



HEALTHY RIVERS TO
REEF PARTNERSHIP
MACKAY-WHITSUNDAY

Development of Methods and Results for the Pilot Report Card

Inshore and Offshore Marine

Final Report

Technical Working Group

April 2016



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1. Introduction

1.1. General

The Mackay-Whitsunday Healthy Rivers to Reef Partnership was established in October 2014, with the aim to release a pilot report card in 2015. The pilot report card reports on the 2013-14 year (1 July to 30 June), and includes assessments of the freshwater environment, the marine environment (to the eastern boundary of the Great Barrier Reef (GBR) Marine Park), economic and social context, and stewardship levels within different industries in the region.

For more detail on the Mackay-Whitsunday report card and Partnership, refer to the Program Design: Pilot Report Card document.

1.2. Purpose of this Document

The purpose of this document is to provide information to support the Program Design for the pilot report card. This document describes the methods and results for the inshore and offshore marine environments, including:

- Indicator selection process;
- Data collection methods;
- Scoring methods; and
- Results.

Similar documents are available describing the indicators and methods for social and economic assessments, the freshwater basins and estuaries, and the stewardship assessments.



2. Selection of Indicators

The sections below outline the process and final outcomes of determining the most appropriate indicators used in the inshore and offshore marine assessments for the pilot report card Figure 1 and Figure 2.

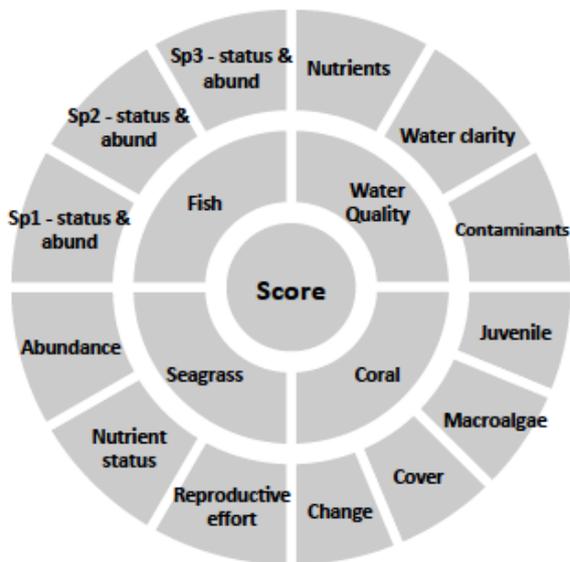


Figure 1. Marine inshore condition coaster for the pilot report card.

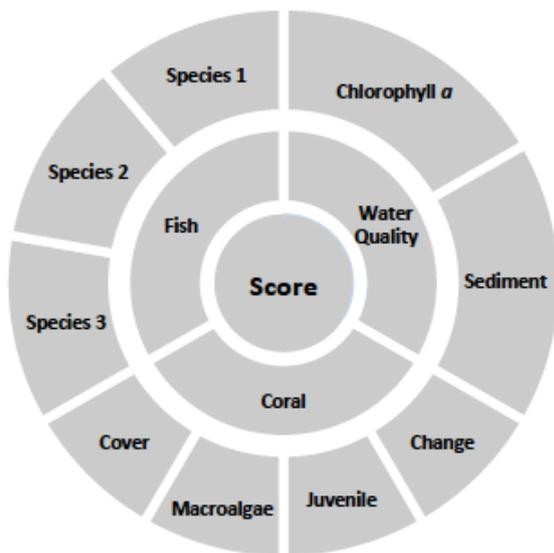


Figure 2. Marine offshore condition coaster for the pilot report card.

All potential indicators were analysed and shortlisted based on the following questions:

- Is the indicator clearly linked to an objective of the report card?
- Can the indicator easily be used to provide a report card score?



- Do other programs and report cards use this indicator?

Additionally, it was identified that indicators needed to be:

- Indicative of what the Partnership is trying to protect (or a good 'proxy');
- Sensitive to change;
- SMART (specific, measurable, achievable, relevant, time-bound);
- Of strong scientific and conceptual basis - i.e. indicators based on well-defined or validated cause-and-effect chains linking human-related pressures to ecosystem response if possible;
- Signals that can be measured in simple, cost-effective ways with available resources, and analysed in a fashion that allows unambiguous interpretation;
- Well-established regarding links with specific management objectives and responsive to related management actions; and
- Easily communicated and understood by stakeholders and/or the target audience.



2.1. Water Quality Indicators

2.1.1. Inshore Marine Environment

The water quality indices included in the pilot report card for the inshore marine zone were determined through an analysis of the range of programs historically, currently, and planned, which are collecting water quality data in the marine environment. The indicators were shortlisted based on the following questions:

- Is the indicator relevant to the Mackay-Whitsunday region, regional issues, and report card objectives?
- Is there *in situ* information available?
- Is the frequency of monitoring sufficient to be able to detect change in the indicator measured?
- Relevance of the indicator to GBRMPA/Queensland/ANZECC water quality guidelines? and
- Are there redundancies/double-ups in the selected indices and if so, which are the most relevant for the region?

The results of this assessment are shown in Table 1 below, with the shortlisted indicators grouped by indicator category shown in Table 2. The table refers to two programs – “Ports” being data collected by North Queensland Bulk Ports Corporation (NQBP), and “MMP” being data collected by Australian Institute of Marine Science (AIMS) or James Cook University (JCU) for the Great Barrier Reef Marine Park Authority (GBRMPA) Marine Monitoring Program (MMP).



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Table 1. Potential inshore water quality parameters to be included as indices for inshore marine water quality. Green shading indicates the indices and data source used.

Index	Program	Type / frequency (2013-14 year)	Comments	Use? (Y/N)
Total Suspended Solids (TSS)	MMP	Remote sensed	<i>In situ</i> data available	N
		Grab / 5x per year	Relevant; GBR trigger value; use <i>in situ</i> data	Y
	Ports	Grab / Monthly		
Chlorophyll- <i>a</i>	MMP	Remote sensed	<i>In situ</i> data available	N
		Grab / 5x per year + CTD profiles	Relevant; GBR trigger value; use <i>in situ</i> data	Y
		Logger / Contin.		
	Ports	Grab / Monthly		
Temperature (°C)	Ports	Logger / Contin.	Not relevant for report card score. Could use for contextual information.	N
		Profile/ Monthly		
	MMP	CTD Profile/ 5x per year		
	Loggers / Contin.			
Conductivity (µS/cm)	Ports	Logger / Contin.	Not relevant for report card	N
		Profile/ Monthly		
Salinity (PSU)	Ports	Logger / Contin.	Not relevant for report card	N
		Profile/ Monthly		
	MMP	Grab / 5x per year +CTD profiles		
		Loggers / Contin.		
Dissolved Oxygen (%)	Ports	Logger / Contin.	Not relevant for report card	N
		Profile/ Monthly		
Dissolved Oxygen (mg/L)	Ports	Logger / Contin.	Not relevant for report card	N
		Profile/ Monthly		
pH	Ports	Logger / Contin.	Not relevant for report card	N
		Profile/ Monthly		
Turbidity (NTU)	Ports	Logger / Contin.	Relevant; GBR trigger value	Y
		Profile/ Monthly		
	MMP	Logger / Contin.		
		CTD Profile/ 5x per year		
Secchi depth	MMP	5x per year	Relevant; GBR trigger value	Y
Various hydrocarbons	Ports	Monthly	Not relevant currently for region	N



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Index	Program	Type / frequency (2013-14 year)	Comments	Use? (Y/N)
Range of metals	Ports	Monthly	Not relevant currently for region	N
Priority PSII herbicides	Ports	Monthly	Relevant; GBR trigger value; use PSII Herbicide Equivalent Factor, with the aim to use ms-PAF next year	Y
	MMP	Passive nine times/year; Grab during wet season		
Total Nitrogen	Ports	Monthly	Relevant; QLD guideline; however using NO _x species.	N
	MMP	Derive using PN + TDN		
Nitrate (NO ₂)*	Ports	Monthly	ANZECC guideline; Qld guideline for NO _x applied in MMP	Y
	MMP	Grab / 5x per year		
Nitrite (NO ₃)*	Ports	Monthly	ANZECC guideline; Qld guideline	Y
	MMP	Grab / 5x per year		
Particulate Nitrogen	MMP	Grab / 5x per year	Relevant; GBR trigger value	Y
	Ports	Monthly		
Ammonia (NH ₄)	Ports	Monthly	Relevant; Qld guideline	N
	MMP	Grab / 5x per year		
Total Phosphorus	Ports	Monthly	Relevant; Qld guideline	N
	MMP	Derive using PP + TDP		
Particulate Phosphorus	MMP	Grab / 5x per year	Relevant; GBR trigger value	Y
	Ports	Monthly		
Depth	Ports	Profile / Monthly	No guideline; not relevant for report card	N
Phosphate (PO ₄)	MMP	Grab / 5x per year	Qld guideline; relevant	N
Silicic Acid (Si(OH) ₄)	MMP	Grab / 5x per year	Not relevant for report card	N
Dissolved Organic Nitrogen (DON)	MMP	Calculated	Not relevant for report card	N
Dissolved Organic Phosphorus (DOP)	MMP	Calculated	Not relevant for report card	N
Dissolved Organic Carbon (DOC)	MMP	Grab / 5x per year	Not relevant for report card	N
Particulate Organic Carbon (POC)	MMP	Grab / 5x per year	Not relevant for report card	N
Particulate Organic Carbon (POC)	MMP	Grab / 5x per year	Not relevant for report card	N

*combined to report on NO_x

Table 2. Shortlisted inshore marine water quality indices categorised into indicators.

Indicator	Index	Index Abbreviation	Index Unit
Nutrients	Particulate nitrogen	PN	µg/L
	Particulate Phosphorus	PP	µg/L
	Nitrogen oxides	NO _x	µg/L
	Chlorophyll- <i>a</i>	Chl- <i>a</i>	µg/L
Water clarity	Total Suspended Solids	TSS	mg/L
	Turbidity	Turb	NTU
	Secchi depth (m)	Secchi	m
Contaminants	PSII-HEq method*	N/A	N/A

*The PSII-HEq method will be used in the pilot report card, and the ms-PAF method used in subsequent report cards. The ms-PAF method and risk classifications for the GBR are still under review.

2.1.2. Offshore Marine Environment

The offshore marine water quality indicators and indices were selected based on the data that is currently collected, and likely to be collected in the future. The dataset available includes remote-sensed annual exceedances of total suspended solids (TSS) and chlorophyll-*a*.

The rationale for the selection of indicators in the MMP is based on:

- Chlorophyll-*a* is a measure of overall phytoplankton biomass, and is widely considered as a useful proxy for nutrient availability and the productivity of a system; and
- TSS is a measure of particulate matter in the water column, which influences water clarity and sedimentation regimes. Suspended solids concentrations are in turn controlled by sediment inputs from rivers and oceanographic factors such as wind, waves and tides.

2.2. Coral Indicators

The coral indicators were selected based on existing monitoring programs that are also likely to continue in the future. The indicators from the coral monitoring conducted by the Australian Institute of Marine Science (AIMS) for the GBRMPA Marine Monitoring Program (MMP) and also used in the Reef Plan report card were determined to be the most appropriate coral indicators to use for the pilot Mackay-Whitsunday report card. These indicators and monitoring program were set up to assess the health of coral reefs in the Great Barrier Reef area and also the potential for the reefs to recover from disturbance (i.e. resilience). The program also provides a method for integrating the indicators into a coral reef condition index. The indicators include:

- Coral cover;
- Macroalgae cover;
- Rate of coral cover increase (change in coral); and
- Density of juvenile corals.

