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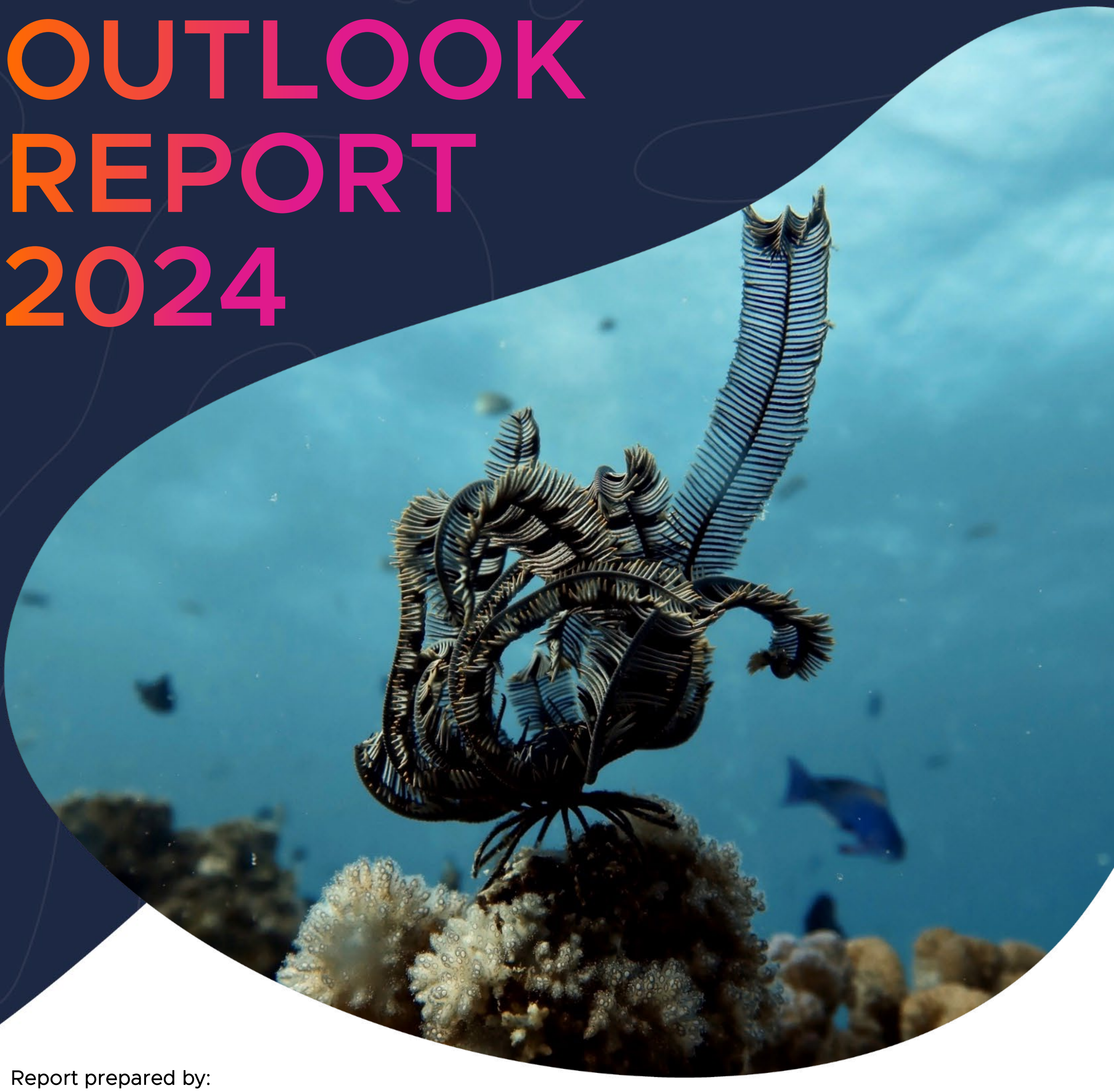
Reef Authority

The rapid assessment workshops to elicit expert input to inform the

GREAT BARRIER REEF OUTLOOK REPORT 2024



Report prepared by:
Anthony Boxshall, *Science into Action* and Simon Torok, Scientell
For the Great Barrier Reef Marine Park Authority

SCIENCE INTO ACTION

scientell
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Great Barrier Reef Outlook Report 2024

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August 2023

Published by the Great Barrier Reef Marine Park Authority
ISBN 978-0-6453809-0-3

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A catalogue record for this report is available from the National Library of Australia

Cover image: Feather star on the top of the reef crest.© Ryan Ramasamy (2023)

This publication should be cited as:
Boxshall, A. and Torok, S. 2024, *The Rapid Assessment Workshops to Elicit Expert Input to Inform the Development of the Great Barrier Reef Outlook Report 2024*, Great Barrier Reef Marine Park Authority, Townsville.

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Acknowledgements

Science into Action, Scientell, and the Great Barrier Reef Marine Park Authority acknowledge the expertise, wisdom, and enduring connections that have informed the guardianship of the Reef for millennia. We pay our respects to the Traditional Owners as the first managers of this land and sea Country, and value their traditional knowledge, which continues to inform the current management and stewardship of the Reef for future generations.

We gratefully acknowledge the time and effort given by participants in the workshops, including for preparation, attendance and post-workshop follow-up.

The facilitators and the Great Barrier Reef Marine Park Authority acknowledge the substantial contribution that participating experts made to the workshops, drawing on their time, effort and expertise (see Appendix 3 for a list of all experts).

We acknowledge the work done for past Outlook Reports by other authors to produce the previous versions of this report. We have learned from their processes and reports and have built on the content, process and format of previous reports, especially the 2019 report by Terry Harper.

Thanks to the Outlook Report team at the Great Barrier Reef Marine Park Authority for their input and energy, in particular Rohana Rogan-Darvill, Ryan Ramasamy, Dieter Tracey and Chloe Schauble.

Summary

The Great Barrier Reef Marine Park Authority (the Reef Authority) convened the rapid assessment workshops in Townsville from 7 to 11 August 2023. The workshops obtained independent expert judgements on the condition, trends, and risks to the Great Barrier Reef Region's Indigenous cultural values, historic heritage, biodiversity, and ecosystem health. The outputs informed the Great Barrier Reef Outlook Report 2024, augmenting other lines of evidence, including consultation with Reef Authority experts, research papers, and information sent by internal and external experts.

The workshops were facilitated by Dr Anthony Boxshall, *Science into Action*, and Dr Simon Torok, Scientell, external facilitators independent of the Reef Authority with extensive knowledge of marine, climate and environmental science, and experience in facilitating science and management teams. Forty-eight participants (including three by proxy) participated, invited for their discipline expertise and direct experience with scientific research and monitoring in the Region.

Each workshop involved anonymous voting on the condition, trends and risks relating to the Region. Groups of experts assessed four Indigenous living culture values, four historic heritage values, and 57 biodiversity and ecosystem health values. They also assessed 45 threats to heritage values, and 42 threats to natural values.

For each component, experts assessed the condition and trend, confidence in these, comfort in the process, discussed caveats, provided any new information about the component, and made any final comments. The condition and trend were assessed for 'Worst 10%', 'Most', and 'Best 10%'. Risk levels for each threat were assessed as low, medium, high, or very high. Experts generally assessed risks for the current state and immediate future (from 2024 to 2029). Participants were introduced to the potential for several sources of bias so these could be addressed and documented.

The voting was completed using methods derived from the Great Barrier Reef Outlook Report 2009, repeated in 2014 and 2019, to maintain consistency. Overall, the participants were supportive of the workshop process and outcomes, providing a solid basis for the Reef Authority to use the outcomes in the 2024 Outlook Report. Workshop participants provided important feedback about potential improvements in the process and offered constructive comments about future rapid assessment workshops. In particular, Indigenous participants commented on the need for significant change to the process, including deeper Indigenous engagement. Other suggested improvements to the method include continuing to use small but deep expert discussions, altering the condition assessment voting to use three integers for

each of the four condition-grading categories, and altering the risk assessment process to focus on evidence of change since the previous Outlook Report. There was a general call from most experts for most components that there is a need to collect more data on the biota that contribute to the functioning of the reef ecosystems.

The rapid expert assessment of Indigenous living culture values did not involve formal voting due to the need for broader representation of Traditional Owners and a desire to consider land and sea country holistically. However, the general expert opinion about the condition of cultural values was that it is poor and continuing to deteriorate, that cultural values are not systematically known or identified, and that the condition of cultural values would not be uniform across different groups.

Of the five historic heritage values, the three considered in detail were assessed to be in poor to very poor condition. The condition of those values assessed was determined to be deteriorating due to an acceleration of natural degradation likely due to human activities. While confidence in the results was generally high, experts noted the lack of information for many historic sites and artefacts.

Eight of the identified threats to heritage values components assessed at the Region scale were considered to pose a Very High risk, with 17 a High risk. Four were assessed to be a Medium risk, and one a Low risk. In addition, of the 13 threats assessed at the local scale, three were considered Very High, nine High, and one Medium risk.

Biodiversity experts assessed 10 habitats that support species to be in generally good condition although coral reefs (except in the north of the Region) were assessed as poor. Confidence in the condition result was generally medium to high. There was generally medium confidence in a stable or no clear trend for most habitats.

The assessment of 16 components describing species populations was generally good, with the condition of some species being poor. Confidence ranged from low to high, depending on the extent of monitoring of different species. Many showed no clear trend, and some were stable.

Participants provided a narrative assessment for most physical and chemical processes components. Of those not formally assessed through voting, many had little evidence of any change, or no changes adversely affecting the Region.

The condition assessments of ecological processes were variable, being poor, good, or very good, with stable or no clear trends.

Two of the seven components in the category of coastal ecosystems that support the Great Barrier Reef were assessed in detail, with voting on condition as good and poor, with a stable trend.

Of the 42 threats assessed for residual risk against natural values components at a Region scale, two were considered to pose a Very High risk, 13 a High risk, 19 a Medium risk, and eight a low risk. The risks were assessed to be greater at the local scale.

Participants also assessed the risks against a climate change scenario involving more significant mitigation action, noting a change in the risk level of some threats over the next 20 to 30 years. For a more optimistic climate change scenario, there would be a chance for the negative impacts on the Great Barrier Reef Region to be reduced earlier and recovery to occur faster.

Reason for the workshops

The purpose of the rapid assessment workshops was to obtain input from independent scientific experts, including a generally accepted opinion among participants, on the condition and trend of, and risks to, identified ecosystem and heritage values of the Great Barrier Reef Region. The information and expert judgements collected supported the drafting of the Great Barrier Reef Outlook Report 2024.

The Great Barrier Reef Outlook Report is produced every five years. The focus is on the Great Barrier Reef Region (the Region), as defined in the *Great Barrier Reef Marine Park Act 1975*. The Region's boundaries match those of the Great Barrier Reef Marine Park (Marine Park), except that the Region also includes designated areas around major ports (see Figure 1). The *Great Barrier Reef Outlook Report 2009*[1], the *Great Barrier Reef Outlook Report 2014*[2] and the *Great Barrier Reef Outlook Report 2019*[3] (hereafter referred to as the 2009, 2014, and 2019 Outlook Report, respectively) assessed all parts of the ecosystem within the Region, including mangroves and seagrass meadows, fish, coral reefs and the open ocean. These components of the natural system are collectively referred to as the Great Barrier Reef ecosystem. Where relevant, the reports also looked beyond the boundaries of the Region and included information about adjacent islands, and the adjacent catchment that connects to, supports and influences the Region (also illustrated in Figure 1, which was displayed at the workshops).

In assessing the Region, workshop participants included considerations of Commonwealth islands but excluded consideration of those not part of the Region, such as Queensland state islands. For example, if a historic lightstation was on a state island, this was not considered. However, when assessing species such as birds, cultural landscape, or natural processes that are outside the Region but affect the Great Barrier Reef ecosystem, these were considered as they, or their influence, physically extend inside the Region's boundaries (see Clause 3(a) below).

The 2024 Outlook Report is structured around nine assessments required by the

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[1] Great Barrier Reef Marine Park Authority. 2009, Great Barrier Reef Outlook Report 2009. https://hdl.handle.net/11017/199

[2] Great Barrier Reef Marine Park Authority. 2014, Great Barrier Reef Outlook Report 2014. https://hdl.handle.net/11017/2855

[3] Great Barrier Reef Marine Park Authority. 2019, Great Barrier Reef Outlook Report 2019. https://hdl.handle.net/11017/3474

Great Barrier Reef Marine Park Act 1975 (Section 54) and Great Barrier Reef Marine Park Regulations 2019 (section 176 – relevant heritage values), with each forming a chapter of the report.

Extract from the *Great Barrier Reef Marine Park Act 1975 (Section 54)*:

Content of report

(3) The report must contain the following matters:

(a) an assessment of the current health of the ecosystem within the Great Barrier Reef Region and of the ecosystem outside that region to the extent it affects that region;

(b) an assessment of the current biodiversity within that region;

(c) an assessment of the commercial and non-commercial use of that region;

(d) an assessment of the risks to the ecosystem within that region;

(e) an assessment of the current resilience of the ecosystem within that region;

(f) an assessment of the existing measures to protect and manage the ecosystem within that region;

(g) an assessment of the factors influencing the current and projected future environmental, economic and social values of that region;

(h) an assessment of the long-term outlook for the ecosystem within that region;

(i) any other matter prescribed by the regulations for the purposes of this paragraph.

Extract from the Great Barrier Reef Marine Park Regulations 2019 – Section 176

(1) For Paragraph 54(3)(i) of the Act, an assessment of heritage values of the Great Barrier Reef Region is prescribed as a matter that must be contained in the Great Barrier Reef Outlook Report

(2) An assessment of the heritage values, of the Great Barrier Reef Region, includes the following:

(a) an assessment of the current heritage values of the region;

(b) an assessment of the risks to the heritage values of the region;

(c) an assessment of the current resilience of the heritage values of the region;

(d) an assessment of the existing measures to protect and manage the heritage values of the region;

(e) an assessment of the factors influencing the current and projected future heritage values of the region;

(f) an assessment of the long-term outlook for the heritage values of the region.

Figure 1. The Great Barrier Reef Region and Catchment.[4]

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[4] Great Barrier Reef Marine Park Authority. 2019, Great Barrier Reef Outlook Report 2019. https://hdl.handle.net/11017/3474

Following legislative amendment in 2013, the 2014 Outlook Report included an assessment of heritage values, which was not within the scope of the assessment in 2009. The assessment was conducted internally by the Reef Authority in 2014 and as part of external expert rapid assessment workshops in 2019. As in 2019, the 2024 Outlook Report includes a chapter assessing heritage values within the Region, recognising that natural heritage values discussed in Chapters 2 and 3 of the Outlook Report also form part of overarching heritage values for the Region. The Reef Authority recognises the importance of First Nations Peoples' perspectives. Hence the first day of the series of five workshops was dedicated to discussion and assessment of Indigenous living culture values, as well as historic heritage values, and a risk assessment of these.

In each Outlook Report, the statutory assessments use a series of criteria that are, in turn, comprised of several components. Some components are specific or small in scope (e.g. seagrass or dugongs) while others are broad (e.g. bony fishes or other invertebrates). The assessment criteria allow an ordered analysis of the available evidence. In these reports, for each criterion, grading statements guided the allocation of a 'grade of best fit'. A qualitative grading system allows a wide range of evidence and knowledge to be collectively assessed when assigning each grade. Expert rapid assessment workshops did not use highly quantitative approaches as they were impractical given the scope of the assessment area (the entire Region), the time available, the amount of evidence available, the lack of analytical resources and the variety of components to be assessed. An even number of four grading options (Very Good, Good, Poor, Very Poor) meant workshop participants could not 'sit on the fence' by allocating a neutral grade. The 2009, 2014 and 2019 Outlook Reports included a summary of each assessment and the allocated grades at the end of each, which are informed by multiple lines of evidence, including the expert rapid assessment workshops. In 2023, so that results are comparable with previous reports, we followed a similar process to develop the workshops for expert input to the 2024 Outlook Report.

Integrity and independence of information collected at the workshops are integral to the process. The outcomes from the 2023 workshops informed the development of the 2024 Outlook Report and contributed to understanding of the values and threats to the Region. The workshops are one input to the writing of the Outlook Report. This workshop report aims to assist that process, as well as enable transparency of the expert input and final Outlook Report. Note there are also other lines of evidence that provided input to the component grades, including consultation with Reef Authority experts on the same topics covered in these workshops to gather opinions of risks and grades, research papers, long-term datasets and peer-reviewed monitoring programs, and information sent by internal and external experts. All the gathered inputs have been integrated and distilled into the narrative and grades by the Reef Authority for the 2024 Outlook Report.

This full workshop report became public when published by the Reef Authority after the 2024 Outlook Report was submitted to the Minister for the Environment and Water and tabled in Parliament. The timeframes for the independently facilitated expert rapid assessment process are shown in Table 1.

Table 1. Timeframe for the independent assessment process

Date	Milestone
7–11 August 2023	Workshops (for Indigenous culture, historic heritage, and natural values)
25 August 2023	Workshops Report submitted by independent facilitators to the Reef Authority, with feedback incorporated in September-October.
Remainder of 2023 and into 2024	Outputs of the workshops inform drafting of 2024 Outlook Report
By 30 June 2024	Final 2024 Outlook Report submitted to the Minister for tabling in Parliament
Second half 2024	2024 Outlook Report and 2023 Rapid Assessment Workshops Report publicly available

The rapid assessment workshops

The rapid assessment workshops to elicit expert input to inform the development of the Great Barrier Reef Outlook Report 2024 were organised and convened by the Reef Authority in Townsville from 7 to 11 August 2023.

The objective of the series of five workshops, involving a varying list of scientific experts for each, was to obtain an independent set of expert judgements about the condition, trends and risks in the Region that could be used to inform the preparation of the 2024 Great Barrier Reef Outlook Report. The consultation and workshop process has been adapted from the approach and decision model established for the assessment and reporting of Australia's national marine environment (Australia State of the Environment 2011[5]) and applied internationally for aspects of the United Nations Environment Program (UNEP) World Ocean Assessment.[6] The focus of the 2023 series of workshops was on achieving input from independent scientific experts on the biodiversity, ecosystem health, historic heritage and Indigenous heritage values, and potential threats, in the Region.

Past expert workshops had been recognised as 'consensus workshops', where consensus was defined as 'a generally accepted opinion or decision among a group of people'. While this definition did not require all people to agree on a single proposition, it implied unanimous acceptance of the gradings by a group of experts. In 2023, due to the small (more targeted) number of participants for each session in order to focus on a small, related series of components, the word consensus has not been used. Nonetheless, the discussion and voting process ensured the gradings represent the prevailing or generally accepted views of participants. Any divergent views were recorded as part of the assessment process to be considered in the findings of the 2024 Outlook Report.

Care was taken to maintain consistency in methods between the 2009, 2014, 2019,

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[5] State of the Environment 2011 Committee. 2011, Australia state of the environment 2011—in brief. Independent report to the Australian Government Minister for Sustainability, Environment, Water. *Population and Communities. Canberra: DSEWPaC*. https://catalogue.nla.gov.au/catalog/5740225

[6] Inniss, L., Simcock, A., Ajawin, A.Y., Alcala, A.C., Bernal, P., Calumpong, H.P., Araghi, P.E., Green, S.O., Harris, P., Kamara, O.K. and Kohata, K. 2016, The first global integrated marine assessment. *United Nations. Accessed at on 5th February*. https://www.unep.org/resources/report/first-global-integrated-marine-assessment-world-ocean-assessment-i

and 2024 Outlook Reports. Accordingly, a principle of 'minimum change' (no wordsmithing) and a willingness to accept the inherent limitations of the initial methodology was promoted by the facilitators at the workshops. Suggested improvements to the methodology, based on participant feedback and other discussions, are included at the end of this report (see Participant workshop evaluation section). Following publication of the 2024 Outlook Report, the Reef Authority may review this feedback and other research to ensure the rapid assessment methods for future workshops remain fit-for-purpose, based on best-practice principles and consider suggested improvements.

Over 110 experts were invited by the Reef Authority to attend the workshops and participate in the elicitation process. Invitation was based primarily on their discipline expertise and their direct experience with, and conduct of, scientific research and monitoring in the Region. Experts were selected to provide discipline expertise to cover the breadth of issues expected to be addressed by the workshops and elicitation process. Availability of experts enabled 45 participants to participate in at least one session of the workshops in person (see Appendix 3). Experts were encouraged to talk openly about knowledge, question the information discussed, and share information to inform the 2024 Outlook Report writing process.

If experts could not attend in person, or had to leave during the week, they were invited to provide remote input and grades prior to, during, or immediately after the workshops. Online attendance at the workshop was not provided for, due to the potential bias and difficulty to properly involve online participants in a hybrid format. Eleven responses from three experts were provided electronically and included in the workshop process by proxy. In these cases, the following provisions were applied.

1. During the workshops, a member of the Outlook Report team acted as proxy for these participants and submitted their grades during the voting using Menti.
2. Each intended vote was viewed by the independent facilitators prior to voting.
3. Proxy votes were added to the first round of voting, and then added without modification to the second round of voting. Consistent with the approach taken in 2014 and 2019, if this vote was part of a contested grade, or a third vote, it was to be removed at the facilitator's discretion, or at any subsequent part of the iterative process at the workshops (because the absent expert could not modify their vote based on the new information available to workshop participants). However, there were no circumstances where a third vote occurred during the workshops.
4. Experts who had mainly remote input under this provision were identified and acknowledged in the attendance register (see Appendix 3) separately from those

who attended the full workshop process.

To inform discussions and assist the experts attending the workshops, the Reef Authority provided the following pre-workshop documentation:

- Paper 1 – Value Scoring Method for Biodiversity/Ecosystem Health
- Paper 1b – Value Scoring Method for Heritage Values (Historic and Indigenous)
- Paper 2 – A draft working document with some draft assessments provided to seed the expert discussions
- Paper 3 – Values Score Sheet (for remote participants)
- Paper 3b – Heritage Values Score Sheet (for remote participants)
- Paper 4 – Risk Assessment Criteria for Biodiversity/Ecosystem Health
- Paper 4b – Risk Assessment Criteria for Heritage Values (Historic and Indigenous).
- Paper 5 – Risks Score Sheet (for remote participants) – includes both Ecosystem and Heritage values.

Workshop participants were provided with this material for their information. The draft assessments in Paper 2 were not intended to influence their assessments at the workshops other than to provide a starting point for discussion and prompt additional background information they may wish to draw on in forming their independent conclusions. Further prompting for discussion of the latest research and caveats during the process was included as part of the voting for each component (see process below: Assessing condition and trend).

The workshops were managed by independent facilitators (Dr Anthony Boxshall, *Science into Action*, and Dr Simon Torok, Scientell). They had oversight and control of the process, to maintain independence and robustness of the outcomes, as with past expert workshops informing the Outlook Reports.

The rapid assessment workshops over five days considered four assessments, as follows. Day 1 focussed on (1) four Indigenous living culture values, and (2) four historic heritage values, as well as the related risks to these. Days 2 to 4 focussed on (3) biodiversity and (4) ecosystem health values (57 in total), as well as the risks.

Four Reef Authority staff from the Outlook Report team attended each day of the workshops, with two others attending to observe the process for a day. Their role was to:

- observe the process (to ensure independence and transparency)
- act as proxies for any pre-workshop participants or those with technical

difficulties
- record participant comments in addition to reporting by *Science into Action* and Scientell
- provide technical clarifications about the Outlook Report or background information provided to participants
- assist with workshop logistics.

Reef Authority staff did not participate in any assessment of the conditions, trends and risks in the Region during the workshops and did not attempt to influence experts' views on grades. They did participate in discussions about the most recent scientific information and sought advice from participants on additional data, useful case studies or vignettes for potential inclusion in the Outlook Report narrative.

The Outlook Report team sought declarations of potential conflicts of interest from participants. Any identified perceived or real conflicts of interest were announced to all participants in the relevant workshop and recorded. Conflicts of interest were declared or identified for 12 participants throughout the series of workshops. The facilitators and Outlook Report team identified no conflicts of interest that required abstaining from voting or similar action. Conflicts of interest included leadership of, or involvement in, projects relevant to reef research or funded by relevant bodies, awareness of confidential information, and participation in relevant national and international research and management organisations. Two potential conflicts of interest declared were of a personal nature, but manageable.

All information provided prior to, and derived from, the workshops was confidential unless already publicly available. To enable robust discussion about the draft results and facilitate the presentation of other information sources that may not have been public at the time of the workshop (e.g. *in-prep* or *in-press* journal articles), all participants signed non-disclosure agreements.

In summary, all participants were asked to:

Pre-workshops

- Sign a non-disclosure agreement so that background material could be sent to each participant.
- Review the draft condition and trend grades and summary statements for biodiversity and ecosystem health assessment components and heritage

values.

- Review the description of threats to be assessed.
- For participants who could not be at the workshops but wished to have input, email this information to the Outlook Report team for inclusion in discussions – three participants completed this task.
- Provide feedback if there were any concerns with the methodology being used, including grading statements and benchmarks.

During the workshops

- Share expert knowledge about the state of scientific knowledge and other critical considerations relevant to each assessment.
- Consider, make an informed judgement, and vote at the workshops based on the scientific and other relevant knowledge about each scoring question.
- Provide judgements that best represent professional personal opinion, not an institutional position (in the case where that may be different, and recognising that polling was anonymous).
- Provide examples that best represent the underlying data/knowledge to support the grade assigned, for annotation in the 2024 Outlook Report.
- Contribute positively to any discussion about issues and questions that arise during the workshops.
- Participate under the Chatham House Rule, where participants agree that the content of discussions may be reported without the information being attributed to an individual or their organisation.

After the workshops

- Provide additional information (e.g. emerging research papers, potential case studies, names of other experts who could provide useful commentary on the components being assessed, and discussion and scoring of topics that were not completed at the workshops due to time constraints).

Ultimately, this report was prepared by *Science into Action* and Scientell in good faith. The authors exercised all due care and attention, noting the narratives given by experts during the workshops. The design of the rapid expert assessment process does not enable peer review by the experts involved. The intention of this report is to provide a robust record of the rapid expert assessments to inform the 2024 Outlook Report writing process. This report is not intended to be a stand-alone, peer-reviewed publication. Care should be taken when citing this report for anything other than its purpose as a supporting document to the 2024 Outlook Report.

Components assessed

The rapid assessment workshops (and the supporting remote process) were designed to assess the status of:

- nine components for Indigenous living culture and heritage values
- 57 components for natural (biodiversity and ecosystem health) values

and assess risk to:

- 45 threats to Indigenous living culture and heritage values
- 42 threats to natural values.

The order of values discussed during the workshops was tailored to the availability of experts. The order of values in this report follows the order in which they are presented in the Outlook Report.

See Tables 2 and 3 for a summary of the components.

Table 2. Heritage values of the Region assessed for condition, trend and confidence in the rapid assessment workshops and remote process.

Assessment	Assessment criteria	Number of components
Heritage	Indigenous living culture and heritage values	4
	Historic heritage values	5
Total		9

Table 3. Biodiversity and ecosystem health of the Region assessed for condition, trend and confidence in the rapid assessment workshops and remote process.

Assessment	Assessment criteria	Number of components
Biodiversity	Habitats to support species	10
	Species populations or groups of species	16
Ecosystem health	Physical processes	7
	Chemical processes	3
	Ecological processes	10
	Outbreaks of disease, introduced species and pest species	4
	Terrestrial habitats that support the Great Barrier Reef	7
Total		57

Assessing condition and trend

For each component, experts assessed the condition and trend, confidence in these, and comfort in the process. The resulting information is a broadly based expert agreement on condition and trends. Experts included those with a range of experience and expertise and, for many of the components considered, involved the pre-eminent regional experts, as well as scientists with long experience in the Region and scientists who are active in many relevant research fields.

Grades were assigned to the assessment components using a system of real-time anonymous voting by the individual experts, using Menti software. The software allowed free-text input by participants regarding concerns, caveats or recent research. It also enabled real-time feedback at the end of each vote to enable informed discussion about variations in expert assessment of each component, and progress towards general agreement on a grade by each group.

A placemat summarising key aspects of the assessment method was printed and available for each participant to use as a reference during the workshops. The facilitators regularly highlighted the relevant grading statement to help focus participants' attention on the component and scope under consideration.

The process began with an introduction to the component and a brief summary statement on the draft assessment of the condition and trend of the component. Participants raised any clarifying questions, and discussed any issues, before further discussion highlighting, for example, the state of scientific knowledge and any other critical considerations for each component. Participants were encouraged to speak up and share their views on the statement and the component before commencing the voting process.

The first vote was then held on the condition of a component, along with a vote on their confidence in the assessment of the condition. The group grades were tallied and displayed, including the number of people who voted (the number of voting participants is noted in the summary of each component in the Assessment section as N).

When grading the condition, participants were encouraged to consider a grade for the entire Region. If data are deficient, but there is no evidence to suggest it is in poor condition, for the sake of consistency, experts erred on the side of Good condition. This is counterbalanced with the confidence in the grade – which would be inferred or limited – based on the evidence.

There was then time to discuss any differences in opinion on the assessment of the condition based on the real-time feedback on the voting. Participants then conducted the first vote on the trend for a component, again with a vote on their confidence in the assessment of the trend. There was again time to discuss any differences in opinion on the assessment of the trend, based on the real-time feedback on the voting. The trend was defined as the trend in the component since 2019.

The process was then repeated, as per the Delphi approach, to complete the second round of voting. The Delphi approach or method, developed by the RAND Corporation in the 1950s, is named after the Greek temple where priests interpreted for the public the advice of an oracle. The process includes characteristics including anonymity of experts to enable honest opinions, iteration to enable experts to change their opinion, controlled feedback to enable views of experts to be shared, and statistical aggregation to provide quantitative analysis. It should be noted that the Reef Authority and independent facilitators considered non-anonymous voting in discussion with some expert groups as a potential adjustment for transparency (i.e. making vote attributions visible to participants at the workshop). In practice this was not an option due to the design of the voting software, which enabled anonymous voting only.

After the second vote on condition (and confidence in the condition assessment), a vote was taken on the overall expert comfort with the resulting condition. This new question about comfort was introduced at the 2023 workshops to evaluate participants' level of comfort with the agreed grading. This was to establish that, there were no major concerns about the process or results. This was also completed for the trend for the component.

The results were then discussed. There was allowance for the process to be repeated a third time if there was a lack of comfort with the result of voting on condition and trend. However, while some concerns were raised for some components, a third vote was not required in any of the sessions. Any concerns raised are discussed in the relevant section about the component in this document.

The discussion for each component concluded with a recording of any caveats, input of any new information about the component, and any final comments.

The group's agreed decision (noting that a range of grades was acceptable and was reflected in the free text input and record of discussion) for each component was then saved and backed up to an online archive.

See Table 4 for a summary of the process of condition and trend assessment.

Table 4. Summary of the process of assessing condition and trend.

Task	Activity
1. Component introduction and scope	Reef Authority statement
2. Summary statement	Reef Authority statement
3. Clarifying questions	Participant discussion
4. Issues with statement; opportunities for expert commentary	Free text in Menti
5. General discussion	Participant discussion
6. Condition	Vote 1 in Menti
7. Confidence in condition	Vote 1 in Menti
8. Discussion of any difference in opinion	Participant discussion
9. Trend	Vote 1 in Menti
10. Confidence in trend	Vote 1
11. Discussion of any difference in opinion	Participant discussion
12. Condition	Vote 2 in Menti
13. Confidence in condition	Vote 2 in Menti
14. Overall expert comfort with the condition voting process	Vote 2 in Menti
15. Trend	Vote 2 in Menti
16. Confidence in trend	Vote 2 in Menti
17. Overall expert comfort with the trend voting process	Vote 2 in Menti
18. Discussion	Participant discussion
19. Condition	Vote 3 if required
20. Confidence in condition	Vote 3 if required
21. Overall expert comfort with the condition voting process	Vote 3 if required
22. Trend	Vote 3 if required
23. Confidence in trend	Vote 3 if required
24. Overall expert comfort with the trend voting process	Vote 3 if required
25. Discussion	Participant discussion

26. Caveats	Free text in Menti
27. Important new information	Free text in Menti
28. Final comments	Participant discussion

Before voting began on a component, it was agreed that participants who choose to vote should respond to all questions relating to the component. That is, participants who assessed condition or trend should also provide an assessment of confidence in the grades given, and participate in the second and, if necessary, third vote. It was noted that a participant might only vote on condition or trend or may choose to vote on both given their expertise. If participants did not participate in the first-round vote on a component, they were ineligible to vote in the second round.

While there was no formal quorum (i.e. minimum number of votes) set for the assessment of each component, it was decided to alter the process for a component's assessment where fewer than three participants felt qualified to vote. In these cases, the component was discussed to inform the narrative of the 2024 Outlook Report without artificially inflating the credibility of a vote by including statistics in this workshop report. Where three or more experts participated in voting, the number of votes cast was recorded in Menti – these are illustrated in the tables summarising expert input for each component.

The vote results from the workshops contributed to the grade, trend and confidence in the 2024 Outlook Report. They were not the final assessment, particularly for components where data are deficient or there was limited expert input. The Outlook Report team sought additional evidence following the workshops to strengthen confidence and certainty in the grades. Where data and evidence exist, the text concentrates on that, but the narrative also highlights knowledge gaps.

An attendance register was completed for each session (see Appendix 3 for the full list of attendees).

In line with the aim of obtaining quick assessments of many components, there were about 15 minutes allocated per component, including time for discussion and voting. The process was designed as a rapid assessment. Some components took longer than 15 minutes to complete; others were shorter.

Considering condition and trend

The condition and trend of Indigenous living culture, historic heritage, and ecosystem components (including processes) were assigned three categories (metrics): 'Worst

10%', 'Most', and 'Best 10%' (Figure 2). The exact meaning of each of these categories depends on the specific component being assessed (see Appendix 1 for grading criteria). Broadly, it refers to a sense of the frequency distribution of grades across a spatial gradient. Separating voting on Best, Most and Worst focused discussion on the bulk of the component's distribution rather than over-concentration on any specific areas/examples that are in very good or very bad condition, which is the tendency when discussing condition and trend.

For the worst 10 per cent of places (Worst 10%), participants assigned a whole number grade that represented their overall estimate of the condition and trend of the 10 per cent of places (occurrences of the component) they considered to be in the worst condition in the Region. Note that this is not the condition of the worst place or occurrence – this can be used to range-find a grade, but the intention here is to elicit a grade on the lowest 10 per cent, not the extreme. For components that are area-based (such as habitats), this refers to the majority of the area occupied by the habitat or the number of occurrences of the habitat. For species, it could be the worst 10 per cent of the example populations.

For the best 10 per cent of places (Best 10%), on the same scale, participants assigned a grade that represented their estimate of the condition and trend of the 10 per cent of places (occurrences of the component) they considered to be in the best condition in the Region.

For most places (Most), on the same scale, participants assigned a grade that represented their overall estimate of the condition and trend of most (80 per cent of) occurrences of the component within the Region, ranging between 0 (worst) to 10 (best) for the current (2023) condition.

For example, where 'historic lightstations' (in the case of a heritage value) or the habitat 'mangrove forests' (in the case of a natural value) is being assessed, for the 'Worst 10%', a grade would be assigned that reflects the condition (as per the grading statements) of historic lightstations or mangrove forests in the worst 10 per cent of the places (or area) where they occur across the Region. Conceptually this would be represented by the 10 per cent grade on a frequency distribution of condition quality grades across individual areas/forests across the Region (see the distribution shown in Figure 2). Similarly, the 'Best 10%' represents the 90th percentile grade on the same distribution. 'Most' represents the majority of the value over the full distribution (i.e., the middle 80 per cent).

The grade for Most is the one reflected in this workshop report. The worst and best 10 per cent were graded to show the full range of conditions for each value to inform report writing by the Outlook 2024 team.

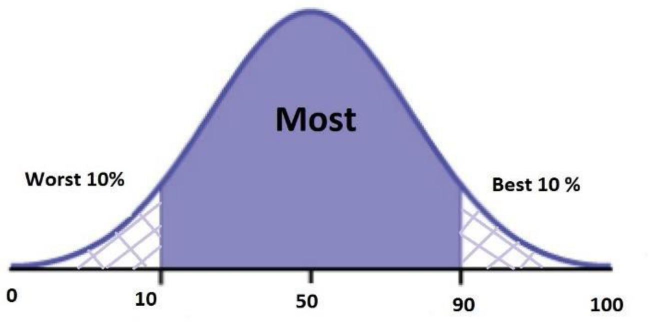


Figure 2. Distribution of Worst 10%, Most and Best 10% of assessed components.[7]

For grades and trends associated with the Most grade, experts were asked to apply their judgement at the scale of the whole Region, and not be overly influenced by small areas of very good or very bad condition, or small areas where changes are very great, but always relative to the historical or potential spatial distribution of the component being assessed. So, for example, if one habitat type (say *Halimeda* beds) only occurs in a proportion of the Region, then the assessment of condition and trend applies to the area occupied (either now, historically, or potentially), to avoid an area bias that would otherwise apply to small but important habitat types.

For species groups, the assignment of condition and trend in the worst-best metric gradient was based on the number of species that constituted the condition quality. For example, in the sharks and rays group, the condition grade assigned to the Worst 10% metric represents the condition grade assigned to 10 per cent of the species considered to be in the worst condition.

Scoring and grading

Condition

The condition grades fall into four categories: Very Poor, Poor, Good, and Very Good. These correspond with the range of numbers on the linear scale (Figure 3), where 1 is consistent with the worst condition, and 10 is the best condition. Note that while the thresholds are 2.5, 5, and 7.5 for the four categories of condition, scoring was done using only whole integers. At each of the specific thresholds, an integer grade at the threshold is assigned to the lower grade. So, grades of 5 were assigned to Poor; if a

[7] Harper, T.W. 2019, The rapid assessment workshop to elicit expert consensus to inform the development of the Great Barrier Reef Outlook Report 2019. https://hdl.handle.net/11017/3480

grade of zero was recorded it would fall in the Very Poor grade. Figure 3 was refined after the 2014 Outlook Report to show the break points more clearly between condition class grades (at 2.5, 5, 7.5, and 10) and adopt consistent colours with the Expert Rapid Assessment Workshops. It was not changed before the 2023 workshops. Experts were encouraged to consider the category for condition before assigning a number for voting in Menti.

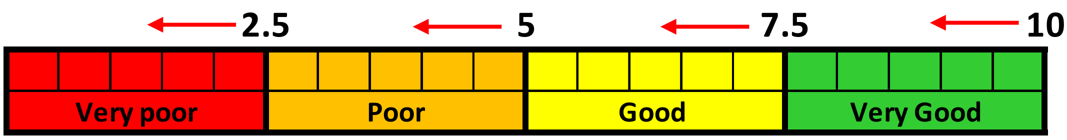


Figure 3. Scoring and grading scales for the rapid assessment workshops.

Trend

Trend was estimated as change that had occurred over the past 5 years (since the 2019 Outlook Report). The trend in each component was assigned to Best 10%, Most and Worst 10% within one of four categories that relate to condition quality: Improved, Stable, Deteriorated, or No Clear Trend (no data/information; not enough information to determine a trend; or highly variable and/or conflicting trends across the Region or sub-components).

Confidence

There were only limited data available for many components, but the condition grades and trend assignments were applied using best judgement of the expert participants. The confidence assigned to the condition grade and trend was represented by one of the four confidence levels: High (adequate high-quality evidence), Medium (limited evidence), Low (inferred, very limited evidence) or Unknown/No Score (which referred to a complete lack of confidence and was rarely used. Confidence generally referred to confidence in the 'Most' vote, consistent with past reports' processes:

- High confidence was assigned when the grade was considered sufficiently accurate and precise that, even if considerable extra data or information became available, it would be unlikely that the true grade would lie outside the range of that grade (i.e., statistically speaking at about a 95 per cent confidence level).
- Medium confidence was assigned when it was unlikely the true grade would lie outside the assigned grade by more than one grade (a grade of Good with Medium confidence could actually be Poor or Very Good, but not Very Poor).
- Low confidence was assigned when it was unknown where the true grade would lie (e.g. a grade of Good with Low confidence could be Very Poor, Poor,

Good or Very Good).

- There was a fourth level of (lack of) confidence: Unknown/No Score. This was used if it was not known whether there is any evidence or anecdotal information available.

Comfort (with the final consensus)
To identify any potential group-based bias (such as status quo or false-consensus biases), a new type of grade was collected for both condition and trend: overall level of comfort. This information was not collected in the 2019 or 2014 rapid assessment workshops.

The Comfort grade reflected participants' overall comfort level with the condition or trend result for each component. There were four categories for Comfort:

- Support – the expert broadly supports the consensus
- Can live with it – while the expert has some reservations, they can live with this consensus
- Minor concerns – the expert has some minor evidence-based concerns that make it hard for them to live with this consensus
- Major concerns – the expert is genuinely concerned that there is evidence this consensus is incorrect and they want to discuss the concerns before the next steps.

This new vote provided an opportunity for participants to raise and capture any discomfort about the process or sources of bias. Major concerns would have triggered a third discussion and rapid assessment vote, however this was not required in any session. For consistency, the comfort vote was completed for all groups that voted, even with smaller groups.

The discussion for each component enabled checking of results and testing of values. It was not intended to lead to consensus, but to capture the breadth of expertise and understand why there may be a spread of views.

Explanation of grades

Condition: For each component, the highest number of votes (mode) in each of the four grades (from the final, second vote) was used to assign a grade to the three metrics (i.e. Most, Worst 10% and Best 10%). The Menti software required consideration of categories of condition as integers ranging from 0 to 10. Hence during the workshop, the Menti software enabled voting for Very Good as 10, 9 and 8, Good as 7 and 6, Poor as 5, 4 and 3, and Very Poor as 2, 1 and 0.

For each component, the most commonly voted grade for the 'Most' metric is presented as the result most relevant for informing the 2024 Outlook Report condition grade. The Best 10% and Worst 10% grades determined at the workshops were used to identify specific examples of performance issues and provide context for descriptions of the spatial distribution of condition.

