Tropical Water Quality Hub

National Environmental Science Programme

How do we assess and monitor aesthetic values of the Great Barrier Reef?

CSIRO

Reef Ecologic
For a better planet

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Why monitor GBR aesthetics?

1. World Heritage Criterion (vii): "*to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance*"
   - Yet monitoring and reporting of aesthetic values has so far proven elusive

2. It is a key driver of tourist visitation, contributing to the GBR's $5.7 billion industry.
   - And there are increasing concerns of declining values due to multiple and cumulative pressures

3. It's a key consideration for environmental assessments and permissions
   - Yet to date there is no systematic approach to such assessments

4. People relate to aesthetics*, deriving psychological wellbeing and inspiration
   - And there may be opportunities for tourists and local groups to contribute to such monitoring, and become more engaged in GBR protection, restoration…

*People relate to aesthetics…

2013

2017

“What are the first words that come to mind when you think of the GBR?”

Curnock et al. (2019),.. *Nature Climate Change* 9: 535-541.

…and the experience of GBR aesthetic values appears to be changing.

What are GBR aesthetic values?

2012 Retrospective Statement of Outstanding Universal Value of the Great Barrier Reef, addressing *Criterion vii:*

The GBR is of superlative natural beauty above and below the water, and provides some of the most spectacular scenery on earth. It is one of a few living structures visible from space, appearing as a complex string of reefal structures along Australia's northeast coast.

From the air, the vast mosaic patterns of reefs, islands and coral cays produce an unparalleled aerial panorama of seascapes comprising diverse shapes and sizes. The Whitsunday Islands provide a magnificent vista of green vegetated islands and spectacular sandy beaches spread over azure waters. This contrasts with the vast mangrove forests in Hinchinbrook Channel, and the rugged vegetated mountains and lush rainforest gullies that are periodically cloud-covered on Hinchinbrook Island.

On many of the cays there are spectacular and globally important breeding colonies of seabirds and marine turtles, and Raine Island is the world's largest green turtle breeding area. On some continental islands, large aggregations of over-wintering butterflies periodically occur.

Beneath the ocean surface, there is an abundance and diversity of shapes, sizes and colours; for example, spectacular coral assemblages of hard and soft corals, and thousands of species of reef fish provide a myriad of brilliant colours, shapes and sizes. The internationally renowned Cod Hole near Lizard Island is one of many significant tourist attractions. Other superlative natural phenomena include the annual coral spawning, migrating whales, nesting turtles, and significant spawning aggregations of many fish species.









Photos © Matt Curnock

What contributes to aesthetic values in natural settings?

- Geomorphology
- Spatial dimensions & visibility *(through air, water)*
- Habitat type *(e.g. beach, island, coral reef, mangroves)*
- Ecosystem state (*health and functionality of living components*)
- Faunal presence (*transitory animals; e.g. birds, fish, turtles, marine mammals*)
- Human presence (*including people, vessels, built infrastructure and visible effects*)
- Season, climate & weather conditions
- Time of day, light & colour

Place-based environmental characteristics

Experiential characteristics

- Expectations (*influenced by previous experience, marketing & media*)
- Viewpoint (*position, timing, direction, proximity & immersion*)
- Activity (*including use of devices that augment interaction with surroundings; e.g. scuba, sailboat, jetski, aircraft*)
- Sensory experience (*visual, auditory, olfactory, haptic*)
- Interpretation (*information accompanying the place-based experience; e.g. guide narratives, signage, brochures*)
- Social factors (*interactions with other people*)
- Cultural factors (*including normative beliefs*)
- Emotion (*affective responses to the myriad stimuli*)

(*Work in progress*, adapted from *Context (2013)* and other sources)

How can we assess and monitor GBR aesthetic values?

Context (2013) – developed a comprehensive, phenomenological landscape assessment methodology, including sensitivity and risks.

- Comprehensive, holistic and scalable to WHA property for OUV assessment (e.g. for Strategic Assessment, Outlook reporting)
- BUT costly, time intensive, does not seem feasible for monitoring purposes

Marshall et al. (2019) – tested a "rapid assessment" method involving non-expert 'gestalt' assessment of coral reef images on a rating scale (1-10).

