Multi-criteria decision analysis for prioritising crown-of-thorns starfish (COTS) control under resource constraints

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COTS Control Innovation Program | A research and development partnership to better predict, detect and respond to crown-of-thorns starfish outbreaks

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Traditional Owner Acknowledgement

The COTS Control Innovation Program extends its deepest respect and recognition to all Traditional Owners of the Great Barrier Reef and its Catchments, as First Nations Peoples holding the hopes, dreams, traditions and cultures of the Reef.

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Acronyms and Abbreviations

AHP	Analytical Hierarchy Process
AIMS	Australian Institute of Marine Science
CCIP	Crown-of-thorns starfish Control Innovation Program
COTS	Crown-of-thorns starfish
EMC	Environmental Management Charge
GBR	Great Barrier Reef
MCDA	Multi Criteria Decision Analysis
Reef Authority	Great Barrier Reef Marine Park Authority

EXECUTIVE SUMMARY

The Great Barrier Reef (GBR) delivers substantial ecological, cultural, and economic value. Crown-of-thorns starfish (COTS) outbreaks threaten these values, and sustained manual control is a key, actionable intervention. Because control capacity is limited relative to the spatial scale of the GBR, the COTS Control Program must prioritise which reefs to visit each year. Those prioritisation decisions inevitably involve trade-offs as different reef selections protect different bundles of value for different stakeholder groups.

Project CCIP-R-07 of the COTS Control Innovation Program (CCIP) delivered a formal Multi-Criteria Decision Analysis (MCDA) framework to strengthen the reef prioritisation process by improving (i) the quality and integration of multiple data layers, (ii) repeatability and transparency of decision logic, and (iii) the structured inclusion of stakeholder preferences. The MCDA framework provides a defensible mechanism to combine disparate inputs into a single prioritisation score, while making the key normative step explicit, the weighting of different types of value.

The project operationalised two complementary approaches to estimating these weightings. First, a swing-weighting survey elicited stakeholder preferences for the relative importance of ecological versus economic value among participants engaged in the annual prioritisation process. Second, retrospective statistical inference estimated implied weights from previous prioritisation outcomes, providing an empirical baseline and a method for checking consistency across years and decision contexts.

Together, these components establish an end-to-end prioritisation architecture that (a) connects reef selection decisions to the values they are intended to protect, (b) clarifies where subjective judgements enter the process, and (c) creates a transparent pathway for expanding inclusivity, for example by broadening the values elicitation to additional rights-holders and stakeholder groups. In doing so, CCIP-R-07 strengthens the evidentiary basis and legitimacy of operational prioritisation for COTS control on the GBR.

1. INTRODUCTION

The Great Barrier Reef (GBR) has immense value to Australia's Traditional Owners (Marshall et al. 2018), to the Australian economy (Deloitte 2013), and to the global environment (Bode and Day 2020). However, the GBR and the values it provides are jeopardised by a range of interacting major threats, including increasing cyclone damage, bleaching, and damage of coral by crown-of-thorns starfish (COTS) (De'Ath et al. 2012; Mellin et al. 2019; Dietzel et al. 2021). Of these threats, COTS have been estimated to be responsible for as much as 42% of all coral lost on the GBR between 1985 and 2012 (De'Ath et al. 2012). However, unlike cyclones and bleaching, COTS can be physically removed from individual reefs across the GBR to provide immediate protection at these locations (Westcott et al. 2020). Because of this, the Australian government has invested significant resources to create the largest reef intervention program in the world to manage COTS across the GBR, funding a fleet of 5–8 vessels to travel to specific reefs on the GBR and reduce COTS densities to levels that support growth of coral (Great Barrier Reef Marine Park Authority 2025).

Even a fleet of eight control vessels cannot manage the entire GBR (Westcott et al. 2018; Babcock et al. 2020; Westcott et al. 2021; Matthews et al. 2024), and so decisions must be made about which reefs will be targeted for control and therefore protected from COTS. At each reef where resources are invested to remove COTS and protect coral, the ongoing health of the reef will provide increased ecological, economic and social value. Depending on the mix and locations of those values, they will benefit some stakeholders in the GBR more than others. Conversely, at each reef that is not protected, some or all of those values will be lost, and stakeholders that especially valued those locations will not benefit as much from COTS control efforts. This makes the decision about which reefs to target important for both the overall performance of the Control Program in terms of number of COTS culled and area of coral saved, but also for the values that are protected through those actions, and how those values benefit different stakeholders.

Since 2017, the COTS Control Program has made decisions about when and where to distribute control effort during an annual prioritisation process. The process has evolved over time to take account of a broader range of data, to incorporate more stakeholder input, and to improve repeatability and transparency. Over this time, the prioritisation process has matured from a topic of research to a regular part of the operational COTS Control Program. As part of this, from 2020 onwards, the Great Barrier Reef Marine Park Authority (Reef Authority) introduced multiple innovations to the prioritisation process, including automated data processing to streamline the preparation of data to inform prioritisation, and in 2021, an annual prioritisation workshop was introduced where the list of reefs proposed for prioritisation was discussed and refined in response to operational insights from on-water contractors, Traditional Owners, and researchers.

In 2020, further innovation of the prioritisation process was identified as a research priority during the Design and Feasibility Phase of the COTS Control Innovation Program (CCIP). Three key goals were identified: 1) innovate the quantity and quality of data used to inform the prioritisation process; 2) innovate the repeatability and transparency of the prioritisation process, and 3) innovate the prioritisation process to include a broader cross-section of stakeholder perspectives and values. Underpinning all three of these goals was the need for a formal method of incorporating multiple data streams, values and perspectives into prioritisation. The proposed solution – a formal Multi-Criteria Decision Analysis (MCDA) framework – was the major innovation produced by project CCIP-R-07 and was designed to directly support and complement the on-going development of the Reef Prioritisation Process at the Reef Authority.

The decision to adopt a MCDA framework was motivated by the specific structure of the COTS prioritisation problem, and the current state of the prioritisation process. Reef selection requires combining heterogeneous data layers into a single, repeatable ordering under binding resource limits. Many alternative approaches are poorly suited to this task. Single-metric optimisation frameworks collapse all objectives into a single proxy outcome, obscuring trade-offs. Rule-based or expert-judgement approaches lack transparency and are difficult to audit or adapt over time. Fully mechanistic or dynamic optimisation models are data-hungry, and computationally intensive.

The MCDA framework creates a repeatable process for incorporating multiple data sets, with clear points of engagement for participants, and clear links between engagement and the prioritisation decisions reached. It links the decisions about which reefs to target for control to the values that are being protected across the GBR, which allows reefs to be prioritised based on the values they provide. However, because not all stakeholders will value the GBR in exactly the same way, the approach also facilitates discussion around how different priority lists provide different mixes of values to different stakeholders. This underpins COTS control decisions on the GBR with more data and makes the decision process more inclusive and more transparent.

Project CCIP-R-07 developed the MCDA component of the COTS Control Program prioritisation process. Where this fits in the overall prioritisation process is illustrated approximately in **Figure 1** above and **Figure 2** below. **Figure 1** presents a diagrammatic representation of the operational prioritisation process run by GBRMPA. **Figure 2** shows a simplified representation of the way data is processed to inform the prioritisation process emphasising three key components: the combination of ecological data sets to estimate the ecological value of a reef, the combination of ecological and economic values, and the weighting of ecological and economic values based on a values analysis.

From 2021 onwards, the Reef Authority led innovation around the quantity and quality of data that went into determining the ecological value of reefs during prioritisation. From 2022, Project CCIP-R-07 began to contribute to this effort in discussions about potential data sources, but more importantly in providing a formal method allowing the combination of multiple data layers within the ecological value score that is used during the prioritisation process. Together, these innovations allowed the ecological data used to inform prioritisation to increase from two layers (Coral Source, COTS Source) to five (COTS Risk, Coral Source, Zoning, Resilience, and COTS Outbreak History), while creating a framework flexible enough to incorporate an arbitrary number of ecological layers in future.

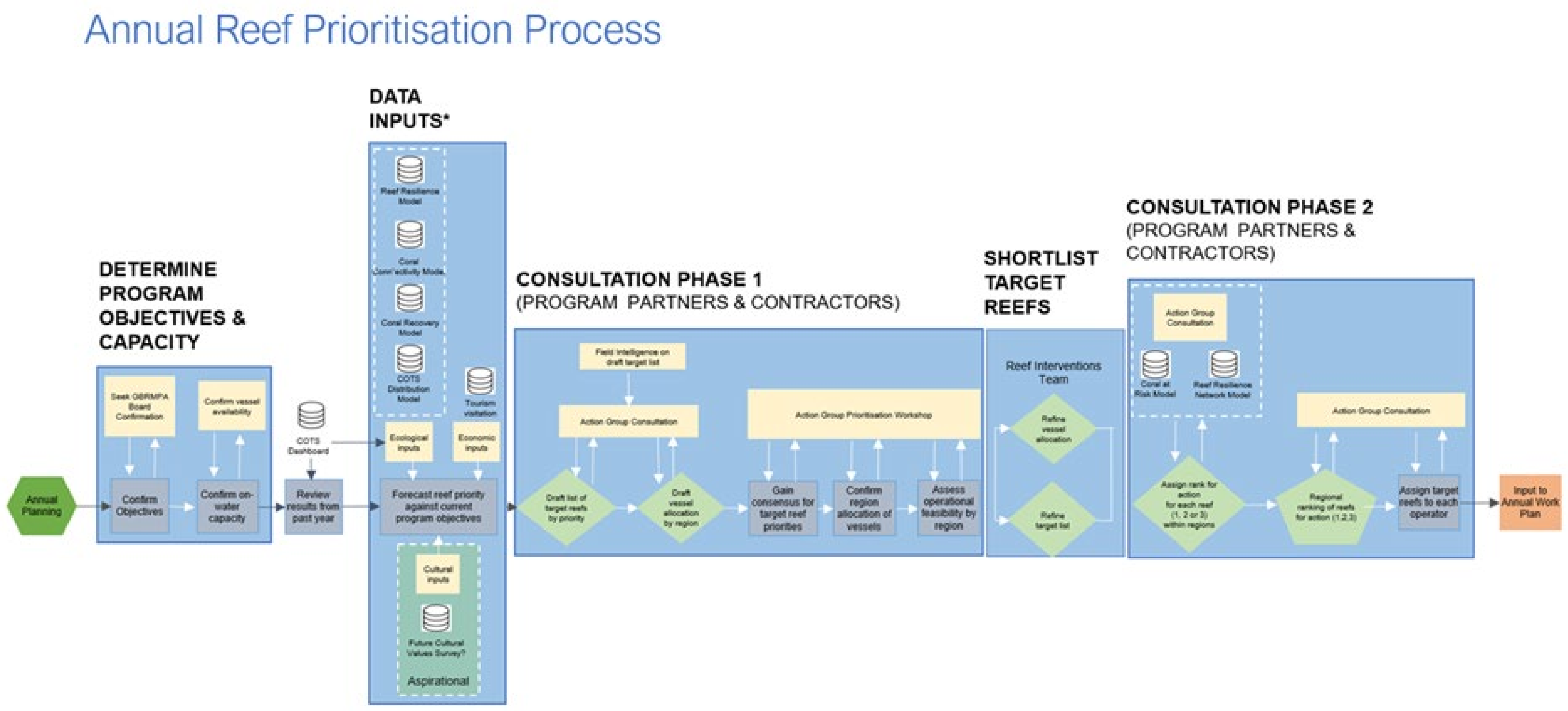

Figure 1. The Reef Authority's operational prioritisation process. Reproduced with permission of the Reef Authority. The figure illustrates the key phases in the prioritisation process, including opportunities for input from stakeholders through consultation. Not explicitly shown in this diagram is the swing weighting process that allowed Program Partners & Contractors from the Consultation phases to contribute to the weighting used to combine Ecological and Economic values.

