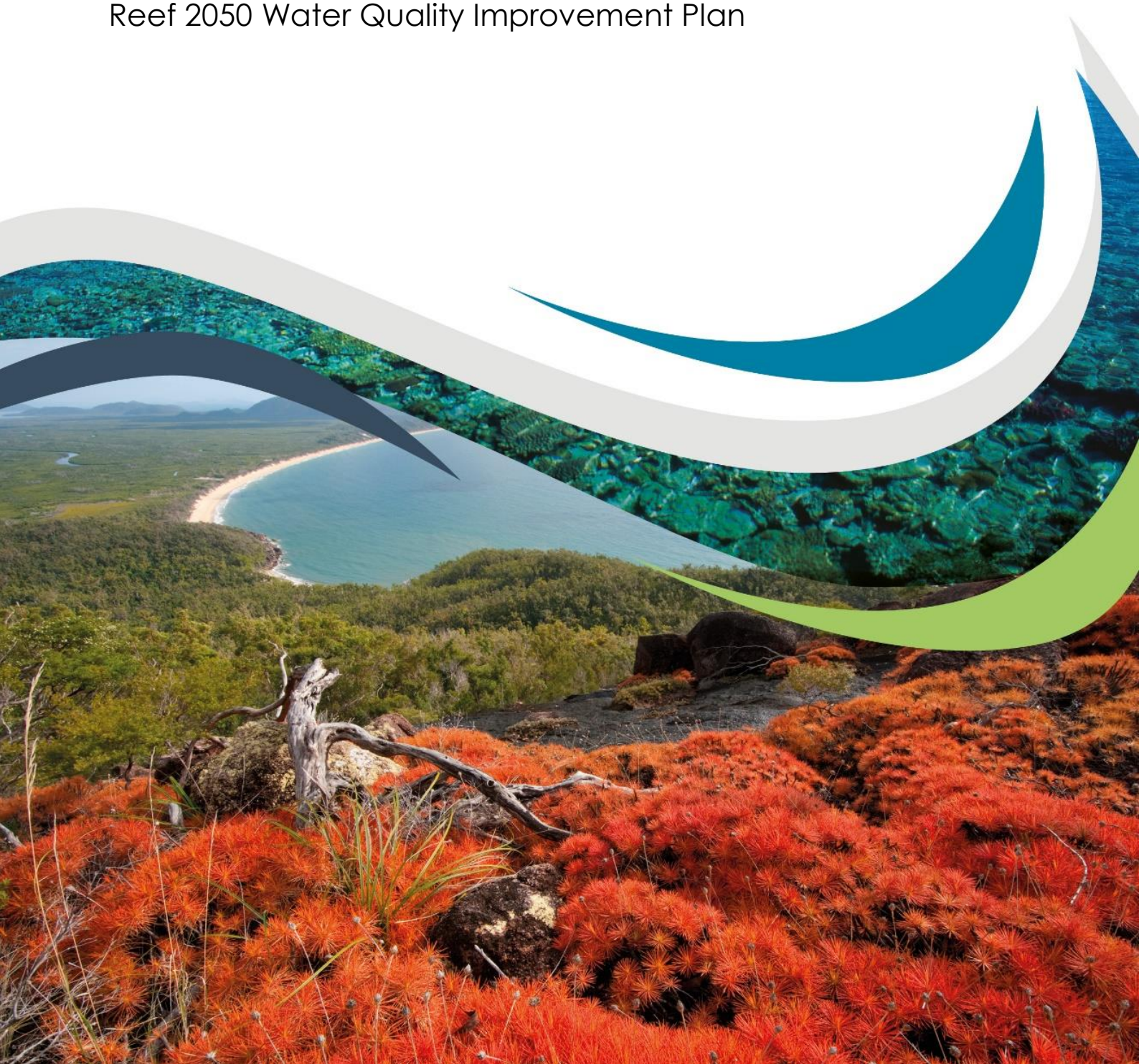
Australian Government

Queensland Government

Marine monitoring methods

Reef Water Quality Report Card 2019

Reef 2050 Water Quality Improvement Plan



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The Great Barrier Reef Marine Park Authority acknowledges the continuing Sea Country management and custodianship of the Great Barrier Reef by Aboriginal and Torres Strait Islander Traditional Owners whose rich cultures, heritage values, enduring connections and shared efforts protect the Reef for future generations.