The same coral indicators are collected through both the inshore monitoring program (through MMP) and the offshore long-term monitoring program (led by AIMS).

Further justification for the indicators used in the MMP program can be found in various documents, including Thompson et al. (2014). The methodologies used to generate condition scores for the indicators are under review in 2015.

2.3. Seagrass Indicators

Similar to the coral indicators, the seagrass indicators were selected based on existing monitoring programs likely to continue in the future. The monitoring of seagrass conducted by James Cook University (JCU) for the GBRMPA MMP (also used in the Reef Plan report card) were determined to be the most appropriate seagrass indicators to use for the pilot Mackay-Whitsunday report card. These indicators were originally selected by GBRMPA in conjunction with advice from expert working groups and the Paddock to Reef Integration Team as they provide information on the state of the seagrass to resist stressors, the potential for seagrass to recover from loss, and the condition of the environment in which the seagrass is growing. A seagrass condition index was also developed for the MMP using these three indicators.

The three seagrass indicators are:

- Abundance;
- Nutrient status; and
- Reproductive effort.

Only the inshore marine environment will include an assessment of seagrass as there are no seagrass sampling sites in the Mackay-Whitsunday report card offshore area.

2.4. Fish Indicators

The development of marine (inshore and offshore) fish indicators and methods is still progressing and is not included in the pilot report card. The indicators and scoring methods will be determined by a subgroup of the TWG specialising in fisheries knowledge, with the inclusion of any additional appropriate personnel (such as from the Queensland Department of Agriculture and Fisheries (DAF), GBRMPA, etc.). Once a draft indicator list and scoring method has been developed and documented, there will be a process of consultation with relevant regional fisheries expertise in order to finalise the process. It is most likely that three to four fish species will be selected as representatives of important species in the region for each environment (inshore or offshore), and these species will be assessed in terms of the stock status and abundance in the region.

3. Methods for Data Collection

The sections below provide an overview of the data collection methods for the various marine indicators and indices reported on in the Mackay-Whitsunday report card.

3.1. Inshore Water Quality Data Collection

Data collection methods for the water quality indicators for the pilot report card are described below. All water quality data is collected in accordance with the Queensland water quality Monitoring and Sampling Manual (EHP 2009).

Due to existing monitoring programs and coverage, the pilot report card will utilise water quality data from NQBP for the Northern reporting zone, and the MMP data for the Whitsunday and Central reporting zones.

A comprehensive baseline water quality monitoring program at Abbot Point was developed by NQBP with the purpose to inform development of environmental compliance criteria for dredging and other marine activities (Worley Parsons 2014). Key criteria in the development of the program included the selection of representative monitoring locations, identification of suitable types of monitoring, and relevant parameters to be monitored (Worley Parsons 2014). For the 2013-14 year, the program monitored water quality at 14 sites, consisting of:

- *In situ* water quality loggers at seven sites – monitoring turbidity, photosynthetic active radiation (PAR), sedimentation rate, conductivity, temperature, dissolved oxygen, and pH;
- Depth profiling at each of the 14 locations – monitoring turbidity, dissolved oxygen, conductivity, temperature, pH and depth (pressure); and
- Periodic sampling of surface waters at 14 sites (Worley Parsons 2014).

Further detail on the site locations and sampling methods can be found in Worley Parsons (2014).

The AIMS data was collected as per Thompson et al. 2014, with grab samples collected with Niskin bottles from the surface, 1 m from the seabed and from mid-water (if depth >15 m). Samples taken from the Niskin bottles were analysed for relevant parameters.

Additionally, both monitoring programs also include a range of loggers, CTD profiles and continuous *in situ* measurements, etc. as shown in Table 1.

3.2. Offshore Water Quality Data Collection

The data for the offshore assessment of water quality will be extracted from the Bureau of Meteorology (BoM) dashboard. The offshore data for the Mackay-Whitsunday region will be extracted, for the 2013-14 year. The data will be in the form of the percentage of the Mackay-Whitsunday offshore area that exceeds the relevant GBRMPA guideline.

3.3. Coral Data Collection

All coral reefs monitored were selected by either GBRMPA (for MMP/inshore) or AIMS (offshore) with expert advice, for the purposes of specific coral monitoring programs.

Inshore data was collected from seven permanently marked sites within the Mackay-Whitsunday region by AIMS through the MMP program in the 2013-14 reporting year. All seven sites (Hook, Pine, Dent, Double Cone, Reef and Daydream Islands and Seaforth and Shute Harbour) are within the Whitsunday inshore reporting zone. Inshore reefs were surveyed at depths of 2 m ('shallow') or 5 m below datum (Thompson et al. 2014).

The data collection methods for the inshore and offshore coral in the pilot report card are largely comparable. These methods are described below, and can be found in further detail in Thompson et al. (2014) and Sweatman et al. (2007).

The inshore reef monitoring consisted of five 20 m (each 5 m apart) transects along the 5 m or 2 m depth contour. Digital depth gauges and electronic tide charts (produced by the Australian Hydrographic Service) were used to determine the desired depths of 5 m and 2 m below lowest astronomical tide (LAT).

For the offshore monitoring, permanent sites on ten reefs were surveyed during the 2013-14 reporting year as part of the AIMS Long-term Monitoring Program assessment of "Effects of rezoning the GBRMP in 2004". The offshore Penrith Island site is located within the Central inshore reporting zone for the Mackay-Whitsunday report card, but the Penrith Island Reef clearly resembles a mid-shelf reef so it has been included with the offshore reefs.

Offshore reef sampling includes:

- Perimeter of each reef surveyed using manta tows; and
- Fish and seafloor organisms surveyed intensively at three sites, in a habitat that is standardised across reefs.

The intensive survey sites are located in the first stretch of continuous reef encountered when following the perimeter from the back reef zone towards the front reef in a clockwise direction, usually on the north-east flank of the reef. Sites are located at least 250 m apart, where possible, with five 50 m transects (within each site). Transects follow the reef slope parallel to the reef crest (at approximately 6-9 m depth).

The Standard Operational Procedures from the AIMS Long-term Monitoring Program were used for both inshore and offshore monitoring:

- #9: Crown-of-thorns starfish and coral surveys using the manta tow and SCUBA search techniques; and
- #10: Surveys of benthic reef communities using underwater digital photography and counts of juvenile corals.

The data collection method for the density of juveniles (number of juveniles per square metre of unoccupied suitable space) differs slightly between the inshore and offshore monitoring due to differences in algae between the habitats. These differences are:

- Offshore monitoring only records colonies up to 5 cm diameter, while the inshore (MMP) records those up to 10 cm; and
- Inshore monitoring includes the area occupied by turf algae as available space for coral settlement, while the offshore monitoring does not. This has been addressed by correcting for local density of turf algae on offshore reefs (at the site level), noting that algae are not as prevalent on offshore reefs.

It should be noted that the methods for calculating condition scores is currently under revision and will likely change for the release of the next report card in 2016. For further information on data collection methods, please refer to Thompson et al. 2014 and AIMS SOPs #9 and #10.

3.4. Seagrass Data Collection

As mentioned in Section 2.3 above, the MMP seagrass data is being relied upon for the pilot Mackay-Whitsunday report card, therefore the data collection methods are the same as for MMP and the Reef Plan report card, as described in McKenzie (2009) and McKenzie et al. (2015). The pilot Mackay-Whitsunday report card has used data collected on seagrass from the Sarina Inlet for the Central report zone, and from Pioneer Bay and Hamilton Island for the Whitsunday reporting zone.

The MMP seagrass sampling design was developed to detect change in (inshore) seagrass meadows in response to improvements in water quality parameters associated with specific catchments or regions and in context of disturbance events (McKenzie et al. 2015). The meadows monitored within the MMP were selected by the GBRMPA, using expert advice.

Mapping surveys were conducted to select representative meadows, which were those that had greater extent. They were also generally the dominant community type, and within GBR average abundances (McKenzie et al. 2015). Sampled meadows were lower littoral (rarely exposed to air) and sub littoral (permanently covered with water) (McKenzie et al. 2015). Two sites were selected at each location to account for spatial heterogeneity (McKenzie et al. 2015). Additionally, minimum detectable difference (MDD) had to be 20% (McKenzie et al. 2015).

Monitoring timing was determined by GBRMPA for the MMP, with advice from experts. Monitoring occurred during the late dry (growing) season and late wet season, in order to obtain information on the seagrass communities' status pre- and post- wet.

Methods adopted for seagrass monitoring were largely as per McKenzie et al. (2010), specifically:

- Seagrass abundance, composition, and distribution – as per standardised protocols in McKenzie et al. 2003 and McKenzie 2009;
- Reproductive health – samples processed in accordance with McKenzie et al. 2010;
- Macroalgae cover – measured according to McKenzie et al. 2010; and



- Tissue nutrient status – described in McKenzie et al. 2015.

For further information on site selection and methods, refer to McKenzie et al. 2015, McKenzie et al. 2010, and McKenzie 2009.

3.5. Fish Data

As the development of marine (inshore and offshore) fish indicators and methods is still progressing and will not be included in the pilot report card, the data collection methods are also yet to be confirmed. This information will be included in the supporting technical reports for the 2014-15 report card.

4. Development of Condition Assessments Scoring Methods

4.1. Grading for Condition Assessments

Grading needs to be scaled appropriately for each indicator, and then standardised so all indicators present the same ranges in the report card. The overall ranges used in the pilot report card are the same as those for the Reef Plan report card, shown in Table 3. However, in order to translate results for differing indices, standardising across all indices was required. The different indicators and scoring methods are described in the sections below.

Table 3. Overall range of scores (source: Reef Plan report card).

Range of index condition scores	Condition grade and colour code
81-100	Very Good
61-80	Good
41-60	Moderate
21-40	Poor
0-20	Very Poor

4.2. Decision Rules

Decision rules were developed for the minimum proportion of information required to generate the rolled up scores, as follows:

- ≥ 50% of indices to generate the indicator score
- ≥ 60% of indicators to generate the indicator category score

All overall scores will be presented in the pilot report card, even if not all indicator categories are available, however the coaster will visually show what components the overall grade is made up of, e.g. which three out of four categories.

4.3. Inshore Water Quality Condition Assessment

The formula used to translate the raw water quality monitoring results into a report card condition score is:

$$\text{Condition score} = \log_2 \text{AM} - \log_2 \text{GV}$$

Where:

- AM* means annual mean of measured values
- GV* means guideline value or target

The condition score is then translated to the report card five-point grading scale using the ranges and grades shown in Table 4. This formula and method is described in full in Thompson et al. 2013.



Table 4. Scoring ranges for results.

Condition grade and colour code	Score Range
Very Good	-0.5 – -1
Good	0 – -0.5
Moderate	0.33 – 0
Poor	0.66 – 0.33
Very Poor	1.0 – 0.66

4.3.1. Water Quality Data used in Reporting Zones

Northern inshore reporting zone

The northern inshore reporting zone utilised NQBP data for the 2013-14 year, collected as per Table 5 below.

Table 5. Water quality data collected in northern reporting zone and relevant guideline value.

