Great Barrier Reef

Report Card 2012 and 2013

Reef Water Quality Protection Plan

Methods

Australian Government

Queensland Government

Methods

This report details how the key indicators were measured for Report Card 2012 and 2013. Ongoing improvements will be made to the methods and data sources to improve the accuracy and precision of reporting over time.

Management practices methods

This report details the per cent of landholders who improved practices between 2009 and 2013. The status of each industry under the ABCD management practice reporting framework as at 2012 and 2013 is also presented.

Management practice frameworks

ABCD management practice frameworks (rated from A to D for reporting purposes) describe a continuum of practices that are recommended to maintain and/or improve water quality and land resource condition. A group of specific management practices together describe a management system.

For cropping systems, the ABCD framework details management practices and systems for managing nutrients, herbicides and soils. For grazing systems, the framework describes practices impacting upon land condition, soil erosion and water quality.

Management practice system ABCD classes and definitions for sugarcane, horticulture and grains (Source: Drewy J, et al., 2008)

Class	Description of practice	Farm management plan	Community and industry standard	Effect on resource condition	Effect on profitability
A	Cutting-edge practices that require further validation of environmental, social and economic costs/benefits	Yes, develops and tests innovative technology.	When validated is an acceptable practice for the long term. (May not be universally endorsed as feasible by industry and community.)	When validated, practice likely to achieve long term resource condition goals if widely adopted.	When validated, improves profitability in the medium to long term. (May reduce profitability during the transition.)
B	Currently promoted practices often referred to as 'Best Management Practices'.	Yes, and utilises common technology.	Acceptable practice for the medium term.	Practice likely to achieve medium term resource condition goals if widely adopted.	Improves profitability in the short to medium term.
C	Common practices. Often referred to as 'Code of Practice'.	Basic.	Acceptable practice today but may not be acceptable in medium term.	Practice unlikely to achieve acceptable resource condition goals if widely adopted.	Decline of profitability in the medium to long term.
D	Practices that are superseded or unacceptable by industry and community standards.	None.	Superseded or unacceptable practice today.	Practice likely to degrade resource condition if widely adopted.	Decline of profitability in the short to medium term.

Management practice system ABCD classes and definitions for grazing

	A	B	C	D
Management practice category	Practices are highly likely to maintain land in good (A) condition and/or improve land in lesser condition	Practices are likely to maintain land in good or fair (A/B) condition and/or improve land in lesser condition	Practices are likely to degrade some land to poor (C) condition or very poor (D) condition	Practices are highly likely to degrade land to poor (C) or very poor (D) condition
Soil erosion and water quality risk associated with grazing land management	Very low risk	Low risk	Low to moderate risk	Moderate to high risk

It is important to note that not all improved management practices result in a change in management practice system (rated from A to D for reporting purposes). This means that the number of landholders estimated to have improved management practices will typically be greater than the number estimated to have improved management systems.

Grazing

Management practice framework

The ABCD management practice framework for the grazing industry describes management practices based on their likely impacts upon land condition, soil erosion and water quality.

Data collection and synthesis

Collated datasets were reviewed by expert panels at the regional level when developing the 2009 and 2010 Report Cards. These expert panels identified data gaps and errors, and provided advice on the appropriate interpretation of management change resulting from the various drivers of management practice change. These reviews developed a small suite of change drivers (capacity building services) which contributed to management practice improvements, and a further subset which are credited with achieving overall management system improvements.

Management system improvements are restricted to:

- completed Reef Rescue Water Quality grants projects (generally including training plus hard infrastructure improvements)
- a smaller group of highly intensive training/consultancy courses
- a small selection of Natural Resource Management body and/or Queensland Government extension projects with documented impacts of management system change.

Any management changes which graziers have implemented without direct influence or assistance from recognised service providers has not been captured. As such, the results are likely to be a conservative estimate of the degree of management practice improvement.

Sugarcane

Management practice framework

The ABCD management practice framework for the sugarcane industry includes practices relating specifically to nutrients, herbicides, soils, on-farm water management (irrigation and drainage), record keeping and planning.