DISCLAIMER

Comments and questions regarding this document are welcome and should be addressed to:

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Marine monitoring methods

This report summarises the data and methods used for monitoring and reporting within the Marine Monitoring Program managed by the Great Barrier Reef Marine Park Authority and reported in the Reef Water Quality Report Card 2019 (see Figure 1 - elements other than eReefs marine modelling). Detailed methods are available in the Marine Monitoring Program annual technical report series that undergo independent peer review before being published in the Great Barrier Reef Marine Park Authority's eLibrary.

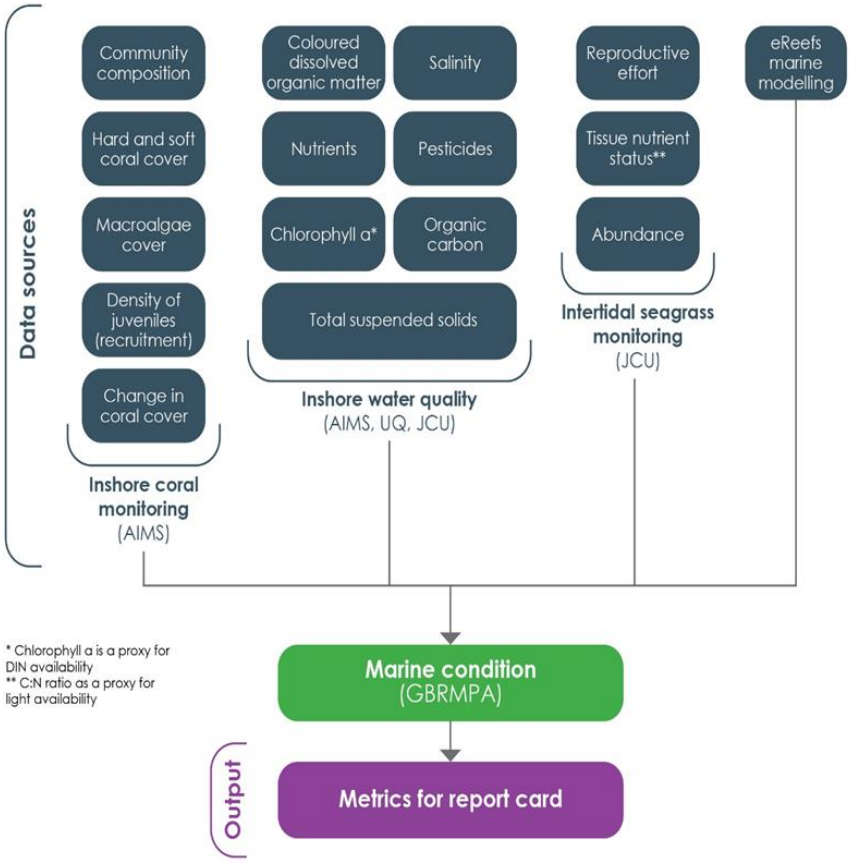

Figure 1: Main data sources, inputs and outputs for the Marine Monitoring Program, which include inshore coral, inshore water quality and inshore seagrass monitoring. The Marine Modelling Program provides the water quality metric based on eReefs model output.

The Marine Monitoring Program was established in 2005 and assesses trends in ecosystem health and resilience indicators for the inshore Great Barrier Reef in relation to water quality and its linkages to end-of-catchment pollutant loads. The inshore Marine Monitoring Program has three sub-components:

- water quality, including pesticides (Gruber *et al.* 2020)
- seagrass condition (McKenzie *et al.* 2020)
- coral reef condition (Thompson *et al.* 2020).

The Marine Monitoring Program is one line of evidence used to report progress towards the Reef 2050 Water Quality Improvement Plan (Reef 2050 WQIP) (Australia and Queensland Governments 2018) 2025 water quality outcome:

- Good water quality sustains the outstanding universal value of the Great Barrier Reef, builds resilience, improves ecosystem health, and benefits communities.

The Marine Monitoring Program objectives are:

- Assess temporal and spatial trends in inshore marine water quality and link pollutant concentrations to end-of-catchment loads.
- Monitor, assess and report the condition and trend of inshore coral reefs in relation to the extent, frequency and intensity of acute and chronic impacts.
- Monitor, assess and report the condition and trend of inshore seagrass meadows in relation to the extent, frequency and intensity of acute and chronic impacts.