- Visual only, but amenable to non-expert (i.e. crowd-sourced), scalable monitoring

Becken et al. (in progress) – developing AI/ML automated assessment method of coral reef images (1-10 rating + identification of attributes)

- Visual only, but can draw on large data streams (e.g. from social media) and process rapidly

Indigenous Heritage Expert Group (2018) Reef 2050 Plan monitoring program design report "Strong People, Strong Country" framework

- Includes environmental and experiential components that relate to aesthetic values

Outlook 2019:

Section 4.5.2

"… evidence on the current condition of the tangible elements of aesthetic heritage values is lacking."

"The emerging social-ecological field continues to expand methodologies to improve techniques in monitoring aesthetic heritage values, using potential indicators and computations of aesthetic value. However, ongoing examination of which locations or biophysical elements are the most important to the Reef's spectacular seascapes and scenery, remains an information gap. Evidence about the condition of the aesthetic heritage values of the Region is inferred from the condition of the Reef's natural heritage values assessed in Chapters 2 and 3."

4.6.1 Natural heritage values — world heritage value and national heritage value

Grade and trend			Confidence		Criterion and component summaries
2009	2014	2019	Grade	Trend	
		↓			**Natural heritage values – world heritage value and national heritage value** The Reef's world heritage and national heritage value represents the outstanding universal value of the Region. Outstanding universal value remains, however, the grade is borderline with poor because the condition of the property has deteriorated to varying extents with respect to criteria vii, viii, ix and x. While the property remains whole and intact, ecosystem resilience is deteriorating and the property's size is becoming less effective as a buffer against these disturbances.
		↓	◐	◐	**Natural beauty and natural phenomena:** At a broad scale, the Region retains much of its spectacular scenery. However, its natural beauty is being affected in some areas (for example, by poor inshore water quality). Components of natural phenomena, such as turtle breeding, whale migration and coral spawning, continue but these elements (criterion vii) are being increasingly challenged by climate change, resulting in the condition being good borderline poor. Much of the evidence is inferred from the assessments in Chapters 2 and 3.

4.6.5 Other heritage values

Grade and trend			Confidence		Criterion and component summaries
2009	2014	2019	Grade	Trend	
		–			**Other heritage values:** The Region's scientific heritage value is escalating. The Australian people's concern about the declining condition of the Reef is an emerging observation, as their connection to its environment and natural beauty continues to be strong.
		↔	●	◐	**Social heritage values:** The inherited pattern of cultural activity present in the communities that value the Reef is embedded in the way they access, use or think about the Reef. New studies show the socio-economic worth of the Region supports strong social heritage values.
		↓	◐	○	**Aesthetic heritage values:** Aesthetic beauty is closely aligned to the condition of the ecosystem. Strong evidence has established that several disturbances have damaged parts of the Reef's naturalness. Widespread and localised impacts are also inferred to have diminished some of the Region's aesthetic heritage values.
		↑	●	●	**Scientific heritage values:** The long history of Traditional Owners living on, and researchers studying, the Reef is significant. The Reef's prominence in long-term scientific studies continues to increase.

Project (5.6) aims:

1. **Identify reliable indicators for coral reef aesthetics that are ecologically relevant & relate to existing GBR monitoring**

2. **Design a monitoring program** (that integrates human and AI assessments)

3. **Implement a pilot program** (in 2020)

Sister project: NESP TWQ 5.5 (Susanne Becken, et al., Griffith University)