Data collection and synthesis

There were no consistent industry wide systems in place for collecting data on the adoption of improved land management practices in the sugarcane industry between 2008 and 2011. As such, the only reliable source of data is the Reef Rescue Water Quality Grants program. Management system changes identified in this Report Card are restricted to those identified by regional Natural Resource Management bodies as an outcome of completed Reef Rescue Water Quality Grants projects, which generally include planning and/or training plus hard equipment or infrastructure improvements.

Any management changes which sugarcane growers have implemented without direct influence or assistance from regional Natural Resource Management bodies and the Reef Rescue initiative were not captured, with the exception of growers engaged in the Queensland Government's *Reefocus* extension program in 2012 and 2013. Therefore, the degree of change reported in Report Card 2012 and 2013 is likely to be a conservative estimate. Similarly, regional Natural Resource Management bodies, through the Reef Rescue program, have in several instances directed funding toward projects which are likely to have significant industry-wide benefits. These are meritorious investments for which little impact evaluation information exists.

Horticulture

Improved land management practices are described within the Growcom Farm Management System (FMS) - the accepted industry best practice program - and Natural Resource Management body ABCD management practice frameworks.

Management practice frameworks

Practical application of ABCD management practice frameworks in an industry as diverse as horticulture means there are variations in the practices described for different crops or climatic zones. The Burnett Mary, Fitzroy, Mackay Whitsunday and Cape York regions share a common ABCD management practice framework for horticulture. In the Burdekin region, the ABCD framework developed and used by NQ Dry Tropics specifically serves the regional production system, while remaining similar to other frameworks. In the Wet Tropics region, Terrain Natural Resource Management uses separate management practice frameworks to describe practices in bananas, pawpaws and a combined 'multicrop' category.

Data collection and synthesis

Data on management practice adoption within the horticultural sector is collected through Growcom's FMS. The Water Quality module within the FMS allows detailed assessment of water quality risks and key actions to reduce those risks. These assessments involve one-on-one interaction between growers and Growcom or Natural Resource Management body field officers. Results of these assessments are aligned with regional and industry ABCD frameworks to estimate ABCD proportions within the grower population, on a year-by-year basis.

The reported number of growers adopting improved practices is limited to those that successfully implemented Reef Rescue Water Quality Grants, as an outcome of their engagement with Growcom FMS from 2008 to 2013. This is likely to provide a conservative estimate of the number of growers implementing improved practices.

Industry-wide management practice adoption is estimated using the proportions established through the Growcom FMS in each region, and expressed as the percentage of growers with A, B, C or D management systems.

It is important to note that the level of grower participation in the program has increased year by year. As the proportion of the grower population represented in the program increases, so the distribution of A, B, C or D management systems changes over time as a reflection of the larger and more representative sample size. Early participants in the program are often relatively advanced growers, and this is apparent in terms of relatively high proportions of A and B in the management system distribution in early years. Increasing program participation over time can have the effect of diluting the percentage of growers in the A and B categories over time. This is not to be seen as a regression of farm management systems.

Number of growers engaged in the Growcom FMS, 2009 to 2013							
Region	Burnett Mary	Fitzroy	Mackay Whitsunday	Burdekin	Wet Tropics		
					Banana	Pawpaw	Multicrop
2008-2009	43	13	21	42	61	4	12
2009-2010	77	26	22	54	75	8	28
2010-2011	167	35	22	84	90	9	33
2011-2012	275	37	22	113	125	12	44
2012-2013	286	50	25	117	125	12	44

Grains

Improved management practices are described within the industry-endorsed farm management system, Grains Best Management Practices (BMP).

Management practice frameworks

The ABCD management practice framework for the grains industry is derived from the Grains BMP program:

- nutrient management practices are described in the Crop Nutrition and Soil Fertility module
- chemical management practices are described in the Pesticide Application module
- soil management practices are described in the Property Design and Layout and Making Best Use of Rainfall modules.

The Grains BMP modules articulate three levels of practice for each key area – Below BMP Standard, Minimum BMP Standard and Above BMP Standard - which correspond to C/D, B and A, respectively.