Indicator	Index	Type / frequency	Guideline value (µg/L unless otherwise specified)
Nutrients	PN	Monthly	20 [^]
	PP	Monthly	2.8 [^]
	NO _x	Monthly	3 [^]
	Chl- <i>a</i>	Monthly	0.45 [*]
Water clarity	TSS (mg/L)	Monthly	2 [*]
	Turb (NTU)	Monthly	1 [*]
	Secchi (m)	N/A	10 [*]
Contaminants	Priority PSII herbicides (PAF)	Monthly	PSII-HEq method (differ by herbicide)

^{*}GBRMPA guideline value for open coast (refer to Appendix A)

[^]Qld guidelines for open coastal waters (refer to Appendix A)

Note: there is also continuous logger data available for turbidity, but for consistency, all reporting zones and parameters are using monthly data. The continuous data will be used as explanatory or supporting data in the case of any abnormalities.



Whitsunday Coast reporting zone

The Whitsunday Coast reporting zone utilised MMP data for the 2013-14 year, collected as per Table 6 below.

Table 6. Water quality data collected in Whitsunday Coast reporting zone and relevant guideline value.

Indicator	Index	Type / frequency	Guideline value (µg/L unless otherwise specified)
Nutrients	PN	Grab / 5x per year	20 [^]
	PP	Grab / 5x per year	2.8 [^]
	NO _x	Calculated from NO ₂ and NO ₃	3 [^]
	Chl- <i>a</i>	Grab / 5x per year + CTD profiles	0.45*
Water clarity	TSS (mg/L)	Grab / 5x per year	2*
	Secchi depth (m)	Grab / 5x per year	10*
	Turb (NTU)	CTD Profile / 5x per year	1*
Contaminants	Priority PSII herbicides	Passive; Grab during wet season	PSII-HEq method

*GBRMPA guideline value for open coast (refer to Appendix A)

[^]Qld guidelines for open coastal waters (refer to Appendix A)

Note: there is also continuous logger data available for chl-*a*, but for consistency, all reporting zones and parameters are using monthly data. The continuous data will be used as explanatory or supporting data in the case of any abnormalities.

Central reporting zone

In the central reporting zone the only data collected is contaminant data through the MMP for the 2013-14 year, collected as per Table 7 below.

Table 7. Water quality data collected in central reporting zone and relevant guideline value.

Indicator	Index	Type / frequency	Guideline value (µg/L unless otherwise specified)
Contaminants	Priority PSII herbicides	Passive; Grab during wet season	PSII-HEq method

Note: there is also continuous logger data available for chl-*a*, but to keep it consistent with the other data collection methods, the monthly data has been selected for inclusion. The continuous data will be used as explanatory or supporting data in the case of any abnormalities.

Southern reporting zone

No data is collected by either program within the southern reporting zone.

4.3.2. Assessment of Contaminants

In the pilot report card the assessment of contaminants analysed the priority PSII (photosystem II) herbicide concentrations using the PSII herbicide equivalent concentrations (PSII-HEq) method, as used in the MMP. In subsequent report card the ms-PAF method that is being used in the freshwater

and estuarine environments will be used in the marine environment, however at the time of the pilot report card development, the ms-PAF risk classifications for the GBR were still being finalised. The development and rationale of the new variation of the ms-PAF method is detailed in “Rationale and Revised Methods for Reporting Pesticides Using the Multisubstance – Potentially Affected Fraction (ms-PAF)” by Smith et al. (in prep).

Using the MMP methods, the PSII-HEq analysis was conducted by the National Research Centre for Environmental Toxicology (Entox). The PSII-HEq values were derived using relative potency factors (RPF) for each individual PSII herbicide with respect to a reference PSII herbicide diuron (Gallen et al. 2014). A given PSII herbicide with an RPF of 1 is equally as potent as diuron, while a more potent herbicide will have an RPF of >1 , and a less potent herbicide will be <1 (Gallen et al. 2014). To calculate the PSII-HEq concentration of a given sample (the sum of the individual RPF-corrected concentrations of each individual PSII herbicide), it is assumed that these herbicides act additively (Gallen et al. 2014).

For the Mackay-Whitsunday report card, individual herbicide concentrations from water quality sampling were provided to Entox to analyse for the different report card reporting zones. The results were then assigned categories based on the Figure 3 below and corresponding grades for the report card shown in Table 8. Refer to Gallen et al. (2014) for further details on methods.

Category	Concentration (ng L ⁻¹)	Description
5	PSII-HEq ≤ 10	No published scientific papers that demonstrate any effects on plants or animals based on toxicity or a reduction in photosynthesis. The upper limit of this category is also the detection limit for pesticide concentrations determined in field collected water samples
4	10 < PSII-HEq ≤ 50	Published scientific observations of reduced photosynthesis for two diatoms.
3	50 < PSII-HEq < 250	Published scientific observations of reduced photosynthesis for two seagrass species and three diatoms.
2	250 \leq PSII-HEq ≤ 900	Published scientific observations of reduced photosynthesis for three coral species.
1	PSII-HEq > 900	Published scientific papers that demonstrate effects on the growth and death of aquatic plants and animals exposed to the pesticide. This concentration represents a level at which 99 per cent of tropical marine plants and animals are protected, using diuron as the reference chemical.

Figure 3. Categories applied to contaminants results in the PSII-HEq assessments.

Table 8. The PSII-HEq score and corresponding grade used in the Mackay-Whitsunday report card.

PSII-HEq Index Score	Grade
5	Very Good
4	Good
3	Moderate
2	Poor
1	Very Poor

4.3.3. Weightings

The indices were equally weighted to generate the indicator score. The score for each index was assigned the median of the relevant scoring range to average into an indicator score, and then into an indicator category score for water quality. This can be amended in future report cards if there is substantial justification on why equal weighting should not be used. Following the release of the pilot report card, the indicator weightings etc. will be reviewed and refined where appropriate during the review process. Table 9 shows the relationship of indices to indicators and indicator categories, and the weightings associated. The scoring is as shown in Table 4.

Table 9. Relationship of selected indices to indicators.

Indicator Category	Indicator	Index	Weighting of index within indicator
Water Quality	Nutrients	PN	Equally, therefore 25% each
		PP	
		NO _x	
		Chl- <i>a</i>	
	Water clarity	TSS	Equally, therefore 33.3% each
		Secchi depth	
		Turbidity	
Contaminants	PSII-HEq method	Entire score	

4.4. Offshore Water Quality Condition Assessment

The offshore water quality condition assessment was scored using the same methods as the MMP (and Reef Plan report card) water quality assessments. This method uses the per cent of area in the relevant zone exceeding the relevant water quality guideline value (Table 10). The MMP uses the “Inner” or “Inshore” values to assess the GBR lagoon, while the Mackay-Whitsunday report card used the “Offshore” values as these are the relevant values for the area assessed.

Table 10. Queensland guideline values to assess the offshore water quality indices against.

Indicator	Index	Guideline value
Sediment	TSS	0.7 mg/L
Chlorophyll- <i>a</i>	Chlorophyll- <i>a</i>	0.4 µg/L

Each index score (chlorophyll-*a* and sediment) was calculated by subtracting the percentage of the area which exceeded the guideline value from 100%, with the resulting value being that percentage

of area that did NOT exceed the water quality guideline value, within the 2013 calendar year. The score was then directly translated to a report card grade using the Reef Plan report card grading (Table 3).

4.4.1. Weightings

The TSS and chlorophyll-*a* results were averaged to provide the water quality indicator category result for the offshore zone.

4.5. Coral Condition Assessment

The condition assessment of inshore and offshore coral used the same method as the MMP. The threshold values are shown in Table 11 below.

Table 11. Threshold values for the condition assessment of inshore and offshore coral. (Source: Table A1-5 from Thompson et al. 2014).

Community attribute	Assessment category	Decision rule
Combined hard and soft coral cover	+	> 50%
	neutral	between 25% and 50%
	-	< 25%
Rate of increase in hard coral cover (preceding 3 years)	+	above upper confidence interval of model-predicted change
	neutral	within confidence intervals of model-predicted change
	-	below lower confidence interval of model-predicted change
Macroalgae cover	+	< 5%
	neutral	stable between 5-15%
	-	> 15%
Density of hard coral juveniles	+	> 10.5 juvenile colonies per m ² of available substratum (2m depth), or > 13 juvenile colonies per m ² of available substratum (5m depth)
	neutral	- between 7 and 10.5 juvenile colonies per m ² of available substratum (2m depth), or - between 7 and 13 juvenile colonies per m ² of available substratum (5m depth)
	-	< 7 juvenile colonies per m ² of available substratum

The decision rules shown in Table 11 are based on what would be expected from a coral community that has had a low (or no) level of disturbance. For coral communities, this information is assumed to

be similar to the “near pristine” or “pre-European” levels used as the reference condition in the freshwater basin and estuarine etc. assessments.

The scores attributed to coral results (Table 11) were aggregated for each indicator and reef/depth combination within each reporting zone to generate the pilot report card scores. As per Thompson et al. (2014), observations for each indicator were scored on a three point scale of negative, neutral, or positive as per rules in Table 11. Results were converted to numeric scores (positive = 1, neutral = 0.5, and negative = 0), which were then averaged for each indicator to derive an indicator score. The indicator scores were then averaged to determine the score for the reporting zone on a scale of 0 to 1. These were then converted to the five-point report card scoring as per Table 12.

Table 12. Scoring ranges for aggregated coral results.

Condition grade and colour code	Score Range
Very Good	> 0.8
Good	> 0.6 – 0.8
Moderate	> 0.4 – 0.6
Poor	> 0.2 – 0.4
Very Poor	0 – 0.2

4.6. Inshore Seagrass Condition Assessment

Through the MMP, a method has been developed and documented (refer to McKenzie et al. 2015) to roll up seagrass data results into the Reef Plan reporting framework (Table 3). Each set of seagrass indicator results are analysed to provide a relevant score and grade. These scores are translated to fit the Reef Plan scoring. The scoring thresholds and their relation to the Reef Plan scoring ranges are provided for seagrass abundance in Table 13, reproductive effort in Table 14, and nutrient status in Table 15.

An overall seagrass index is then calculated by averaging the three seagrass indicator scores (scores of 0 - 100) for each reporting zone. All indicators are equally weighted.

This method has been applied to the Mackay-Whitsunday reporting zones to generate the seagrass result for the pilot report card.

Table 13. Seagrass abundance scoring thresholds in relation to condition grades (low = 10th or 20th percentile guideline). Source McKenzie et al. 2015.

Category	Score	Score Range	Condition grade
75 – 100	100	80 – 100	Very Good
50 – 75	75	60 – < 80	Good
Low – 50	50	40 – < 60	Moderate
< Low	25	20 – < 40	Poor
< Low by > 20%	0	0 – <20	Very Poor

Table 14. Seagrass reproductive effort scoring in relation to condition grades. Source McKenzie et al. 2015.

Reproductive effort Monitoring period / long-term	Ratio	Score	0-100 Score	Score Range	Condition grade
≥ 4	4.0	4	100	80 – 100	Very Good
2 to < 4	2.0	3	75	60 – < 80	Good
1 to < 2	1.0	2	50	40 – < 60	Moderate
0.5 to < 1	0.5	1	25	20 – < 40	Poor
< 0.5	0.0	0	0	0 – <20	Very Poor

Table 15. Seagrass nutrient status scoring in relation to condition grades. Source McKenzie et al. 2015.

