations being used to support decision making, all using a structured-decision-making framework e.g., RIMReP Monitoring Activity Trade-Off Analysis (multi-criteria analysis) and RRAP Investment Case (cost-benefit analysis). To enable greater consistency in application, uptake and to optimise capability development, it is recommended that a standardised, bespoke set of structured decision-making process descriptions be developed and utilised that reflect the needs of GBR decision-makers and managers. The RRAP program is expected to be undertaking activity to develop these for the purposes of RRAP. While parallel investment in this activity outside RRAP is not recommended, it is recommended that there be a formal mechanism by which GBR decision contexts are communicated to those responsible for this task in RRAP, and, a formal mechanism by which these artefacts can be disseminated beyond RRAP to relevant decision-makers and practitioners once developed. Capability development (e.g., training) for decision-makers and practitioners outside RRAP will require funding, given that supporting the needs of RRAP are likely covered with existing investment.

The additional benefit from a standardised set of processes is in the ability to focus subsequent efforts in development of both generic decision-support systems and models to enhance the efficacy, efficiency and transparency of decisions made using these processes (per Recommendation 11), but also to de-risk the potential for the development of highly bespoke DSSs that have no utility beyond the decisions that they are developed to support.

Recommendation 15 – Generate an initial and high-level decision framework for the GBR Marine Park Area

<table>
<tr><td colspan="2">*What:* Development</td><td>*Priority:* Medium</td><td rowspan="2">*Horizon 1:*
 
</td></tr>
<tr><td colspan="3">*Who:* Executive, Investors / Funders</td></tr>
<tr><td colspan="3">*Pre-conditions:*</td><td>Recommendation 12 – Conduct a current state baseline and gap analysis focused on Traditional Owners within the GBR-wide decision landscape</td></tr>
<tr><td colspan="4">*Rationale:*
RTP and RIMReP partners should consider developing an initial and high-level decision framework that enables visibility on objectives, decisions and supporting people, processes, information systems and knowledge as it pertains to the GBR Marine Park Area. This decision framework should be established within the remit of the Reef 2050 Plan. Currently, this information is characterised to varying degrees within individual programs, making it difficult to transparently assess overlapping or consistently absent elements. Undertaking this task would enable key decision makers to understand the interaction of these programs and sub-programs that generate knowledge, how that knowledge relates to an understanding of progress towards highest-level objectives, and the relevant decisions, decision processes and information systems in existence to achieve those objectives. As a result, subsequent activities (and investment) in decision quality and information systems (including DSSs) would be more efficient, in particular, rationalisation of investment in knowledge generation and dissemination (e.g., prioritisation of knowledge streams to be captured in the RKS).
Specific activities that this could include and / or enable are:
▪ This activity should be informed by with the establishment of a Traditional Owner perspective on the GBR-wide decision framework (Recommendation 12).
▪ Establishment of an objectives hierarchy for the GBR and its catchments, with a subsequent establishment of a related decision hierarchy, including evolution/iteration over time.</td></tr>
</table>

- Mapping program actions on GBR to their outcomes using indicators.
- Mapping GBR outcomes (and indicators) to program and Reef 2050 objectives.
- Measuring and making data available on the efficacy of specific management actions to improve future decision making
- Characterising uncertainty to ensure that relevant decision processes can focus on the selection of the most robust options across a range of values (including trade-offs) and across a range of uncertainties.
- Re-characterising the range of stakeholders that are most impactful in their participation and representation in relevant decision-making processes.
- Objective setting for tactical decisions, ensuring alignment between decision making and desired strategic outcomes.
- Alignment of new program design to desired Reef 2050 plan objectives.

Recommendation 16 – Focus efforts to increase decision literacy amongst senior decision-makers through greater opportunities to participate in mature structured decision-making processes

<table>
<tr><td colspan="2">*What:* **Development**</td><td>*Priority:* **Medium**</td><td rowspan="2">*Horizon 2:*
 
</td></tr>
<tr><td colspan="2">*Who:* **Executive**</td><td></td></tr>
<tr><td colspan="3">*Pre-conditions:*
Recommendation 2 – Develop and socialise a high-level technology strategy, including capture of key decision literacy components, followed by a coherent strategic planning process
Recommendation 9 – Focus and fund efforts to increase decision literacy across the GBR</td><td>Recommendation 6 – Leverage existing investment in quality decision making processes from RRAP and other programs to increase decision literacy and build capacity for quality decision making GBR-wide
Recommendation 14 – Develop standardised, fit-for-purpose, qualitative and quantitative structured decision-making (SDM) processes</td></tr>
<tr><td colspan="4">*Rationale:*
Improving decision literacy amongst senior decision-makers is a priority to enable more uniform application and uptake of activities in pursuit of quality decision making. The least-cost, highest-value approach is to encourage participation of senior decision-makers in decisions that use mature structured decision-making processes. Increasing literacy through participation is likely to generate numerous benefits, including capability development, leadership of organisational efforts to enhance decision quality, advocacy for efforts to improve decision quality across the GBR in other contexts, and in enhancing visibility of decision-makers and their role throughout the decision-making process.
There are multiple options for participation. It can occur through active participation through an entire decision process where the senior decision-maker is the ultimate responsible and accountable party for the decision. It can be achieved through participation as an observer throughout an entire decision process, or as an observer in highly important sub-stages of the process (e.g., decision framing workshops), for decisions where another individual is the ultimate decision-maker. Thirdly, it could be achieved through participation as a member of a decision review board (see Recommendation 18) providing decision assurance for a decision where another individual or organisation has accountability for decision making.</td></tr>
</table>

Recommendation 17 – Develop and implement decision assurance frameworks through existing governance structures

What: **Development**	*Priority:* **Low**	*Horizon 3:* 
Who: **Executive**		
Pre-conditions: Recommendation 14 – Develop standardised, fit-for-purpose, qualitative and quantitative structured decision-making (SDM) processes		Recommendation 16 – Focus efforts to increase decision literacy amongst senior decision-makers through greater opportunities to participate in mature structured decision-making processes
Rationale: There is an opportunity to enhance the decision support effectiveness of existing governance structures through development and application of more formal decision assurance frameworks. This is of particular value in strategic decision contexts where governance groups can use the decision assurance function to manage the execution of the largest and/or most critical decisions. However, at all levels of decisions, a decision assurance function ensures that they can be confident that decision processes are being followed. Leading practice proponents of quality decision making may include decision review boards (DRBs) in their governance processes. The DRB will, throughout the course of a decision process, periodically and formally review the decision process against the 6 requirements of quality decision making presented in Section 2.4. DRBs typically comprise a small group (3-6 members) of multi-functional stakeholders (including subject matter experts) and are often subsets of broader steering committees in situations where those committees are large. In the GBR and its catchments, the analogue in terms of representation would be Expert Panels. DRBs are trained in or have experience with the application of structured decision processes and use a structured framework to review and assess decision-making processes. The primary intent of a DRB is to provide ongoing feedback to a decision-maker on the appropriateness of a decision process and its application over the course of a decision, to 1) enable improvements to be made prior to the ultimate decision point, 2) provide assurance to the decision-maker that the highest quality decision is being made, and 3) increase transparency and defensibility of the decision. In the GBR and its catchments, it was noted that stakeholder involvement in decision processes, especially strategic decisions, were skewed conservatively. Establishment of DRBs using formal decision assurance processes would likely enable greater value from existing steering committees.		

Recommendation 18 – Generate an initial and high-level decision framework for GBR catchments

What: **Development**	*Priority:* **Low**	*Horizon 2:* 
Who: **Managers, Executive, Investors / Funders**		
Pre-conditions: Recommendation 15 – Generate an initial and high-level decision framework for the GBR		Recommendation 16 – Focus efforts to increase decision literacy amongst senior decision-makers through greater opportunities to participate in mature structured decision-making processes
Rationale: Future integration of the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (P2R) with RIMReP will likely benefit from an exercise similar to that suggested in Recommendation 15. Undertaking this task would enable key decision makers to understand the interaction of programs and sub-programs that generate knowledge, how that knowledge relates to an understanding of progress towards highest-level objectives, and the relevant decisions, decision processes and information systems in existence to achieve those objectives. Integration activities can then start with transparent understanding of the existing decision landscape as it pertains to GBR catchments and the GBR itself,		

enabling more efficient rationalisation of decision framework elements (in particular, rationalisation of investment in knowledge generation and dissemination) to inform a unified integrated monitoring and reporting program under RIMReP.

Recommendation 19 – Continuously improve systems for better integration, higher decision quality, better capabilities and incorporation of emerging technology

What: **Development**	*Priority:* **Low**	*Horizon 3:* 
Who: **Managers, Executive**		
Pre-conditions: Recommendation 2 – Develop and socialise a high-level technology strategy, including capture of key decision literacy components, followed by a coherent strategic planning process		Recommendation 10 – Develop DSSs where the opportunity presents during MOS and decision process mapping, and following investment to mature people, process, and knowledge management Recommendation 11 – Apply open architecture DSSs opportunistically enabling subsequent customisation for specific decision
Rationale: To ensure the longevity of the investments in MISs and DSSs, funds should be reserved for ongoing continuous improvement. These considerations should be considered in the technology strategy planning processes (Recommendation 2). This will ensure that: ▪ The systems are maintained past redundant or breaking changes. ▪ System capabilities will be upgraded as opportunities for higher quality decisions are surfaced. ▪ Different systems (internal and external) can be better integrated over time to gain efficiencies (whilst ensuring not past the point of diminishing returns). ▪ Emerging technology can be leveraged, by replacing or updating the operational technology.		

Recommendation 20 – Inform the next iteration of the Reef 2050 Plan framework with a comprehensive "GBR-wide" decision framework

What: **Development**	*Priority:* **Medium**	*Horizon 4:* 
Who: **Executive, Investors / Funders**		
Pre-conditions: Recommendation 15 – Generate an initial and high-level decision framework for the GBR Recommendation 18 – Generate an initial and high-level decision framework for GBR catchments		Recommendation 12 – Conduct a current state baseline and gap analysis focused on Traditional Owners within the GBR-wide decision landscape Recommendation 16 – Focus efforts to increase decision literacy amongst senior decision-makers through greater opportunities to participate in mature structured decision-making processes
Rationale: The current Reef 2050 Plan framework includes description of objectives, programs, indicators and reporting of progress towards achievement of desired outcomes. There is an opportunity to inform the next iteration of the Reef 2050 Plan framework with a comprehensive "GBR-wide" decision framework that describes the decisions that are being made and need to be made to achieve identified objectives, and the		

existence (or lack thereof) and maturity of supporting processes, systems and knowledge that may require investment. Development of the “GBR-wide” decision framework would include an exercise to establish an objectives hierarchy from the objectives of Reef 2050 Plan, which could be valuable in helping rationalise and prioritise subsequent planning and management efforts.

Appendix A – Glossary

Across organisational, managerial, and scientific contexts, a heterogeneous and consistent understanding and use of key terms pertaining to decision-making is recommended. A list of key terms used throughout this document are presented below,

Decision	The point at which a decision-maker makes a choice between 2 or more alternatives, and results in resources being allocated to action the chosen alternative".
Strategic decisions	Decisions which influence whole of or a major part of an organisation or program, typically infrequent (i.e., > every 2 years) and forward looking across a long-term time horizon.
Tactical decisions	Decisions that concern the more detailed implementation of strategy, typically made with moderate frequency (i.e., monthly – annual), usually with a medium-term impact on an organisation or program.
Operational decision	Decisions that relate to the day-to-day operations of an organisation or program, frequently made (i.e., daily – weekly), with generally a short-term time horizon impact.
Decision quality	The quality of a decision at the moment the decision is made, regardless of its outcome.
Quality decisions	Decisions are considered high quality if they meet the following 6 requirements, regardless of the outcome of the decision: (1) a well-defined frame, (2) feasible and diverse alternatives, (3) relevant and reliable information, (4) clear understanding of the consequences and trade-offs of alternatives, (5) robust logical analysis, and (6) a commitment to action.
Decision framework	The architecture of people, processes, knowledge and knowledge systems used to make decisions.
Delegation of authority	The agreed system of distributed accountability and responsibility to ensure the appropriate level of participation and engagement in decision making to enable efficient and quality decisions.
Assurance	In the context of decision making, assurance refers to an independent, objective assessment of decision quality.
Decision processes	The processes by which decisions are framed, choices are identified, developed and logically analysed for their consequences and trade-offs, and commitments to action are made, across the decision landscape.
Decision rules	In the context of decision processes: primarily a conditional, formulaic approach to decision making.
Decision guidance	In the context of decision processes: primarily recommendations / directions of a list of potential activities to inform decision making.
Structured decision making	In the context of decision processes: primarily an organised approach to identifying, evaluating and selecting between options to inform decision making.

Knowledge base	The data, modelling and information available pertaining to the asset, including understanding of provenance and uncertainty, used to inform decision making.
Management information system (MIS)	The computerised system that gathers data from multiple sources and makes it available to users (including synthesis) to support quality decision making.
Decision-support system (DSS)	The computerised system that gathers data from identified sources, synthesises it, and makes it available to users in accordance with specified decision processes to support quality decision making on specific semi-structured and unstructured decision problems.
“Management Operating System” (MOS)	The tools, meetings and behaviours used to manage a project, program or organisation’s forecasting, planning, execution and reporting processes and people to translate goals into outcomes.

Appendix B – Methodology - Detailed

Desktop document review and mapping of programs across the GBR

The desktop review included a number of stages as outlined below:

1. Identification of all GBR related programs, organisations, funding entities, representative bodies and stakeholders;
2. Collection of all documents relevant from these areas to the GBR decision landscape;
3. Review of documents to assess for content relating to decisions and decision processes; and
4. Review of decision quality in documented decision processes and terms of reference for GBR decision-making groups.

First the project team, together with the project Steering Committee, developed a long list of programs, organisations, funding entities, representative bodies and highly involved stakeholder groups, or stakeholders responsible for management actions on the GBR and its catchments. The purpose of this exercise was threefold – 1) to focus the Project team's effort in identifying potential high-value documents with information on management actions, the decisions that preceded them and funding of those actions, 2) to characterise those actions and associated decisions subject to high levels of investment, and 3) to assist in the identification and prioritisation of relevant stakeholders for interviews.

Following this, a comprehensive document list pertaining to identified programs and organisational plans within the GBR were collected for review, including business plans and strategies, strategic plans, policies and guidelines, annual reports, summary reports, review reports and research reports. A full list of reviewed documents is presented in Appendix F.

As a first step in the review process, all the documents were reviewed for their content corresponding to strategic, tactical or operational decision making, to understand how frequently and to what extent information relating to these types of decisions was reported in the GBR landscape.

The next step involved honing the review of decisions further, by selecting those documents relating to the programs that had been identified as cross-cutting enablers and investment priorities in the Reef 2050 Plan. These documents were reviewed to identify decisions and decision processes in these related programs, with the intention of:

- Classifying the decisions (strategic, tactical or operational);
- Identifying the decision-maker(s) and other stakeholders involved in the decision-making process; and
- Understanding the knowledge, systems and processes utilised to inform the decisions.

The review established that although decisions that were being made in the programs could be inferred through their associated documents, in most cases the documents provided limited detail relating to the decision-makers, stakeholders, processes, knowledge and systems involved in those decisions. As a result, only a list of decisions and their classifications could be properly established for these programs. The full list of decisions identified in the sample of documents assessed for these programs can be found Appendix I.

The final step of the review process was to assess for the presence of decision quality in GBR decision making, by reviewing any documented decision processes that had been identified (in this case four decision processes) for the presence of the six elements of quality decision making and to review a sample of available terms of reference for GBR decision-making groups for any reference to quality decision making.

Mapping of GBR investments for identification of high potential DSS applications

In most organisational and large program contexts, actions that require significant levels of investment typically require comprehensive effort in establishing the case for investment (often a business case), and therefore are subject to 1) more comprehensive decision-making process requirements, 2) more involvement of subject matter experts and stakeholders, 3) greater need of evidence (i.e., data and knowledge) and 4) greater levels of executive management oversight and sanction. The Project team sought to identify where and on what actions large flows of investment were planned, and the decisions that informed them, as these represented potential candidate decisions that could benefit from application of DSSs. The rationale is that where there is highest investment, the marginal benefit from use of a DSS would potentially be more likely to exceed the cost of development and implementation, thus representing a preferential opportunity.

At the GBR-wide scale, decisions on program funding, and the highest-level decisions within programs, are predominately strategic in nature (accordingly to the classification presented in Section 2.2). They are largely decisions focussed, either explicitly or implicitly on 'will spending money enable us to achieve Reef 2050 (or program) objectives and management goals, and if so, what do we spend money on?'. Tactical decision making, at the GBR-wide scale, is largely focussed on 'how do we spend the money effectively' to realise program objectives and goals, and operational decision making, at the GBR-wide scale, is largely focussed on 'how do we ensure the money we have to spend on the things the program has decided to spend them on are spent efficiently?'

Using publicly available information on funding on GBR-wide programs between FY21 and FY25, subsequently validated with information contained within the reviewed documents (e.g., annual business plans), a 'Sankey' map was generated by first mapping the aggregated FY21-25 spend from funding sources to individual programs, representing the spectrum of likely strategic decisions and decision making. Specifically, this involved:

- Gathering program budget information available for the 5-year period FY21 to FY25;
- Using reasonable assumptions to extrapolate or interpolate where the full period was not available; and
- Qualifying the split of ultimate sources of investment for each program across the following:
  - - Federal Government direct or indirect investment,
  - - Queensland Government direct or indirect investment,
  - - Program revenue or non-government investment, and
  - - Other investment.

A subsequent mapping of funds was performed from these programs towards clearly discernible target areas for management action across the GBR, which represent the likely focus of tactical decisions (e.g., annual investment plans). For this version of the mapping we divided the GBR and its catchments ("GBR assets") into 4 high-level target areas:

- Reef and fisheries management;
- Catchments and wetlands management;
- Human dimensions & governance; and
- Other.

Operational decision making is the penultimate stage before the flow of investment from funding sources becomes management action, and the (reporting of) outcomes of management actions (eg: state of the system, efficacy of the management actions, fulfilment of KPIs) are the ultimate determinant of progress towards Reef 2050 objectives and goals. Thus, for several demonstrative programs a further mapping was attempted of their budgets, through each target area for action (the 4 areas above) to GBR asset outcomes (indicators), and then to the Reef 2050 objectives and goals.

The mapping of investment at this resolution is intended to gain high-level preliminary insights about investment decision making and how it links to action on the asset under management (GBR and its catchments). The intention is not to highly specify investment flow, but to generate a preliminary mapping of strategic decision making and how it links through to strategic and tactical decision making at program level, through to tactical and operational decisions on management actions on the asset. Refer to Section 5.4 for the results of this exercise.

Stakeholder identification, interviews and synthesis framework

Through a combination of the program identification, document review and discussions with the project Steering Committee, an initial shortlist of 16 high-value interview candidates representing a broad cross-section of organisations in the GBR community were identified, with diverse roles and professional backgrounds, varying levels of involvement in decision making and varied history of working in the GBR. Interviewees included representatives of state and federal regulators, science agencies, universities, industry groups, non-governmental organisations and representative bodies (e.g., Independent Expert Panel). Individual approximate one-hour interviews were held with each interviewee, with a briefing pack and sample questions issued in advance (see Appendix D). Through the course of the interviews, additional high-value interviewees were nominated and / or identified, and in total 38 individual interviews were held throughout the course of the project.

The overarching intent of each interview was to elicit perspectives on the decision-making landscape that individuals were part of and exposed to, including problem / opportunity identification, decision-making authority, delegation and accountability, participation in and communication of decision making, decision-making processes, availability and accessibility of knowledge and understanding of uncertainty and attitudes towards information and decision-support systems. Interview notes were synthesised according to themes aligned to the elements of a typical asset or program decision framework as presented in Section 2.5 and depicted in Figure 3, with results discussed in Section 5:

- Objectives (requiring actions and therefore decisions);
- Problems / opportunities (with choices and therefore decisions);
- People (making decisions, contributing to decisions, impacted by decisions);
- Processes (for making decisions);
- Knowledge (informing decisions);
- Information and decision-support systems (supporting decisions); and
- Actions (resulting from decisions).

Owing to the extent of rich commentary about the broader landscape within which individuals and organisations operate, collaborate and make decisions specific to the GBR, relevant insights were also captured according to the following themes:

- GBR-wide decision-making landscape;
- Influence of legacy experiences with decision making and decision-support systems;
- Individuals and relationships in the GBR; and
- Objectives of GBR and catchment managers, scientists, and funders.