It was important to consider the extent of a component as well as its quality, diversity, and function. While an assessment of the condition may integrate these aspects, they differ. For example, the condition may be reported as stable if there has been no change in extent, but if there is limited information on quality, diversity, and function then the assessment should be given medium confidence. The grade may not capture the subtlety, but the associated narrative and caveats will.

Note that while the Menti software provides an average grade, this quantitative measure was not considered by the Outlook Report team as it is a misleading numerical mean of categorical data. The distribution of the Most grade is key, not the quantitative average. For example, grades may show the grade at the top end of Poor or the bottom end of Good to assist understanding of the state of the component. There was potential for participants to misinterpret the quantitative average number, so the facilitators noted the importance of focusing on the qualitative grade (Poor, Good, etc.), and participants noted any concerns in the caveats and their vote on comfort.

Trend: For each component grade, the highest number of votes (from the final, second vote) was used to assign a trend. As for condition, the trend in the 'Most' metric informed the overall grade for the component in the 2024 Outlook Report, with the Best 10% and Worst 10% grades used to identify specific examples of performance issues and provide context for descriptions of the spatial distribution of trend.

Confidence: For each component, the highest number of votes was used to identify the level of confidence assigned to both condition and trend grades. During the discussion, experts were able to enter free text in Menti. These comments are summarised for each component below. In some cases, the facilitators have removed names to abide by the Chatham House Rule and have edited the text for clarity and grammar without changing any meaning during the summarising process.

Grading statements

The grading statements (Appendix 1) were uniquely derived for each group of the assessment components to represent and best meet the requirements of the *Great Barrier Reef Marine Park Act 1975* for maintaining the structure and function of the Region's ecosystems. The grading statements provided experts with the specific criteria and guidance about the thresholds to use in determining a grade that is consistent with their knowledge of the data and information, and best represents their judgement as experts.

Benchmarks

The grade assigned to a component is formed by the experts based on relativity to a benchmark or point of reference. For this assessment, and to best meet the requirements of the Act, experts were asked to form their judgement about the current condition and trends relative to the condition that would have been expected to prevail if there had been no influence of post-European settlement human activity. This broadly represents the condition in the absence of human uses or exploitation and can be considered to best represent a relatively natural set of conditions perhaps only slightly impacted by pre-European settlement human activities.

The use of a 'natural conditions' benchmark here should not be confused with the setting of a target or an objective for current management systems to achieve. The benchmark is used here for 'anchoring' the scoring and grading system to a common point of reference that relates to all components that are assessed across the Region.

The use of the 'natural conditions' benchmark is a critical aspect of condition assessment, as it is only in this way that actual 'distance' of the current system from a natural and 'undisturbed' system can be estimated. Estimates of this distance provide a point of reference that is common across the condition of all components and enables a consistent form of evaluation of the different components within a single assessment framework. Such evaluations are central to the design of efficient and effective management to maintain or recover natural ecosystem structure and function, to avoid shifting baselines in long-term management systems, and to enable robust prioritisation of investment strategies for management systems that address these issues.

Using pre-European disturbance as the natural condition baseline was considered by workshop participants to be most useful for species and habitats, but problematic when considering ecosystem processes such as nutrient cycling, sedimentation, ocean acidification, and competition. This concern was especially strong where a large number of factors needed to be considered under a single component (i.e. 'other invertebrates' required an assessment of an estimated more than 8,000 species). Several concerns were raised during the Indigenous living culture session of the workshops and are addressed in the Assessment Results (Day 1) section of this report.

Assessing risk

Prior to discussing the threats and risks assessed for each one, the facilitators noted the decision to stick with the historic use of the terms ‘risk’ and ‘threat’ in the Outlook Report process despite it being slightly different to the use in the Australian Standard for Risk Management (AS/NZS ISO 31000). For this expert rapid assessment, a ‘risk’ is assessed for each ‘threat’ by combining the consequence and likelihood categories. All risks were assessed based on residual risk. There was no formal discussion of ‘hazard’ or risk mitigations. The final outcome in this process is the ‘risk rating’ or ‘risk assessment result’. The linguistic and definitional differences with the Australian Standard are noted. Likelihood and consequence (definitions provided in Appendix 1) were assigned using a method slightly modified from the Australian Risk Management Standard.

Risk levels for each threat were resolved into four grades (low, medium, high, very high) based on the five-point scales of likelihood and consequence adopted in the 2009, 2014 and 2019 Outlook Reports and consistent with the widely adopted Australian Standard for Risk Management (AS/NZS ISO 31000). Participants considered the likelihood and consequence of each threat to arrive at an assessment of the likely level of risk to the Region’s ecosystem and heritage values from that threat. Each threat was considered for the whole Region (as defined above) and, in some cases, locally (defined as between 2 and 10 km around a specific area). The definitions for the likelihood and consequence scales and the previous risk assessment results (adapted from the 2019 Outlook Report) were provided prior to the workshops to support participants in their voting decisions (Appendix 1).

Experts generally assessed risks for the current state and immediate future (from 2024 to 2029). However, for threats influenced by climate change, assessment of the long-term impact (and impact of relevant policies) was considered as well as the 5-year horizon, to align with expert input in previous Outlook Reports.

The consequences of a factor that may affect the environment during this period were estimated by comparison with the current condition of the environment (notionally estimated as the condition prevailing over the past 5 years). The frequency and timeframe of factors contributing to an assigned risk grade are embedded in the definitions for the classes of likelihood. The classes of consequence are established based on the effects of the risk factors on ecological and ecosystem receptors, such as those described in the grading statements for condition and trend of habitats and species, combined with their spatial and temporal impacts relative to the current condition. Voting for categories of likelihood and consequence was conducted in the same manner as the first iteration of voting for condition and trend. There were no second or third iterations of voting for the risk assessments. As in 2014 and 2019, confidence was not recorded for risk grades.

When considering the threats, participants were encouraged to first think about the consequence, followed by the likelihood. Their assessments were collected via the Menti tool in that order.
When a range of consequence or likelihood was given by experts, the majority conservative response was used. For example, if two experts voted *Major* and three voted *Catastrophic*, the rating given is *Catastrophic*. For a threat with a highly variable range of responses, when the range covered three rating levels, the middle rating was used. When a range of four categories were covered the higher middle one was used. In the cases where there was high uncertainty in expert assessments generally the most conservative (i.e., higher consequence or likelihood) has been used to calculate the risk category. This is unless there was a strong skewing in the underlying data (i.e., 10 experts commented, and eight said Rare, one said Likely and one said Almost Certain), the majority of inputs were considered, and the category was moved closer to the majority view rather than using the most conservative response.

The risk levels assigned were those that are current and remain in place even though there may be a range of management measures and activities underway; hence, the risks reported here are 'residual' risks – those expected to remain after considering current management arrangements. When considering current management arrangements, participants were instructed not to consider policies, strategies and programs that are under development or not yet implemented. For example, for climate change, risks were considered in the context of Australia's current 2050 net zero policy, and local and national activities aligned to these, as well as management strategies currently in place. Further discussion of the risk assessment process is at the end of this report.

Potential biases

The assessment process used in these workshops was potentially subject to a number of sources of bias. These include such matters as a limited representation of the knowledge base at the workshops (including insufficient experts in attendance), and the other forms of bias always inherent in a Delphi-style rapid assessment process. The most important aspect of this matter is recognising the type and extent of bias that may apply, and where any aspect may be important (taking account of the coarse resolution of the overall process), the existence of such bias should be addressed in the workshops and documented in the workshop outcome.

The verbal preamble in each workshop with new participants briefly highlighted the main types of individual and group bias that could affect the process. The main bias thought to potentially influence the workshop outcomes was the advance provision of the Reef Authority's draft working summary assessment to seed discussion of the components being assessed in the workshops. The attention of all participants was drawn to this potential for 'anchoring' bias, so that it could be avoided. The workshop participants were advised that if any other forms of bias were suspected, they should be brought to the attention of the facilitator as soon as possible for corrective action.

Any unweighted voting bias (where less well-qualified participants have the same vote value as highly qualified participants) was minimised by having smaller groups discuss individual components, rather than having a large group discuss all components as has occurred in past workshops. Even so, if an individual participant felt unqualified to contribute, then they abstained from voting on that component. If participants did not participate in the first-round vote, they were ineligible to vote in the second round.

The potential bias towards in-person participants at the expense of online participants was avoided by not having online participants. Proxy votes were obtained for only a small number of experts in their field of expertise.

To address area bias, where, for example, one type of component only occurs in a small part of the Region, the assessment of condition and trend applies to the area it appears.

To address potential group-based bias (such as status quo or false-consensus biases), a final grade on participants' overall level of Comfort was collected for condition and trend.

Only two integer numeric grades (6, 7) were available for the condition grade of 'Good', while there were three for each of the other grades (Very Good, Poor, and Very Poor). Associated potential for bias was minimised by ensuring that participants were aware of the arrangement and navigated to a grade by first identifying a grade that best represents the condition (Very Poor, Poor, Good, Very Good), then assigning a number (from 0 to 10) in that grade. This was discussed with experts during each session where voting was used.

Insights and reflections on the methods

As a result of the workshop process and building on some of the caveats and issues raised above or in the following pages, the following insights are offered about the process or possible updates in the future.

- **Deeper Indigenous engagement** is needed to broaden the input from Traditional Owners both across components and Country. Traditional Owners reported having interest in both biological and cultural components and considered a separation of such values as artificial and unhelpful.

- **The number of experts in the room** for this Rapid Assessment was similar to past years, however the voting approach restricted discussion and input to self-declared (verifiable) deeper experts in a given topic. This was very valuable as a tool to gather deep expert input. However, as past Rapid Expert Workshops have often involved everyone in the room voting, the numbers of experts in this report seems lower and hence potentially less comparable across Outlook cycles. An argument can be made to have most experts in the room vote as they are likely to be more expert in a given topic than most people, however the facilitators consider having discussions only involving people who opt in as having (verifiable) deep expertise, the input is richer. We suggest continuing this approach of small but deep expert discussions as most likely to give a better rapid assessment, being mindful of needing to have a diversity of thought available.

- **Workshop facilitators could direct the process to build more clearly on a draft assessment for the new Outlook report.** Following the 2024 Outlook report, future experts will have four past reports to consider, plus considerable pre-assessment done by a future Outlook writing team for the next report. Given the depth of pre-assessment done by the Outlook writing team, it is likely to be more efficient to ask experts to focus on the new draft assessment developed by the Outlook team and consider how well they feel the pre-assessment reflects the available evidence for any changes (or lack of) since the previous four Outlook reports' grades. The discussion and voting processes thus enable the participants a way to voice their expertise and opinions on the latest draft Outlook assessment. While the current process began with a review of the draft assessment, in many cases the discussion navigated away from the focus of change since 2019 highlighted in the draft assessment. It was a robust and appropriate approach used to produce this current report. However, this small but important change in emphasis to focus experts on evidence for change from the draft assessment is likely to be a more efficient use of their time and energy. In the interests of continuous improvement, making this direction even more explicit enables the participants to build on the decades of past expertise and recent evidence gathered. It is likely to lead to a more consistently targeted rapid expert assessment.

- Slightly altering the condition assessment voting for categories will clarify the breakdown of integers available on online voting software. In the past two Outlook cycles, online voting software limitations created unintended areas for potential bias. We suggest using 12 integers for the four condition-grading categories in the future, with three integers available per category. This would be preferred over maintaining historical consistency with a method that may create unnecessary bias if unmanaged.

- Alter the risk assessment process so that experts are asked to review the current risk assessment (i.e., from the previous Outlook Report) and discuss if there is new evidence or information that would result in a change for the coming 5 years. Most experts involved in this process found that starting with a blank page created an unnecessarily complex task in the time available. Building on past expert and Outlook Report assessments means considering and adding to a historical expertise base. While there is an increased chance of anchoring bias, we consider the quality of discussion and input will be higher, which will be worth the trade-off.

Assessment results

Summary

The rapid expert assessment of Indigenous living culture values did not involve formal voting due to the need for broader representation of Traditional Owners and a desire to consider land and sea country holistically. However, the general expert opinion about the condition of cultural values was that it is poor and continuing to deteriorate, that cultural values are not systematically known or identified, and that the condition of cultural values would not be uniform across different groups.

Of the five historic heritage values, the three considered in detail were assessed to be in poor to very poor condition (voting was not completed for Commonwealth or other historic lightstations). The condition of those values assessed was determined to be deteriorating due to an acceleration of natural degradation likely due to human activities. While confidence in the results was generally high, experts noted the lack of information for many historic sites and artefacts. Participants suggested including a broader range of artefacts in the assessment of components, including integration with, rather than arbitrary separation from, Indigenous values.

Biodiversity experts assessed 10 (of 13) habitats that support species to be in generally good condition, although coral reefs (except in the north of the Region) were assessed as poor. The best 10 per cent of habitats were rated very good (or good in the case of coral reefs), but the worst 10 per cent were rated very poor (or poor for mangrove forests). Confidence in the condition result was generally medium to high, with some new data sources identified. There was generally medium confidence in a stable or no clear trend for most habitats, other than seagrasses for which there was high confidence in an improving trend, and some signs of improvement for northern and central coral reefs.

The assessment of 16 (or 19) components describing species populations was generally good, with the condition of other invertebrates, marine turtles and dugongs being poor. The best 10 per cent was assessed consistently as very good, but the worst 10 per cent was poor to very poor. Confidence ranged from low to high, depending on the extent of monitoring of different species. Many showed no clear trend, or were stable, but marine turtles and dolphins were assessed to be deteriorating.

There were not enough experts to provide a robust vote on eight of the 10 physical and chemical processes components affecting ecosystem health. Participants instead provided a narrative assessment for these components. Of those not formally assessed through voting, there were comments about changes adversely affecting the Region, with two components having a stable trend and one (ocean acidification) a declining trend. For the other five, there was either no comment offered about the trend (three) or inferences of stability based on limited evidence (two). Of the two assessed, one (sediment exposure) was good with a broadly stable trend, and one (light) was good to poor with a stable trend.

The condition assessments of ecological processes were variable, being poor, good, or very good, with stable or no clear trends. Experts noted the lack of indicators or systematic monitoring for many processes, improvement for some components, and the difficulty in generally assessing processes.

Experts assessing coastal ecosystems that support the Great Barrier Reef noted the definition of 'condition' combines information about extent, function, diversity and quality, potentially obscuring important patterns in the evidence. Only two of the seven components in this category were formally assessed, with voting on condition as good for saltmarshes and poor for freshwater wetlands, both with a stable trend. By agreement with the experts available at the workshops, there was no assessment or discussion about outbreaks of disease, introduced species or pest species.

See Table 5 for a summary of condition, trend and confidence assessments for all Indigenous living culture, historic heritage, and natural value components. In summary, for the category Most (representing 80 per cent of the component being assessed), of 34 components formally assessed, there are two grades of Very Good condition, 14 grades of Good, 10 grades of either Good – or Poor +, five grades of Poor, and three grades of Poor – or Very Poor. This represents a decrease in the number of components rated as good in 2019.

Day 1: Indigenous living culture values assessments

There were nine experts in the room, six of whom identified as Traditional Owners of some part of the Region. Of the more than 70 mobs with Country across the Region, there were participants present from six Countries. Participants were not asked to speak on behalf of their Traditional Owner groups or Country. Rather, their expertise was drawn on in a more general sense, particularly around reflections on the method currently being used for the rapid assessment workshops.

Following an introductory discussion, a collective decision was made to not hold any votes. Instead, information was gathered for three questions following a discussion in the room.

The three questions for which input was gathered from participants using Menti were:

1. My overall comments about improving the method are…
2. There are some caveats I think it is important are noted for this value assessment …
3. My general expert opinion about cultural values is… OR Important new information to note includes…

The inputs gathered from participants are provided below and are edited only for grammar, as per the agreement made in the room to present the exact words used by participants. The unedited original inputs are available in Appendix 4.

Input provided via Menti in response to the question 'My overall comments about improving the method are…' included:

- *Need broader representation of Traditional Owners and other Indigenous people involved in Sea Country. Pioneer a new approach to recognise the holistic nature of Indigenous values. Avoid nature/culture dual.*
- *Engage with more Traditional Owners to get a broader consensus regarding the grade and trends of the components.*
- *Need regional focus of engagement with Traditional Owners.*
- *Broader engagement with all Traditional Owner communities with connections to the GBR. A complete overhaul of the process to reflect diversity of perspectives.*
- *More GBR Traditional Owners should be here.*
- *It's going to be hard getting representative opinion for all Traditional Owners with this outlook report. I understand your goal but doesn't make it any easier*

to get it done.

- *Identify a process to discuss community priorities and needs, then think through how those priorities and needs impact the health of the four heritage values through discussions with Traditional Owners.*
- *Is it worth having a few more meetings with Traditional Owners or TUMRA mob to get their views as well.*
- *Technology is available for ease of interactions with Traditional Owner Groups to ensure information is sourced thoroughly and effectively.*
- *The process needs to consider more than one sitting, it needs time to digest information, consider and provide a balanced view. Consider locally/regionally based views versus GBR-wide responses.*

Input provided via Menti in response to the question 'There are some caveats I think it is important are noted for this value assessment…' included:

- *For next time, looking at biocultural values could be a better way to go forward. Biocultural – biology + cultural values.*
- *It's problematic to separate Indigenous and Historic heritage, as much heritage is shared, particularly for the invasion period.*
- *It can't be a blanket approach – Cultural Values can be interpreted differently by region, and urban/rural/remote settings. Cultural Authority needs to be considered. We can't talk or speak for others.*
- *Very hard to be representative for different Traditional Owner groups and come to one conclusion.*
- *Very challenging to get meaningful representation of Traditional Owners across the GBR. Structures like TUMRAs are excellent, but not representative.*
- *Different Traditional Owner groups will have different grades and trends for their country*
- *Ensuring each Traditional Owner group speaks about their Country, as each Country is different from the other.*
- *Cultural Values assessment will differ in different regions, so giving Traditional Owners an opportunity to voice concerns will help process*
- *The four heritage values should be able to adaptation and consider ways cultural continuity is navigated in the everyday through employment and training, digital interfaces knowledge sharing etc.*
- *People may be reluctant to grade good or very good as they perceive a link between grading and resources to improve their score next time.*
- *Needs to be a better mechanism for representing diverse knowledge in this*

space.

Input provided via Menti in response to the question 'My general expert opinion about cultural values is… OR Important new information to note includes…' included:

- *My expert opinion is that the condition across all of these arbitrary values is Poor. Sea Country condition continues to deteriorate owing to numerous factors.*
- *As Indigenous Heritage is living heritage, Cultural Values grading needs to be adaptable to mitigate pressures of the day. This would be subject to Traditional Owner's advice and consent (FPIC).*
- *Participation in Sea Country management activities is not equivalent to assessing the strength of knowledge reproduction. If senior knowledge holders are not engaged, knowledge reproduction is less.*
- *My general expert opinion about Cultural Values is that each and every Traditional Owner Group has their own Voice around their Country, Land or Sea. Acknowledge that we are a part of the GBR.*
- *Look at land and sea country holistically not separate.*
- *To make sure that all levels of Government are sharing information and ensuring it evolves and changes as we get new technology as well.*
- *Difficult to generalise. Broadly the cultural values are not systematically known or identified as those conversations/engagement with Traditional Owners have not occurred across the whole Region.*
- *As a Traditional Owner I feel that we need to support the Reef Traditional Owner groups more to help them better manage their values and build capacity to ensure they have a better voice to tell their story.*

Reflections drawn from the expert discussions

The following reflections from the facilitators are based on the information above and other discussions during the workshop.

1. There was strong discomfort within the room at the initial process to gather the values assessment about Indigenous living cultural values via the rapid assessment workshop.

2. Many excellent and constructive suggestions were made by Traditional Owners and Reef Authority staff to update the Outlook approach for Outlook 2029, as well as to gather a more robust and representative input for Outlook 2024.

3. There was a strong and genuine sense in the room from all participants (and staff) that it is important the Outlook process occurs with a highly visible voice of Traditional Owners and that work be done to improve the representation of Indigenous cultural values, their strong links to other values in the Outlook reports, and that the cultural safety of Traditional Owners involved be fundamental to the process.

Three quotes from the participants summed up the sentiment of the room and help guide the planning for improving the process for Traditional Owners input to this and future Outlook Reports.

Considering the importance of embracing cultural authority:

> *'My input does not represent my Country – I'm not an elder. I can't speak for Country.'*

Considering the general view that Traditional Owners strongly link cultural and natural values, and have broad interests in both:

> *'Why aren't the mobs in the room for all the values?'*

Considering the importance of Traditional Owners context:

> *'Strong people is strong Country.'*

Day 1: Historic heritage values assessments

A summary of the expert discussion and inputs to Menti is presented for each component, followed by a summary of the expert perspectives about condition and trend (consolidated in Table 5). Where voting on, or discussion of, a specific condition assessment led to a split vote, the category has been shown as a single category with a – or + sign showing the direction of skewed opinions. For example, Poor – means there was a split in opinion between Poor and Very Poor. Good + means there was a split between Good and Very Good. A Poor + result means there was a split in opinion between Poor and Good. The category assigned in the tables (where a – or + sign is shown) is the one with a marginally higher vote. Complete visual details of the results are contained in Appendix 5.

Commonwealth lightstations

The Commonwealth lightstations component was not assessed at the workshop. This was because participants felt that the expertise/info was held by Reef Authority staff with associated management responsibilities, who were not present at this workshop.

Historic voyages and shipwrecks

Summary of discussion

Participants discussed that six wrecks have special protection through Protected Zones, but there are many more wrecks in the Region. Potentially thousands of shipwrecks remain unknown and unrecorded in the waters of the Region. Experts noted that for many vessels there has been minimal inspections or site recording. Historic shipwrecks include those older than 75 years, so most known vessel wrecks are likely now historic.

Experts noted that the routes that historic voyages took through the Region are generally poorly known.

The term ‘relics’ was suggested to be changed to ‘associated artefacts’, because a site and its associated artefacts are all protected.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence

Historic voyages and shipwrecks	4	Very Poor	Good	Poor –	High	Deteriorated	High

Condition

The condition is assumed to be poor for known wrecks, as materials degrade in the environment. With historic heritage, condition is assumed to be poor by historic heritage experts unless there is evidence of it being good.

Participants considered that most shipwrecks would be in poor to very poor condition, with the caveat that not much has been published about condition of shipwrecks.

Confidence in condition

Confidence in the assessment of condition was based on inference rather than evidence. The 'high' confidence in the summary table above reflects that participants were highly confident in saying the condition is unknown. In the workshop there was agreement that the condition of lots of wrecks is unknown as there are no data. *Note: In the Outlook Report such situations are communicated as a condition (e.g. poor) with a confidence assignment of 'Inferred' to reflect the lack of data.*

Trend

There is natural deterioration with all heritage artefacts. Hence, for the purposes of this assessment, a declining trend should be interpreted as deterioration being faster than expected. Natural deterioration through usual processes would be considered stable. With increased storminess and higher temperatures, there would likely be accelerated deterioration. The primary environmental factors that drive stability are changing, so there is high confidence in the assumption of a deteriorating trend.

Confidence in trend

There is high confidence there is a deteriorating trend. Once again this is an inference by experts based on their understanding of changing environmental factors. They were unable to provide specific evidence (i.e. of observed deterioration at rates faster than anticipated) but were confident that it was.

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For both the condition and trend assessments, four experts in the room voted 'support'. No third vote was required.

Some experts thought that much more data, inspections and site recording was needed to definitively know about the condition of all historic shipwrecks.

Other historic lightstations

Summary of discussion

Five experts were in the room for this component, however they felt comfortable giving only narrative feedback on the scope of the component and suggestions on where to find information, rather than completing a vote.

The discussion concluded that this component included one lightstation (Pine Islet) that is within the Region as others are Commonwealth Lightstations. The participants felt the Reef Authority could consider including other navigational aids, floating and temporary lights, light ships and related infrastructure in this component that are not currently captured elsewhere. They also felt there could be other lightstation heritage artefacts in the Region that are not known by those at the workshop or the Outlook Report team, and that this is a common occurrence with historic artefacts. One expert noted that the Australian Maritime Safety Authority has ‘incredible records’ that may be able to be used if needed, as Commonwealth staff managed a number of locations.

World War II features and sites

Summary of discussion

The five participants questioned why this component is just WWII, with everything else included in ‘other places of historic significance’. WWII category could be broadened to include the physical and social dimensions (like jetties for loading and unloading, convalescence facilities or hospital ships moving through region), as well as other wars (like WW1, the Russian War). In this context, an expert noted that the component misses an enormous range and type of defence heritage in Reef waters associated with world wars and conflicts, including small boats and naval vessels. Many of these could also be added to ‘other places of historic significance’.

Some vessels have longer lifetimes. Small boat operations taking munitions to PNG were sunk but often their locations are unknown. The wreck of HMAS *Warrnambool* may be under 75 years old, but experts suggested it be considered in the assessment.

For this component, experts also noted some potential clarifying the language used. For example, the word ‘relics’ does not tell the full story in this context. The experts suggested use of terms such as ‘WWII site’, and if there are relics then ‘site and associated artefacts’, to be consistent with contemporary heritage studies.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
World War II features and sites	5	Very Poor	Good	Very Poor	High	Deteriorated	High

Condition

The same overarching process (as with other historic components above) of changing environmental conditions is potentially increasing deterioration; however, there is no evidence of direct physical anthropogenic activities accelerating the rate of deterioration (excluding looting), noting the previously mentioned impacts of anthropogenic climate change. The condition was graded as Very Poor, with high confidence at the inference.

Trend

The trend was assessed as deteriorated, with high confidence in the inference.

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, all four experts in the room voted ‘support’. For the trend assessment, four experts in the room voted – three ‘support’ and one ‘can live with it’ ‘support’. No third vote was required.

Other places of historic significance

Summary of discussion

Five experts discussed this component included a very broad group of tangible and intangible elements. They noted that most places of historical significance are poorly known, documented and managed and, in their view, there is a need for an active and ongoing historic heritage mapping project in the Region.

The experts noted that this component could illustrate histories and values that are shared with Indigenous Australians (e.g., missions, the influence of First Nations people, marine or coastal landscapes as sites of frontier violence in the colonial period, or Kanaka labour)

Experts noted that, although tourism was included in Chapter 5 (direct use, including tourism), historical aspects of tourism should be included in the ‘Other places of historic significance’ component. For example, the story of how the Region became a world-class destination, the development of the tourism industry, the history of SCUBA diving on the Reef and the history of fishing in the Region might be considered in future as a part of this component. Experts did note there was little information, collection of physical evidence, or interviews to gather information on many of these stories.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Other places of historic significance	5	Very Poor	Poor +	Very Poor	High	Deteriorated	High

Condition

The condition was graded as Very Poor, with high confidence for this inference.

Trend

The trend was assessed as deteriorated, with high confidence for this inference.

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, four experts in the room voted – three 'support' and one 'can live with it' '. For the trend assessment, four experts in the room voted – two 'support' and two 'can live with it'. No third vote was required.

Days 2 to 5: Natural values assessment (biodiversity and ecosystem health)

A summary of the expert discussion and inputs to Menti is presented for each component, followed by a summary of the expert perspectives about condition and trend (consolidated in Table 5). Where voting on, or discussion of, a specific condition assessment led to a split vote, the category has been shown as a single category with a – or + sign showing the direction of skewed opinions. For example, 'Poor –' means there was a split in opinion between Poor and Very Poor. 'Good +' means there was a split between Good and Very Good. 'Poor +' means there was a split in opinion between Poor and Good. The category assigned in the tables (where a – or + sign is shown) is the one with a marginally higher vote. Complete visual details of the results are contained in Appendix 5.

Biodiversity: habitats

Islands

Summary of discussion
During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to inform a narrative assessment for these components.

The experts reiterated that the scope of this component included all islands (regardless of jurisdiction) where those islands support values of the Region. Hence they considered the more than 1,000 islands in the Region with diverse type and relevant importance.

One expert with knowledge of islands noted that a sentence in the summary statement could consider impacts of plastic pollution on islands as locations where plastics may end up due to oceanic currents.

One expert noted that beach temperatures are increasing, as measured by *in situ* thermometers, which may affect species that this type of habitat supports (e.g. turtle nesting success). Net movement of sand can occur naturally, which can affect turtle nesting habitat.

Compared with the mainland, small islands have less buffering ability and fewer refugia, so there is less opportunity for species migration in the context of climate change.

Mainland beaches and coastlines

Summary of discussion

Four experts were in the room for this component, however they preferred to give narrative feedback rather than completing a vote.

They noted that erosion has dominated the east coast of Australia in the past 5 years due to a dominant La Niña affecting wave directions. The impact depends on beach orientation, so varies along the coast. Experts agreed there are data available on erosion now in the Region that were previously unavailable. They also noted that the temporal and spatial variability within this component may be problematic for defining a trend that is universal and/or beyond the range of natural variability.

As the trend being discussed was since 2019, significance over the past 5 years was considered as the ENSO cycle has produced a change that is part of natural variability, not a long-term trend. There was some agreement that the 35-year long-term trend is stable for this habitat.

The experts agreed that a change is only a deteriorating trend if condition doesn't bounce back via natural processes, or the change is not driven by a natural process. There was disagreement on the current erosion being a non-natural trend. The term 'deteriorated' implies a trend that is due to a pressure, not part of a natural trend. Some felt the erosion was part of natural variability. Some felt the overall narrative is that the change over the past 5 years is 'deteriorated with confidence', with the past 35 years being 'stable with low confidence'. However, others thought that the past 5 years may be a natural event due to ENSO.

Experts commented that if the grade remains 'Good' as it has for the previous three reports, then the trend should be 'Stable'.

Experts also agreed there needs to be an agreed benchmark against which mainland beach and coastline information is compared, which may not be the role of the Reef Authority. There was general agreement that the Outlook Report could continue to include the long-term trend in the narrative.

Mangrove forests

Summary of discussion

The discussion (involving three experts) included concern about documented evidence (based on helicopter transect observations) of shifting ecotones. Experts noted there has been no change in mangrove extent in the Region (based on observations of extent), although there is evidence of localised loss (such as after an extreme event or other natural impacts). Mangroves appear to be very stable ecosystems, compared with other coastal ecosystems.

It was noted that mangroves have huge ecosystem services, but there is no current program to monitor their condition. A caveat noted in Menti was the need to look at opportunities to have a program in future to report on mangrove forest quality, which could be partly possible through remote sensing.

Voting on condition was towards very good, reflecting the discussion, with medium confidence. The trend was assessed as stable with medium confidence.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Mangrove forests	3	Poor	Very Good	Very Good	Medium	Stable	Medium

Caveats and comfort level in assessment
Experts were comfortable with the rapid assessment outcome. For the condition assessment, three experts in the room voted – two 'support' and one 'can live with it'. For the trend assessment, three experts in the room all voted 'support'. No third vote was required.

Seagrass meadows

Summary of discussion

In general, there has been a trend of improved condition since the 2019 grade, although there are some exceptions. Not all seagrass monitoring suggests a poor condition in the southern Great Barrier Reef (e.g. see the Gladstone Healthy Harbour Partnership (GHHP) seagrass report[8]).

Participants considered if an improvement (which is mainly in the north) is enough to

[8] Gladstone Healthy Harbour Partnership. 2022, Technical Report, Gladstone Harbour Report Card 2022, GHHP Technical Report No. 9. Gladstone Healthy Harbour Partnership, Gladstone.

move from a Poor to Good category in a reef-wide grade. Even in the southern Great Barrier Reef, where there is less evidence available, condition seems to depend on local factors. The condition had dropped in the south during this reporting period, and it has now recovered slightly: so it is improving but still poor in some locations. Overall the condition is good, but borderline poor in the south, with localised declines and localised improvements. This is based on adequate evidence to have high confidence.

Voting on condition was good, reflecting the discussion, with high to medium confidence. The trend was assessed as improved with high confidence in that result.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Seagrass meadows	3	Very Poor	Very Good	Good	High-Medium	Improved	High

Caveats and comfort level in assessment

Only two experts in the room voted on comfort with the rapid assessment. For the condition assessment, both experts voted on 'support', which was the same for the trend assessment. No third vote was required.

In Menti, one expert noted the overall trend of improved condition in seagrass in the majority of locations where monitoring is conducted. There are still some locations where seagrasses have yet to show substantive recovery and some places where interventions are required, but these are currently few and a very small percentage of the areas where seagrasses are regularly assessed.

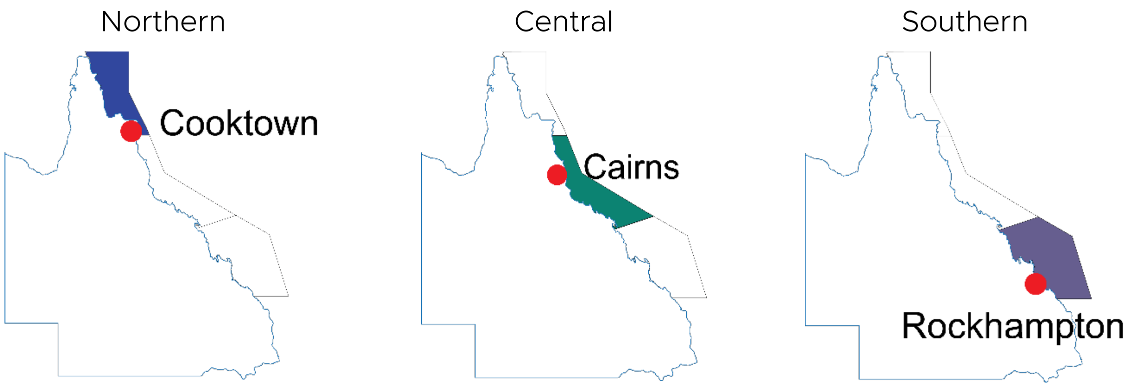
In the discussion, participants noted that little is known about deep-water (> 15 m) seagrass, other than a small amount of monitoring in ports. As a result, the assessment reflects shallow seagrasses only.

Coral reefs

Summary of discussion

Experts assessed grades for coral for the whole Region. The Outlook Report includes finer-scale regional-scale assessments within the narrative of the report. However, historically it has only presented a single grade for each component at a Region-wide scale. For the 2024 Outlook Report, the workshops presented an opportunity to trial assessments at a smaller spatial scale. The trial was based on feedback at past workshops that it is hard to consider at the spatial scale of the whole Region. As this was a trial, it was not intended to be extended to regional-scale assessments for all components because in many cases there is insufficient data to do so. This would also make the report a significantly larger task, and in some cases, there are alternative reports that serve this purpose at a regional scale. Coral reef habitat was selected as the trial component on the basis that there is long-term systematic monitoring of this habitat type at the spatial resolution required.

At the time of drafting this workshop report, the Outlook Report team had not specifically committed to include these smaller regional grades in the final 2024 Outlook Report, but will continue to report on regional differences in the narratives. For this trial, coral reef habitat was assessed for the northern, central and southern regions, as defined by the AIMS Long-Term Monitoring Program (see Figure 4).



The northern region includes coral reefs from Cape York down to Lizard Island and Cape Tribulation	The central region includes reefs from Cape Tribulation, down to the Whitsundays.	The southern region includes reefs from south of the Whitsundays down to the Capricorn-Bunkers and out to the Swain Reefs.

Figure 4. The scope of the northern, central and southern regions used in the Expert Rapid Assessment Workshops.[9]

Before discussing the condition or trend in any depth for any section of the Region, experts discussed a number of topics to help clarify the thinking or context from which they were providing input. One noted there is a great deal of variance around the mean – some reefs have not 'recovered' at all, others have. Others noted a mid-

[9] Great Barrier Reef Marine Park Authority. 2023, Reef Snapshot: Summer 2022-23. https://hdl.handle.net/11017/4002

recovery stage after extremely severe bleaching disturbances. A low anthropogenic disturbance environment could serve as a proxy to predict successful recovery trajectory. Some noted it was likely a stage of early to mid-recovery with the community of recovering reefs dominated by fast-growing *Acropora* (noting there are still large *Porites* alive and well on many reefs).

One expert noted that, as all corals in the Region have already experienced the effect of ocean acidification, they are growing more slowly.

The components of habitat quality are difficult to divorce from organism demographics because the organisms build the habitat. Coral habitat needs to consider coral cover but also be complemented with other measures, such as diversity (of hard and soft corals) and functional categories. There is very little knowledge on any diversity change. The condition of the habitat is highly dependent on community composition and size frequency distribution, of which there is less information. Other suggested metrics included macroalgal cover, Crustose Coraline algal condition or reef growth. As final comment on understanding effects on coral reef habitat, one expert noted that coral cover is only the tip of the iceberg: other biota will respond to pressures that are gradually ramping up, although acute disturbances were low in the past 5 years.

Despite the comments about the coral cover alone being a less complete metric of coral reef health, experts noted that cover of hard corals is a robust indicator to use as a general indicator of the state of the ecosystem in the Region overall.

A knowledge gap was the recovery of faunal assembly change, especially regarding the smaller invertebrates after thermal stress, and the non-dominant species population explosion and recession post-recovery. An expert noted specifically that the dynamics of soft corals are complex; interpreting their role in habitat state is complicated – there are areas where soft corals have declined below historic values, and areas where they are above.

In summary, the trends are inconsistent: there has certainly been recovery in coral cover since the mass bleaching, but most ecosystem components are unknown.

Coral reefs: Northern

Summary of discussion

Participants noted a potential bias by starting in the north, due to that region's better condition. Discussion of coral includes hard and soft coral reef habitat and deeper coral communities. All of the relevant measures of health and functioning of coral reef habitat were considered by experts, not just the metric of coral cover. Experts noted some evidence of decline in soft corals, with other areas showing an increase that prevented growth of hard corals.

The results revealed the worst is in very poor condition, while most coral in the north is marginally good, which means more experts voted Good than Poor often giving a lower grade in the Good category.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Coral reefs (Northern Region)	12	Very Poor	Very Good	Good –	Medium / High	Improved / Stable	Medium – High

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, 12 experts in the room voted – eight voted ‘support’ and four voted ‘can live with it’. For the trend assessment, 12 experts in the room voted – nine voted ‘support’ and three voted ‘can live with it’. No third vote was required.

Participants noted that communication of the result when close to the boundary between poor and good is important. The nuance of one vote possibly moving the assessment from good to poor needs to be understood, which is why we have recommended the ‘marginally good’ outcome. There were a number of experts who assessed it as ‘Poor’ for this subregion.

Experts noted some caveats. The current condition is viewed in the context of a baseline of hundreds or thousands of years. In the context of the past 5 years, there may have been good growth, but it has been from a low baseline in the broader context of an overall decline. Other details noted by experts included that although there was improvement from 2019 to 2022, this year (2023) has seen a pause in that trajectory.

Despite the AIMS Long Term Monitoring Program sites in this region, the experts noted there are knowledge gaps in the north for three reasons: remote areas are potentially under-sampled as they are harder to access, some inshore monitoring sites can be difficult to complete due to safety concerns from crocodiles (note that this is a challenge in all three sub-regions) and finally as less is known about inshore or deeper reefs offshore in this subregion. Experts noted that research efforts need to increase in this region. One noted that as it may be the most resilient part of the Region, better understanding is needed.

Coral reefs: Central

Summary of discussion

Participants noted that the draft summary statement is based on hard corals, and more consideration is needed about soft corals. Monitoring that has not been published yet was factored into the expert opinion.

Experts noted that multiple disturbances, including water quality, crown of thorns starfish (CoTS) and overfishing, remain intense in this region. Recovery of the central region has been observed primarily on the upper slopes. There is very limited information on recovery in deeper areas, and limited recovery inshore in the south of the Central subregion. Experts suggested that acidification and deoxygenation can be added to the list of disturbances noted in the draft summary statement as chronic ongoing disturbances to build on the current cyclones and bleaching that are noted.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Coral reefs (Central Region)	12	Very Poor	Good	Poor	Medium / High	Stable / Improved	Medium

Condition

The central subregion has had less recovery in coral reef condition than the north. In the Central subregion, there is a clear pattern that most coral reefs are in poor condition than the marginally good condition suggested for the Northern subregion. Experts noted little evidence of a loss of diversity in this subregion.

Trend

The trend is improving holistically over the whole system with some experts suggesting a stable trend in this subregion. There was less expert agreement in the central region compared with the north. In the north, coral condition has improved from a low base. In the central region, the effect of previous bleaching events was less, so the trend is from a higher base. As a result, it is not as clear whether the whole system is increasing. This resulted in some experts suggesting that it should be rated as stable as it is not getting worse.

Caveats and comfort level in assessment
Experts were comfortable with the rapid assessment outcome. For the condition assessment, 11 experts in the room voted – seven voted 'support' and four voted 'can live with it'. For the trend assessment, 11 experts in the room voted – nine 'support' and two 'can live with it'. No third vote was required.

Experts noted that this region is the best studied of all reefs. And there has been some recovery in some parameters, whereas other ecosystem components will take decades. The disturbance frequency remains a concern, which was covered by the draft assessment. They noted this is a highly disturbed area for CoTS with a lack of real baseline knowledge of the impacts on invertebrates.

An expert noted that there are some really high diversity reefs, particularly inshore, with quite low cover. The condition assessment depends on how the metric is weighted.

Coral reefs: Southern

Summary of discussion
Experts wanted to change the reference in the draft summary statement from 'escaped' to 'mostly escaped' bleaching events and 'escaped' severe bleaching. It was noted that new information from the Australian Institute of Marine Science's Long-Term Monitoring Program annual report released during the week of the workshops should be considered in the 2024 Outlook Report. Most experts in the room had not yet had a chance to review these results, but lead researchers from this program were present for the vote.

The southern region is larger, with more remote areas, more variability in coral, and more tourism use and industry. In this huge area many remote offshore reefs are rarely visited. Across the subregion, there is heavy inshore use (industrial, coastal living, tourism) and many outer reef areas with little knowledge of faunal assemblages. As a result, some experts found assessing an 'overall' trend and condition is difficult in this subregion.

The underlying reef structure is generally flatter, so the habitat relies more on living corals for its structure. As a result, hard coral cover as a metric for condition is more robust in the south perhaps than other subregions.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Coral reefs (Southern Region)	10	Very Poor	Good +	Poor	Variable – Medium	Stable / No Clear Trend	Medium – Low

Condition

The Worst 10% are Very Poor, and the best examples are marginally Very Good. Experts were divided on the Most condition category. Some experts were comfortable improving the condition to poor but no higher, hence Most is given as Poor.