Data collection and synthesis

Data on management practice status within the grains sector is collected through the Grains BMP program. Growers typically engage with the program through facilitated workshops where they complete self-assessments with process and technical support available. Management practice data is then able to be accurately reported on the basis of area impacted, or number of growers.

Grains industry reporting for Report Card 2012 and 2013 is relevant to the Fitzroy region only (which includes the majority of the grains industry in Great Barrier Reef catchments).

Growers engaged in the Grains BMP, 2009 to 2013								
Year	2008-2009		2009-2010		2010-2011		2012-2013	
Fitzroy region	Growers	Area (ha)	Growers	Area (ha)	Growers	Area (ha)	Growers	Area (ha)
	66	90,178	111	150,370	134	179,384	274	273,352

As is the case in the horticulture industry, increasing program engagement can mean that overall management practice status appears to be static or regressing over time (e.g. if the proportion of growers with A or B level management practice in the sample reduces over time). This is not the case, and is an artefact of early program participants generally being relatively advanced farmers. It is, therefore, appropriate that the most recent data is used as the best estimate of management practices, meaning that the baseline status is hindcast from the most recent data.

The number of growers adopting improved practices is the number of growers that completed specific intensive training or consultancy and/or implemented infrastructure and equipment changes on-farm as a result of their engagement with Grains BMP and the Reef Rescue Water Quality Grants program (through the field network of the Fitzroy Basin Association). This is likely to provide a conservative estimate of the number of growers implementing improved practices.

Dairy

Improved land management practices are described in the dairy industry's accepted best practice program, Dairying Better 'n Better for the Reef (DBnBR). The program is funded through the Australian Government's Reef Rescue program and is driven by the industry peak body, the Queensland Dairyfarmers' Organisation Ltd (QDO), the Burnett Mary Regional Group (BMRG) and Terrain Natural Resource Management.

Evidence of dairy producers adopting improved management practices is limited to the number of producers that:

- completed and acted upon soil and water management plans (QDO)
- collaborated with the Queensland Government's Rural Water Use Efficiency program (QDO)
- implemented on-farm projects with the assistance of Reef Rescue Water Quality Grants through BMRG, Terrain, and the DBnBR program.

The number of producers adopting improved practices is likely to be a conservative estimate.

Management practice frameworks

The DBnBR program includes detailed soil and nutrient management planning processes including benchmarking current practices, identifying risks and planning priorities for action. DBnBR assesses management practices against three categories:

- above acceptable industry practice
- acceptable industry practice
- unacceptable industry practice.

Data collection and synthesis

Data is provided through the DBnBR program. Reporting of regional or industry-wide management system status is not possible. However, there is reliable evidence of the adoption of improved management practices as described by:

- the number of producers that have completed professional risk analyses and soil and nutrient management plans, and acted upon those plans
- the number of producers that have successfully accessed services through the On-Farm System Assessment and Financial Assistance Scheme components of the Queensland Rural Water Use Efficiency program
- the number of producers that have implemented on-ground works with the support of Reef Rescue Water Quality Grants, usually as an outcome of their engagement with the soil and nutrient management planning process.

Many producers have collaborated with several or all of these initiatives during the life of Reef Plan 2009. Detailed record keeping by QDO (with producer details anonymous) enables the identification of any overlap in engagement which ensures that progress toward the Reef Plan adoption target includes individual growers once only.

Estimates of the proportion of producers adopting improved management practices are presented at the Great Barrier Reef-wide scale only.

Catchment indicators methods

This report presents information on catchment attributes (wetlands, riparian areas and groundcover) that play a role in water quality entering the reef.

Progress for wetlands and riparian areas is not provided in Report Card 2012 and 2013 as they are only monitored every four years (see Report Card 2010 for latest data).

The Groundcover section reports on mean late dry season groundcover for 2012 and 2013, the 26-year mean groundcover for the period 1988 to 2013 and the area of land with mean groundcover below 50 per cent.