Survey of GBRMPA managers

To understand the decision landscape from the perspective of GBRMPA Reef Managers, the project team issued a survey via Survey Monkey to 16 individuals identified by the project Steering Committee. The questions focussed on eliciting their views on the current state of decision making within the organisation and their needs with respect to knowledge, knowledge accessibility and supporting information and decision-support systems in support of their decision-making activities.

In particular, the survey focussed on assessing four key themes:

- Decision participation and decision-making frequency (i.e., what decisions each respondent contributes to or makes and how often does this occur);
- Decision-making processes and accountabilities (i.e., what decision-making processes are followed and who is involved in making and endorsing decisions);
- Current and desired future states for knowledge availability and accessibility (i.e., what type of information is available to inform decisions, and what is the ideal future state for accessing this knowledge); and
- Decision quality (i.e., how effective, transparent, defensible and efficient is decision making currently).

Individuals to whom the survey was issued were identified as those who are responsible for GBR management decisions and who could provide input and perspectives of Reef Managers' needs with respect to decision-support systems, and general attitudes towards them. The full list of respondents is presented in Appendix C. Survey results were collated and analysed to determine key trends, themes and points of interest. A complete survey question transcript is presented in Appendix E.

Desktop review of GBR systems and group interviews with developers and users

There are many different models and systems in use or in development across the GBR that are used, can be used, or are intended for use in supporting decision making. Understanding the current state of these various models and systems is an important activity in identifying potential existing use cases for DSSs, connecting decisions and systems already available that are not being utilised in support of decision making, identifying potential candidate systems for further development for ultimate application as a DSS, and, in characterising gaps in existing capability relative to GBR decision-makers needs and aspirations.

Through a combination of the program identification, document review, initial stakeholder interviews and discussions with the project Steering Committee, a shortlist of 13 candidate information systems, models and decision-support systems currently in use or in development across the GBR for the purposes of supporting decision making were identified. An initial desktop review was performed, using supporting information provided by the project Steering Committee, sourced through public searches and received by the Project team through engagement with system owners.

Group interviews were conducted with 14 developers and users to further characterise the identified systems and models, focussed on developing an understanding of their current and aspirational utility and application, in particular:

- the background and development history of the system (why does the system exist?),
- the capability and characterisation of the system (what decision(s) does the system support?), and
- the end user(s) and decision-makers associated with the system (who uses it and how?).

A complete list of interview questions is presented in Appendix J. Results are discussed in Section 5.5.

Desktop review of systems used in similar contexts to the GBR

Similar to the rationale for conducting a review of models and systems used to inform decision making in the GBR, a parallel desktop review of potential candidate decision-support systems used in other contexts was undertaken. The aim of the review was to develop a synthesised list of potential candidate systems that could be considered for application in the GBR, and, to provide a framework for a deeper assessment of the applicability of potential decision-support system candidates. The framework used the qualification and classification bases presented in Sections 3.5 and 3.6 to assess whether a system was an MIS or DSS.

The review leveraged the Project team's knowledge and experience with using and developing DSSs in other domains, most notably in large scale asset-management and sustainability domains, accompanied by review of both commercially available models and systems and those referenced in peer-reviewed literature. Systems were organised in several tiers: 1) those in use in the GBR, 2) those used in coral reef settings, 3) those used in environmental management decision making, and 4) those used in other complex decision-

making settings. For completeness, several generic decision-support systems were also reviewed and profiled to help with contextual understanding.

Appendix C – Methodology - Stakeholder List

The insights presented in this report were generated through a combination of desktop reviews of relevant literature, interviews with decision makers and system developers and users, and a survey of select GBRMPA Reef Managers. The list of stakeholders is presented below.

GBR Decision Landscape Discussions

Person	Organisation	Role
Christian Roth	GBRF	IMR DSS Steering Committee, Chair IMR
Dylan Horne	GBRMPA	IMR DSS Steering Committee, A. Dir Reef Knowledge Section
Ken Anthony	AIMS	IMR DSS Steering Committee, Research Scientist
Cedric Robillot	GBRF	ED RRAP
Liz Wren	GBRF	Director, RTP Traditional Owner Partnership program
Josh Thomas	GBRMPA	CEO
Paul Hardisty	AIMS	CEO
Craig Moore	DAWE	Acting Head, Reef Branch
Margaret Johnson	GBRMPA	General Manager Policy
Bruce Taylor	CSIRO	GBR Coordinator
Matt Curnock	CSIRO	SELTMP Project Lead
David Wachenfeld	GBRMPA	Chief Scientist, Acting Director Reef Knowledge Section
Di Tarte	MEPA	Consultant
Elisa Nichols	Qld DES	Executive Director, OGBR
Eddie Jebreen	Qld DAF	Executive Director (Fisheries), Office of the DDG
Kevin Kane	NQBP	Director, Environment
Scott Crawford	NQDT	CEO
Jane Hutchinson	TNC	Executive Director, Strategy & Innovation
Richard Brinkman	IMOS	Program Leader
Wendy Morris	GBRMPA	Board Member
Gareth Phillips	AMPTO	Director, Reef Teach; Alt Rep - Tourism
Simon Banks	GBRMPA	General Manager, Reef Protection Branch
Belinda Jago	GBRMPA	Director, Policy and Planning, Reef Protection Branch
Rhona MacPherson	GBRMPA	Director, Environmental Assessment & Protection, Reef Protection Branch
Richard Quincey	GBRMPA	Director, Field Management Program, Reef Protection Branch
Ian Chubb	IEP	Chair, Reef IEP
Peter Mumby	UQ	Research scientist
Richard Leck	WWF	Head of Oceans and Sustainable Development
Katrina Dent	Reef Catchments	CEO
Stephen Oxley	DAWE	Assistant Secretary, Heritage Reef and Marine
Leanne Fernandes	GBRMPA	Assistant Director, Policy and Planning
Darren Cameron	GBRMPA	Director, Reef Interventions
Julia Chandler	GBRMPA	Director, Environmental Planning
Mel Cowlishaw	GBRMPA	Assistant Director, Natural Science
Chris Cochrane	GBRMPA	Operations Director, Field Management Program, Reef Protection Branch

Systems Review Discussions

Person	Organisation	Candidate System
Robert Speed	GBRF	Reefonomics (Water Quality Investment Tool)
Mark Baird	CSIRO	eReefs
Ken Anthony	AIMS	ADRIA
Beth Fulton	CSIRO	Atlantis
Joseph Street	GBRMPA	Reef Knowledge System
Karen Chong-Seng	GBRMPA	Resilience Network
Genevieve Williams	GBRMPA	Reef Explorer
Sam Matthews	GBRMPA	COTS Dashboard
Anya Jaeckli	GBRMPA	COTS Dashboard
Darren Roy	DAF	Fisheries Framework
Tom Roberts	DAF	Fisheries Framework
Peter Mumby	UQ	Reefmod
Yves-Marie Bozec	UQ	Reefmod
Scott Condie	CSIRO	COCONET, CONNIE
Roger Beeden	GBRMPA	RSP5
Cameron Fletcher	CSIRO	COTS DSS
David Wescott	CSIRO	COTS DSS

GBRMPA Survey Respondents

Person	Organisation	Section / Program
Randall Owens	GBRMPA	Fisheries Policy
Tony Galt	GBRMPA	Joint Field Management Program
Phil Koloi	GBRMPA	Joint Field Management Program
Mark Read	GBRMPA	Joint Field Management Program
Peta Ross	GBRMPA	Joint Field Management Program
Matt Slatcher	GBRMPA	Joint Field Management Program
Owen Witt	GBRMPA	Joint Field Management Program
Alicin Everson	GBRMPA	Permits
Sandra Garvin	GBRMPA	Permits
Kimberly Glover	GBRMPA	Permits
Thea Waters	GBRMPA	Permits
Kevin Edison	GBRMPA	Permit Compliance
Holly Cantin	GBRMPA	Policy and Planning
Kerrie Jocumsen	GBRMPA	Policy and Planning
John Tapim	GBRMPA	Policy and Planning
Fiona Merida	GBRMPA	Stewardship

Appendix D – Methodology - Stakeholder engagement briefing pack

Project Context

This Project, jointly developed by the Reef Trust Partnership and GBRMPA, is the first step in the early-stage development and prototyping of a GBR-wide, fit-for-purpose decision-support system.

- The Integrated Monitoring and Reporting (IMR) Component of the Reef Trust Partnership (RTP) supports the implementation of the Reef 2050 Plan Reef Integrated Monitoring and Reporting Program (RIMREP), including eReefs and the Paddock to Reef (P2R) monitoring and reporting programs.
- The purpose of the IMR Component is to **improve health monitoring and reporting** of the Great Barrier Reef World Heritage Area, **ensure monitoring and reporting to UNESCO is scientifically robust**, and **investment outcomes are measurable**.
- As part of the IMR Component, the Great Barrier Reef Foundation (GBRF) is investing in the **early stage development and prototyping** of a **GBR-wide decision-support system (DSS)**.
- Aurecon has been contracted to conduct an **independent comprehensive analysis of the decision support landscape** within the GBR and the Reef 2050 Plan Framework, to inform **recommendations for developing and implementing a fit-for-purpose DSS**. The scope of the analysis has been co-developed with GBRMPA.

2

The Need for GBR-Wide Decision-Support

Optimising investments in Reef Management is predicated by robust decision-making. A decision-support system is central to ensuring the value from monitoring and modelling programs that inform decision-making is maximised.

- Within the context of historic and projected decline in coral reef ecosystem condition, primarily due to climate change, there is the need to **target management actions and investments** by multiple partners in a multiple use Marine Park.
- As such, the GBR needs a **transparent and risk-based approach to decision-making** founded on available evidence and models that enable forecasting and scenario planning.
- A coordinated DSS will **greatly increase the value that can be extracted from existing monitoring and modelling programs**. This approach could be used more systematically to target management actions, policy decisions and investments, across the full range of GBR activities.
- Currently there is a **significant time lag between the acquisition of some data and its availability to inform management or policy decisions**. In a rapidly changing climate with a predicted increase in frequency and intensity of high impact events (including bleaching, cyclones and floods), adaptive management will only be achieved if **monitoring and modelling data can be more readily and more consistently used** to inform decisions.

3

The Aspiration for a GBR-Wide Decision-Support System

This Project looks to build on work performed by RIMReP to improve and enhance the timeliness and efficacy of GBR management decisions that are informed by monitoring and model data through a flexible decision-support environment.

- The strategic objective of the RTP and GBRMPA is not to develop an all-encompassing, integrated model for decision-making, as 'one size fits all' approaches have historically failed to meet expectations.
- Instead, it is to support the development and implementation of a **flexible decision-making environment** that recognises the **value of diversity in monitoring and model data**, **consolidates existing systems** and **streamlines the flow of information**, and builds on the foundational work of RIMREP to address decision-support needs for management or the Marine Park and its catchments.
- The Project team will engage with RIMReP and the broader GBR community to **identify key hurdles, step changes and transformations required** to achieve the ultimate objective of an adaptive system. Realising the full value and co-benefits of integrating observation and modelling will require the strategy to **address the entire value chain from monitoring data to modelling, decision-making, evaluation and reporting**.
- Significant progress has been achieved by RIMReP which the Project will look to build on, focusing on **reducing the time between monitoring data collection and impact**.
- Ultimately, this Project is the first step in developing a DSS that enables partners to consider **evidence-based projections of Reef futures, and the optimal location, timing and combination of management investments** to achieve the objectives of the Reef 2050 Plan.

4

Project Objectives

This 3 month project has a number of critical aims and desired outcomes which serve as foundational activities for the ultimate development and implementation of a decision-support system.

- To establish line-of-sight on the **current state of decision-making and decision-support** pertaining to the GBR and its catchments that contributes to the achievement of Reef 2050 Plan objectives;
  - including the dissemination and use of knowledge (i.e., information, data and model outputs) and the application of decision-support systems, decision-support processes and decision-support tools.
- To establish line-of-sight on **state-of-the-art decision support systems used in similar contexts to the GBR**, and, on decision support frameworks, processes, models, systems and tools with potential and / or actual utility in informing decisions on the GBR and its catchments;
- To establish line-of-sight on **the current and potential future needs of GBR managers and decision-makers** with respect to decision-support, and the gap between the current state, their immediate needs, and their aspirational needs;
- To understand **options available** to the RTP, GBRMPA and RIMReP partners to progress **development and implementation of fit-for-purpose decision support system**;
  - in alignment with RTP Investment Strategy objectives, RIMReP management guidance objectives, and development pathways of decision-support systems and strategies of complementary GBR programs including the Reef Restoration and Adaptation Program (RRAP), Paddock-to-Reef Program (P2R) and Crown-of-Thorns Starfish Control Program.

5

Project Stages

This 3 month project has 4 distinct stages, commencing with stakeholder interviews to gain an appreciation of the decision landscape pertaining to the GBR and its catchments.

- **Phase 1 – Stakeholder Engagement (where we are today)**
  - Engagement and elicitation interviews with senior GBR decision-makers (incl. GBRMPA), managers, influencers and investors to characterise perspectives on GBR decisions, understanding of their role in decision-making, decision processes, and use of decision-support systems and tools
  - Survey to potential GBRMPA decision-support system users to characterise perspectives on GBRMPA decisions, understanding of their role in decision-making, decision processes, and existing and desired use of decision-support systems and tools
- **Phase 2 – Establishing Current State**
  - Synthesis of information from interviews and document review, and, characterisation of state-of-the-art decision-support system from literature review and industry engagement
  - Decision landscape mapping, comprising decisions, decision-makers, decision support frameworks, processes, models, systems and tools
- **Phase 3 – Establishing Future State(s)**
  - Determining potential aspirational future states for the purpose, remit and functionality of a fit-for-purpose GBR-wide decision-support system
- **Phase 4 – Identification of Critical Activities and Options to Progress Development**
  - Development and assessment of key enabling activities and options for progressing further development

6

Stakeholder Interviews – Topics to Cover (Government Perspective)

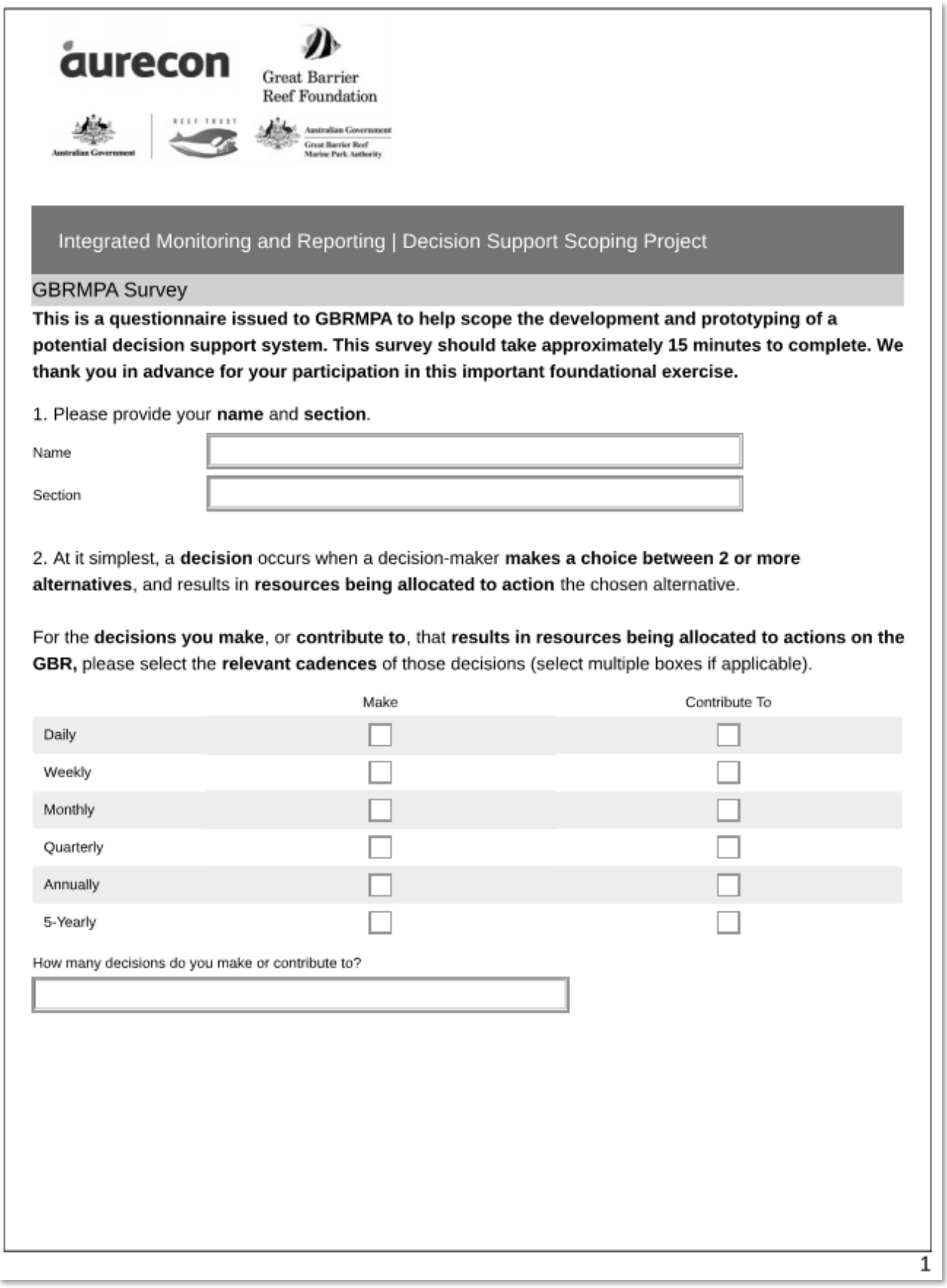
Each interview will be bespoke, however there are core areas and common questions that will be covered. Below is a ***long list of potential questions*** and topics we will cover in each interview.

- How familiar are you with the objectives of the Reef 2050 Plan?
- What role does your organisation play, if any, with respect to meeting the objectives of the Reef 2050 plan?
- To what extent do the Reef 2050 plan objectives guide decisions made by your organisation pertaining to the GBR*?
- What decisions has your organisation made, or what decisions does your organisation routinely make, in the context of the GBR*?
- What decisions has your organisation been a part of, or what decisions are your organisation routinely part of, in the context of the GBR*?
- What would be the split between strategic, tactical and operational decisions pertaining to the GBR that your organisation makes or is involved in?
- In your opinion, how many decision-makers are there in the GBR making strategic decisions? What about tactical decisions? What about operational decisions?
- Do you think that strategic decision-makers have access to the information they need to make quality decisions? What are the other challenges with decision making?
- What examples of decision-support systems can you point to that are being used in the GBR? How effective are these?
- Who has accountability for outcomes on the GBR?
- Who has accountability for the management actions on the GBR?
- Who controls management actions on the GBR?
- What accountability do you think your organisation has with respect to outcomes or management actions, if any?
- What do you think would improve your organisation's ability to help achieve the objectives of the Reef 2050 plan?

7

* and / or its catchments

Appendix E – Methodology - GBRMPA survey



aurecon

Great Barrier Reef Foundation

Australian Government

Great Barrier Reef Marine Park Authority

Integrated Monitoring and Reporting | Decision Support Scoping Project

GBRMPA Survey

This is a questionnaire issued to GBRMPA to help scope the development and prototyping of a potential decision support system. This survey should take approximately 15 minutes to complete. We thank you in advance for your participation in this important foundational exercise.

1. Please provide your **name** and **section**.

Name

Section

2. At it simplest, a **decision** occurs when a decision-maker **makes a choice between 2 or more alternatives**, and results in **resources being allocated to action** the chosen alternative.

For the **decisions you make**, or **contribute to**, that **results in resources being allocated to actions on the GBR,** please select the **relevant cadences** of those decisions (select multiple boxes if applicable).

	Make	Contribute To
Daily	☐	☐
Weekly	☐	☐
Monthly	☐	☐
Quarterly	☐	☐
Annually	☐	☐
5-Yearly	☐	☐

How many decisions do you make or contribute to?

1

3. Decisions are often classified as being **strategic** (developing 5-year strategies, establishing long-term goals and policies), **tactical** (setting annual plans, responding to events) and **operational** (resource allocation to tasks, choices made in executing defined tasks).

What is the **split of the decisions you make or contribute to** across these 3 classifications?

(Responses should add up to 100% down each column.)

	% of decisions (of those you make)	% of decisions (of those you contribute to)
Strategic		
Tactical		
Operational		

4. For each classification of decision, **who is typically involved** in decision-making?

Note: Executive Decision Makers include General Managers and above.