Trend

There was little agreement on the trend in the southern region, with low to medium confidence in a stable trend or no clear trend.

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, 10 experts in the room voted – seven 'support' and three 'can live with it'. For the trend assessment, 10 experts in the room voted – six 'support' and four 'can live with it'. No third vote was required.

Experts noted quite local variability – for example, within areas such as Keppel Island that are relatively well studied there is considerable variability in condition and trends on coral reefs. However they noted there is disparity in data availability between sites. The lack of data at many locations makes it difficult to allocate a condition and/or trend.

In a call to action for the research community, an expert noted that given the unknown but emerging cascading effects on reef-dependent species, there is still much to be learned regarding the ecosystem health of coral reefs.

Coral reefs: Region

Summary of discussion

It was noted that the assessment may be more accurate from a quantitative aggregate of the regional assessments above, rather than doing a mental aggregation in this whole-Region assessment, hence fewer attendees chose to participate in the vote for the whole Region.

Experts noted that research may focus on what is easily found and hence is showing recovery. In terms of coral-dependent fish, total density bounces around with no clear trend, but at a detailed scale there are winners and losers. There are shifts in the structure of species composition that haven't bounced back, but some experts note this may be an expected lag. Experts suggested the Outlook Report team could seek further expert advice about what has rebounded from long-term reef monitoring.

The trend considers a 5-year timeframe, but some experts expressed uncertainty about short-term recovery and assessment of long-term recovery: as with bushfires, fast-growing species recover before others, but detailed knowledge of species recovery is lacking.

There is improvement but it is patchy: there is more improvement in the north and not as much in central and southern regions.

Voting by experts on condition was split 50:50 between a high Poor result and a low Good result for Most Coral Reefs from a Region-wide perspective, which reflected the discussion. The Worst 10% were Very Poor and the Best 10% ranged from Good to Very Good, with more experts assessing it as Very Good. There was variable but generally medium confidence. No clear trend was assessed with variable but generally medium confidence.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Coral reefs (Region wide)	10	Very Poor	Very Good	Poor +	Variable – Medium	No Clear Trend	Variable – Medium

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, nine experts in the room voted – five 'support', three 'can live with it' and one 'Minor Concern'. For the trend assessment, nine experts in the room voted – four 'support', four 'can live with it' and one 'Minor Concern'.

Following a discussion with the experts in the room, the minor concern was highlighted as questioning the need to do a Region-wide assessment following the three regional assessments (these were done first in the workshop) rather than a sense that they had not been heard or felt uncomfortable with the process as it was applied in the room.

Feedback was given that the minor concern expressed would not change any votes if voting occurred again, so no third vote was required.

Lagoon floor

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote. The Reef Authority Outlook Report team followed up with some experts, reports and sources nominated by those present to complete an assessment for these components.

The discussion noted that the rate of deterioration slowed due to lower temperatures during La Niña, but it is not a stable trend. The condition is inferred from other habitats around the lagoon floor that are monitored. Due to the shallow water, some experts suggested that the lagoon's soft floor species and sponges are affected by heat more than corals.

One expert with knowledge of lagoon floor habitats suggested that the condition is good, but declining in trend due to no reduction in threat from climate change (especially temperature).

As for some other similar habits, experts suggested reviewing the language and scope of these components to align to the newly updated Queensland intertidal and subtidal classification scheme.

Other shoals and banks

(Suggested re-naming: **Unconsolidated sediments with positive relief/Sediment banks**)

Summary of discussion

While three experts were in the room for this component, they felt more comfortable giving narrative feedback rather than having a vote due to data gaps and some lack of clarity about the definition and scope of this component in the Outlook Report, which led to a good constructive discussion about what this component contains, and could be named.

The Outlook Report team sought advice from the experts specifically about the scope of this component. A rich and detailed discussion occurred with ideas and suggestions about how future Outlook Reports could define this habitat in a useful and practical way for reporting purposes. The experts reiterated their support for a previous decision from the 2019 Outlook Report that coral-dominated habitats better belonged in the ‘Coral Reefs’ component, as the plain language definition of ‘shoals’ used by fishers and others is not considered a separate habitat by experts.

Experts suggested there is a habitat that could genuinely be defined as ‘Shoals’. From a geological and ecological perspective, it is distinct and important enough to consider as a component. The suggestion was to redefine this component to cover the large areas of unconsolidated sediments with positive relief that exist in the Region. These are what would scientifically be referred to as ‘Shoals’. However, given the historical and regional confusion of the scientific and plain language use of ‘shoals’, a new or different name for the component could be considered. There is also an opportunity to align this category with the recent changes made to the Queensland Intertidal and subtidal classification scheme.

In future, the components could be categorised as unconsolidated sediments with positive relief (drawing on the Queensland tidal and intertidal classification), with a simpler title, such as ‘Unconsolidated banks’ or ‘Sediment banks’.

There was strong agreement among the experts that these are an important and prevalent habitat, and are likely very widespread in the Region. There is a large data and knowledge gap in relation to these habitats, which experts noted was research needing to be filled. There is little idea about the extent, aside from a single small 20-year-old study, a lack of understanding of how they function, or any sense of trend in the condition. Experts noted that some are likely to be relic and others may be still active.

Halimeda banks

Summary of discussion

The discussion noted that, while mapping has improved to provide enhanced spatial analysis, this covers spatial extent, not condition and trend. More high-resolution mapping has found more *Halimeda*, but that doesn’t mean an increase in extent of real coverage of the habitat, as it may be simply due to low past sampling effort and changing technology mapping more habitat – i.e., ‘the more we look the more we find’. One expert noted that the draft assessments of condition are likely based on extent/areal distribution and consideration needs to be given to the thickness and accretion rates of *Halimeda* bioherms, for which there is no, or limited, data.

Experts made a number of points about the importance of *Halimeda* Banks as habitats and climate refuges in the overall context of the health of the ecosystems in the Region. Experts drew on their expertise in the habitat to note that there is a growing understanding about the importance of *Halimeda* beds in the Region, especially *Halimeda* bioherms, which are critically important ecologically to a number of other species. There has been an increased recognition of the importance of *Halimeda* banks as a habitat for biodiversity and carbon/nutrient cycling. They noted that little is known about *Halimeda* biology, its contribution to buffering effects of ocean acidification, and even the species diversity of *Halimeda*, the thickness of Bioherms and the potential refugia provided by this habitat in the future under a warming climate. One expert contented that understanding *Halimeda* may be critical to understanding the health of the reef as a whole and more work is needed to understand its ecological importance as a habitat.

Experts suggested that more information is required on the extent and function of *Halimeda* banks and Bioherms including their role in ocean buffering, and increased understanding of basic biology. Improved mapping and monitoring would also be necessary to improve understanding of this habitat.

Given these gaps, little is known about the impact of natural variability and seasonality. Experts noted that *Halimeda* banks do suffer thermal stress, but the impact is unknown on *Halimeda* extent, condition and, in detail, their biology. Much of the depth range for meadows can be down to 80-90 m, and bioherms can rise to 20 m, which exposes them to both waves and thermal stress.

Both bioherm banks and flat meadows are combined for consideration in this vote.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Halimeda banks	4	Poor	Very Good	Good	Low	No Clear Trend	Low

With low confidence in the evidence base, Experts assessed the condition as Good. There was no clear trend assessed with low confidence.

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, four experts in the room voted – one 'support' and three 'can live with it'. For the trend assessment, four experts in the room voted – two 'support' and two 'can live with it'. No third vote was required.

Continental slope

There were not enough participants with expertise in this component to provide a robust input to the assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components.

As the slope gradient changes, habitats vary, and experts noted more than 20 to 30 different types of habitats could be considered. Participants suggested a potential name change to 'continental slope habitats' to assist with clarity.

Water column

(Open waters)

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components.

However, four individuals with experience in the area did offer narrative inputs including that changes to the water column would lead to changes to species that rely on this as a habitat. Many species use the water column for entire life stages or partial stages of the life cycle. Excluding estuarine areas from the definition of this component may be helpful as many species move upstream prior to moving back out to the open ocean thus biasing species diversity counts or distribution.

To understand the effect of different processes on the water column experts suggested the need to understand seasonal variability and effects of other factors. Experts made some suggestions for solutions to some identified gaps. Plankton counts and assembly correlated to the ocean chemistry and temperature could close the knowledge gap. Information regarding factors such as jelly blooms of species outside of those related to weather conditions or harmful to human health may shed some light on processes in the water column.

The experts inferred no clear trend due to a lack of evidence-based information.

Biodiversity: species

Mangroves

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. Participants suggested three mangrove experts for the Outlook Report team to contact, along with other experts, if needed, to complete an assessment for these components.

Experts did note large dieback in the Gulf of Carpentaria (outside of the Region) due to ENSO, but big shifts in the Region have not been observed.

Participants highlighted that the 2019 Outlook Report noted a new species introduced from southeast Asia, but with no systematic monitoring, and because the tree was well developed, it could have been introduced around 100 years ago.

Seagrasses

Summary of discussion

The discussion included a suggestion to consider a grade of good and improving, as it is no longer poor and there is no evidence of specific threats to particular species in the Region. When there are species losses, colonising species have arrived changing the species composition; if there has been a reduction in colonising species it is inferred that the relative proportion of foundation species has improved.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Seagrasses	3	Poor –	Very Good	Good	High	Improved – Stable	High

Experts assessed the condition was Good, reflecting the discussion, with high confidence. The trend was assessed as being between Improved or Stable based on high confidence by the experts who voted.

Experts noted that there is strong evidence from some areas of the southern Reef of seagrasses being in good condition. For example the Gladstone Healthy Harbour Partnership (GHHP) monitoring shows seagrasses improved in 2022 to be in a good condition from the Narrows to Rodds Bay.

Caveats and comfort level in assessment
Only two experts in the room voted on comfort with the rapid assessment. One had done a pre-assessment and was not in the room for the vote. For the condition assessment, both experts voted one ‘support’, which was the same for the trend assessment. No third vote was required.

Benthic algae

Summary of discussion
Prior to 2019, microalgae and benthic microalgae were separate, and then combined. A discussion to clarify what is included in this component concluded there are four potential broad categories: microphytobenthos (also called benthic microalgae), algal turfs, fleshy macroalgae, and crustose coralline algae (CCA). Experts noted that coralline algae have not been systematically monitored. Experts noted that fleshy macroalgae is composed of very different groups, that are highly seasonal and variable. Note that Halimeda is a group of benthic algae, and is included in the Outlook Report as a standalone component.

Algae are a big component of reef ecosystems, in addition to the more commonly discussed coral and seagrasses. Systematic monitoring of benthic algae trends may become important because as coral is lost, algae will keep the productivity of the reef going.

Diseases in algae are sighted in shallow reef transects, but are not common and not recorded. For example, one expert noted observed patches of coralline algae are turning green, with a section of white between the pink and green, suggesting it has died. However, the scale of these observations is unlikely to result in a poor grade on a Region scale.

Regarding the evidence base, experts noted there is no or limited monitoring of ‘benthic algae’ across inter-reef areas of the Reef with only observations on shallow coral reefs within the AIMS LTMP. In general, species-level identification of almost all algae remains a challenge with very low percentage of species monitored. Diversity metrics of benthic symbiodinium populations have shifted and persisted following the 2016 bleaching, with increased diversity of symbiodinium observed including in thermally tolerant clade D. More broadly it was noted that no repeat surveys have occurred since the 2007 Inter-reef Biodiversity Project, which provides a good single snapshot in time.[10]

There was a discussion about geological timescales as there have been shifts between coral and algae dominance over these scales hence shifts are possible. Monitoring of broad-scale trends in calcareous algae (green and red) may become increasingly important considering potential future phase shifts in major calcifiers from coral-dominated to algal-dominated. Some experts suggested that algae may be a more important habitat moving forward in the Reef. There are geological records showing cyclical shifts between coral-dominance and calcareous algal dominance aligned with climatic or other perturbations.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Benthic algae	6	Poor –	Very Good	Good	Medium	Mostly Stable	Low-Medium

Expert assessment of condition for Most areas was Good, reflecting the discussion, with medium confidence. One noted that the 'Stable' assessment is based on limited major disturbances and perturbations since 2019. The trend was assessed as mostly stable based on low to medium confidence.

Other notes included that this may be due to no obvious change because most of the loss of corals in mid and outer shelf reefs have resulted in more heavily grazed algal turfs rather than macroalgae. However, there is a global trend of decline in crustose coralline algae with replacement of Peyssonnelids. It is not clear if this is happening on the Reef and the lack of reliable data on trends in Peyssonnelids could be problematic.

Experts noted that while they were happy with the draft assessments provided at the scale examined, given the value of benthic algae habitat to other important ecosystem values on the Reef the lumping of the different types of algae may be problematic. The breadth of the classification used in the component may mean that a homogenised assessment misses important detail relevant to condition, extent, distribution and trends.

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[10] Pitcher, R., Doherty, P., Arnold, P., Hooper, J., Gribble, N., Chalmers, S., Coles, R., Ehrke, B., Good, N. and Kistle, S. 2007, Seabed biodiversity on the continental shelf of the Great Barrier Reef World Heritage Area. https://era.daf.qld.gov.au/id/eprint/1704/1/CRC_GBR_Seabed_Biodiversity_Final_Report__Fri20July07c-sec.pdf

Caveats and comfort level in assessment
Experts were comfortable with the rapid assessment outcome. For the condition assessment, five experts in the room voted – two 'support' and three 'can live with it'. There was the same result for the trend assessment. No third vote was required.

Corals

Summary of discussion

Experts discussed a recovery in the north of the Region, noting caution in relation to extrapolating these findings from observations of recovery in small groups of species. Some of the recovery related to rapid growing and fast-colonising species that are not representative of recovery in broader genus. Hence the recovery of *Acropora* as a genus of corals should not be generalised to other coral taxa for this assessment, nor should it be treated as having a single response within the genus given the diversity of species within it.

There have been declines in abundance but no evidence of loss of diversity. That doesn't mean there haven't been declines or even extinctions as corals are not monitored at that level. It is unclear if there is species loss due to the lack of large-scale data beyond genus/lifeform and the continued uncertainty in taxonomy. Functional assessments of key ecosystem services are often data deficient (e.g. coral calcification rates) that feed into service provision and recovery. Hence it is difficult to evaluate any recovery.

It is hard to assess based on diversity within the coral as there are more endemic species with discrete distribution that may be adversely affected and not recover as fast. Evidence is lacking for the recovery of coral diversity.

One expert noted the 'massive' evolutionary pressure on corals towards greater temperature tolerance and faster re-colonisation, with implications for genetic diversity, that is occurring with climate change.

The discussion involved a range of opinion, which is reflected in the large spread of results for 'Most', although there is agreement that most corals in the Region are growing more slowly with more experts suggesting condition leaning towards Poor with some Good. There was low confidence in this assessment.

No clear trend was inferred with low to medium confidence.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Corals	9	Very Poor	Very Good	Good –	Low	No Clear Trend	Low – Medium

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. They noted it is hard to assess coral species at the Region scale. They could be more confident at the smaller scale in communicating what is happening to coral species.

Experts noted some specific caveats for consideration. Little is known about rare species, and their densities needed to continue to reproduce. Some rare species, even when still present, may be reproductively isolated so may be ecologically regionally extinct even if some colonies are still to be found. Little is known about smaller endemic species ranges.

Critically, experts noted that the southern Reef supports many species not found elsewhere on the Reef, many of which are likely subtropical endemics. This could dramatically influence estimations of population size, extinction risk, etc.

There was a call to researchers for more knowledge about the symbioses and what contribution each member plays relative to each other. A research question was posed: How do symbioses change across environments and environmental states?

For the condition assessment, eight experts in the room voted – four 'support', three 'can live with it' and one 'Minor Concern'. For the trend assessment, eight experts in the room voted – one 'support', five 'can live with it' and two 'Minor Concern'. Following a discussion with the experts in the room, the minor concern was explained as relating to the lack of clarity about the scope of this component (especially as it related to how to measure this component – populations or groups of species, or both), and the data and information available to make general inferences about it, rather than a sense that they had not been heard or felt uncomfortable with the process as it was applied in the room. Feedback was given that the minor concerns expressed would not change any votes if voting occurred again, hence no third vote was taken.

Other invertebrates

Summary of discussion

Participants noted that this component includes more than 1,200 species in 32 phyla – everything that's not coral, mammals, reptiles, fish, sharks or rays – making assessment in a single category challenging. In summary experts felt that there is a wide scope of animals and spatial area included, there are different management strategies for these, and there are lots of gaps in knowledge in various species.

Combining diversity into a single component may give an overall misleading synthetic picture. Some suggestions for future Outlook Reports to manage the large number of taxa in this component included breaking it into arthropods, molluscs, echinoderms, and others.

An expert suggested one other way to review the invertebrate phyla is to comment on economically important invertebrates, those listed under IUCN or CITEs, those reflected in management strategies, or iconic long-lived species.

Linkages with environmental processes are a key data source as they may tell a story about long-term trends in invertebrates.

An expert noted that there have been bleaching events in 2020, 2021, and 2022 during La Niña years, which may have impacted invertebrate condition.

Many calcifying species of invertebrates are ecosystem engineers and will be worse off due to climate effects. For example once sea urchin are reduced in numbers, algae could put more pressure on corals due to loss of grazers (i.e., urchins). Along similar lines there was a call to include forams (at least the benthic ones) in this group as they are important sediment producers (e.g. needed for building sand cays for turtle nesting).

Condition

The breadth of results reflects the diverse range of species considered and the low confidence in the evidence bases various experts considered.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Other invertebrates	5	Very Poor	Very Good	Poor +	Low	No Clear Trend	Low – Medium – High

Trend
The agreement was there was no clear trend.

Caveats and comfort level in assessment
There was wide agreement that there are large knowledge gaps and the component would benefit from being split.

Experts ranged in comfort with the rapid assessment outcome. For the condition assessment, five experts in the room voted – one ‘support’, two ‘can live with it’ and one ‘Minor Concern’. For the trend assessment, four experts in the room voted – three ‘can live with it’ and one ‘Minor Concern’. Following a discussion with the experts in the room, the minor concern was similar to those highlighted above relating to the large breadth in what was being considered in scope, and the lack of a clear metric, and hence the data and information available to make general inferences about it, rather than a sense that they had not been heard or felt uncomfortable with the process as it was applied in the room.

Caveats noted include that the vast majority of invertebrates live in coral rubble. As reefs degrade, invertebrate habitat improves (from a biodiversity perspective, though some taxa will decline with the loss of coral). However, recent studies also show that persistent rubble sees a decline in biodiversity. Fresh rubble has the highest structural complexity and biodiversity.

Plankton and microbes

Summary of discussion
This component is broad in scope, including lots of species leading to a sense by the experts that a combined metric is uninformative. Plankton is composed of very different groups, all responding differently to environmental factors, e.g. phytoplankton, zooplankton, viruses, etc. Experts noted that within groups, e.g. zooplankton, there is large range of types. For some groups, i.e. bacteria and viruses, there is improving knowledge and more confidence in trends. For many plankton groups there is little to no knowledge and hence low confidence in assessment.

This component is very cross-disciplinary and there is an increase in our understanding of pelagic microbes but not a strong enough evidence base to see patterns. There is some understanding of community dynamics for some members of the planktonic communities, and it is known that several are influenced by environmental changes. There is an improving understanding of links between water quality and changes in bacterial communities.

Change may be able to be identified if there is:

- an abundant change but different assemblages (e.g. due to it being hotter)
- disappearance of some species
- changes in the composition or abundance of communities (not processes)
- shifts in geographic spread.

Ongoing data collection is needed as there is very selective information available about this component currently with holistic summaries remaining difficult. Communities are known to shift very fast temporally and spatially.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Plankton and microbes	3	Very Poor	Very Good	Good	Low	No Clear Trend	Low

Condition
The discussion noted there had been little change, the condition is good, but there are large knowledge gaps leading to low confidence in the assessment.

Trend
There was no clear trend, with low confidence.

Caveats and comfort level in assessment
Experts were comfortable with the rapid assessment outcome. For the condition assessment, three experts in the room voted – one 'support' and two 'can live with it'. There was the same result for the trend assessment. No third vote was required.

Bony fishes

Summary of discussion
The experts had confidence in the summary, due to good data covering reef fish on shallow reefs. Knowledge about fish is not equally captured in all habitats.

They noted that when they assessed condition it was compared with pre-European states including all modern pressures – e.g., fishing (commercial and recreational), water quality, and pollution. They noted that while overall condition may look good, at a species level the data suggest otherwise.

Participants had a long discussion about the available data for the assessment. There was use of fishery-dependent data (i.e., data sources from commercially or recreational fished species) as input into assessing this component. Information is collected on 40 commercial species for catch numbers. The status of commercially harvested species ranges from healthy to overharvested. Some experts questioned if fisheries-dependent data for target species are enough to give a reliable overall indication of condition and trend.

In addition, there are reef monitoring programs that measure fish (non-recreational and non-commercially fished species), but monitoring of fish in seagrass is patchy. The non-fisheries species information is largely restricted to shallow reef slopes, but there is some information from deeper habitats. There is little long-term independent data on non-reef fishes, especially non-commercial fishes and deep water fishes, herbivores, and planktivores. There is a heavy bias towards knowledge of coral reef species.

Noting all that, experts assessed the condition for most areas as Good. The voting shows a consistent picture: while there are examples of poor condition in the Worst 10%, for most the condition is good, with the Best 10% showing very good.

This was not surprising to the experts present, due to the amount of monitoring available (even if specific in scope to species or populations as discussed above) hence this assessment was based on medium confidence.

The trend was assessed as Stable based on medium confidence.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Bony fish	6	Poor	Very Good	Good	Medium	Stable	Medium

Caveats and comfort level in assessment
Experts were comfortable with the rapid assessment outcome. For the condition assessment, five experts in the room voted ‘support’ – which was the same as for the trend assessment. No third vote was required.

Sharks and rays

Summary of discussion

Since the previous Outlook Report, a 2019 national report card for sharks that gave a species-by-species assessment showed that the condition of most species across Australia is not poor. In the main there is limited long-term information for many species, but the assessments follow global trends of declines. A link (https://www.fish.gov.au/shark-report-card) was provided for more information.

An Australia-wide risk assessment for sharks and rays is underway – most (of 140 sharks and rays) are facing a manageable level of risk. A recent Global Finprint[11] survey showed that reef sharks are more common in the Region compared with other areas around the world. However, experts noted that, globally, reef sharks are depleted.

There are good data on reef shark species, and comparison research for two species of reef sharks, but for most (around 140) species experts noted there is very little information. New citizen science records, plus ongoing research by taxonomists may improve this situation.

Experts noted that there is evidence that Green Zones and Pink Zones are showing signs of working to improve the numbers of some species of shallow reef-associated sharks (especially for grey reef sharks and white tips species).

Overfishing of sharks was suggested to lead to an increase in rays, leading to reductions of seagrass, but there are no data to provide any more than an inference currently of the shark-ray-seagrass loss interaction.

There is engagement with recreational fishers to gather data about shark-fisher interactions and 'de-predation'. For example, intermittent observers on boats collect genetic samples, and observers on commercial fishing boats contribute to assessment of some fisheries. However, there is no ongoing monitoring of a pattern or de-predation. An increase in total shark numbers is unlikely due to other evidence discussed by the experts. A recent review paper shows some recovery of some species, while others are unknown. Sharks are known to learn to follow boats, so there may be a false positive from fishers feeling there are too many sharks due to them being near boats. This leads to a communication challenge: there needs to be a distinction between species – many species are in poor condition but not seen, while some seem to be doing well and are seen by fishers, whose fishing may inadvertently

[11] Global Finprint, Florida International University 2020, https://globalfinprint.org/

be leading to a perception in the shark numbers increasing.

Experts noted that there is catch information, but fishery operations change over time leading to a lack of consistent monitoring or long-term data on how species numbers change. Experts suggested caution in use of information outputs from the Queensland Shark Control Program, due to alterations in methods and changes in equipment over time.

Experts gave some notes, datasets, papers and suggestions for other experts to the Outlook Report team to consider following up for more information on some of the above items discussed.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Sharks and rays	6	Very Poor	Very Good	Good –	Medium	No Clear Trend	High-Medium

Condition
Species doing well are marginally very good. The Worst 10% are Very Poor. Most are Good to Poor based on medium confidence.

Compared to global populations of sharks and rays, the Region is doing well, but in a historical context the condition of sharks and rays species are poor. For example, experts noted that if comparing to pre-European baseline, confidence will be low and assessment inferential.

The 'Good to Poor' assessment, may appear to conflict with the lived experience of some users of the Region – in relation to observations of increasing incidences of depredation when fishing. (Depredation is a type of human-wildlife interaction that occurs in interactions of socio-ecosystems. In the marine context it is known where predators feed on fishery catches by following or accessing fishing gear. It is known as a behaviour developed by many marine species interacting with human fisheries or recreational activities.) Whilst these observations may be accurate and incidents may be increasing, caution should be taken to assume this means an increase in overall abundance. It can be confounded by the ability of sharks to learn to follow fishing boats. This context of depredation is important to communicate to a broader audience.

Trend
There was high to medium confidence in there being no clear trend.

Caveats and comfort level in assessment
Experts were comfortable with the rapid assessment outcome. For the condition assessment, six experts in the room voted – five 'support' and one 'can live with it'. For the trend assessment, all six experts voted 'Support'. No third vote was required.

Sea snakes

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for this assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components.

Marine turtles

Summary of discussion
During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. However, there were experts present who gave a detailed narrative of their insights about condition, trends, confidence and any caveats or knowledge gaps. A short summary of the patterns from this input is below and the Outlook Report team have been provided with more information about datasets, site surveys, papers, research and other experts to consider contacting.

The discussion noted there are good data on trends, but species are doing different things so there is likely to be an overall deterioration in trend with turtles in some areas having no consistent trend. This was based on medium confidence.

Different patterns were described for different species and subregions of the Region:

- Green turtles have spatially different trends between the southern (increasing) and northern (decreasing) sections of the Region.
- Flatback turtles are varied but mostly increasing slightly.
- Loggerheads: there has been an increase in nesting numbers. For some areas there is a strong female bias in the population.
- Hawksbill turtles: in summary the decline in numbers is still occurring but the rate of decline is slowing.

When decreases have been seen experts suggested that it is likely due to low hatchling production, unknown hunting pressures and feminisation in some species.

There was agreement that the grade on balance is poor, with more evidence of deterioration of certain species. In summary, discussion about condition of Most settled on Poor with the Best 10% being Very Good and Worst 10% being Very Poor. There is medium to high confidence in the condition assessment and medium confidence in the deteriorating trend.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Marine turtles	3	Very Poor	Very Good	Poor	High – Medium	Deteriorated	Medium

Estuarine crocodiles

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a robust input to the assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components.

Seabirds

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components.

Experts gave some detailed narrative inputs for the use of the Outlook Report team, including a breakdown of patterns seen for some different species showing variability across species and subregions. For example, one expert noted that two species are probably increasing in numbers (red-tailed tropicbirds and lesser frigatebirds), which could be examples of the Best 10% that they said were likely to the Good. They noted that two species are probably stable (brown boobies and crested terns) and three species are probably declining (brown noddy, sooty tern, masked booby), which could be the Worst 10%. They noted that for the other 14 species there is not enough data to determine trends – in general, there is not a lot of information on trends.

Shorebirds

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components. One expert noted that there is not enough data to determine trends in the Region for the condition or trend in Shorebird. However nationally most species are considered to be declining. They also noted that they would grade shorebirds worse than seabirds above.

Whales

Summary of discussion

During the Expert Rapid Assessment there were some megafauna experts present who gave a narrative of their insights about condition, trends, confidence and any caveats or knowledge gaps. In some cases, they suggested follow-up to the Outlook Report team.

The participants noted that we don't know much about most whale species. Condition is very variable by species as some species have recovered better since whaling was stopped. For example, West coast species in Australia appear to be doing better than east coast whales, but the data are unclear. Overall, for the Region, the condition was agreed to be Good but with low confidence for most species and high confidence for only two species.

Information is available about dwarf minke whales (although no expertise was in the room). Anecdotally, a few have been seen behaving strangely by not migrating as far north, which may be due to water temperature. This inference of the effect of water temperature in the Region on movement of minke whales is highly uncertain.

Information is available about humpback whales, with the population high and increasing.

For baleen and other whales, the climate, krill availability, fisheries and autumn productivity all influence populations – satellite data could be used to infer krill population data overall, which might be a proxy for whale population potential.

Data from IMOS and acoustic arrays could inform the assessment by the Outlook Report team.

The trend was discussed based on low confidence and agreed to be overall Stable.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence

Whales	3	Very Poor	Very Good	Good	Low – High (2 species)	Stable	Low

Dolphins

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. However, there were some megafauna experts present who gave a narrative of their insights about condition, trends, confidence and any caveats or knowledge gaps. In some cases they suggested follow-up to the Outlook Report team.

The national species status for both Australian humpback and snubfin dolphins is currently under assessment. Draft results suggest they may be on track to be declared vulnerable due to declines in numbers, but understanding of population status is spatially variable. For both species there is limited to no data in the north, and on the urban coast there is conflicting data. The experts recommended following up this new data – specifically for areas around central and southern areas of the Region and from around Townsville

The condition for most dolphins was considered to be Good, based on low confidence and the trend was Deteriorated, also based on low confidence.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Dolphins	2			Good	Low	Deteriorated	Low

Dugongs

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment, however there were megafauna experts present who gave a narrative of their insights about condition, trends, confidence and any caveats or knowledge gaps. In some cases they suggested follow-up to the Outlook Report team.

The experts did not disagree with the Outlook Report team's draft working summary statement. New survey data (2018–19) for the area north of Cape Bedford suggest a stable (or slightly increasing) population. A 2022 survey for the urban coast showed a long-term decline of 2.3 per cent per year (2005-2023), previously declining by 4 per cent per year (2005-2016). Confidence in this assessment is very high. However, the trend isn't consistent between areas, and this recent data in the long-term analysis are less positive. Across the Region, one area shows no change while another is going down: combining the two, as there are more dugongs in the north. Hence there was agreement with the draft summary statement.

Fisheries collect data within commercial logbooks on interaction with species of conservation interest. There was some concern about the quality and repeatability of these data. Fishery-wide data validation methods are being implemented (e.g. cameras are being installed on boats) so in future there may be more robust data for interactions of dugongs, sharks, and other species with the fisheries.

The experts agreed that gill netting is the biggest threat to dugong populations globally. Understanding this threat in Queensland relies on fishery logbook data and shark net data. This data is available but is not considered a robust metric as it relies on self-reporting through logbooks and there is currently limited data validation of logbooks. Experts noted that gill netting is to be phased to zero by 2027, which is likely to have a positive impact on dugongs.

In summary the experts assessed the condition to be Poor for this species based on high confidence. There is no spatially consistent trend, again based on high confidence.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Dugongs	2			Poor	High	No Spatially Consistent Trend	High

Ecosystem health: physical processes

Currents

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote on the assessment, however there were some experts present who gave a narrative of their insights. In some cases they suggested follow-up to the Outlook Report team.

It is likely that changes in currents have been observed, but are not adversely impacting the Region. Experts noted the trend in currents has not changed much over the past 5 years (i.e. stable trend). North of Lizard Island is one of the least surveyed areas in the world, so there is very little data. There would likely be currents transporting heat away from the Region, but they are not currently surveyed. The discussion noted that data are not available for off-shelf upwelling currents. Hence the stable trend is inferred.

Experts noted the influence of other regional currents and that they might be important for the Region. There is very limited observation for the Coral Sea and the North Vanuatu jet, North Caledonia jet. The North Papua current is very important to the transport of heat towards and away from the shelf however there are no data to support modelling of the current and its complexity. Experts noted that there are no monitoring instruments in Far North Queensland where the high variability of wind-driven currents can be caused by the monsoon trough during the summer.

A link was provided to a paper that may assist the Outlook Report team.[12]

[12] Ridgway, K. R., Benthuysen, J. A., & Steinberg, C. 2018, Closing the gap between the Coral Sea and the equator: Direct observations of the north Australian western boundary currents. *Journal of Geophysical Research: Oceans,123,* 9212–9231. https://doi.org/10.1029/2018JC014269

Cyclones and wind

Summary of discussion
During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment, however there were some experts present who gave a narrative of their insights. In some cases they suggested follow-up to the Outlook Report team.

The scope of this component was clarified as not solely about the number of cyclones, but any changes to storms, wind and cyclones, and related impacts in the Region. An expert noted that the overall long-term prediction is a 2 to 4 per cent increase in windiness by 2050 across the Region. It is not clear if that will have a major impact. There have been relatively few intense cyclones in the Region since 2019, and several of those that have occurred have been in the northern Reef. Rising sea temperature will mean stronger cyclone systems.

Experts noted that there has been a relative quiescence of category 3 cyclones compared with the past 6,000 years. However, climate models project an increase in wind, mainly winter trade winds, with no overall summer trend, with less frequent but more intense cyclones. The impact of cyclones on the Region is from high winds. As they are relatively rare events, any change in impact over the past 5 years is uncertain. In the reduced number there may be a trend for higher intensity in which it is difficult to have confidence due to lack of numbers/data.

Understanding projected impacts on ecosystems from cyclones and winds is complex; assessment cannot rely solely on one metric. Overall cyclone damage is a function of five parameters: i) diameter, ii) forward movement, iii) intensity, iv) track direction (along versus across), v) frequency.

There was a suggestion for this component to consider decadal to multi-decadal trends as being more meaningful.

Freshwater inflow

Summary of discussion
During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. The three experts present felt more comfortable giving a narrative of their views on conditions, trend and any caveats. In some cases they suggested follow-up to the Outlook Report team.

One expert noted that discharge across the reef is close to, or below, the long-term average, with regional variability. The discussion noted there is little knowledge, particularly on the coast, on the negative impact of flooding or, conversely, low flows on productivity of mudflats. Development along the coast, leading to a hardening of surfaces along the coastline, will reduce infiltration and increase flow to the Region. The assessment could consider quality, as well as quantity, of inflows. Increased inflows have negative effects due to links to CoTS in some places, but inflows can be positive in other areas. An expert suggested consideration of inputs of groundwater as part of this assessment.

This wet season was average; after the past 5 years the discharge across the Reef has been close to or below the long-term median, except for 2018–19. Regional variability shows a less consistent pattern. Graphs from the Marine Monitoring Program – Annual report for inshore water quality monitoring 2021-22 (see Figure 5) were provided to support the assessment.

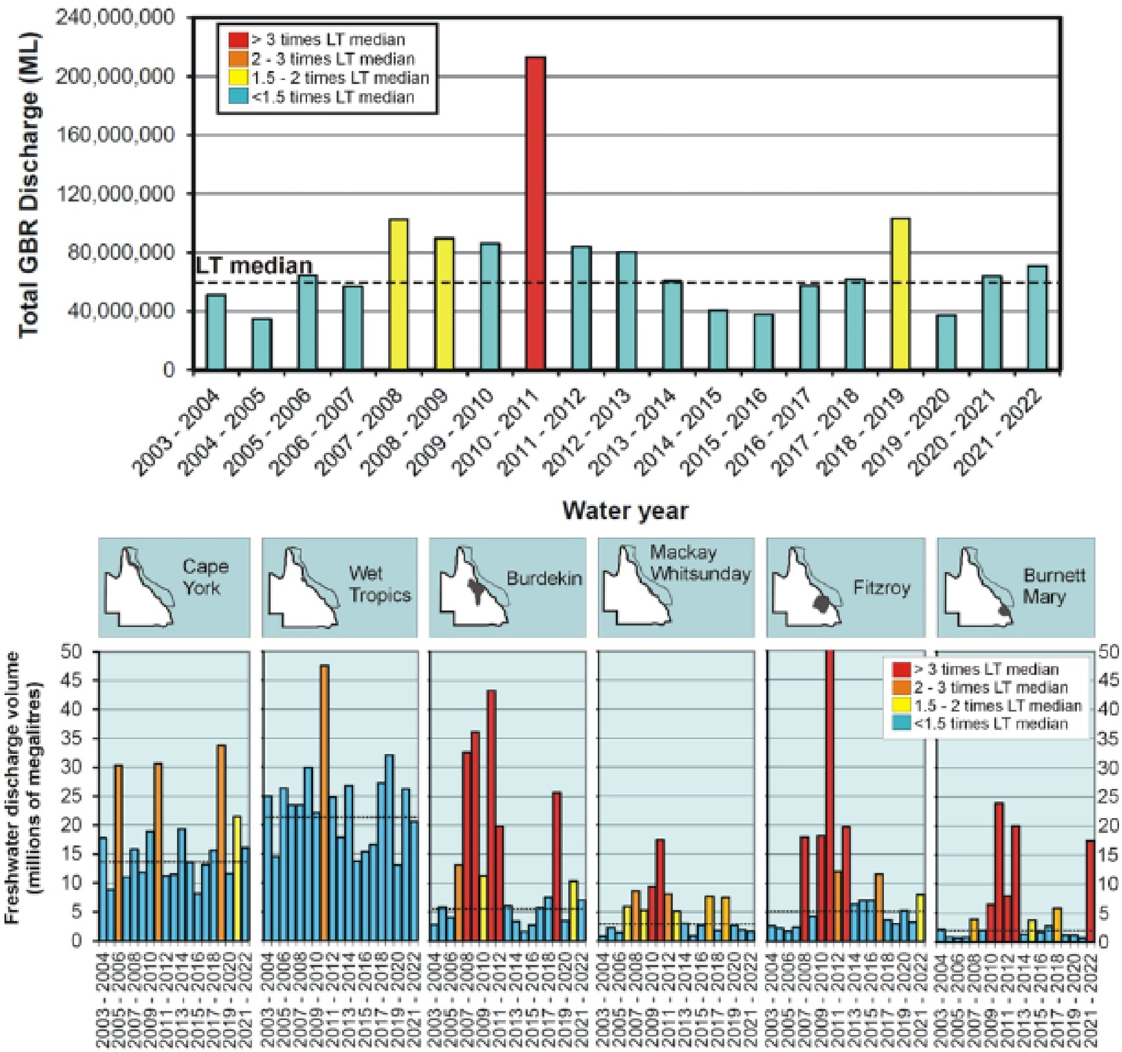

Figure 5. Discharge across the Reef.[13]

Sediment exposure

Summary of discussion

The assessment is based on the broader extent of the areas where there is knowledge that sediment exposure is an active and important process which is primarily (but not only) in inshore and mid-shelf areas. An expert suggested sediment exposure was relatively stable due to major storm activity over the past 5 years in terms of offshore sedimentation and rubble creation.

[13] Moran, D., Robson, B., Gruber, R., Waterhouse, J., Logan, M., Petus, C., Howley, C., Lewis, S., Tracey, D., James, C. and Mellors, J. 2023, Marine Monitoring Program Annual Report 2021-22 Water Quality. https://hdl.handle.net/11017/3998

Experts supported the reference to resuspension as well as land-derived sediment in the draft summary statement discussed. They noted that there are strong cross-shelf gradients in exposure to sediments and that substantial areas of seagrass occur in the inshore and are exposed to sediment loads. Sediment exposure is an important process in inshore and some mid-shelf areas on other components. Turbidity can also affect offshore reefs but sedimentation is mostly biologically relevant on inshore reefs. Turbidity elevation is measurable offshore in years of high river loads.

The discussion noted that even without anthropogenic impacts, there would be sediments, so the best and worst assessment become important. Experts noted that the Worst 10% affected are in the central and southern inshore areas of the Region.

Experts noted that the Scientific Consensus Statement on Water Quality provides helpful input for this component (in draft at the time of the workshop).

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Sediment exposure	5	Very Poor	Very Good	Good	Medium – High	No Clear Trend – Stable	Medium

Condition
The condition was assessed as good, with the worst very poor, based on medium to high confidence.

Trend
Condition has changed in some locations (hence there may be no clear trend) but broadly the trend was thought to be stable (in terms of major offshore activity that causes sediment exposure). Some catchments are doing better than others. This is based on medium confidence.

Trends may differ for varied reasons across the geographic area – and the direction and distribution of changes make it difficult to argue for a Region-wide consistent trend. Responses vary across North, Centre and South, inshore and offshore.

Caveats and comfort level in assessment
Experts were comfortable with the rapid assessment outcome. For the condition assessment, five experts voted: four 'support' and one 'can live with it'. For the trend assessment, five voted and were all in support of the outcome. No third vote was

required.

Sea level

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment, however there were some experts present who gave a narrative of their insights. In some cases they suggested follow-up to the Outlook Report team. There was no strong alignment across the experts about some insights in this assessment.

As reported in Outlook 2019, sea-level rise in the Region is faster than the global average. Experts suggested that there is a difference between the longer-term scenario and the past 5 years, so measurable impacts over past 5 years would justify a deteriorating trend however one expert countered that view suggesting that there is not sufficient evidence to justify measurable impacts in the past 5 years that would suggest 'deteriorated' trend.

Sea-level rise generally has a negative effect on coral reefs, but there may be some values on the Reef for which it does not mean deterioration. It has more influence in areas with a low tide range than those with large tidal ranges. Some experts suggested that it is incorrect to say that impacts from sea-level rise are universally negative. Sea-level rise will certainly have negative impacts, especially in the littoral zone, but it may also have beneficial impacts in many other habitats. Sea-level rise may open opportunities for recolonisation on some emergent reef flats. Sea-level rise may enable sediment stored on some reef flats to be transported to cays more efficiently – and thus cause accretion on cays rather than erosion.

Despite these considerations, experts felt that sea-level rise is a generally negative impact in the Region. It is the variation and pace of sea level rise that matters as well as interactions with other factors. For example, cyclones and short-term extreme events on top of the sea-level rise are important and may result in more impacts. The discussion considered at what point the Great Barrier Reef would no longer act as a barrier, which could have very large implications for much of the Region.

Sea temperature

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment, however there were some experts present who gave a narrative of their views on conditions, trend, any caveats or some insights into other data sources. In some cases they suggested follow-up to the Outlook Report team.

Improvements in technology have led to lots of temperature data being available: satellites measure the thin upper layer, while gliders and other instruments (National Reference Stations, Argo, moorings) measure temperature at greater depths and finer spatial/temporal scales.