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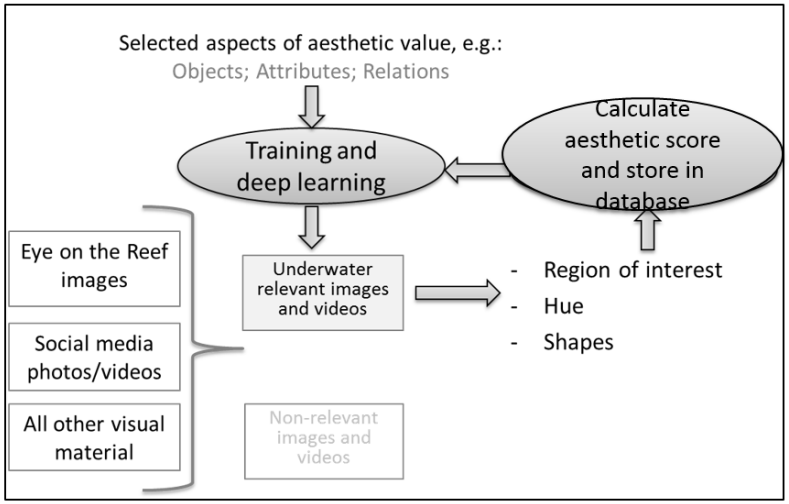
Project 5.5 Measuring aesthetic and experience values using Big Data approaches

Project Summary

This project responds to the urgent need of understanding how ecological changes affect the aesthetic value and the user experience of the Great Barrier Reef (GBR), and how these could be measured and monitored in a cost-effective way. The research capitalises on two major trends, namely peoples' ability and willingness to share large amounts of information through various online platforms, and rapid development in computing technology to store, process and interpret these data.

AI development, deep learning



Griffith UNIVERSITY
Queensland, Australia

Approach:

1. **Identify reliable indicators for coral reef aesthetics that are ecologically relevant & relate to existing GBR monitoring**
   - Complete, published in Marshall *et al*. (2019),… *PLOS ONE* 14: e0210196.
     - Online survey on 1400 Australians, rating 180 photos of coral reef scenes
     - Carefully selected images included attributes that were correlated with ratings of aesthetic beauty
     - Significant attributes/indicators included *water clarity*, *fish abundance*, *coral topography*, *fish diversity*, *fish size range* (noting co-correlates)
     - Strong correlation between 'expert' reef health ratings & 'non-expert' beauty ratings
2. **Design a monitoring program** (that integrates human and AI assessments)
3. **Implement a pilot program** (in 2020)

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2. **Design a monitoring program (that integrates human and AI assessments)**
   - **Extensive end-user & stakeholder engagement** (collaborative action research process with interviews & workshops), informing:
     - Program objectives, integration with existing programs and management processes, spatial and temporal sampling, data curation and integration (human + AI), reporting & comms needs…
     - Monitoring in different settings (e.g. islands, built sites) & from different perspectives
   - **Statistical design requirements to establish confidence parameters** in data/results:
     - Sensitivity, power analysis to inform minimum sample sizes
     - Accounting for inter-observer biases

3. **Implement a pilot program (in 2020)**

Sensitivity of rating scores *(2017 online survey; n=1400 respondents scoring 180 images)*