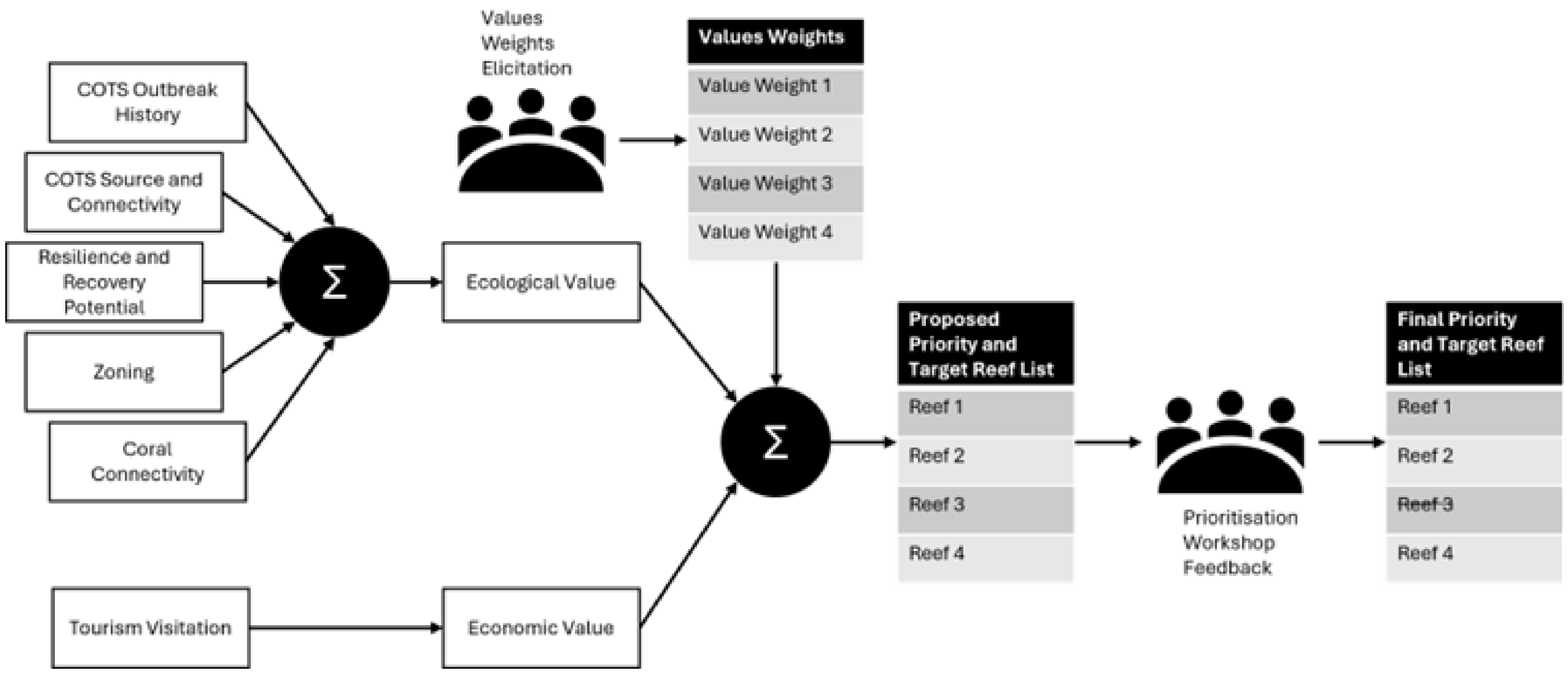

Figure 2. The role of MCDA in the prioritisation process. MCDA has no role in the objective amalgamation of components of ecological value, for example (the first Σ). However, it can support the amalgamation of different types of value (e.g. ecological and economic value, the second Σ).

Unlike the combination of similar types of data layers (e.g. different dimensions of ecological value), combining dissimilar types of data (e.g. ecological and economic value) is more complex, because the relative priority of those values represents a subjective valuation. As a consequence, there is no objective process through which they are best combined. Instead, we need to understand the different, subjective preferences that each stakeholder holds.

1.1 CCIP Program Logic

Project CCIP-R-07 drives real world impact through its direct connection to the COTS Control Program operational reef prioritisation process run by the Reef Authority.

Figure 3 illustrates this path to impact, and where project CCIP-R-07 fits within the CCIP Program Logic. What is not captured in the diagram are cross-connections to other CCIP projects, such as CCIP-R-05 (Choukroun et al. 2026), where the outputs of larval connectivity modelling, which are used in the prioritisation process, can be leveraged more effectively through the MCDA informed prioritisation.

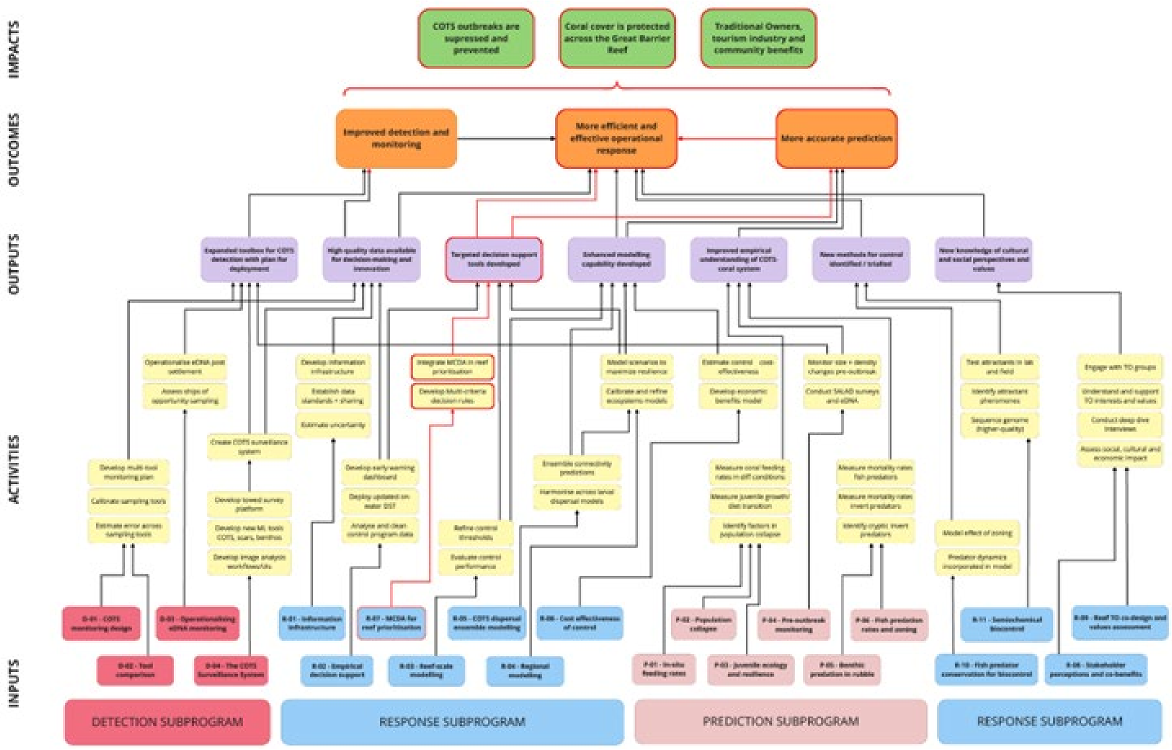

Figure 3. CCIP Program Logic. Project CCIP-R-07 and the path through Activities, Outputs, Outcomes, and Impacts are highlighted in red. Not shown are the cross-project connections, which are important in the case of project CCIP-R-07 due to its core role enabling impact from CCIP research outputs to be delivered into the prioritisation process, such as outputs of CCIP-R-05 (Choukroun et al. 2026).

1.2 Project Aims

Project CCIP-R-07 aimed to develop and apply a set of targeted MCDA tools to support COTS control actions on the GBR. The tools were based on standard concepts from MCDA analysis – ranging from linear additive models, through to swing weighting methods – that were chosen and developed in collaboration with participants. The tools were introduced into the Reef Authority's prioritisation process in 2022 and 2023 to support prioritisation decisions about where COTS Control efforts were targeted in the following year.

The specific aims of project CCIP-R-07 were to:

- Develop and apply a set of targeted MCDA tools to support COTS control actions on the GBR. These tools will be based on standard concepts from MCDA analysis and will be chosen and developed in collaboration with participants.
- Introduce the final set of tools into the Reef Authority's prioritisation committee process in early 2022 and 2023, as decision-support systems.

2. METHODS

Managing complex, real-world environmental management programs often requires balancing multiple objectives, frequently across multiple decision makers with different values, priorities, and constraints. To navigate such complexity, a variety of decision analysis methods have been developed to help structure various parts of the decision-making process using formal and repeatable techniques. These methods do not algorithmically resolve tensions between multiple objectives or perspectives, but they make the information used to inform decisions objective and transparent, and focus how those trade-offs are made.

Project CCIP-R-07 employed MCDA to innovate key components of the prioritisation process by which reefs are selected for control in the COTS Control Program. Below, the rationale for this approach, and the activities undertaken, are outlined.

2.1 Multi-Criteria Decision Analysis

In this project, MCDA provided a logical framework for (i) identifying which criteria (and combinations of criteria) make reefs on the GBR valuable and worth protecting, (ii) identifying which datasets and information are needed to evaluate the reefs according to these criteria, and (iii) formulating a mathematical framework for quantitatively combining the different criteria to rank reefs for COTS control in the coming year.

2.1.1 Motivation for MCDA

When multiple independent criteria are important in a managed system, decision-making becomes complex due to differing priorities among these criteria (Adem Esmail et al. 2018). In wildfire management for instance (Driscoll et al. 2010a; Driscoll et al. 2010b; Driscoll et al. 2016), intense fire management (i.e. backburning) delivers protection for human and economic assets, while less frequent burns are better for species conservation. These conflicting priorities can make it challenging to determine the best course of action.

At its most basic and fundamental level, MCDA addresses this challenge by providing a structured framework and methods to amalgamate various criteria into a single utility. This unified utility allows decision-makers to evaluate all factors collectively, enabling them to make a single choice that maximises overall benefit. Through MCDA, complex decisions are simplified, offering a comprehensive approach to balancing multiple, often conflicting, objectives in a systematic and transparent manner (Gregory et al. 2012; Adem Esmail et al. 2018).

It is important to note that MCDA is not a conflict resolution tool (Gregory et al. 2012). In MCDA, the single utility represents the preferences of a single decision-maker or the shared preferences of a group of decision-makers. This distinction is crucial; the role of MCDA is not to resolve conflicts between different stakeholders or interest groups. The effectiveness of MCDA relies on the assumption that the decision-makers have a common set of priorities and can agree on the relative importance of each criteria. To address the different (and sometimes incompatible) values and priorities of multiple stakeholders or rights-holders, other methods like voting theory are better able to navigate the complexities of decisions influenced by different valuations of criteria among various groups (Adem Esmail et al. 2018).

There are three elements of MCDA problem-solving (Gregory et al. 2012; Adem Esmail et al. 2018). The first is qualitatively understanding the criteria by which decision maker(s) evaluate the options available to them, which could include factors such as economic impact, ecological benefits, and social implications. Once the key criteria have been identified, the second element is to quantitatively estimate the preferences of the decision maker(s) for each of them, and then evaluate the accuracy and sensitivity of these estimates. Estimating how different decisions would affect these criteria requires careful analysis and data collection to ensure that all potential impacts are accurately represented.