Experts noted that inshore/intertidal temperature monitoring across gradients of exposure to air was initiated at several locations throughout the Region in 2022 with more sites in 2023. This research is not publicly available or reported yet. There are data sources available for in situ inshore shallow water and intertidal seagrass meadows covering from far north to south from 2003.[14]

Light

Summary of discussion

The discussion covered the different impacts on light. Unlike most other variables, light changes are depth-dependent (where water quality is the main driver of light quality rather than clouds). Deeper areas are more affected by changes in water quality impacting light than shallow waters. Experts noted that light will be affected by not only cloud, wind and sediment but also absorption and refraction from the seafloor. Absorption may matter for sea temperature. Light related to turbidity will also depend on sediment properties (e.g. grain size) in relation to resuspension and hence there is a likely interaction between light and sediment exposure.

One expert noted that changes in cloudiness are decadal processes (plus other long-term drivers like ENSO), so a 5-year horizon may not be relevant.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Light	4	Very Poor	Very Good –	Good –	High – Medium	Stable	High – Medium

Condition

[14] McKenzie, L.J., Collier, C.J., Langlois, L.A. and Yoshida, R.L., 2023. Marine Monitoring Program Annual Report 2021-22 Inshore Seagrass Monitoring. https://elibrary.gbrmpa.gov.au/jspui/handle/11017/3999

The condition was assessed as good to poor, but the Worst 10% is very poor, with high to medium confidence as light is one of the best-measured parameters on the reef with satellite observations, plus loggers on the inner reef.

Trend

The trend was assessed as stable: there has been some improvement, but not enough to indicate a different trend, again with high to medium confidence.

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, four experts voted: three 'support' and one 'can live with it', which was the same for the trend assessment. No third vote was required.

Ecosystem health: chemical processes

Nutrient cycling

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment, however there were some experts present who gave a detailed narrative of their insights. In some cases they suggested follow-up to the Outlook Report team. They suggested datasets, papers and other experts for further review or discussion.

Some of the insights from experts about the programs included that knowledge of the Reef nutrient budget has not really been updated since the early 1990s. There is no information on nutrient cycling within seagrass habitats of the Region. The Marine Monitoring Program measured tissue nutrients in seagrass until about 2020 but ceased use of it as an indicator because it was complex to interpret. Nutrient parameters measured in the Marine Monitoring Program are generally stable, apart from Dissolved Organic Carbon (DOC), which is increasing – a finding that the experts noted they do not understand.

There was a lack of consensus about definition of a nutrient and there is a need to consider the relationship between micronutrients, macronutrients and other nutrients. One expert specifically suggested broadening nutrients to include trace metals/micro-nutrients as they are important for many metabolic functions on reefs.[15]

[15] Reich, H.G., Camp, E.F., Roger, L.M. and Putnam, H.M. 2023, The trace metal economy of the coral holobiont: supplies, demands and exchanges. *Biological Reviews*, *98*(2), pp.623-642. https://pubmed.ncbi.nlm.nih.gov/36897260/

Insights about the parameters included that it is predicted that P (phosphorus) may become more important as a nutrient source, as P can become more bioavailable with increasing temperature – this might lead to a potential shift in primary productivity. Seagrass habitats use nutrients from sediment and water column and facilitate processing and movement between them, but there is limited to no data for the specific nutrient cycles of the various seagrass species in the Region. Other insights included that eReefs modelling suggests *Trichodesmium* may be a major nitrogen source in the Reef. Micronutrients that are taken up by coral (e.g., magnesium, ironome) are important during heat stress and bleaching events, but little is known about their patterns.

Even though the modelled end of catchment loads of Dissolved Inorganic Nitrogen (DIN) have theoretically reduced, particularly in the Wet Tropics, corresponding trends in the marine environment have not been clearly detected. One of the challenges is that nutrients transform rapidly in the marine environment so solid understanding of cycling and potential changes is hard to measure.

An expert suggested that further information about elementome data for corals on the Reef is available.[16]

Ocean pH

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. However, there were some experts present who gave a narrative of their insights into other data sources.[17]

An assessment of 'slowly' declining is misleading, as it has already changed by 30 per cent, directly correlated with increases in carbon dioxide in the atmosphere. Carbon dioxide in the ocean is increasing by 2 per cent per year, as it is coupled to the

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[16] Grima, A.J., Clases, D., Gonzalez de Vega, R., Nitschke, M.R., Goyen, S., Suggett, D.J. and Camp, E.F. 2022, Species-specific elementomes for scleractinian coral hosts and their associated Symbiodiniaceae. *Coral Reefs*, *41*(4), pp.1115-1130. https://link.springer.com/article/10.1007/s00338-022-02259-2

[17] Steinberg, C., Cantin, N., Benthuysen, J. and Klein, E. Drivers of Bleaching on the Great Barrier Reef-Compilation of temperature data from 2015, 2016, 2017. https://eatlas.org.au/gbr/nesp-twq-4-2-temperature-data-2015-17

increase in the atmosphere. The more you add to the ocean, the more the ocean's buffering capacity decreases, and then ocean pH rapidly increases – there may be a projected tipping point (pH 7.2) around the middle of this century. This increase is consistent across the Reef.

One expert noted that ocean acidity is 30 per cent more than 250 years ago and continues to increase. Acidity reduces calcification rates (inc. corals), alters life history traits, survival and development, and alters behaviour in marine water-breathing animals (inc. invertebrates and fishes) at multiple trophic levels. Carbonate chemistry is well understood in the oceans, and pH continues to decrease and acidity and pCO_2 increase. It can impact aragonite production, which is in turn the second strongest predictor for new coral abundance on the Reef.

It is important that the scope of this component includes consideration of rates of calcification, carbon dioxide and dissolved inorganic carbon, and photosynthesis enhancement (not just pH in isolation). Nickel and zinc cycling will change as the pH of the water changes – however there remains uncertainty about the mechanisms of change.

Ocean salinity

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components.

Salinity, variability and trends in ocean salinity are not reported in detail for the Region however there are some data available for salinity but not the changes in salinity. It seems that it is such a simple parameter that no one reports on it despite large amounts of historical data. A paper was provided for more information.[18]

Ecosystem health: ecological processes

Microbial processes

Summary of discussion

The expert discussion noted there is a much better understanding of Microbial

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[18] Röthig, T., Trevathan-Tackett, S.M., Voolstra, C.R., Ross, C., Chaffron, S., Durack, P.J., Warmuth, L.M. and Sweet, M. 2023, Human-induced salinity changes impact marine organisms and ecosystems. *Global Change Biology*, *29*(17), pp.4731-4749. https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/gcb.16859

processes than some parameters in the ecosystem health group, with a large database developed in the past 5 years (in collaboration between AIMS, Queensland Government and IMOS). There is an improving understanding of microbial communities and their functions across the Region, particularly in pelagic microbiology. Microbial processes are heavily dependent on shifting environmental parameters, including currents, temperature, water quality, etc.

Experts noted that the focus has been on microbial indicators of reef health with improved understanding of microbial processes for corals/sponges but little information is available for other organisms.

This component also includes viruses, which is a growing area of further knowledge. There are connections of viral processes that are contributing to host-associated systems. Viral genes are connected to herbicide and pesticide resistance but there is an absence of observed heavy metal and plastic degradation.

Microbes respond to the environmental conditions around them, so condition will be okay in general, but with coral bleaching they will struggle in the coral host.

In summary experts noted that if microbial processes start to degrade in observable ways, there will be serious issues in overall reef health. They are essential for cycling nutrients in otherwise poor-quality environments.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Microbial processes	3	Poor	Very Good	Good	Medium – Low	Stable – Improved	Low

Condition

Condition was seen as good, but with medium to low confidence.

Trend

There was Stable to Improved but it was noted there was no clear baseline or metric. The expert participants could infer that condition is stable and may be improving, in that the microbial processes follow the expected variation, or improved, but this was with low confidence.

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, three experts voted – one ‘support’ and two ‘can live with it’. For the trend assessment, three experts voted with one ‘support’ and two ‘can live with it’ results. No third vote was required.

Caveats noted by experts included the pattern of microbial stability is very microhabitat-specific. Some host-associated systems remain stable despite environmental changes; others are highly influenced by environmental changes. Trends in microbial processes may be improved as there may be more microbes due to increased DOC (e.g. released by macroalgae). Interestingly microbial processes in some reef environments (i.e. Inshore macroalgal dominated reefs) can drive negative feedback on reef health due to higher carbon exudates driving copiotrophic microbial processes.

Particle feeding

Summary of discussion

While five experts were in the room for this component, they did not feel comfortable having a vote given the lack of data, monitoring and questions about the scope and/or indicators. They chose to make a series of narrative comments on conditions, trend, caveats and suggestions in relation to scope.

They noted that there are some long-term data sets, but usually for commercially important species based on fishery-dependent surveys (e.g. for the scallop fishery). It is unknown what percentage of animals in this component this represents. The participants noted that it would be possible to consider particle feeders at a cross Region-wide scale when it comes to water quality, however there would be local and species-based variation with low confidence in the data (for example, sea cucumber populations are fished). Any findings from those data would be inferred at a Region-wide scale, given the spatial variability. The inference was that some species of sea cucumbers and scallops are in poor condition, which would impact particle feeding.

Water quality is a consideration. Sediment can be a threat to particle feeders (e.g. blocking up sponges), but experts doubt this has improved or changed.

In summary the experts noted that any assessment would be by inference and not based on any evidence-based science at present for the majority of feeders. With gaps in data, this is also linked to those areas that see minimal disturbance and remote areas versus heavily used inshore areas vs estuarine species. Others suggested no clear trend was appropriate.

Primary production

Summary of discussion

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment, however there were some experts present who gave a narrative of their views on conditions, trend and any caveats. In some cases they suggested follow-up to the Outlook Report team. Experts suggested further discussions with experts in water quality, plankton, and biological oceanography (especially with respect to diatom biomass).

Experts generally agreed with the proposed 'no change' summary and proposed grade, trend and confidence (limited). One suggested that offshore macroalgae could be included in blue carbon assessments. From the benthic algal perspective, the proposed statement was accepted as fine, with the trend variable depending on functional group. Algal turfs may be much more productive than the statement suggests, due to more dead coral on which to grow. Fleshy macroalgae primary production may be stable.

One noted that primary production should be considered in the context of ocean acidification, that is increasing carbon dioxide available for plant growth. More research is needed in this space before the process can be understood.

Another suggested that the condition and trend of habitats could be used as a guide for primary productivity. It was noted that algae, mangroves, and seagrasses, have been used as a proxy for primary production in lieu of direct measurement. Foundation seagrasses will sequester more carbon. There is an interest in carbon stores, with primary production being the mechanism.

In discussing the draft summary statement, the experts noted that coral declines no longer apply (upon which the 2019 condition was inferred), and that the calcification process (including the production of organic matter) is not included in a component, and may be considered as an addition in future.

With ocean acidification there is more carbon dioxide available for plants in the water. There is no information about whether increasing carbon dioxide (and photosynthesis) is increasing primary production, as it could be offset by more sediment and rising temperatures.

Summary of expert input

COMPONENT	Voters/ Experts	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Primary production	3			Very Good	Medium – Low	No Clear Trend	Medium – Low

Condition and trend
Some expertise was missing at the workshop for this topic, but from the context of benthic algae, seagrass, and halimeda, the experts present discussed the assessment. They noted it is unchanged since the 2019 Outlook Report, with limited confidence.

In summary they assessed it as Very Good with medium to low confidence and no clear trend based on medium to low confidence as well.

Herbivory

Summary of discussion
Experts noted that there is considerable detail for some locations but not for a Region-wide assessment, especially for fish herbivory, and relatively little for other groups, including grazing by diverse communities of invertebrates, zooplankton, etc. For example chiton are very important for CCA, which is a process that has not been investigated in the Region. Therefore it is challenging to draw conclusions of this process.

The experts generally agreed with the draft summary statement. There is a study in one region that demonstrates herbivory changes following a bleaching event, however this saw an increase in growth of individuals as opposed to an increase in population abundance so it is difficult to extend this more broadly.[19]

In summary they assessed it as Good with a range of low to high confidence and no clear trend based on a similar range in confidence from low to high.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Herbivory	3	Poor	Very Good	Good	Low – High	Stable	Low – High

Caveats and comfort level in assessment

Only two experts in the room voted on comfort with the rapid assessment. For the condition assessment, one expert voted one 'support' and one 'can live with it'. For the trend assessment, both experts voted 'can live with it'. No third vote was required.

[19] Taylor, B. M., Benkwitt, C. E., Choat, H., Clements, K. D., Graham, N. A., & Meekan, M. G. 2020, Synchronous biological feedbacks in parrotfishes associated with pantropical coral bleaching. *Global Change Biology, 26*(3), 1285-1294. https://doi.org/10.1111/gcb.14909

Predation

Summary of discussion

Experts noted that predation is extremely broad and that some elements positively related to reef health, others negatively related. It includes apex predators and a range of predatory fishes and past experts seemed to have focused on these species. This component specifically relates to the process of predation, which can be inferred from the condition and trend of the predatory species. Some experts felt that predation for some of the non-apex species has not been considered, such as turtles and impact on jellyfish blooms, and gave examples knowledge gaps like the more sedentary animals like sea-anemones with fish and crustacea diets.

Since 2019 there has been more evidence that predation is the leading function controlling CoTS via predation on juvenile and adult CoTS having a role in controlling CoTS outbreaks or reducing primary outbreaks.

Other important changes in the knowledge base make longer-term comparisons across Outlook Reports more complex. For example, we are learning more about how increasing carbon dioxide is altering predation interactions. Hence experts in this assessment may be considering predation differently from how it has been considered in past reports.

One expert questioned if and where depredation is considered as it might have impact on overall predation as a process.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Predation	6	Very Poor	Very Good	Good –	Low	No Clear Trend	Low

Condition

Experts considered the process was Good to Poor. All had low confidence in the evidence base. Considering predation broadly across more taxa this is unsurprising – there are more taxa considered than in the past, where higher apex predators with more datasets were a focus.

Trend

There was no clear trend, and confidence was low.

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, six experts voted – two 'support' and three 'can live with it' and one 'minor concerns'. Following a discussion with the experts in the room, the minor concern was highlighted as relating to the lack of breadth usually considered in this component with the focus being on apex predators and some fish, rather than a sense that they had not been heard or felt uncomfortable with the process as it was applied in the room. It is noted that other experts considered 'new' taxa for their assessments. For the trend assessment, six experts voted with one 'support' and five 'can live with it' results.

Feedback was given that the minor concern expressed would not change any votes if voting occurred again, so no third vote was required.

Symbiosis

Summary of discussion

Some experts struggled to understand how to assess this component given the lack of any program to collect data or directly monitor symbiosis at scale in the Region, although symbiosis at fine scale is monitored to some degree. It can be measured by proxy by identifying impacts between species and considering whether the process is achieving its intended purpose. The process is complex and costly to measure in-situ and it is rarely done as a part of large-scale monitoring programs. However, the effect of it can be visible. A change could lead to dysregulation of the process as the relation between two symbiotic species goes out of balance.

There is a general lack of knowledge concerning invertebrate symbiosis, e.g. symbioses like CCA-coral larvae are too diverse within themselves to aggregate. Commensalism is very challenging to prove or measure. Measuring the strength or functional significance of the interactions between organisms is challenging. One expert noted that there are trade-offs are everywhere when considering a process like Symbiosis at the Region scale. There has been no significant improvement in availability of information on non-coral-symbiotic relationships.

One expert noted that looking across natural gradients on reefs can help infer changes in symbiosis across environmental states, e.g. carbon translocation between symbionts and host.[20]

[20] Ros, M., Suggett, D.J., Edmondson, J., Haydon, T., Hughes, D.J., Kim, M., Guagliardo, P.,

At times knowledge of changes in symbiosis occurs when there is a catastrophic failure, such as bleaching. In relation to this, one expert commented for this component that '*We don't know what we don't know' applies to this question more than to any other*.'

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Symbiosis	5	Very Poor	Good +	Poor –	Highly Variable – Low	No Clear Trend	Highly Variable – Low

Condition

There is a lack of knowledge for a diverse component. In summary, the condition was rated Poor to Good based on low confidence due to the highly variable responses on confidence given.

Trend

In summary, there was no clear trend based on low confidence due to the highly variable responses on confidence given.

Caveats and comfort level in assessment

Experts were generally comfortable with the rapid assessment outcome. For the condition assessment, four experts voted – one 'support', two 'can live with it' and one 'major concerns'. For the trend assessment, three experts voted with one 'support', one 'can live with it' and one 'major concerns' results. Following a discussion with the experts in the room, the major concern related to the lack of metrics used for measuring symbiosis as a process, making it hard to assess and suggesting reporting on it may even be 'unhelpful'. There was no concern with the process, nor any sense that they had not been heard or felt uncomfortable with the process as it was applied in the room. They were concerned about the lack of metrics. Feedback was given that the major concern expressed would not change any votes if voting occurred again, so no third vote was required.

Bougoure, J., Pernice, M., Raina, J.B. and Camp, E.F. 2021, Symbiont shuffling across environmental gradients aligns with changes in carbon uptake and translocation in the reef-building coral Pocillopora acuta. *Coral Reefs*, *40*(2), pp.595-607. https://doi.org/10.1007/s00338-021-02066-1

An expert provided the following caveat that assessments are likely to be biased towards coral bleaching because it is the easiest 'macroscopic' symbiosis to measure at broad spatial scales.

Recruitment

Summary of discussion

Experts noted that there are a lot of data on coral and CoTS, but not much on fish or seabirds. Others noted that despite the Hughes study in 2018,[21] there is limited data on actual level of recruitment to reefs however they noted they could assess recruitment as poor to good given the increase in brooders being noted by AIMS (+ *pers obs*).

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Recruitment	6	Very Poor	Good +	Good –	Low-Medium	No Clear Trend	Low-Medium

Condition

In summary, the condition was rated Good to Poor based on low to medium confidence.

Trend

Trend was noted as no clear trend (some trends up and some down mainly due to the lack of data).

Caveats and comfort level in assessment

Experts in the room were comfortable with the rapid assessment. For the condition assessment, four experts voted, with two 'support' and two 'can live with it', which was the same for the trend assessment. No third vote was required.

Reef building

Summary of discussion

Experts noted new information providing new areas to consider as this is a changing field; for example, the importance of sand and net calcification on coral reefs and the

[21] Hughes, T.P., Kerry, J.T., Baird, A.H., Connolly, S.R., Chase, T.J., Dietzel, A., Hill, T., Hoey, A.S., Hoogenboom, M.O., Jacobson, M. and Kerswell, A. 2019, Global warming impairs stock–recruitment dynamics of corals. *Nature*, *568*(7752), pp.387-390. https://www.nature.com/articles/s41586-019-1081-y

lack of understanding of the impacts if this process is lost.[22] Another important paper is about quantifying rates of ocean acidification being largely atmospherically forced and the impact on reef stability.[23]

The draft assessment focused on coral growth (which may be visible in the past 5 years). There may be other inputs to consider that are slower and only visible on longer time frames. Coral growth is important but when corals die, the reef can still build due to sedimentation. After bleaching, lots of coral falls over and adds to rubble, which contributes to reef-building but is not stable until accreted/consolidated. There is also evidence that most likely following coral bleaching there may be an increase in CCA cover growing over dead coral skeletons.

Data are available showing a decline in general calcification over the past 5 years. Reef growth is not just about coral growth – it is the net balance between calcification and erosion (physical/chemical/biological) – focusing mostly on the coral growth is only half the story. There is also a distinction between attrition and consolidation/sedimentation. It is important to consider dissolution as well as accretion (i.e., 'net calcification'). Experts also noted the lack of information about molluscs and shells that also contribute to reef-building structures as substrates, and invertebrate housing.

Spatiotemporal and even local variations around specific reefs have a big influence. Whether this can be captured meaningfully at Region scale is not clear.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Reef building	4	Very Poor	Good +	Good	Medium – Low	No Clear Trend	Medium & Low

Condition

In summary, the condition was rated Good based on medium to low confidence due to the highly variable responses on confidence given.

[22] Eyre, B., Andersson, A. & Cyronak, T. 2014, Benthic coral reef calcium carbonate dissolution in an acidifying ocean. *Nature Clim Change 4*, 969–976. https://doi.org/10.1038/nclimate2380

[23] Fabricius, K.E., Neill, C., Van Ooijen, E., Smith, J.N. and Tilbrook, B. 2020, Progressive seawater acidification on the Great Barrier Reef continental shelf. *Scientific reports*, *10*(1), p.18602. https://www.nature.com/articles/s41598-020-75293-1

Trend
In summary, there was no clear trend based on medium to low confidence.

Caveats and comfort level in assessment
The experts in the room were comfortable with the rapid assessment. For the condition assessment, four experts voted, with one 'support' and three 'can live with it'. For the trend assessment, all four experts voted 'can live with it'. No third vote was required.

Competition

Summary of discussion
There were not enough participants with expertise in this component to provide a vote for the assessment. However, there were some experts present who gave insights about papers and information sources for follow-up by the Outlook Report team. The discussion noted there are some changes but no evidence for anything other than the condition being at least good, with no clear trend. An invasive pest that out-competed species would be notable. One expert noted that the underlying challenge to understanding if there are changes in competition in fish and invertebrates is that it is difficult to get enough data across time due to movement of species. Two papers were suggested for review.[24, 25]

Connectivity

Summary of discussion
In relation to the draft summary, the experts noted that hydrodynamic potential connectivity is good, but connectivity over coral cover is not good. Another expert noted that connectivity and inter-dependencies between species and ecosystem component is reasonably well understood. There is limited new evidence of measured connectivity and changes to ecosystem function.

Recent modelling based on observed and predicted coral cover, combined with Reef

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[24] McDonald, R.A., Neuhausler, R., Robinson, M., Larsen, L.G., Harrington, H.A. and Bruna, M. 2022, Topological descriptors for coral reef resilience using a stochastic spatial model. *arXiv preprint arXiv:2209.08974*. https://doi.org/10.48550/arXiv.2209.08974
[25] Fabricius, K.E., Crossman, K., Jonker, M., Mongin, M. and Thompson, A., 2023. Macroalgal cover on coral reefs: Spatial and environmental predictors, and decadal trends in the Great Barrier Reef. *PLoS One*, *18*(1), p.e0279699. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0279699

connectivity suggests a 70 per cent decline in larval supply post 2016, 2017 and 2020 events.[26] Experts suggested a paper to review.[27]

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Connectivity	4	Very Poor	Good +	Poor +	Highly Variable	No Clear Trend	Low – High

Condition

Condition was assessed as poor to good, where a small part of the Worst 10% has actual physical barriers so this change in condition is permanent and irreversible. This assessment is based on highly variable confidence depending on what dataset experts were considering, so it should be considered as low confidence.

Trend

The experts noted the lack of information to identify a trend suggesting 'no clear trend' based on highly variable but generally low confidence.

Caveats and comfort level in assessment

The experts in the room were comfortable with the rapid assessment. For the condition assessment, three experts voted, two 'support' and one 'can live with it', which was the same for the trend assessment. No third vote was required.

Ecosystem health: coastal ecosystems that support the Great Barrier Reef

For this group of components, experts made a consistent set of comments regarding the definition of 'condition' and that they felt it does not align with practice in their field. In their view the current definition of condition may obscure important patterns in the data or evidence base being used. The Outlook process combines information about extent and quality (quality is what this group of experts called 'condition'). While both are important, there is more confidence in the evidence base about

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[26] Cheung, M.W., Hock, K., Skirving, W. and Mumby, P.J. 2021, Cumulative bleaching undermines systemic resilience of the Great Barrier Reef. *Current biology*, *31*(23), pp.5385-5392. https://doi.org/10.1016/j.cub.2021.09.078

[27] Wolanski, E. and Kingsford, M. J. 2023, *Oceanographic processes of coral reefs: physical and biological links in the Great Barrier Reef*. Second Edition. CRC Press. https://www.taylorfrancis.com/books/edit/10.1201/9781003320425/oceanographic-processes-coral-reefs-eric-wolanski-michael-kingsford

extent, because there is active monitoring. However, the experts noted there is little or no information about the habitat quality (their definition of 'condition'). One noted that in another related report card about these habitats, the extent and the quality ('condition') are reported separately. The experts suggested future Outlook Reports consider this practice for these habitats and report on both.

This is one of the challenges of settling on languages in a Report with such a broad coverage as the Outlook Report – experts in different given fields often refer to different elements of scope in different ways. Importantly, for clarity and consistency with the rest of this workshop report and the Outlook Report process, in the sections below on coastal ecosystem components 'condition' was considered by the experts to encompass both extent and quality, as well as function and ecological performance at times. They endeavoured to articulate on what datasets they drew when making these assessments.

Saltmarshes

Summary of discussion

Experts noted that best practice for saltmarshes is to consider extent and quality separately. While the extent of saltmarshes is well documented with a high level of confidence, there is limited evidence of saltmarsh condition in the Reef Catchment, as no quality monitoring occurs. Experts noted that only using one of these metrics of condition available from monitoring may be problematic.

Experts noted that the trend should remain stable, as there is no evidence of change in habitats neighbouring the Region. There has been a minuscule change in extent of saltmarshes, with high confidence in this information from monitoring. The overall confidence in the trend is medium, with the condition being summarised as Good based on medium confidence.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Saltmarshes	3	Very Poor	Very Good	Good	Medium	Stable	Medium

Caveats and comfort level in assessment

Experts were comfortable with the rapid assessment outcome. For the condition assessment, only two experts voted – one 'support' and one 'can live with it'. For the trend assessment, three experts voted with one 'support' and two 'can live with it' results. No third vote was required.

Freshwater wetlands

Summary of discussion

A monitoring program for wetlands shows quality and pressures vary considerably by Natural Resource Management (NRM) region: some regions are under higher pressure, with the wet tropics and Fitzroy under most pressure. Disturbance is widespread and quality poor. Regarding changes in extent, there has been very little loss in natural wetlands in the past 4 years.

For the assessment, the experts considered the range of ongoing threats and pressures on wetlands throughout the catchment: it is variable between regions, and includes weeds, feral animals, hydrological modification, connectivity and impacts. In some areas there are inputs of sediment and pesticides (one expert cited a reference to be published regarding a case study of pesticide concentrations in sugarcane areas showing consistent exceedances of levels) but more understanding is required. Regarding pollutant-related inputs, experts considered sediment accumulation, fertiliser inputs and pesticide inputs. There is a greater understanding of sedimentation as a key threat to this habitat and some suggested that there might be a climate and sedimentation interaction that is not yet fully understood.

Experts noted that the impacts of climate change are still unclear, especially about the potential for refugia for (and in) this habitat.

Summary of expert input

COMPONENT	Voters	CONDITION				TREND	
		Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Freshwater wetlands	3	Very Poor	Very Good	Poor	Medium – High	Stable	Medium

Condition

In summary, the condition was rated Poor with medium to high confidence. An example of a Best 10% was given as Shellbourne Bay at Cape Flattery, where there are no feral animals.

Trend

In summary, the trend was rated as Stable based on medium confidence.

Caveats and comfort level in assessment

Experts noted a number of caveats. For example, the impact of climate change is unclear, including on refugia, and impact of pesticides and sedimentation.

Experts were confident about increasing regional variation and representativeness. They noted a plan to include wetlands in modelling assessments (including a sample of 340 wetlands, visiting up to 90 in a year), results of which will be available for the next Outlook Report in 2029.

Experts were comfortable with the rapid assessment outcome. For the condition assessment, three experts voted – two 'support' and one 'can live with it'. For the trend assessment, three experts voted with one 'support' and two 'can live with it' results. No third vote was required.

Forested floodplains

During the Expert Rapid Assessment workshops there were not enough participants with expertise in this component to provide a vote for the assessment, however there were some experts present who gave a narrative of their views on conditions, trend and any caveats. In some cases they suggested follow-up to the Outlook Report team.

They noted that there is a conceptual understanding of the ecosystem services of forested floodplains to the Reef, however, the performance of these functions is not quantified. There is very little quantified information on function and services. Forested floodplains can play an enhanced role in material processing and they noted the habitat is becoming less forested due to human and other impacts.

A concern was raised about patterns seen outside the Region (specifically K'gari) where there is a climate change-induced change in drying and fire regimes for this habitat. It is possible this can occur inside the Region as well. Experts noted a recent paper published in June/July 2023 for consideration by the Outlook Report team. They also suggested contacting Queensland Herbarium, which may have mapping about the extent and spatial biocondition of this component.

In summary, the experts noted some confusion in the scope of this habitat, and suggested a possible renaming to 'Floodplains' to capture those forested, and those not forested but equally important as a functional ecosystem supporting the reef. Experts noted that very little is known about the extent, condition and even ecosystem functions and processes in this habitat.

Heath and shrublands

Summary of discussion

There were two experts in the room for this component. While a narrative was reported, no votes were taken.

Condition

Both experts agreed that the condition was between a low 'Good' to a low 'Very Good' for most of the habitat in the Region. Both agreed that the Best 10% was Very Good. However, they disagreed on the condition of the Worst 10%, ranging from a low 'Poor' to a low 'Good'. With just two experts contributing, care should be taken with generalising this assessment.

As for Forested Floodplains, the experts noted some new information shows changed fire regimes where these habitats dry out and catch fire. However the extent and condition are unchanged, but there are new climate change impacts to consider.

Confidence in condition

Both experts agreed that there was medium (i.e., limited) confidence in the data and evidence on which they drew their assessment of condition.

Trend

Both experts agreed that the trend for this component was stable.

Caveats and comfort level in assessment

Both experts were comfortable with the rapid assessment outcome. For the condition assessment, one noted 'support' and one 'can live with it', with the same result for the trend assessment.

Grass and sedgelands

Woodlands and forests

Rainforests

During the Expert Rapid Assessment workshops there were not enough participants with expertise in these three components to provide a robust input to the assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components.

In each case, the participants noted that the key experts for this component are at the Queensland Herbarium; they can provide assessments of extent and quality. They would also know who else to consult.

Ecosystem health: outbreaks of disease, introduced species and pest species

During the Expert Rapid Assessment workshops there were not enough participants with expertise in the following four Outbreak components to provide a robust input to the assessment. The Reef Authority Outlook Report team followed up with some experts nominated by those present and others to complete a narrative assessment for these components: Outbreaks of disease; Outbreaks of crown-of-thorns starfish; Introduced species; Other outbreaks.

Table 5. Summary of workshop outcomes for all natural and heritage components – condition, trend and confidence

Note that in the table below, if voting on a specific condition assessment led to a split vote, the category is shown as a single category with a – or + sign indicating the direction of skewed opinions. For example, Poor – means there was a split in opinion between Poor and Very Poor. Good + means there was a split between Good and Very Good. A Poor + result means there was a split in opinion between Poor and Good. The category assigned in the tables (where a – or + sign is shown) is the one with a marginally higher vote. Visualisations of the results are contained in Appendix 5.

COMPONENT		Voters / Experts	CONDITION				TREND	
			Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Indigenous cultural values	Cultural practices, observances, customs and lore	*No experts voted on these components at the Rapid Assessment – see component narratives for important insights or next steps suggested by Traditional Owners and experts.*						
	Sacred sites, sites of particular significance, places important for cultural tradition							
	Stories, songlines, totems and languages							
	Indigenous structures, technology, tools and archaeology							
Historic heritage	Historic voyages and shipwrecks	4	Very Poor	Good	Poor –	High	Deteriorated	High
	Commonwealth lightstations	*No experts voted on this component at the Rapid Assessment*						
	Historic lightstations	*No experts voted on this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts*						

	World War II features and sites	5	Very Poor	Good	Very Poor	High	Deteriorated	High
	Other places of historic significance	5	Very Poor	Poor +	Very Poor	High	Deteriorated	High

COMPONENT		Voters / Experts	CONDITION				TREND	
			Worst 10%	Best 10%	Most	Confidence	Most	Confidence
Habitats to support species	Islands	4	*No experts voted on this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts*					
	Mainland beaches and coastline	4			Good	Low	Stable	Low
	Mangrove forests	3	Poor	Very Good	Very Good	Medium	Stable	Medium
	Seagrass meadows	3	Very Poor	Very Good	Good	High / Medium	Improved	High
	Coral reefs (Region wide)	10	Very Poor	Very Good	Poor +	Variable / Medium	No Clear Trend	Variable / Medium
	Coral reefs (Northern Region)	12	Very Poor	Very Good	Good –	Medium / High	Improved / Stable	Medium – High
	Coral reefs (Central Region)	12	Very Poor	Good	Poor	Medium / High	Stable / Improved	Medium
	Coral reefs (Southern Region)	10	Very Poor	Good +	Poor	Variable / Medium	Stable / No Clear Trend	Medium / Low
	Lagoon floor	4	*No experts voted on this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					
	Shoals and other banks	3	*No experts voted on this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts. This component had an in-depth discussion about scope and definition.*					
	Halimeda banks	4	Poor	Very Good	Good	Low	No Clear Trend	Low
	Continental slope	3	*No experts voted on this component at the Rapid Assessment – see component narrative for insights or next steps*					

			suggested by experts.					
	Water column	4	*No experts voted on this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					
Populations of species and groups of species	Mangroves	3	*No experts voted on this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					
	Seagrasses	3	Poor –	Very Good	Good	High	Improved / Stable	High
	Benthic algae	6	Poor –	Very Good	Good	Medium	Mostly Stable	Low / Medium
	Corals	9	Very Poor	Very Good	Good –	Low	No Clear Trend	Low / Medium
	Other invertebrates	5	Very Poor	Very Good	Poor +	Low	No Clear Trend	Low / Medium / High
	Plankton and microbes	3	Very Poor	Very Good	Good	Low	No Clear Trend	Low
	Bony fish	6	Poor	Very Good	Good	Medium	Stable	Medium
	Sharks and rays	6	Very Poor	Very Good	Good –	Medium	No Clear Trend	High / Medium
COMPONENT		Voters/Experts	CONDITION				TREND	
			Worst 10%	Best 10%	Most	Confidence	Most	Confidence
	Sea snakes	*No experts voted on this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*						
	Marine turtles	3	Very Poor	Very Good	Poor	High / Medium	Deteriorated	Medium
	Crocodiles	*No experts discussed these components at the Rapid Assessment – see component narrative for insights or next steps*						

	Sea birds	*suggested by experts.*						
	Shorebirds							
	Whales	3	Very Poor	Very Good	Good	Low – High (2 species)	Stable#	Low
	Dolphins	2			Good	Low	Deteriorated#	Low
	Dugongs	2			Poor	High	No Spatially Consistent Trend	High
Physical processes	Currents	3	*Experts chose to provide a narrative assessment for this component. No experts voted at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					
	Cyclones and wind	3	*Experts chose to provide a narrative assessment for this component. No experts voted at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					
	Freshwater inflow	3	*Experts chose to provide a narrative assessment for this component. No experts voted at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					
	Sediment exposure	5	Very Poor	Very Good	Good	Medium / High	No Clear Trend / Stable	Medium
	Sea level	3	*Experts chose to provide a narrative assessment for this component. No experts voted at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					
	Sea temperature	3	*Experts chose to provide a narrative assessment for this component. No experts voted at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					
	Light	4	Very Poor	Very Good –	Good –	High / Medium	Stable#	High / Medium
Chemical processes	Nutrient cycling	*No experts assessed this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*						

	Ocean pH	*No experts assessed this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*						
	Ocean salinity	*No experts assessed this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*						
Ecological processes	Microbial processes	3	Poor	Very Good	Good	Medium / Low	Stable / Improved#	Low
	Particle feeding	5	*Experts chose to provide a narrative assessment for this component. No experts voted at the Rapid Assessment – see component narrative for insights about the variability and the metric or next steps suggested by experts.*					
	Primary production	3			Very Good	Medium – Low	No Clear Trend#	Medium / Low
	Herbivory	3	Poor	Very Good	Good	Low – High	Stable	Low / High
	Predation	6	Very Poor	Very Good	Good –	Low	No Clear Trend	Low
	Symbiosis	5	Very Poor	Good +	Poor +	Highly Variable / Low	No Clear Trend	Highly Variable / Low
	Recruitment	6	Very Poor	Good +	Good –	Low / Medium	No Clear Trend#	Low / Medium
	Reef building	4	Very Poor	Good +	Good	Medium / Low	No Clear Trend	Medium / Low
	Competition	*No experts assessed this component at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*						
	Connectivity	4	Very Poor	Good +	Poor +	Highly Variable	No Clear Trend#	Low / High
Coastal ecosystems that support the Great	Saltmarshes	3	Very Poor	Very Good	Good	Medium	Stable	Medium
	Freshwater wetlands	3	Very Poor	Very Good	Poor	Medium / High	Stable	Medium
	Forested floodplains	3	*Experts chose to provide a narrative assessment for this component. No experts voted at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*					

Barrier Reef	Heath and shrublands	2	*Experts chose to provide a narrative assessment for this component. No experts voted at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*
	Grass and sedgelands	*No experts discussed these components at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*	
	Woodlands and forests	*No experts discussed these components at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*	
	Rainforests	*No experts discussed these components at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*	
Outbreaks of disease, introduced species and pest species	Disease	*No experts discussed these components at the Rapid Assessment – see component narrative for insights or next steps suggested by experts.*	
	Crown-of-thorns starfish outbreaks		
	Invasive species		
	Other outbreaks		

For all these assessments, experts specifically highlighted other experts, reporting sources or research for the Outlook Report team to confirm these condition grades or trends.

Risks

Summary

Experts participating in the workshops' heritage sessions did not feel suitably qualified to assess the risk level of 12 of the 42 identified threats. Of the remaining 30 threats to heritage values components assessed at the Regional scale, eight were considered to pose a Very High risk, with 17 a High risk. Four were assessed to be a Medium risk, and one a Low risk. In addition, of the 13 threats assessed at the local scale, three were considered Very High, nine High, and one Medium risk.

The 25 threats to heritage values considered to have High or Very High levels of residual risk at a Region scale were Altered ocean currents, Altered weather patterns, Atmospheric pollution, Barriers to flow, Behaviour impacting heritage values, Damage to reef structure, Damage to seafloor, Discarded catch, Dredging, Exotic species, Fragmentation of cultural knowledge, Grounding large vessel, Grounding small vessel, Illegal activities – other, Incompatible uses, Marine debris, Modifying coastal habitats, Nutrient run-off, Ocean acidification, Outbreak of crown-of-thorns starfish, Sea level rise, Sea temperature increase, Sediment run-off, and Spill – large chemical, Terrestrial discharge. See Table 6 for a summary of the assessment of residual risks for heritage values.

The threats to Indigenous heritage values were not specifically discussed or assessed via voting. Hence the risk levels summarised above, and detailed below, generally represent the risk level of threats to historic heritage values only.

Of the 42 threats assessed for residual risk against natural values components at a Region scale, two were considered to pose a Very High risk, 13 a High risk, 19 a Medium risk, and eight a low risk. At the local scale, the risks were assessed to be greater: two were considered to pose a Very High risk, 27 a High risk, 11 a Medium risk, and two a low risk.

The 15 threats to natural values considered to have High or Very High levels of residual risk at a Region scale, were: Altered ocean currents, Altered weather patterns, Extraction from spawning aggregations, Extraction of predators, Genetic modification, Marine debris, Modifying coastal habitats, Nutrient run-off, Ocean acidification, Outbreak of crown-of-thorns starfish, Outbreak of disease, Pesticide run-off, Sea level rise, Sea temperature increase, and Sediment run-off. See Table 7 for a summary of residual risks assessed for natural values components.

As well as assessing risks to natural values in the context of current government policy, the workshop also included an alternative climate change scenario exercise. For a scenario involving more significant mitigation action and less warming, participants noted a change in the risk level over the next 20 to 30 years of some threats: decreased ocean acidification, less sea temperature increase, a reduction in the potential outbreaks of disease and pests, fewer extreme heat and floods, and a higher chance for reef recovery. The participants discussed that, for a more optimistic climate change scenario, there would be a chance for the negative impacts on the Great Barrier Reef Region to be reduced earlier and recovery to occur faster.

Indigenous living culture risk assessment

As requested by participants, as for the values assessment noted earlier in this report, a vote was not held for any of the listed threats to Indigenous living culture. Instead, there was a broad-ranging discussion about threats to Indigenous living and historic culture in the Region.

When asked to name other threats to Traditional Owner cultural values, the participants listed the following in Menti:

- Inequity in access to funding and resources.
- The vast capacity gaps that exist between Traditional Owner communities in the Region.
- Materials and samples taken from Country without authority, which threatens the integrity of Country.
- Free Prior and Informed Consent guidelines not being followed.
- Indigenous Cultural Intellectual Property issues.
- Inequities in access to opportunities to manage Sea Country (nations/groups/genders).
- Destruction of littoral and riparian revegetation programs connected to traditional knowledge language names of plant species.
- Marine debris in coastal environments that impact story sites.
- Research agendas set by scientists instead of working with Traditional Owners for their priority lists.
- Traditional Owner knowledge versus modern/social science. Traditional Owners are not engaged early in the project; i.e. co-designing from the outset.
- Treating Traditional Owners as stakeholders and not as partners in projects.
- Continuing with the pursuit/reification of nature/culture dualism.
- Using legislation as a stop-go for working well with Traditional Owners.

Heritage risk assessment

Threats over the next 5 years were considered. Due to time limitations, this session focused on risk to heritage values at the Region scale, rather than at local scales. However, where participants wanted to discuss the risk level of a particular threat that happens at a local scale, these were raised for discussion and vote. Consideration of local threats occurred for the following threats:

7. Behaviour impacting heritage values
8. Damage to reef structure
9. Damage to seafloor
12. Dredging: Dredging of the seafloor
21. Grounding large vessel
22. Grounding small vessel
26. Incompatible uses
27. Marine debris
28. Modifying coastal habitats
36. Sea level rise
37. Sea temperature increase
38. Sediment run-off

Some threats were not relevant to historic heritage, so were skipped. This occurred for:

14. Extraction from spawning aggregations
15. Extraction of herbivores
16. Extraction of particle feeders
17. Extraction of predators
18. Foundational capacity gaps
20. Genetic Modification
21. Illegal fishing and poaching
22. Incidental catch of species of conservation concern
29. Noise pollution
30. Outbreak of disease
31. Outbreak of other species
32. Pesticide run-off
43. Vessel strike
44. Vessel waste discharge
45. Wildlife disturbance

Due to the rapid nature of the assessment, only limited discussion was noted for each threat – any discussion is summarised for each threat below.