Groundcover

Groundcover consists of the non-woody plant cover at or near the soil surface and all litter including woody litter. It affects soil processes including infiltration, runoff and surface erosion. In the Great Barrier Reef catchments, low groundcover can contribute to increased sediment loads reaching the reef lagoon (Queensland Government, 2009).

Reporting regions

Groundcover is not reported for the Cape York region and the Wet Tropics region, with the exception of the Herbert catchment. These areas have high tree cover which makes groundcover monitoring derived from satellite imagery difficult and grazing pressure is generally lower in these areas compared to the reporting regions.

Grazing lands

Grazing lands in the reporting regions were spatially defined based on the most recent version of land use data provided by the Queensland Land Use Mapping Program (Department of Science, Information Technology, Innovation and the Arts, 2012).

Groundcover data

Reporting is based on data derived using the fractional cover method described by Scarth et al. (2010). The method measures the proportion of green cover, non-green cover and bare ground using reflectance information from late dry season Landsat 5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper (ETM+) satellite imagery. This data is calibrated using field observations. The spatial resolution of Landsat imagery is approximately 30 metres. Total groundcover is given by summing the green and non-green cover fractions.

For the purposes of reporting on groundcover, it is only possible to provide estimates where tree cover is low. This is because higher tree cover obstructs the ground and can contribute to reflectance measurements when viewed from the satellite. This can impact on the accuracy of groundcover estimates. Reporting is, therefore, limited to grazing areas of less than 15 per cent foliage projective cover. Foliage projective cover is a measure of the density of woody vegetation and is defined as the percentage of ground area occupied by the vertical projection of foliage (Specht *et al*., 1981). The data used for masking out areas of greater than 15 per cent foliage projective cover are also derived using Landsat 5 TM and 7 ETM+ satellite imagery using a method described in Armston et al. (2009).

The fractional cover method used for reporting differs to the approach used for the 2009 and 2010 report cards. Reporting for these two previous report cards was based on the Groundcover Index (Scarth *et al*., 2006). The fractional cover method is generally more accurate than the Groundcover Index because it uses a larger sample of field data and has a lower model error for prediction of groundcover. Using the fractional cover method has changed the distribution of groundcover levels significantly in some cases, but this is considered to be more representative of the true level of groundcover. When averaged across large catchments, the statistics for mean late dry season groundcover and the 26-year mean groundcover can be considered to be nominally the same as for previous reporting and can, therefore, be readily compared. However, the statistics for area of mean groundcover less than 50 per cent are not comparable with previous reporting. This is due to the change in distribution of groundcover at the extremes, leading to a significant reduction in the amount of groundcover that is less than 50 per cent, relative to previous estimates derived from the Groundcover Index.

It is important to note that averaging groundcover across whole catchments can mask localised areas of lower cover, particularly in large catchments with a strong rainfall gradient (e.g. Burdekin or Fitzroy). The mean groundcover reported is, therefore, indicative of general levels of cover within the reporting catchment. It is important to consider the spatial distribution of cover when accounting for its impact on sediment generation. Future reporting will focus on improved ways of representing spatial and temporal variability in groundcover.

2012 and 2013 mean late dry season groundcover
Mean late dry season groundcover for 2012 and 2013 was calculated by averaging the per pixel amount of total cover across the reporting area for each region.

26-year mean groundcover
The 26-year mean groundcover was assessed by calculating, per pixel, the mean annual late dry season groundcover for the period 1988 to 2013 inclusive and averaging for the reporting area of each catchment. This is the period for which Landsat TM/ETM+ satellite imagery is available.

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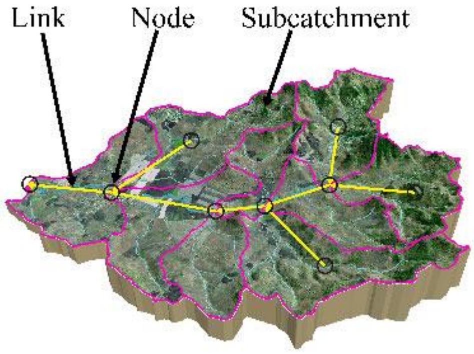
Catchment pollutant loads methods

Catchment modelling

The Source Catchments modelling framework (eWater 2010) is used to model pollutant loads for the 35 catchments in the Great Barrier Reef region. It is a catchment scale water quantity and quality model which uses a node link network to represent the stream. The model generates runoff and pollutant loads for each landuse within a sub-catchment, and runoff and pollutants are transported through the node link stream network to the end of the catchment.