Once the preferences of the decision maker(s) are estimated, the third element is to choose a mathematical method for converting these preferences into a single dimension and identify the best decision. This process typically (but not universally) involves dimensional reduction, which simplifies the analysis by transforming the multi-criteria problem into a single-criteria problem. Techniques such as weighted sum models, utility functions, or outranking methods are often used to aggregate the various criteria into a single utility function. This process creates a clear choice that enables decision-makers to make balanced choices that align with their overall objectives.

2.1.2 Identifying Decision Making Criteria

Identifying which criteria should be considered in the MCDA decision-making process is a crucial step (Gregory et al. 2012). Because they define and constrain all subsequent decisions, the choice of criteria likely has the largest effect on the final outcome of the MCDA process. Participatory methods help to ensure that the criteria considered in MCDA are inclusive and representative of the broader community, leading to more robust and accepted decision-making outcomes. However, without specific efforts to select appropriate values, pragmatic considerations often constrain values to those which have traditionally been considered by decision makers, or those which are readily and reliably able to be measured.

Explicit criteria identification may involve the application of public participation methods to ensure that the criteria selected reflect the values and concerns of all stakeholders involved. Techniques such as surveys or literature searches are commonly used to elicit stakeholder values (Whitehead et al. 2014). These methods allow decision-makers to gather a wide range of perspectives. By contrast, focus groups and interviews provide more in-depth insights into the factors that matter for different stakeholders, and why they're considered important (O.Nyumba et al. 2018). Citizen juries involve a small, representative group of citizens who deliberate on the issues at hand, providing a balanced and informed perspective (Wallace et al. 2016; Mukherjee et al. 2018).

In MCDA, it is critical that the criteria identified are values themselves, rather than components of a value (Gregory et al. 2012). For example, consider a decision problem where the action is to protect a reef with the goal of maximising the total larval contribution to reef X. We might have data on (1) the total larval output of reefs A, B, and C, and (2) the proportion of larvae from these reefs that travel to reef X. In this case, we would not treat larval output and proportional transport as separate criteria, since their product – representing the actual contribution to reef X – is the key factor. It is essential to assess whether different criteria can be rationally amalgamated before undertaking MCDA, to ensure that the analysis is focused on balancing fundamental objectives.

For the primary COTS control decision problem – choosing which reefs to target for manual control actions in a given year, we identified three criteria by which a reef has value. These are the economic value of a reef, the ecological value of a reef, and the social and cultural values of a reef. The first two criteria were selected because they are consistently identified as important values offered by a reef, and because they have been used in past prioritisation exercises for COTS control. The final criterion was identified because it is consistently mentioned as an important driver of value that is being omitted by the current approaches. Furthermore, the first two criteria were partly chosen because reasonable and complete data was available to measure them for the GBR.

2.1.3 Estimating Decision Maker Preferences for Different Decisions

MCDA is fundamentally challenging because ranking alternatives by different criteria yields incompatible orders. Effectively, the best alternative according to criteria A is not the best alternative according to criteria B. Most (but not all) MCDA techniques solve this challenge by converting each of the multiple criteria with different units into a single criteria with a single unit (Adem Esmail et al. 2018), often using a weighted sum with weighting coefficients w_j, where j identifies the criteria. These coefficients are extremely important, but quite hard to estimate.

A range of approaches are available for estimating the value of these weights. We applied one method from each of the two types described below to measure the different weights assigned to each of the dimensions of the COTS manual control prioritisation problem.

Indirect elicitation methods: Sometimes weights are elicited using discrete choice experiments (Belton and Stewart 2002). Users are asked to choose their preferred option, when faced with a series of hypothetical paired scenarios. Statistical methods are then used to implicitly calculate their underlying weightings, and clever adaptive methods (e.g. PAPRIKA and its variants) can pose a series of questions that allow weights to be estimated with a minimum of questions (Hansen and Ombler 2008).

We applied the method of swing weighting to elicit the w_j values indirectly from stakeholders. Swing weighting is a technique in MCDA commonly used to calculate relative weights for the contributions of the different criteria to the overall value of a choice. It uses a structured process to elicit the relative weight from a sample of respondents or stakeholders. The swing weighting procedure we applied was based on an online questionnaire (see **Appendix A**). Respondents were asked to reflect and report on their preference for a finite set of scenarios. The respondents were given two bounds – a hypothetical best-case scenario, an ideal reef providing both benefit types; and a hypothetical worst-case scenario, a reef providing neither of the benefit types. In between these bounds were a set of two scenarios where a reef offered one benefit type in isolation. For example, a reef that delivers ecological benefits but no economic benefits.

Respondents were first asked to rank the scenarios from most desirable to least desirable. They were then asked to assign each of the scenarios with a score from 0 to 10, with 10 being the most desirable. Where respondents were uncertain about the weights, they could offer a range instead of a single value. This range was then interpreted as a uniform distribution on the value of the option. The answers to these questions can be used to assign relative weightings to the different criteria. The online form can be seen in **Appendix A**.

Retrospective statistical inference: An alternative to indirect elicitation is to statistically estimate preferences from the pooled decisions of previous rounds of decision-making (De Almeida et al. 2016). Given the sets of prioritised and unprioritised decisions from previous rounds, and ideally given rankings of the prioritised (and unprioritised) decisions, we can make statistical guesses about the weightings that were implicitly assigned to the different elements of the MCDA. While the result would not be perfect estimates of the weights (e.g. as a result of bounded rationality, changing dimensions, changing data, changing information, or changing decision-makers and stakeholder groups), they could operate as reasonable and defensible initial estimates, with the aim of further refining them.

We applied retrospective statistical inference to estimate the relative weightings of ecological and economic values (the only two criteria that had previously been considered), by fitting an additive function with free w_j values to binary COTS control prioritisation decisions (i.e. reefs were designated priority reefs, 1, or non-priority reefs, 0) made in previous years. Operationally, we standardised the additive utility function to create a probability that a given reef with particular ecological and economic characteristics would be chosen as a priority reef, as a function of w_j. We then performed a local gradient search through w_j vectors values, looking for combinations that gave a local maxima for the likelihood of the observed prioritisation vector. We then initialised the local gradient search from 1,000 different random initial locations, and retained the top 5% of local maxima. This was performed for the priority list agreed upon in 2022.

2.1.4 Amalgamating Multiple Criteria into a Decision

Once the criteria have been identified and the weights associated with each decision have been determined, there are many methods available for amalgamating multiple criteria into a single utility. These methods, such as weighted sum models, utility functions, and outranking methods, simplify the decision-making process by consolidating diverse criteria into a unified measure that can be maximised to achieve the best overall outcome.

All these methods are based on the same key problem elements. MCDA is structured around a decision matrix, which can be written as:

$$\mathrm{D} = \begin{bmatrix} x_{1,1} & \cdots & x_{1,k} \\ \vdots & x_{i,j} & \vdots \\ x_{n,1} & \cdots & x_{n,k} \end{bmatrix} \qquad \text{Equation 1}$$

Where x_{ij} represents the value of the i^{th} alternative (out of n total options) according to the j^{th} criteria (out of k total criteria). For instance, this could be the number of annual tourists (i)

visiting Moore Reef (j). Because no single row contains the maximum of all columns, optimising for one criteria will not lead to optimal outcomes for others.

Once the decision matrix D has been defined, MCDA applies a function that effectively maps each action-associated vector of criteria values onto a single real number. The simplest and most common approach attaches relative weights to each criteria, and calculates a total additive utility:

$$r_i = \sum_{j=1}^{k} w_j x_{ij}, \quad \text{Equation 2}$$

where r_i is the i^{th} site's rank and w_j is the weighting of criteria j according to the decision-maker(s). The w_j values are generally constrained between zero and one, but any set of weightings can be standardised to fit within this interval without loss of information. The additive utility approach in Equation 2 is a standard method, but it generally requires the distribution of the criteria to have well-behaved mean values, and covariance matrices. Otherwise, particular elements of the problem dominate the decision, which is only acceptable if that's a fair reflection of the decision-makers' values.

The additive utility formulation in Equation 2 was adopted deliberately in this project because it aligns closely with both standard practice in MCDA and the pre-existing COTS Control Program prioritisation logic. Additive models are widely used, well understood by practitioners, and straightforward to interpret, making them particularly suitable for transparent, repeatable decision-making in applied management settings. They provide a natural formalisation of the existing methods, rather than a disruptive methodological shift. Additive utility functions also support clear communication with stakeholders, allow intuitive sensitivity analysis, and enable incremental refinement as new data layers or value types are introduced.

We will limit our discussion of different utility functions, as we applied additive functions in our analysis. However, it is important to note that there are various other methods for transforming multiple criteria into a single-dimensional utility. For instance, multiplicative utility functions consider the product of weighted criteria, reflecting interactions between factors. Identifying non-dominated sets can also resolve parts of the MCDA challenge (Driscoll et al. 2016). This approach involves comparing reefs across all criteria simultaneously, to determine whether any reef is strictly inferior to another in all respects. Such dominated reefs would never be selected by a rational decision-maker under any weighting of the criteria, because another available reef provides equal or greater benefit without additional trade-offs. Removing these dominated options reduces the size of the decision space, clarifies the set of genuinely competitive reefs, and allows attention to be focused on meaningful trade-offs among non-dominated reefs where value judgements about relative importance are required.

2.2 Stakeholder Engagement

The primary stakeholder engagements in project CCIP-R-07 centred around: 1) the swing weighting survey, outlined in section 2.1.3 above and section 3.1.1 below; and 2) significant contributions in 2022, 2023 and 2024 to the operational annual prioritisation workshops coordinated by the Reef Authority in March – April each year, or the mid-year prioritisation review workshops coordinated by the Reef Authority in November each year.

On 30th March 2022, the CCIP-R-07 team, working closely with Reef Authority colleagues, presented on the *Future development of the COTS Control Program reef prioritisation process* at the at the annual prioritisation workshop run by the Reef Authority. This involved close collaboration with the Reef Authority's COTS Team, including workshop planning meetings on 4th March 2022. This was also sequenced with a presentation at the online COTS Action Group meeting on 14th March 2022 to managers and on-water operators, during which key concepts were introduced to prepare participants for the workshop engagement.

In 2023, the CCIP-R-07 team coordinated the swing weighting values elicitation, leading additional discussions at the annual prioritisation workshop around formal capture of logistics data to guide future prioritisation. This involved extensive stakeholder engagements over a number of interconnected forums to build understanding, ownership, and drive engagement.

On 20th March 2023, CCIP-R-07 and the Reef Authority team ran sequential presentations at the COTS Action Group forum with managers and on-water control staff, introducing the concepts behind swing weighting and a new logistics data layer.

The logistics data layer refers to a spatially and temporally explicit estimate of operational feasibility, that is, the probability that COTS surveillance and culling can be safely and effectively conducted at a given reef and time. This probability can be derived using statistical models fitted to historical operational records and environmental data (e.g. wind speed, wave height, seasonality), which predict when conditions are likely to permit vessel access and in-water operations. In the context of COTS prioritisation, the logistics layer complements ecological and economic value layers by indicating where and when control effort is realistically deliverable.

From 22nd March 2023 to 5th April 2023 CCIP-R-07 ran the swing-weight elicitation of stakeholder preferences for reef values. The elicitation involved an online survey using the SurveyMonkey platform. Responses were received from 14 respondents involved with the Reef Authority prioritisation workshops, including managers, on-water contractors, and researchers.

Through regular fortnightly meetings of the project team from February to April 2023, and in a dedicated online planning session on 17th April 2023, the CCIP-R-07 team met with the Reef Authority to coordinate and plan the annual workshop. On 21st April 2023, the CCIP-R-07 team delivered two sessions at the workshop, reviewing outcomes of the swing weighting elicitation, and eliciting input from on-water operators about logistics data.