The results for each threat assessed at the workshops contains a summary table of the risk assessment. The 'Key' table below explains the different elements of the tables.

In keeping with risk management standards and practice, when a range of consequence or likelihood was given by experts, the majority response was used. For example, if two experts voted for *Major* and three voted for *Catastrophic*, the rating given is *Catastrophic*.

For a threat with a highly variable range of responses, when the range covered three rating levels, the middle rating was used. This approach is detailed more in the 'Assessing risk' section of this report (see page 20).

Note that a range of responses can have either (a) a skew (or clumping) to one part of that range, or (b) votes spread more evenly across the range (which we have called a *highly variable result*). Only instances of votes spread evenly across the range are described as *highly variable* because they represent a genuine spread of opinion. Hence it is possible to have a spread of responses that were not a *highly variable result*.

The range of responses is reported for confidence in the table for each threat. In Table 6 (a consolidated table), the range of responses is also reported for consequence and likelihood.

Key

Scale	Risk Rating	Confidence ** = variable (i.e., skewed) result*
Local	*Colour = risk rating*	*Greyed means no input from experts*
Regional	*Colour = risk rating*	*Overall confidence**

<u>Results</u>

1 Acid sulphate soils: Exposure of acid sulphate soils

Scale	Risk Rating	Confidence

Local	High	Low
Regional	Medium	Medium – Low*

2 Altered ocean currents: Climate change induced altered ocean currents

Scale	Risk Rating	Confidence
Local		
Regional	High	High

3 Altered weather patterns: Climate change effects on weather patterns (e.g. cyclones, wind, rainfall, air temperature), includes both chronic and acute aspects.

Scale	Risk Rating	Confidence
Local		
Regional	Very High	High

4 Artificial light: Artificial lighting including from resorts, industrial infrastructure, mainland beaches and coastlines, vessels and ships.

Scale	Risk Rating	Confidence
Local		
Regional	Medium	High – Medium

5 Atmospheric pollution: Pollution of the atmosphere related to domestic, industrial and business activities in both the region and adjacent areas. The contribution of gases such as carbon dioxide to climate change is not included as this is encompassed under threats such as sea temperature increase and ocean acidification.

Scale	Risk Rating	Confidence
Local		
Regional	High	High – Medium

6 Barriers to flow: Artificial barriers to riverine and estuarine flow (e.g. dams, weirs, break walls and gates, roads and linear infrastructure).

Scale	Risk Rating	Confidence
Local		

Regional	High	High – Medium

7 Behaviour impacting heritage values: Disturbance of, or damage to, the values of intangible Indigenous and historic heritage site through inappropriate presence of people. Examples include: visitation to locations considered dangerous or sensitive in Indigenous culture; access by people of culturally inappropriate gender or seniority; overly high visitor traffic levels at Indigenous sites open to visitation (e.g. creating too much noise); and disrespectful behaviour or activities at Indigenous and historic heritage sites (e.g. burial areas).

Scale	Risk Rating	Confidence
Local	Very High	High
Regional	Very High	High

8 Damage to reef structure: Physical damage to reef benthos (reef structure) through actions such as snorkelling, diving, anchoring and fishing, but not vessel grounding.

Scale	Risk Rating	Confidence
Local N=4	High	High – Medium
Regional N=5	High	High

9 Damage to seafloor: Physical damage to non-reef benthos (seafloor) through actions such as trawling and anchoring.

Scale	Risk Rating	Confidence
Local N=4	Very High	Medium – High
Regional N=5	Very High	Medium – High

10 Discarded catch: Immediate or post-release effects (such as death, injury, reduced reproductive success) on discarded species (non-retained catch) as a result of interactions with fishing gear. Does not include species of conservation concern.

Scale	Risk Rating	Confidence
Local		

Regional	High	High

11 Disposal of dredge material: Disposal and resuspension of dredge material.

This threat occurs mainly around the ports of Townsville, Cairns, Gladstone, Mackay; that is, close to where the dredging is located due to spatially restricted location for disposal.

Scale	Risk Rating	Confidence
Local		
Regional	Low	High – Medium

12 Dredging: Dredging of the seafloor.

Townsville and Cairns are expanding their ports, and others may be expanded in future. Minor vessel channels were also included in consideration of this threat, so this was also considered at a local scale.

Scale	Risk Rating	Confidence
Local N=4	High	High – Medium
Regional N=5	High	High – Medium

13 Exotic species: Introduced exotic species from aquaculture operations, hull fouling, ballast release, biocontrol, translocation of other marine species, and release of aquarium specimens to the region, plus the introduction of weeds, pests and feral animals to islands. Includes both new introductions and outbreaks of previously introduced exotic species. Does not include considerations covered under 'genetic modification' threat.

Species can be introduced when vessels are cleaned locally, so this threat was also considered an issue at a local scale.

Scale	Risk Rating	Confidence
Local N=4	Medium	Medium – High
Regional N=5	High	Medium

19 Fragmentation of cultural knowledge: Loss and fragmentation of knowledge of tangible and intangible heritage values (e.g. as Indigenous Elders age and young people leave their traditional land and sea country, or availability of specialist skills in historic heritage preservation declines)

Note this discussion considered cultural and heritage knowledge. While the threat is specific to Indigenous culture, it also leads to a loss of knowledge of technical experts in heritage, so influences cultural knowledge.

Scale	Risk Rating	Confidence
Local		
Regional	Very High	High

21 Grounding large vessel: Grounding of large vessels (> 50 m) including physical damage and the dislodging of antifoulants.

Scale	Risk Rating	Confidence
Local N=4	Very High	High – Medium
Regional N=5	High	High – Medium

22 Grounding small vessel: Grounding of small vessels (< 50 m) including physical damage and the dislodging of antifoulants.

Scale	Risk Rating	Confidence
Local N=4	High	High – Medium
Regional N=5	High	High – Medium

23 Illegal activities – other: Illegal activities such as entering a protected or restricted area, illegal release of industrial discharge, shipping outside of designated shipping areas, and removal or damage of artefacts (ship anchors, stone implements), scar trees, middens, fish traps, burial grounds, stone arrangements, artwork.

Scale	Risk Rating	Confidence
Local N=4	Very High	High

Regional N=5	High	High

26 Incompatible uses: Activities undertaken within the region that disturb or exclude other users, such as recreational use in areas important for cultural activities.

Participants discussed tourism and other activities impacting cultural heritage.

Scale	Risk Rating	Confidence
Local N=4	High	High – Medium
Regional N=5	High	High – Medium

27 Marine debris: Manufactured material discarded, disposed of or abandoned in the marine and coastal environment (including discarded fishing gear and plastics and abandoned or damaged equipment and infrastructure).

Scale	Risk Rating	Confidence
Local		
Regional	High	High

28 Modifying coastal habitats: Clearing or modifying wetlands, mangroves and other coastal ecosystems in the Catchment or inshore areas or on islands.

Scale	Risk Rating	Confidence
Local		
Regional	Very High	High – Medium

30 Nutrient run-off: Nutrients from diffuse land-based run-off.

Scale	Risk Rating	Confidence
Local		

Regional	High	High – Medium

31 Ocean acidification: Decreasing pH of the region's waters.

Scale	Risk Rating	Confidence
Local		
Regional	Very High	High

32 Outbreak of crown-of-thorns starfish: Outbreak of crown-of-thorns starfish.

Scale	Risk Rating	Confidence
Local		
Regional	High	High – Medium

36 Sea-level rise: Rising sea level.

Scale	Risk Rating	Confidence
Local N=4	Very High	High – Medium
Regional N=5	High	High – Medium

37 Sea temperature increase: Increasing extreme and average sea temperature.

Scale	Risk Rating	Confidence
Local N=4	High	High – Medium
Regional N=5	High	High – Medium

38 Sediment run-off: Sediments from diffuse land-based run-off.

Scale	Risk Rating	Confidence
Local	High	High – Medium
Regional	High	High – Medium

39 Spill – large chemical: Chemical spill that triggers a national or regional response or is more than 10 tonnes (includes substances such as sugar).

Scale	Risk Rating	Confidence
Local		
Regional	High	Medium – High

40 Spill – large oil: Oil spill that triggers a national or regional response or is more than 10 tonnes (includes all petroleum products).

Scale	Risk Rating	Confidence
Local		
Regional	Medium	High – Medium

41 Spill – small: Chemical or oil spill that does not trigger a national or regional response and is less than 10 tonnes. Includes materials (liquids and solids) used in attempts to restore or protect marine habitats but not materials considered under 'Marine Debris'.

Scale	Risk Rating	Confidence
Local		
Regional	Medium	Medium – High

42 Terrestrial discharge: Terrestrial point-source discharge (including within ports), such as polluted water, sewage, wastewater and stormwater.

Scale	Risk Rating	Confidence
Local		
Regional	High	Medium – High

Natural values risk assessment

Each threat contains a summary table of the risk assessment. The following example explains the different elements of the tables. In keeping with risk management standards and practice, the majority response the was used when a range of consequence or likelihood was given by experts. For example, if two experts voted for *Major* and three voted for *Catastrophic*, the rating given is *Catastrophic*.

For a threat with a highly variable range of responses, when the range covered three rating levels, the middle rating was used. This approach is detailed more in the 'Assessing risk' section (see page 20).

Note that a range of responses can have either (a) a skew (or clumping) to one part of that range, or (b) votes spread more evenly across the range (which we have called a *highly variable result*). Only instances of votes spread evenly across the range are described as *highly variable* because they represent a genuine spread of opinion. Hence it is possible to have a spread of responses that were not a *highly variable result.*

The range of responses is reported for confidence in the table for each threat. In Table 7 (a consolidated table), the range of responses is also reported for consequence and likelihood.

Key

Scale	Risk Rating	Confidence ** = variable result*
Local	*Colour = risk rating*	*Greyed means no input from experts*
Regional	*Colour = risk rating*	*Overall confidence**

Important caveat regarding the natural values risk assessments

Individual experts were not expected to have in-depth knowledge or insights across all of the threats being considered, particularly where it is the staff of management agencies rather than researchers who have the best access to relevant data and knowledge (e.g. large vessel grounding statistics and management measures in place to prevent such incidents). The experts were asked in that context as the rapid assessment workshop is one of several lines of evidence used by the Reef Authority in arriving at the final risk assessment results in the 2024 Outlook Report. Some experts participating in the workshop expressed that they did not fully understand the breadth and depth of the scope of some of the threats, or how they might interact with many different natural values in the Region.

This helps explain why there are a number of measures of expert confidence in the evidence supporting their assessment in a wide range from Unknown to High* (an asterisk signifies that there was higher than normal variability in the views expressed by experts and care should be taken when using this result without that caveat). In this case, they found it difficult to draw on an evidence base with high confidence. This is reflected in the wide range of confidence levels recorded for some elements of the assessment. We have noted some of the detailed concerns or comments expressed in the narrative for each threat in this section.

As noted above, in keeping with Australian Risk Management Standards, for all ranges in responses given by experts with high uncertainty in expert assessments, generally the most conservative (i.e., higher consequence or likelihood) has been used to calculate the risk category. This is unless there was a strong skewing in the underlying data (e.g. if 10 experts commented, and eight said Rare, one said Likely and one said Almost Certain) the majority of inputs were considered and the category was moved closer to the majority view rather than using the most conservative response. In general, with the lack of confidence and minor concerns expressed about the risk assessment process, the scope of threats and the availability of data sources on which to draw conclusions, caution should be taken with reporting these risk assessment outcomes without further detailed review or input from the Reef Authority outlook staff, internal experts, other external experts or published peer-reviewed literature regarding the threats faced by the natural values in the Region.

1. Acid sulphate soils: Exposure of acid sulphate soils

This threat relates to potential acid sulphate soils in coastal ecosystems below certain elevations, which become acidic when exposed to oxygen. They can be exposed by storms, lowering of water table, etc. This releases sulfuric acid and can lower the pH of water to two, killing species at a local level. A lot of potential acid sulphate soil sites are mapped, and there are policies in place to prevent exposure. Acid sulphate soils can be neutralised by sea water, or in severe cases by lime.

The assessment of consequence at a local scale involved a wide spread of opinion. Likelihood (local) after current management actions is low (partly due to sea-level rise).

Likelihood (Regional) is rare, as exposure is going to be at a local scale, with minimal impact on the Region. Confidence is based on published information.

Scale	Risk Rating	Confidence
Local N=10	Low	Medium – High
Regional N=8	Low	Medium – Low

2. Altered ocean currents: Climate change induced altered ocean currents

This threat relates to water moving differently due to climate change. With the potential breakdown of large global ocean currents (that is, the thermohaline circulation), there is an identified threat but detail of the impact is unknown. Changing currents will change climate and weather, which in turn could impact the Region. The description of this threat in the 2024 Outlook Report could refer to concerns about global circulation changing.

Scale	Risk Rating	Confidence
Local N=12	High	Low – High*
Regional N=11	High	Low – High*

3. Altered weather patterns: Climate change effects on weather patterns (e.g. cyclones, wind, rainfall, air temperature), includes both chronic and acute aspects.

The discussion noted this threat includes increased air temperature, related extreme events, and changes to what we understand as regular weather patterns.

Cyclones are difficult to consider, as projections suggest fewer cyclones but a greater proportion of intense cyclones. The scale and nature of impacts from cyclones depend on factors such as a cyclone's size and speed and whether it crosses the coast into the catchment (affecting rainfall, etc.), so emerging information on changes to cyclones may influence other threats. Need to integrate consideration of this threat with other extreme events (including heatwaves, drought, and flood). The time scale for these considerations may be longer than 5 years.

Scale	Risk Rating	Confidence

Local	High	Medium – High
Regional	High	Medium – High

4. Artificial light: Artificial lighting including from resorts, industrial infrastructure, mainland beaches and coastlines, vessels and ships.

Scale	Risk Rating	Confidence
Local	High	Low – High*
Regional	Low	Low – High*

5. Atmospheric pollution: Pollution of the atmosphere related to domestic, industrial and business activities in both the region and adjacent areas. The contribution of gases such as carbon dioxide to climate change is not included as this is encompassed under threats such as sea temperature increase and ocean acidification.

Participants noted the important caveat that greenhouse gases are not included here. Bushfire smoke, dust from mining, vessel and vehicle exhaust, and other air pollutants could be considered.

Scale	Risk Rating	Confidence
Local	High	Low – High*
Regional	Medium	Low – High*

6. Barriers to flow: Artificial barriers to riverine and estuarine flow (e.g. dams, weirs, break walls and gates, roads and linear infrastructure).
Participants noted that this was an example of an impact occurring outside the Region that affects the Region.

The risk relates to barriers currently built or planned. There are three planned in the Burdekin, for example. But proposed or aspirational barriers (such as dams) are not included.

Participants noted that, since the last Outlook Report, all the barriers and fishways have been mapped and available on the Queensland Government's website. This fundamentally changes the confidence on which an assessment of this threat can be made.

Scale	Risk Rating	Confidence
Local	High	Low-High*
Regional	Low	Unknown-High*

7. Damage to reef structure: Physical damage to reef benthos (reef structure) through actions such as snorkelling, diving, anchoring and fishing, but not vessel grounding.

The discussion clarified these are anthropogenic impacts, including walking on inter-tidal reefs, not damage from cyclones or vessel groundings that have a separate assessment. Experts suggested that walking on reefs be specifically noted in future as a hazard in this threat.

Scale	Risk Rating	Confidence
Local N=11	High	Low – High
Regional N=10	Low	Low – High

8. Damage to seafloor: Physical damage to non-reef benthos (seafloor) through actions such as trawling and anchoring.

This threat refers to damage (or disturbance) to anything that isn't a reef structure, by anthropogenic activities including, for example, prawn trawling, propellor damage under large ships, and anchors, but not dredging (as this is covered in a separate threat).

Scale	Risk Rating	Confidence
Local	High	Unknown – High*
Regional	Medium	Unknown – High*

9. Discarded catch: Immediate or post-release effects (such as death, injury, reduced reproductive success) on discarded species (non-retained catch) as a result of interactions with fishing gear. Does not include species of conservation concern.

The broad definition of species of conservation concern was discussed as listed species (Federal and State), plus some fish, sharks and rays, and other iconic species. It includes the species-level, population and ecosystem impacts on the area, not about individuals. It may also include flow-on effects on food chains. In this context, it was suggested to clarify the definition of species of conservation concern within the Outlook Report.

Scale	Risk Rating	Confidence
Local	Medium	Unknown – High*
Regional	Low	Unknown – High*

10. Disposal of dredge material: Disposal and resuspension of dredge material.

The discussion noted that this occurs under permit, as it has an impact on soft sediment seafloor. There are 12 trading ports, including four priority ones. This threat is more likely to impact the inshore Reef than the outer Reef.

Likelihood refers to the threat as a result of the activity, not the likelihood of the activity as it is known this happens regularly.

Scale	Risk Rating	Confidence
Local	High	Unknown-High*
Regional	Medium	Unknown-High*

11. Dredging: Dredging of the seafloor.

Scale	Risk Rating	Confidence
Local	High	Unknown-High*
Regional	Medium	Unknown-High*

12. Exotic species: Introduced exotic species from aquaculture operations, hull fouling, ballast release, biocontrol, translocation of other marine species, and release of aquarium specimens to the region, plus the introduction of weeds, pests and feral animals to islands. Includes both new introductions and outbreaks of previously introduced exotic species. Does not include considerations covered under 'genetic modification' threat.

Scale	Risk Rating	Confidence

Local	High	Unknown – High*
Regional	Medium	Unknown – High*

13. Extraction from spawning aggregations: Retained take (extraction) of fish from unidentified or unprotected spawning aggregations.

There was some confusion on the day regarding which species fell into this threat, compared to what was included in threat number 15 regarding particle feeders. The experts asked about the taking of corals, jellies, and other cnidarians (which also spawn and some may aggregate) and were advised by the Outlook Report team that these taxa are considered under 'Extraction of particle feeders'.

Scale	Risk Rating	Confidence
Local	High	Unknown – Medium*
Regional	High	Unknown – Medium*

14. Extraction of herbivores: Retained take (extraction) of herbivores (e.g. some fishes, molluscs, dugongs, green turtles) through commercial and non-commercial uses.

Scale	Risk Rating	Confidence
Local	High	Unknown-High*
Regional	Medium	Unknown-High*

15. Extraction of particle feeders: Retained take (extraction) of particle feeders (filter feeders, detritivores) through commercial and non-commercial uses.

Note the clarification to scope for threat number 13 – corals, jellies, and other cnidarians were considered in this threat.

Scale	Risk Rating	Confidence
Local N=11	Medium	Unknown – High*
Regional N=10	Low	Unknown – High*

16. Extraction of predators: Retained take (extraction) of predators (e.g. sharks, fish) *through commercial and non-commercial uses.*

Scale	Risk Rating	Confidence
Local	High	Unknown – High*
Regional	High	Unknown – High*

17. Genetic modification: Genetic modification of native species, manipulation of natural genotype frequencies (e.g. through translocations or intentional releases of specimens), and products of synthetic biology.

Scale	Risk Rating	Confidence
Local	Medium	
Regional	High	

18. Grounding large vessel: Grounding of large vessels (> 50 m) including physical damage and the dislodging of antifoulants.

Scale	Risk Rating	Confidence
Local	Medium	
Regional	Medium	

19. Grounding small vessel: Grounding of small vessels (< 50 m) including physical damage and the dislodging of antifoulants.

Scale	Risk Rating	Confidence
Local	Low	
Regional	Medium	

20. Illegal activities – other: Illegal activities such as entering a protected or restricted area, illegal release of industrial discharge, shipping outside of designated shipping areas, and removal or damage of artefacts (ship anchors, stone implements), scar trees, middens, fish traps, burial grounds, stone arrangements, artwork.

Scale	Risk Rating	Confidence
Local N=11	High	Low – Medium

Regional N=10	Low	Low – Medium

21. Illegal fishing and poaching: Illegal fishing, collecting and poaching.

Experts suggested that the compliance team at the Reef Authority can contribute more detail about consideration of this threat, such as how many incidents occur. The Reef Authority conducts an internal rapid risk assessment to elicit such information, however the external expert perspective is also considered important to the assessment. The scope of the discussion and assessment was broader than solely fish.

Scale	Risk Rating	Confidence
Local	High	Low-High
Regional	Medium	Low-High

22. Incidental catch of species of conservation concern: Immediate or post-release effects (such as death, injury, reduced reproductive success) of interactions of species of conservation concern with fishing gear.

The consideration of species of conservation concern included listed species, plus dugongs, as defined in the Outlook Report.

Scale	Risk Rating	Confidence
Local	High	Low – High
Regional	Medium	Low – High

24. Marine debris: Manufactured material discarded, disposed of or abandoned in the marine and coastal environment (including discarded fishing gear and plastics and abandoned or damaged equipment and infrastructure).

Scale	Risk Rating	Confidence
Local	High	
Regional	High	

25. Modifying coastal habitats: Clearing or modifying wetlands, mangroves and other coastal ecosystems in the Catchment or inshore areas or on islands.

Scale	Risk Rating	Confidence
Local	High	Low – High
Regional	High	Low – High

26. Noise pollution: Noise from human activities, both below and above water.

Scale	Risk Rating	Confidence
Local	Medium	
Regional	Medium	

27. Nutrient run-off: Nutrients from diffuse land-based run-off.

Scale	Risk Rating	Confidence
Local	High	
Regional	High	

28. Ocean acidification: Decreasing pH of the region's waters.

This assessment considered the threat to natural values of the Region and locally, over a longer scale (to 2050). A 20-to-30-year time horizon is needed when considering this threat. Ocean acidification is already leading to observed declines in natural values condition in the Region, but as soon as carbon dioxide emissions are reduced, the uptake of carbon dioxide by the oceans is immediately reduced.

A change in pH is just one impact of increased carbon dioxide. Ocean acidification is due to the increase of carbon dioxide in seawater, leading to an increased dissolving of inorganic carbon, and a decline in pH. Changes in pH are also a proxy for other changes, such as less inorganic chemicals, such as iron, being available.

The Outlook Report team could consider a change in the name or context in the narrative to reflect that ocean acidification is associated with more chemistry changes than just pH changes.

Scale	Risk Rating	Confidence
Local	Very High	High – Medium
Regional	Very high	High – Medium

29. Outbreak of crown-of-thorns starfish: Outbreak of crown-of-thorns starfish.

Scale	Risk Rating	Confidence
Local	High	High – Medium
Regional	High	High – Medium

30. Outbreak of disease: Outbreak of disease, both naturally occurring and introduced.

This threat relates to outbreak of disease in any organism due to accidental or deliberate anthropogenic introduction of disease or natural causes of an outbreak. Consequence rating at regional scale may depend on which taxa are considered.

Scale	Risk Rating	Confidence
Local N=10	High	Unknown – High (Medium)
Regional N=9	High	Medium – Low

31. Outbreak of other species: Outbreak or bloom of naturally occurring species other than crown-of-thorns starfish.

This threat includes bacteria, cyanobacteria, plants not living in the water, ants, trees, native rats, jellyfish, etc. The threat is associated with overabundant native species, not exotic species. With threats such as water quality and development, the impact of their interactions with outbreaks on ecosystems is understood. However, disease can shift an entire system and the likelihood of this potentially catastrophic outcome is unknown.

Scale	Risk Rating	Confidence
Local	Medium	Low – Medium
Regional	Low	Low – Medium

32. Pesticide run-off: Pesticides (including herbicides, insecticides, fungicides) from diffuse land-based run-off.

Scale	Risk Rating	Confidence

Local	High	
Regional	High	

33. Sea level rise: Rising sea level.

Scale	Risk Rating	Confidence
Local	High	
Regional	High	

34. Sea temperature increase: Increasing extreme and average sea temperature.

Participants considered overall sea water, not different levels of the ocean strata. There are different rates of warming, but changes generally involve an increase in temperature.

Scale	Risk Rating	Confidence
Local	Very High	High
Regional	Very High	High

35. Sediment run-off: Sediments from diffuse land-based run-off.

Scale	Risk Rating	Confidence
Local	High	
Regional	High	

36. Spill – large chemical: Chemical spill that triggers a national or regional response or is more than 10 tonnes (includes substances such as sugar).

Scale	Risk Rating	Confidence
Local	High	
Regional	Medium	

37. Spill – large oil: Oil spill that triggers a national or regional response or is more than 10 tonnes (includes all petroleum products).

Scale	Risk Rating	Confidence
Local	High	
Regional	Medium	

38. Spill – small: Chemical or oil spill that does not trigger a national or regional response and is less than 10 tonnes. Includes materials (liquids and solids) used in attempts to restore or protect marine habitats but not materials considered under 'Marine Debris'.

Scale	Risk Rating	Confidence
Local	Medium	
Regional	Medium	

39. Terrestrial discharge: Terrestrial point-source discharge (including within ports), such as polluted water, sewage, wastewater and stormwater.

Scale	Risk Rating	Confidence
Local	Medium*	
Regional	Medium	

40. Vessel strike: Death or injury to wildlife as a result of being struck by a vessel of any type or size.

Scale	Risk Rating	Confidence
Local	Medium	
Regional	Medium	

41. Vessel waste discharge: Waste discharge from a vessel (including sewage).

Scale	Risk Rating	Confidence
Local	Medium	
Regional	Medium	

42. Wildlife disturbance: Disturbance to wildlife (including from snorkelling, diving, fish feeding, walking on islands

Scale	Risk Rating	Confidence
Local	High	
Regional	Medium	

Alternative climate change scenario exercise

The assessment of risks above deals with residual risk in light of current government policy. This meant participants effectively assessed threats under a mid-emissions warming scenario – that is, alignment with Paris Agreement, Shared Socioeconomic Pathways (SSP) 4 or Representative Concentration Pathway (RCP) 4.5.[28] However, a number of experts in the room noted that the planet is on a trajectory of greater warming.

The workshop included an exercise that provided an opportunity for experts to discuss the consequences of certain policy actions. There was concern from participants that the experts at the workshop would not know the detail of the impacts, with unknowns and multiplication of uncertainties. Participants suggested holding another expert session on this exercise and discussion, as physical climate researchers need to be involved to set the climate parameters, with ecology researchers to consider the impacts.

Nonetheless, the exercise considered a more optimistic scenario involving more action to address climate change, with rapid and significant mitigation. Within this context, experts were asked to consider if there would be a material reduction in the risk ratings of the threats considered above over the next 20 to 30 years (to 2050). This information can help decision-makers understand the effect of differing policy scenarios in relation to climate change scenarios.

The participants noted the change in risk depended on the timescales and potential for rapid mitigation. The assessment was not repeated for each threat, but the discussion identified a material impact from a higher emissions reduction scenario for the following threats:

- decreased ocean acidification

[28] O'Neill, B.C., Kriegler, E., Riahi, K., Ebi, K.L., Hallegatte, S., Carter, T.R., Mathur, R. and Van Vuuren, D.P. 2014, A new scenario framework for climate change research: the concept of shared socioeconomic pathways. *Climatic change*, *122*, pp.387-400. https://link.springer.com/article/10.1007/s10584-013-0905-2

- less sea temperature increase
- reduction in the potential outbreaks of disease, introduced species and pest species
- fewer extreme heat and floods
- higher chance for reef recovery.

The participants noted the reduction in threat would be most certain for ocean acidification and chemistry; none of the other threats had the same degree of certainty that immediate mitigation would provide to decreased ocean acidification.

In summary, if the scenario of greater action and less warming were to occur, there would be a chance for the negative impacts of the Region to be reduced earlier and recovery to occur faster. The threats that would be decreased relate to water quality, altered weather patterns, sea temperature increase, disease and species outbreaks, and ocean acidification.

Table 6. Summary of workshop outcomes for residual risks that were assessed (**heritage values components**)

** Signifies that there was higher than normal variability in the views expressed by experts and care should be taken when using this result without that caveat. In practice, it meant that experts were evenly split across a range of responses and there was not an obvious skewed pattern towards one response across a range of expert opinions. A greyed box means there was no input from experts.*

2024 Outlook Report Threats to Heritage Values (45 threats)	# Experts involved	Regional Scale				Local Scale			
		Risk Rating	Confidence	Consequence	Likelihood	Risk Rating	Confidence	Consequence	Likelihood
Acid sulphate soils: Exposure of acid sulphate soils	3-5	Medium	Medium – Low*	Major – Minor*	Possible	High	Low	Major	Possible
Altered ocean currents: Climate change induced altered ocean currents	5	High	High	Major	Possible – Almost Certain*				
Altered weather patterns: Climate change effects on weather patterns (e.g. cyclones, wind, rainfall, air temperature), includes both chronic and acute aspects.	5	Very High	High	Catastrophic – Major*	Likely – almost Certain				
Artificial light: Artificial lighting including from resorts, industrial infrastructure, mainland beaches and coastlines, vessels and ships	5	Medium	High – Medium	Insignificant – Catastrophic	Rare – Almost Certain				
Atmospheric pollution: Pollution of the atmosphere related to domestic, industrial and business activities in both the Region and adjacent areas. The contribution of gases such as carbon dioxide to climate change is not included as this is encompassed under threats such as sea temperature increase and ocean acidification.	4-5	High	High – Medium	Minor – Major	Possible – Almost Certain				
Barriers to flow: Artificial barriers to riverine and estuarine flow (e.g. dams, weirs, break walls and gates, roads and linear infrastructure)	5	High	High – Medium	Minor – Major	Possible – Almost Certain				
Behaviour impacting heritage values: Disturbance of, or damage to, the values of intangible Indigenous and historic heritage site through inappropriate presence of people. Examples include: visitation to locations considered dangerous or sensitive in Indigenous culture; access by people of culturally inappropriate gender or seniority;	5	Very High	High	Moderate – Catastrophic	Likely – Almost Certain	Very High	High	Catastrophic	Likely – Almost Certain

overly high visitor traffic levels at Indigenous sites open to visitation (e.g. creating too much noise); and disrespectful behaviour or activities at Indigenous and historic heritage sites (e.g. burial areas).									
Damage to reef structure: Physical damage to reef benthos (reef structure) through actions such as snorkelling, diving, anchoring and fishing, but not vessel grounding	4-5	High	High	Minor – Catastrophic	Likely – Almost Certain	High	High – Medium	Minor – Catastrophic	Likely – Almost Certain
Damage to seafloor: Physical damage to non-reef benthos (seafloor) through actions such as trawling and anchoring	4-5	Very High	Medium – High	Major – Catastrophic	Unlikely – Almost Certain	Very High	Medium – High	Moderate – Catastrophic	Likely – Almost Certain
Discarded catch: Immediate or post-release effects (such as death, injury, reduced reproductive success) on discarded species (non-retained catch) as a result of interactions with fishing gear. Does not include species of conservation concern.	5	High	High	Insignificant – Major	Unlikely – Almost Certain				
Disposal of dredge material: Disposal and resuspension of dredge material	5	Low	High – Medium	Moderate – Minor	Rare				
Dredging: Dredging of the seafloor	4-5	High	High – Medium	Moderate	Possible – Almost Certain	High	High – Medium	Moderate – Catastrophic	Possible – Almost Certain
Exotic species: Introduced exotic species from aquaculture operations, hull fouling, ballast release, biocontrol, translocation of other marine species, and release of aquarium specimens to the Region, plus the introduction of weeds, pests and feral animals to islands. Includes both new introductions and outbreaks of previously introduced exotic species. Does not include considerations covered under 'genetic modification' threat.	4-5	High	Medium	Minor – Major	Possible – Almost Certain	Medium	Medium – High	Minor – Major	Possible – Likely
Extraction from spawning aggregations: Retained take (extraction) of fish from unidentified or unprotected spawning aggregations									

Extraction of herbivores: Retained take (extraction) of herbivores (e.g. some fishes, molluscs, dugongs, green turtles) through commercial and non-commercial uses	Not considered relevant by Experts as a threat to Heritage in the Region.								
Extraction of particle feeders: Retained take (extraction) of particle feeders (filter feeders, detritivores) through commercial and non-commercial uses									
Extraction of predators: Retained take (extraction) of predators (e.g. sharks, fish) through commercial and non-commercial uses									
Foundational capacity gaps: Lack of capacity of Traditional Owners to exercise their Indigenous heritage (cultural) rights by accessing and managing their land and sea country. Relates to capacity of Traditional Owners and their groups, and is not about loss of knowledge or about access restrictions or conflicting use. Potential impacts include those on the enduring connection Traditional Owners have with their land and sea country and on the maintenance of culture and the transfer of knowledge to younger generations (e.g. reduced opportunities to conduct knowledge transfer)	See notes about threats to Indigenous living culture in narrative above.								
Fragmentation of cultural knowledge: Loss and fragmentation of knowledge of tangible and intangible heritage values (e.g. as Indigenous Elders age and young people leave their traditional land and sea country, or availability of specialist skills in historic heritage preservation declines)	5	Very High	High	Major – Catastrophic	Possible – Almost Certain				
Genetic modification: Genetic modification of native species, manipulation of natural genotype frequencies (e.g. through translocations or intentional/unintentional releases of specimens), and products of synthetic biology	Not considered relevant by Experts as a threat to Heritage in the Region.								

Grounding large vessel: Grounding of large vessels (> 50 m) including physical damage and the dislodging of antifoulants	4-5	Very High	High – Medium	Major – Catastrophic	Rare – Possible	High	High – Medium	Moderate – Major	Possible – Likely
Grounding small vessel: Grounding of small vessels (< 50 m) including physical damage and the dislodging of antifoulants	4-5	High	High – Medium	Minor – Major	Possible – Likely	High	High – Medium	Major	Possible – Almost Certain
Illegal activities – other: Illegal activities, such as entering a protected or restricted area, illegal release of industrial discharge, shipping outside of designated shipping areas, and removal or damage of artefacts (e.g. ship anchors, stone implements), scar trees, middens, fish traps, burial grounds, stone arrangements, art work	4-5	Very High	High	Major – Catastrophic	Possible – Likely	High	High	Moderate – Catastrophic	Possible – Almost Certain
Illegal fishing and poaching: Illegal fishing, collecting and poaching	Not considered relevant by Experts as a threat to Heritage in the Region.								
Incidental catch of species of conservation concern: Immediate or post-release effects (such as death, injury, reduced reproductive success) of interactions of species of conservation concern with fishing gear									
Incompatible uses: Activities undertaken within the Region that disturb or exclude other users, such as recreational use in areas important for cultural activities	4-5	High	High – Medium	Minor – Major	Possible – Almost Certain	High	High – Medium	Moderate – Catastrophic	Possible – Likely
Marine debris: Manufactured material discarded, disposed of or abandoned in the marine and coastal environment (including discarded fishing gear, plastics, and abandoned or damaged equipment and infrastructure)	5	High	High	Minor – Major	Likely – Almost Certain				
Modifying coastal habitats: Clearing or modifying wetlands, mangroves and other coastal ecosystems in the Catchment or inshore areas or on islands	5	Very High	High – Medium	Major – Catastrophic	Unlikely – Almost Certain				
Noise pollution: Noise from human activities, both below and above water	Not considered relevant by Experts as a threat to								

	Heritage in the Region.								
Nutrient run-off: Nutrients from diffuse land-based run-off	5	High	High – Medium	Minor – Major	Possible – Almost Certain				
Ocean acidification: Decreasing pH of the Region's waters	5	Very High	High	Major – Catastrophic	Unlikely – Almost Certain				
Outbreak of crown-of-thorns starfish: Outbreak of crown-of-thorns starfish	5	High	High – Medium	Moderate – Major	Possible – Almost Certain				
Outbreak of disease: Outbreak of disease, both naturally occurring and introduced	Not considered relevant by Experts as a threat to Heritage in the Region.								
Outbreak of other species: Outbreak or bloom of naturally occurring species other than crown-of-thorns starfish									
Pesticide run-off: Pesticides (including herbicides, insecticides, fungicides) from diffuse land-based run-off									
Sea level rise: Rising extreme and average sea level	4-5	High	High – Medium	Moderate – Catastrophic	Possible – Almost Certain	Very High	High – Medium	Major – Catastrophic	Unlikely – Almost Certain
Sea temperature increase: Increasing sea temperature	4-5	High	High – Medium	Moderate – Catastrophic	Possible – Almost Certain	High	High – Medium	Moderate – Catastrophic	Possible – Almost Certain
Sediment run-off: Sediments from diffuse land-based run-off	5	High	High – Medium	Moderate – Catastrophic	Possible – Almost Certain	High	High – Medium	Minor – Catastrophic	Possible – Almost Certain
Spill – large chemical: Chemical spill that triggers a national or regional response or is more than 10 tonnes (includes substances, such as sugar)	5	High	Medium – High	Major – Catastrophic	Rare – Possible				
Spill – large oil: Oil spill that triggers a national or regional response or is more than 10 tonnes (includes all petroleum products)	5	Medium	High – Medium	Moderate – Catastrophic	Rare – Possible				
Spill – small: Chemical or oil spill that does not trigger a national or regional response and is less than 10 tonnes includes materials (liquids and solids) used in attempts to restore or protect marine habitats but not materials considered under 'Marine debris'	5	Medium	Medium – High	Minor – Major	Unlikely – Likely				
Terrestrial discharge: Terrestrial point-source discharge (including within ports), such as polluted water, sewage, wastewater and stormwater	5	High	Medium – High	Minor – Major	Likely – Almost Certain				

Vessel strike: Death or injury to wildlife as a result of being struck by a vessel of any type or size	Not considered relevant by Experts as a threat to Heritage in the Region
Vessel waste discharge: Waste discharge from a vessel (including sewage)	
Wildlife disturbance: Disturbance to wildlife including from snorkelling, diving, fish feeding, walking on islands and beaches, and the presence of boats; not including noise pollution	

Table 7. Summary of workshop outcomes for residual risks that were assessed (**natural values components**)

** Signifies that there was higher than normal variability in the views expressed by experts and care should be taken when using this result without that caveat. In practice, it meant that experts were evenly split across a range of responses and there was not an obvious skewed pattern toward one response across a range of expert opinions. For some threats the experts responding did not provide a measure of their confidence in their assessment, which is shown as a greyed box. Where the number of experts giving an opinion is three or lower, these results should be treated with a degree caution due to the small sample size.*

2024 Outlook Report Threats to Biodiversity and Ecosystem Health Values (42 threats)	# Experts involved	Regional Scale				Local Scale			
		Risk Rating	Confidence	Consequence	Likelihood	Risk Rating	Confidence	Consequence	Likelihood
Acid sulphate soils: Exposure of acid sulphate soils	8-10	Low	Medium – Low	Insignificant – Minor	Rare-Possible	Low	Medium – High	Insignificant – Major	Rare – Possible

Altered ocean currents: Climate change induced altered ocean currents	11-12	High	Low – High*	Minor – Catastrophic	Rare – Almost Certain	High	Low – High*	Moderate – Catastrophic	Unlikely – Likely
Altered weather patterns: Climate change effects on weather patterns (e.g. cyclones, wind, rainfall, air temperature), includes both chronic and acute aspects.	12	High	Medium – High	Moderate – Catastrophic	Possible – Almost Certain	High	Medium – High	Moderate – Catastrophic	Rare – Almost Certain
Artificial light: Artificial lighting including from resorts, industrial infrastructure, mainland beaches and coastlines, vessels and ships	11	Low	Low – High*	Insignificant – Moderate	Rare – Likely	High	Low – High*	Minor – Major	Unlikely – Almost Certain
Atmospheric pollution: Pollution of the atmosphere related to domestic, industrial and business activities in both the Region and adjacent areas. The contribution of gases such as carbon dioxide to climate change is not included as this is encompassed under threats such as sea temperature increase and ocean acidification.	11	Medium	Low – High*	Insignificant – Major	Rare – Almost Certain	High	Low – High*	Minor – Major	Unlikely – Almost Certain
Barriers to flow: Artificial barriers to riverine and estuarine flow (e.g. dams, weirs, break walls and gates, roads and linear infrastructure)	10	Low	Unknown – High*	Insignificant – Moderate	Rare – Almost Certain	High	Low – High*	Minor – Major	Unlikely – Almost Certain
Damage to reef structure: Physical damage to reef benthos (reef structure) through actions such as snorkelling, diving, anchoring and fishing, but not vessel grounding	10-11	Low	Low – High	Insignificant – Moderate	Rare – Almost Certain	High	Low – High	Minor – Major	Unlikely – Almost Certain
Damage to seafloor: Physical damage to non-reef benthos (seafloor) through actions such as trawling and anchoring	12	Medium	Unknown – High*	Insignificant – Major	Rare – Almost Certain	High	Unknown – High*	Minor – Catastrophic	Possible – Almost Certain
Discarded catch: Immediate or post-release effects (such as death, injury, reduced reproductive success) on discarded species (non-retained catch) as a result of interactions with fishing gear. Does not include species of conservation concern.	11	Low	Unknown – High*	Insignificant – Moderate	Rare – Almost Certain	Medium	Unknown – High*	Minor – Major	Possible – Almost Certain

Disposal of dredge material: Disposal and resuspension of dredge material	10	Medium	Unknown-High*	Insignificant – Major	Rare – Almost Certain	High	Unknown – High*	Moderate – Catastrophic	Unlikely – Almost Certain
Dredging: Dredging of the seafloor	11	Medium	Unknown – High*	Insignificant – Major	Rare – Almost Certain	High	Unknown – High*	Moderate – Catastrophic	Rare – Almost Certain
Exotic species: Introduced exotic species from aquaculture operations, hull fouling, ballast release, biocontrol, translocation of other marine species, and release of aquarium specimens to the Region, plus the introduction of weeds, pests and feral animals to islands. Includes both new introductions and outbreaks of previously introduced exotic species. Does not include considerations covered under 'genetic modification' threat.	11	Medium	Unknown – High*	Insignificant – Major	Rare – Likely	High	Unknown – High*	Moderate – Catastrophic	Unlikely – Almost Certain
Extraction from spawning aggregations: Retained take (extraction) of fish from unidentified or unprotected spawning aggregations	11	High	Unknown – Medium*	Minor – Catastrophic	Rare – Likely	High	Unknown – Medium*	Minor – Catastrophic	Unlikely – Almost Certain
Extraction of herbivores: Retained take (extraction) of herbivores (e.g. some fishes, molluscs, dugongs, green turtles) through commercial and non-commercial uses	12	Medium	Unknown – High*	Insignificant – Catastrophic	Rare – Likely	High	Unknown – High*	Minor – Major	Unlikely – Almost Certain
Extraction of particle feeders: Retained take (extraction) of particle feeders (filter feeders, detritivores) through commercial and non-commercial uses	10-11	Low	Unknown – High*	Insignificant – Major	Rare – Likely	Medium	Unknown – High*	Minor – Major	Rare – Likely
Extraction of predators: Retained take (extraction) of predators (e.g. sharks, fish) through commercial and non-commercial uses	12	High	Unknown – High*	Minor – Major	Unlikely – Almost Certain	High	Unknown – High*	Insignificant – Major	Unlikely – Almost Certain
Genetic modification: Genetic modification of native species, manipulation of natural genotype frequencies (e.g. through translocations or intentional/unintentional releases of specimens), and products of synthetic biology	3	High		Minor – Moderate	Unlikely – Almost certain	Medium		Moderate – Catastrophic	Rare – Likely