Since the 2015-2016 water year, the Reef water quality report card marine result has been based on averaging the scores for water quality from the eReefs models (Robillot et al. 2018) with scores for coral and seagrass condition from the Marine Monitoring Program. The inshore water quality component (see Figure 1) provides data on exposure and risk to marine communities by analysing flood plumes and pesticide concentrations as well as *in situ* measurements to detect long-term trends at specific locations and in three regions. Further details on these methods can be found in the Marine Monitoring Program annual technical report for inshore water quality (Gruber *et al.* 2020) and the annual technical report for pesticides (Thai *et al.* 2020).

Seagrass condition

Monitoring is conducted in six regions, covering each major seagrass habitat type where possible (estuarine, coastal intertidal, coastal subtidal, reef intertidal and reef subtidal) (see Figure 2).

Sixty-nine sites at 30 locations were assessed during 2018–2019. This covered 14 coastal, four estuarine and 12 reef locations (i.e. two or three sites at each location). Reef intertidal sites in the Burdekin and Wet Tropics were paired with a subtidal site (McKenzie *et al.* 2020).

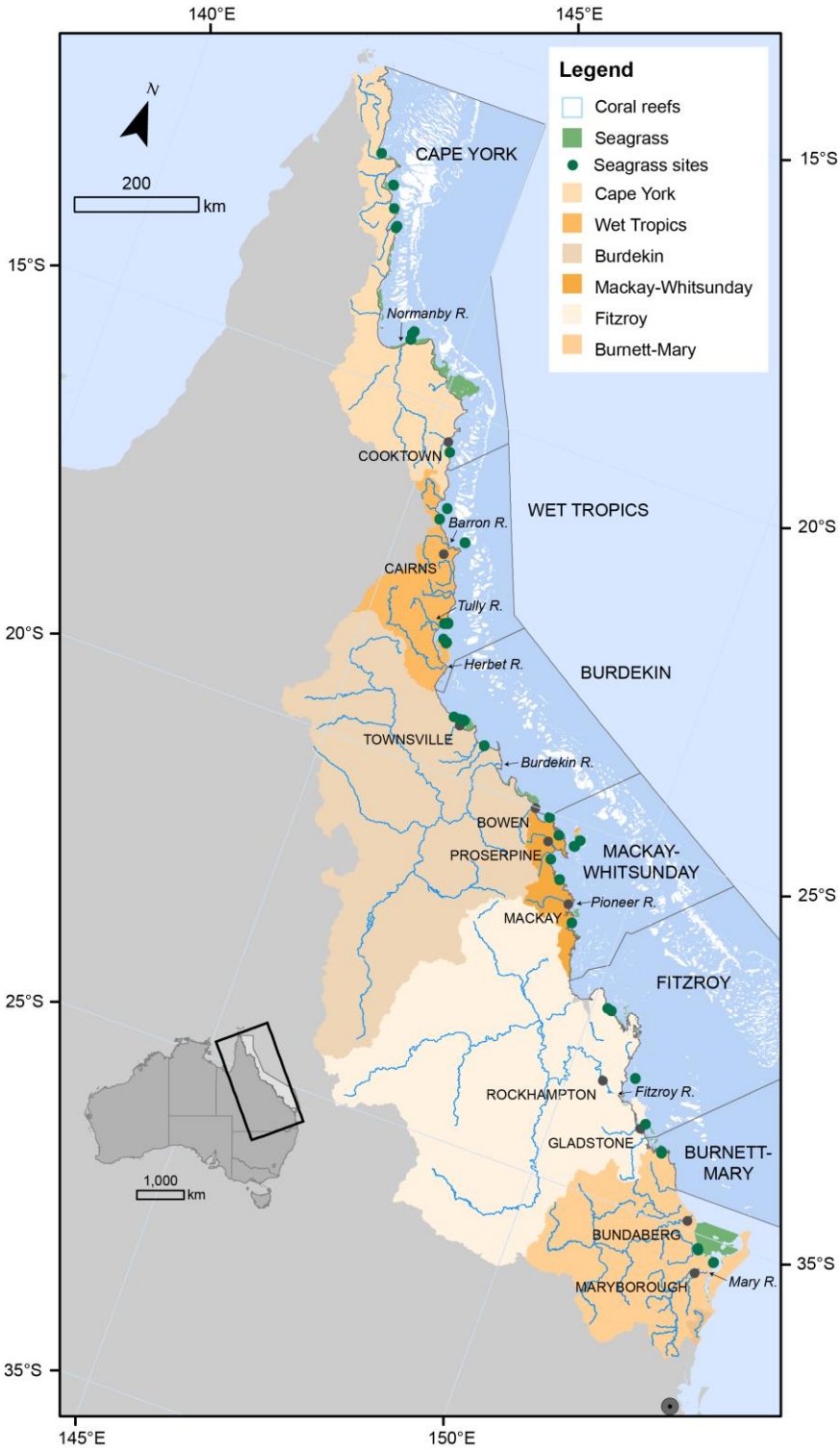

Figure 2: Marine Monitoring Program seagrass monitoring locations (including Queensland Parks and Wildlife Service and Seagrass-Watch). Source: (McKenzie et al. 2020).

At each location, with the exception of subtidal sites, sampling included two sites nested within 500m of each other. Subtidal sites were not always replicated within locations. Intertidal sites were defined as a 5.5ha area within a relatively homogenous section of a representative seagrass community/meadow. Monitoring occurs at sites in the late dry season (September-November) and late wet season (March/April) each year.

Three indicators are assessed:

- seagrass abundance (per cent cover) is an assessment of the average per cent cover of seagrass per monitoring site in relation to the Seagrass Abundance Guidelines (McKenzie 2009)
- reproductive effort is the ratio of the average number of reproductive structures (spathes, fruits, female and male flowers) of plants on an area basis relative to the long-term average, and provides an indication of the capacity for meadow recovery following disturbances