On 8th March 2024, the CCIP-R-07 team, in conjunction with the Reef Authority, ran the afternoon session of a researcher-focused prioritisation workshop. This research focus differed from previous' years prioritisation workshops, which were predominantly focused on on-water operators. The workshop was preceded by workshop planning sessions between

CCIP-R-07 researchers and Reef Authority managers on 1st, 22nd and 29th February 2024, and 4th March 2024. The CCIP-R-07 team ran five workshopped discussions in the afternoon, focused on:

- Combining data to inform prioritisation: expert elicitation vs process-based weighting, what are the risks, what's missing?
- Leveraging new connectivity data to improve prioritisation: uncertainty, reef clusters, connections to GBR scale models.
- How should the amount of effort required to control a reef factor into prioritisation? Effort prediction tools.
- Manual steps in the Prioritisation Process – can we formalise?
- How should we measure success - can we learn from current efforts to improve future prioritisations?

These discussions underpin some of the future needs discussed in section 4.4.1.

In addition to the explicit manager-focused engagement outlined above, CCIP-R-07 researchers presented and engaged with researchers, managers and end-users at numerous CCIP and external workshops and symposia multiple times each year.

3. RESULTS

Project CCIP-R-07 developed Multi-Criteria Decision Analysis (MCDA) methods to innovate key components of the reef prioritisation process in the COTS Control Program.

The first significant innovation was the estimation of stakeholder preferences, using both a swing weighting survey methodology and post-hoc statistical inference from previous years' prioritisations.

The second was innovations in the quantity and quality of data incorporated into prioritisation, and the formalisation of how these multiple data sets and the criteria they represented were combined to inform prioritisation. Below, the results of these innovations are described.

3.1 Estimating Prioritisation Preferences for MCDA

To apply MCDA to prioritise COTS manual control between the different reefs on the GBR, we needed to first estimate the preference weights for the additive utility function. We approached this problem using two approaches. First, using explicit stakeholder elicitation methods - specifically, a swing weighting survey. Second, by retrospectively fitting an additive utility function to decisions from a previous year. Below, we outline the results from each of these analyses.

3.1.1 Swing Weighting Survey

Our swing weighting project developed and applied swing weighting elicitation, focusing on identifying the correct relative weighting between ecological and economic factors. This approach ensured that both environmental and financial considerations were appropriately balanced in the decision-making process, reflecting the priorities of the stakeholders involved.

Fourteen members involved in the COTS control process participated in our online questionnaire. All respondents completed all questions. Their rankings enabled us to estimate the relative importance they each placed on ecological versus economic factors in the decision-making process. The responses reported a range of preferences, reflecting the diversity of priorities among stakeholders. **Figure 4** illustrates the results for each respondent, showcasing the varying degrees of emphasis on ecological and economic aspects.

These results reveal a wide diversity of opinions among respondents, but also a wide range of uncertainty for each individual respondent (note the width of the error bars in **Figure 4**). Additionally, respondents differed in the amount of variation they described in the value they placed on reefs. The grey lines in **Figure 4** describe the value that respondents placed on reefs with neither ecological nor economic values, and the range was further normalised so that the value of reefs with both economic and ecological values was equal to one. We normalised this variation to standardise the variation in reported absolute satisfaction that is common among individuals. Here, absolute satisfaction refers to the overall scale on which individual respondents expressed how rewarding or valuable they found different reef outcomes, independent of the relative importance they placed on ecological versus economic factors. Normalisation was applied to remove differences in how generously or conservatively respondents used this scale, allowing comparisons to focus on relative preferences rather than individual response intensity.

Despite this variation, the responses were consistent in notable ways. Qualitatively, all participants agreed that reefs with only ecological value were more important than those with only economic value. However, the relative importance of ecological and economic factors varied greatly among respondents, indicating differing priorities. Interestingly, reefs lacking significant ecological or economic attributes were still often given substantial scores, suggesting that respondents recognised other intrinsic values or potential benefits not explicitly captured by the main criteria. These observations highlight the complexity and variability of stakeholder perspectives in the COTS control process.

These results were aggregated to form the coefficients of an additive utility function, which can be seen in the lower panel of **Figure 4**. These aggregate results provide insights into the relative importance of economic and ecological factors, as well as our uncertainty about the relative value, and the variation among members of the decision-making group (the range of results shown captures both dimensions of variation). The estimated coefficients exhibited significant variability (note the width of the distributions), but they remained well-distributed, indicating that despite the range of opinions, the criteria were clearly distinguished and not confused.

The median weight assigned to economic factors was approximately one-third, with 95% bounds ranging between 0.1 and 0.42. Meanwhile, ecological factors received a median weight of two-thirds, with 95% bounds between 0.58 and 0.9. These distributions reflect a general and strong preference towards ecological values in reefs. However, this does not imply that 1/3 of priority reefs would be chosen on the basis of economic factors, while 2/3 would be chosen based on ecological factors. Instead, the priority is to pursue options that offer both economic and ecological benefits. In practice, this means that decisions will primarily target reefs that exhibit attributes of both economic and ecological value.

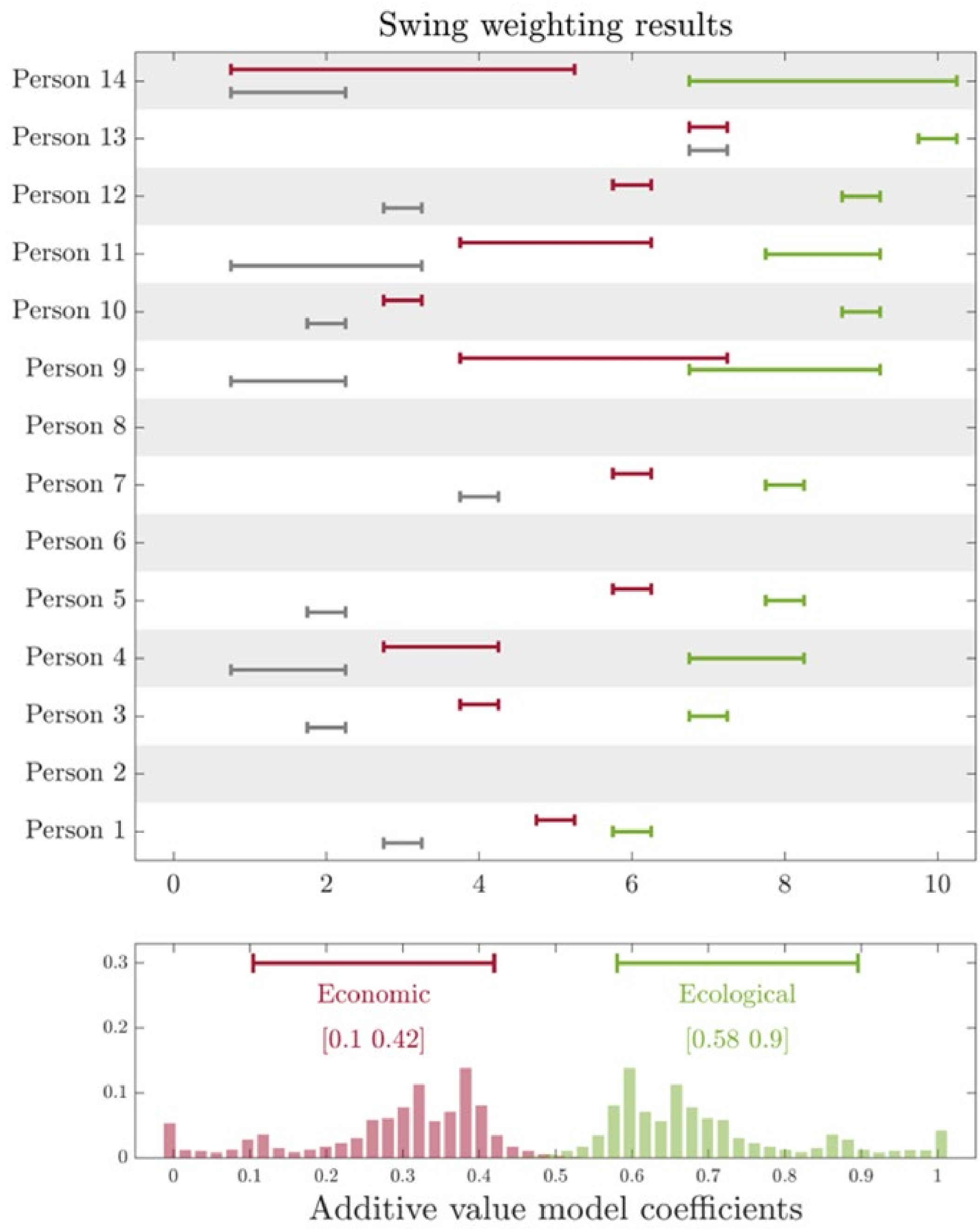

Figure 4. Results for the swing weighting elicitation. Upper panel shows the responses of the participants. Red shows the value given to economic outcomes, green shows value given to ecological outcomes, grey shows value given to reefs without either attribute. The latter result was used to standardise the range of values. Lower panel shows these results, translated into an overall relative weight for each attribute. Error bars span 95% of the weights.

3.1.2 Statistical Inference

In 2022, decision-makers identified a number of criteria that they agreed should affect the priority ranking of reefs for COTS control. Here, we analysed how five of these—COTS Risk, Larval Source, Tourism Visitation, previous Management Effort, and previous Survey Effort—influenced the reefs prioritised. The first two were considered ecological criteria and the third was considered an economic criterion.

To standardise the utility function weights and reduce the effect of outliers, the values of each criterion were translated into rankings. This was particularly important for tourism visitation, which is highly positively skewed. We then used a local gradient search to identify the best-fit weighting parameters that maximised the likelihood of the priority reef set from that year. The optimisation landscape is multimodal, and so the gradient search was initiated 10,000 times from random initial weights to find multiple local maxima (i.e. multiple sets of weights which could explain the observations). All local maxima were recorded, and the best 5% by likelihood were sub-selected.

Figure 5 shows the results. The last two rows illustrate the weights attributed to reefs with previous COTS management effort and previous Australian Institute of Marine Science (AIMS) survey effort. These two factors had variable effects across all local maxima; in some cases, they were associated with high priority, while in others they were associated with low priority. This variability led us to consider their mean effect as ambiguous. Additionally, the scatterplots showed that these two factors were not strongly correlated, indicating that the ambiguous effect was not the result of a two-way trade-off. Consequently, they were excluded from the overall weighting calculation.

The first row of **Figure 5** shows the weights attributed to COTS risk. The overwhelming majority of local maxima had positive weights - often strongly positive - associated with high COTS risk reefs. This indicates that decision-makers were prioritising reefs with historically high risks of COTS outbreaks. As a result, we considered COTS risk to have a strong mean positive weight.

The second row shows the weights attributed to the estimated coral larval source effect of each reef. Similar to COTS risk, the weights were consistently positive and often strong. Decision-makers were thus prioritising reefs with strong coral larval source attributes. Consequently, coral larval source was also considered to have a strong mean positive weight.

The third row shows the weights associated with tourism visitation. These weights were more consistently positive, and often larger in magnitude, than those associated with each individual ecological criterion. This reflects the fact that tourism was represented by a single economic variable, whereas ecological value was decomposed into two separate criteria—COTS risk and coral larval source.

Importantly, these results should be interpreted at the level of individual criteria rather than aggregated value categories. Although tourism visitation exhibited a strong positive weight as a single criterion, the combined influence of the two ecological criteria was greater. When the weights for COTS risk and coral larval source were aggregated within the additive MCDA utility function, their combined contribution was approximately twice that of tourism visitation. This yields an overall ecological:economic weighting of approximately 2:1, consistent between the historical prioritisation outcomes and the swing weighting elicitation.