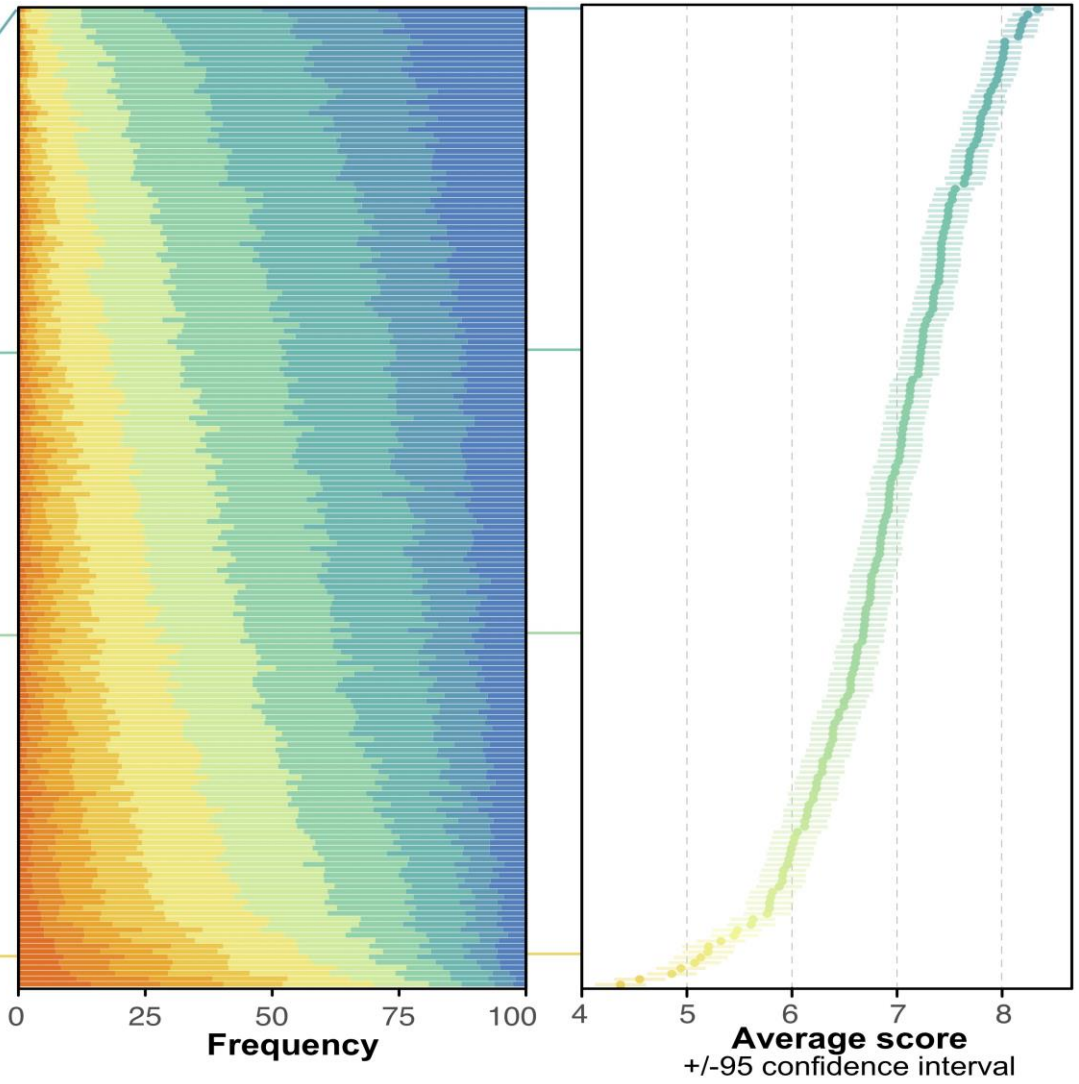
Mean rating *(rank):*

8.34 (#1)

7.26 (#59)

6.70 (#112)