Example of a node link network generated in Source Catchments to represent a catchment and stream network.

Source Catchments runs at a daily time step which allows exploration of the interactions of climate and management at a range of time-steps. However, for the report card, average annual catchment loads are reported.

The model was run for each scenario using the same climate period from 1986 to 2009 to remove the influence of climate on estimated load reductions. The latest land use mapping (Department of Science, Information Technology, Innovation and the Arts, 2012) was maintained for each of these scenarios. The scenarios were: the baseline (2008-2009), then each subsequent year 2009-2010, 2010-2011, 2011-2012 and 2012-2013 with the proportion of ABCD land management adjusted each year, following the adoption of improved management practices. The proportion of ABCD areas is the only variable that changes between modelled scenarios. This allows for the relative load reductions attributed to the areas of improved land management to be reported.

A total of 17 pollutants were modelled including fine and coarse sediments, various nutrients and eight pesticides. Key land uses were modelled for the baseline scenario including open and timbered grazing, cane, cropping, horticulture and forestry.

Modelled load estimates are validated against monitored data at 25 sites across the Great Barrier Reef catchments. For further information on validation processes, see Waters et al. 2014.

The catchment loads modelling program undergoes an external peer review every three years. The next review is due in 2015. Prior to the release of each report card, modelled load estimates are reviewed both internally and externally.

Management practice change
An ABCD management system framework was used to describe and categorise farming practices according to recognised water quality improvements at a paddock scale. Improvements in water quality as a result of adopting improved management practices are determined by linking paddock model time series outputs to catchment models.

Management practice change has been modelled for the sugarcane and grazing areas of the Great Barrier Reef catchments. For details on how management practice changes are represented in the modelling, see the modelling technical reports volume 1-7 (references are listed in further reading below).

Improved grazing management (in particular cover management) through riparian fencing can have both a direct and indirect effect on gully and streambank erosion rates. Indirect effects of improved grazing management or increasing cover on hillslopes can reduce runoff rates and volumes from upstream contributing areas to a gully or stream. This process is represented in the model by implementing relative reductions in rates of erosion per management class, as described by Thorburn and Wilkinson, 2012. The direct effects of riparian fencing are a result of increased cover on the actual stream or gully. Both have a beneficial effect on erosion rates from these areas. Where data was provided, investments in riparian management practices were modelled for the 2012 and 2013 report card. Where regional bodies did not provide data on riparian fencing investments, the effects of this management change could not be modelled.

Modelling assumptions
- Loads reported for each scenario reflect the relative change in modelled average annual loads for the specified model run period (1986 to 2009).
- Land use areas in the model are static over the model run period and were based on the latest available Queensland Land use Mapping Program (QLUMP) data (Department of Science, Information Technology, Innovation and the Arts, 2012).
- Paddock model runs used to populate the catchment models represent "typical" management practices for a given management class and do not reflect the actual array of management practices being used within the Great Barrier Reef catchments.
- Application rates of herbicides used to populate the paddock models were derived through consultation with relevant industry groups and stakeholders.
- Practice adoption areas represented in the model are applied at the spatial scale of the data supplied by regional bodies, which is not spatially explicit for all areas.
- The water quality benefits from adopting a management practice change are assigned in the year that investment occurs.
- Water quality improvements from the baseline for the horticulture, dairy and cotton industries are currently not modelled due to a lack of management practice data.