	(A) Decision Maker Only	(B)	(C) Decision Maker + Subject Matter Experts	(D)	(E) Decision Making Group + Subject Matter Experts	(F)	(G) Executive Decision Making Group + Subject Matter Experts	N/A
Strategic	○	○	○	○	○	○	○	○
Tactical	○	○	○	○	○	○	○	○
Operational	○	○	○	○	○	○	○	○

5. For each classification of decision, **what process is typically involved** in decision-making?

Note:
Ad-hoc: primarily judgement-based approach to decision making.
Routine method: a simple, sequential approach to decision making.
Decision rule: a conditional, formulaic approach to decision making.
Decision guidance: recommendations / directions for a combination of activities to inform decision making.
Structured decision making: an organised approach to identifying, evaluating and selecting options to inform decision making.

	(A) Ad-hoc	(B)	(C) Routine methods	(D)	(E) Decision rules	(F)	(G) Decision guidance	(H)	(I) Structured decision-making	N/A
Strategic	○	○	○	○	○	○	○	○	○	○
Tactical	○	○	○	○	○	○	○	○	○	○
Operational	○	○	○	○	○	○	○	○	○	○

6. For each classification of decision, what is the **current state of knowledge used to inform** decision-making?

Please nominate percentages that add up to 100% across each row.

	Data not easily available	Data easily available	Data easily available and synthesised for communication (e.g., dashboards)	Data easily available and synthesised for insight (e.g., model outputs)	Other
Strategic					
Tactical					
Operational					

If you specified 'Other', please describe.

7. For each classification of decision, what your **desired state of knowledge used to inform** decision-making?

Please nominate percentages that add up to 100% across each row.

	Data not easily available	Data easily available	Data easily available and synthesised for communication (e.g., dashboards)	Data easily available and synthesised for insight (e.g., model outputs)	Other
Strategic					
Tactical					
Operational					

If you specified 'Other', please describe.

8. What **knowledge don't you have**, but you'd ideally like to have, when making decisions? (if you have all the information you need for each decision, please enter 'none'.)

9. Please list the **systems** that are used, or enter 'none'.

10. Please list the **decision support systems** that are used, or enter 'none'.

11. Thinking about decisions that you have been a part of or privy to at GBRMPA, **please provide your agreement** with the following statements about decision making.

	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree
It is Effective (right choices made):	○	○	○	○	○
It is Efficient (timeliness of making decisions):	○	○	○	○	○
It is Transparent (easy for others to understand the rationale for the decision):	○	○	○	○	○
It is Defensible (decision can be well supported against criticism):	○	○	○	○	○

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Appendix F – Methodology - Document Register

Register of documents reviewed and broad assessment of content specific to different classifications of decisions

#	Document Name	Source	Primary Type	% Strategic (GBR-wide)	% Tactical (GBR-wide)	% Operational (GBR-wide)
1	RTP Monitoring and Evaluation Plan (Stage 3)	RTP | GBRF	Strategic	80	20	0
2	COTS Control Program: Control of crown-of-thorns starfish is protecting coral on the Great Barrier Reef	RRRC	Tactical	0	80	20
3	Risk analysis of the governance system affecting outcomes in the Great Barrier Reef	Dale et al	Strategic	80	10	10
4	RIMReP Strategy Update 2018	GBRMPA	Tactical	10	80	10
5	RIMReP Research Report 2017	Enhance Research	Strategic	70	20	10
6	An Integrated Monitoring Framework for the Great Barrier Reef World Heritage Area (RSP6)	NESP	Strategic	70	20	10
7	Identifying Management Needs: Informing the program design of the Reef 2050 Integrated Monitoring and Reporting Program | Final Report	James Udy | Science Under Sail	Strategic	40	30	30
8	RIMReP Data Management Strategy Report	GBRMPA	Strategic	70	20	10
9	RIMReP Data Audit and Data Practices Review Report	AODN | AIMS | CSIRO | JCU	Operational	20	30	50
10	GBRMPA Communication and Engagement Strategy	GBRMPA	Strategic	80	10	10
11	Reef 2050 Water Quality Improvement Plan 2017-2022	QLD Gov	Strategic	80	10	10
12	Reef 2050 Policy Guideline For Decision Makers	Aus Gov / QLD Gov	Tactical	30	50	20
13	Reef 2050 Plan (latest)	Aus Gov / QLD Gov	Strategic	80	10	10
14	Reef 2050 Plan 2018 Annual Report	Aus Gov / QLD Gov	Tactical	10	20	70
15	Reef 2050 Net Benefit Policy 2018	Aus Gov / QLD Gov	Tactical	30	50	20
16	Reef 2050 Good Management Practice for the Great Barrier Reef	Aus Gov / QLD Gov	Tactical	20	60	20
17	Reef 2050 Cumulative Impact Management Policy	Aus Gov / QLD Gov	Tactical	30	50	20
18	Informing Resilience Based Management in the Great Barrier Reef	Aus Gov / AIMS / CSIRO / University of Melbourne	Strategic	70	20	10
19	GBRMPA Draft Policy on Great Barrier Reef Interventions	GBRMPA	Tactical	30	60	10
20	Paddock to Reef Summary 2017-2022	Aus Gov / QLD Gov	Tactical	10	70	20
21	Paddock to Reef Program Design 2018-2022	QLD Gov	Strategic	70	20	10
22	An ecologically-based operational strategy for COTS Control	NESP	Operational	20	30	50
23	COTS Strategic Management Framework	GBRMPA	Strategic			

#	Document Name	Source	Primary Type	% Strategic (GBR-wide)	% Tactical (GBR-wide)	% Operational (GBR-wide)
24	A Strategy to Link Research and Management of COTS on the Great Barrier Reef: An Integrated Pest Management Approach	NESP	Strategic	80	10	10
25	MMP Annual Report for Quality Assurance and Quality Control Manual 2017/18	Aus Gov / QLD Gov / AIMS / UQ / CSIRO / JCU / GBRMPA	Tactical	20	60	20
26	MMP Modelling the environmental drivers and abundance of seagrass communities in Cleveland Bay	CSIRO / Data 61 / GBRMPA	Tactical	20	60	20
27	MMP Annual Report for Inshore Water Quality Monitoring 2017/18	JCU / GBRMPA / Aus Gov / AIMS	Tactical	20	60	20
28	MMP Annual Report for Inshore Seagrass Monitoring 2017/18	JCU / GBRMPA	Tactical	20	60	20
29	MMP Annual Report for Inshore Pesticide Monitoring 2017/18	UQ / GBRMPA	Tactical	20	60	20
30	MMP Annual Report for Inshore Coral Reef Monitoring 2017/2018	Aus Gov / AIMS / GBRMPA	Tactical	20	60	20
31	MMP Assessment of reproductive effort as an indicator of seagrass health for the Marine Monitoring Program	CSIRO / GBRMPA	Tactical	10	60	30
32	Maintenance Dredging Strategy for Great Barrier Reef World Heritage Area Ports	QLD Gov	Strategic	70	20	10
33	JFMP Business Strategy 2019-2023	GBRMPA | QLD Gov	Strategic	60	20	20
34	JFMP Annual Report Summary 2018/2019	GBRMPA | QLD Gov	Tactical	10	70	20
35	JFMP Business Plan 2019-2020	GBRMPA | QLD Gov	Tactical	10	70	20
36	ICT Strategic Plan 2019-2023	GBRMPA	Strategic	80	10	10
37	Outlook Report 2019	GBRMPA	Strategic	70	20	10
38	Independent Assessment of Management Effectiveness for the GBR Outlook Report 2019	GBRMPA	Strategic	60	30	10
39	GBRMPA Corporate Plan 2018-19	GBRMPA	Tactical	10	80	10
40	GBR Blueprint for Resilience	GBRMPA	Strategic	70	20	10
41	Structure of Intergovernmental Agreement	GBRMPA		80	10	10
42	A Framework for Understanding Cumulative Impacts, Supporting Environmental Decisions and Informing Resilience Based Manage of the Great Barrier Reef World Heritage Area (RSP5)	Aus Gov / AIMS / CSIRO / University of Melbourne / GBRMPA	Strategic	70	20	10
43	Current and committed investment in monitoring and modelling under the Reef 2050 Plan 2018-23	GBRMPA	Strategic	80	20	0
44	Evolving Polycentric Governance of the Great Barrier Reef	JCU	Strategic	80	20	0
45	Queensland Sustainable Fisheries Strategy 2017-2027	DAF	Strategic	80	20	0
46	Queensland Sustainable Fisheries Strategy 2017-27 | Progress Report | Year 1	DAF	Strategic	80	20	0
47	Queensland Sustainable Fisheries Strategy 2017-27 | Progress Report | Year 2	DAF	Strategic	80	20	0
48	Reef Line Harvest Strategy 2020-2025	DAF	Strategic	80	20	0

#	Document Name	Source	Primary Type	% Strategic (GBR-wide)	% Tactical (GBR-wide)	% Operational (GBR-wide)
49	Spanner Crab Harvest Strategy 2020-2025	DAF	Strategic	80	20	0
50	Queensland Sustainable Fisheries Strategy 2017-27 | Fisheries Queensland Monitoring and Research Plan	DAF	Strategic	70	20	10
51	Dredging and Australian Ports Subtropical and Tropical Ports 2014	Ports Australia	Strategic	60	30	10
52	Great Barrier Reef Models	CSIRO	Tactical	20	50	30
53	No-anchoring areas reduce coral damage in an effort to build resilience in Keppel Bay, southern GBR	Australian Journal of Environmental Management	Tactical	80	20	0
54	RIMReP Business Analyst Report 2019	Aurecon | AIMS | CSIRO	Strategic	70	20	10
55	Reef 2050 Plan Most Likely Influencers | Reef 2050 Risk Workshop 2019	GBRMPA	Strategic	100	0	0
56	RTP Annual Work Plan 20-21	GBRF	Tactical	0	100	0
57	RTP Investment Strategy and Annual Work Plan Consultation Plan	GBRF	Strategic	80	20	0
58	RTP Investment Strategy	GBRF	Strategic	80	20	0
59	RRAP Annual Investment Plan	RRAP	Tactical	20	80	0
60	RRAP Investment Case	RRAP	Strategic	80	20	0
61	RRAP Initial Investment Prioritisation	RRAP	Strategic	80	20	0
62	Queensland Reef Water Quality Program 5-year investment plan 2017-2022	QLD Gov	Strategic	80	20	0
63	Queensland Reef Water Quality Program Annual investment plan 2019-2020	QLD Gov	Tactical	20	80	0
64	AIMS Annual Report 2019-2020	AIMS	Tactical	20	80	0
65	AIMS Strategy 2025	AIMS	Strategic	80	20	0
66	IMOS Five Year Plan 2017-2022	IMOS	Strategic	80	20	0
67	IMOS Annual Business Plan 2019-2020	IMOS	Tactical	20	80	0
68	IMOS Strategy 2015-2025	IMOS	Strategic	80	20	0

Appendix G – Results – Stakeholder Interviews

The synthesis framework described in Section 2.5 has been used to present the major findings from the stakeholder interviews, which are presented in below. Insights from interviews with system developers, owners and users are presented in Section 5.5. Thirty-eight (38) individual stakeholder interviews were conducted, with the interviewees listed in Appendix C. Results have been largely synthesised as enabling or impeding factors for the utility of and value proposition for DSSs, to inform recommendations for development and prototyping.

Objectives

Summary:

The complex, inter-related map of equally weighted objectives under Reef 2050 permeates to challenges in decision making at strategic and tactical levels across GBR programs, in the identification of recurrent problems / opportunities, development of consistent options, and the identification of values / criteria for assessment of trade-offs between choices (all elements that are pre-requisite for DSSs.)

Detailed Observations:

Complexity of Objectives

- Objectives across GBR programs, institutions and collaborative efforts were described as inter-related, sometimes complementary, sometimes competitive, multi-level, variously identified, variously communicated and variously understood.
- The complex objectives space requires significant inter-agency, inter-group and inter-personal effort to ensure alignment is sufficiently maintained as programs and GBR realities evolve.

Relative Importance of Objectives:

- Due to the relationship-based management of complex and inter-related objectives, objectives within and across agencies / programs / groups tend to be considered equally important, with limited stated hierarchy.
- Equally weighted objectives appear to encourage an environment where investment decisions are based on perceived “fairness” as well as efficacy, such that there are no real or perceived “winners” and “losers”.
- The tendency is for investment to be spread thinly to satisfy complex stakeholder groups (typically linked to consensus-based decision making and concepts of “fairness”), potentially at the expense of efficacy and outcomes.
- Management plans are the definition of success in enabling the achievement of objectives, as opposed to decisions to act.

Clarity of Objectives Hierarchy Elements

- The use of key terms is inconsistent and sometimes not appropriate across various contexts (e.g., a stated objective is actually a value).

Direct Quotes:

“It’s too hard [to prioritise] so just write [all objectives] down”

“We don’t have enough information to know whether the decisions we have made have been effective”

“The Audit Office said that nobody knows where money is spent and how much”

“The Reef ecosystem is nowhere near as complex as the human ecosystem”

“Has investment in [GBR asset area] delivered value commensurate with the investment?”

“Primary drivers of those on the ground are not considered”

“Most [stakeholder group] are sick of talking about [Reef 2050 objective], because it’s not what they actually care about”

- Strategic and tactical decision making within programs is made more challenging by the equal weighting of objectives (e.g., option development, assessment of trade-offs.)

Reporting on Achievement of Objectives

- There does not appear to be a coherent understanding of the relationship between the objective hierarchy of Reef 2050, the pathway for this to inform / reset strategy, and the availability of data to measure success.

Problems and Decisions

Summary:

There are a multitude of decisions made by a highly distributed group of individual decision-makers at annual and sub-annual frequency in programs and agencies across the GBR, especially at the tactical and operational levels. Strategic decision-making is limited to a select few individuals at ~5 year timescales. Future problems (and therefore decisions) are likely to be focussed on those related to potential climate-change impacts on the GBR.

Detailed Observations:

Understanding of Decisions and Decision Making

- There are many decisions across the GBR, however there is a lack of consistent understanding of what a 'decision' is.

Strategic Decisions:

- Typically, strategic decisions are those made over ≥5-year time scales (e.g., 5-year management plan), made by very few decision-makers.
- Many senior interviewees expressed the view that only the Ministers (QLD / FED) are strategic decision makers.
- Many problems are resolved through the process of creating a management plan or management strategy, not a decision with specific, defined action(s) with resources allocated towards them.
- There was a stated perception of strategic decisions being largely politically driven with a robust process for arriving at the decision being a secondary concern.

Tactical Decisions

- Typically, tactical decisions are those made on a monthly to annual frequency, focussed on
  - Resource allocation in line with 5-year plans, or
  - Responses to specific unplanned events (e.g., cyclones, coral bleaching).

Operational Decisions

- Typically, operational decisions are those made on daily / weekly timescales, focussed on executing actions in accordance with monthly or annual plans.

Direct Quotes:

"Decisions should map explicitly to objectives – the link is often implicit as opposed to explicit"

"The value of a decision-support system is greatest for investment prioritisation decisions"

"There are a lot of instances where a decision is not a decision, but we think it is – there's a default choice."

"It is rubbery to say who is responsible for the big decisions about the GBR"

"'When problems sit with the science folks, they seem to go into the weeds"

Decision-Making Accountability and Responsibility

- There is a perception that strategic decision-makers don't like being in situations where they must make decisions, i.e., where there is a choice between options. They are perceived to prefer situations where there is a default solution. This is deemed understandable due to high uncertainty.
- When the broader decision frame involves more than one agency, strategic decision makers are believed to be hesitant to make decisions, due to friction at the interfaces of the agencies.
- At a GBR scale, it is not clear to everyone who is accountable for
    1) asking the big questions,
    2) thinking about the decisions that must be made in the future,
    3) progressing the work to be able to identify and resolve those decisions,
    4) decisions pertaining to the area of the GBR between mid-shore Reefs and outer Reefs.
- Different groups are known to make decisions at tactical and operational levels that have similar knowledge needs and consider similar issues, but appear to be making decisions somewhat independently.
    - E.g., within the Joint Field Management Program, decisions are routinely made by different people on where to put markers and buoys in the MPA, where Park Rangers go to monitor compliance, and where COTS eradication teams go, all of which through coordination may result in more optimised decisions for cost / effort / impact.

Historic, Current and Future Problems

- The focus of GBRMPA has evolved over the past 3 decades from understanding and mitigating the impacts of mining activity, to fishing and zoning, to catchment management, and now moving into climate change.

Knowledge

Summary:

There is strong universal desire amongst GBR decision-makers for information to be made available and easily accessible, with tactical and strategic decision-makers seeking synthesised information that is defensive and communicable. There is recognition of the imminent need for predictive information given management decision-making needs in the face of climate change. Interviewees identified knowledge gaps in non-biophysical realms (e.g., human use in the MPA, social dimensions, Traditional Owner values).

Detailed Observations:

Availability and Accessibility of Knowledge

- All GBR DMs: *Very strong* desire for data to be *available.*
- Operational DMs: *Strong* desire for data that is easily *accessible*.
- Tactical DMs: *Strong* desire for synthesised information to be *available and accessible.*
- Strategic DMs: Desire for synthesised information to be available that is defensible, easily understood, and communicable.
- Agency and jurisdictional boundaries impede knowledge sharing and access.

Nature and Type of Knowledge

- There is misalignment between scientists' desire to characterise the *state of the system now and into the future* and managers and decisions-makers immediate need for better understanding of the *current state of the system*.
    - Needs identification and communication is relatively weak and largely opportunistic.
    - The engagement of scientists with managers appears to be limited to a small subset of 'usual suspects'
    - Potentially driven by a lack of clarity in who is accountable for thinking about the decisions of the future.
- Knowledge-generating activities are more *understanding* focussed and less *decision* focussed.
    - There is a perception that monitoring data is collected for the purpose of better understanding the system, not driving management action.
- There is universal desire for greater availability of, and accessibility to, knowledge that is not 'biophysical' in nature (e.g., human use in the MPA, social dimensions, Traditional Owner values, understanding of geological timescales)
- There is believed to be a disproportionate representation of diagnostic data vs prognostic data
- There is a belief that the data needed for future strategic decisions are not readily available, reflective of the nature of historic and current decisions
    - There is related concern with the current capability in predictive analysis / scenario planning available to decision-makers being underdeveloped
- Decision-makers believe that there is a lack of available information on the outcomes of actions.
    - There is believed to be a significant gap between the science being done and the analysis of whether a given management action was appropriate

Direct Quotes:

"Uncertainty is the basic currency of science, but decision-makers and the public don't like uncertainty"

"Greater availability of data won't help address issues caused by people with extreme views"

"There is enough information available to assess pros and cons"

"There has been exposure of the gaps in the science"

"Access to the right information takes decision making from 2 out of 10 to 7 out of 10"

"Ministers would hate to see uncertainty"

"There is an overreliance on information for decision making"

"Social and economic knowledge streams are available, but decisions are made on ecological function because they preclude the others"

"Half [of decision makers] are hungry for information, half don't care"

"I don't have enough information to make no-regrets moves"

"We want to understand some of the longer-term trends, so we know whether we should change our tactical and strategic approaches."

"We use the best available information we can get access to"

- It was noted that once stakeholders become affected, the underlying data that underpins decisions become critical (for defensibility of decisions)

Uncertainty in Knowledge

- It is a major concern for some interviewees that believe that decisions are largely made based on data only, without sufficient consideration of the uncertainties that exist in the data, and, of the uncertainties associated with a lack of data.
    - This leads to a perceived focus in decision making on what can be measured, and not on what is not known and what knowledge brokers are uncertain about.
- The full extent of uncertainty in knowledge / synthesised knowledge is often obfuscated to enable easier communication and decision making.
- Decision makers are perceived to be uncomfortable with uncertainty – this is problematic in a complex system
    - This is believed to be greater the more senior the decision-maker
- Where uncertainty exists, there is a perception that decision-makers want the uncertainty to be quantified
- It was noted that there is not enough focus on communicating the assumptions that underpin knowledge, e.g., in the data supply chains that feed models.

Knowledge Communication

- A strong theme with those working at the interfaces of policy and strategy, strategy and planning, and planning and action, is the importance of translating the science to enable acceptance and support for decisions.
    - Developing a process for translating between science and management was identified as a potential opportunity.

Future Knowledge Needs

- It was stated that the Reef is changing fast, and managers need to become increasingly familiar with those changes and be enabled with new management approaches ("how will we manage the Reef effectively if we only use the approaches from the past?")