C:N Ratio Range	Value	Score	Score Range	Condition grade
C:N ratio > 30	30	100	80 – 100	Very Good
C:N ratio 25 – 30	25	75	60 – < 80	Good
C:N ratio 20 – 25	20	50	40 – < 60	Moderate
C:N ratio 15 – 20	15	25	20 – < 40	Poor
C:N ratio <15		0	0 – <20	Very Poor

For further detail on the seagrass scoring methods, refer to McKenzie et al. 2015.

4.7. Inshore and Offshore Fish Condition Assessment

As the mentioned above, the development of marine fish indicators and methods is still progressing and is not included in the pilot report card. This information will be included in the supporting technical reports for the 2014-15 report card.

5. Development of Progress to Targets Scoring Methods

To provide information on how the region is tracking toward targets set for certain aspects, progress to targets should be presented in the report card and associated documentation. This will enable progress on a year-to-year basis to be assessed and allow comparison across years and trends to be established.

5.1. Calculating Progress to Targets

In order to provide a score in how the region is progressing toward meeting its targets, the following information is required:

- Baseline condition (i.e. a starting point);
- Current condition; and
- Target condition.

The calculation of the results of the progress to targets in each report card will use the following equation:

$$\text{Progress to target} = ((X-Z)/(X-Y))*100$$

Where:

X = Baseline

Z = current condition

Y = target

The pilot report card will be the first report card compiling these different sets of data and assessments together for the Mackay-Whitsunday region. Determining the most appropriate set of targets requires a specific body of work to identify which indicators should have targets, and what the targets (and associated timeframes) should be. Where possible, the targets established for the report card will align with available targets used in the Reef Plan report card and other relevant programs to provide consistency. The condition assessment results from the pilot report card can also be integrated in the development of appropriate targets for this region. This information will also be considered in developing the targets for subsequent Mackay-Whitsunday report cards.

6. Condition Assessment Results

6.1. Northern Inshore Reporting Zone

Water Quality

The water quality results for the northern reporting zone in the 2013-14 year are shown in Table 16 below. The score for each index was assigned the mid-point of the relevant scoring range (see Table 17) to average into an indicator score, and then into an indicator category score for water quality. The overall water quality score was moderate; water clarity scored moderate, nutrients and chlorophyll-*a* scored very poor, and contaminants scored very good. Full working can be found in Appendix B.

Table 16. Water quality results from the inshore northern reporting zone.

Indicator	Water clarity			Nutrients and chl- <i>a</i>			Contaminants
Indices	TSS	Average	-0.75	Chl- <i>a</i>	Average	0.948	VERY GOOD
		Midpoint	-0.75		Midpoint	0.825	-0.75
	Turbidity	Average	1.61	NO _x	Average	0.955	
		Midpoint	0.825		Midpoint	0.825	
Average of indices		0.0375			0.825	-0.75	
Midpoint of average		0.165			0.825	-0.75	
Water quality score	0.08						

Notes:

- The contaminants score was based on the PSII-HEq assessment, where the resulting score was category 1, lowest risk, Very Good. As per other methods employed in the report card, to standardise the results, it has been assigned the mid-point of the relevant scoring range.
- “Average” means the average score for that parameter, averaged across the three monitoring sites’ results. The score for each site was generated using annual means compared to GVs, as according to the MMP formula.
- If AM<GV: a score of -0.75 (midpoint of “Very Good” range) was attributed.

Table 17. Score ranges, grades, and midpoints.

Condition grade and colour code	Range of index condition score	Midpoint
Very Good	-0.5 - -1	-0.75
Good	0 - -0.5	-0.25
Moderate	0.33 - 0	0.165
Poor	0.66 - 0.33	0.495
Very Poor	1.0 - 0.66	0.825

Seagrass

No seagrass data was included in the pilot report card for the northern reporting zone, due to different programs utilising different seagrass methods.

Coral

No coral data was included in the pilot report card for the northern reporting zone, due to different programs utilising different coral methods.

Fish

As mentioned above, fish assessments have not been included in the pilot report card.

Overall

Water quality is the only indicator category that had data included in the 2013-14 report card in the northern reporting zone. The final score for the reporting zone is moderate, as shown in the coaster in Figure 4.

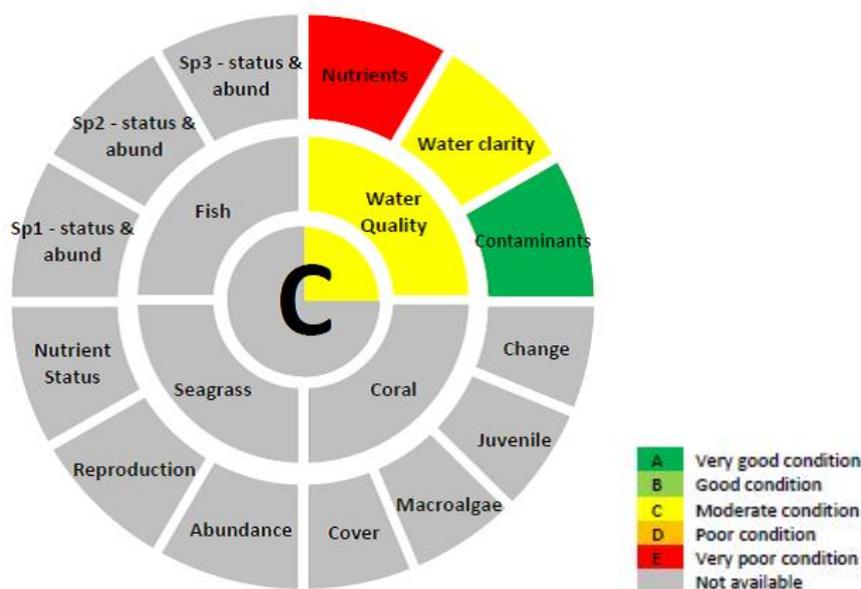


Figure 4. Results coaster for the northern inshore reporting zone.

6.2. Whitsunday Coast inshore reporting zone

Water Quality

The water quality results for the Whitsunday Coast reporting zone in the 2013-14 year are shown in Table 18 below. The score for each index was assigned the mid-point of the relevant scoring range (see Table 17) to average into an indicator score, and then into an indicator category score for water quality. The overall water quality score was moderate; water clarity scored very good, nutrients and

chlorophyll-*a* scored poor, and contaminants scored very good. Full working can be found in Appendix B.

Table 18. Water quality results from the Whitsunday Coast reporting zone.

Indicator	Water clarity			Nutrients and chl- <i>a</i>			Contaminants		
Indices	Secchi	Average	1.65	Chl- <i>a</i>	Average	0.495	VERY GOOD		
		Midpoint	0.825		Midpoint	0.495	-0.75		
	TSS	Average	0.965	NOx	Average	1.413			
		Midpoint	0.825		Midpoint	0.825			
				PN	Average	0.388			
					Midpoint	0.495			
				PP	Average	0.577			
					Midpoint	0.495			
	Average of indices			0.825				0.5775	-0.75
	Midpoint of average			0.825				0.495	-0.75
Water quality score	0.19								

Notes:

- The contaminants score was based on the PSII-HEq assessment, where the resulting score was category 1, lowest risk, Very Good. As per other methods employed in the report card, to standardise the results, it has been assigned the mid-point of the relevant scoring range.
- “Average” means the average score for that parameter, averaged across the three monitoring sites’ results. The score for each site was generated using annual means compared to GVs, as according to the MMP formula.
- If AM<GV: a score of -0.75 (midpoint of “Very Good” range) was attributed.

Coral

The results of the coral assessment for the pilot report card are shown in Table 19. All MMP coral sites in the region are within the Whitsunday Coast reporting zone. The overall grade for the Whitsunday coral was Moderate. For full results please refer to the Mackay Whitsunday results for coral within the Reef Plan report card supporting technical reports.¹

Table 19. Coral results from the Whitsunday Coast reporting zone.

Reporting zone	Cover	Macroalgae	Juvenile	Change	OVERALL Coral grade
Whitsunday Coast	Good	Good	Moderate	Very Poor	Moderate

¹ <http://www.gbrmpa.gov.au/managing-the-reef/how-the-reefs-managed/reef-2050-marine-monitoring-program/marine-monitoring-program-publications>

Seagrass

The results for the seagrass assessment for the pilot report card from Pioneer Bay and Hamilton island monitoring sites for the June 2013 to May 2014 period are shown in Table 20. Note that the Whitsunday Coast reporting zone includes both coastal and reef habitats and the index score is averaged across the habitats. All indicators as well as the overall seagrass score were assessed to be in poor condition.

Table 20. Seagrass results from the Whitsunday Coast reporting zone.

	Abundance	Reproduction	Nutrient Status	OVERALL Seagrass grade
Index Score	20	25	27	24
Grade	Poor	Poor	Poor	Poor

Values are indexed scores scaled from 0-100; ■ = very good (80-100), ■ = good (60 - <80), ■ = moderate (40 - <60), ■ = poor (20 - <40), ■ = very poor (0 - <20).

For full results please refer to the Mackay Whitsunday results for seagrass within the Reef Plan report card supporting technical reports, noting that the Reef Plan results have been split into two reporting zones for this pilot report card.

Fish

As mentioned above, fish assessments have not been included in the pilot report card.

Overall

The final coaster for the Whitsunday Coast inshore marine reporting zone is shown in Figure 4. The reporting zone was scored as moderate overall, generated from a moderate score for water quality and coral, and a poor score for seagrass.

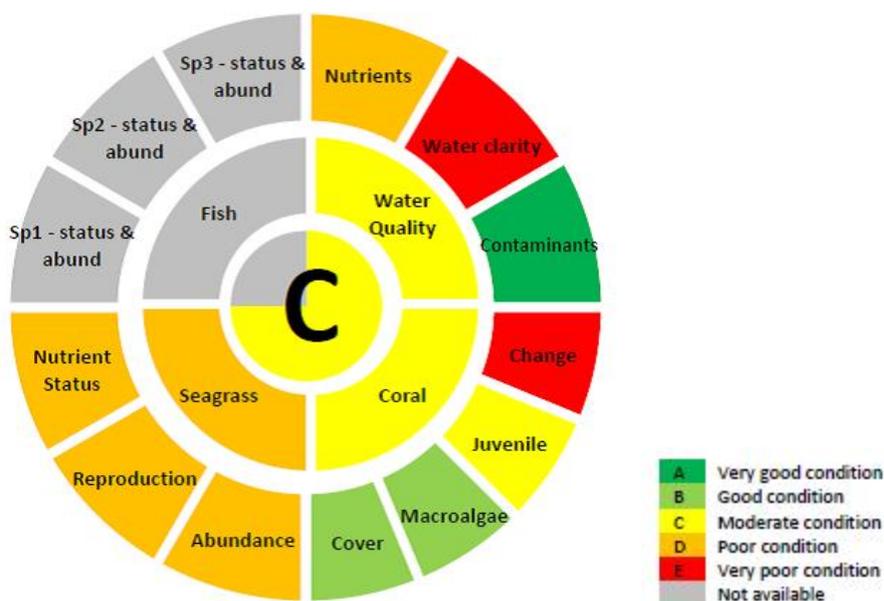




Figure 5. Results coaster for the Whitsunday Coast inshore reporting zone.