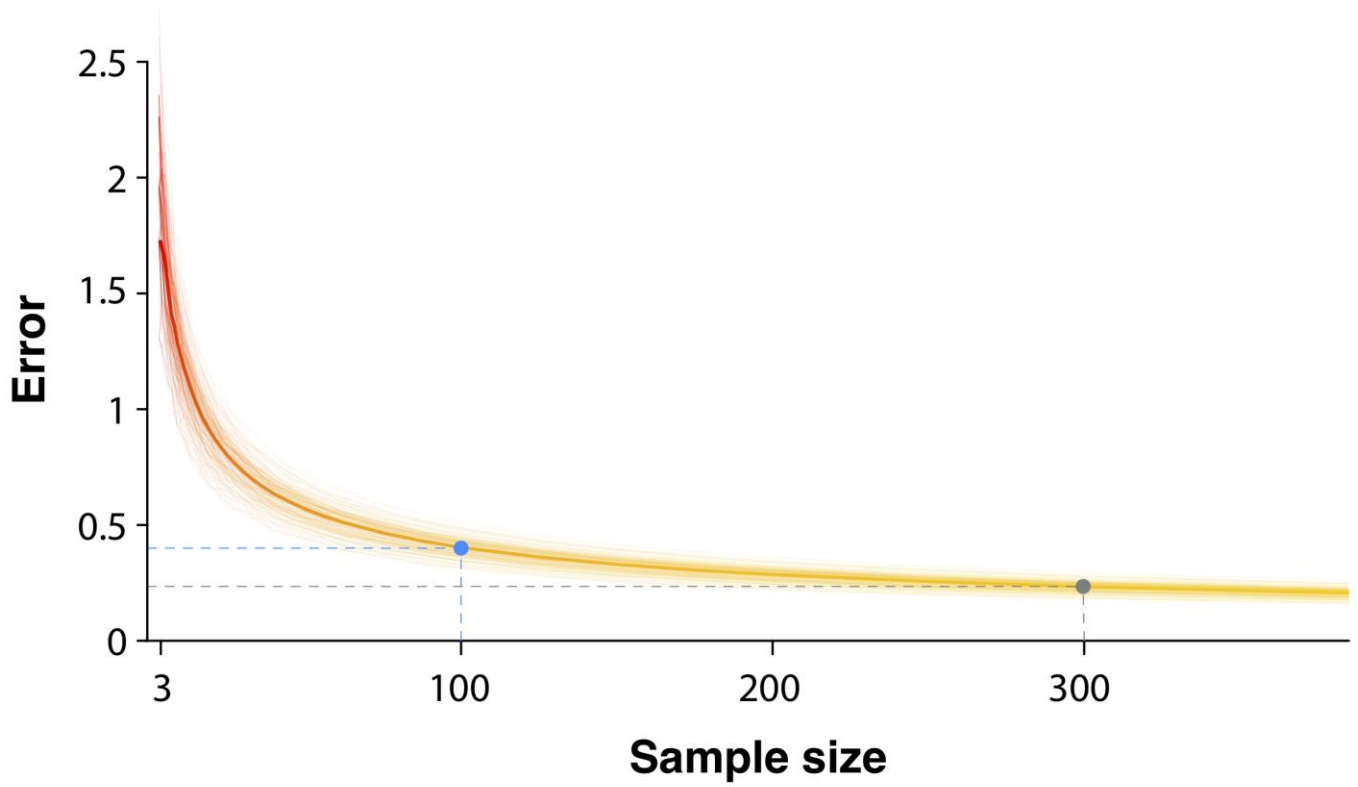
5.13 (#175)



From: Pert, Thiault, Curnock, et al. *paper in prep*

Power analysis: How many people does one need to…

…assess a coral reef scene, to be confident in the representativeness of the mean score? *(2017 online survey, n=1400 respondents)*