"RIMReP is all about predictive information"

"As long as I can remember, the interface between science and management hasn't been done very well"

"There is a gap in spatial information"

People

Summary:

GBR decision making broadly and appropriately involves many stakeholders and subject matter experts, especially for strategic decisions, though the number of actual strategic decision-makers is small. External stakeholders' welcome being participants but are not always clear on their role in decision processes, nor always feel like their views are heard. Strategic decision-makers emphasise the role of 'politics' that influences decision making. Existing power dynamics (inter-personal, inter- and intra-agency, inter- and intra-representative group, etc) were strongly acknowledged to drive the quality of strategic-decision

making, including driving perceived differences in opinion among stakeholders of the resulting quality of decisions. Delegations of authority for decision making is appropriate within agencies and programs, though erring slightly conservatively in some.

Detailed Observations:

Decision-Makers

- Decision-makers are not always equipped with the right or best resources to be effective.
- There is a strong need and appetite for better translation between science and management.
- Decision making often involves large cohorts. This is a result of the largely strategic decisions undertaken in the past 5 years but represents a risk with greater proportion of tactical decisions likely to be made in response to the impacts of climate change.
- External stakeholders' welcome participation but don't feel like their views are necessarily heard
- Strategic decision makers place significant emphasis on the 'politics' surrounding decision making
- Strategic decision-makers are uncomfortable with, and resistant to, the notion of decision making becoming more codified
- Existing power dynamics (inter-personal, inter- and intra-agency, inter- and intra-representative group, etc) were strongly acknowledged to drive the quality of decision making, including driving perceived differences in opinion among stakeholder of the resulting quality of decisions.
- The tenure of senior decision-makers is believed to be becoming increasingly shorter.

Stakeholders

- It was widely stated that the "decision-makers" in the GBR and its catchments are a limited number of people, who are potentially already overcommitted, potentially beyond a reasonable ability to do justice to the required scope.
- The complexity of the GBR and its catchments was widely mentioned and acknowledged as causing difficulties with decision making, difficulties for individuals to accumulate the requisite experience to contribute.
- Concerns were raised by many interviewees about a lack of visible, communicated or actively funded succession planning to preserve knowledge, and ensure expertise was not lost, whilst opportunities for personal development were maintained.
- The limited availability of stakeholders considered "qualified" or "preferred" to engage in decision processes, when combined with a lack of visible, communicated or actively funded plans to invest in stakeholder groups with historically lower representation, organisational history or power, was acknowledged as characteristic of the GBR and its

Direct Quotes:

"We have a seat at the table, but no-one is listening"

"Operators don't trust decision makers"

"I don't know who makes decisions now"

"There are a lot more people involved in decision-making these days"

"The engagement exercise and conflict during the [topic] decision was scarring. People are still scarred."

"There is a lot of authoritative decision-making"

"When scientists become advocates, they become a nuisance"

"Senior people aren't deep enough in the science, nor will they be"

"Reef thinkers are fairly interconnected and on the same track."

"Reef Managers need to be clearer on what they want"

"There are no managers of communication between scientists and managers"

catchments, and widely considered inadequate relative to Reef 2050 aspirations.

- The limited availability of stakeholders can sometimes lead to inclusion of stakeholders who then feel it necessary to "catch-up", including such scenarios as forced leadership where the enabling conditions for a decision-maker to be successful are more limited than they could be.

Translators, Communicators and Educators

- Translators between science and policy play an important role, and while a number of scientists, policy makers and managers are effective at this, scientists say they must tread carefully - they can't get into advocacy because it undermines their scientific authority.
- Education of GBR decision makers in decision-making processes, concepts and systems was seen as a possible path to improving decision making and thus better achieving GBR outcomes.

Authority, accountability, responsibility

- Authority over marine assets on the GBR was relatively well understood (except for the area of the GBR between mid-shore Reefs and outer Reefs) with authority over land assets not so clear.
    - Land owners were largely seen as "the managers" on land, equivalent to GBRMPA and QPWS for marine assets, being accountable for actions in the catchments, however, they were not seen as accountable for investment decision making on their asset (instead QLD Gov).
    - Translation between managers and investment decision makers in catchments was seen as having historical issues, with little mediation.

Processes

Summary:

Decision processes exist widely across the GBR. There is a strong bias towards consensus in decision making. The predominant form of decision process for strategic and tactical decisions are those specified through decision guidance documents, which give flexibility for decision-makers to use appropriate expertise to arrive at a decision. There is an opportunity to improve transparency and defensibility of strategic decisions through use of more structured decision processes and improve the effectiveness and efficiency of more frequent tactical decisions through codification of decision processes into decision rules. Previous experiences with and attitudes towards structured-decision processes create some resistance to its broader application, especially at more senior decision-making levels. Assurance is largely achieved through steering committees and not a formal decision assurance framework.

Detailed Observations:

Understanding of Processes

Direct Quotes:

"Most [stakeholder group] are sick of talking about [GBR

- The primacy of processes (over systems) in driving quality decisions could be more widely understood, and offers early wins for GBR-wide decision makers.
- Focusing on "decision support" rather than "decision-support systems" ensures focus on process and education, rather than aspirational tools.

Focus on Processes

- Decision-making processes in established decision frames are often quite mature and considered appropriate for the decision scenario, particularly given the limited resources available to decision-makers in a complex space.
- For unique or occasional decision frames, attempts to elicit examples where decision processes were coherently planned with the range of involved stakeholders prior to the process being executed were not successful; commentary suggested that these processes were often ad-hoc and evolved as time progressed.
- Tight timeframes and tight resource availability were acknowledged frequently as both a feature of a highly complex industry, but also limiting the perceived appropriateness of engagement with involved stakeholders, including with concepts of free and informed prior consent (FPIC).
- For senior decision makers, evidence is only one part of the decision-maker's operating environment
- In the absence of structured decision-making processes, decisions are largely made by personality, knowledge and charm / force of will based on individual judgement and discretion
    - While decision guidance is the predominant type of decision process used across the GBR, there is little visibility of process to choose the process that meets the intent of the guideline
    - Choice of decision processes in particular is largely personality driven
- Decision processes almost always default to consensus and consensus-based decision making

Historic Experiences

- Previous efforts in developing more defined decision processes seen as 'largely theoretical and not focussed on what's 'usable'. Stakeholders didn't respect it.
- It was stated that once something gets criticised in the GBR, it is hard to come back.

Structured Decision Making

- There is resistance at some strategic decision-making levels to structured decision-making approaches, due to perception of it being an unnecessary use of time and reducing discretion in decision-making power

Decision Assurance

value driver], because it's not what they actually care about"

"Primary drivers of those on the ground are not considered"

"Has investment in [GBR asset area] delivered value commensurate with the investment?"

"People are still scarred from the [topic] decision"

"There is resistance to take on structured decision-making processes"

"Stakeholders didn't respect [previous decision support efforts]"

"There is a lot of authoritative decision making"

"There is no consistent structured process to make choices in the Reef space"

"Strategic decisions are made by personality, knowledge, charm and force of will"

"Consensus based decision making is dangerous in times of crisis"

"There is pushback if you try to structure the process too much'

"Framing decisions is the single most important part – it should be standard practice"

"There are lots of Steering Committees"

"We are pretty good at setting up governance"

"It's a combination of staff expertise and lived experience"

- While there are often steering committees that are intended to provide assurance over strategic decisions, no evidence of a formal decision assurance framework was identified.

Systems

Summary:

Various knowledge and modelling systems support decision making on the GBR. The majority of existing systems are management information systems (MISs) servicing specific needs. There is significant demand and likely benefit from a larger scale, consolidated MIS that makes information available and accessible to decision makers across strategic, tactical and decision levels. Decision-support systems (DSSs) are conflated with decision-making systems, negatively impacting the perception of their utility.

Detailed Observations:

Definition and Understanding of Systems

- Decision-support systems (DSS) are commonly understood as “decision-making systems”, with associated perception issues.
- The term DSS has been used in a number of contexts to describe management information systems (MISs), contributing to negative perception issues that have impacted broader information system development and utilisation efforts.
- Communication efforts to date do not yet appear to have explicitly corrected these perceptions.

Systems for Decision support in the GBR

- Systems have historically been built with varying levels of effort put into understanding and mapping decision-making processes, preferences, and choices; more often a “build it and they will come” approach
- RIMReP is widely understood to be the GBR “knowledge system”
- There has been characterisation and perception of a GBR-DSS as a “where and when tool” e.g., highest value reefs to do [x]
- Some previous efforts seen as ‘largely theoretical’ and not focussed on what’s ‘usable’ – comes with baggage that will influence future development
- Scientists are seen by some as often coming with ideas about the applicability of potential new tools for management, however, managers then sometimes question how effective they can be given lack of evidence to date.

MIS vs DSS

- There was strong recurring feedback expressing the desire decision-makers to have access to knowledge through a MIS, that had the latest, relevant information, and would save

Direct Quotes:

“There are absolutely no decision-making systems on the Reef”

“I would absolutely use a DSS to prioritise my organisation’s spend”

“A DSS can’t make the decision for me”

“We want the DSS to give us the information to make decisions”

“There are many things that Reef Managers already use and trust – there are barriers to uptake of new ideas”

“I’d be more comfortable if [in the term GBR-wide DSS] system was replaced by approach.”

“Wrap DSS in people, wrap it in processes, wrap it in ideas”

“A good DSS should not only help make decisions but also provide the feedback loop”

“A DSS is about better data and better other decision elements”

“Decision-makers need to be able to easily interface with it”

them time and effort in seeking and ensuring they had the latest, most relevant information when making decisions.

- For tactical and strategic decision makers, the desire extended to having access to an MIS that had information that was synthesised in a form that would be helpful for the decisions they were making.
- There was little appetite or demand from tactical and operational decision makers for a DSS at this time; some strategic decision-makers saw a DSS as being useful and likely necessary for the imminent and future decisions that need to be made.
- There is a mix of 'push and pull' from Reef Managers for MIS, driven by desire for new information, new system capability, and automation – all driving towards 'Operationalising Resilience Based Management'.

Future Development

- System developers will likely need to hit a sweet spot between motivating data gatherers' vested interests and value to decision makers
- Strong feedback that any system, for it to be successful, needs to be trusted by stakeholders and management agents, easy to use and easy for people to access.

"If you have a well communicated tool, then it's a useful tool"

"We hear 'we want a tool' then once its all set and the button is pushed, we hear 'its not the outcome we want'"

"We all talk the talk about DS tools but we never use them"

"Decisions should be about a process, with a tool to support that"

"Should be Stage 5 of RIMReP, need the RIMReP up and running first"

"[DSS]s are great but there is a mis-representation of what they are able to do"

"It's a bit of an insider term; no good using terms that others don't know"

Appendix H – Results - GBRMPA Survey

The responses provided from the GBRMPA Reef Managers' survey have been synthesized and presented in Section 5.2 and below. Note at the time of writing, 10 of the 16 individuals surveyed had provided responses.

Initial responses indicate there is a trend towards respondents making decisions more frequently in the short term (daily/ operational) whereas they contribute to decisions more over the long term (5 yearly/strategic). Respondents are more active (contributing and making decisions) at the operational level compared to the strategic level.

Decision making: strategic vs tactical vs operational

Respondents are largely responsible for making and contributing to operational and tactical decisions (average 78% and 68% respectively). Despite this, 50% of respondents are also make strategic decisions, accounting for 13% of all decisions by the respondents, while 90% contribute towards them, accounting for 32% of all decisions by this group.

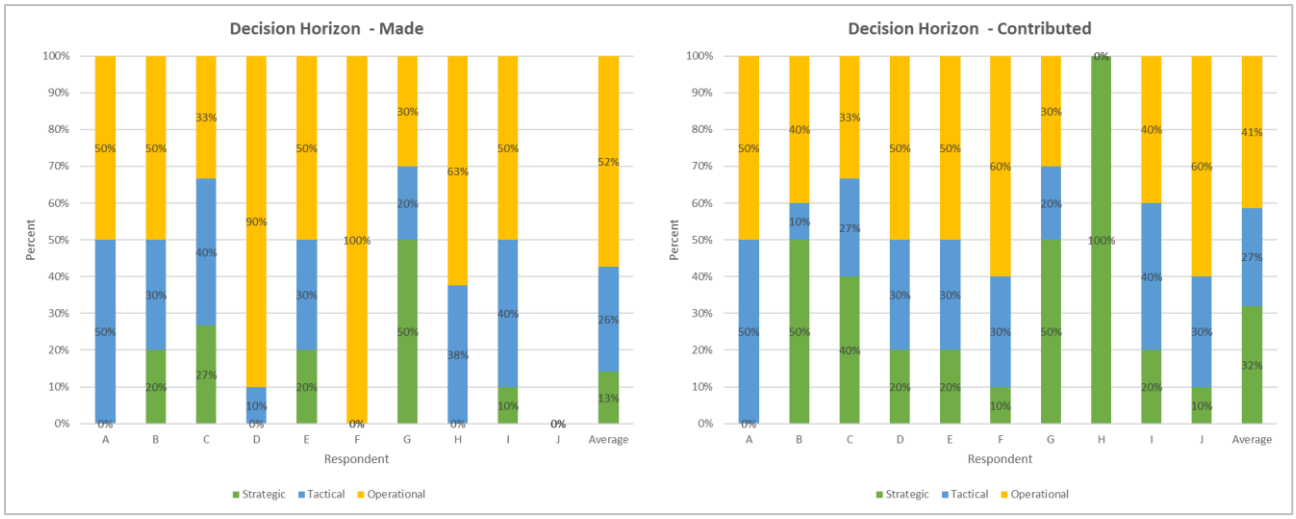


Figure 19. Individual and average responses to the question "What is the split of decisions you make (left chart) or contribute to (right chart) across strategic, tactical and operational levels?

Decision making: frequency

Responses indicate mixed responsibilities in terms of involvement in decision making at various frequencies.

- 3 respondents make or contribute to operational decisions only, that occur on a daily or weekly basis,
- 1 respondent makes or contributes to tactical decisions only, that occur on a monthly or quarterly basis,
- 1 respondent contributed to operational decisions on a weekly basis, but otherwise was responsible for making tactical decisions on a monthly, quarterly and annual basis,
- 1 respondent contributed only to operational, tactical and strategic decisions, while a further 1 respondent contributed only to tactical or strategic decisions.

- The remaining 3 respondents made or contributed to operational, tactical and strategic decisions.

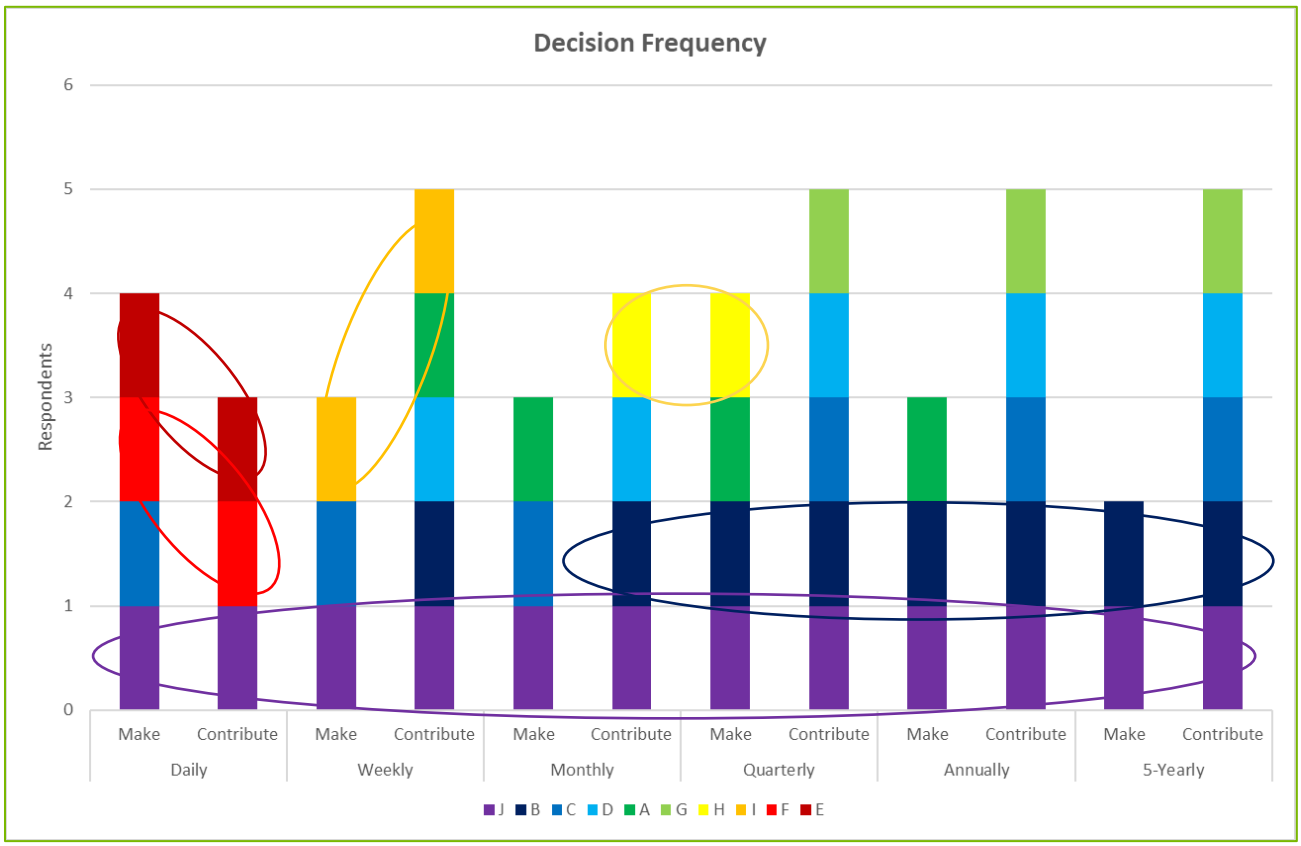


Figure 20. Individual responses to the question "Select the relevant cadence of decisions you make or contribute to".

Decision making: relevant processes

Respondents were largely in consensus about the use of structured decision-making for strategic decisions, however, this is a surprising result as findings from the interviews would suggest that the predominant processes used to guide strategic decision-making is from decision guidance. This indicates differing degrees of understanding of what structured decision processes consist of. Tactical and operational decisions appear to be made using a number of different processes, with a trend towards less intensive processes for operational decisions and moderately intensive processes (such a decision rules) for tactical decisions, which is expected.

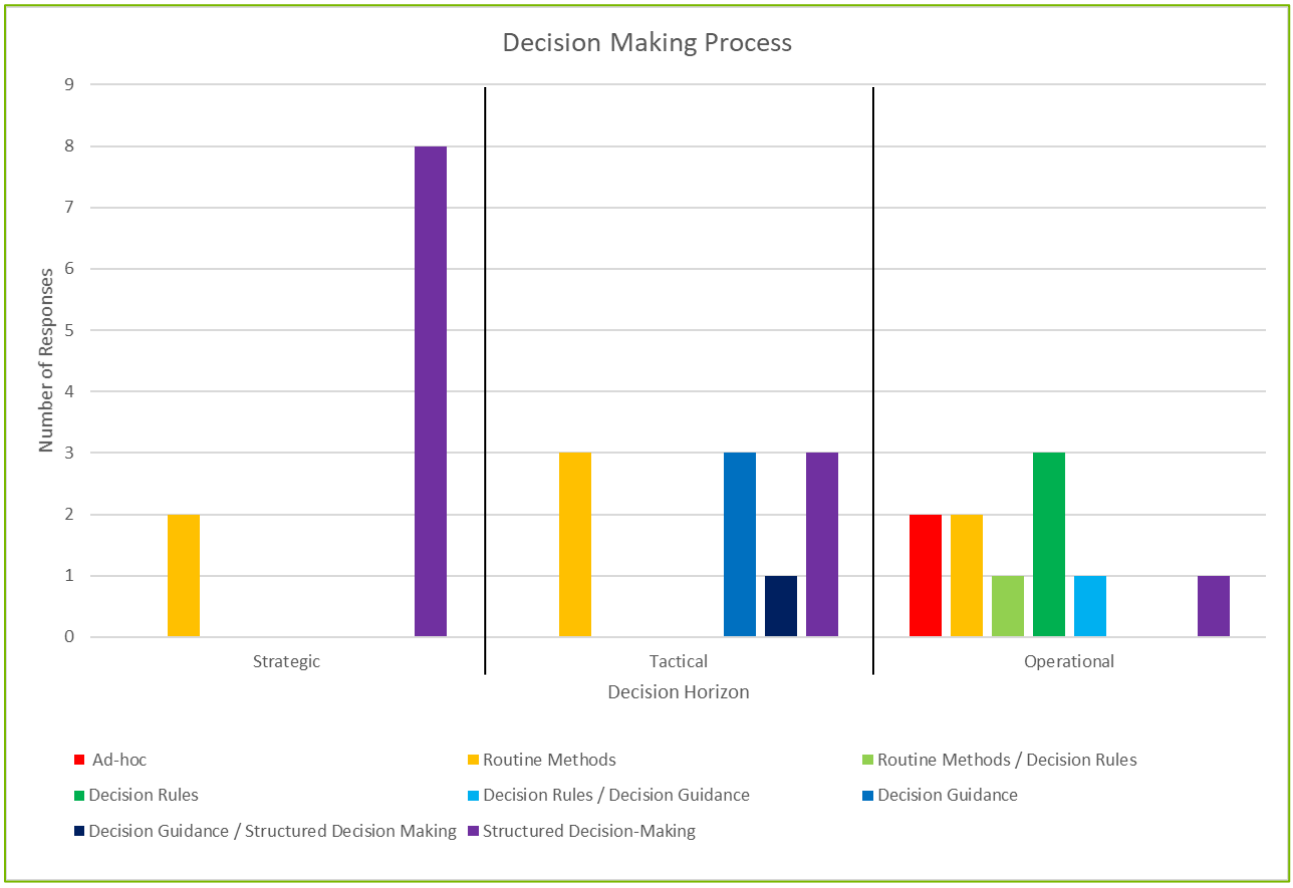


Figure 21. Sum of responses to the question "What process is typically involved in decision-making?"