6.3. Central Reporting inshore zone

Water Quality

The only water quality parameter measured within the central zone for the 2013-14 reporting year was contaminants, with the pesticide monitoring data from the MMP. The score for contaminant was good, using the PSII-HEq method. However as per the decision rules stated in Section 4.3, an indicator category (i.e. water quality) grade cannot be generated from only one out of three indicators.

Coral

No coral data was available for the 2013-14 reporting year for the inshore central reporting zone.

Seagrass

The results for the seagrass assessment for the pilot report card from the Sarina Inlet monitoring site for the June 2013 to May 2014 period are shown in Table 20. Overall seagrass within the central reporting zone was assessed to be in poor condition. Abundance was scored as very poor, and reproduction and nutrient status as poor.

Table 21. Seagrass results from the central reporting zone.

	Abundance	Reproduction	Nutrient Status	OVERALL Seagrass grade
Index Score	13	25	39	26
Grade	Very Poor	Poor	Poor	Poor

Values are indexed scores scaled from 0-100; ■ = very good (80-100), ■ = good (60 - <80), ■ = moderate (40 - <60), ■ = poor (20 - <40), ■ = very poor (0 - <20).

For full results please refer to the Mackay Whitsunday results for seagrass within the Reef Plan report card supporting technical reports, noting that the Reef Plan results have been split into two reporting zones for this pilot report card.

Fish

As mentioned above, fish assessments have not been included in the pilot report card.

Overall

The final coaster for the central inshore marine reporting zone is shown in Figure 6. The reporting zone was scored as poor overall, generated from the poor score for seagrass.

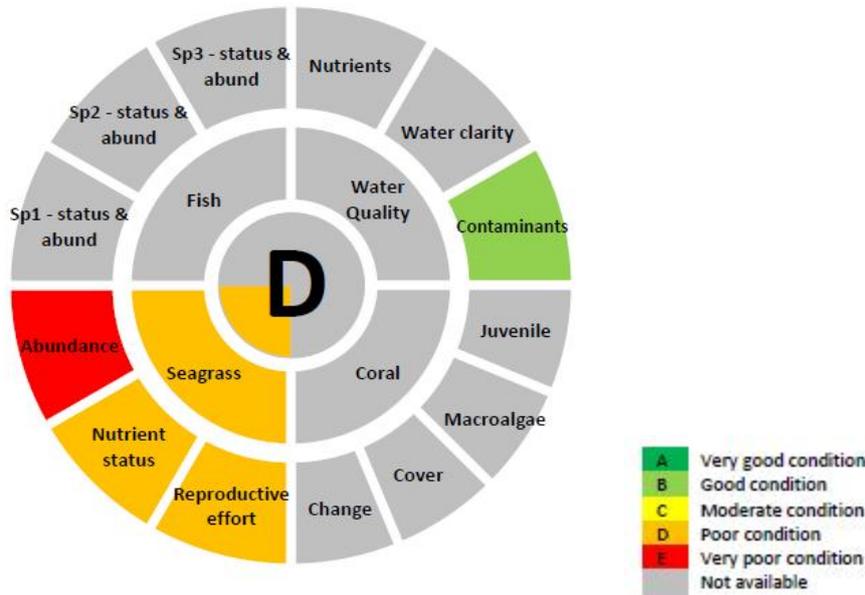


Figure 6. Results coaster for the central inshore reporting zone.

6.4. Southern reporting inshore zone

No data was collected for any of the measured indicators during the 2013-14 reporting year within the southern inshore marine zone.

6.5. Offshore reporting zone

Water Quality

The offshore water quality was assessed using the remote-sensing data and MMP (and Reef Plan report card) method. The overall water quality score was of very good condition, with both TSS and chlorophyll-a scoring very good using the scoring ranges described in Table 3 (Table 22).

Table 22. Water quality results from the offshore reporting zone.

	Chlorophyll-a		TSS		OVERALL water quality grade
	Mean % exceeding guideline	Mean % below guideline	Mean % exceeding guideline	Mean % below guideline	
Score	3	97	8	92	95
Grade		Very Good		Very Good	Very Good

Coral

The offshore coral condition for the 2013-14 reporting year was graded as moderate, based on poor scores for coral cover and macroalgae cover, a moderate score for coral change, and a good score for density of juveniles (Table 23).

Table 23. Coral results from the offshore reporting zone.

	Cover	Macroalgae cover	Juvenile density	Change	OVERALL Coral grade
Score	0.25	0.3	0.75	0.45	0.43
Grade	Poor	Poor	Good	Moderate	Moderate

Refer to Appendix C for the full results of the offshore coral assessments.

Fish

As mentioned above, fish assessments have not been included in the pilot report card.

Overall

The final coaster for the offshore marine reporting zone is shown in Figure 7. The reporting zone was scored as good overall, generated from the very good water quality score and a moderate score for coral.

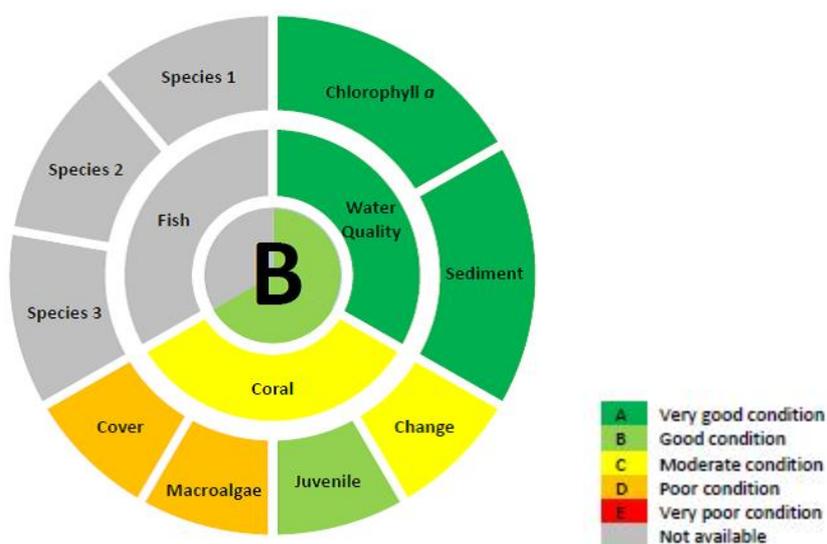


Figure 7. Results coaster for the offshore reporting zone.

6.6. Overall marine results

The overall scores for all marine (inshore and offshore) reporting zones are shown in Table 24. No fish data is available for any zone. The Whitsunday Coast reporting zone had data for three indicators, while the northern and central zones only each had data for one indicator category (water quality and seagrass, respectively). No data for any indicator category is available for the Southern reporting zone.

The central zone is reported as being in poor condition, while the north and Whitsunday Coast zones are assessed as being in moderate condition. Refer to Appendix B for all workings.

Table 24. Results for all marine reporting zones.

Reporting Zone	Water Quality	Coral	Seagrass	Fish	Overall Grade
Northern	Moderate	Not available	Not available	Not available	Moderate
Whitsunday Coast	Moderate	Moderate	Poor	Not available	Moderate
Central	Not available	Not available	Poor	Not available	Poor
Southern	Not available				
Offshore	Very Good	Moderate	-	Not available	Good

7. Confidence, Limitations, and Recommendations

7.1. Confidence Associated with Results

The marine assessment results presented in the report card and this paper have been rated in terms of the confidence surrounding the data used in the analysis. The “uncertainty” ratings developed through the Reef Plan report card have been utilised in the Mackay-Whitsunday pilot report card. The uncertainty/confidence score is based on five criteria:

- Maturity of methodology (the score is weighted half for this criteria so not to outweigh the importance of the other criteria);
- Directness of measurement;
- Spatial/temporal coverage;
- Strength of relationship between the methodology, indicator reported and measured data; and
- Measured error.

The scores for each criteria range from 1 (lowest) to 3 (highest), with the total score calculated and prescribed an overall confidence score (from 1 to 5) based on the following rules:

- 0 to <5 = one bar ranking;
- 5 to <7.5 = two bars ranking;
- 7.5 to <10 = three bars ranking;
- 10 to <12.5 = four bars ranking; and
- 12.5 to <15 = five bars ranking.

The data inputting into the marine assessments has been separately evaluated for confidence levels, due to the use of different data sets. The full ratings are shown on the assessment matrices in Appendix D, and summarised as:

- Inshore water quality (Ports – northern zone) – Score: 12.5, Number of confidence bars: 5;
- Inshore water quality (MMP – Whitsunday Coast zone) – Score: 10.5, Number of confidence bars: 4;
- Inshore seagrass – Score: 11.5, Number of confidence bars: 4;
- Inshore coral – Score: 11.5, Number of confidence bars: 4;
- Offshore water quality – Score: 6, Number of confidence bars: 2;
- Offshore coral cover – Score: 11.5, Number of confidence bars: 4;
- Offshore coral change – Score: 9.5, Number of confidence bars: 3;
- Offshore juvenile coral density – Score: 9, Number of confidence bars: 3; and
- Offshore coral macroalgae cover – Score: 11.5, Number of confidence bars: 4.

7.2. Limitations and Recommendations

Following the release of the pilot report card, the program design, indicators, and scoring methods will be reviewed to determine any aspects that require improvement.

Particular focus for the marine assessment components will be given to:

- Reviewing of all indicators, scoring ranges, and methods (with input from a statistician);
- Reviewing reference condition for all indicators and indices;
- Integrating datasets, specifically:
 - Coral datasets from the MMP (AIMS) and Ports
 - Seagrass datasets from MMP (JCU), Ports (JCU), and SeagrassWatch;
- Inclusion of the ms-PAF method for assessing pesticides, which involved consensus on the risk ranges to be adopted in the marine environment; and
- Shortlisting potential fish indicators, including:
 - Selecting key fish species and confirming appropriate data sources
 - Expert workshops
 - Consultation with all key stakeholders (recreational and commercial fishers, local marine advisory committees, Department of Agriculture and Fisheries, etc.).

It should also be noted that different scoring methods are used for assessing the freshwater and estuarine conditions to that which is used in the marine conditions assessments. Refer to the freshwater and estuarine methods and results reports for further detail on the method used in those environments. The method applied in the marine water quality condition assessments is that which is used in the MMP assessments, so is consistent with other Reef programs and reporting. However, this means there are inconsistencies in the pilot report card in terms of what the scores mean – in the freshwater and estuaries method meeting guidelines is attributed a “very good” score, whereas in the marine assessments meeting guidelines is attributed a “moderate” score. The differences between methods and merits should also be reviewed after the release of the pilot report card.

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Appendix A – Regional marine water quality guidelines

Source: Department of Environment and Heritage Protection (2009) Queensland Water Quality Guidelines, Version 3, ISBN 978-0-9806986-0-2.