Grounding large vessel: Grounding of large vessels (> 50 m) including physical damage and the dislodging of antifoulants	3	Medium		Minor	Possible – Likely	Medium		Minor – Major	Rare – Likely
Grounding small vessel: Grounding of small vessels (< 50 m) including physical damage and the dislodging of antifoulants	3	Medium		Insignificant – Minor	Possible – Almost Certain	Low		Insignificant – Minor	Unlikely – Likely
Illegal activities – other: Illegal activities, such as entering a protected or restricted area, illegal release of industrial discharge, shipping outside of designated shipping areas, and removal or damage of artefacts (e.g. ship anchors, stone implements), scar trees, middens, fish traps, burial grounds, stone arrangements, art work	10-11	Low	Low – Medium	Insignificant – Moderate	Rare – Likely	High	Low – Medium	Minor – Major	Unlikely – Almost Certain
Illegal fishing and poaching: Illegal fishing, collecting and poaching	10	Medium	Low – High	Insignificant – Major	Rare – Almost Certain	High	Low – High	Minor – Major	Unlikely – Almost Certain
Incidental catch of species of conservation concern: Immediate or post-release effects (such as death, injury, reduced reproductive success) of interactions of species of conservation concern with fishing gear	11	Medium	Low – High	Insignificant – Major	Rare – Almost Certain	High	Low – High	Minor – Major	Unlikely – Almost Certain
Marine debris: Manufactured material discarded, disposed of or abandoned in the marine and coastal environment (including discarded fishing gear, plastics, and abandoned or damaged equipment and infrastructure)	3	High		Minor – Moderate	Possible – Almost Certain	High		Minor – Moderate	Likely – Almost Certain
Modifying coastal habitats: Clearing or modifying wetlands, mangroves and other coastal ecosystems in the Catchment or inshore areas or on islands	12	High	Low – High	Insignificant – Major	Rare – Almost Certain	High	Low – High	Insignificant – Catastrophic	Rare – Almost Certain
Noise pollution: Noise from human activities, both below and above water	3	Medium		Insignificant – Moderate	Likely – Almost Certain	Medium		Insignificant – Moderate	Likely – Almost Certain
Nutrient run-off: Nutrients from diffuse land-based run-off	3	High		Minor – Major	Likely – Almost Certain	High		Minor – Major	Possible – Almost Certain

Ocean acidification: Decreasing pH of the Region’s waters	10	Very high	High – Medium	Moderate – Catastrophic	Likely – Almost Certain	Very High	High – Medium	Moderate – Catastrophic	Possible – Almost Certain
Outbreak of crown-of-thorns starfish: Outbreak of crown-of-thorns starfish	11	High	High – Medium	Insignificant – Major	Rare – Almost Certain	High	High – Medium	Minor – Catastrophic	Possible – Almost Certain
Outbreak of disease: Outbreak of disease, both naturally occurring and introduced	9-10	High	Medium – Low	Minor – Catastrophic	Unlikely – Possible	High	Unknown – High (Medium)	Minor – Catastrophic	Possible – Almost Certain
Outbreak of other species: Outbreak or bloom of naturally occurring species other than crown-of-thorns starfish	10	Low	Low – Medium	Insignificant – Major	Rare – Possible	Medium	Low – Medium	Minor – Catastrophic	Possible – Likely
Pesticide run-off: Pesticides (including herbicides, insecticides, fungicides) from diffuse land-based run-off	3	High		Minor – Major	Unlikely – Almost Certain	High		Minor – Moderate	Possible – Almost Certain
Sea level rise: Rising extreme and average sea level	3	High		Minor – Moderate	Likely – Almost Certain	High		Minor – Major	Likely – Almost Certain
Sea temperature increase: Increasing sea temperature	10	Very High	High	Major – Catastrophic	Likely – Almost Certain	Very High	High	Major – Catastrophic	Possible – Almost Certain
Sediment run-off: Sediments from diffuse land-based run-off	3	High		Minor – Major	Possible – Almost Certain	High		Minor – Moderate	Likely – Almost Certain
Spill – large chemical: Chemical spill that triggers a national or regional response or is more than 10 tonnes (includes substances, such as sugar)	3	Medium		Moderate – Major	Rare – Possible	High		Major	Rare – Likely
Spill – large oil: Oil spill that triggers a national or regional response or is more than 10 tonnes (includes all petroleum products)	3	Medium		Moderate – Major	Rare – Possible	High		Major	Rare – Possible
Spill – small: Chemical or oil spill that does not trigger a national or regional response and is less than 10 tonnes includes materials (liquids and solids) used in attempts to restore or protect marine habitats but not materials considered under ‘Marine debris’	3	Medium		Minor – Moderate	Possible	Medium		Moderate – Major	Rare – Possible
Terrestrial discharge: Terrestrial point-source discharge (including within ports), such as polluted water, sewage, wastewater and stormwater	3	Medium		Insignificant – Moderate	Possible – Almost Certain	Medium*		Minor – Major	Rare – Almost Certain*

Vessel strike: Death or injury to wildlife as a result of being struck by a vessel of any type or size	3	Medium		Insignificant – Minor	Possible – Almost Certain	Medium		Insignificant – Moderate	Possible – Likely
Vessel waste discharge: Waste discharge from a vessel (including sewage)	3	Medium		Insignificant – Moderate	Possible – Almost Certain	Medium		Insignificant – Moderate	Unlikely – Almost Certain
Vessel waste discharge: Waste discharge from a vessel (including sewage)	3	Medium		Insignificant – Moderate	Possible – Almost Certain	Medium		Insignificant – Moderate	Unlikely – Almost Certain
Wildlife disturbance: Disturbance to wildlife including from snorkelling, diving, fish feeding, walking on islands and beaches, and the presence of boats; not including noise pollution	3	Medium		Minor	Possible – Almost Certain	High		Minor – Moderate	Possible – Almost Certain

Participant workshop evaluation

Summary

During the workshops, participants made various comments intended as feedback. While many were incorporated into the feedback in the Values or Risk sections above, the remaining are reported below.

Two types of feedback questions were asked: eight feedback questions that have been asked with very little change since the 2014 Rapid Expert Assessment process; and five new feedback questions asked in the 2023 workshops.

Reporting on the second, new type of questions for the natural values rapid expert workshops, most participants felt their voice was heard, would be involved in a future similar process, and agreed the facilitation was very good. Most found the online technology used (Menti) was helpful for the process. Consistent with the views expressed by experts about the robustness and repeatability of the rapid expert process that were reported above, there was agreement, but some ambivalence and not strong agreement with the proposition that the process was robust.

With the questions only asked in 2023 for the risk assessment process, while there was mostly strong agreement that the experts felt heard and the facilitation was very good, there were mixed views about the online technology, if experts would involve themselves in a future similar process, and if the process was robust. Breaking down the workshops into the content areas, it is clear that the Indigenous and natural values experts were least comfortable with the process. While there was some support for the process, there was a full range of opinion with some strong disagreement and agreement. This pattern of comfort (and lack of comfort) is consistent with the direct expert feedback captured above.

Interestingly, for the questions that have been asked repeatedly over time (for the 2014, 2019 and now 2024 Outlook Reports), there was a more diverse range of responses than for the questions asked in 2023 alone. For some questions, there was a full range of views from strong agreement that the process provided a robust basis for the 2024 Outlook Report through to strong disagreement that it did. The weighted average was closer to *Neither agree nor disagree*, with a slight bias to agreement. Other questions were more consistent and clearer in their response; for example when asked if '*My inputs to the workshop consensus process were able to be fully recognised and incorporated',* most participants strongly agreed. In general most agreed (or strongly agreed) with the statement '*In general, I support the process and the outcomes.'*

By asking the question about expert comfort with the group result for the values gradings and trend assessments, much insight was gathered about where any discomfort in the process lay. That discussion is captured above under the different sections and should be used by future facilitators to consider addressing in any design changes for the 2029 Outlook Report expert rapid assessment process.

Regarding the risk assessment process, similar to the questions asked in 2023, it is clear that the Indigenous and natural values experts were least comfortable with the process. Some disagreed that it was robust or transparent. For other questions, while there was some support for the facilitation and venue, there was a full range of opinion with some strong disagreement and disagreement about the risk assessment process. This is detailed well in the risk assessment questions documented above, and partially underlies the comments made in the methods about insights to consider for updating the risk assessment process for the 2029 Outlook Report. The patterns seen in response to these repeated questions align strongly with the direct expert feedback captured in the body of the document.

More detail on the feedback is included Appendix 6.

Appendix 1. Grading statements

Indigenous living culture and historic heritage

Section 54(3)(i) of the *Great Barrier Reef Marine Park Act 1975* notes '*…an assessment of heritage values of the Great Barrier Reef Region is prescribed as a matter that must be contained in the Great Barrier Reef Outlook Report*.' The assessment conducted in the workshops focussed on two important assessment criteria addressed in the Outlook Report's heritage chapter:

- Indigenous living culture (Indigenous heritage)
- historic heritage values.

Grading Statement	
Very good	Heritage values have been systematically and comprehensively identified and included in relevant inventories or reserves. Known heritage values are well-maintained and retain a high degree of integrity
Good	Heritage values have been mostly identified and included in relevant inventories or reserves. Known heritage values are generally maintained and retain much of their integrity
Poor	Heritage values have not been systematically identified. Known heritage values are degrading and generally lack integrity.
Very poor	Known heritage values have not been identified. Known heritage values are degraded and lack integrity

Biodiversity

Section 54(3)(b) of the *Great Barrier Reef Marine Park Act 1975* requires '*…an assessment of the current biodiversity within …*' the Great Barrier Reef Region. This assessment is based on two assessment criteria:

- habitats to support species
- populations of species and groups of species.

Habitats grading statements

Very good	**All** major habitats are essentially **structurally and functionally intact** and able to support all dependent species.
Good	There is **some** habitat loss, degradation or alteration **in some small areas**, leading to **minimal degradation** but no persistent, substantial effects on populations of dependent species.
Poor	Habitat loss, degradation or alteration has occurred in a **number of areas** leading to **persistent substantial effects** on populations of some dependent species.
Very poor	There is **widespread** habitat loss, degradation or alteration leading to **persistent, substantial effects** on many populations of dependent species.

Populations of species and groups of species grading statements	
Very good	Only a few, if any, populations of species have deteriorated.
Good	Populations of some species (but no groups of species) have deteriorated significantly.
Poor	Populations of many species or some groups of species have deteriorated significantly.
Very poor	Populations of a large number of species or groups of species have deteriorated significantly.

Ecosystem health

Section 54(3)(a) of the *Great Barrier Reef Marine Park Act 1975* requires '*…an assessment of the current health of the ecosystem within the Great Barrier Reef Region and of the ecosystem outside that region to the extent that it affects that region*'. This assessment is based on five assessment criteria:

- physical processes
- chemical processes
- ecological processes
- outbreaks of diseases, introduced species and pest species
- coastal ecosystems that support the Great Barrier Reef.

Physical, chemical and ecological processes grading statements	
Very good	There are **no** significant changes in processes as a result of human activity.

Good	There are **some** significant changes in processes as a result of human activity in some areas, but these are **not to the extent** that they are significantly affecting ecosystem functions.
Poor	There are **substantial** changes in processes as a result of human activity and these are **significantly** affecting ecosystem functions in some areas.
Very poor	There are **substantial** changes in processes as a result of human activity **across a wide area** and ecosystem functions are **seriously** affected in much of the area.

Outbreaks of disease, introduced species and pest species grading statements	
Very good	**No records** of diseases above expected natural levels; no introduced species recorded, pest populations within naturally expected levels.
Good	Disease **occasionally above expected natural levels** but recovery prompt; any occurrences of introduced species successfully addressed; pests sometimes present above natural levels with limited effects on ecosystem function.
Poor	**Unnaturally high levels** of disease regularly recorded in some areas; occurrences of introduced species require significant intervention; pests in some areas affect ecosystem function more than expected under natural conditions.
Very poor	**Unnaturally high levels of disease** often recorded in **many areas**, uncontrollable outbreaks of introduced pests, opportunistic pests seriously affect ecosystem function in many areas.

Trend and confidence in trend for all values

Trend	↑Improving ↔Stable ↓Deteriorating —No clear trend
Confidence in condition and trend	● High: Adequate high-quality evidence and high level of consensus ◐ Medium: Limited evidence or limited consensus

	○ Low: Very limited evidence, assessment based on anecdotal information

- High confidence – it is unlikely the true score would lie outside the range of a single grade (i.e., a grade of 'good' with high confidence remains good).
- Medium – it is unlikely the true score would lie outside the designated grade by more than one grade (i.e., a grade of good with medium confidence could actually be poor or very good, but not very poor).
- Low – it is likely the true score is outside the designated grade (i.e., a grade of 'good' could actually be very poor, poor or very good).
- Unknown / No Score – this should be used if it is simply not known if there is *any* evidence or even anecdotal information available.

Appendix 2. Risk assessment framework

Risks to the Great Barrier Reef Region's ecosystem and heritage values

Section 54(3)(d) of the *Great Barrier Reef Marine Park Act 1975* requires '…an assessment of the risks to the ecosystem…' within the Great Barrier Reef Region.

This assessment of risk is based on the current state and trends of the Great Barrier Reef ecosystem's biodiversity and health, the factors influencing the values of the Region, the effectiveness of protection and management arrangements and ultimately an understanding of the ecosystem's overall resilience.

In essence this is an assessment of the residual risk to the Region-wide ecosystem, noting the items above. For this risk assessment, threats to natural values components are categorised as Region-wide or local based on the scale of the consequence. A threat may be happening in many places but when the consequence is considered, a threat is at Region-wide scale if the Region-wide ecosystem suffers, and at local scale alone if the consequence does not impact at the Region-wide scale. For example:

- Rising sea temperature happens over a very wide area and the Region-wide ecosystem as a whole suffers.
- Ship groundings may happen in many places but the Region-wide system as a whole does not suffer.

Risks to heritage values components were assessed at the scale that was appropriate to their occurrence rather than at a regional or local scale, resulting in a single consequence grade. For example, risks to historic lighthouses were considered based on the known extent of historic lighthouses in the region.

Likelihood	Expected frequency of a given threat
Almost certain	Expected to occur more or less continuously throughout a year
Likely	Not expected to be continuous but expected to occur one or more times in a year

Possible	Not expected to occur annually but expected to occur within a 10-year period
Unlikely	Not expected to occur in a 10-year period but expected to occur in a 100-year period
Rare	Not expected to occur within the next 100 years

Consequence	Scale at which the consequence of the threat operates	
	Region-wide scale	Local scale
Catastrophic	Impact is clearly affecting, or would clearly affect, the nature of the ecosystem over a wide area. Recovery periods greater than 20 years likely.	Impact is clearly affecting, or would clearly affect, the condition of the value in an extremely serious and irreversible manner. No meaningful recovery is likely, even over extended time periods.
Major	Impact is, or would be, significant at a wider level. Recovery periods of 10 to 20 years likely.	Impact is, or would be, extremely serious and possibly irreversible to a sensitive population or community. Condition of an affected part of the ecosystem possibly irretrievably compromised.
Moderate	Impact is, or would be, present at a wider level. Recovery periods of 5 to 10 years likely.	Impact is, or would be, extremely serious and possibly irreversible over a small area. Recovery periods of 10–20 years likely.
Minor	Impact is, or would be, not discernible at a wider level. Impact would not impair the overall condition of the ecosystem, including sensitive populations or communities, over a wider level.	Impact is, or would be, significant to a sensitive population or community at a local level. Recovery periods of 5–10 years likely.
Insignificant	No impact or if impact is, or would be, present then only to the extent that it has no discernible effect on the overall condition of the ecosystem at a wider scale.	No impact or if impact is, or would be, present then only to the extent that it has no discernible effect on the overall condition of the ecosystem.

Combining likelihood and consequence for overall risk

	Consequence				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic

Almost Certain	Low	Medium	High	Very High	Very High
Likely	Low	Medium	High	High	Very High
Possible	Low	Low	Medium	High	Very High
Unlikely	Low	Low	Low	Medium	High
Rare	Low	Low	Low	Medium	High

Appendix 3. Workshop participants

Name of participant in the room for the workshops
Troy Mallie
Carl Grant
Manuwuri Forester
Brenton Creed
Jason Ramsamy
Vincent Backhaus
Ariana Lambrides
Sean Ulm
Christie Berger
Andy Viduka
Maddy McAllister
Graham Hemson
Manuel Gonzalez Rivero
Sven Uthicke
Katharina Fabricius
Michaela Mitchell
Ian Jacobsen
Maria Vandergragt
Mike Ronan
Mark Hamann
Patrick Laffy
Scott Heron
Jane Waterhouse
Mardi McNeil
Angus Thompson
Guillermo Diaz-Pullido
Scott Smithers
Andrew Hoey

David Bourne
Tom Bridge
Matthew Nitscke
Juan Ortiz
Emma Camp
Mike Emslie
Daniela Ceccarelli
Catherine Collier
Len McKenzie
Severine Choukroun
Jennifer Donelson
Amos Mapleston
Andrew Chin
Ana Martins
Sue-Ann Watson
Helene Marsh
Taka Shimada

Name of participant supplying input before the workshops whose input was added by a proxy in the workshops
Peter Mumby
Grant Smith
Michael Rasheed

Appendix 4. Verbatim input from Day 1 session with traditional owners

As per the commitment to Traditional Owners on Day 1, the following are verbatim inclusions of comments made online. They are not edited or altered in any way.

My overall comments about improving the method are...

10 Responses

Broader representation of Traditional Owners and other Indigenous people involved in Sea Country. Pioneer new approach to recognize the holistic nature of Indigenous values. Avoid nature/culture dual

Agree with [redacted] about regional focus of engagement with TOs

Identify a process to discuss community priorities and needs then think through how those priorities and needs impact the health of the 4 heritage values through discussions with Traditional Owners

Broader representation of Traditional Owners and other Indigenous people involved in Sea Country. Pioneer new approach to recognize the holistic nature of Indigenous values. Avoid nature/culture dual

Broader engagement with all Traditional Owner communities with connections to the GBR. A complete overhaul of the process to reflect diversity of perspectives.

Is it worth having a few more meetings with TO s or TUMRA mob to get their views as well

Engage with more TOs to get a broader consenus regarding the grade and trends of the components.

More gbr traditional owners should be here...Its going to be hard getting representative opinion for all TOs with this outlook report...i understand your goal but doesn't make it any easier to get itdone

Technology is available for ease of interactions with Traditional Owner Groups to ensure Information is sourced thoroughly and effectively

The process needs to consider more than one sitting, it needs time to digest information, consider and provide a balanced view. consider locally/regionally paced-based views versus GBR wide responses

There are some caveats I think it is important are noted for this value assessment - Cultural values

11 Responses

It's problematic to separate Indigenous and Historic heritage, as much heritage is shared, particularly for the invasion period

Very hard to be representative for different TO groups and come to one conclusion

Ensuring each Traditional Owner Group speaks about their Country, as each Country is different from the other.

It can't be a blanket approach - CV means and can be interpreted differently by region, and urban/rural/remote settings. Cultural Authority needs to be considered. We can't talk or speak for others

Very challenging to get meaningful representation of TOs across the GBR. Structures like TUMRAs are excellent, but not representative.

I believe CV assessment will differ in different regions, so giving TOs an opportunity to voice concerns will help process

It can't be a blanket approach - CV means and can be interpreted differently by region, and urban/rural/remote settings. Cultural Authority needs to be considered. We can't talk or speak for others

Different TO groups will have different grades and trends for their country

The four heritage values should be able to adaptation and consider ways cultural continuity is navigated in the everyday through employment and training, digital interfaces knowledge sharing etc

People may be reluctant to grade good or very good as they perceive a link between grading and resources to improve their score next time

Needs to be a better mechanism for representing diverse knowleges in this space.

My general expert opinion about cultural values is OR Important new information to note - Cultural values

9 Responses

My expert opinion is that the condition across all of these arbitrary values is Poor. Sea Country condition continues to deteriorate owing to numerous factors.

For next time, looking at biocultural values could be a better way to go forward. Biocultural - biology + cultural values.

To make sure that All levels of Government are sharing Information and ensuring it evolves amd changes as we get new technology as well

As Indigenous Heritage is living heritage, Cultural Values grading needs to be adaptable to mitigate pressures of the day. This would be subject to TO's advice and consent (FPIC).

My general expert opinion about Cultural Values is that eacha nd every Traditional Owner Group has their own Voice around their Country, Land or Sea. Acknowledge that we are apart of the GBR

Difficult to generalise. Broadly the culutral values are not systematically known or identified as those conversations/engagement with Traditional Owners have not occurred across the whole Region.

Participation in Sea Country management activities is not equivalent to assessing the strength of knowledge reproduction. If senior knowledge holders are not engaged, knowledge reproduction is less

Look at land and sea country holistically not seperate

As a traditional owner I feel that we need to support the Reef TO groups more to help them better manage their values and build capacity to ensure they have a better voice to tell their story.

Other threats to cultural values
11 Responses

Inequity in access to funding/resources

Not following Free Prior and Informed Consent guidelines

Destruction of littorial and riparian revegetation programs connected to traditional knowledge language names of plant species Marine debris in coastal environments impacting story sites

Vast capacity gaps between GBR Traditional Owner communities.

Indigenous Cultural Intellectual Property

Research agenda set by scientists instead of working with TOs for their priority lists.

Material/samples taken from Country without authority threatens integrity of Country.

Inequities in access to opportunities to manage Sea Country (nations/groups/genders)

Traditional Owner Knowledge versus Modern / Social Science. Not engaging Traditional Owners early in the project I.e. co-designing from the outset. Treating TO's as Stakeholders and not as Partners,

Other threats to cultural values
11 Responses

Continuing with pursuit/reification of Nature/Culture dualism

Using legislation as a stop go for working well with TOs

Appendix 5. Visual representation of expert input – Menti results

The full visual representation of the expert input as seen in the Menti software at the workshops is available 'after Appendix 6 (due to page size differences).

Appendix 6. Details from the participant feedback

Narrative input from participants during the sessions

During the sessions various comments were made intended as feedback. Many were incorporated into the feedback in the Values or Risk sections above. If not, they are reported below.

- *The process should involve time to have discussion, time to think about it and digest it, and then vote as people coming to this for the first time.*

- *Important for this session (i.e., Indigenous culture) that voices were heard, and this was very positive.*

- *Could have more time for discussion – process means need to do it all in a day. Consider spreading it out to enable more time for discussion.*

- *Need to find a way to have Indigenous voice throughout all sessions in future.*

- *Expert voting in small groups is much better than having large group of experts and non-experts voting in a way that provided everyone with equal weighting.*

Two types of feedback questions were asked

There were five feedback questions only asked in the 2023 process. They were:

I felt my voice was heard
The facilitators were very good
This process to gather expert opinion was robust

If invited I would involve myself in a similar future process
This Menti online technology was helpful for the process

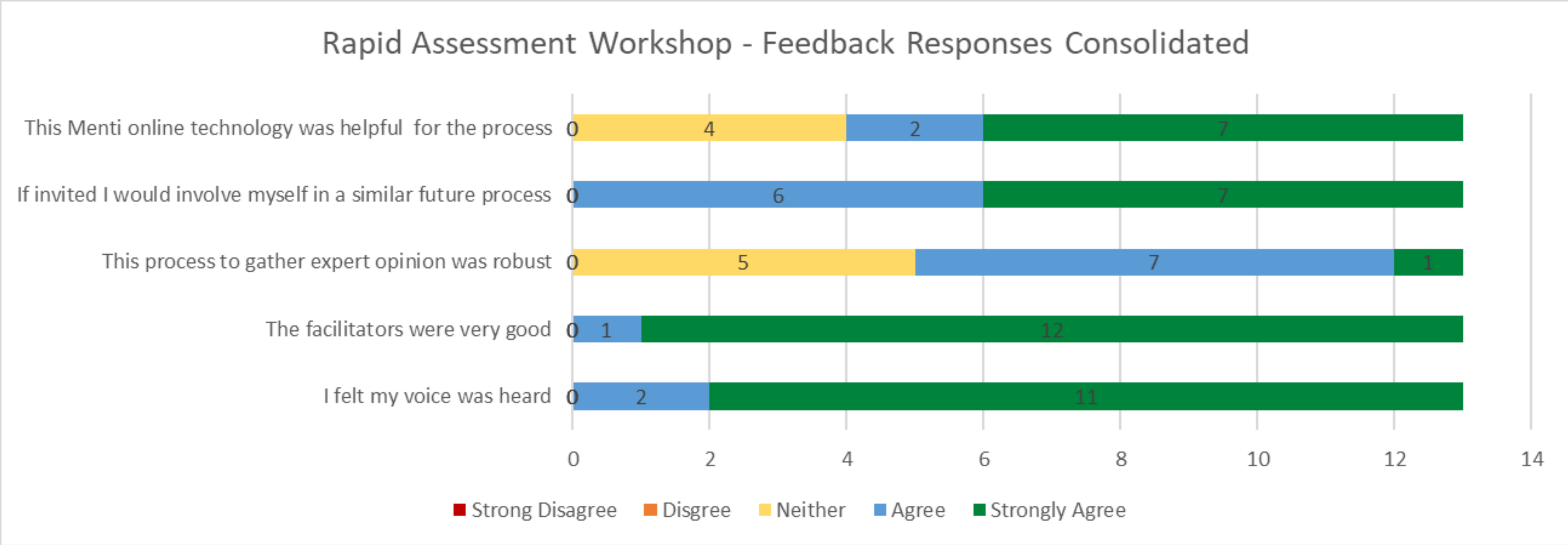
There were eight feedback questions that have been asked with very little change since the 2014 Rapid Expert Assessment process. Only minor changes to wording to make them grammatically clearer were made in 2019. In 2023 the 2019 updated questions were used. They were:

The structure of the questions was correctly framed to allow expert opinion to be polled appropriately
My inputs to the workshop consensus process were able to be fully recognised and incorporated
The workshop process was transparent, and potential bias was adequately managed
The workshop process provided an appropriate mechanism for securing a broad consensus of expert opinion
Arrangements to resolve any persisting disagreements amongst the experts seem appropriate
The logistics, the facilitator and the venue arrangements were appropriate to enable an effective workshop
In general, I support the process and the outcomes
I expect that the outcomes provide a robust basis for Outlook 2024

Results from both questions are included below first for the Natural Values Components, followed by the Risk Assessment.

2023 Feedback Questions

Natural Values Components

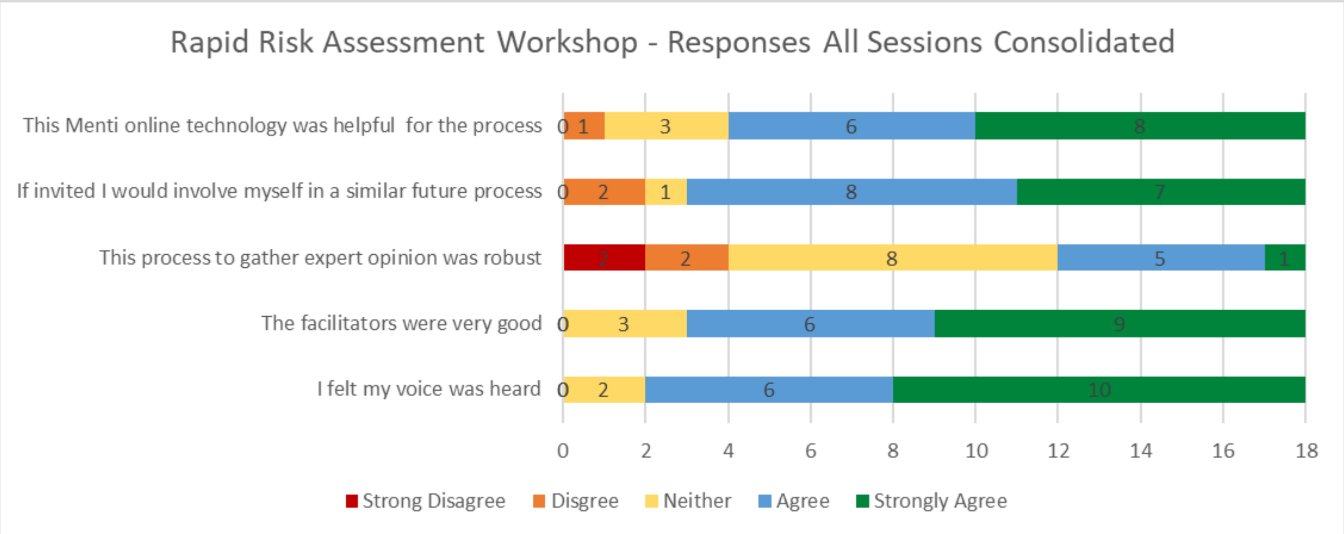


Questions	Weighted average / 5	Level of Agreement
I felt my voice was heard	4.9	Agree – Strongly Agree
The facilitators were very good	4.9	Agree – Strongly Agree
This process to gather expert opinion was robust	3.7	Neither agree nor disagree
If invited I would involve myself in a similar future process	4.6	Agree – Strongly Agree
This Menti online technology was helpful for the process	4.2	Agree

Interpretation

Most participants felt their voice was heard, would be involved in a future similar process and agreed the facilitation was very good. Most found the online technology used (Menti) was helpful for the process. Consistent with the views expressed by experts about the robustness and repeatability of the rapid expert process that were reported in the body of the document, there was agreement and some ambivalence, but not strong agreement with the proposition that the process was robust.

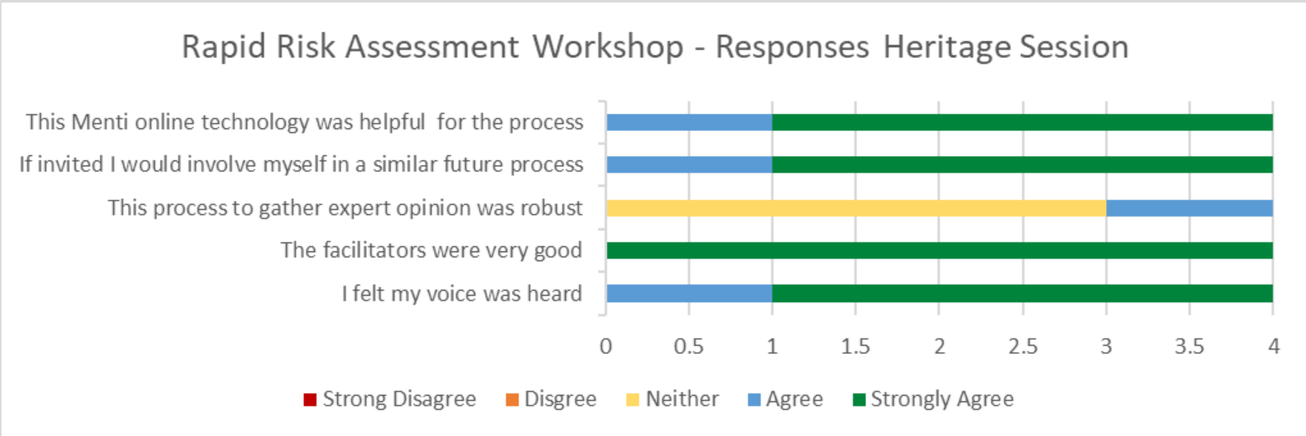
Risk Assessment

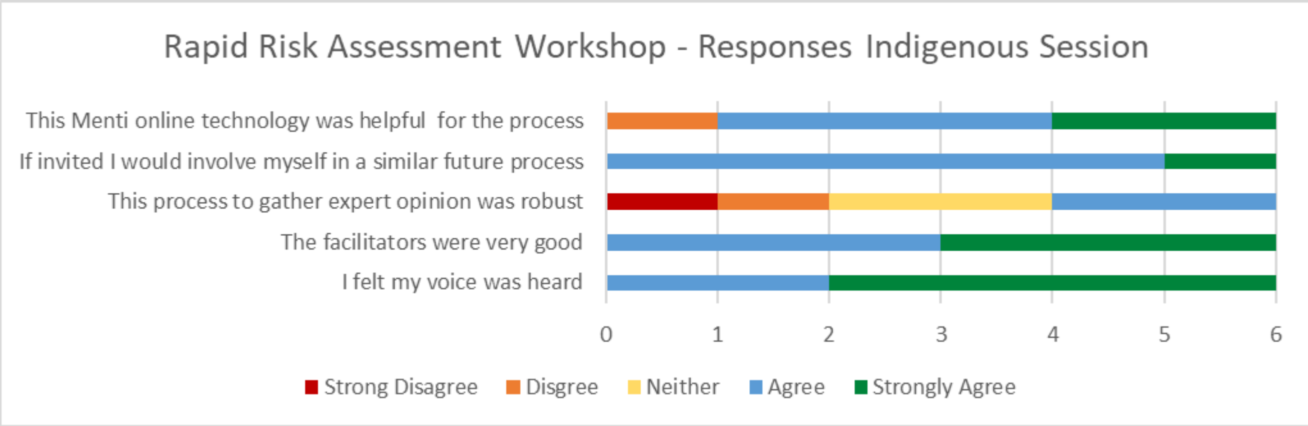


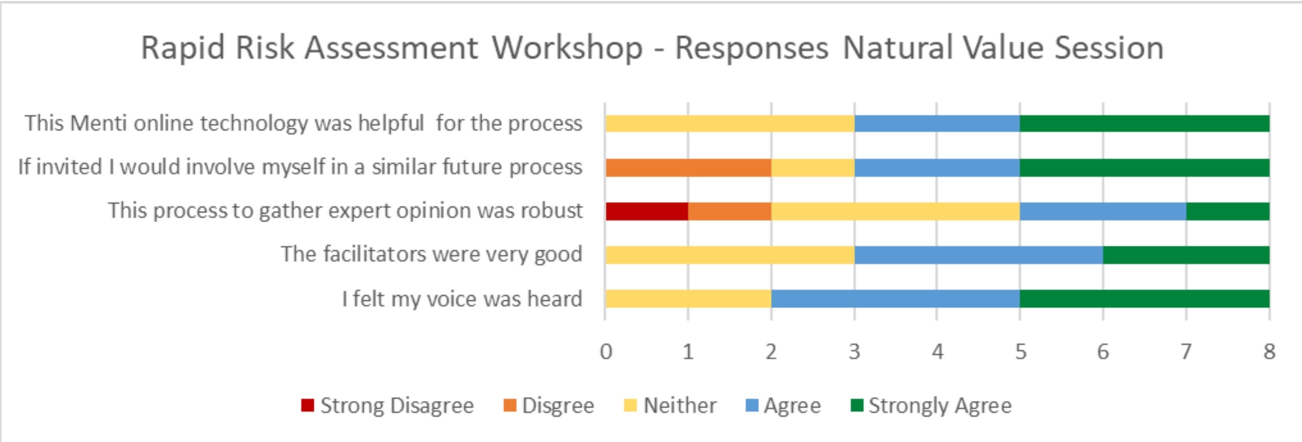
Questions	Weighted average / 5	Level of Agreement
I felt my voice was heard	4.5	Agree – Strongly Agree

The facilitators were very good	4.5	Agree – Strongly Agree
This process to gather expert opinion was robust	3.1	Neither agree nor disagree
If invited I would involve myself in a similar future process	4.2	Agree
This Menti online technology was helpful for the process	4.3	Agree

These data can be broken down into the sessions with specific expertise.





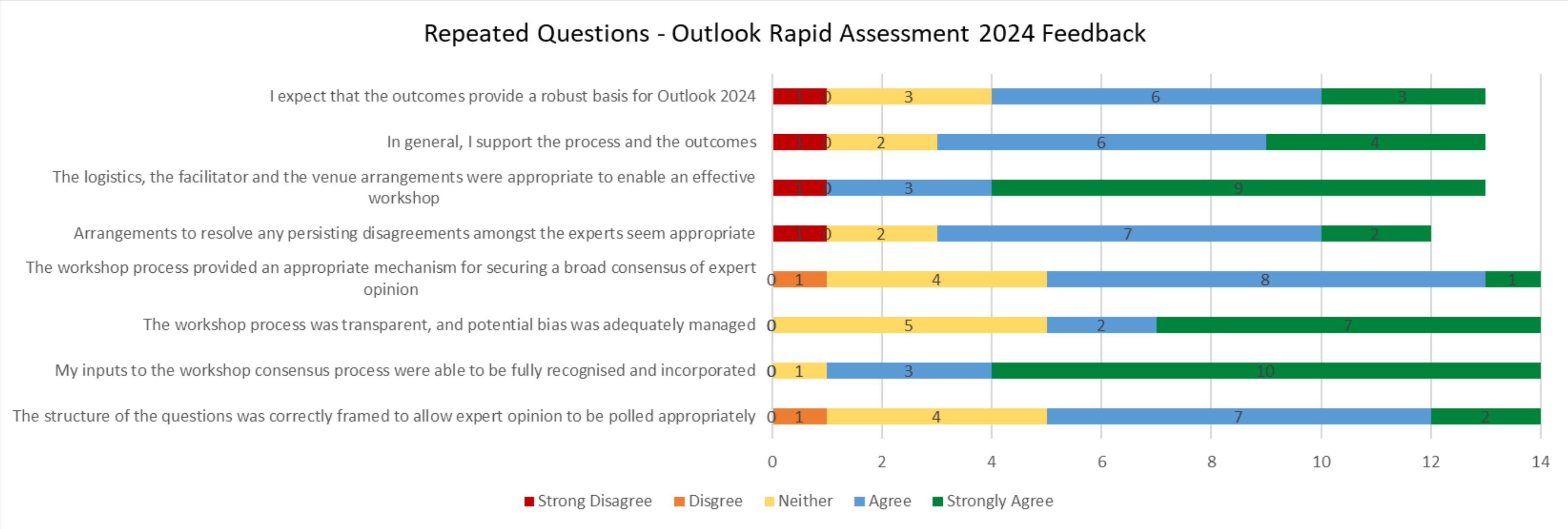


Interpretation

For the risk assessment process, while there was mostly strong agreement that the experts felt heard and the facilitation was very good, there was a mixed view about the online technology, if experts would involve themselves in a future similar process and if the process was robust. Breaking down the workshops into the content areas, it is clear that the indigenous and natural values experts were least comfortable with the process. While there was some support for the process, there was the full range of opinion with some strong disagreement as well as agreement. This pattern of comfort (and lack of comfort) is consistent with the direct expert feedback captured in the body of the document.

Repeated Questions asked in Outlook Expert Rapid Assessment workshop over time

Natural Values Components



Questions	Weighted average / 5	Level of Agreement
The structure of the questions was correctly framed to allow expert opinion to be polled appropriately	3.7	Neither agree nor disagree
My inputs to the workshop consensus process were able to be fully recognised and incorporated	4.7	Agree – Strongly Agree

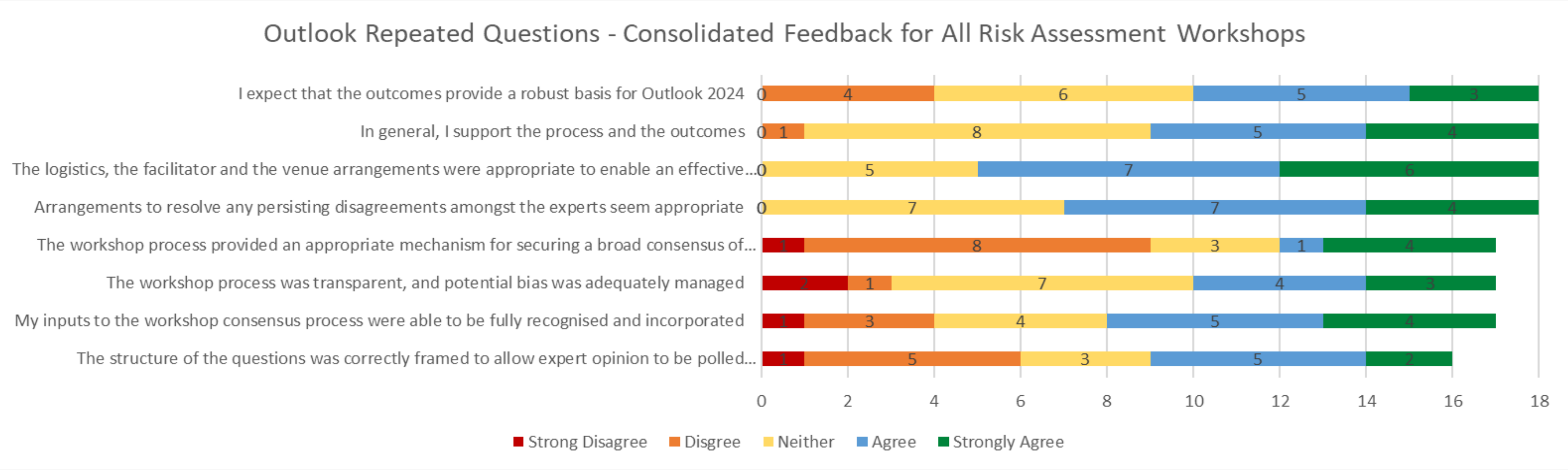
The workshop process was transparent, and potential bias was adequately managed	4.2	Agree
The workshop process provided an appropriate mechanism for securing a broad consensus of expert opinion	3.7	Neither agree nor disagree
Arrangements to resolve any persisting disagreements amongst the experts seem appropriate	3.7	Neither agree nor disagree
The logistics, the facilitator and the venue arrangements were appropriate to enable an effective workshop	4.5	Agree – Strongly Agree
In general, I support the process and the outcomes	4.0	Agree
I expect that the outcomes provide a robust basis for Outlook 2024	3.8	Neither agree nor disagree

Interpretation

Interestingly for the questions that have been asked repeatedly over time (for the 2014, 2019 and now 2024 Outlook Reports), there was a more diverse range of responses than for the questions asked in 2023 alone. For some questions there was the full range of views from strong agreement that the process provided a robust basis for the 2024 Outlook Report through to strong disagreement that it did. The weighted average was closer to *Neither agree nor disagree*, with a slight bias to agreement. Other questions however were more consistent and clear in their response; for example when asked if '*My inputs to the workshop consensus process were able to be fully recognised and incorporated',* most participants strongly agreed. In general most agreed (or strongly agreed) with the statement '*In general, I support the process and the outcomes.'*

By asking the question about expert comfort with the group result for the values gradings and trend assessments, much insight was gathered about where any discomfort in the process lay. That discussion is captured in the body of this report under the different sections and should be used by future facilitators to consider addressing in any design changes made for the Expert rapid assessment process for the Outlook Report 2029.