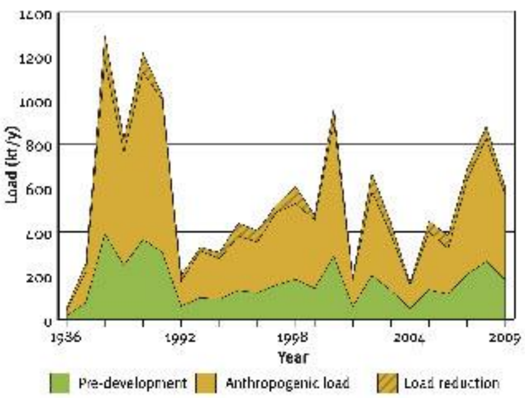
Linking paddock and catchment models
The commercial Source Catchments model was modified to incorporate hillslope generation from the most appropriate paddock models for cropping and sugarcane areas, and the Revised Universal Soil Loss Equation (RUSLE) for grazing. In addition, gully and streambank erosion and floodplain deposition processes were added based on the SedNet/ANNEX approach (Wilkinson et al. 2004). A more detailed description can be found in Ellis and Searle (2013). These features were incorporated to better represent the erosion processes driven by the summer dominant rainfall in northern Australia.

Two approaches were used to represent improved land management practices in Source Catchments depending on the land use of interest. For sugarcane and cropping, the constituent time-series (e.g. load per day per unit area) for the given land use in the Source Catchments model was replaced with an output time-series from a paddock model. Unique combinations of climate, soil type and management class (ABCD) within each land use were identified. For grains cropping using the HowLeaky? model, these unique combinations each represent one model scenario. For sugarcane modelling using the Agricultural Production Systems sIMulator (APSIM), there are several model scenarios run for each region and these are matched to the climate/soil combinations. Each of the climate/soil combinations is also modelled to represent a level of land management practice (A, B, C or D).

In the second approach, the RUSLE model has been written into Source Catchments to model hillslope soil erosion in grazing lands, where the cover term (C-factor) in the model is generated from remotely sensed groundcover satellite imagery on an annual basis. The paddock scale model GRASP was used to provide scaling algorithms for each scenario to account for changes in management in each identified land type, e.g. shifting areas from C class practices to B class. These scaling algorithms are applied at the pixel scale to each annual groundcover satellite image for the modelling period. This is applied according to a spatial map of areas of ABCD management classification as provided by regional Natural Resource Management groups annually. The outputs from each of the modelled land management practices were accumulated into a single land use time-series for a sub-catchment. All loads were then aggregated at a sub-catchment scale and routed through the stream network.

Total load
The total load was the load modelled as at 2008-2009 land management within each Great Barrier Reef catchment. A pre-development land use map was also developed and modelled. The model was then run for a 23-year period to establish the total load over this period. Thus, the anthropogenic load was the total load less the pre-development load.

Load reductions
The model was then re-run for the same climate period using updated proportions of A, B, C and D areas to reflect investment in improved management practices since 2008-2009. The relative change in pollutant loads from the anthropogenic baseline after investment reflects the load reduction due to changes in management practices.



Example of modelled loads for pre-development, anthropogenic baseline and the load reduction following investment in improved practices.

How the information is reported
Progress towards Reef Plan targets is estimated by determining how much the modelled pollutant load has reduced from the average annual modelled anthropogenic baseline (total load less the pre-development load). This is calculated as a percentage reduction in average annual modelled load.

The average annual percentage reduction in load is calculated from:

$$\text{Reduction in load (\%)} = \frac{\text{(Anthropogenic baseline load less anthropogenic change) x 100}}{\text{Anthropogenic baseline load}}$$

Where, anthropogenic baseline load = total load less pre-development load.

Total suspended sediment, nitrogen, phosphorus and pesticides modelled loads at the end of the catchment are reported for the total Great Barrier Reef region and six regions.

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Marine methods

Marine Monitoring Program

The Australian Government's Marine Monitoring Program assesses water quality and the long-term health of key marine ecosystems (inshore coral reefs and seagrasses) in the inshore Great Barrier Reef lagoon. The four elements of the Program are outlined below.