Table 3.2.1b: Regional guideline values for physico-chemical indicators – Central Coast region coastal waters.
(based on the GBRMPA and the QWQG guidelines)

Water type ⁵	Physico-chemical indicators (see Appendix E) and their guideline ¹ values (slightly to moderately disturbed systems)														
	Amm N	Oxid N	Particulate N ³	Total N	FiltR P	Particulate P ³	Total P	Chl-a ²	TSS ³	Turb	Secchi ⁴	pH		DO (% satn)	
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(NTU)	(m)	lower	upper	lower	upper
Open Coastal	4	3	20	140	6	2.8	20	0.45	2	1	10	8.1	8.4	95	105
Midshelf	4	2	20	140	6	2.8	20	0.45	2	<1	10	8.1	8.4	95	105
Offshore	2	2	17	120	5	1.9	12	0.4	0.7	<1	17	8.1	8.4	95	105



Appendix B – Workings for inshore marine zones

Marine Water Quality Scoring sheet

Condition score = $\log_2 AM - \log_2 GV$
 Where:
 AM means annual mean of measured values
 GV means guideline value or target

USING MIDPOINTS

Ports - Northern Reporting Zone																					
Monthly Grab samples	Monthly means																				
Indice	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Annual mean	Log2 AM	GV	Log2 GV	Score	Midpoint of score	Average of indices	Midpoint of average	Overall Score
PN																					
PP																					
NOx			2.67	10.78	5.78		5.17	6.11	5.11		5.11		5.82	2.54	3	1.584963	0.95543	0.825	0.825	0.825	0.08
Chl-a			0.56	0.69	0.83		0.67	0.61	2.22		0.50		0.87	-0.20	0.45	-1.152	0.94786	0.825	0.825	0.825	
TSS (mg/L)			1.00	1.00	1.08		1.08	1.69	1.00		1.31		1.16	0.22	2	1	-0.75	-0.75	-0.75	-0.75	
Turb (NTU)	0.00	0.00	4.00	5.39		4.59	3.82	4.08		3.11	2.48		3.05	1.61	1	0	1.60938	0.825	0.825	0.0375	
Secchi (m)																					
Priority PSII herbicides (PAF)			0.186039	0.186039	0.186039		0.18604	0.361682	0.186039		0.186039	0.18604	0.20799438	-2.26538	1	0	-0.75	-0.75	-0.75	-0.75	

Grade	Score	midpoint
VG	-0.5 - -1	-0.75
G	0 - -0.5	-0.25
M	0.33 - 0	0.165
P	0.66 - 0.33	0.495
VP	1.0 - 0.66	0.825

OLD_NAME	SAMPLE_DATE	STATION_CLASS	SECCHI_DEPTH	Secchi AM	AM log 2	Secchi GV	GV log 2	Secchi score	Adj secchi
Daydream/West Molle Island	04-Oct-13	at logger	2.5						
Daydream/West Molle Island	11-Feb-14	at logger	1.5						
Daydream/West Molle Island	25-Jun-14	at logger	4	2.6666667	1.4150375	10	3.32192809	-1.9068906	1.9068906
Double Cone Island	06-Oct-13	at logger	2.5						
Double Cone Island	10-Feb-14	at logger	4						
Double Cone Island	26-Jun-14	at logger	5	3.83333333	1.93859946	10	3.32192809	-1.38332864	1.38332864
Pine Island	05-Oct-13	at logger	2.5						
Pine Island	12-Feb-14	at logger	1.5						
Pine Island	24-Jun-14	at logger	5.5	3.16666667	1.66296501	10	3.32192809	-1.65896308	1.65896308

Averaged sites midpoint for grade av of indices

OLD_NAME	SAMPLE_DATE	STATION_CLASS	Avg TSS(mg/l)	TSS AM	AM log 2	TSS GV	GV log 2	TSS score
Daydream/West Molle Island	04-Oct-13	at logger	2.54					
Daydream/West Molle Island	11-Feb-14	at logger	6.64					
Daydream/West Molle Island	25-Jun-14	at logger	1.69	3.62	1.85731753	2	1	0.85731753
Double Cone Island	06-Oct-13	at logger	2.64					
Double Cone Island	10-Feb-14	at logger	2.76					
Double Cone Island	26-Jun-14	at logger	2.04	2.48	1.30937024	2	1	0.30937024
Pine Island	05-Oct-13	at logger	6.24					
Pine Island	12-Feb-14	at logger	11.73					
Pine Island	24-Jun-14	at logger	1.90	6.62	2.72761797	2	1	1.72761797

0.96476858 0.825 0.825

OLD_NAME	SAMPLE_DATE	STATION_CLASS	Avg CHL (ug/l)	chl-a AM	AM log 2	chl-a GV	GV log 2	chl-a score
Daydream/West Molle Island	04-Oct-13	at logger	0.70					
Daydream/West Molle Island	11-Feb-14	at logger	0.84					
Daydream/West Molle Island	25-Jun-14	at logger	0.36	0.64	-0.6551715	0.45	-1.15200309	0.49683159
Double Cone Island	06-Oct-13	at logger	0.67					
Double Cone Island	10-Feb-14	at logger	0.89					
Double Cone Island	26-Jun-14	at logger	0.43	0.66	-0.59662319	0.45	-1.15200309	0.5553799
Pine Island	05-Oct-13	at logger	0.53					
Pine Island	12-Feb-14	at logger	0.87					
Pine Island	24-Jun-14	at logger	0.42	0.61	-0.71843032	0.45	-1.15200309	0.43357277

0.49526142 0.495

OLD_NAME	SAMPLE_DATE	STATION_CLASS	av NOx	NOx AM	AM log 2	NOx GV	GV log 2	NOx score
Daydream/West Molle Island	04-Oct-13	at logger	2.66					
Daydream/West Molle Island	11-Feb-14	at logger	16.87					
Daydream/West Molle Island	25-Jun-14	at logger	1.94	7.16	2.83933818	3	1.5849625	1.25437568
Double Cone Island	06-Oct-13	at logger	3.10					
Double Cone Island	10-Feb-14	at logger	18.26					
Double Cone Island	26-Jun-14	at logger	0.90	7.42	2.89137382	3	1.5849625	1.30641132
Pine Island	05-Oct-13	at logger	4.41					
Pine Island	12-Feb-14	at logger	20.80					
Pine Island	24-Jun-14	at logger	3.62	9.61	3.26440632	3	1.5849625	1.67944382

1.41341027 0.825

OLD_NAME	SAMPLE_DATE	STATION_CLASS	Avg PN_SHIM_ugL-1	PN AM	AM log 2	PN GV	GV log 2	PN score
Daydream/West Molle Island	04-Oct-13	at logger	20.97					
Daydream/West Molle Island	11-Feb-14	at logger	40.34					
Daydream/West Molle Island	25-Jun-14	at logger	13.69	25.00	4.64373692	20	4.32192809	0.32180883
Double Cone Island	06-Oct-13	at logger	24.82					
Double Cone Island	10-Feb-14	at logger	28.56					
Double Cone Island	26-Jun-14	at logger	22.85	25.41	4.66736421	20	4.32192809	0.34543612
Pine Island	05-Oct-13	at logger	24.63					
Pine Island	12-Feb-14	at logger	38.17					
Pine Island	24-Jun-14	at logger	21.80	28.20	4.81754396	20	4.32192809	0.49561586

0.38762027 0.495

OLD_NAME	SAMPLE_DATE	STATION_CLASS	Avg PP_ugL-1	PP AM	AM log 2	PP GV	GV log 2	PP score
Daydream/West Molle Island	04-Oct-13	at logger	3.39					
Daydream/West Molle Island	11-Feb-14	at logger	6.90					
Daydream/West Molle Island	25-Jun-14	at logger	2.18	4.16	2.05512912	2.8	1.48542683	0.56970229
Double Cone Island	06-Oct-13	at logger	3.29					
Double Cone Island	10-Feb-14	at logger	4.40					
Double Cone Island	26-Jun-14	at logger	2.73	3.47	1.79619626	2.8	1.48542683	0.31076943
Pine Island	05-Oct-13	at logger	4.50					
Pine Island	12-Feb-14	at logger	8.05					
Pine Island	24-Jun-14	at logger	2.59	5.05	2.33492576	2.8	1.48542683	0.84949893

0.57665688 0.495 0.5775

Coral scores directly from Reef Plan results

	Coral Cover	Coral Change	Algae	Juvenile	Coral Grade
Mackay Whitsundays	61	18	79	46	51
	Good	Very Poor	Good	Moderate	Moderate

*Note - only for Whitsunday Reporting Zone

Seagrass scores - from Reef Plan data, split into WSC and Central zones by Len McKenzie

Report card for seagrass status (community & environment) in the Mackay Whitsunday region: June 2013 - May 2014. Values are indexed scores scaled from 0-100; ■ = very good (80-100), ■ = good (60 - <80), ■ = moderate (40 - <60), ■ = poor (20 - <40), ■ = very poor (0 - <20)

Habitat	Location	Zone	Abundance	Reproductive Effort	Nutrient status (C:N ratio)	Seagrass Index [^]
estuarine intertidal	Sarina Inlet	Central	13	25	39	26
coastal intertidal	Pioneer Bay	Whitsunday	20	25	27	24

Inshore Marine Workings

WATER QUALITY			
Zone	Nutrients & Chl-a	Water Clarity	Contaminants
Northern	0.825	0.0375	-0.75
Whitsunday Coast	0.5775	0.825	-0.75
Central	N/A	N/A	N/A
South	N/A	N/A	N/A
midpoint allocation			
Northern	0.825	0.165	-0.75
Whitsunday Coast	0.495	0.825	-0.75
Central	N/A	N/A	N/A
South	N/A	N/A	N/A

Beer Coaster	
Average score	Assessment
0.080	M
0.190	M
N/A	N/A
N/A	N/A

Water quality scores and ranges

Condition grade and colour code	Score Range	midpoint
Very Good	-0.5 -- -1	-0.75
Good	0 -- -0.5	-0.25
Moderate	0.33 -- 0	0.165
Poor	0.66 -- 0.33	0.495
Very Poor	1.0 -- 0.66	0.825

Coral				
Zone	Coral Cover	Coral Change	Algae	Juvenile
Northern	N/A	N/A	N/A	N/A
Whitsunday Coast	61	18	79	46
Central	N/A	N/A	N/A	N/A
South	N/A	N/A	N/A	N/A
midpoint allocation				
Northern	N/A	N/A	N/A	N/A
Whitsunday Coast	70	10	70	50
Central	N/A	N/A	N/A	N/A
South	N/A	N/A	N/A	N/A

Beer Coaster	
Average score	Assessment
N/A	N/A
50.00	M
N/A	N/A
N/A	N/A

Other attributes scores and ranges

Range of index condition scores	Condition grade and colour code	midpoint
81-100	Very Good	90
61-80	Good	70
41-60	Moderate	50
21-40	Poor	30
0-20	Very Poor	10

Seagrass			
Zone	Abundance	Repro Effort	Nutrient Status
Northern	N/A	N/A	N/A
Whitsunday Coast	20	25	27
Central	13	25	39
South	N/A	N/A	N/A
midpoint allocation			
Northern	N/A	N/A	N/A
Whitsunday Coast	30	30	30
Central	10	30	30
South	N/A	N/A	N/A

Beer Coaster	
Average score	Assessment
N/A	N/A
30.00	P
23.33	P
N/A	N/A

WATER QUALITY & CORAL & SEAGRASS			
Zone	Water Quality	Coral	Seagrass
Northern	M	N/A	N/A
Whitsunday Coast	M	M	P
Central	N/A	N/A	P
South	N/A	N/A	N/A
using midpoints			
Zone	Water Quality	Coral	Seagrass
Northern	50	N/A	N/A
Whitsunday Coast	50	50	30
Central	N/A	N/A	30
South	N/A	N/A	N/A

Beer Coaster	
Average score	Assessment
50	M
43.33	M
30.00	P
N/A	N/A



Appendix C – Offshore zone coral results

Background

Ten reefs were surveyed in 2013-14 as part of the AIMS Long-term Monitoring Program's assessment of "Effects of rezoning the GBRMP in 2004". Penrith Island falls just within the Central inshore zone but Penrith Island Reef clearly resembles a midshelf reefs so has been included with the other reefs in the offshore reporting zone.