These results suggest that decision-makers were likely using three factors to determine whether a reef should be a priority for COTS control. COTS outbreak risk and coral larval source status contributed approximately equally and positively, both being ecological factors. Tourism visitation also contributed positively and was considered an economic factor. As a result, once the two ecological factors were aggregated into the additive MCDA utility function, the ratio of ecological to economic factors was approximately 2:1. Precisely, $w_j = 0.62$ for ecological criteria, and $w_j = 0.38$ for economic criteria.

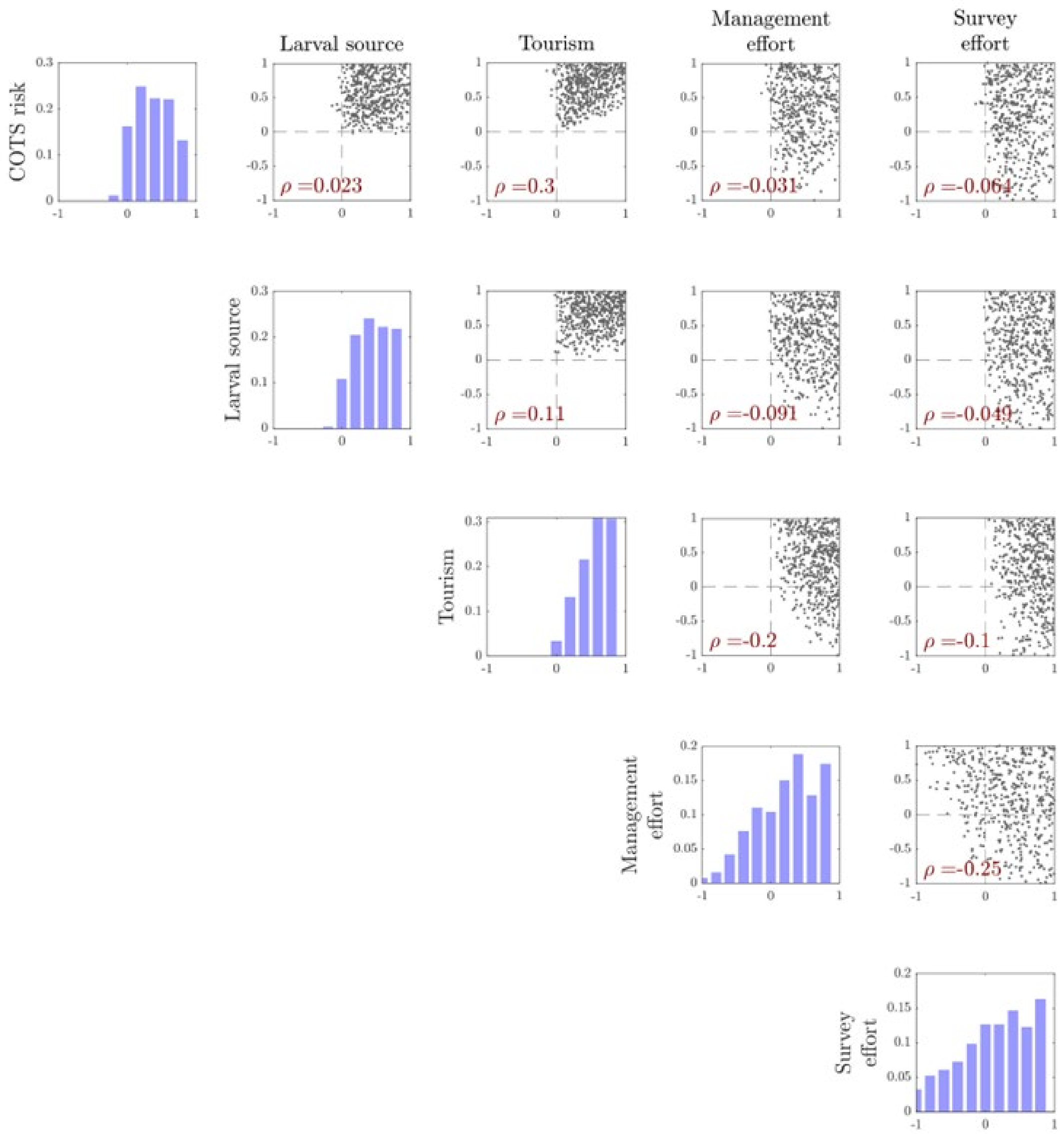

Figure 5. Estimated weights for the additive utility function. Each row corresponds to a different criterion. Histograms show the distribution of criteria weights, estimated by repeatedly fitting the function to previous prioritisation decisions. Scatterplots indicate the co-distribution of the weightings across local maxima.

3.2 Multi-Criteria Decision Analysis and Data Layers

Two significant innovations over the course of CCIP were the increase in the quantity and quality of data incorporated into prioritisation, and the formalisation of how these multiple datasets and the criteria they represented were combined to inform prioritisation. Some of these innovations, notably the increase in data, were driven by operational innovations led by the Reef Authority, often with input from CCIP researchers. Others, such as the formalisation of data combination methods, were led by CCIP researchers in close collaboration with Reef Authority managers. Below, we detail the evolution of the data layers informing prioritisation from 2020 to 2024.

3.2.1 2020 and earlier

In 2020 and prior years, three data layers were used to inform prioritisation: COTS Source / Sink, Coral Source, and Tourism Visitation. COTS Source / Sink was the weighted in and out-degree from an ocean current COTS larval connectivity model (Hock et al. 2014), and Coral Source was defined as the weighted out-degree from a separate ocean current coral larval connectivity model (Hock et al. 2014). Tourism data was generated from commercial-in-confidence internal records of tourism fees collected and passed on to the Reef Authority. The exact method of comparing and combining data records was refined over time, and was not always recorded in detail. The first prioritisation, conducted in 2017, ranked records within each of the three data categories to identify the reefs within the management area that were important as sources of COTS, for coral resilience, and for tourism.

3.2.2 2021

In 2021, the ecological data incorporated into prioritisation was expanded and refined, to include five data layers: COTS Risk, Coral Source, Zoning, Resilience, and COTS History. COTS Risk was now generated by multiplying the probability of a COTS population being present at each reef (taken from a Reef Authority maintained Species Distribution Model; (Matthews et al. 2020), multiplied the weighted out-degree from an ocean current COTS larval connectivity model (Hock et al. 2014). Coral Source was generated by multiplying the estimated coral cover at each reef from ReefMod-GBR (Bozec et al. 2021). Economic value was still captured using Tourism visitation data. Data however were combined using threshold values which were somewhat arbitrary and made ranking reefs problematic. Also in 2021, the first multi-organisational Prioritisation Workshop was held in March 2021 following the International COTS Control Forum in Cairns, a foundation which was built upon in following years.

3.2.3 2022

In 2022, layers were provided with formal definitions. Economic value was still captured using tourism visitation data. Definitions for the six data layers are included below. Ecological layers were scaled for normalisation and combined to create the overall Ecological value score for the reef. The implicit weight between Ecological and Economic values was tuned manually by observing the mix of reefs prioritised to ensure key targets were being captured.

Factors that were not well captured using the prioritisation process were included via a manual lock-in and lock-out process, where reefs that were considered exceptional in a unique manner were specifically included on the list.

Ecological – COTS Risk: Composite metric of ensemble weighted out-degree (as a percentile per sector) multiplied by predicted COTS density (scaled 0–1). Represents how well connected a reef is and how likely the reef is to have problematic COTS densities.

Ecological – Coral Source: Composite metric of coral weighted out-degree (as a percentile per sector) multiplied by predicted Coral Cover. Represents how well connected a reef is and how much coral is available to supply surrounding reefs.

Ecological – Zoning: Scored (0–1) for four categories of protection (Pink = 0; Blue = 0.5; Yellow = 0.75; Green = 1). Green zones are slightly upweighted to 1) uplift reefs that should be easier to control due to enhanced fish predators amplifying zoning protection; and 2) balance the implicit upweighting of blue zones through their more prevalent COTS outbreaks.

Ecological – Resilience: Calculated as: Recovery Potential + (1-Disturbance Exposure). Included to give weighting to reefs that have avoided recent disturbances and have a higher chance of recovery.

Ecological – COTS Outbreak History: Scored 0–1 in five outbreak categories from previous two years of data (Severe = 1; Established = 0.75, Potential = 0.5; No Outbreak = 0.25; No COTS = 0). Designed to upweight places where COTS outbreaks are known and thus give slight preference to empirical observations over modelled estimates.

Economic – Visitation: Number of visits, scaled (0–1), from the Reef Authority's Environmental Management Charge (EMC) data 2019–2022. Best available proxy for tourism value.

3.2.4 2023

In 2023, the prioritisation process was again refined into a two-stage process. The first stage focused on the ecological and economic dimensions separately. The ecological layers, specifically COTS Risk, Coral Source, Zoning, Resilience, and COTS History were evaluated at each reef, and the values were rank-ordered from the most to the least valuable reef in each category. These individual rankings were then aggregated into a single ecological score (the mean of the rankings). The economic dimension, represented by tourism visitation data, was maintained as a distinct economic score.

The second stage amalgamated the ecological and economic scores into a single multicriteria score. This was accomplished using results from the swing weighting elicitation described in section 3.1.1. The swing weighting determined the relative importance of ecological and economic factors in the overall prioritisation process, based on direct elicitation of stakeholder preferences. The weights were applied to combine the ecological and economic scores, resulting in a single, comprehensive score for each reef, which could be ranked to determine the priority list. As in 2022, reefs that were not well captured using the prioritisation process were included via a manual lock-in and lock-out process.

4. DISCUSSION AND OUTPUTS

CCIP-R-07 has developed or contributed to three key innovations to the reef prioritisation process for the selection of target reefs for the COTS Control Program. These include: 1) contributing to Reef Authority-led innovations in the quantity and quality of data used to inform the prioritisation process; 2) leading the development of the MCDA framework innovating the repeatability and transparency of the prioritisation process, and 3) developing and implementing a swing-weighting methodology to include a broader cross-section of stakeholder perspectives and values into prioritisation.

4.1 Multi-Criteria Decision Analysis

The application of an MCDA process to COTS control prioritisation on the GBR has yielded improvements in both methodology and outcomes, while laying the foundation for further innovations in the future. It is important to note that the COTS Control Program was already using an informal multicriteria approach to identify Priority Reefs for control efforts prior to CCIP. Our contribution was to refine this process by establishing a more robust foundation for eliciting the preferences and then amalgamating the multiple criteria into a single ranking dimension. This refinement will help to establish the prioritisation process on clear, well-defined criteria, and generate decisions that are more defensible, as well as better aligned with the overall goals of reef management. The framework developed is also scalable, allowing the incorporation of broader suites of data and stakeholder values in future.

A key objective was to enhance the ongoing decision-making process *without disrupting* the existing workflows or undermining the support of key stakeholders, including boat operators, research scientists, GBR managers, and regulators. By focusing on improving the foundation and transparency of the MCDA process, we aimed to build on the strengths of the current system while addressing any gaps or weaknesses. This approach helped maintain the confidence and cooperation of all involved parties.

4.2 Swing Weighting

To estimate the relative importance that key stakeholders placed on ecological and economic factors, we used a swing weighting survey. This technique allowed us to capture and quantify the preferences of stakeholders, providing a structured approach to evaluate and compare the significance of different factors.