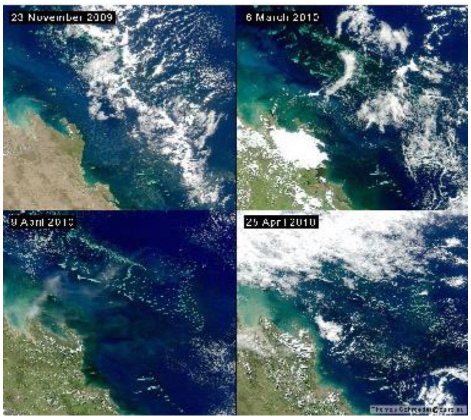
More information about the Marine Monitoring Program is available from the Great Barrier Reef Marine Park Authority website (http://www.gbrmpa.gov.au/about-the-reef/how-the-reefs-managed/reef-rescue-marine-monitoring-program).

Inshore water quality

Monitoring includes the measurement of concentrations of nutrients (nitrogen and phosphorus), chlorophyll, suspended solids (water turbidity) and pesticides. Techniques used to monitor water quality include satellite remote sensing, automated data loggers and collection of water samples from research vessels for standard laboratory analysis. Passive samplers are used to measure the concentration of pesticides in the water column integrated over time (Booij et al., 2007; Shaw & Mueller, 2009).

Flood plume dynamics

The majority of the annual pollutant load to the reef is delivered by flood events in the wet season (Devlin et al. 2001). Monitoring of water quality during flood events and the wet season includes measuring salinity, concentrations of nutrients, chlorophyll, suspended solids (water turbidity) and pesticides. The movement of the flood plume across inshore waters of the reef is assessed using images from aerial flyovers and remote sensing.



Satellite images (MODIS-Aqua) of the Fitzroy Region of the Great Barrier Reef during normal (low) flow conditions in November 2009 (a) and flood conditions in March and April (b, c, d). The discharge from the Fitzroy River was more than four times the annual median flow and images b-d show large plumes of dissolved and suspended material in the coastal waters.

Seagrass status

Monitoring temporal and spatial variation in the status of intertidal seagrass meadows in relation to changes in local water quality is essential in evaluating long-term ecosystem health.

Monitoring includes an assessment of the seagrass abundance and reproductive effort, which provides an indication of the health of seagrass meadows and their capacity to regenerate following disturbances. Tissue nutrient composition is assessed in the laboratory as an indicator of nutrient enrichment.

Seagrass monitoring along the Queensland Coast (Image: L. McKenzie, Queensland Government).

Coral reef status

Monitoring temporal and spatial variation in the status of inshore coral reef communities in relation to changes in local water quality is essential in evaluating long-term ecosystem health.

Monitoring covers a comprehensive set of community attributes including the assessment of hard and soft coral cover, the number of hard coral juvenile colonies, macroalgae cover and the rate of change in coral cover as an indication of the recovery potential of the reef following a disturbance (Thompson and Dolman, 2010). Comprehensive water quality measurements are also collected at many of the coral reef sites.

Coral reefs being monitored on the Great Barrier Reef. (Image: Australian Institute of Marine Science).

The marine environment in the Cape York region is relatively pristine compared to other regions. However, the region is under increasing pressure from development and the likely associated impacts on water quality in the region mean that Cape York is a high priority for increasing monitoring efforts. No coral monitoring occurs in the Cape York region in the Marine Monitoring Program, though some sites are monitored in the southern section as part of the Long Term (Reef) Monitoring Program by the Australian Institute of Marine Science.

Great Barrier Reef-wide and regional report card assessment scores

Synthesis and integration of data and information

The report card provides assessment scores for inshore water quality and inshore seagrass and coral condition at Great Barrier Reef-wide and regional scales. All scoring methods are currently under review and will be improved for the next report card.

A sub-set of indicators are used to assess and report on water quality and seagrass and coral condition. These indicators are scored on a five-point scale (very good, good, moderate, poor, very poor) and aggregated into a score that describes the overall status of the Great Barrier Reef and each individual region.

An overview of the methods used to calculate the Great Barrier Reef wide and regional scores is available from the Marine Monitoring Program Quality Assurance Manual (http://elibrary.gbrmpa.gov.au/jspui/handle/11017/2797).