Combined hard and soft coral cover

Table D1. Assessment criteria for reef condition based on cover of hard and soft corals used by GBR Report card

Community attribute	Assessment category	Decision rule
Combined hard and soft coral cover	+	> 50%
	neutral	between 25% and 50%
	-	< 25%

Coral cover is the most widely used indicator of reef condition, and clearly reefs with high cover of diverse corals are likely to occur where conditions are suitable for reef growth and to represent substantial breeding populations. AIMS has monitored some reefs of the GBR for more than 20 years. The distribution of maximum coral cover values recorded on individual midshelf and outer reefs across the GBR are shown in Figure D1. Figure D2 gives the maximum coral cover values that have been recorded on reefs in the Mackay-Whitsunday offshore zone. Coral cover on the offshore reefs is generally low compared with the combined coral cover on inshore sites monitored by the MMP in 2005, which are the basis for the assessment categories.

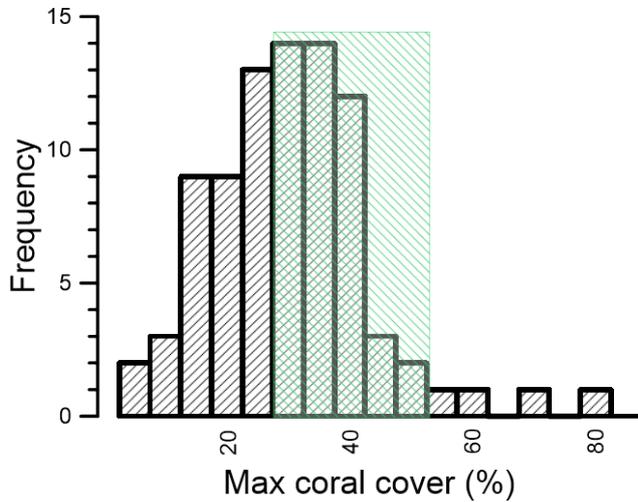


Figure D1. Observed frequency of the maximum average values of cover of hard corals and soft corals combined recorded on each midshelf and outer-shelf reef surveyed by AIMS since 1992. Green hatched box shows the range of “Neutral values” as used in the GBR Report Card.

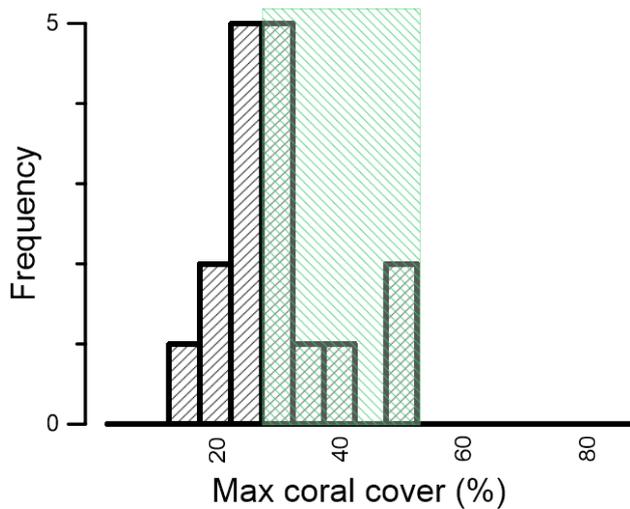


Figure D2. Observed frequency of the maximum average values of cover of hard corals and soft corals combined recorded on each midshelf and outer-shelf reef surveyed by AIMS in the MWHR2R offshore zone since 1992. Green hatched box shows the range of “Neutral values” as used in the GBR Report Card.

Table 2 Mean cover of hard and soft coral combined on reefs in the MWHR2R offshore zone in 2013-14. Following the GBR Report card scoring the region average for reef condition is poor (>0.2-0.4).

Reef Number	REEF_NAME	Avg Coral Cover (%)	Assessment category	Score
20309S	TERN REEF(20309)	38.03	N	0.5
20348S	20348S	17.43	-	0
20351A	POMPEY REEF (NO 1)	46.68	N	0.5
20351B	POMPEY REEF (NO 2)	31.93	N	0.5
20353S	20353S	19.53	-	0
21025S	PENRITH IS REEF	41.43	N	0.5
21060S	21060S	6.97	-	0
21062S	21062S	14.93	-	0
21064S	21064S	12.29	-	0
21591S	21591S	49.70	N	0.5
			Overall score	0.25

Change in coral cover

The coral cover at a site depends on suitable conditions for coral growth and the history of disturbance, so high coral cover usually indicates a healthy and self-sustaining reef, but, rather than indicating the reverse, low coral cover may be due to recent disturbance. The rate of increase in coral cover may be a better indicator of community condition, at least in the early period following disturbance. This indicator uses a multi-species version of the Gompertz growth equation that accounts for the local community composition to predict mean growth (with some variance). Because recent studies suggest that coral cover has been in decline over the long term, only observed growth rates that are higher than the upper 95% confidence interval for predicted growth are considered to be positive, observed rates within the 95% confidence range for modelled growth are considered neutral, and observed rates below the 95% confidence range are rated as negative (Table D3), all based on three years of observations up to the latest surveys (2014).

Table D3. Assessment criteria for reef condition based on cover of change in coral cover used by GBR Report card.

Community attribute	Assessment category	Decision rule
Rate of increase in hard coral cover (preceding 3 years)	+	above upper confidence interval of model-predicted change
	neutral	within confidence intervals of model-predicted change
	-	below lower confidence interval of model-predicted change

One reef, Reef 21-062S, had outbreak densities of *Acanthaster planci*, the crown-of-thorns starfish. Since any coral growth was confounded with losses from starfish predation, coral change was not estimated for this reef. While coral change was lower than predicted by the model on all nine of the other reefs, it was within the 95% confidence band in each case, giving an aggregate score of “moderate” (Table D4).

Table D4. Comparison of observed and modelled values of coral change on reefs in the MWHR2R offshore zone in 2013-14. Following the argument above, the region average score for reef condition is moderate (>0.4-0.6). Note that Reef 21-062S had outbreak numbers of crown-of-thorns starfish and so was excluded.

Reef Number	REEF_NAME	Change in cover		Assessment category	Score
		Observed	Avg Predicted		
20309S	TERN REEF	-0.14	2.17	N	0.5
20348S	20348S	0.41	1.84	N	0.5
20351A	POMPEY REEF (NO 1)	2.08	2.75	N	0.5
20351B	POMPEY REEF (NO 2)	2.03	2.39	N	0.5
20353S	20353S	1.63	1.92	N	0.5
21025S	PENRITH REEF	-0.93	1.65	N	0.5
21060S	21060S	-0.30	1.18	N	0.5
21062S	21062S	-	-	-	-
21064S	21064S	0.54	1.36	N	0.5
21591S	21591S	1.04	1.84	N	0.5
Overall Score					0.45

Macroalgae cover

Table D5. Assessment criteria for reef condition based on cover of macroalgae used by GBR Report card.

Community attribute	Assessment category	Decision rule
Macroalgae cover	+	< 5%
	neutral	stable between 5-15%
	-	> 15%

Macroalgal cover is one variable which is very likely to differ between inshore and offshore reefs. While certain types of algae bloom immediately after cyclones rearrange sediments and rubble and presumably release nutrients in the process, macroalgal cover is very low at other times. The modal value for cover of macroalgae based on all offshore reefs surveyed in each year by the AIMS LTMP is between zero and 1.0% (Figure D3, Figure D4). Offshore reefs in the Mackay Whitsunday region show a similar pattern (Figure D5).

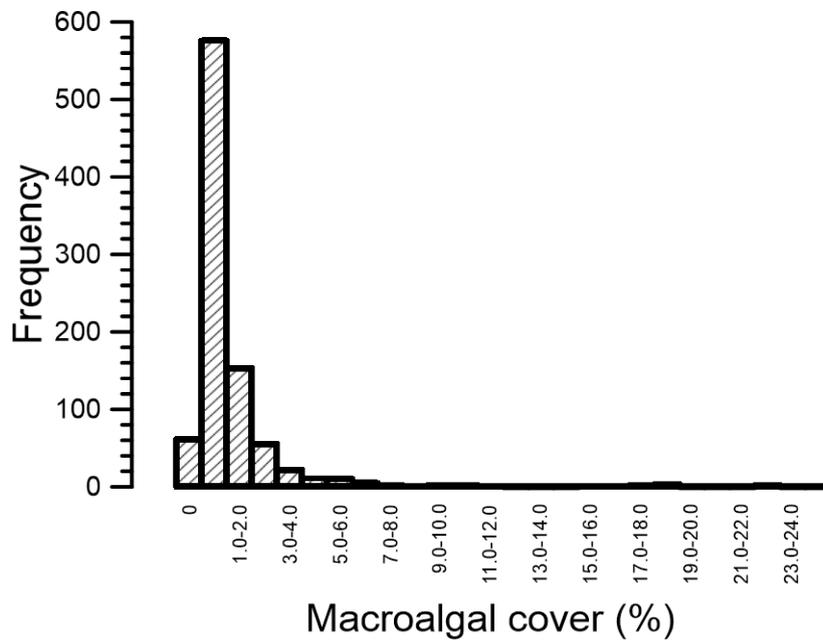


Figure D3. Observed frequency of values for cover of macroalgae on all midshelf and outer-shelf reef surveyed by AIMS in all years since 1992.

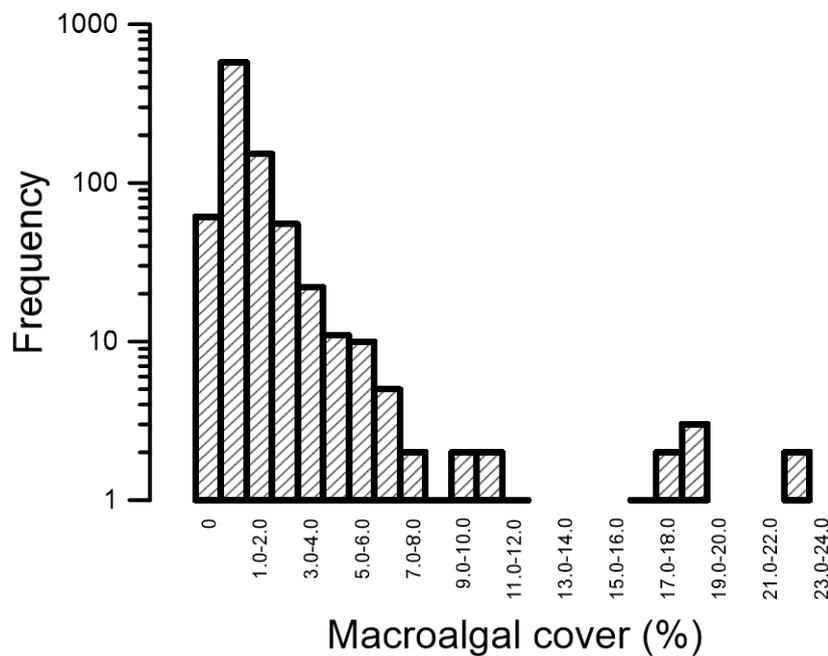


Figure D4. Observed frequency of values for cover of macroalgae on all midshelf and outer-shelf reef surveyed by AIMS in all years since 1992 (as in Fig 3), frequencies plotted on a log scale.