The preferences elicited through this process matched well with the previous decisions made by the COTS control program (i.e. the approximate 1/3 weight on economic factors versus the 2/3 weight on ecological factors), validating the existing prioritisation criteria and decisions. Although stakeholders' responses exhibited some uncertainty, they were unambiguous about the relative importance of the ecological and economic factors. Stakeholders showed a notable willingness to engage in the swing weighting process, actively participating and asking insightful questions. Their inquiries helped clarify our definitions and the options under consideration, ensuring a mutual understanding and alignment of objectives. This engagement not only enriched the weighting process but also reinforced the stakeholders' understanding of, and confidence in, the prioritisation process.

It is important to note that swing weighting is most effective when there is broad agreement on the structure of the decision and when differences in preferences are a matter of degree rather than fundamental conflict. In contexts where stakeholder groups hold strongly divergent or contested values, eliciting a single set of weights through swing weighting may be challenging or inappropriate. In such cases, alternative approaches, including voting-based or deliberative aggregation methods, may provide a more effective means of capturing plural perspectives, identifying areas of disagreement, and supporting transparent decision-making without forcing artificial consensus.

4.3 Ecological Data Layers

A key innovation over the course of CCIP was the increase in the quantity and quality of data incorporated into prioritisation. This was primarily led by Sam Matthews at the Reef Authority, who both leads the operational prioritisation process and was a researcher on the CCIP-R-07 project team. CCIP-R-07 contributed significant innovations in the data informing prioritisation, and especially the formal methods used to combine data. Together, these research and operational innovations enabled the expansion of ecological data used to inform the prioritisation process from two to five data layers, and allowed the process by which dissimilar types of data are combined to rank reefs to be formalised using the weightings from the stakeholder values elicitation.

In 2021, the ecological data incorporated into prioritisation was expanded significantly, to include five data layers: COTS Risk, Coral Source, Zoning, Resilience, and COTS History. In 2023, a formal process for amalgamating ecological and economic scores into a single multicriteria score was introduced, using results from the swing weighting elicitation.

4.4 Reflections

4.4.1 Refinements to Ecological Data Layers

In 2024, the CCIP-R-07 project team led two sessions at the researcher-focused annual prioritisation workshop. Experts were asked about the enabling conditions and barriers to further refinements to the ways ecological datasets were combined to inform prioritisation based on process-understanding rather than normalisation and weighted summation. They were also asked whether there were additional datasets that could improve the estimation of ecological benefits of COTS control beyond those currently employed in the prioritisation process. There was facilitated discussion around the consequences to reef prioritisation of uncertainty and variability in larval dispersal models, and whether the amount of effort expected to be required to control a reef should affect either its annual prioritisation or its operational prioritisation throughout the year. Information about the manual components of the prioritisation, implemented as “lock in” and “lock out” rules for individual reefs, was presented by the Reef Authority and researchers discussed ways of incorporating more of these manual decisions into the formal MCDA framework.

These discussions identified important opportunities to further refine the prioritisation process and the MCDA framework underpinning it. Vitally, project CCIP-R-07 has provided not just direct innovations over the course of CCIP, but also provided the foundation of an extensible framework that can be expanded to incorporate more ecological data, new types of data, and more input from stakeholders.

4.4.2 Other Types of Data

The biggest additional innovation to the current prioritisation process would be the inclusion of a third value type – cultural value – alongside ecological and economic value. The MCDA framework designed as part of CCIP-R-07 enables the inclusion of additional value types, such as community or cultural values. Similarly, the swing weighting method designed to elicit stakeholders' weights for different values is an extensible framework designed to expand to include additional value types.

Currently, the biggest hurdle to inclusion of Traditional Owner (TO) values, or cultural values, or community values, is the availability of data about the distribution of these values across reefs on the GBR. Project CCIP-R-09 (Backhaus et al. 2026) built relationships with Traditional Owner groups on the GBR. Several other research programs and projects are actively attempting to build a research foundation for this type of information.

However, in the case of Traditional Owner values specifically, future work may be needed to respectfully and equitably integrate Traditional Owner values into prioritisation. Formal mathematical methods may not be accessible to Traditional Owners, so alternative methods of engagement, such as TO-focused prioritisation workshops, may be more effective. If Traditional Owner values are incorporated, further innovations in digital tools may be required to maintain data sovereignty.

4.4.3 Improvements to Inclusivity

The third significant opportunity that became apparent during CCIP-R-07 was the potential to broaden the group of stakeholders and rights-holders in the elicitation, deliberation, and values elicitation processes. Involving diverse groups ensures that the prioritisation decisions reflect the comprehensive range of values and interests of all those affected by the management of the reef. By thoughtfully identifying these broader groups through a structured and inclusive process, we can enhance the legitimacy, transparency, and effectiveness of our decision-making.

In particular, the fact that Indigenous Australians have not been explicitly included in the decision-making process – especially Traditional Owners from the sea countries of the GBR – should be promptly addressed. Since 2021, small numbers of Indigenous representatives from some GBR Sea Country have participated at the annual prioritisation workshops run by the Reef Authority, but this needs to be expanded to provide representation from groups covering a larger proportion of the GBR, and to provide formal pathways for input into decision making. Traditional Owners hold invaluable knowledge, cultural connections, and rights over these lands and seas, and their perspectives are crucial for sustainable and respectful stewardship of the GBR. Ensuring their active participation in the MCDA process will not only honour their rights, but will also enrich the decision-making. Integrating their voices in the prioritisation process will help create a more inclusive, equitable, and holistic approach to COTS management.

Importantly, the challenges, time, and resources involved in respectfully and effectively engaging with a more inclusive group of stakeholders, particularly Traditional Owners, cannot be a reason for avoiding this step. Decisions are currently being made each year about the allocation of large amounts of control resources. When the values of parts of the community are not included in the decision-making process, then the process is implicitly assuming that their importance is zero. Efforts to engage with these groups and incorporate their preferences and values into the decision-making process would improve the current approach.

4.4.4 Improvements to Transparency

Transparency and communication are key to building trust and understanding in the MCDA process – both within the decision-making group, and more broadly among stakeholders and rights-holders. There are three key areas for continued refinement: 1) publication of the outcomes of the annual prioritisation, 2) clear documentation of methods; and 3) capability building amongst stakeholders to understand and engage effectively in prioritisation. Publishing clear outcomes and explanations of the annual prioritisation process will be central to building trust and transparency.

Since 2020, the Reef Authority have made significant progress and driven innovation by providing annual reports and a public-facing interactive web dashboard on COTS Control Program progress. As the underlying prioritisation tools continue to be refined, there will be opportunities to create infographic visual aids and prioritisation-specific interactive stakeholder dashboards to more effectively communicate prioritisation results and the decision-making process, making the information accessible and comprehensible to stakeholder groups involved in prioritisation.

These dynamic outputs of prioritisation need to be paired with clear, detailed documentation of the process and its methodologies to help stakeholders and the broader public understand how decisions are made. Additional targeted training sessions on the MCDA process and its components could empower stakeholders with the knowledge and skills needed to participate effectively. Ensuring stakeholders fully understand the implications of their input and the overall decision-making framework could lead to more informed and meaningful contributions, strengthening the process's foundation.

4.4.5 Refinements to the MCDA

The MCDA process developed as part of CCIP-R-07 was implemented in parallel with the operational prioritisation process for the COTS Control Program being run by the Reef Authority. Many of the decisions about how and with whom to engage as part of CCIP-R-07 were guided by the need to avoid disrupting the program itself. Future refinements could consider more advanced MCDA techniques, new types and sources of data, embedding learning, and better characterisation of uncertainty.

CCIP-R-07 provided a formal MCDA framework and structure to underpin the annual prioritisation process. However, more advanced MCDA weighting and amalgamation techniques could provide further refinement. For instance, the Analytic Hierarchy Process (AHP) offers a structured approach to deriving weights through pairwise comparisons of criteria, rather than direct elicitation alone (Anselin et al. 1989). In AHP, decision-makers compare criteria two at a time in terms of their relative importance, producing a comparison matrix from which a consistent set of weights is mathematically inferred. This process includes an internal consistency check, allowing the degree of logical coherence in stakeholder judgements to be quantified and, if necessary, revised. Applying AHP alongside swing weighting would provide a complementary means of validating inferred weights, identifying inconsistencies in preference elicitation, and assessing the robustness of prioritisation outcomes to alternative weighting formulations.

The inclusion of additional criteria could enhance the comprehensiveness of the MCDA process. Integrating new criteria such as climate resilience or socio-economic impacts on local communities could provide a more holistic view of each reef's value. Evaluating the potential benefits of including additional ecological indicators or socio-economic factors would ensure that the prioritisation process reflected a wide range of relevant considerations.

Improving data quality, diversity, and integration would increase the accuracy and relevance of the MCDA process. Continuously updating and refining the ecological and economic data layers that we do have with the latest research and field data will ensure that the prioritisation reflects current conditions. In particular, incorporating more granular data could capture finer-scale variations in tourism and other economic activity that would provide a more detailed and accurate basis for decision-making.

Closing the loop on stakeholder engagement, and establishing regular review and feedback loops would ensure that the MCDA process remains dynamic and responsive to new insights. Over the course of CCIP-R-07, annual workshops were used to incorporate stakeholder feedback and practical experiences to refine the MCDA process itself. Implementing an ongoing feedback loop mechanism would allow for the ongoing refinement of the process based on evolving priorities and conditions, while building stronger consensus and buy-in from all involved parties.

Finally, conducting more extensive sensitivity analyses could add more valuable improvement. These analyses would help us to understand the impact of different weighting scenarios on decision-making. Proposed target lists could be assessed with GBR-scale models to better understand regional scale coral protection outcomes. Sensitivity analysis could reveal how changes in input values affect the final scores, providing insights for more resilient and adaptable prioritisation strategies. Conducting more extensive sensitivity analyses would further strengthen the prioritisation framework. These analyses would clarify, for example, how alternative weighting scenarios influence reef rankings and decision outcomes. Beyond sensitivity to parameter values alone (for example, criterion weights or input layer uncertainty), future analyses should test sensitivity to structural assumptions embedded in the prioritisation process. These include the choice of aggregation function used to combine criteria, the treatment of trade-offs and thresholds, and the handling of correlated or redundant input layers. Exploring alternatives would help identify conditions under which rankings are robust or fragile, and support the development of more resilient and adaptable prioritisation strategies.

4.5 Outputs

CCIP-R-07 produced three key outputs:

- Framework for combining multiple criteria to inform reef prioritisation (e.g. weightings).
- Survey method to elicit values across stakeholders involved in reef prioritisation decision making.
- Analysis of implicit weightings applied in past prioritisation processes.

5. RESEARCH SYNERGIES AND NEXT STEPS

CCIP-R-07 is a strong enabler providing a direct path to impact for several other CCIP projects, and increasing the impact of other CCIP research by facilitating the integration of more effective predictions into management decision making.

CCIP-R-07 has particularly strong existing links to projects CCIP-R-02 *Empirical Decision Support: using Control Program data to make real-world decisions* (Fletcher et al. 2026), and CCIP-R-05 *Ensemble modelling of COTS dispersal: Probabilistic approach to COTS dispersal* (Choukroun et al. 2026). CCIP-R-05 provides the larval dispersal models that underpin two of the five ecological data layers that inform prioritisation. CCIP-R-02 provides empirical analysis of COTS Program Data delivered via CCIP-R-01 (Fletcher and Rezvani 2026) and linked Power BI Dashboards to the Reef Authority some of which inform the prioritisation process, including the CCIP-R-05 data and the Early Warning Dashboard.

Additionally, CCIP-R-07 has strong potential links to projects CCIP-R-04, CCIP-R-06, CCIP-R-08 and CCIP-R-09. CCIP-R-04 *Regional modelling and decision support strategies for COTS control and ecosystem resilience* (Skinner et al. 2025) has the potential to significantly innovate and improve how ecological data is combined within the MCDA using a process-based understanding of how interventions create impact at the GBR scale. Project CCIP-R-06 *Platform for identifying effectiveness, cost-effectiveness, and efficiency gains of manual COTS control* (Scheufele et al. 2025) has the potential to play a similar role for economic data, as well as adding additional data layers to the single tourism visitation data layer currently used to estimate economic value.