- tissue nutrient composition is an indicator of nutrient enrichment relative to light available for growth (McKenzie *et al.* 2020).

Additional indicators of seagrass condition and resilience include species composition, relative meadow extent and density of seeds in the seed bank (McKenzie *et al.* 2020).

Environmental pressures are also recorded including within-canopy water temperature, within-canopy benthic light, sediment composition as well as macroalgae and epiphyte abundance.

- Within-canopy benthic light is compared to long-term recorded light levels at individual sites as well as daily light thresholds likely to support long-term growth requirements of the species in these habitats (Collier *et al.* 2016).
- Within-canopy temperature is considered in context of the number of days above 35°C. Growth reduction can occur in some species from prolonged warm water exposure (Collier *et al.* 2011; Collier *et al.* 2016). The critical canopy temperature threshold for photoinhibition and acute temperature stress for seagrass is 40°C (Campbell *et al.* 2006).
- Changes in sediment composition can be an indicator of broader environmental changes (such as sediment and organic matter loads and risk of anoxia) and an early-warning indicator of changing species composition.

Additional data on climate and water quality is obtained from the Bureau of Meteorology and from the Marine Monitoring Program inshore water quality component (McKenzie *et al.* 2020).

Coral reef condition

Monitoring of inshore coral reef communities occurs every two years at reefs adjacent to four regions: Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy (see Figure 3). No reefs are included in Cape York due to logistic and occupational health and safety issues relating to diving in coastal waters in this region. Increased monitoring of inshore coral reefs in the Burnett Mary region is underway with results to be detailed in future report cards (Thompson *et al.* 2020).

Thirty-two reefs are monitored at two depths under the program, with an additional nine inshore reefs monitored at single depths under the Australian Institute of Marine Science – Long-Term Monitoring Program. All are included in the annual assessment of coral condition, although not all reefs are sampled every year (Thompson *et al.* 2020).