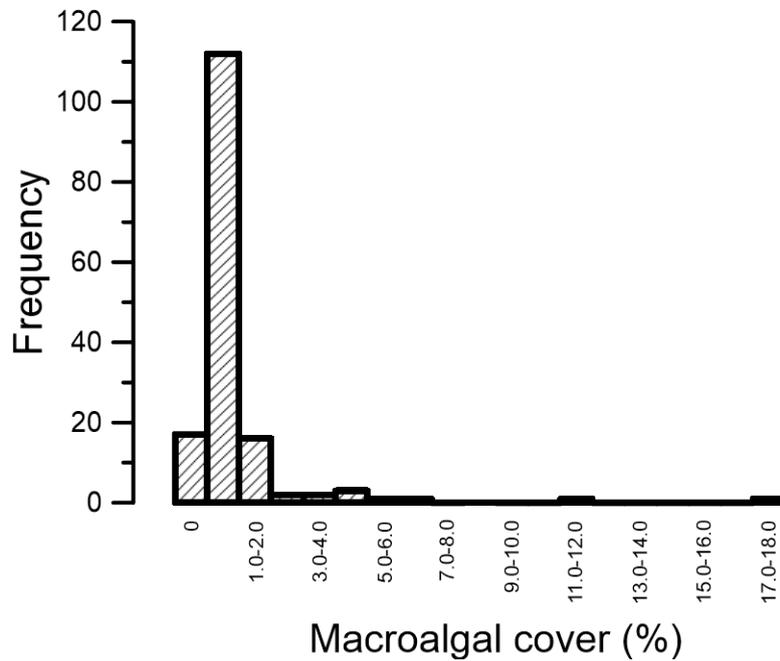


Figure D5. Observed frequency of values for cover of macroalgae on midshelf and outer-shelf reef in the Mackay-Whitsunday offshore area surveyed by AIMS in all years since 1992.

On this basis (considering that low cover of macroalgae is considered a desirable state) we propose the alternative “decision rules” for offshore reefs (Table D6).

Table D6. Decision rules for scoring reef condition based on cover of macroalgae on reefs in the Mackay-Whitsunday offshore zone.

Community attribute	Assessment category	Decision rule	
		GBR report card (inshore reefs)	MWHR2R Report card Offshore Reefs
Macroalgae cover	+	< 5%	0%
	neutral	stable between 5-15%	0.1-2.0%
	-	> 15%	>2.0%

Table D7. Mean cover of macroalgae on reefs in the MWHR2R offshore zone in 2013-14. Following the argument above, the region average score for reef condition is poor (>0.2-0.4).

Reef Number	REEF_NAME	Avg macroalgae cover (%)	Assessment category	Score
20309S	TERN REEF	0.40	N	0.5
20348S	20348S	0.03	N	0.5
20351A	POMPEY REEF (NO 1)	2.10	-	0
20351B	POMPEY REEF (NO 2)	3.13	-	0
20353S	20353S	1.10	N	0.5
21025S	PENRITH REEF	0.57	N	0.5
21060S	21060S	5.80	-	0
21062S	21062S	0.39	N	0.5
21064S	21064S	3.99	-	0
21591S	21591S	0.17	N	0.5
			Overall Score	0.30

Density of juvenile corals

The presence of juvenile corals is a prerequisite for population replacement and for recovery after disturbance, but little is known of coral demographics and hence what density of juveniles indicates a healthy community. In any case, the observed density of juveniles may be constrained by available space in which to settle, since some of the substrate is likely to be unsuitable for juveniles (e.g. sand) or else be already occupied by hard or soft corals. For this reason the densities have been corrected to numbers of juveniles per m² of unoccupied, suitable space. There are two differences between the offshore monitoring and the MMP coral monitoring; the offshore monitoring only records colonies up to 5 cm diameter while the MMP records those up to 10 cm. Secondly, the MMP includes the area occupied by macroalgae as available space for coral settlement, while the offshore monitoring does not. This in part reflects the differences in algae between inshore and offshore habitats in that inshore the macroalgae may be larger and easily permit corals to settle underneath. The latter point has been addressed by correcting for local density of macroalgae on offshore reefs (at the site level), noting that macroalgae are not as prevalent on offshore reefs.

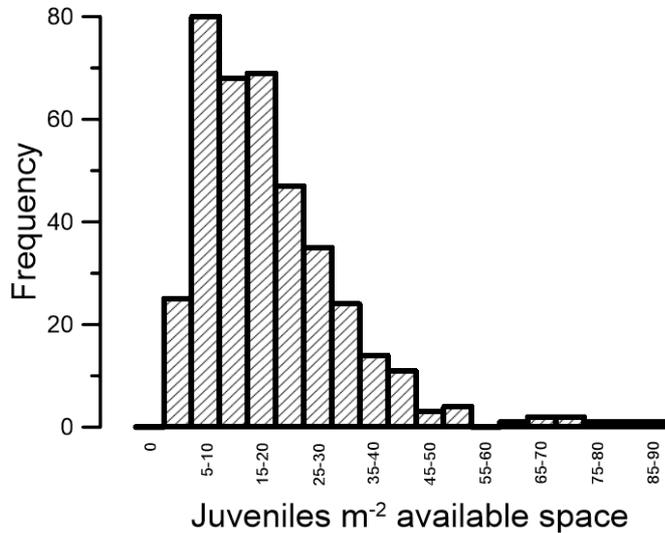


Figure D6. The frequency distribution of densities of juvenile hard corals up to 5 cm in diameter on all offshore GBR reefs monitored by AIMS. Median value = 16.45 m⁻², quartiles (delimiting the central 50% of observations) = 9.65 - 25.38 m⁻².

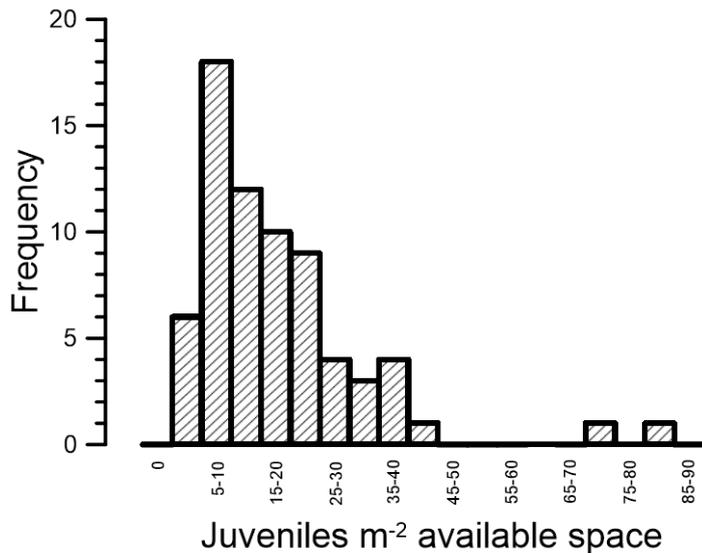


Figure D7. The frequency distribution of densities of juvenile hard corals up to 5 cm in diameter on offshore reefs in the Mackay-Whitsunday region. Median value = 13.37 m⁻², quartiles (delimiting the central 50% of observations) = 8.45 - 21.40 m⁻².

On the basis of observed distribution of juvenile densities, and taking the quartiles as cut-points, offshore reefs in the Mackay-Whitsunday area have medium or high densities of juveniles giving an average score of “Good” (Table D8).

Table D8. Mean densities of juvenile corals (<5cm diameter) per square metre of available space on reefs in the MWHR2R offshore zone in 2013-14. Based on the frequency of densities that have been recorded from offshore reefs on the GBR (Figure 6), reefs in the region have either average or high densities of juveniles, giving an average score for reef condition of good (0.6-0.8).

Reef Number	REEF_NAME	Avg juvenile corals m ⁻²	Assessment category	Score
20309S	TERN REEF	35.27	+	1.0
20348S	20348S	25.25	N	0.5
20351A	POMPEY REEF (NO 1)	31.56	+	1.0
20351B	POMPEY REEF (NO 2)	71.10	+	1.0
20353S	20353S	20.93	N	0.5
21025S	PENRITH REEF	81.38	+	1.0
21060S	21060S	20.35	N	0.5
21062S	21062S	21.66	N	0.5
21064S	21064S	21.40	N	0.5
21591S	21591S	30.85	+	1.0
			Overall Score	0.75

Overall result

The overall result for offshore coral condition was calculated by applying the grades shown in Table D9, and then calculating the average of the four indicators, as shown in Table D10.

Table D9. Scoring ranges for coral results.

Condition grade and colour code	Score Range
Very Good	>0.8
Good	>0.6 – 0.8
Moderate	>0.4 – 0.6
Poor	>0.2 – 0.4
Very Poor	0 – 0.2

Table D10. Scoring ranges for coral results.

Indicator	Score
Coral cover	0.25
Change in cover	0.45
Macroalgae cover	0.3
Density of juveniles	0.75
OVERALL SCORE	0.43



Appendix D – Confidence ratings for marine indicators

Table A3. Confidence ratings associated with inshore water quality data collected through the MMP program (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
1 x 0.5 = 0.5	3	1	3	2
Total score				10.5
Number of confidence bars				4



HEALTHY RIVERS TO REEF PARTNERSHIP

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Table A4. Confidence ratings associated with inshore water quality data collected through the NQBP program (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
3x0.5 = 1.5	3	2	3	3
Total score				12.5
Number of confidence bars				5



Table A5. Confidence ratings associated with inshore coral data (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
3 x0.5 = 1.5	3	2	2	2
Total score				11.5
Number of confidence bars				4



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Table A6. Confidence ratings associated with inshore seagrass data (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
3x0.5 = 1.5	3	2	3	2
Total score				11.5
Number of confidence bars				4



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Table A7. Confidence ratings associated with offshore water quality data (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
2 x 0.5 = 1	1	2	1	1
Total score				6
Number of confidence bars				2



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Table A8. Confidence ratings associated with offshore coral cover data (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
3 x 0.5 = 1.5	3	1	3	3
Total score				11.5
Number of confidence bars				4



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Table A9. Confidence ratings associated with offshore coral change data (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
3 x 0.5 = 1.5	3	1	2	2
Total score				9.5
Number of confidence bars				3



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Table A10. Confidence ratings associated with offshore coral juvenile density data (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
2 x 0.5 = 1	2	1	3	2
Total score				9
Number of confidence bars				3



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Table A11. Confidence ratings associated with offshore coral macroalgae data (highlighted cells indicate the relevant assessment for this data).

Maturity of methodology (weighting 0.5)	Directness of measurement	Spatial/temporal	Strength of relationship between Methodology, indicator reported and measured data	Measured error
New or experimental methodology	Remote sensed data with no or limited ground truthing OR Modelling with no ground truthing OR Survey with no ground truthing	1:1,000,000 OR 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	Remote sensed data with regular ground truthing (not comprehensive) OR Modelling with documented validation (not comprehensive) OR Survey with ground-truthing (not comprehensive)	1:100,000 OR 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	Remote sensed data with comprehensive validation program supporting (statistical error measured) OR Modelling with comprehensive validation and supporting documentation OR Survey with extensive on ground validation or directly measured data	1:10,000 OR 30-50% of population	Direct measurement of reported indicator with error	Less than 10% error
3x0.5 = 1.5	3	1	3	3
Total score				11.5
Number of confidence bars				4