Projects CCIP-R-08 *Stakeholder perceptions of COTS management, socio-economic risks, opportunities and co-benefits* (Lockie et al. 2025) and CCIP-R-09 *Reef Traditional Owner co-design, values and governance assessment* (Backhaus et al. 2026) will provide the underpinning relationships and potentially data to inform new types of values in future prioritisation efforts, including community values and Traditional Owner values.

Finally, CCIP-R-07 has strong research synergies with efforts planned and underway to inform the prioritisation of non-COTS interventions as part of the Reef Restoration and Adaptation Program (RRAP). The framework and methods developed for CCIP-R-07 are transferrable to these other GBR contexts.

5.1 Next Steps

The three key priorities for further development of the MCDA are:

- Inclusion of new value types alongside ecological and economic value, most importantly Traditional Owner values.
- Inclusion of broader cross-section of stakeholders in the values weights elicitation.
- Refinement of the data informing ecological and economic values.

6. MANAGEMENT IMPLICATIONS AND IMPACT

Project CCIP-R-07 drove real world impact through its direct connection to the COTS Control Program operational reef prioritisation process run by the Reef Authority. The project team included in-kind contribution of time, research contribution, and close collaboration from a key manager at the Reef Authority responsible for implementing the operational prioritisation process, giving research innovation a direct path into the operational prioritisation process. The immediate and intrinsic link between research and management allows research innovations to be immediately integrated into management, tested and refined. It also facilitated capability building across the research-management-stakeholder spectrum for new, more inclusive approaches to prioritisation combining analytic approaches to estimating the protection provided by control actions with an understanding of the values being protected.

As such, the key immediate management implications from CCIP-R-07 are already integrated into the prioritisation process, which is now underpinned by a repeatable and transparent framework for multi-criteria decision analysis. The framework is scalable to include multiple new data layers, such as improved measures of ecological value. Vitally, it is able to include new types of data, such as community, cultural, or Traditional Owner values. In addition, a swing weighting framework for stakeholder elicitation has been developed to allow the combination of dissimilar types of values in a repeatable, transparent, and defensible manner.

The key ongoing management implications revolve around the future improvements this framework will enable. The most transformational, and most challenging, of these will be the inclusion of Traditional Owner values. An associated but distinct innovation is the broadening of the stakeholder base from whom value weights are elicited, both across general stakeholder groups, and specifically to include the preferences of Traditional Owners. Project CCIP-R-07 provides the frameworks and tools to enable both of these transformations, but work remains to build the relationships, engage and invite community and Traditional Owner groups into the prioritisation process. While this can be assisted and facilitated by researchers, to put new participants on the same footing as existing stakeholders, it is important that the process is driven by the operational research program managed by the Reef Authority.

There were three key outputs for project CCIP-R-07: 1) a framework for combining multiple criteria to inform reef prioritisation (e.g. weightings); 2) an analysis of implicit weightings applied in past prioritisation processes; and 3) the development of a survey method to elicit values across stakeholders involved in reef prioritisation decision making.

The key entry point for the project into COTS management is the Annual Reef Prioritisation Process. However, the intrinsic integration of stakeholder engagement into the prioritisation process also allows it to contribute to Governance, Engagement & Communications. The connections include:

- **Annual Reef Prioritisation Process:** All three outputs clearly contribute to the Annual Reef Prioritisation Process. The framework for combining multiple criteria to inform reef prioritisation has been integrated into the way the Reef Authority prepares data to rank reefs prior to prioritisation. It provides a repeatable, scalable and transparent framework that will allow the prioritisation process to continue to incorporate new data and new types of data. The survey method to elicit values across stakeholders involved in reef prioritisation decision making has been developed and tested using the current stakeholders of the prioritisation process. It also provides a scalable methodology for incorporating input from a much broader range of stakeholders during future elicitations. Finally, the analysis of the implicit weightings applied in past prioritisation processes confirmed that they were a reasonable reflection of stakeholders' explicit preferences when asked directly, providing confidence in both previous prioritisation efforts, and the new methods developed as part of CCIP-R-07.

- **Governance, Engagement & Communications:** The survey method to elicit values across stakeholders involved in reef prioritisation decision making provides a clear path to innovating the way stakeholders are engaged in the COTS Control Decision making process, and in the process, provides a platform for improved communications and more effective and engaged governance. Not captured is the benefit to engagement and governance of the inclusion of additional value types, such as Traditional Owner values, in the prioritisation process. Both of these examples illustrate that providing stakeholders with clear, well-defined means to engage in the prioritisation process will ensure that communication and engagement are improved, and provide a governance pathway for stakeholder preferences and decisions to influence where COTS Control Program resources are invested in the areas they value.

The prioritisation framework developed as part of CCIP-R-07 also has implications for other GBR research programs planning to invest resources on interventions in the locations stakeholders value, most directly the Reef Restoration and Adaptation Program. Many of the methods developed as part of CCIP-R-07 will be transferable to other contexts. Even more importantly, there are arguments for considering new interventions alongside existing COTS management efforts, and many of the stakeholder groups between the two programs overlap.

Project CCIP-R-07 contributed to the overarching outcomes and impacts identified in CCIPs Research Impact Plan and Program Logic (**Figure 3**). Specifically, it delivers a more efficient and effective operational response by ensuring that the reefs targeted for control are those that protect the greatest ecological and economic value, and that the portfolio of protected reefs reflects the value preferences of key stakeholders. It also facilitates the integration of more effective predictions from other CCIP projects into management decision making. By effectively targeting control actions to protect the GBR values that stakeholders care about, it drives impacts across all three areas identified in the CCIP Program Logic: better suppression and prevention of COTS outbreaks, protection of coral cover, leading to benefits for Traditional Owners, the tourism industry, and the Australian community as a whole.

7. ACKNOWLEDGEMENTS

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8. DATA ACCESSIBILITY

There are no data available with this report. The human ethics and privacy approval require secure storage of the swing weighting elicitation survey data collected from participants.

9. REFERENCES

Adem Esmail B, Geneletti D (2018) Multi-criteria decision analysis for nature conservation: A review of 20 years of applications. Methods in Ecology and Evolution 9:42–53. https://doi.org/10.1111/2041-210X.12899

Anselin A, Meire PM, Anselin L (1989) Multicriteria techniques in ecological evaluation: an example using the Analytical Hierarchy Process. Biological Conservation 49:215-229. https://doi.org/10.1016/0006-3207(89)90037-2

Babcock RC, Plagányi ÉE, Condie SA, Westcott DA, Fletcher CS, Bonin MC, Cameron D (2020) Suppressing the next crown-of-thorns outbreak on the Great Barrier Reef. Coral Reefs 39:1233–1244. https://doi.org/10.1007/s00338-020-01978-8

Backhaus V, Lockie S, Dynevor T, Shipton M and Mann, M (2026) Sharing Story with the Reef: Genuine partnerships with Reef Traditional Owners and Crown-Of-Thorns Starfish (COTS) research and management. A report to the Australian Government by the COTS Control Innovation Program. Belton V, Stewart TJ (2002) Multiple Criteria Decision Analysis. An Integrated Approach. Springer, New York.

Bode M, Day JC (2020) The Great Barrier Reef - systematically protecting connectivity without connectivity data. IUCN Guidance for Conserving Connectivity through Ecological Corridors and Networks. IUCN, Gland.

Bozec Y-M, Hock K, Mason R, Baird ME, Castro-Sanguino C, Condie SA, Puotinen M, Thompson A, Mumby PJ (2021) Cumulative impacts across Australia's Great Barrier Reef: A mechanistic evaluation. Ecological Monographs 91:1–2. https://doi.org/10.1002/ecm.1494

Choukroun S, Bode M, Stewart O, Porobic J, Langlais C, Lambrechts J, Mason L (2026) Crown-of-thorns starfish (COTS) connectivity modelling under multidimensional uncertainties on Australia's Great Barrier Reef. A report to the Australian Government by the COTS Control Innovation Program.

De Almeida AT, De Almeida JA, Costa APCS, De Almeida-Filho AT (2016) A new method for elicitation of criteria weights in additive models: Flexible and interactive tradeoff. European Journal of Operational Research 250:179–191. https://doi.org/10.1016/j.ejor.2015.08.058

De'Ath G, Fabricius KE, Sweatman H, Puotinen M (2012) The 27-year decline of coral cover on the Great Barrier Reef and its causes. Proceedings of the National Academy of Sciences of the United States of America 109: 17995–17999. https://doi.org/10.1073/pnas.1208909109

Deloitte (2013) Economic contribution of the Great Barrier Reef. GBRMPA, Townsville.

Dietzel A, Connolly SR, Hughes TP, Bode M (2021) The spatial footprint and patchiness of large-scale disturbances on coral reefs. Global Change Biology 27:4825–4838. https://doi.org/10.1111/gcb.15805

Driscoll D, Lindenmayer D, Bennett A, Bode M, Bradstock R, Cary G, Clarke M, Dexter N, Fensham R, Friend G, Gill M, James S, Kay G, Keith D, MacGregor C, Russell-Smith J, Salt D, Watson J, Williams R, York A (2010a) Fire management for biodiversity conservation: Key research questions and our capacity to answer them. Biological Conservation 143:1928–1939. https://doi.org/10.1016/j.biocon.2010.05.026

Driscoll D, Lindenmayer D, Bennett A, Bode M, Bradstock R, Cary G, Clarke M, Dexter N, Fensham R, Friend G, Gill M, James S, Kay G, Keith D, MacGregor C, Possingham H, Russel-Smith J, Salt D, Watson J, Williams D, York A (2010b) Resolving conflicts in fire management using decision theory: asset-protection versus biodiversity conservation. Conservation Letters 3:215–223. https://doi.org/10.1111/j.1755-263X.2010.00115.x

Driscoll DA, Bode M, Bradstock RA, Keith DA, Penman TD, Price OF (2016) Resolving future fire management conflicts using multicriteria decision making. Conservation Biology 30:196–205. https://doi.org/10.1111/cobi.12580