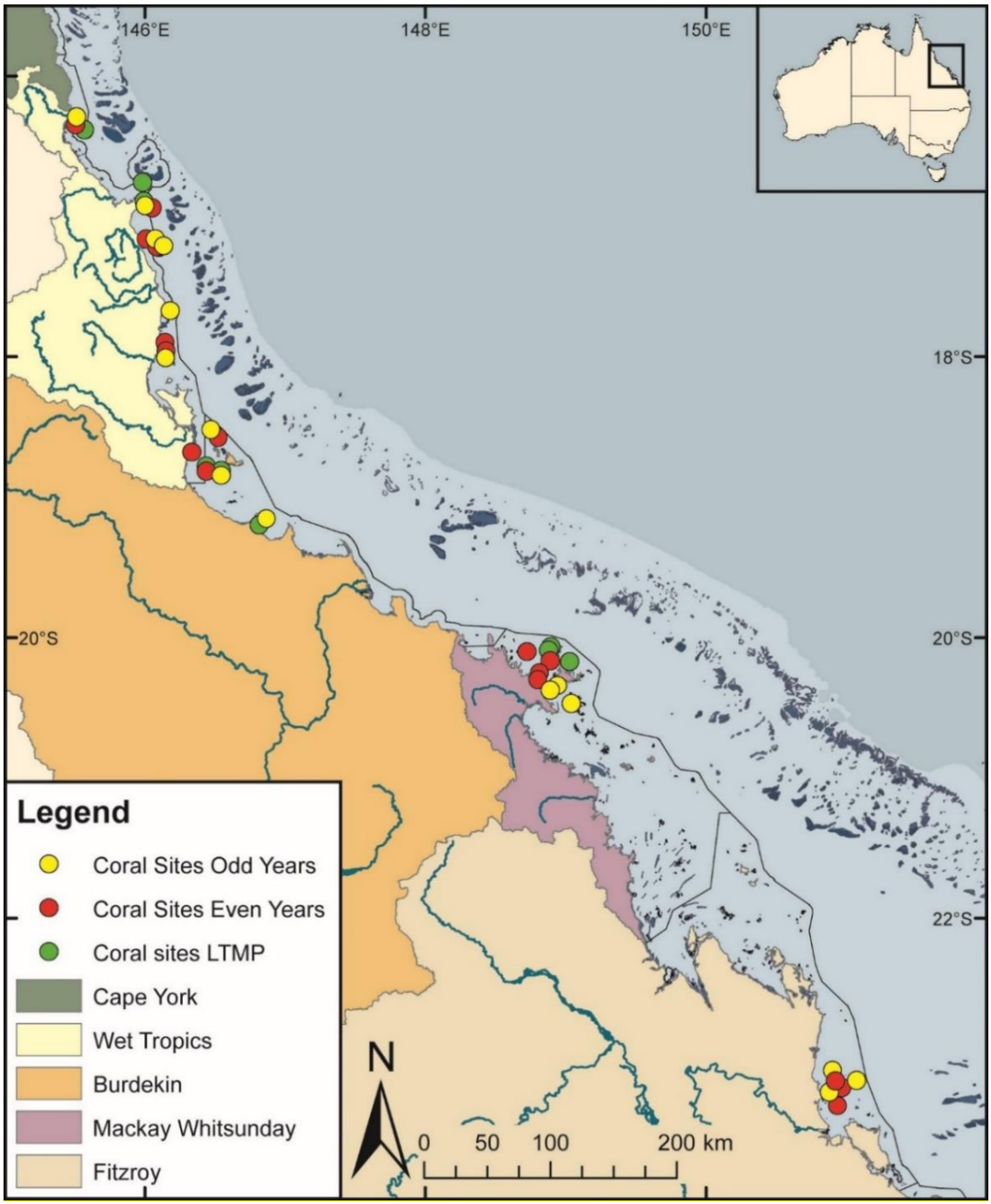

Figure 3: Sampling locations of the Marine Monitoring Program coral monitoring. Reefs are scheduled to be monitored biennially. Yellow indicates sites scheduled to be monitored in even years, and red dots are scheduled to be monitored in odd years. Green dots indicate sites monitored as part of the long-term monitoring program conducted by the Australian Institute of Marine Science. Region boundaries are represented by coloured catchment areas. Source: (Thompson et al. 2020).

Two sites at each reef are permanently marked with fence posts at the beginning of each of five, 20m-long, transects with smaller steel rods at the midpoint and end of each transect. Monitoring is conducted by divers along these transects. They assess community attributes including hard and soft coral cover, the number of hard coral juvenile colonies (up to 5cm in diameter), proportion (per cent) of macroalgae cover, rate of change in coral cover (as an indication of the recovery potential of the reef following a disturbance) and coral community composition (Thompson *et al.* 2020).