Decision making: relevant people

Respondents were largely in consensus about executive decision-making groups with subject matter experts (SMEs) being the default decision-makers for strategic decisions. Tactical and operational decisions are largely believed to be made by decision-making groups or an individual decision maker with SME support. This is largely consistent with insights gained from the stakeholder interviews i.e., that within GBRMPA, there is a greater degree of involvement of decision-making groups and SMEs than is typical or would be expected for operational decisions.

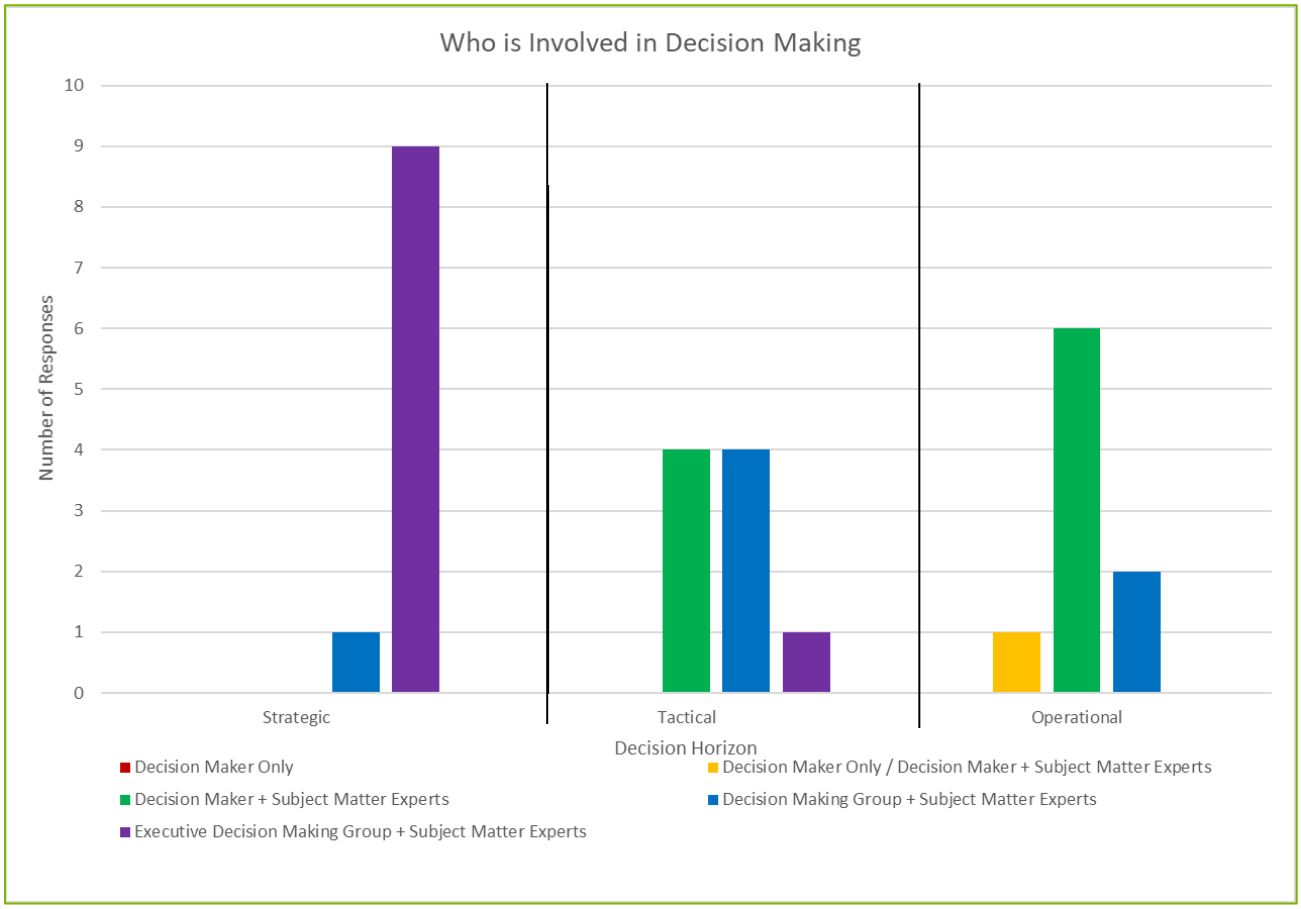


Figure 22. Sum of responses to the question "What people are typically involved in decision making?"

Decision making: decision quality

Respondents had mixed views on the transparency and defensibility of decision making in GBRMPA, trending towards somewhat agreeing with the statements that decision making in GRBMPA is transparent and defensible. Respondents more strongly agree with the statement that decisions in GBRMPA are effective, but somewhat disagree that decision making is efficient.

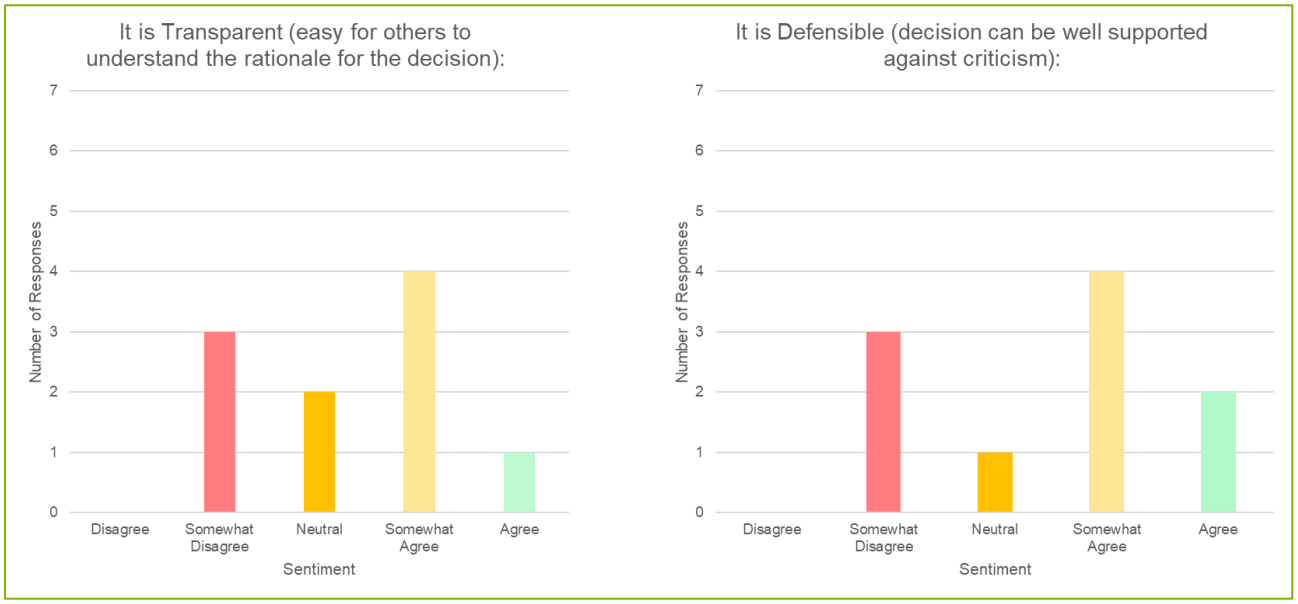


Figure 23. Attitudes towards transparency and defensibility of decision making in GBRMPA.

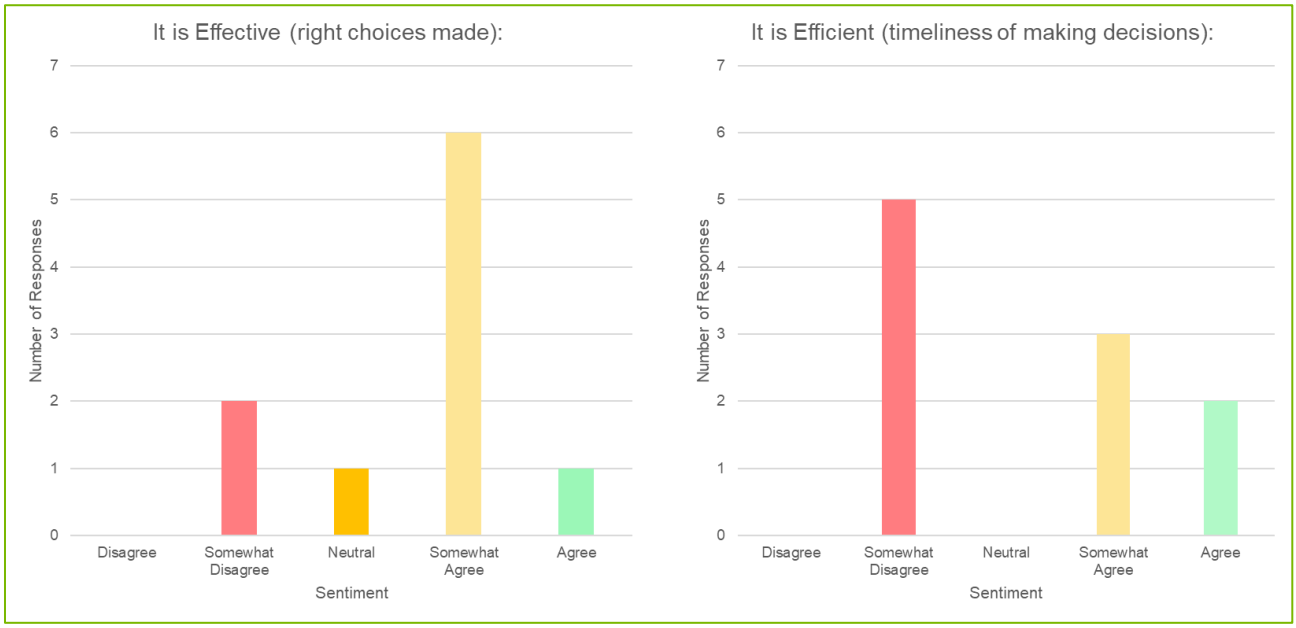


Figure 24. Attitudes towards efficacy and efficiency of decision making in GBRMPA.

Appendix I – Results – List of Decisions Reviewed

Document Review

The table below outlines a range of decisions that are being executed across GBR programs, identified through the document review process.

Program	Decision	Type	Sources
COTS Control Program	Which reefs do we select for inclusion in COTS management? - Key ecological assets (coral) - Key economic assets (tourism) - Key sources of COTS larvae	Tactical	COTS Control Program: Control of crown-of-thorns starfish is protecting coral on the Great Barrier Reef | RRRC An ecologically-based operational strategy for COTS Control | NESP A Strategy to Link Research and Management of COTS on the Great Barrier Reef: An Integrated Pest Management Approach | NESP COTS Strategic Management Framework | GBRMPA
	Where do we focus surveillance efforts to enable early detection of COTS outbreaks? - Monitoring - COTS Control Program, LTMP, JFMP, EOTR, MMP - Modelling	Tactical	
	What preventative actions should we take to eliminate COTS outbreaks? - Water quality improvement - Protection of natural predators - Zoning	Strategic	
	What is the optimal Catch-Per-Unit-Effort (CPUE) to keep COTS densities below the ecological threshold (consumption of coral < regeneration of coral) on reefs?	Tactical	
	What are the optimal voyage plans for our control vessels?	Tactical	
	What are the priority sites on a reef for culling?	Tactical	
	What are the maximum number of sites we can cull on a control voyage?	Tactical	
	What is the optimal length of time between subsequent culls at a site?	Tactical	
	What is the optimal length of time between subsequent surveillance (manta tows) of Maintenance Mode Reefs?	Tactical	
	What is the optimal length of time between subsequent surveillance (manta tows) of Intensive Control Reefs?	Tactical	
	What technologies can we invest in to improve the efficacy of COTS control?	Strategic	
Joint Field Management Program (JFMP)	What are the optimal patrol and surveillance routes to ensure compliance is being adhered to?	Tactical	JFMP Business Strategy 2019-2023 | GBRMPA | QLD Gov JFMP Annual Report Summary 2018/2019 | GBRMPA | QLD Gov JFMP Business Plan 2019-2020 | GBRMPA | QLD Gov
	What are the necessary zoning measures to ensure compliance is adhered to?	Strategic	
	What practices can we implement to ensure high levels of voluntary compliance? - Stewardship - Education	Strategic	
	What are the priority sites for field management conservation efforts?	Strategic	
	Where should we undertake reef health and impact surveys to assess reef health?	Tactical	
	What practices should we implement to maintain the ecological function of our target island ecosystems? - Planned burns to prevent wildfires	Tactical	
	What are the necessary monitoring and assessment activities to inform and enable improved conservation of marine habitats, islands, vulnerable species, sites of cultural and historic importance?	Strategic	
	Where do we invest in implementing new facilities for visitors to the Reef, including public moorings, campgrounds, picnic areas and amenities, walking tracks and lookouts?	Strategic	
	Where do we invest in maintain existing facilities for visitors to the Reef?	Tactical	

Program	Decision	Type	Sources
	What are our mitigation strategies we invest in to reduce the risks associated with vessel events - groundings and sinkings, and ensure we protect key environment? - Reef protection markers	Strategic	
	Where are the areas at highest risk of incidents occurring and how do we invest in preparing and planning for these events?	Strategic	
	What are the optimal response and recovery actions in the event of an incident occurring?	Tactical	
Reef Restoration & Adaptation Program (RRAP)	What interventions should we invest in?	Strategic	R1, R2, R3, R4, R5, R6, T3, T5, T6, T9, T10, T11, T12, T13, T14 | RRAP RRAP Annual Investment Plan | RRAP RRAP Investment Case | RRAP RRAP Initial Investment Prioritisation| RRAP
	When is an intervention ready / safe to undergo a field trial?	Strategic	
	Where do we want to undertake field trials?	Strategic	
	What permits do we require to undergo field trials?	Strategic	
	What do we need to do to ensure we have social licence to undergo field trials?	Strategic	
	What models and systems will we use to analyse the results of field trials to determine if they have been successful?	Strategic	
	Where are the priority / optimal locations / reefs for deployment of interventions?	Strategic	
	What ecological processes do we need to understand better to improve our modelling to predict the efficacy of interventions?	Strategic	
	What permits do we require to deploy interventions?	Strategic	
	What do we need to do to ensure we have social licence to deploy interventions at scale?	Strategic	
	When is the optimal time of year to deploy an intervention?	Strategic	
	Who will be responsible for deploying and operating the intervention?	Strategic	
Sustainable Fisheries Programs	What are the target catch species for sustainable management in the fishery?	Strategic	Queensland Sustainable Fisheries Strategy 2017-2027 | DAF Reef line Harvest Strategy 2020-2025 | DAF Spanner crab Harvest Strategy 2020-2025 | DAF Queensland Sustainable Fisheries Strategy 2017-27 - Fisheries Queensland Monitoring and Research Plan | DAF Queensland Sustainable Fisheries Strategy 2017-27 - Progress Report, Year 1 | DAF Queensland Sustainable Fisheries Strategy 2017-27 -
	What are the total allowable catch limits for different sectors that will keep species populations below the maximum sustainable yield?	Strategic	
	What are the trigger points for reducing total allowable catch limits?	Strategic	
	What are the stock threshold limits that will result in the closing of a fishery for that species?	Strategic	
	What are the necessary licence requirements to maintain sustainability of the fishery?	Tactical	
	What are the necessary gear requirements for the fishery?	Tactical	
	What species are prohibited from being caught in the fishery?	Tactical	
	What is the minimum legal size limit for a target catch species?	Tactical	
	What are the vessel size limits?	Tactical	
	What processes do we implement to ensure compliance of catch limits and rules?	Tactical	
	What additional management actions can we implement (other than catch limits) for maintaining sustainable fisheries?	Tactical	
	What are our catch limits for the next fishing season?	Tactical	

Program	Decision	Type	Sources
			Progress Report, Year 2 | DAF
QLD Reef Water Quality Program	What pollutants do we want to reduce and by how much?	Strategic	Reef 2050 Water Quality Improvement Plan 2017-2022 | QLD Gov Queensland Reef Water Quality Program 5-year investment plan 2017-2022 | QLD Gov Queensland Reef Water Quality Program Annual investment plan 2019-2020 | QLD Gov
	What catchment management strategies should we invest in to improve water quality?	Strategic	
	Which catchments do we implement management actions in to improve water quality?	Strategic	
	What minimum practice standards do we implement for all relevant agricultural industries? - Industry led best management practice - Regulation	Strategic	
	What initiatives do we implement to support land managers to increase capacity to adopt improved management practices? - Coordinated extension - Education and awareness programs - Stewardship	Strategic	
	What innovation in technologies do we trial and implement for on-ground management, water treatment and monitoring?	Strategic	
	Where do we invest in implementing, updating and enhancing guidelines, Traditional knowledge, and other decision-support tools to design and inform interventions?	Strategic	
	What are priority knowledge gaps that need filling through the Reef 2050 Water Quality Improvement Plan Research, Development and Innovation Strategy (RD&I)?	Strategic	
	What forms of knowledge do we need to integrate, including science, policy, management, Traditional Owner and community through regular synthesis workshops and theme-specific working groups, to support consistent communication messages?	Strategic	
	What programs can we implement to evaluate our performance? - P2R	Strategic	
Marine Monitoring Program (MMP)	What indicators to do we need to monitor to fulfil program objectives?	Tactical	MMP | Assessment of reproductive effort as an indicator of seagrass health for the MMP | GBRMPA MMP Annual Report for Inshore Coral Reef Monitoring 2017-2018 | GBRMPA MMP Annual Report for Inshore Pesticide Monitoring 2017-18 | GBRMPA MMP Annual Report for Inshore Seagrass Monitoring 2017-18 | GBRMPA MMP Annual Report for Inshore Water Quality
	What are the optimal sampling sites for monitoring of indicators?	Tactical	
	What is the optimal sampling frequency for monitoring indicators?	Tactical	
	What event-based monitoring do we need to carry out?	Tactical	
	What indicators do we need to monitor to assess management effectiveness?	Tactical	
	What models do we need to utilise to fill monitoring gaps?	Tactical	

Program	Decision	Type	Sources
	What is the best way to manage the data we collect?	Tactical	Monitoring 2017-18 | GBRMPA MMP Modelling the environmental drivers and abundance of seagrass communities in Cleveland Bay | GBRMPA MMP Annual Report for Quality Assurance and Quality Control Manual 2017-18 | GBRMPA
	What is the most effective way to report on the data we collect?	Tactical	
AIMS Long Term Monitoring Program (LTMP)	What indicators to do we need to monitor to fulfil program objectives?	Tactical	AIMS Annual Report 19-20 | AIMS AIMS Strategy 2025 | AIMS
	What are the optimal sampling sites for monitoring of indicators?	Tactical	
	What is the optimal sampling frequency for monitoring indicators?	Tactical	
	What event based monitoring do we need to carry out?	Tactical	
	What indicators do we need to monitor to assess management effectiveness?	Tactical	
	What models do we need to utilise to fill monitoring gaps?	Tactical	
	What is the best way to manage the data we collect?	Tactical	
	What is the most effective way to report on the data we collect?	Tactical	
Paddock to Reef Program (P2R)	What indicators to do we need to monitor to fulfil program objectives?	Tactical	Paddock to Reef Summary 2017-2022 | QLD Gov Paddock to Reef Program Design 2018-2022 | QLD Gov
	What are the optimal sampling sites for monitoring of indicators?	Tactical	
	What is the optimal sampling frequency for monitoring indicators?	Tactical	
	What event based monitoring do we need to carry out?	Tactical	
	What indicators do we need to monitor to assess management effectiveness?	Tactical	
	What models do we need to utilise to fill monitoring gaps?	Tactical	
	What is the best way to manage the data we collect?	Tactical	
	What is the most effective way to report on the data we collect?	Tactical	
QLD Fisheries Monitoring and Research Plan	What indicators to do we need to monitor to fulfil program objectives?	Tactical	Queensland Sustainable Fisheries Strategy 2017-27 - Fisheries Queensland Monitoring and Research Plan | DAF
	What are the optimal sampling sites for monitoring of indicators?	Tactical	
	What is the optimal sampling frequency for monitoring indicators?	Tactical	
	What event-based monitoring do we need to carry out?	Tactical	
	What indicators do we need to monitor to assess management effectiveness?	Tactical	
	What models do we need to utilise to fill monitoring gaps?	Tactical	
	What is the best way to manage the data we collect?	Tactical	
	What is the most effective way to report on the data we collect?	Tactical	
IMOS	Which national stakeholders do we engage with, with a need for systematic and sustained observing of Australia's marine environment in the ongoing design and implementation of the system?	Strategic	IMOS Five Year Plan 2017-2022 | IMOS IMOS Annual Business Plan
	What processes do we implement to turn observations and data into time series of essential marine and coastal variables, providing timely support to a wide range of science and research, meeting current and future needs?	Strategic	