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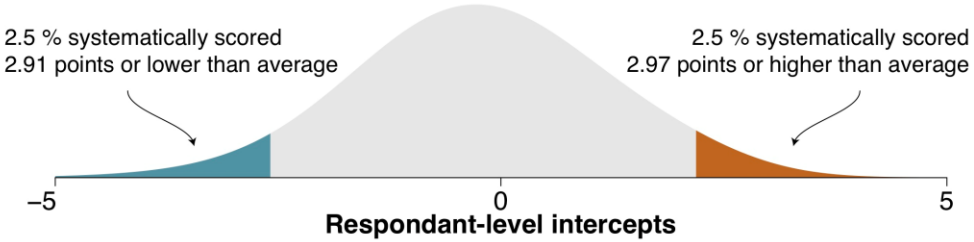
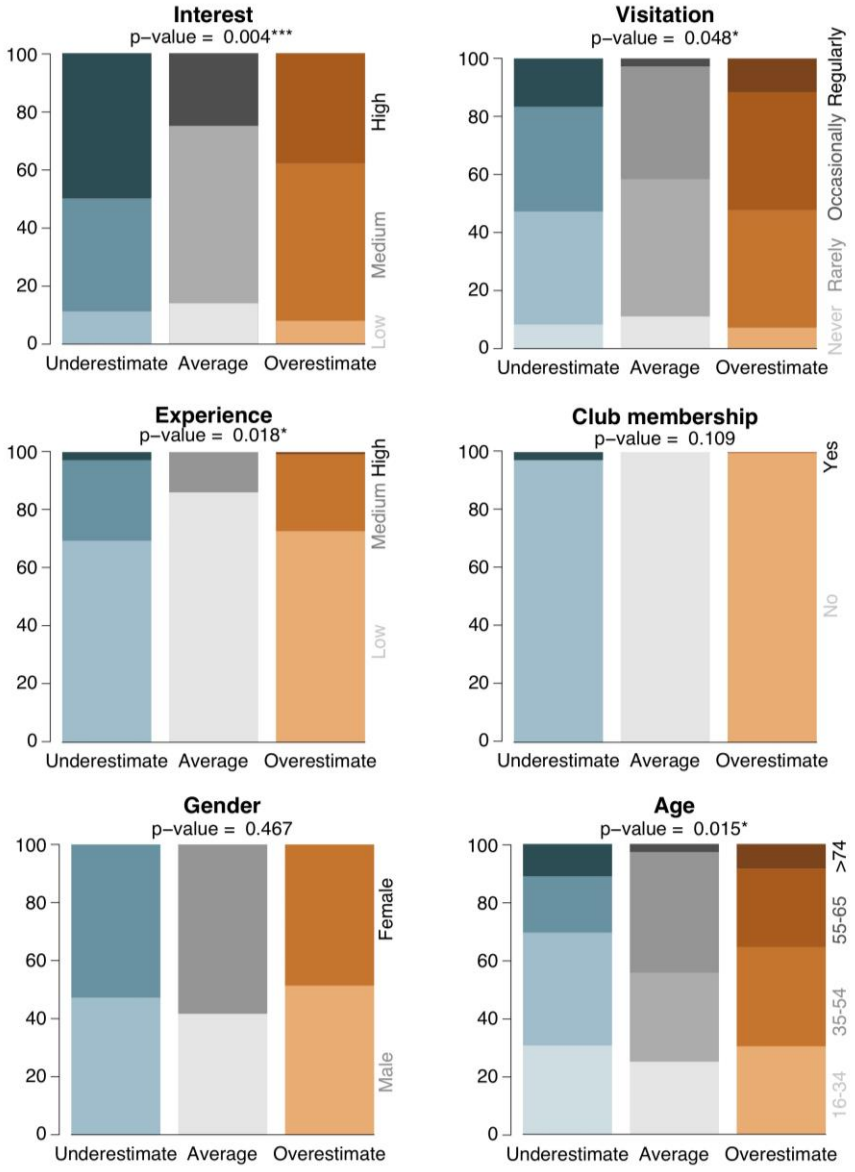
Inter-observer biases:

2017 online survey, n=1400 respondents



Extreme ends of over and under-estimation (beauty rating scores):

- Have a higher level of interest in coral reefs (p=0.004***)
- More likely to visit reef regularly (p=0.048*)
- Higher self-assessed coral reef experience (p=0.018*)
- Higher proportion of >65s (p=0.015*)
- No apparent prevalence of bias in either positive or negative direction
- While these groups inflate the error margin, they tend to cancel each other out around the mean score…



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Lessons learned so far from end-user engagement:

- There are numerous potential management (and other) uses of aesthetic assessments & monitoring; however, their information needs appear to vary.
- The “rapid assessment” approach will be useful for some purposes (not all), with statistical design requirements & limitations now better understood.
    - ***Strengths***: (i) simplicity, (ii) cost effective, (iii) scalable, (iv) accessibility
    - ***Weaknesses***: (i) Visual only, (ii) Spatial, temporal and observer variability, (iii) Links to environmental indicators in many settings not yet established, (iv) The baseline has already shifted and will keep moving.
    - ***Opportunities***: (i) Amenable to positive public engagement (e.g. tourism, community & citizen science), (ii) Easy to augment/add on to existing programs (e.g. LTMP, Eye on the Reef), (iii) Can contribute to coral restoration goals and benchmarking (and potentially also underwater art), (iv) AIML systems advancing rapidly
    - ***Threats***: (i) No existing program or reporting, (ii) Not currently prioritised in GBR monitoring, (iii) No obvious resourcing stream(s) to support implementation or longer term operation…

Thanks for listening!

More info: https://nesptropical.edu.au/index.php/round-5-projects/project-5-6/

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