Fletcher CS, Chen C, Waters EK, Matthews S, Rezvani M (2026) Empirical Decision Support: using Crown-of-Thorns Starfish (COTS) Control Program data to make real-world decisions. A report to the Australian Government by the COTS Control Innovation Program.
Fletcher CS, Rezvani M (2026) Information Infrastructure to Underpin and Accelerate Innovation in COTS Control. A report to the Australian Government by the COTS Control Innovation Program.
Great Barrier Reef Marine Park Authority (2025) Crown-of-thorns Starfish Control Program Annual Report Great Barrier Reef Marine Park Authority, Townsville, Australia.
Gregory R, Failing L, Harstone M, Long G, McDaniels T, Ohlson D (2012) Structured decision making: a practical guide to environmental management choices. John Wiley & Sons.
Hansen P, Ombler F (2008) A new method for scoring additive multi-attribute value models using pairwise rankings of alternatives. Journal of Multi-Criteria Decision Analysis 15:87–107. https://doi.org/10.1002/mcda.428
Hock K, Wolff NH, Condie SA, Anthony KRN, Mumby PJ (2014) Connectivity networks reveal the risks of crown-of-thorns starfish outbreaks on the Great Barrier Reef. Journal of Applied Ecology 51:1188-1196. https://doi.org/10.1111/1365-2664.1232
Lockie S, Fidelman P, Paxton G, Bartelet H, Brooksbank L, Graham V, Draaisma L, Backhaus V (2025) Perceptions of crown-of-thorns starfish (COTS) management in the Great Barrier Reef, economic and social co-benefits, and regulatory considerations. A report to the Australian Government by the COTS Control Innovation Program.
Marshall N, Barnes ML, Birtles A, Brown K, Cinner J, Curnock M, Eakin H, Goldberg J, Gooch M, Kittinger J, Marshall P, Manuel-Navarrete D, Pelling M, Pert PL, Smit B, Tobin R (2018) Measuring what matters in the Great Barrier Reef. Frontiers in Ecology and the Environment 16:271–277. https://doi.org/10.1002/fee.1808
Matthews SA, Mellin C, Pratchett MS (2020) Larval connectivity and water quality explain spatial distribution of crown-of-thorns starfish outbreaks across the Great Barrier Reef. Advances in Marine Biology 87:223–258. https://doi.org/10.1016/bs.amb.2020.08.007
Matthews SA, Williamson DH, Beeden R, Emslie MJ, Abom RT, Beard D, Bonin M, Bray P, Campili AR, Ceccarelli DM (2024) Protecting Great Barrier Reef resilience through effective management of crown-of-thorns starfish outbreaks. PloS One 19:e0298073. https://doi.org/10.1371/journal.pone.0298073
Mellin C, Matthews S, Anthony KRN, Brown SC, Caley MJ, Johns KA, Osborne K, Puotinen M, Thompson A, Wolff NH, Fordham DA, MacNeil MA (2019) Spatial resilience of the Great Barrier Reef under cumulative disturbance impacts. Global Change Biology 25:2431–2445. https://doi.org/10.1111/gcb.14625
Mukherjee N, Zabala A, Huge J, Nyumba TO, Adem Esmail B, Sutherland WJ (2018) Comparison of techniques for eliciting views and judgements in decision-making. Methods in Ecology and Evolution 9:54–63. https://doi.org/10.1111/2041-210X.12940
O.Nyumba T, Wilson K, Derrick CJ, Mukherjee N (2018) The use of focus group discussion methodology: Insights from two decades of application in conservation. Methods in Ecology and Evolution 9:20–32. https://doi.org/10.1111/2041-210X.12860
Scheufele G, Skinner C, Fletcher CS (2025) Economic assessment of manual crown-of-thorns-starfish (COTS) control scenarios on the Great Barrier Reef. A report to the Australian Government by the COTS Control Innovation Program.
Skinner C, Condie SA, Fletcher CS, Mumby PJ (2025) Assessing Alternative Control Scenarios for Crown-of-Thorns Starfish on the Great Barrier Reef: An Ensemble Approach. A report to the Australian Government by the COTS Control Innovation Program.
Wallace KJ, Wagner C, Smith MJ (2016) Eliciting human values for conservation planning and decisions: A global issue. Journal of Environmental Management 170:160–168. https://doi.org/10.1016/j.jenvman.2015.12.036
Westcott D, Fletcher C (2018) How effective are management responses in controlling crown of-thorns starfish and their impacts on the Great Barrier Reef. A Report for NESP Tropical Water Quality

Hub Integrated Pest Management Program. https://nesptropical.edu.au/wp-content/uploads/2020/07/CSIRO-COTS-Control-Effectiveness-Report.pdf

Westcott DA, Fletcher CS, Gladish DW, Macdonald S, Condie S (2021) Integrated pest management crown-of-thorns starfish control program on the Great Barrier Reef: current performance and future potential. Reef and Rainforest Research Centre Limited, Cairns. https://nesptropical.edu.au/wp-content/uploads/2021/03/NESP-TWQ-Project-5.1-Technical-Report-4.pdf

Westcott DA, Fletcher CS, Kroon FJ, Babcock RC, Plagányi EE, Pratchett MS, Bonin MC (2020) Relative efficacy of three approaches to mitigate Crown-of-Thorns Starfish outbreaks on Australia's Great Barrier Reef. Scientific Reports 2020 10:1 10:1–12. https://doi.org/10.1038/s41598-020-69466-1

Whitehead AL, Kujala H, Ives CD, Gordon A, Lentini PE, Wintle BA, Nicholson E, Raymond CM (2014) Integrating biological and social values when prioritizing places for biodiversity conservation. Conservation Biology 28:992–1003. https://doi.org/10.1111/cobi.12257

APPENDIX A– ONLINE SWING WEIGHTING ELICITATION SURVEY

Background

The elicitation process is designed to capture how different people value different benefits provided by different types of reefs, without trying to analyse the impossibly wide range of specific characteristics that would be required to fully specify any real reef. The process does not require a detailed knowledge of crown-of-thorns starfish or how reefs function ecologically. There is no right answer; the process is designed to elicit how you value the qualities described, and the survey will separately ask a small number of questions to understand where you sit in the community of GBR stakeholders.

The survey you complete will inform a research project designed to improve our understanding of how to incorporate stakeholder values into prioritisation. The outcomes of the elicitation will not be used in their raw format.

Instead, a large number of results will be analysed statistically and combined with advanced scientific, model output and empirical data to estimate the mix of values protected under different management strategies. The questions ask you to estimate each answer as a “range” of values encompassing your best estimate and your certainty. The fact that this information gets accumulated across a number of stakeholders provides for diverse input and reduces the sensitivity of the process to the precise value of any one answer.

This structure means that individual answers do not have to be precise or certain. It is recommended that you don’t invest too much time over the selection of the precise value with which you answer each question, but that you instead focus on getting values that are reasonable in both an absolute and a relative sense.

Swing weighting exercise #1: Ranking reefs.

Consider four hypothetical reefs:

Reef 1: is an ideal reef, which delivers both Ecological and Economic benefits.
Reef 2: delivers Economic benefits but fails to deliver Ecological benefits.
Reef 3: delivers Ecological benefits but fails to deliver Economic benefits
Reef 4: A worst-case reef, that delivers neither Ecological nor Economic benefits

The reefs are otherwise identical (e.g. similar distance to ports, similar harbouring options).

	Ecological benefits?	Economic benefits?
Reef 1	**Yes**	**Yes**

Reef 2	No	Yes
Reef 3	Yes	No
Reef 4	No	No

Question 1:

A COTS outbreak is occurring on each of these reefs. You can't afford to effectively control COTS on every one of the reefs. You need to choose the most valuable reefs from the set.

Rank the reefs in the order that you would choose them, from the most valuable, to the least valuable, or select “Prefer not to answer”.

- Reef 1
- Reef 2
- Reef 3
- Reef 4

Swing weighting exercise #2: Assigning value.

Consider the same six hypothetical reefs:

Reef 1: is an ideal reef, which delivers both Ecological and Economic benefits.
Reef 2: delivers Economic benefits but fails to deliver Ecological benefits.
Reef 3: delivers Ecological benefits but fails to deliver Economic benefits
Reef 4: A worst-case reef, that delivers neither Ecological not Economic benefits

The reefs are otherwise identical (e.g. similar distance to ports, similar harbouring options).

	Ecological benefits?	Economic benefits?
Reef 1	Yes	Yes
Reef 2	No	Yes
Reef 3	Yes	No
Reef 4	No	No

In the questions that follow, we're going to ask you to assign a numerical value to each of these reefs. We are going to assume that you will assign the highest value to **Reef 1**, which delivers on all the criteria.

Ideally, the numerical value you assign to each reef will yield the same ranking as the previous swing-weighting exercise.

Question 2:

Reef 2: delivers Economic benefits but fails to deliver Ecological benefits.

Please tell us how much you value **Reef 2**, one a scale of 1 to 10, where 10 is the value of the ideal reef (i.e., **Reef 1**).

Please provide your assessment as a range of values based on your certainty. For instance, if you believe Reef 2 has a “moderate” value and you are relatively certain of that, you might select values of 4 and 5. However, if you feel Reef 2 has a “moderate” value, but you are not very certain, you might select values of 2, 3, 4, 5, 6 and 7. If you are completely uncertain or do not want to or feel comfortable answering a question, select all values 1 – 10, or select the option “Prefer not to answer”.

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Question 3:

Reef 3: delivers Ecological benefits but fails to deliver Economic benefits

Please tell us how much you value **Reef 3**, one a scale of 1 to 10, where 10 is the value of the ideal reef (i.e., **Reef 1**).

Please provide your assessment as a range of values based on your certainty. For instance, if you believe Reef 3 has a “moderate” value and you are relatively certain of that, you might select values of 4 and 5. However, if you feel Reef 3 has a “moderate” value, but you are not very certain, you might select values of 2, 3, 4, 5, 6 and 7. If you are completely uncertain or do not want to or feel comfortable answering a question, select all values 1 – 10, or select the option “Prefer not to answer”.

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Question 4:

Reef 4: A worst-case reef, that delivers neither Ecological nor Economic benefits

Please tell us how much you value **Reef 4**, one a scale of 1 to 10, where 10 is the value of the ideal reef (i.e., **Reef 1**).

Please provide your assessment as a range of values based on your certainty. For instance, if you believe Reef 4 has a “moderate” value and you are relatively certain of that, you might select values of 4 and 5. However, if you feel Reef 4 has a “moderate” value, but you are not very certain, you might select values of 2, 3, 4, 5, 6 and 7. If you are completely uncertain or do not want to or feel comfortable answering a question, select all values 1 – 10, or select the option “Prefer not to answer”.

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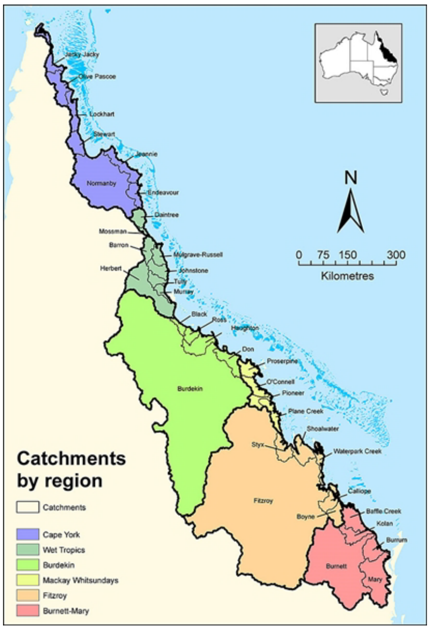
Detail about yourself

The goal of this process is to understand how different individuals and different groups value the Great Barrier Reef, so that the COTS control decisions can reflect the values of the community.

To ensure that we're engaging with a broad cross-section of this community, the following questions are designed to help understand which parts of the GBR community your views represent. The information provided will be used to assess and summarise the representativeness of the questionnaire sample when reporting results.

Question 5:

Which of the following broad regions of the GBR do you have connections to? This could include where you were born, where you have previously or currently live, or locations where you have worked.



Multiple answers are possible.

☐ Cape York region

☐ Wet Tropics region

☐ Burdekin region

☐ Mackay Whitsunday region

☐ Fitzroy region

☐ Burnett Mary region

☐ Prefer not to answer

Question 6:

What age range are you?

○ Under 25

○ 25 – 35

○ 35 – 45

○ 45 – 55

○ 55 – 65

○ Over 65

☐ Prefer not to answer

Question 7:

What gender do you identify as?

○ Woman

○ Man

○ Non-binary

☐ Prefer not to answer

Question 8:

Do you identify as Aboriginal or Torres Strait Islander?

○ Yes

○ No

☐ Prefer not to answer

Question 9:

Do you relate to the Great Barrier Reef in the role of (tick all that apply):

☐ Resident of a GBR catchment

☐ Recreational user (e.g. recreational fisher or diver)

☐ Tourism operator or employee

☐ Other commercial user (e.g. commercial fisher, other commercial uses)

☐ Scientist or researcher

☐ Reef manager

☐ Traditional Owner

☐ Prefer not to answer

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