Program	Decision	Type	Sources
	What is the optimal way to collaborate as a strong partner in the global ocean observing enterprise, to generate synergies from international efforts and provide leadership within the Australasian region?	Strategic	2019-2020 | IMOS IMOS Strategy 2015-2025 | IMOS
	What is the optimal way to sustain established IMOS capability, so as to realise full value from investments to date, and avoid loss of value through discontinuity, as well as evolve established capability in response to scientific and technological developments, and performance and delivery?	Strategic	
	What is the optimal way to improve IMOS capability so as to maximise benefits from related investments in remote sensing, vessel operation, marine data management, and ocean and coastal modelling?	Strategic	
	What is the optimal way to articulate major gaps, develop costed solutions, and work with partners and stakeholders to identify opportunities for addressing them?	Strategic	
	What is the optimal way to evolve the observing system in response to national priority setting?	Strategic	
	What is the optimal way to sustain effort in areas where impact is high and focus effort on increasing relevance and impact in sectors with unrealised potential?	Strategic	
	What is the optimal way to build partnerships with State Governments and marine industries around the core investment by Australian Government?	Strategic	

Appendix J – Results –Systems Review

List of Potential Candidate MISs and DSSs Reviewed

System	System Owner/ Developer	Description	Classification
Atlantis	CSIRO	Atlantis is a socio-ecological model that considers all parts of marine ecosystems – biophysical, economic and social. Originally focused on the biophysical world and fisheries, it has grown to begin to be used for multiple use and climate questions.	MIS (Insight)
Reefonomics	OGBR	The Reefonomics tool developed to model and optimise investment decisions based on water quality interventions and their associated costs.	DSS
eReefs	CSIRO / QLD Gov / AIMS/ BoM	eReefs provides visualisation, communication and reporting tools for various ecosystem indicators including water quality, ocean hydrodynamics and catchment flow.	MIS (Insight)
CONNIE	CSIRO	Connie is an ecosystem model that uses archived currents from oceanographic models and particle tracking techniques to estimate connectivity statistics from user-specified source regions (or to user-specified sink regions).	MIS (Insight)
NOAA Coral Reef Watch	NOAA	Coral Watch provides the only global early-warning system of coral reef ecosystem physical environmental changes. It aims to observe, predict, and report to its users on the coral reef environment worldwide.	MIS (Insight)
AURIN	Aus Gov	An online workbench with access to thousands of multi-disciplinary datasets, from hundreds of data sources and analytical tools covering spatial and statistical modelling, planning and visualisation.	MIS (Comms)
AgReFed	Agricultural Research Federation (supported by Aus gov)	AgReFed provides a data portal for research organisations, government, agricultural producers and other agricultural industry players by providing a data sharing platform. Aims to enable researchers, industry and government to share and use data to increase the application of knowledge, accelerate innovation and improve decision making	MIS (Insight)
AMSIS	Aus Gov (Geoscience Australia)	AMSIS is a web based interactive mapping and decision-support system that improves access to integrated government and non-government information in the Australian Marine Jurisdiction. AMSIS contains many layers of information displayed in themes of Maritime Boundaries, Petroleum, Fisheries, Regulatory, Environment, Native Title and Offshore Minerals	MIS (Comms)
Aurecon Mining Management Tool	Aurecon	Management information dashboard developed by Aurecon to assist in operational decision making for a mining client. The tool uses an asset register database to provide up to date visualisations and statistics to better inform front-line managers.	MIS (Insight)
Reef VTS	QLD Gov	The Great Barrier Reef and Torres Strait Vessel Traffic Service (Reef VTS) monitors vessel traffic in the region to prevent collisions or incidents.	MIS (Comms)
TERN	Aus Gov (in collaboration with UQ)	TERN delivers data, tools and expertise to researchers who are working to understand Australia's environment. It aims to enable its science-based management for sustainable social and economic benefit.	Database
Workday	Workday, Inc.	Workday is a cloud-based software that specializes in human capital management, enterprise resource management , and financial management. Workday delivers an all-in-one package that provides features like payroll management, time tracking, human resource management, talent management and data analysis to better inform organisational decision making.	MIS (Insight)
SharePoint	Microsoft Corporation	SharePoint is primarily a document management and storage system; it is highly configurable, and usage varies substantially among organizations. Common uses include as a document and knowledge sharing platform.	MIS (Comms)

System	System Owner/ Developer	Description	Classification
ARENA	Aurecon	The ARENA decision tool facilitates visual assessment of project options to support decision making for a defined set of project variables. The tool provides four charts; Net present value, variable sensitivity, cash flow forecasts and cost benefit analysis.	EDSS
Evacuation Modelling DSS	CSIRO	The Evacuation Modelling decision-support system (DSS) is a software application developed by CSIRO that is used for bushfire evacuation modelling. The system conducts preliminary analysis of the potential impact of a predicted hazard on a road network, designs an evacuation scenario to be simulated, runs an evacuation simulation, and visualizes the outcome of the simulated evacuation.	DSS
Reef Knowledge System	GBRMPA	Developed as a communication tool for RIMReP, Reef Managers, public, educators, funding providers to access monitoring, modelling, reporting information relating to the GBR.	MIS (Comms)
Reef Explorer	GBRMPA	Developed as a spatial mapping tool of the GBR (based on GIS data) to show different layers of interest spatially across the GBR.	MIS (Comms)
Fisheries Harvest Strategy	QLD Gov (DFAT)	The strategy provides reef line fishery managers with a framework to make decisions on management actions, such as annual fishing quotas. The system uses a combination of models, data and decision rules to inform management strategy.	MIS (Insight)
ADRIA	AIMS	ADRIA is an algorithm that helps to optimise deployment choices for Reef interventions and site selection for intervention based on environmental forecasts, ecological criteria, value preferences and risk tolerance.	MIS (Insight)
Resilience Reef Network	GBRMPA	Dashboard managed by GBRMPA to provide information on reef resilience levels across the GBR. The dashboard incorporates various factors including COTS cover, water quality and sea surface temperature.	MIS (Comms)
CoCoNet	CSIRO	CoCoNet is GBR-wide ecosystem connectivity model that links multiple reefs together using various species (COTS) and environmental data (bleaching, cyclones). The primary aim of the model is understanding the connectivity between reef ecosystems for marine species.	MIS (Insight)
COTS Dashboard	GBRMPA	Dashboard managed by GBRMPA to provide information on COTS population, management interventions and locations. Primarily used as a reporting and administration tool.	MIS (Comms)
COTS DSS	CSIRO	Decision-support system to provide COTS field managers with best practice COTS control strategies on a per location basis. The system feeds in real time data to provide the user with optimised suggestions for COTS control intervention.	DSS
SIMA Austral	CSIRO	An operational information system for managing the Chilean aquaculture industry with international application. Developed in partnership with the Chilean government and CSIRO Chile.	MIS (Synthesis)
IMOS	Consortium of institutions (UTAS is the lead agent)	IMOS provides Australian marine ecosystem data and includes a geospatial portal as well as a metadata system, file formats, controlled vocabularies, file storage, servers, web services, and data tools.	MIS (Comms)
GIDEON	The Premier Global Infectious Disease Database	GIDEON (Global Infectious Disease and Epidemiology Network) provides a current, evidence-based resource for diagnosis, treatment and teaching in the fields of tropical and infectious diseases, epidemiology and microbiology.	DSS
ReefMod	UQ	ReefMod is a model developed by UQ that is individual coral-based and simulates the fate of coral colonies evolving on a regular square lattice representing a 20 x 20m horizontal reef substratum.	MIS (Insight)
Ecocloud	Consortium of institutions (funded by Aus Gov)	Ecocloud delivers cloud-based computing tailored to ecological data and researchers. It provides a platform that brings together servers, storage, databases, coding languages, training, analytics for environmental data.	Database

System	System Owner/ Developer	Description	Classification
GoldSim	GoldSim Technology Group	GoldSim is a simulation software solution for dynamically modelling complex systems in engineering, science and business. GoldSim supports decision making and risk analysis by simulating future performance while quantitatively representing the uncertainty and risks inherent in all complex systems.	DSS

System review table

Example of assessment framework for review of Reefonomics and Reef Knowledge systems

Item			Qualification Features (is it a DSS?)							
Candidate	**Bio**	**Decision Scope**	**Database?**	**Database Management System?**	**Model?**	**Model Management System?**	**User interface?**	**Is there evidence of it currently being used for a decision?**	**Is it a DSS?**	**System Classification**
Reefonomics	Tool developed to model investment decisions on water quality interventions and their associated costs	GBR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	DSS
Reef Knowledge	Online website under development to be a one-stop-shop for all information on the reef.	GBR	Yes	Yes	No	No	Yes	No	No	MIS (Comms)

Item	Decision Characterisation					Systems Characterisation		
Candidate	**Where evidence exists - What is the primary decision?**	**What other decisions have been identified that could utilise the system?**	**Who are the decision makers?**	**Primary Decision Structure Supported**	**Primary Decision Type Supported**	**What type of database management system**	**What type of model?**	**Type of user interface?**
Reefonomics	Water quality intervention decisions on	N/A	Reef Foundation prioritising water quality investment	Structured	Strategic	Relational Model	Optimisation Model	Truii custom interface with visuals
Reef Knowledge	N/A	Policy & planning, field management, traditional owner groups (strategic decisions)	Varied - Policy & planning, field management, traditonal owner groups (strategic decisions)	Unstructured	Strategic	Relational Model	N/A	Varied - document & data library, interactive Q&A feature, mapping etc.

Item	System Characteristics		Utility				Review	Reference
Candidate	**Primary System Characteristic**	**Secondary System Characteristic**	**How well does the system demonstrate in practice it's intended capability?**	**How useful is the system in supporting the decision making process?**	**How much does the sytem improve the quality of the decision making?**	**Does the system have predictive capability?**	**Quality of review process per candidate (0-5)**	**Source**
Reefonomics	Data	Model	4	4.5	3	Yes	4	*Link to website*
Reef Knowledge	Document	Data	4	3	4	No	5	*Link to website*

Sample system review interview questions

DSS Systems Review – Stakeholder Interviews – Question Prompts

Background:

- Why was the system developed / for what purpose was it developed?
- How was the system developed?
- How adaptable is the system to changing needs?

Utility

- How useful is the system?
- How esoteric is it? (how many people can use it?)

Capability:

- What types of decisions can the system be used to make?

  - Strategic = long term (5 years)

  - Tactical = short term (1 year)

  - Operational = day-today

- What are its limitations of the system in enabling / supporting decision-making?

Users:

- Who uses the system to make decisions?
- What decisions do they use it to make?
- How do they use it to make decisions? E.g. how do they access it
- What predictive capabilities does the system have?

Qualification Features

- Does it have the below components?:

  - Database - ?

  - DBMS - ?

  - Model - ?

  - MBMS – ?

  - User Interface - ?

System characterisation

MISs and DSSs can be further characterised in both their system type and where applicable, their model type. The review utilises available literature for classifying different system and model types based upon their characteristics. For example, the Reefonomics tool is characterised by its use of an optimisation model with a system based upon the use of data. Characterising candidate systems to this more detailed level of granularity potentially enables synergies to be identified across multiple candidate systems. Additionally, with the use of models commonplace across several candidates, assessing model types may provide further insight into the most effective and pertinent type of model used within a MIS or DSS context. The definitions used to further characterise both the modelling components and the systems are provided below in Table 6 and Table 7.

Table 6: **Model System Types and their Associated Descriptions**

Model System Type	Description
File Drawer System	Allow on-line access only to particular data items.
Data Analysis System	Allow on-line data retrieval, manipulation and display of current and historical data by means of such operations as pictorial representation, summarisations and calculation of data.
Analysis Information System	Capable of manipulating the internal data from transaction processing systems and augmenting the internal data with external data using statistical packages and other small models to generate management information.
Accounting System	Facilitate planning by calculating the consequences of planned actions on the estimate-of-income statements, balance sheets and other financial statements, based on definitional relationships and formulas.
Representational Model	Estimate the future consequence of actions on the basis of partially nondefinitional models, including all simulation models.
Optimisation Model	Generate the optimal solution consistent with a series of constraints
Suggestion Model	Leads to specific, suggested decision for a structured task. Such systems perform mechanical calculations and leave little room for managerial judgement.

Table 7: Decision System Types and their Associated Descriptions

Decision System Type	Description
Communication	Supports more than one person working on a shared task and sharing information, examples of such integrated tools include google docs
Data	A data-orientated system that emphasises access, manipulation and analysis of a time series of internal and external data
Document	A system that manages, retrieves and manipulates unstructured information in a variety of electronic formats, an example of this would be SharePoint
Knowledge	A system that provides specialised problem-solving expertise stored as rules, procedures or facts. A knowledge-based system aims to incorporates expert human knowledge into the process.
Model	A model driven system emphasises access and manipulation of a statistical, financial, optimization or simulation model. A model-based system uses data and parameters provided by users to assist decision makers in analysing a situation.

System Review - GBR Candidates Only

In general, the majority of systems reviewed were classified as management information systems (for Insight). The most prevalent primary decision types supported were tactical and strategic decisions, while more than half of the secondary decision types were tactical. From a decision structure standpoint, unstructured and semi-structured decisions were the most common, making up over 80% of all the systems assessed. The systems themselves predominately featured representation models which accounted for approximately 40% of the total share of candidates. Lastly, around 75% of candidates surveyed were primarily based upon data.

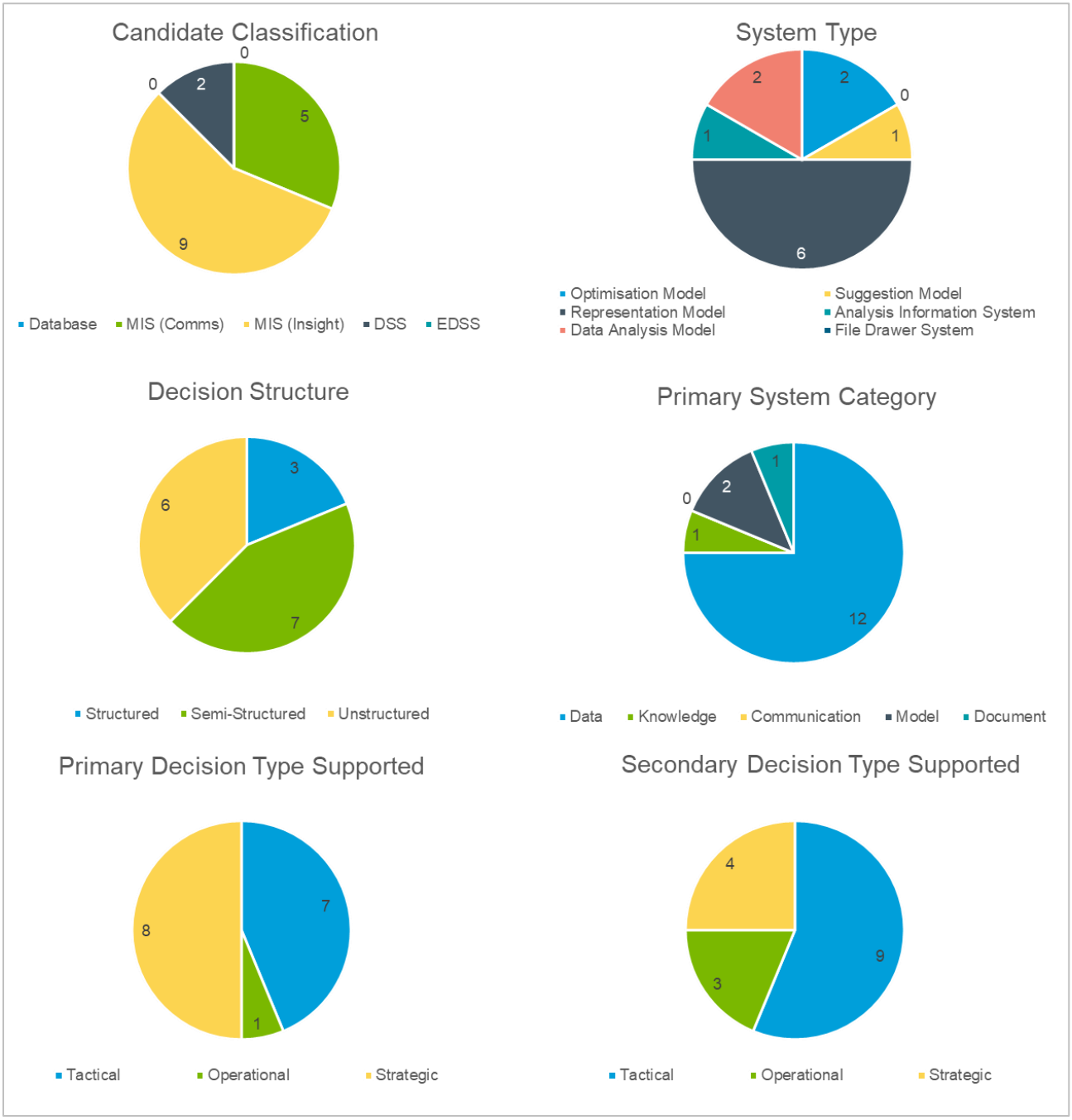


Figure 25. System Review - Classification and Characterisation for GBR System Candidates Only

System Review - All Industries

Overall, the scope of review was skewed towards GBR and Environmental Management candidates with approximately 75% being classified in either scope. Again, the majority of systems assessed were classified as management information systems (either for communication or insight) with approximately 66% of candidates falling into these categories. In terms of the decision structure, there were mixed results with an even number of candidates spread across the three structure levels. For the decision type, the results were skewed towards long term decision making with over 40% being classified as strategic.