Assessing status against the objectives

Improved seagrass condition

Three indicators are used to assess and report inshore seagrass condition: abundance, reproductive effort and tissue nutrient status. Trend graphs show the combined score of the indicators over time (colour-graded circles) as well as the indicator's contribution to scores (lines). Further detail about the selection and scoring of these indicators is available in the annual technical report (McKenzie *et al.* 2020).

Regional scores for seagrass are derived as the unweighted averages of the three indicator scores. Detailed information is available in the Marine Monitoring Program's annual technical reports published in the Great Barrier Reef Marine Park Authority's eLibrary.

To calculate the overall score for seagrass, the regional scores were weighted on the percentage of World Heritage Area seagrass (shallower than 15m) within that region (see Table 1).

Table 1: Area of seagrass shallower than 15m in each region within the boundaries of the Great Barrier Reef World Heritage Area*

Region	Area of seagrass (km^2)	Per cent
Cape York	2,078	0.60
Wet Tropics	207	0.06
Burdekin	587	0.17
Mackay Whitsunday	215	0.06
Fitzroy	257	0.07
Burnett Mary	120	0.03
World Heritage Area	**3,464**	**1.00**

* Derived from (McKenzie, Yoshida, Grech *et al.* 2014; McKenzie, Yoshida, and Unsworth 2014; Carter *et al.* 2016; Waterhouse *et al.* 2016).

Improved coral condition

Five indicators are used to assess and report on inshore coral reef condition: coral cover, coral cover change, juvenile coral density, coral community composition and proportional macroalgal cover. Trend graphs show the combined score of the indicators over time (colour-graded circles) as well as the indicator's contribution to the scores (lines). Further detail about the selection and scoring of these indicators is available in the annual technical report (Thompson *et al.* 2020).

Regional scores for coral are derived as the unweighted averages of the five indicator scores. Detailed information is available in the Marine Monitoring Program's annual technical reports published in the Great Barrier Reef Marine Park Authority's eLibrary.

To calculate the overall score for coral, the regional scores were weighted on the percentage of the total inshore reef area in the Great Barrier Reef Marine Park that is represented by each of the monitored regions (see Table 2).

Table 2: Area of inshore reef in each region within the Marine Park*

Region	Area of inshore reef (km^2)	Per cent
Cape York	264.73	
Wet Tropics	64.42	0.209
Burdekin	28.23	0.092
Mackay Whitsunday	117.25	0.381
Fitzroy	97.66	0.318
Burnett Mary	4.58	
Marine Park	**576.85**	**1.00**

* Area statistics supplied by the Authority's Spatial Data Centre, 2011

Synthesis and integration of data and information

The Reef Water Quality Report Card 2019 provides scores for the condition of inshore water quality, seagrass and coral at Great Barrier Reef-wide and regional scales.

Reef-wide and regional marine scores are unweighted averages of these three indicator scores.

The Marine Monitoring Program provides the coral and seagrass scores, based on annual technical reports published in the Great Barrier Reef Marine Park Authority's eLibrary.

The eReefs Marine Modelling Program provides the water quality metric for the inshore Reef score based on open coastal waters (Robillot *et al.* 2018).

Qualitative confidence rankings

A multi-criteria analysis was used to qualitatively score the confidence in each indicator used in the Reef Water Quality Report Card 2019, from low to high. The approach combined expert opinion and direct measures of error for program components where available. Seagrass and coral both received a four-dot confidence ranking (see *Figure 1*4).

Figure 4: Qualitative confidence rankings for seagrass and coral scores. Source: Refer to Appendix A.

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Appendix A: Derivation of confidence ranking

A multi-criteria analysis approach was endorsed by the Independent Science Panel in July 2016 and used to qualitatively score the confidence for each key indicator used in the report card. The approach enables the use of expert opinion and measured data.

A multi criteria analysis identifies the key components that contribute to a problem. These are known as criteria. Each criterion is then scored using a defined set of scoring attributes. The attributes are ranked from those that contribute weakly to the criteria to those that have a strong influence. If the criteria are seen to have different levels of importance for the problem being addressed, they can be weighted accordingly. The strengths of this approach are that it is repeatable, transparent and can include contributions from a range of sources. The weaknesses are that it can be subjective and open to manipulation.