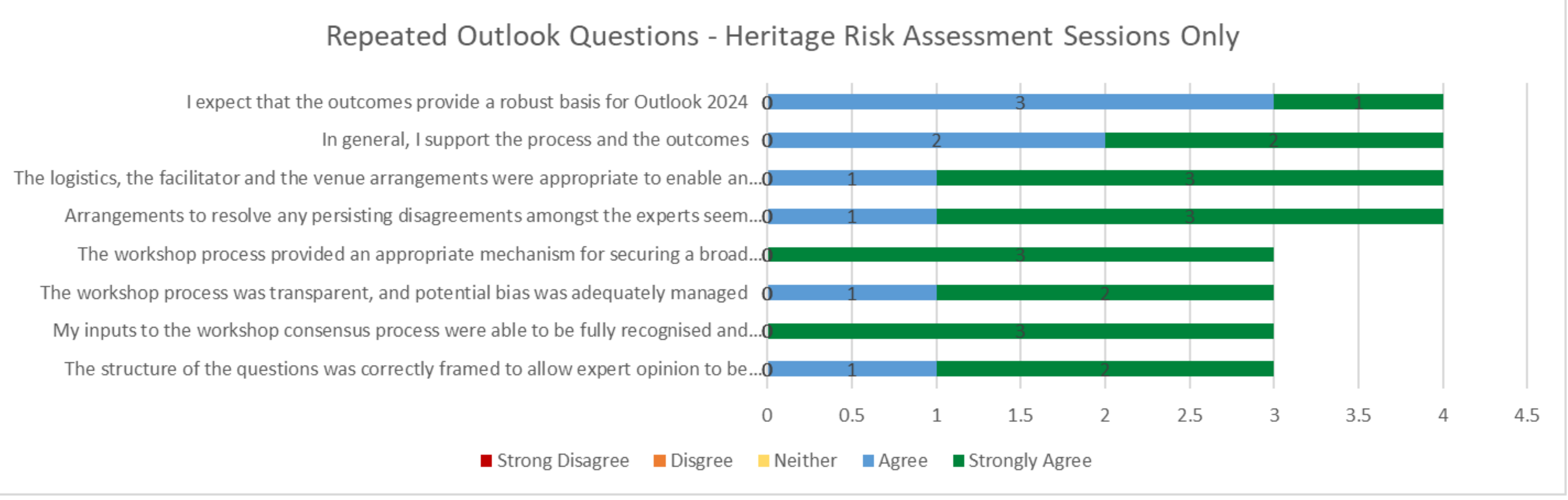
Risk Assessment

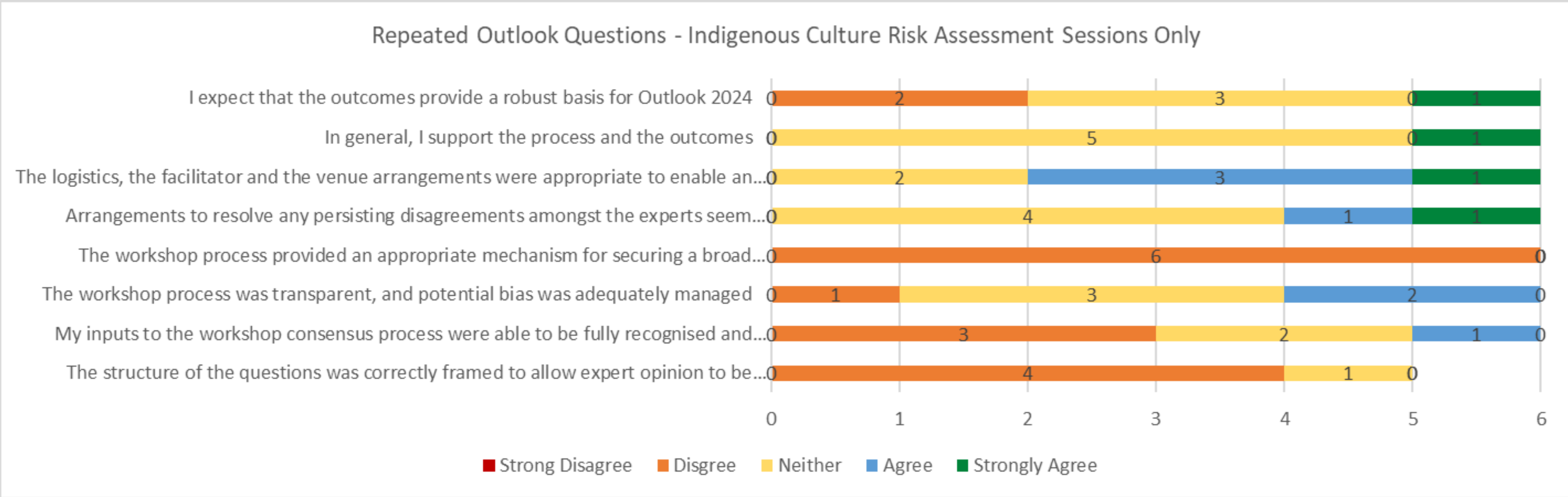


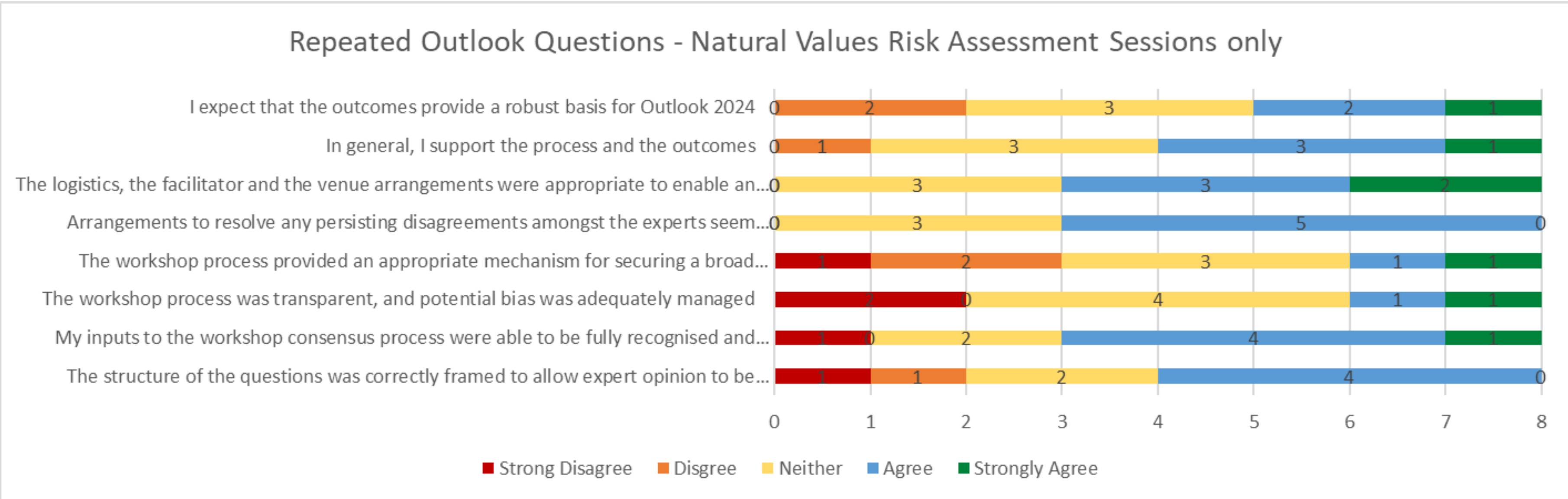
Questions	Weighted average / 5	Level of Agreement
The structure of the questions was correctly framed to allow expert opinion to be polled appropriately	3.0	Neither agree nor disagree – Disagree
My inputs to the workshop consensus process were able to be fully recognised and incorporated	3.4	Neither agree nor disagree
The workshop process was transparent, and potential bias was adequately managed	3.3	Neither agree nor disagree
The workshop process provided an appropriate mechanism for securing a broad consensus of expert opinion	3.0	Neither agree nor disagree – Disagree

Arrangements to resolve any persisting disagreements amongst the experts seem appropriate	4.0	Agree
The logistics, the facilitator and the venue arrangements were appropriate to enable an effective workshop	4.2	Agree
In general, I support the process and the outcomes	3.8	Neither agree nor disagree
I expect that the outcomes provide a robust basis for Outlook 2024	3.5	Neither agree nor disagree

These data can be broken down into the sessions with specific expertise.




Repeated Outlook Questions - Indigenous Culture Risk Assessment Sessions Only
I expect that the outcomes provide a robust basis for Outlook 2024
In general, I support the process and the outcomes
The logistics, the facilitator and the venue arrangements were appropriate to enable an...
Arrangements to resolve any persisting disagreements amongst the experts seem...
The workshop process provided an appropriate mechanism for securing a broad...
The workshop process was transparent, and potential bias was adequately managed
My inputs to the workshop consensus process were able to be fully recognised and...
The structure of the questions was correctly framed to allow expert opinion to be...
0 2 3 0 1
0 5 0 1
0 2 3 1
0 4 1 1
0 6 0
0 1 3 2 0
0 3 2 1 0
0 4 1 0
0 1 2 3 4 5 6
Strong Disagree
Disgree
Neither
Agree
Strongly Agree


Repeated Outlook Questions - Natural Values Risk Assessment Sessions only
I expect that the outcomes provide a robust basis for Outlook 2024
In general, I support the process and the outcomes
The logistics, the facilitator and the venue arrangements were appropriate to enable an...
Arrangements to resolve any persisting disagreements amongst the experts seem...
The workshop process provided an appropriate mechanism for securing a broad...
The workshop process was transparent, and potential bias was adequately managed
My inputs to the workshop consensus process were able to be fully recognised and...
The structure of the questions was correctly framed to allow expert opinion to be...
0 2 3 2 1
0 1 3 3 1
0 3 3 2
0 3 5 0
1 2 3 1 1
2 0 4 1 1
1 0 2 4 1
1 1 2 4 0
0 1 2 3 4 5 6 7 8
Strong Disagree
Disgree
Neither
Agree
Strongly Agree

Interpretation

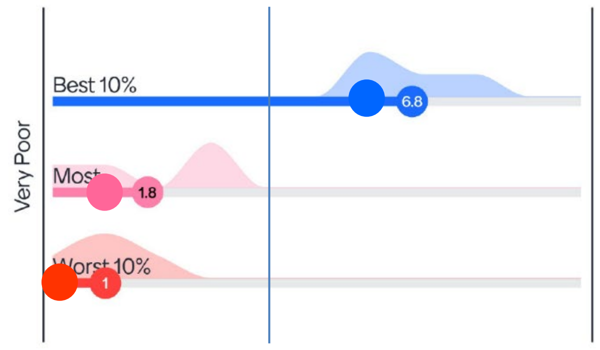
Similar to the questions asked in 2023, it is clear that the Indigenous and natural values experts were least comfortable with the process. Some disagreed that it was robust or transparent. For other questions, while there was some support for the facilitation and venue, there was the full range of opinion with some strong disagreement and disagreement about the risk assessment process. This is detailed well in the body of the document in the Risk Assessment questions and partially underlies the comments made in the methods about insights to consider for updating the Risk Assessment process for the next Outlook Report (2029). The patterns seen in response to these repeated questions align strongly with the direct expert feedback captured in the body of the document.

APPENDIX 5 - VISUAL REPRESENTATION OF EXPERT INPUT

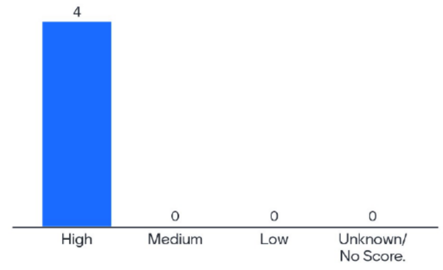
DAY ONE: HISTORIC HERITAGE VALUES ASSESSMENTS

Historic voyages and shipwrecks

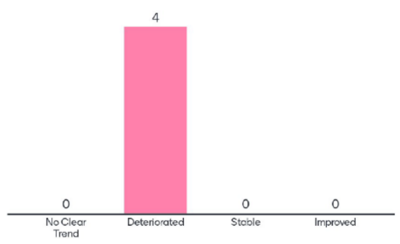
Vote 2: Condition of Component - Historic voyages



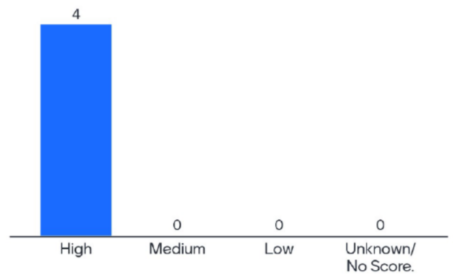
Vote 2: Confidence in Condition of Component - Historic voyages



Vote 2: Trend for Component - Historic voyages



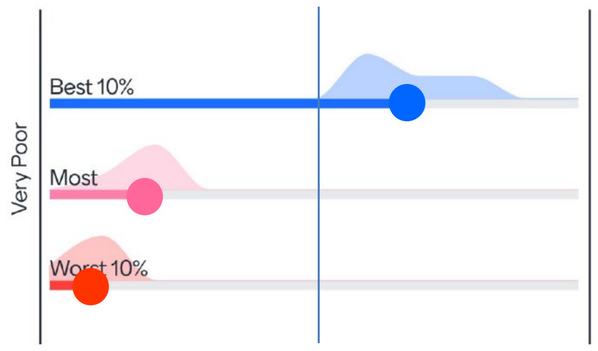
Vote 2: Confidence in Trend of Component - Historic voyages



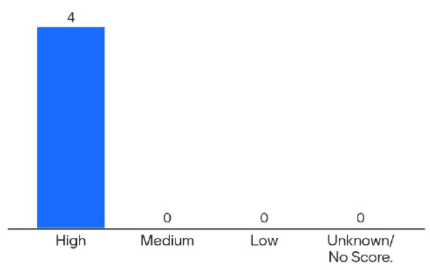
Historic lightstations

World War II features and sites

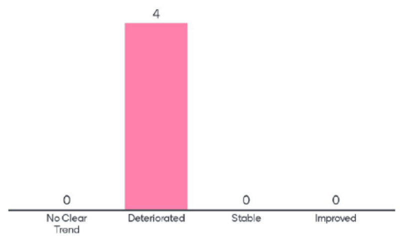
Vote 2: Condition of Component - WWII features



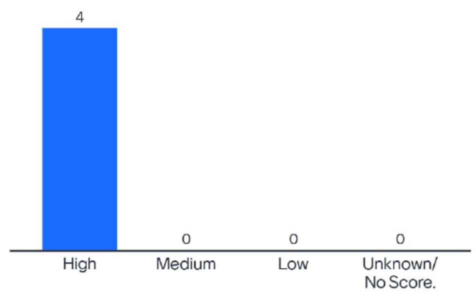
Vote 2: Confidence in Condition of Component - WWII features



Vote 2: Trend for Component - WWII features

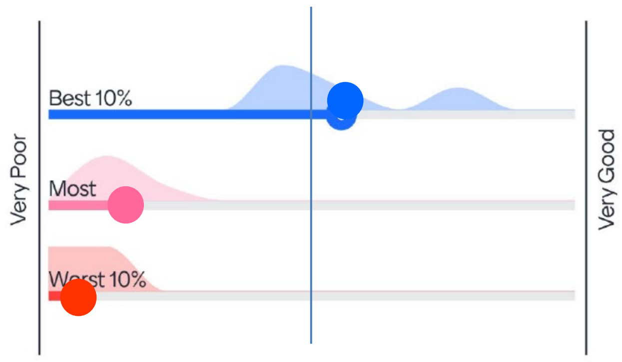


Vote 2: Confidence in Trend of Component - WWII features

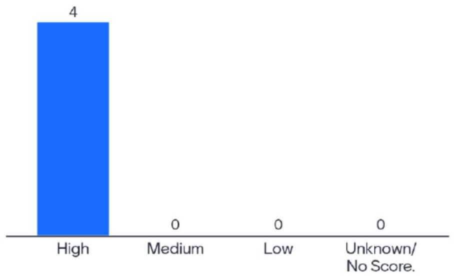


Other places of historic significance

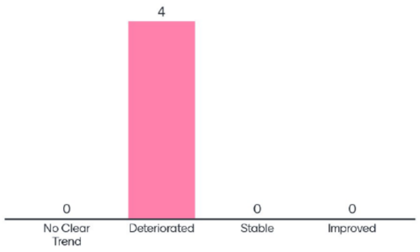
Vote 2: Condition of Component - Other significant places



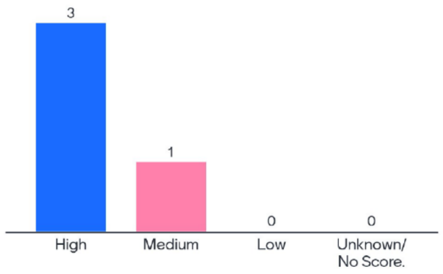
Vote 2: Confidence in Condition of Component - Other significant places



Vote 2: Trend for Component - Other significant places



Vote 2: Confidence in Trend of Component - Other significant places

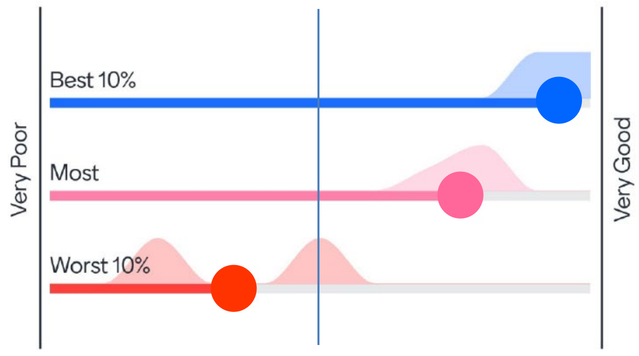


DAYS TWO TO FIVE: NATURAL VALUES ASSESSMENT (BIODIVERSITY AND ECOSYSTEM HEALTH)

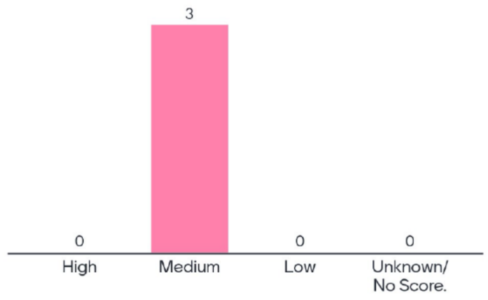
Biodiversity: habitats

Mangrove forests

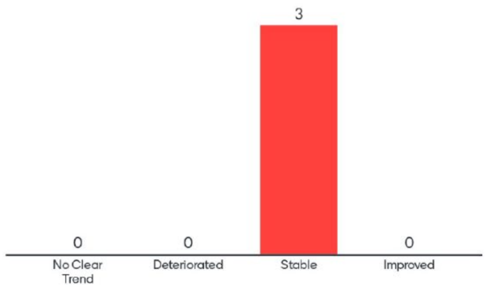
Vote 2: Condition of Component - Mangrove forests



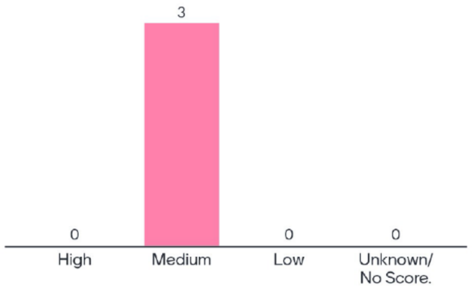
Vote 2: Confidence in Condition of Component - Mangrove forests



Vote 2: Trend for Component - Mangrove forests

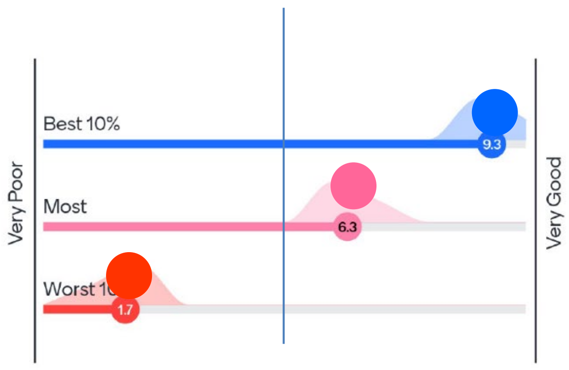


Vote 2: Confidence in Trend of Component - Mangrove forests

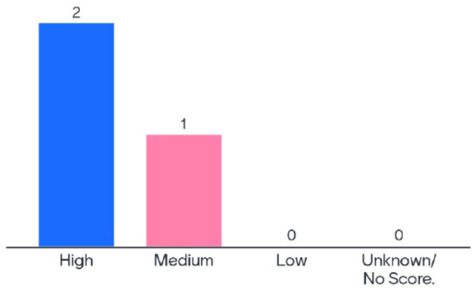


Seagrass meadows

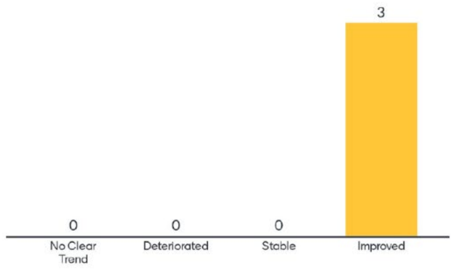
Vote 2: Condition of Component - Seagrass meadows



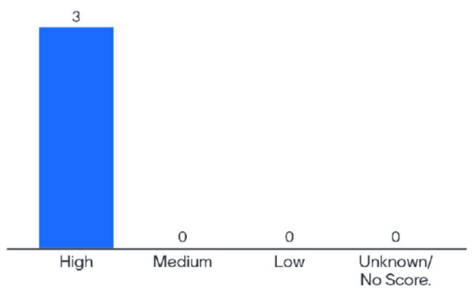
Vote 2: Confidence in Condition of Component - Seagrass meadows



Vote 2: Trend for Component - Seagrass meadows



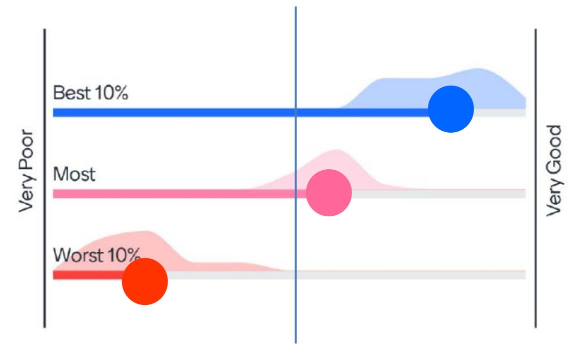
Vote 2: Confidence in Trend of Component - Seagrass meadows



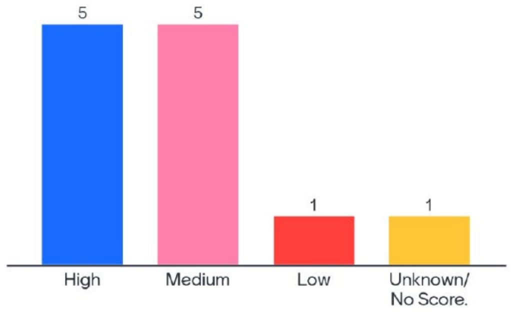
Coral reefs

Coral reefs: Northern

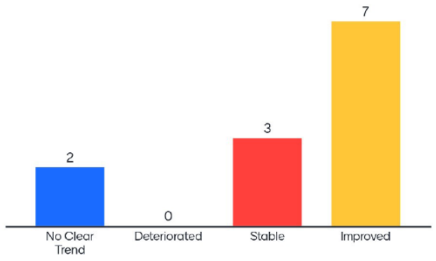
Vote 2: Condition of Component - Coral reefs Northern Region



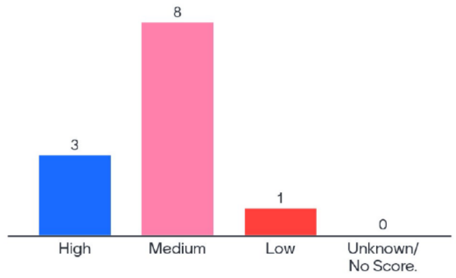
Vote 2: Confidence in Condition of Component - Coral reefs Northern Region



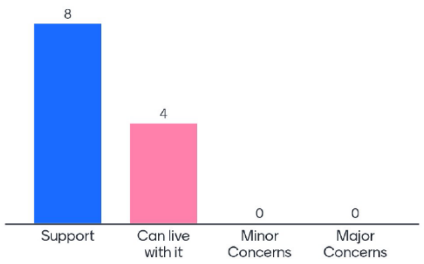
Vote 2: Trend for Component - Coral reefs Northern Region



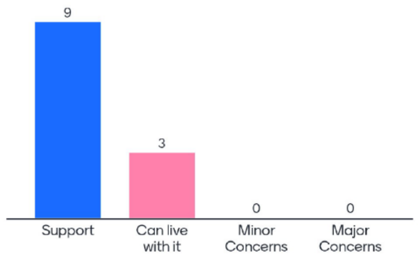
Vote 2: Confidence in Trend of Component - Coral reefs Northern Region



My overall comfort level with Condition Trend Consensus for component - Coral reefs Northern Region

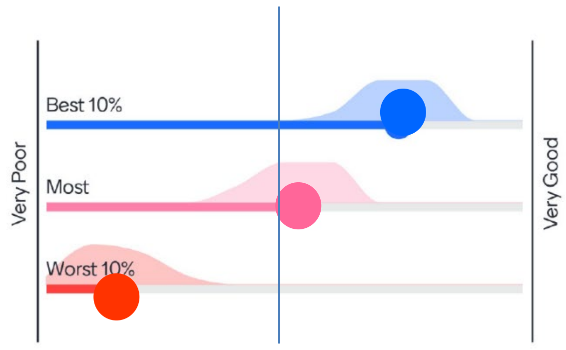


My overall comfort level with Trend Consensus for component - Coral reefs Northern Region

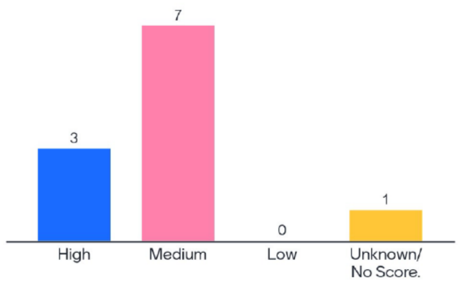


Coral reefs: Central

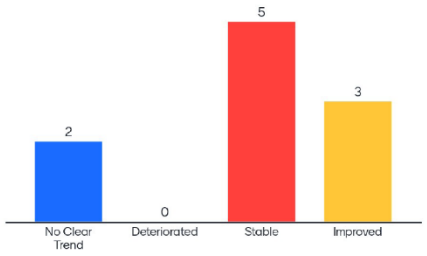
Vote 2: Condition of Component - Coral reefs Central Region



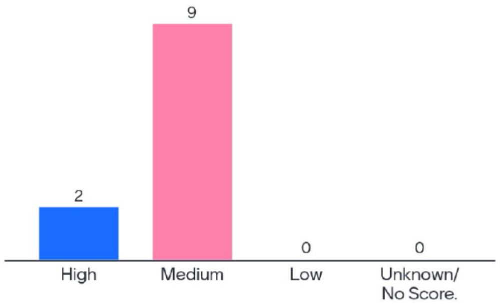
Vote 2: Confidence in Condition of Component - Coral reefs Central Region



Vote 2: Trend for Component - Coral reefs Central Region

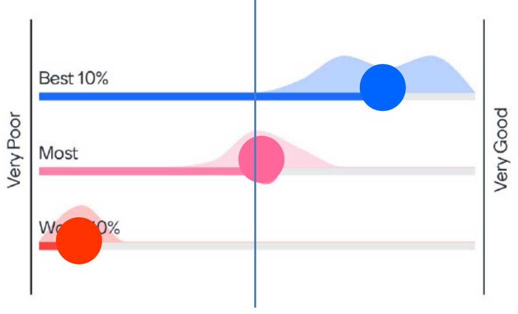


Vote 2: Confidence in Trend of Component - Coral reefs Central Region

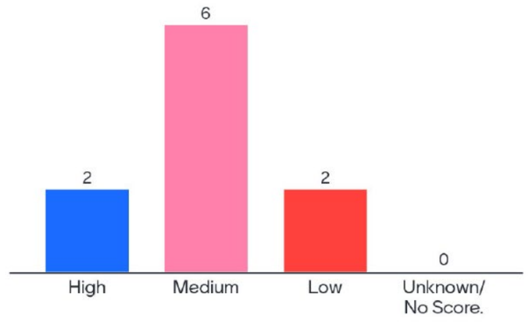


Coral reefs: Southern

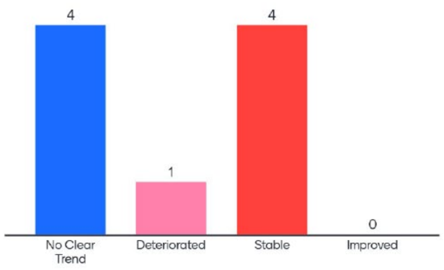
Vote 2: Condition of Component - Coral reefs Southern Region



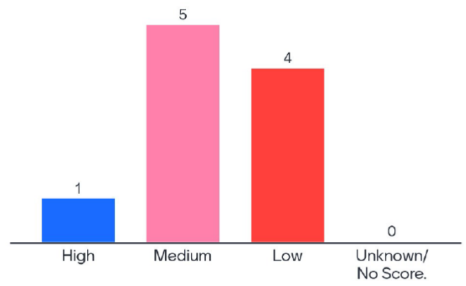
Vote 2: Confidence in Condition of Component - Coral reefs Southern Region



Vote 2: Trend for Component - Coral reefs Southern Region

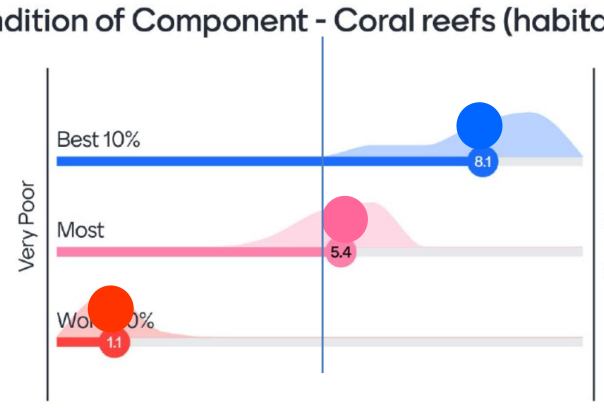


Vote 2: Confidence in Trend of Component - Coral reefs Southern Region

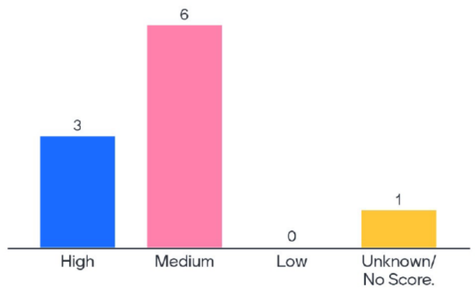


Coral reefs: Region

Vote 2: Condition of Component - Coral reefs (habitat)

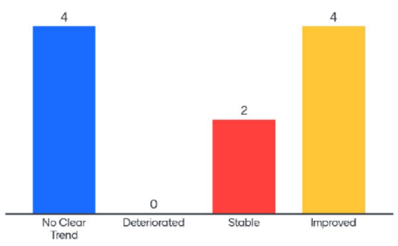


Vote 2: Confidence in Condition of Component - Coral reefs (habitat)

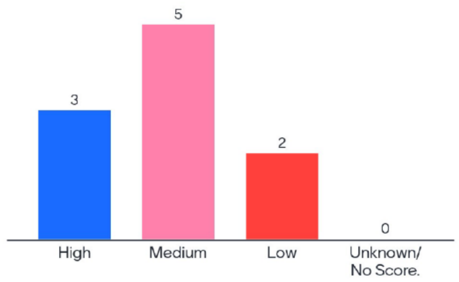


Condition

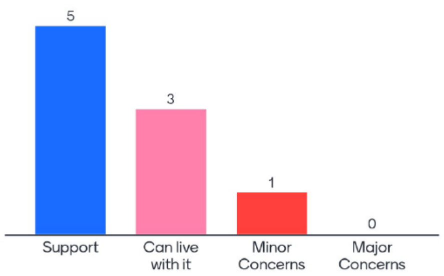
Vote 2: Trend for Component - Coral reefs (habitat)



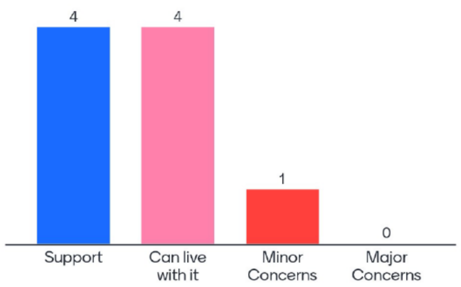
Vote 2: Confidence in Trend of Component - Coral reefs (habitat)



My overall comfort level with Condition Trend Consensus for component - Coral reefs (habitat)

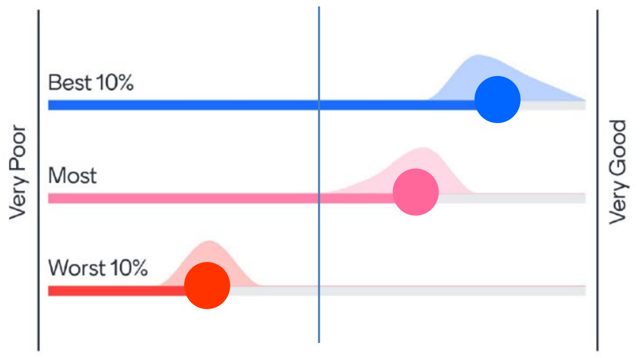


My overall comfort level with Trend Consensus for component - Coral reefs (habitat)

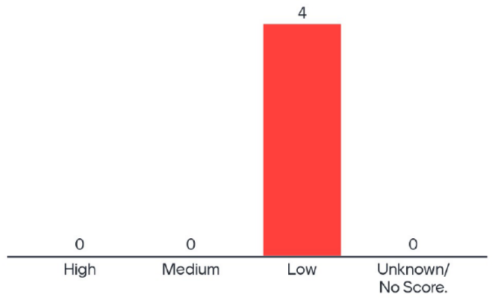


Halimeda banks

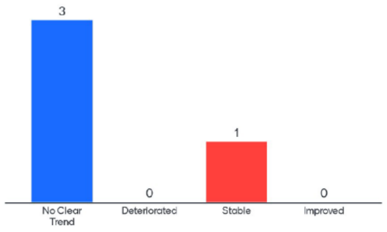
Vote 2: Condition of Component - *Halimeda* banks



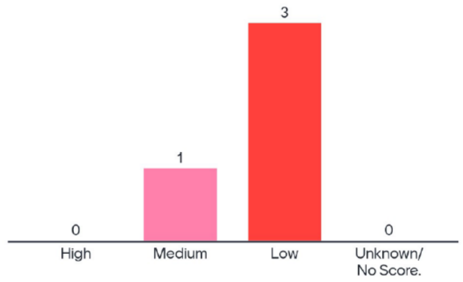
Vote 2: Confidence in Condition of Component - *Halimeda* banks



Vote 2: Trend for Component - *Halimeda* banks



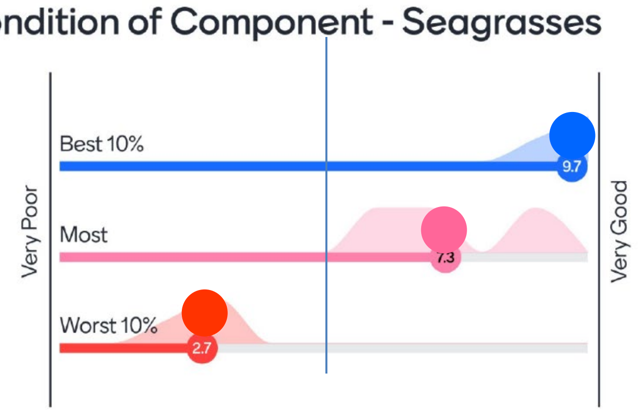
Vote 2: Confidence in Trend of Component - *Halimeda* banks



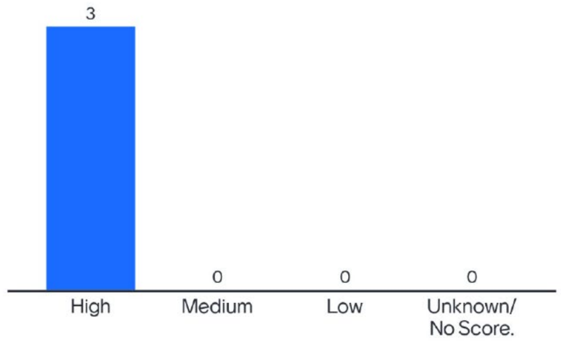
Biodiversity: species

Seagrasses

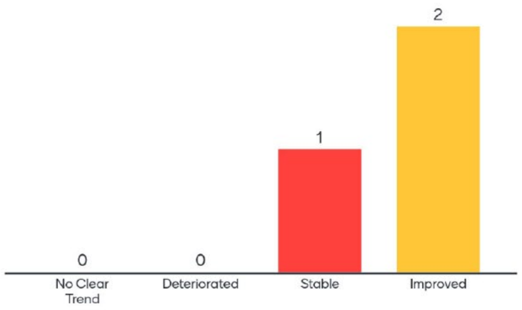
Vote 2: Condition of Component - Seagrasses



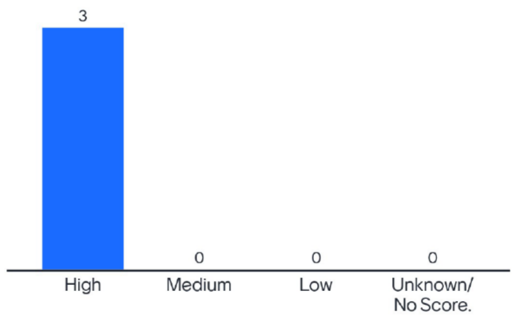
Vote 2: Confidence in Condition of Component - Seagrasses



Vote 2: Trend for Component - Seagrasses

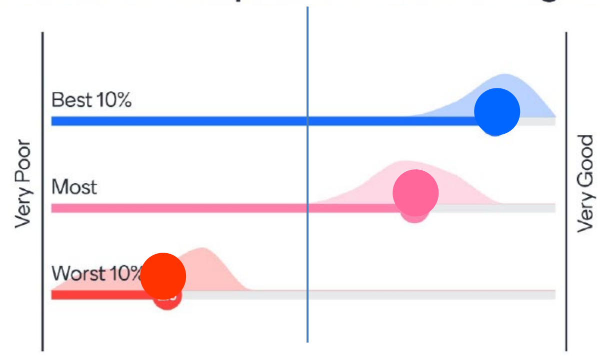


Vote 2: Confidence in Trend of Component - Seagrasses

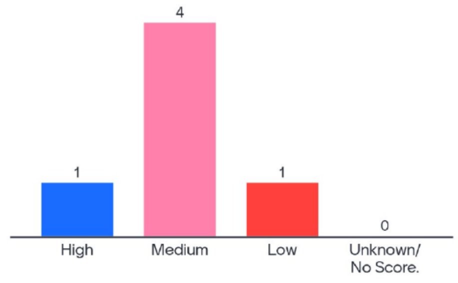


Benthic algae

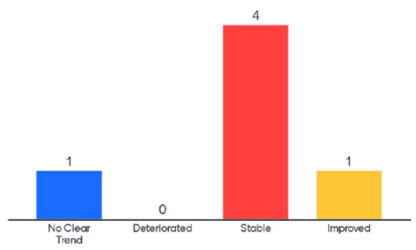
Vote 2: Condition of Component - Benthic algae



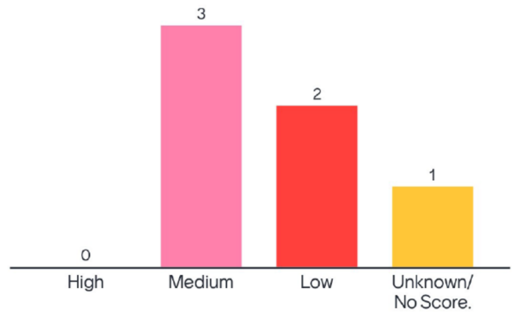
Vote 2: Confidence in Condition of Component - Benthic algae



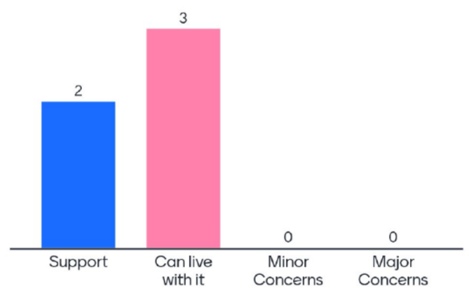
Vote 2: Trend for Component - Benthic algae