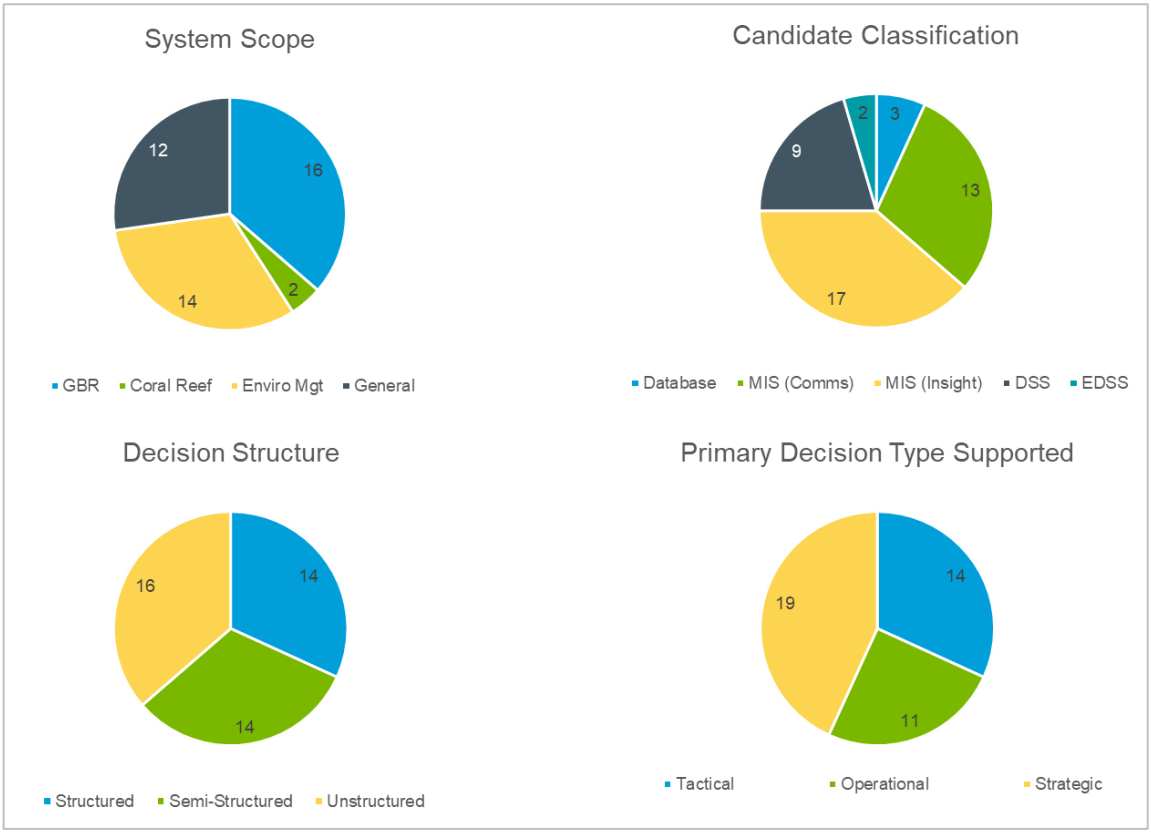


Figure 26. System Review – Classification and Characterisation for Candidates from all Industries

Appendix K – Results - Case Studies

Case study: Reef line fishery harvest strategy

Decision scope and stakeholders

The 5-year Reef line harvest strategy was one of two harvest strategies implemented in 2020 (the other being the Spanner crab harvest strategy), in response to the Queensland Sustainable Fisheries Strategy (implemented in 2017) target to have '*implemented harvest strategies for all Queensland fisheries, which set clear targets for fishery performance, triggers for action and clear decision rules for the actions that will be taken'.*

The Reef line harvest strategy outlines:

- **Objectives** – for the fishery, including maintaining species (ecological), maximising profitability of sectors (economic) and monitoring benefits of the fishery to the community (social)
- **Performance indicators** – to inform on objectives, including biomass, catch rates, catch per unit effort and fisher satisfaction
- **Reference points** – for management action, including desirable levels of fishery performance (targets), points where management response is required to move the fishery towards its objectives (triggers) and points where the fishery performance is considered unacceptable and requires immediate and drastic management action (limits).
- **Appropriate management responses/decision rules** – for different species and sectors when reference points are reached, including reducing fishing effort and quotas, minimum legal size limits and suspending fishing of a given species.

One of the key benefits of the harvest strategy, is it provides Reef line fishery managers with a framework to make decisions on management actions, such as annual fishing quotas, without the need for approval from the Minister of Fisheries – providing the management decision is within the boundaries of the framework approved in the strategy.

The strategy was developed by the Reef line working group, in consultation with stakeholders and the Sustainable Fisheries Expert Panel. Members of the working group include representatives from Fisheries Queensland, commercial fishing, recreational fishing, charter fishing, exports, GBRMPA and conservation[35].

Decision process

Decision Process:				
Ad Hoc	Routine Methods	Dec. Rules	Dec. Guidance	Struct. Desc. Processes

Figure 27. Characterisation of the decision processes adopted by the Reef line fishery

[35] Department of Agriculture and Fisheries, 2019, *Reef line working group - Terms of reference*, Queensland Government, available at: https://www.daf.qld.gov.au/business-priorities/fisheries/sustainable/fishery-working-groups/reef-line-fishery-working-group/reef-line-working-group-terms-of-reference

Systems overview

The reference points for management action (or decisions) for the Reef line fishery are related to stock levels for coral trout (primary fishery species) and red throat emperor (secondary fishery species). The stock levels for the fishery are estimated by the fishery assessment team, comprising fishery managers and scientists, and utilising a model-based stock assessment software called Stock Synthesis, that brings together large volumes of data to model the species populations in the fishery. Data inputs into the model include:

- Commercial logbook data
- Recreational fishing surveys
- Charter fishing logbook data
- Indigenous fishing surveys
- Historical Queensland Fish Board data
- Age and length data
- Underwater visual survey data
- Observer program data
- Boat ramp surveys

The model runs generate output graphs of species selectivity, length and biomass, that the Reef line fishery working group can review against the reference points and decision rules outlined in the harvest strategy, to assess whether any management action, such as reducing fishing quotas for coral trout or red throat emperor, is required for the following fishing season. In addition to this the working group reviews the harvest strategy in consultation with the Sustainable Fisheries Expert Panel to assess whether the reference points and appropriate management actions/decision rules are still suitable. Any changes to the strategy are then recommended by the Expert Panel to the Minister of Fisheries for approval to be implemented the following year. Recommendations for data to improve the parameters and accuracy of the modelling will also be put forward by the fishery assessment team to enable updates in the model for the following years stock assessment.

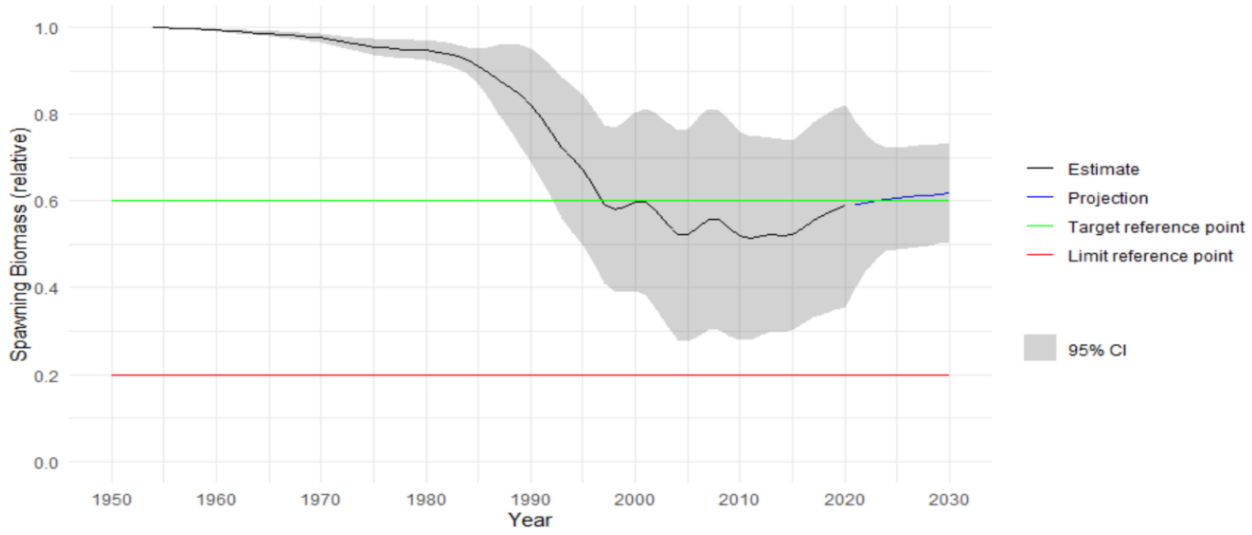
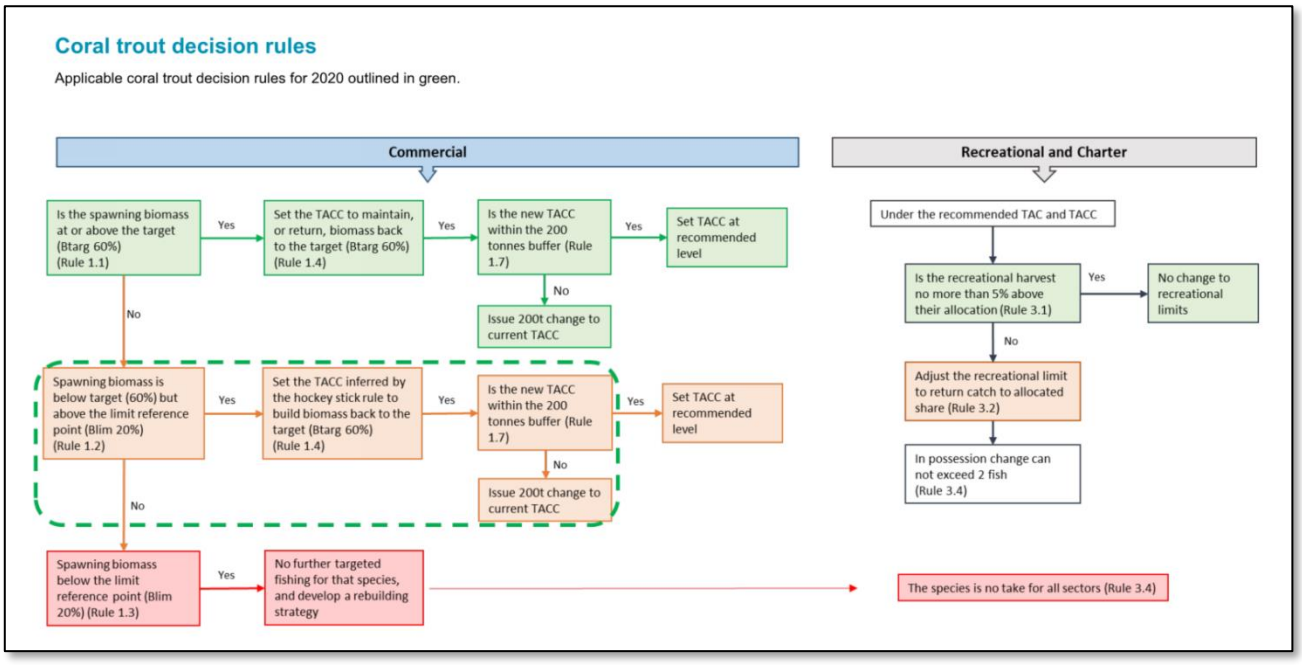


Figure 28. Example output of the Stock Synthesis model calculating spawning biomass for coral trout

A visual representation of the decision rule framework used to set coral trout fishing quotas in the commercial, recreational and charter fishing sector for the Reef line fishery



Systems qualification

System Qualification:	
Data Base	
DBMS	
Data GUI	
Model Base	
MBMS	
Model GUI	
Decision GUI	
MIS for Insight	

Figure 29. Qualification of the system (Stock Synthesis) utilised by the Reef line fishery

Decision horizons

The decision-making process occurs on an annual basis and can therefore be classified as a tactical decision horizon. The model-based stock assessments begin in January using datasets generated from the previous 12 months. The results of the modelling are finalised by March in time for the working group harvest strategy workshop, where they are reviewed against the harvest strategy reference points and management action/decision rule framework. Final quotas for each species and sector in the fishery are then agreed by the end of May and announced in June, in time for the new fishing season beginning in July. As such fishing quotas for the new season are based off the last 6 months of the second previous fishing season (January-June) and the first 6 months of the previous fishing season (July-December) i.e., the previous calendar year. In addition to any decisions made using the harvest strategy framework, any updates to the strategy are recommended to the Minister of Fisheries via the Sustainable Fisheries Expert Panel, to be implemented for

the following year, noting that the overall strategy is updated every 5 years. Furthermore, any updates to stock assessment models occur on an annual basis.

Insights for GBR DSS

- Pre-determined decision rules, outlined in the harvest strategy and approved by the Minister of Fisheries, enable a delegation of authority for changes in fishing quotas to be set by fishery managers without the need for an approval process, therefore improving the efficiency of the decision-making process.
- Harvest strategies use a multitude of datasets to inform their stock assessment models and would benefit from a centralised knowledge database to collect all information relevant to decision-making process - GBRMPA
- Codifying decision rules outlined in harvest strategies would enable development of a DSS capable of determining annual fishing quotas for different species, sectors and fisheries.
- Implementing a structured decision-making process for the development of the 5 yearly harvest strategies would enable more robust objectives, performance indicators, management responses and decision rules to be identified and developed.

Case study: COTS operational management DSS

Decision scope & stakeholders

The first on-water COTS management decision framework was implemented in 2018, as part of the expanded COTS Control Program (increasing from 1-2 vessels to 6 vessels), to enable COTS control vessel operators to make decisions on which reefs to visit and the appropriate COTS management actions at each reef. The decision framework is a simplified decision tree that is used manually (i.e., without the use of bespoke software) and employs simplified decision points and uses Control Program data directly, rather than requiring detailed analysis prior to decision making. The decision framework was developed by the NESP5 COTS IPM Research Program[36], in consultation with COTS control vessel operators and has been refined with their feedback since its implementation. The simplified decision tree framework has formed the basis of a digital COTS Control Centre DSS (also developed by NESP5 COTS IPM Research Program) that will provide COTS control vessel operators with management decisions at the:

- Local area / voyage scale – including optimised voyage planning based on previous voyages results
- Reef scale – including whether a reef is a ‘maintenance mode’ or ‘intensive control’ reef and the appropriate action to take as a result (i.e., surveillance or culling), as well as updating the status of the reef based on the results of the given action (i.e., moving from ‘intensive control’ to ‘maintenance mode’, or ‘vice versa’).
- Site / dive scale – including prioritising cull sites on the reef based on highest COTS density estimates.

In addition to the above, the DSS will have the ability to:

- Optimise the amount of time between manta tows of ‘maintenance mode’ reefs
- Optimise the amount of time between manta tows of ‘intensive control’ reefs
- Optimise the amount of time between subsequent dives at reef sites

Decisions made at the regional and GBR scale, relating to which reefs are included in the COTS Control Program to be managed, are currently made by the program managers at GBRMPA and the RRRC, and

[36] Fletcher CS, Bonin MC, Westcott DA, 2020, *An ecologically-based operational strategy for COTS Control: Integrated decision making from the site to the regional scale*, Reef and Rainforest Research Centre Limited, Cairns.

informed by monitoring and modelling data from the program, as well as monitoring data collected by other programs including the JFMP and LTMP.

Decision process

Decision Process:				
Ad Hoc	**Routine Methods**	**Dec. Rules**	**Dec. Guidance**	**Struct. Desc. Processes**

Figure 30. Characterisation of the decision process adopted by the COTS Operational Management DSS

System overview

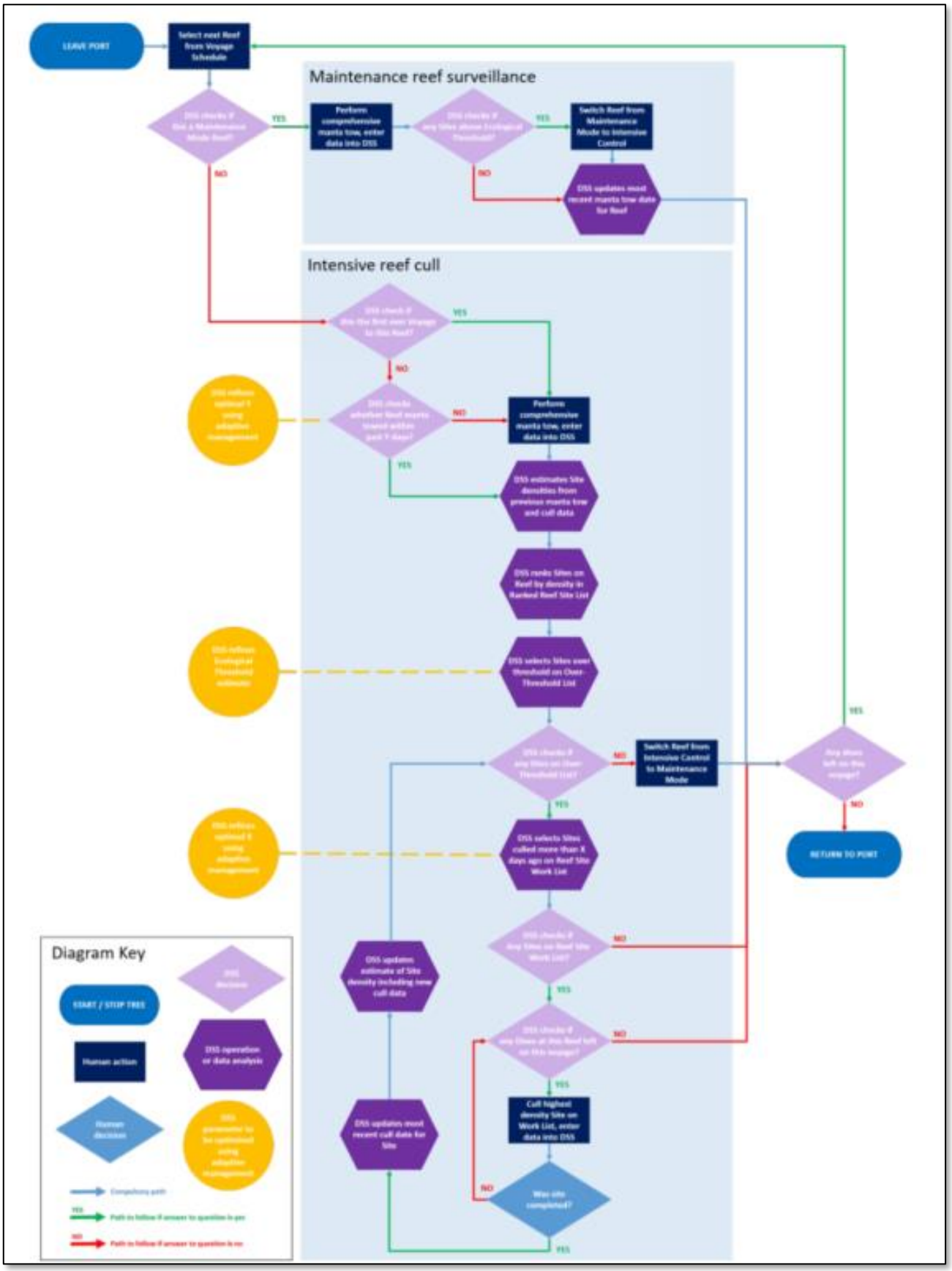
The DSS has an application that can be stored on a tablet, with a user interface that allows the COTS control vessel operators to input the necessary information for the DSS to determine the appropriate management decision, as well as providing the operators with a spatial representation of the voyage plan and sites on a reef that require management action. The DSS uses 3 different data sets to determine the management decision:

- Manta two surveillance data
- Cull data
- Reef Health Information Survey (RHIS) data

This data can be entered immediately by the operators at the control sites, for the DSS to provide them with an immediate on-water decision for the next appropriate action on the voyage.

At the time of writing, the DSS is not currently operational, however it is expected to be implemented shortly. Its development is being overseen by Cameron Fletcher and David Westcott from CSIRO as part of the NESP5 COTS IPM Research Program.

A visual representation of the decision tree that has been codified for the COTS Operational Management DSS is presented below.


LEAVE PORT
Select next Reef from Voyage Schedule
Maintenance reef surveillance
YES
Perform comprehensive manta tow, enter data into DSS
YES
Switch Reef from Maintenance Mode to Intensive Control
NO
DSS updates most recent manta tow data for Reef
Intensive reef cull
YES
NO
NO
Perform comprehensive manta tow, enter data into DSS
YES
DSS estimates Site densities from previous manta tow and cull data
DSS ranks Sites on Reef by density in Ranked Reef Site List
DSS selects Sites over threshold on Over-Threshold List
NO
Switch Reef from Intensive Control to Maintenance Mode
YES
YES
DSS selects Sites culled more than X days ago on Reef Site Work List
NO
YES
NO
DSS updates estimate of Site density including new cull data
YES
NO
Cull highest density Site on Work List, enter data into DSS
DSS updates most recent cull data for Site
NO
YES
YES
NO
RETURN TO PORT
Diagram Key
START / STOP TREE
Human action
DSS operation or data analysis
Compulsory path
Path to follow if answer to question is yes
Path to follow if answer to question is no

System Qualification

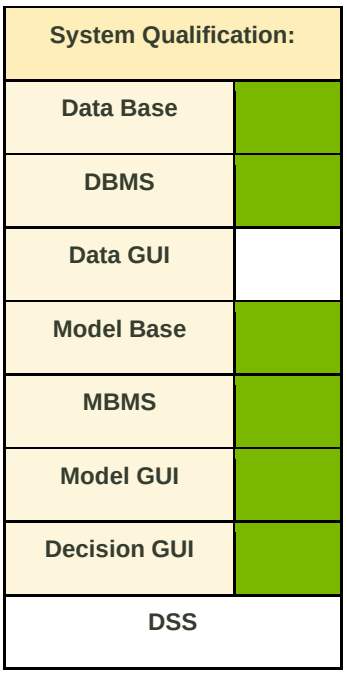


Figure 31. Qualification of the COTS Operational Management DSS

Decision Time Horizons

The DSS is an operational decision-making tool, providing 'on water' decisions at the voyage scale, down to the site scale. Voyages typically take around 10 days and the DSS can be utilised by vessel operators at the beginning of the voyage to optimise their voyage plan i.e., which reefs to visit first, as well as make real-time decisions at the control sites based on the surveillance and cull data entered by the operators during the voyage and from previous voyages. It does not currently have the capability to make decisions at the strategic or tactical level, relating to which reefs should be included for management in the COTS control program.