The determination of confidence for the report card used five criteria:

- maturity of methodology (the score is weighted half for this criteria so not to outweigh the importance of the other criteria)
- validation
- representativeness
- directness
- measured error

Seagrass

Maturity of methodology (weighting 0.5)	Validation	Representativeness	Directness	Measured error
New or experimental methodology	Survey with no ground truthing	Less than 10% of population survey data	Measurement of data that have conceptual relationship to reported indicator	Error not measured or >25% error
Peer reviewed method	Survey with ground-truthing (not comprehensive)	**10%-30% of population survey data**	Measurement of data that have a quantifiable relationship to reported indicators	**10-25% error**
Established methodology in published paper	**Survey with extensive on ground validation or directly measured data**	30-50% of population	**Direct measurement of reported indicator with error**	Less than 10% error
3 x0.5 = 1.5	3	2	3	2

Bolded and grey shading in cells indicates assessment ranking. Total score = 11.5, equates to **Four dots**.

Coral

Maturity of methodology (weighting 0.5)	Validation	Representativeness	Directness	Measured error
New or experimental methodology	Survey with no ground truthing	Less than 10% of population survey data	Measurement of data that have conceptual relationship to reported indicator	Error not measured or >25% error
Peer reviewed method	Survey with ground-truthing (not comprehensive)	**10%-30% of population survey data**	Measurement of data that have a quantifiable relationship to reported indicators	**10-25% error**
Established methodology in published paper	**Survey with extensive on ground validation or directly measured data**	30-50% of population	**Direct measurement of reported indicator with error**	Less than 10% error
3 x0.5 = 1.5	3	2	3	2

Bolded and grey shading in cells indicates assessment ranking. Total score = 11.5, equates to **Four dots**.

Appendix B Erratum: seagrass scores for 2017-2018

A comprehensive quality assurance and quality control assessment of seagrass data was undertaken for the Reef Water Quality Report Card 2019, in parallel with generating seagrass scores through a new statistical program using 'R' scripts. This review identified errors in past data, which only appeared in the Reef Water Quality Report Card 2017 and 2018. These errors, which are minimal, will be corrected for seagrass abundance and nutrient scores from 2005-2006 to 2017-2018.

What are the errors that were identified?

- Some calculations did not include all data during a transition in methodology.
- Some calculations incorrectly included additional collections outside the late dry season *(only applies to Report Card 2017 and 2018, errors did not occur in previous years*).
- Some data was scored against the wrong guideline *(only applies to Report Card 2017 and 2018, for sites established in 2017)*.
- Some sites were allocated to the wrong seagrass habitat type.

How have the errors affected scores and grades?

Most of the recalculations resulted in minor changes to scores of less than one and no change in grades, which has minimal impact on the evaluation of condition and trend. However, there were five corrections of two or more, and one resulted in a grade change for an indicator, with flow-on effects. This change relates to the 2017-2018 scores for Cape York where:

- the abundance indicator was amended from 40 to 45 (improvement from poor to moderate)
- the regional score was amended from 25 to 27 (no change in grade)
- the marine score was amended from 43 to 44 (no change in grade)
- the coral abundance indicator was amended from 42 to 45 (no change in grade)
- the seagrass score was amended from 29 to 30 (no change in grade).

The revised scores are presented in the annual technical report for inshore seagrass 2018-2019 (McKenzie *et al.* 2020).

Glossary

Ecosystem: dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

Ecosystem health: ecological processes, biodiversity and function of biological communities is maintained.

eReefs: coupled hydrodynamic and biogeochemical models of water quality and ecosystem condition for the Marine Park <https://research.csiro.au/ereefs/models/>.

Guideline value: a measurable quantity (e.g. concentration) or condition of an indicator for a specific community value below which (or above which, in the case of stressors) there is considered to be a low risk of unacceptable effects occurring to that community value.

Inshore: the enclosed coastal and open coastal water bodies combined. These terms are defined and mapped under schedules in the Environmental Protection (Water) Policy.

Marine Park: Great Barrier Reef Marine Park.

msPAF: multisubstance-potentially affected fraction.

Pollutant: a substance that is present in concentrations that may harm organisms or exceed an environmental quality standard. In this program, the term refers primarily to nutrients, sediment and pesticides.

Reef 2050 WQIP: Reef 2050 Water Quality Improvement Plan.

Reef 2050 Plan: Reef 2050 Long-Term Sustainability Plan.