Vote 2: Confidence in Trend of Component - Benthic algae

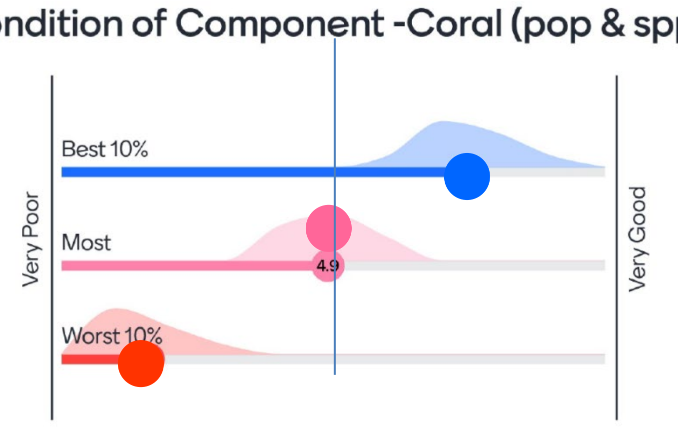


My overall comfort level with Condition Consensus for component - Benthic algae

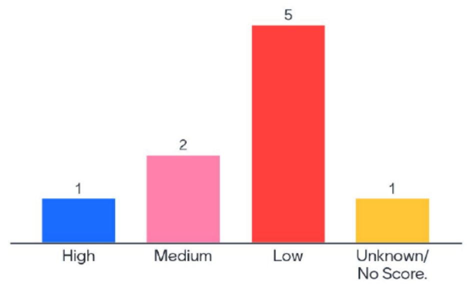


Corals

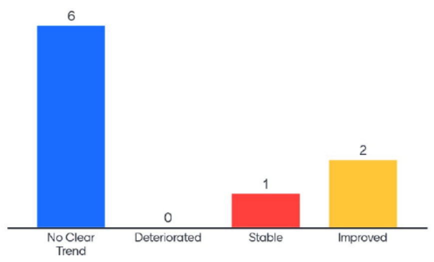
Vote 2: Condition of Component -Coral (pop & spp)



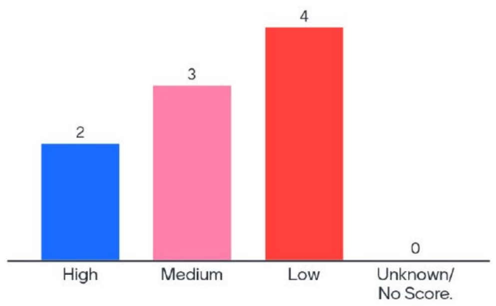
Vote 2: Confidence in Condition of Component - Corals (Pop and species)



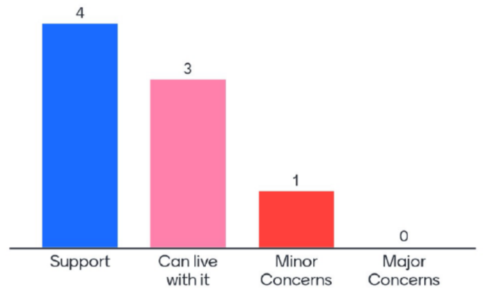
Vote 2: Trend for Component - Corals (Pop and species)



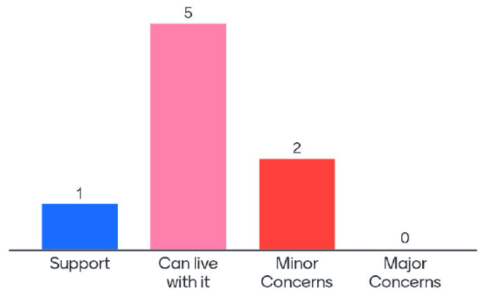
Vote 2: Confidence in Trend of Component - Corals (Pop and species)



My overall comfort level with Condition Consensus for component - Corals (Pop and species)

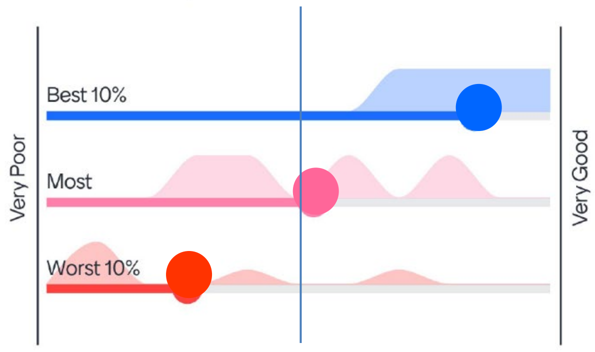


My overall comfort level with Trend Consensus for component - Corals (Pop and species)

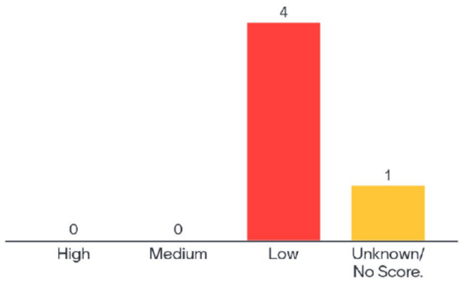


Other invertebrates

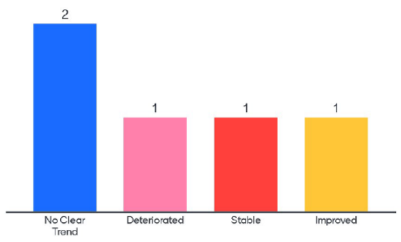
Vote 2: Condition of Component - Other invertebrates



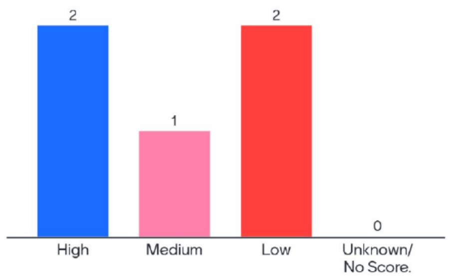
Vote 2: Confidence in Condition of Component - Other invertebrates



Vote 2: Trend for Component - Other invertebrates

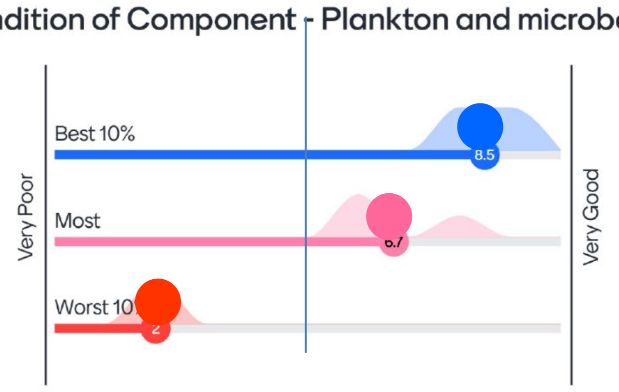


Vote 2: Confidence in Trend of Component - Other invertebrates

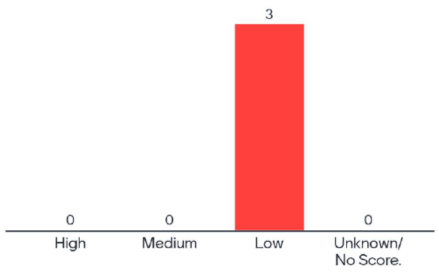


Plankton and microbes

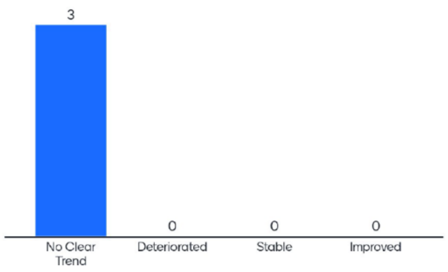
Vote 2: Condition of Component - Plankton and microbes



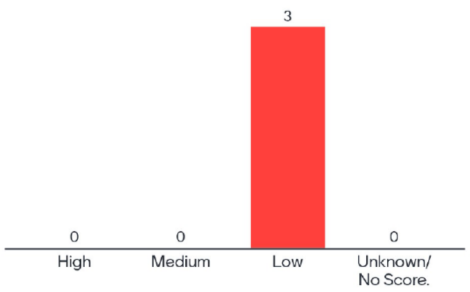
Vote 2: Confidence in Condition of Component - Plankton and microbes



Vote 2: Trend for Component - Plankton and microbes

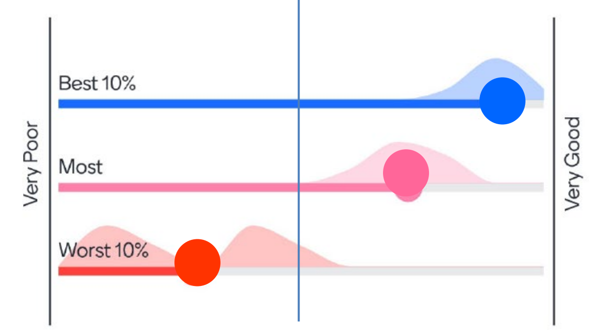


Vote 2: Confidence in Trend of Component - Plankton and microbes

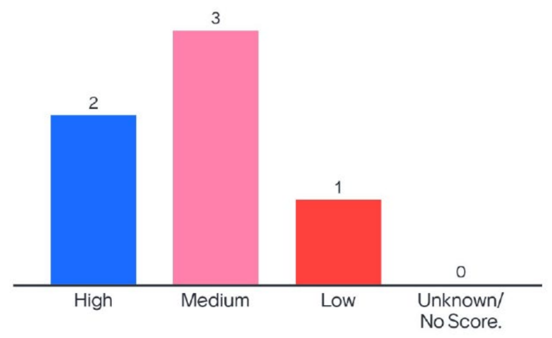


Bony fishes

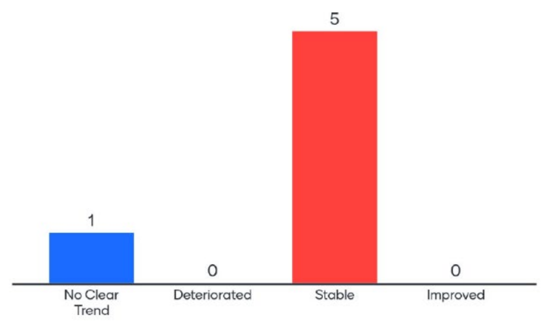
Vote 2: Condition of Component -Bony Fishes



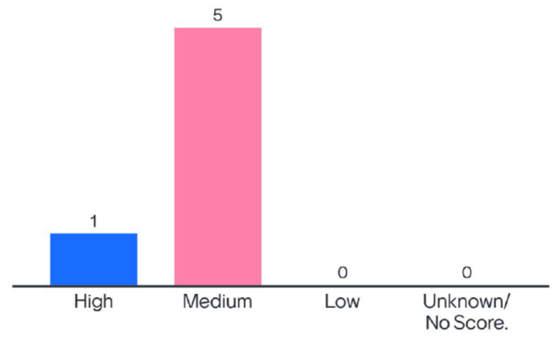
Vote 2: Confidence in Condition of Component - Bony fishes



Vote 2: Trend for Component - Bony fishes

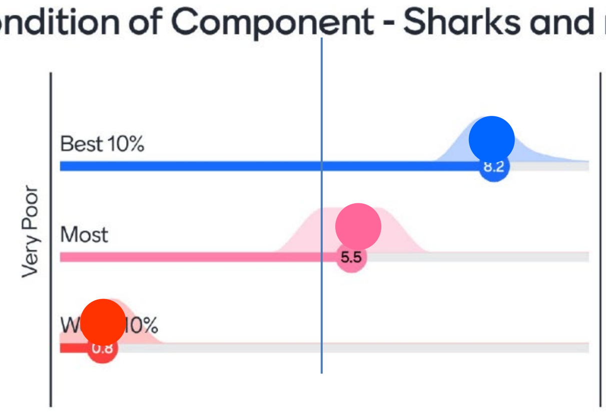


Vote 2: Confidence in Trend of Component - Bony fishes

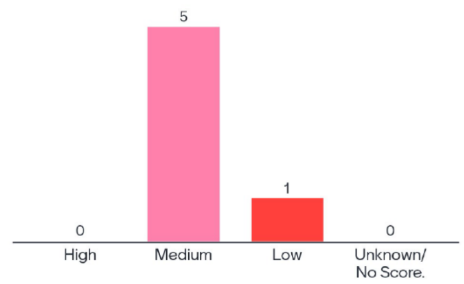


Sharks and rays

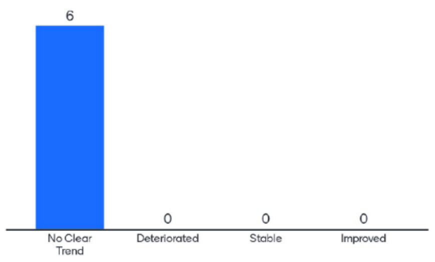
Vote 2: Condition of Component - Sharks and rays



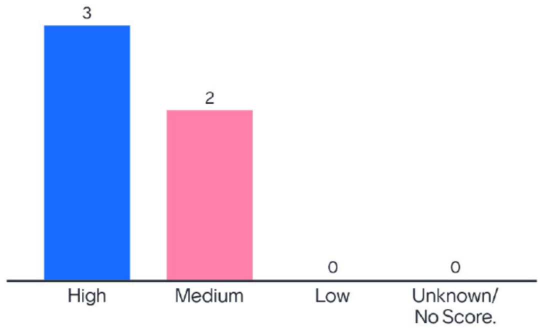
Vote 2: Confidence in Condition of Component - Sharks and rays



Vote 2: Trend for Component - Sharks and rays

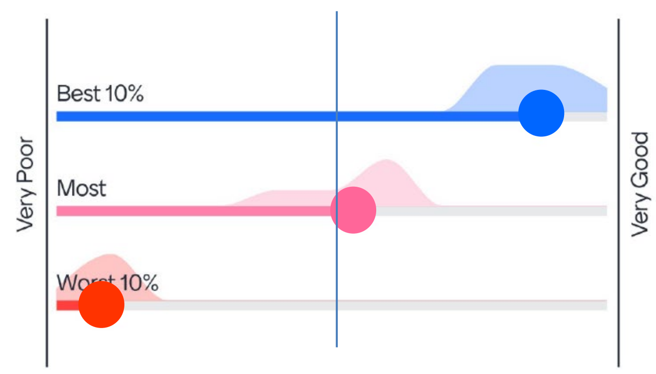


Vote 2: Confidence in Trend of Component - Sharks and rays

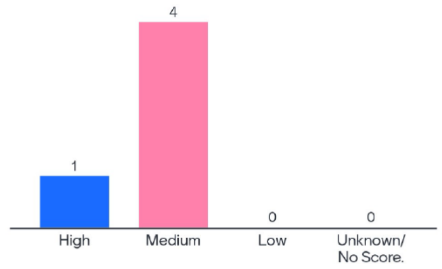


Sediment exposure

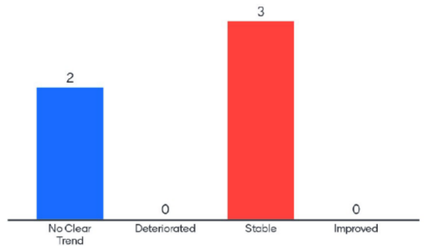
Vote 2: Condition of Component - Sediment exposure



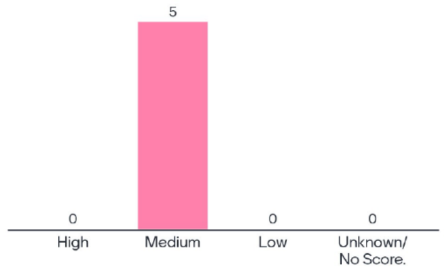
Vote 2: Confidence in Condition of Component - Sediment exposure



Vote 2: Trend for Component - Sediment exposure

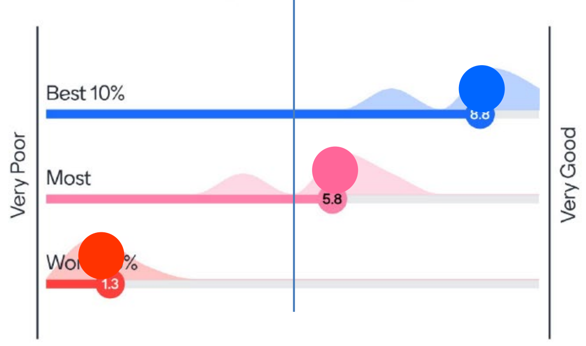


Vote 2: Confidence in Trend of Component - Sediment exposure

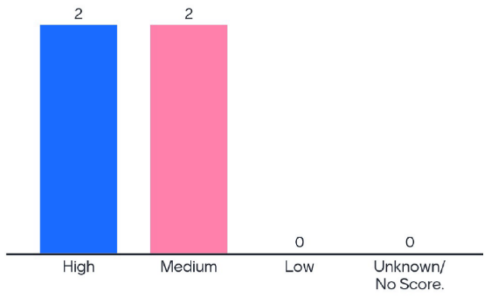


Light

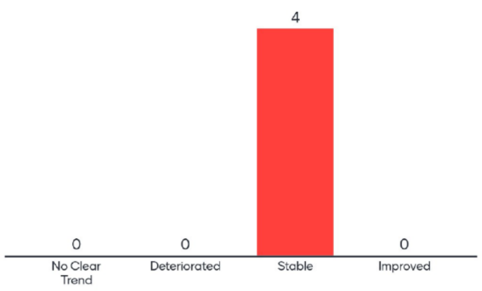
Vote 2: Condition of Component - Light



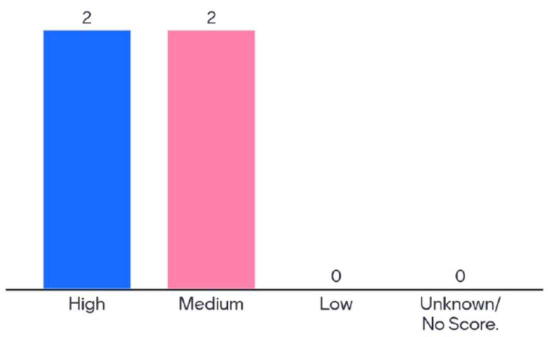
Vote 2: Confidence in Condition of Component - Light



Vote 2: Trend for Component - Light

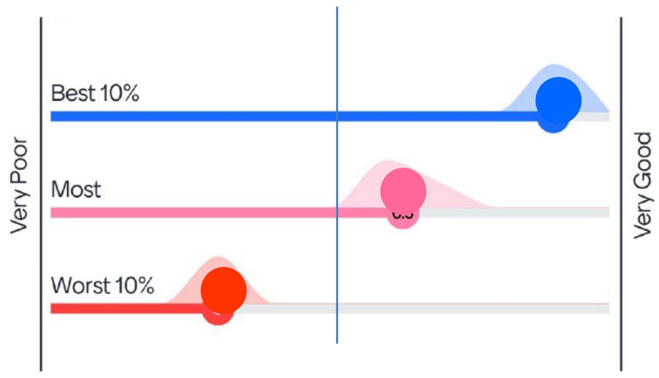


Vote 2: Confidence in Trend of Component - Light

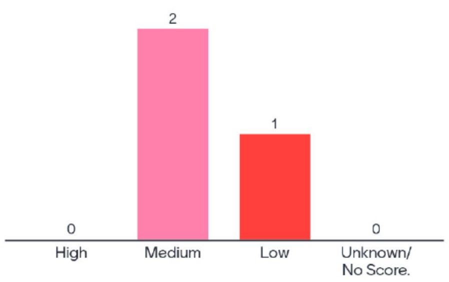


Microbial processes

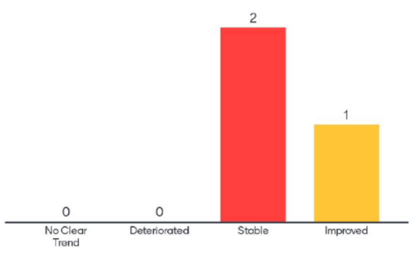
Vote 2: Condition of Component - Microbial Processes



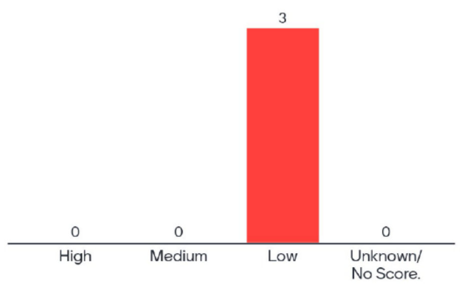
Vote 2: Confidence in Condition of Component - Microbial processes



Vote 2: Trend for Component - Microbial processes

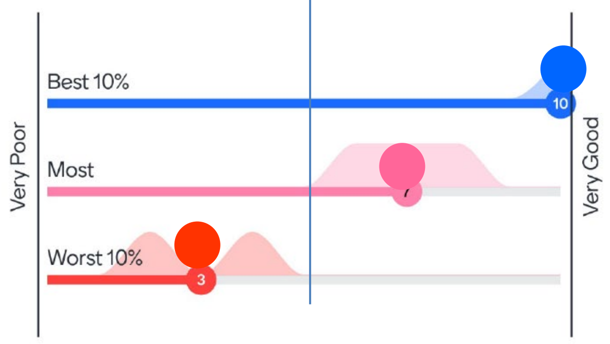


Vote 2: Confidence in Trend of Component - Microbial processes

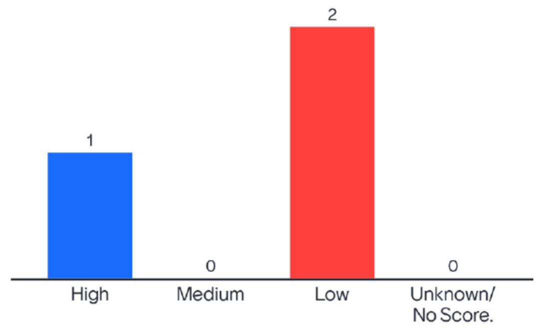


Herbivory

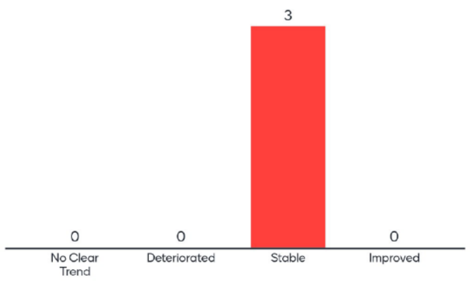
Vote 2: Condition of Component - Herbivory



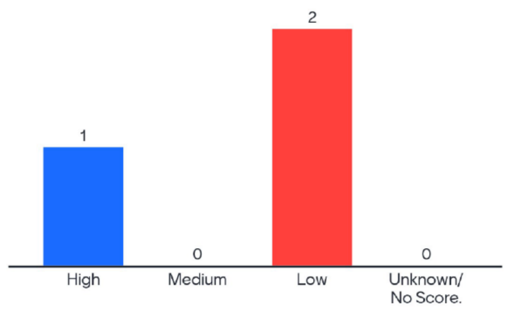
Vote 2: Confidence in Condition of Component - Herbivory



Vote 2: Trend for Component - Herbivory

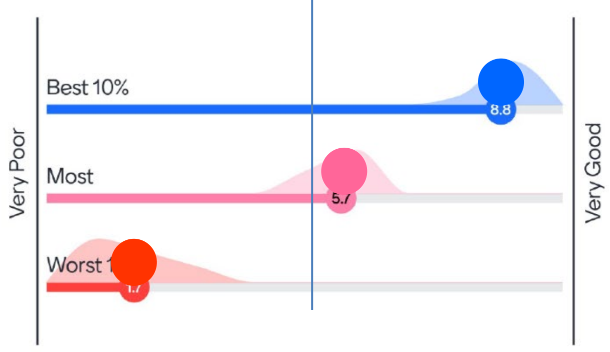


Vote 2: Confidence in Trend of Component - Herbivory

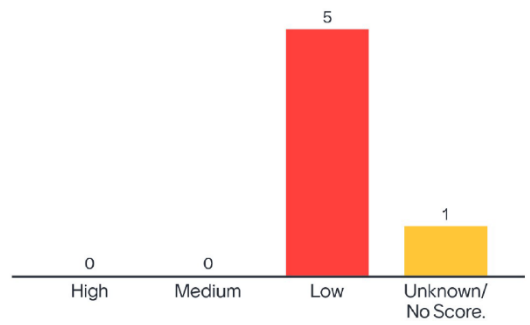


Predation

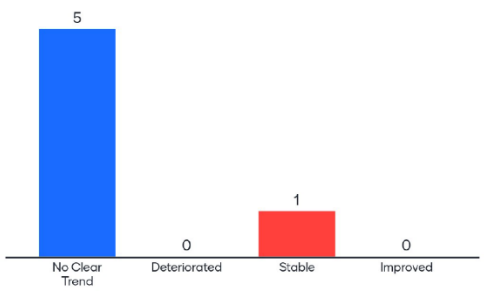
Vote 2: Condition of Component - Predation



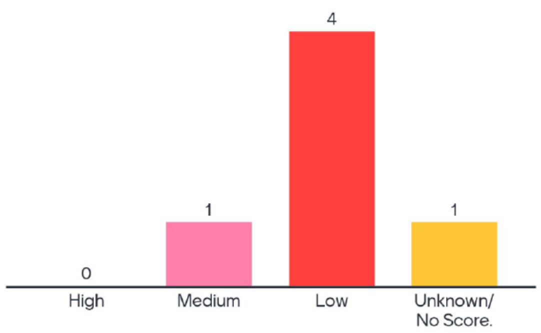
Vote 2: Confidence in Condition of Component - Predation



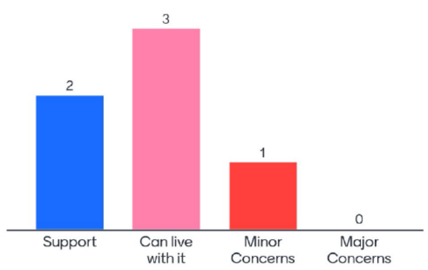
Vote 2: Trend for Component - Predation



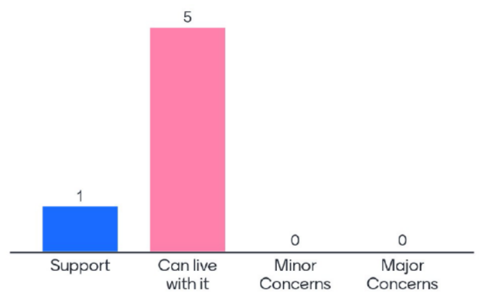
Vote 2: Confidence in Trend of Component - Predation



My overall comfort level with Condition Consensus for component - Predation

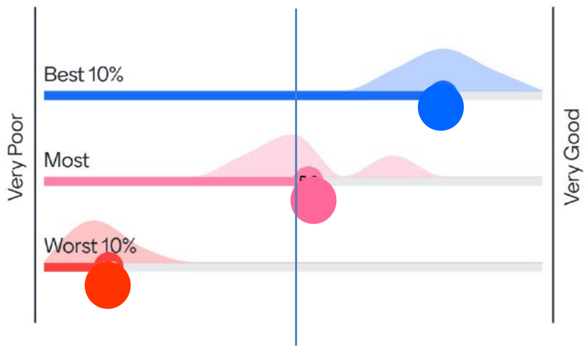


My overall comfort level with Trend Consensus for component - Predation

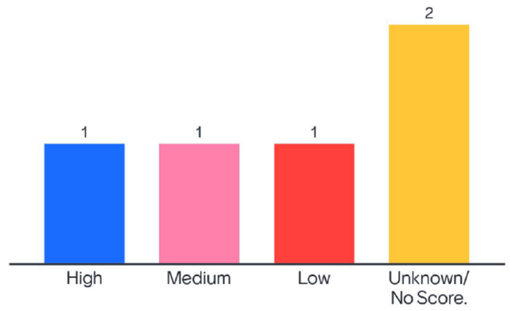


Symbiosis

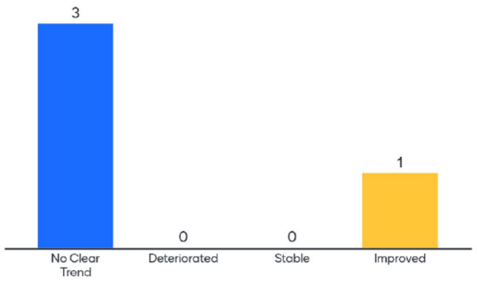
Vote 2: Condition of Component - Symbiosis



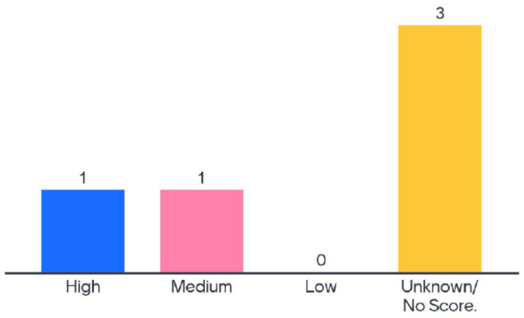
Vote 2: Confidence in Condition of Component - Symbiosis



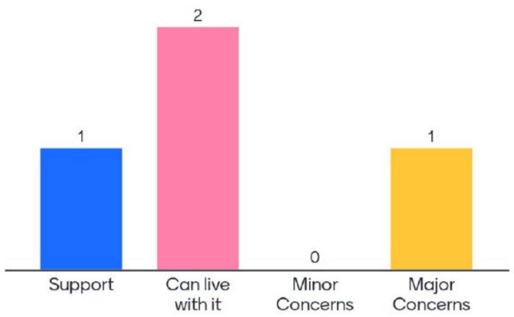
Vote 2: Trend for Component - Symbiosis



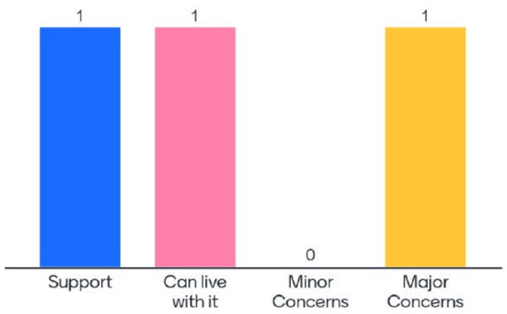
Vote 2: Confidence in Trend of Component - Symbiosis



My overall comfort level with Condition Consensus for component - Symbiosis

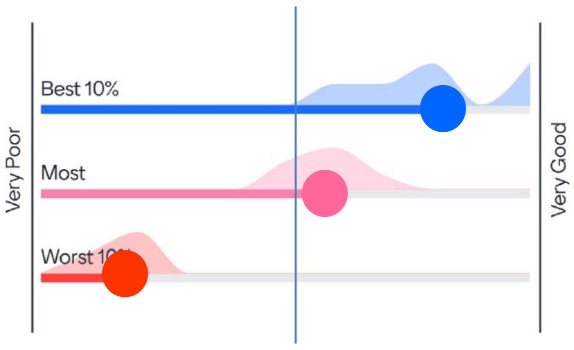


My overall comfort level with Trend Consensus for component - Symbiosis

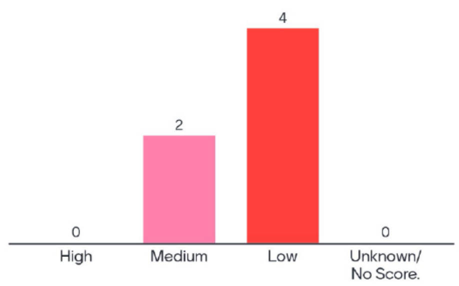


Recruitment

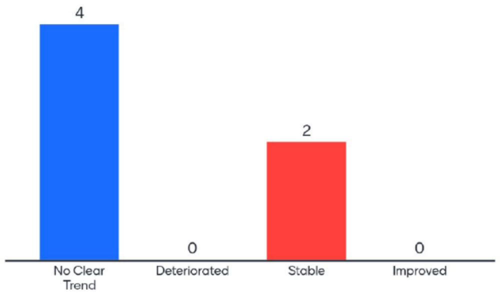
Vote 2: Condition of Component - Recruitment



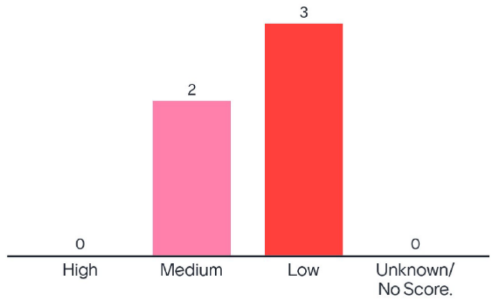
Vote 2: Confidence in Condition of Component - Recruitment



Vote 2: Trend for Component - Recruitment

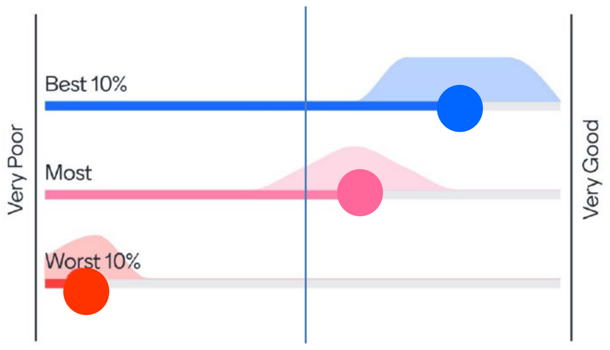


Vote 2: Confidence in Trend of Component - Recruitment

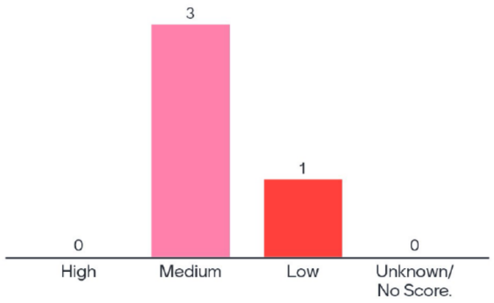


Reef building

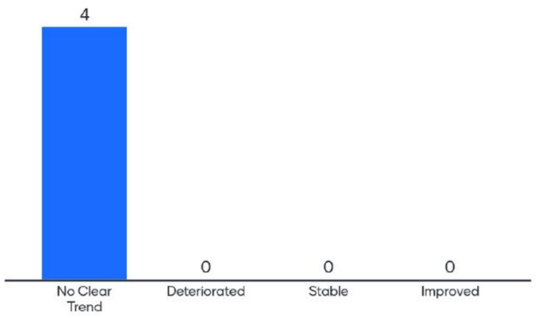
Vote 2: Condition of Component - Reef building



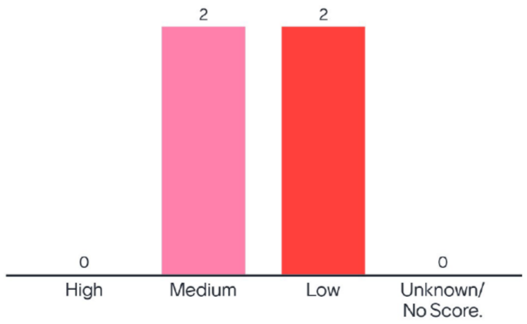
Vote 2: Confidence in Condition of for Component - Reef building



Vote 2: Trend for Component - Reef building



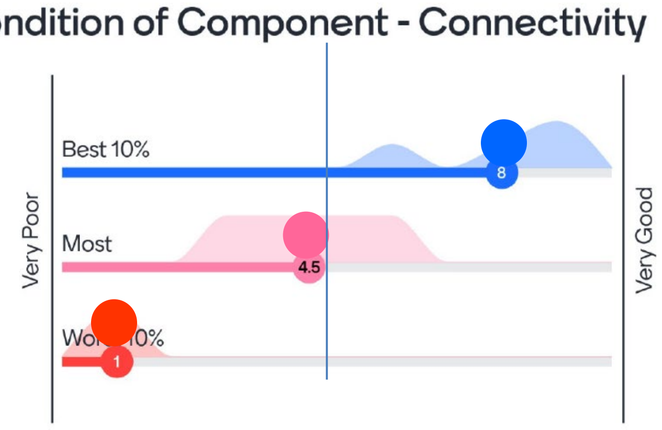
Vote 2: Confidence in Trend of Component - Reef building



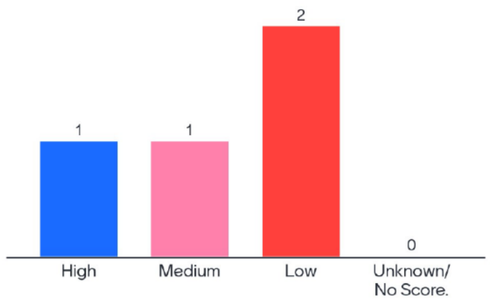
Connectivity

Condition

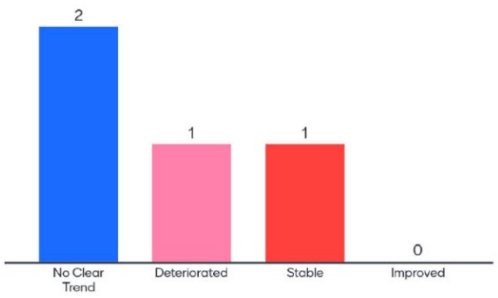
Vote 2: Condition of Component - Connectivity



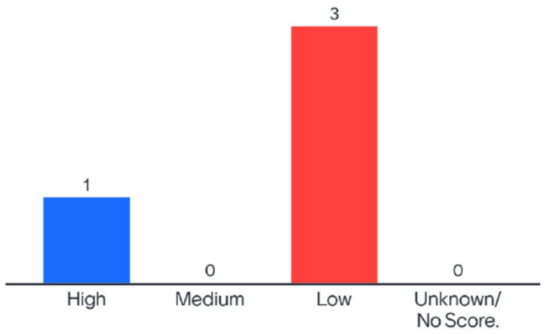
Vote 2: Confidence in Condition of Component - Connectivity



Vote 2: Trend for Component - Connectivity



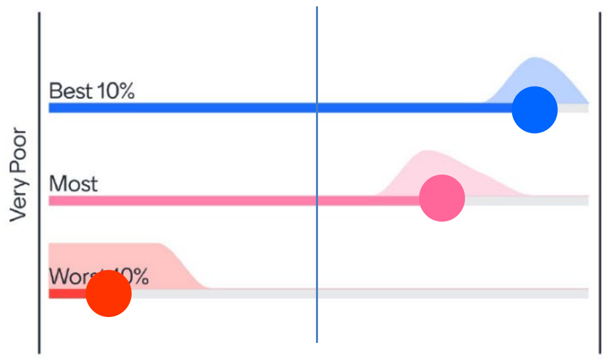
Vote 2: Confidence in Trend of Component - Connectivity



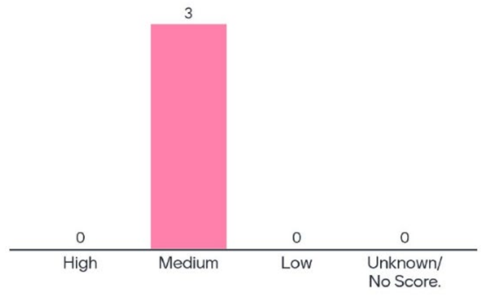
Ecosystem health: coastal ecosystems that support the Great Barrier Reef

Saltmarshes

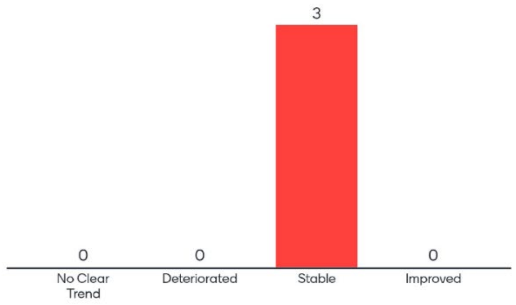
Vote 2: Condition of Component - Saltmarshes



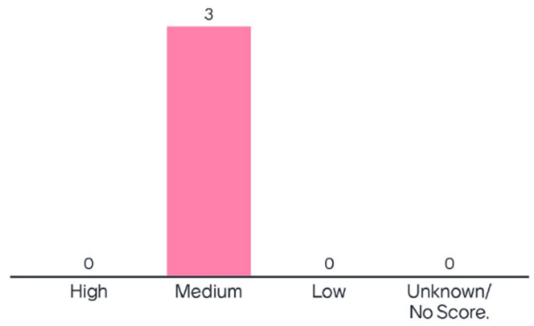
Vote 2: Confidence in Condition of Component - Saltmarshes



Vote 2: Trend for Component - Saltmarshes

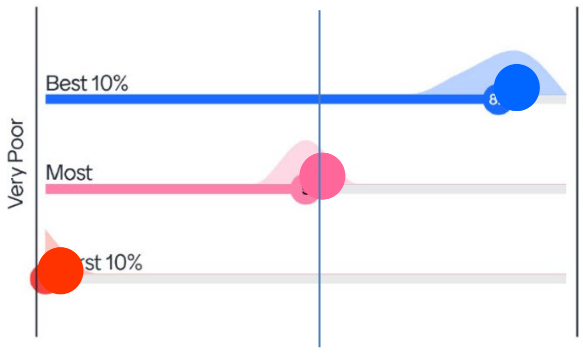


Vote 2: Confidence in Trend of Component - Saltmarshes

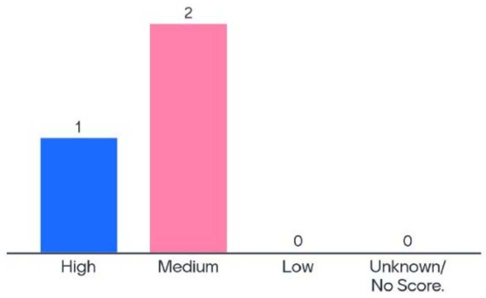


Freshwater wetlands

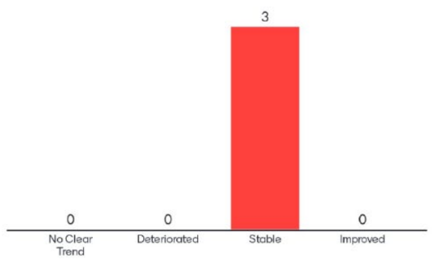
Vote 2: Condition of Component - Freshwater wetlands



Vote 2: Confidence in Condition of Component - Freshwater wetlands



Vote 2: Trend for Component - Freshwater wetlands



Vote 2: Confidence in Trend of Component - Freshwater wetlands