Insights for GBR DSS

- The decision framework underpinning the DSS has been developed through application of an integrated pest management framework and first tested as a manual version by COTS control vessel operators to refine and optimise the decision rules before codifying.
- Pre-determined, optimised and codified decision rules enable efficient and consistent operational decisions to be made, using an organised and centralised database – EoTR.
- Decisions at the GBR and Regional scale i.e., which reefs to include in the control program, are currently selected by program managers through annual workshop processes and data reviews, however could benefit from similar codifying of processes, as per the operational DSS.
- Research into efficacy of management interventions currently informed by modelling provided by CoCoNet and ReefMod.

Case Study: Reefonomics

Decision Scope & Stakeholders

The Reefonomics DSS is an updated version of the 'investment pathways tool', developed in 2018 by the RTP to help inform on the optimal course of action for prioritising its $201m investment in water quality improvement strategies, now used as part of the Queensland Reef Water Quality Program. The original tool

was able to assess the most cost effective management actions (from 10 different types) for reducing the loads of 3 different pollutant types (nitrogen, sediments and pesticides) across 46 different catchments and a range of land uses, using economic costings data and water quality data.

The Queensland Water Modelling Network and the Office of the Great Barrier Reef have partnered to develop the tool further, to ensure the most cost effective use of a $35m per annum ongoing investment from the Queensland Government towards water quality improvements across the GBR catchment. Users can create different scenarios to provide an estimate of cost and prediction of water quality improvement for implementing a range of different on-ground management actions. Around 100 default on-ground actions (agricultural management practice-based, point source-based and system repair-based) are included and users will easily be able to add new actions and edit action parameters (cost, efficacy, extent). The system provides users with a visually engaging spatial representation of management actions across the GBR catchment and an accessible interface to communicate model results to investors, land users and delivery organisations of water quality improvement programs.

Decision Process

Decision Process:				
Ad Hoc	**Routine Methods**	**Dec. Rules**	**Dec. Guidance**	**Struct. Desc. Processes**

Figure 32. Characterisation of the decision processes adopted by the Reefonomics system

System Overview

The system interface is being developed by Truii (developers of the original interface tool) and brings together water quality monitoring and modelling data from the Paddock to Reef Program, economic costings data for different management actions (developed by Alluvium) and estimates efficacy of interventions modelled by the Agricultural Production Systems Simulator (APSIM), in a single data portal, to enable spatial prioritisation on-ground investment in management actions.

The user can input variables through a user interface including available funding, catchment location and reduction in load by pollutant type, to assess the most cost-effective management action based on the chosen variables. A separate process is therefore required to determine which variables are most favourable to the user i.e., which locations for management action and water quality outcomes are a priority and why, particularly when funding is limited

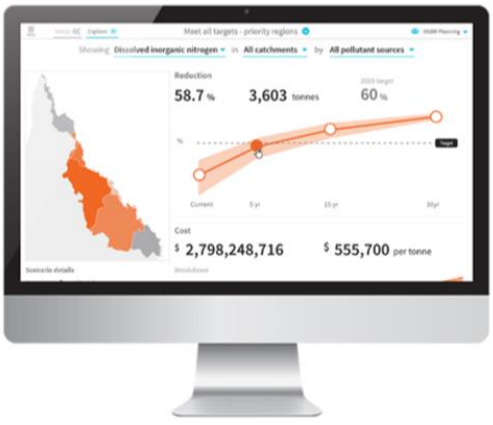


Figure 33. Representation of the user interface for the Reefonomics DSS

System Qualification

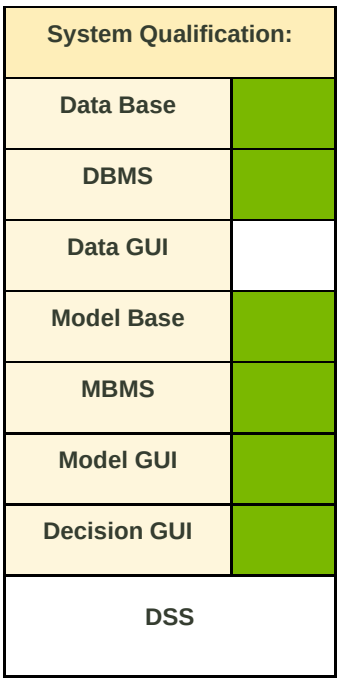


Figure 34. Qualification of the Reefonomics system

Decision Time Horizons

The system can provide the user with information relating to the necessary funding required to achieve a chosen water quality outcome in a chosen location, or the most cost-effective management actions to invest in with limited funding. Decisions around investment and implementation of management actions tend to be made at a strategic or tactical level by investors or program managers. These types of decisions are usually lead by strategic objectives such as those outlined in the Water Quality Improvement Plan, which has a 5 year time horizon.

Insights for GBR DSS

- An engaging and simple to use graphical user interface enables a multitude of stakeholders to operate and benefit from the insights of this DSS.
- A centralised information portal ensures data can be quality controlled and managed.
- A structured-decision-making process is still necessary for the user to undertake, to prioritise what is important to them in terms of management outcome, particularly in cases where funding is limited.

Case Study: ARENA

Decision Scope & Stakeholders

ARENA is an open architecture decision-support tool developed to aid in complex decision-making scenarios. The tool is predominately used for infrastructure and resources development in both the public and private sector. ARENA provides an opportunity for decision makers to assess concept feasibility and business cases at an early stage in a project's lifestyle. Typically used by program managers, senior managers, project directors and executives, the tool is a typical executive decision-support system (EDSS). The tool provides an opportunity for decision makers to consider a breadth of potential options and ultimately make more effective decisions.

Decision Process

Table 5. Characterisation of the decision processes adopted by the ARENA system

Decision Process				
Ad Hoc	Routine Methods	Dec. Rules	Dec. Guidance	Struc. Desc. Processes

System Overview

At its core, the tool facilitates visual assessment of project options to support decision-making for a defined set of project variables. There are 4 pre-set charts (as shown in Figure X), these include:

- Net Present Value (NPV)
- Variable Sensitivity (Tornado)
- Cash Flow Forecast
- Cost Benefit Analysis

Each chart provides a breakdown of variables for each option with the functionality to manually modify slider bars for each variable. This allows decision makers to visually compare project options and the effect specific variables have upon each option. Accessed via a web-based GUI, ARENA runs from a code-based algorithm that generates an initial template for data input. The template is populated by the decision specialist in collaboration with a project team. Once the data is available, ARENA allows for real time manipulation of key decision influencing parameters.

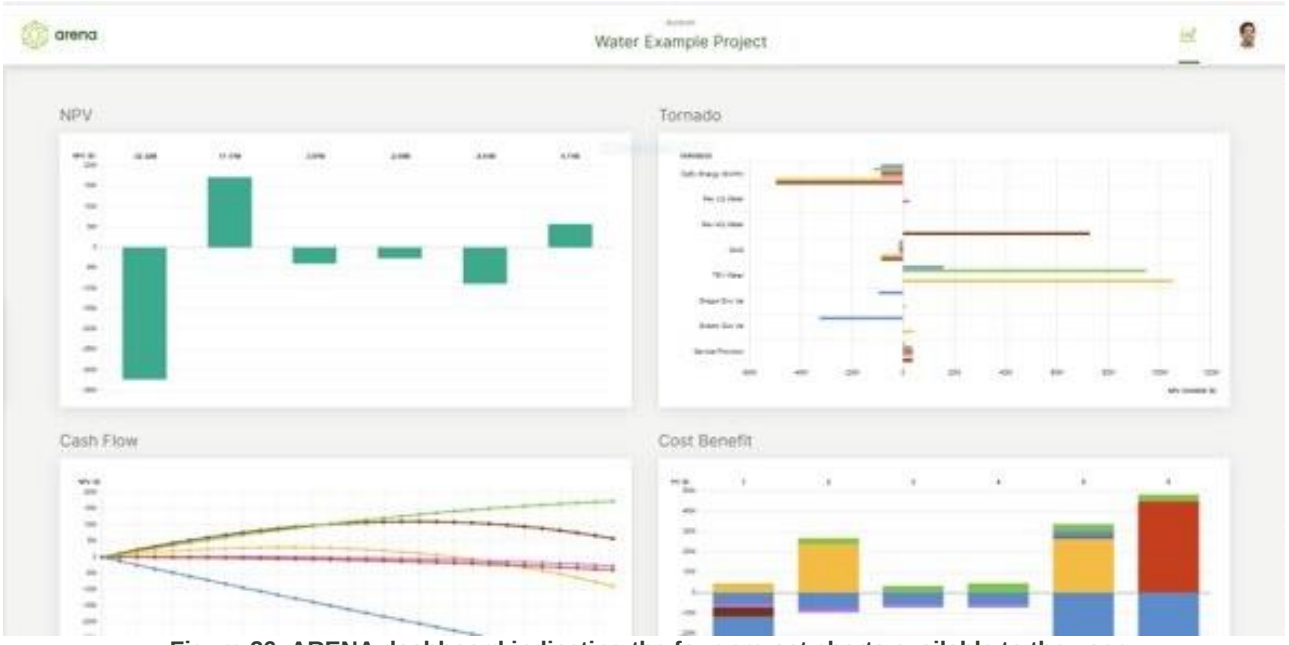


Figure 26. ARENA dashboard indicating the four pre-set charts available to the user

System Qualifications

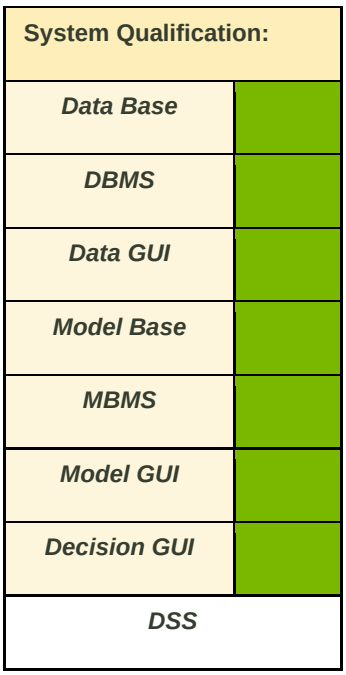


Figure 27 Qualification of the ARENA system

Decision Horizon

ARENA can be used for decisions across varying time horizons up to 100 years. The system allows users to define the time period over which they are looking to make assessment.

Insights for GBR DSS

- An EDSS of this nature with an easy to navigate GUI is a relatively simple process and can demonstrate the potential of decision support at the early stages of a project. The system is typically a low investment, high value proposition for a project.
- The tool works best in conjunction with good processes and can help with advancing the application of a DSS and Structured Decision-Making processes
- The need to quantify uncertainty investment provides further clues to the development of a GBR -wide decision-support system

Appendix L – Results - Documented Decisions - Decision Quality Review

Documented Decision	A well-defined frame	Feasible and diverse alternatives	Relevant and reliable information	Clear understanding of the consequences and trade-offs of alternatives	Robust logical analysis	Commitment to action
Reef line harvest strategy	The frame of the Reef line harvest strategy is informed by the objectives of the sustainable fisheries strategy and is outlined in the harvest strategy objectives and reference points for the fishery.	It is unclear from the Reef line harvest strategy or the Sustainable Fisheries Strategy, the number of options that were considered in terms of implementing a management strategy for the fishery. A range of management strategies and rules are implemented for different sectors, reviewed for their efficacy on annual basis and updated accordingly.	The Reef line harvest strategy accrues a range of data from a number of sources to inform its decision making and stock assessments for the fishery, including: - commercial logbook data - age and length data - statewide recreational fishing surveys - boat ramp surveys - charter fishing logbook data - underwater visual survey data - stock assessments In addition to this, it utlises the expertise of the working group and expert panel, as well as consultations with key stakeholders in the fishery to inform its decisions.	The Reef line harvest strategy prioritises the management of two target species in its fishery; - coral trout - red throat emperor. There are alternative management actions for different sectors, which are implemented depending on the stock levels of these two species using a set of reference points and decision-making rules, which could also be classified as criteria.	Analysis is applied in the decision-making process using stock assessment models and approved decision-making rules, in addition to workshops with the working group and expert panel.	A commitment to action is demonstrated annually by the implementation of new fishing quotas for the target species in the following season and any updates to the management strategy.

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GBRMPA Permit Assessment Guidelines	The frame is defined in the guidelines in the context and general principles sections of the guidelines.	Alternatives in this context can be classified as the different zones of the reef where different activities are permitted.	Permits are applied for through an application process, which includes provision of supporting relevant documentation and is reviewed against the guideline criteria and existing regulations.	Consequences and trade-offs are considered through the assessment criteria outlined in the guidelines.	Analysis is applied through application of the guidelines which requires are number of steps to be fulfilled before a permit can be approved.	A commitment to action is achieved when the permit is approved and awarded to the applicant, enabling them to proceed with the activity they were seeking permission for.
Representative Areas Program (RAP): Zoning of the Great Barrier Reef	The frame is defined through the objectives for the RAP and the application of comprehensive, adequate and representative (CAR) principles to guide the development of a national representative system of marine protected areas. Public consultation and consideration of other values contributed to the basis for zoning.	30 in reef and 40 in non-reef areas, that include 8 poorly known offshore areas, were established. The areas were finalised after numerous iterations and advice from the experts, the various steering committees and public input.	Interviews were conducted with 60 scientists and a range of geographic, environmental and ecological data was collated.	Biophysical operational principles were developed through a literature review, interviews w/ scientists and 12 months iteration between the Scientific Steering Committee and expert panels. Implementation of these principles was intended to identify networks of areas that could meet biodiversity objectives of RAP and comply with the CAR principles.	Analysis was applied through development and application of biophysical operational principles, the development of models to assist with optimal zoning design and iterative consultation with the Scientific Steering Committee, expert panels, scientists and other key stakeholders.	A commitment to action was demonstrated through the implementation of the new GBR zoning.

Appendix M – Results - Terms of Reference – Decision Quality and Assurance Guidelines

Terms of Reference	Role of Group	Decision Quality Review
Reef line fishery working group	The role of working group members is to: - Provide operational advice to Fisheries Queensland on particular fisheries - Consider information and provide advice on shery performance (e.g catch rates, fishing power) - Provide advice on management actions or reforms needed to achieve the establishedmanagement objectives for the fishery - Assist with identifying ways to best manage broader ecosystem impacts of fishing - Provide advice on emerging issues (e.g compliance, data, legislation) - Assist with disseminating factual information back to other stakeholders in the fishery	No clear reference in the ToR to the application or implementation of decision quality or decision assurance in the decision-making processes of the committee
Sustainable Fisheries Expert Panel	The role of the expert panel members is to: - Provide independent expert advice to the Minister and Fisheries Queensland on the appropriateness and feasibility of fisheries management proposals and strategies including options to improve management; - Provide commentary on and review of species stock assessments and ecological risk assessments and the science that supports these activities; - Advise on fishery performance and strategies to improve performance; - Provide independent expert advice on sustainable limits and target and limit reference points for individual fisheries/species; - Provide expert commentary on the adequacy of proposed fishery harvest strategies including whether proposed approaches are likely to meet the relevant objectives and guidelines; - Provide independent expert advice on data, research and monitoring needs; - Provide independent expert fisheries economic advice as requested; - Provide linkages and advice to other relevant strategic advisory groups (e.g., Reef 2050 Advisory Committee) where needed; - Provide advice on other fisheries management issues as requested by the Minister or Fisheries Queensland.	No clear reference in the ToR to the application or implementation of decision quality or decision assurance in the decision-making processes of the committee

Terms of Reference	Role of Group	Decision Quality Review
Cape York NRM Constitution	The objects for which the Company is established are to carry out the role of a regional Natural Resource Management body for the Cape York Region by: (a) working with the people of the Cape York Region to develop and deliver natural resource management activities for the purpose of protecting, enhancing or improving the natural environment or a significant aspect of the natural environment of the Cape York Region; and (b) building the capacity of people and organisations within the Cape York Region to care for the natural environment and to practice sustainable use of natural resources. (c) promoting the recognition and protection of the unique cultural heritage of Cape York including its sites, structures and objects of cultural significance as well as the intellectual property inherent in the traditional knowledge and practices of its Indigenous people. (d) to support and facilitate the ecological sustainability and viability of industry to improve quality of life for the community.	No clear reference in the ToR to the application or implementation of decision quality or decision assurance in the decision-making processes of the committee
North Queensland Dry Tropics NRM Constitution	The objects for which the Company is established are to develop and deliver natural resource management activities for the purpose of protecting, enhancing or improving the natural environment or a significant aspect of the natural environment.	No clear reference in the ToR to the application or implementation of decision quality or decision assurance in the decision-making processes of the committee
Fitzroy Basin NRM Constitution	The objects for which the Association is established are to be a non-profit natural resource management organisation operating within the Fitzroy Basin, Boyne Calliope and adjacent coastal catchments in the State of Queensland; to undertake and otherwise facilitate at a regional level: (a) provide a non-partisan, non-political forum that reflects the community; (b) work towards a sustainable region where all natural resource managers are operating in an integrated and co-operative way; (c) promote full integration of the social, economic and environmental aspects of sustainable development; (d) enhance capacity within the regional community to plan and manage for sustainability; (e) improve knowledge about the region and ensure that all stakeholders have equal access to existing knowledge; and (f) be an influential part of decision making in the region, and develop stronger relationships to unite our communities and improve interaction between people and groups in the region.	No clear reference in the ToR to the application or implementation of decision quality or decision assurance in the decision-making processes of the committee

Terms of Reference	Role of Group	Decision Quality Review
Burnett Mary NRM Constitution	The objects of the Company are: (a) to develop and deliver natural resource management activities for the purpose of protecting, enhancing or improving the natural environment or a significant aspect of the natural environment within the Burnett Mary region; (b) to establish and maintain a public fund to be called the Ecovery Environment Fund for the specific purpose of supporting the environmental objects/purposes of the Burnett Mary Regional Group for Natural Resource Management Ltd. The fund is established to receive all gifts of money or property for this purpose and any money received because of such gifts must be credited to its bank account. The fund must not receive any other money or property into its account and it must comply with subdivision 30E of the Income Tax Assessment Act 1997. (c) to promote the objects of the Company in any manner the Board considers appropriate, and to do things incidental or conducive to the attainment of these objects;	No clear reference in the ToR to the application or implementation of decision quality or decision assurance in the decision-making processes of the committee
GBRMPA Board Charter	In undertaking its role, the Board will act with a view to ensuring the Authority: - continues to provide world-class Marine Park management to protect the Outstanding Universal Value of the Reef - continues to champion the Australian Government's overarching adaptive management approach to address pressures on the Reef - takes an agile, risk-based and outcomes-focused approach to regulation and management of the Reef that supports its resilience and ability to respond.	- Reference to a skills matrix to inform Board member recruitment decisions - Code of conduct to deliver 'responsible decision-making as members' - Governing principles - Board decision-making is informed by an understanding of risk and how risk is managed. - ensuring individual positions are not publicly advocated ahead of decisions being made by the Board - not advocating individual positions contrary to the established decision of the Board - Must keep a record of decisions made - Outlines guidelines for making decisions with a quorum, voting rights and decisions without meetings

Terms of Reference	Role of Group	Decision Quality Review
RIMReP Executive Committee Terms of Reference	The Executive Group is considered the primary body that sets RIMReP strategy and overall direction, and provides the key interface at executive level between the program and the partner organisations. The Executive Group has no executive powers, delegations, supervisory functions or decision-making authority in relation to the program. Specific responsibilities include: - Guide program delivery by providing a forum for cross-agency advice, coordination and input - Guide development of and endorse the 5-year Business Strategy. - Endorse Annual Business Plans and any emerging critical projects. - Endorse the PMO charter and oversee the PMO's role to ensure the PMO is appropriately delivering for the benefit of the program and for each partner organisation. - Advise on actions to ensure the program is appropriately resourced, managed, coordinated and evaluated. - Resolve barriers to cross-agency collaboration	No clear reference in the ToR to the application or implementation of decision quality or decision assurance in the decision-making processes of the committee
RIMReP Steering Committee Terms of Reference	The Steering Committee was a previous iteration of RIMReP governance tasked with providing advice to the Ministerial Forum on monitoring and reporting requirements for the Great Barrier Reef (this includes monitoring of activities in the catchments as they relate to the Great Barrier Reef such as runoff).	No clear reference in the ToR to the application or implementation of decision quality or decision assurance in the decision-making processes of the committee

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