Water quality

Near-surface concentrations of chlorophyll *a* and total suspended solids from remotely sensed images are used to assess and report on inshore water quality. Chlorophyll *a* is a measure of phytoplankton biomass that is related to the amount of available nutrients in the water column and therefore the productivity of the system. Total suspended solids is a measure of all other particulate matter in the water column. These two parameters are measured against their relevant Great Barrier Reef Water Quality Guideline trigger values as the proportion of the water body (GBRMPA, 2010) that exceeds the guideline annual trigger value. The metric score is then calculated as 100 minus the relative area of the water body where the annual mean value exceeds the Great Barrier Reef Water Quality Guidelines. It should be recognised that the accuracy of these estimates from satellites is limited in Cape York and Burnett Mary regions by the amount of on-ground data for validation and these regions were excluded from overall assessments of Great Barrier Reef water quality and reef condition.

In 2011-2012, major improvements in the remote sensing method mean the historical data is no longer directly comparable, so trends in the Water Quality Index have only been shown for 2011-2012 to 2012-2013. The full historical time-series will be reprocessed using the new algorithm for the next report card and an independent review of the methods is planned to ensure that the implications of any changes on reporting metrics are properly quantified.

Seagrass

Abundance, reproductive effort and nutrient status are used to assess and report on inshore seagrass condition. Seagrass abundance includes assessment of percent cover determined in reference to the Seagrass Abundance Guidelines (McKenzie 2009). For example, if median abundance is at or above the 50^{th} percentile, the condition is considered 'good'. Reproductive effort is based on the average number of reproductive structures on an area basis and provides an indication of the capacity for recovery following disturbances. The nutrient status of seagrass is based on the ratio of carbon to nitrogen in leaf tissue and reflects the level of nutrients in the surrounding waters. The number of seagrass sites in Cape York does not adequately reflect the variability of seagrass habitats in the region and were excluded from overall assessments of Great Barrier Reef seagrass condition and reef condition.

Corals

Coral cover, coral cover change, juvenile density and macroalgae cover are used to assess and report on inshore coral reef condition. Coral cover is a measure of the abundance of hard and soft corals, and indicates the capacity of coral to persist under the current environmental conditions and to recover from disturbances by estimating the availability of adult broodstock. Coral change is a measure of the change in hard coral cover from the preceding three years compared to modelled predictions and is an indicator of the balance between disturbance and recovery. A healthy and resilient coral reef is expected to show an increase in coral cover during periods free from disturbances. Coral change can only be reported from 2007-2008, because three years of data needs to be available to run the model for comparisons. Juvenile density is a measure of the abundance of hard coral juveniles and is an indicator of the potential of the community to recover from disturbances or stress. Macroalgal cover is a measure of the abundance of large, fleshy algae. A low score for macroalgae (i.e., poor or very poor) means macroalgal cover is high, which is indicative of poor water quality. Conversely, a high score for macroalgae (i.e., good or very good) means cover is low. High macroalgal cover, once established, reduces the recovery of corals by denying them space and the ability to produce chemical deterrents.

Additional site-specific information

To complement reef-wide and regional water quality scores, the Report Card provides additional, site-specific information on water quality and detected pesticides.

Water quality

To complement the broad-scale assessment of water quality from remotely sensed images used in the report card, site-specific water quality data are also reported using an interim water quality index based on the monitoring data and expert opinion.

The index aggregates scores for four indicators of water quality parameters (turbidity/water clarity, chlorophyll and concentrations of particulate nitrogen and phosphorus) relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2010), using four-year running means to give an overall rating for each of the fixed sampling sites. Decision rules for the water quality index are outlined in more detail in Thompson *et al.* 2013 (http://www.gbrmpa.gov.au/resources-and-publications/publications/annual-reef-rescue-marine-monitoring-science-report).

The water quality index may be refined with future research and data analysis.

Pesticides

Pesticides are monitored using two methods: grab samples of pesticides are collected in flood plumes during the wet season and passive samplers are used to provide an integrated assessment of pesticide concentrations over time in wet and dry seasons (Booij et al., 2007; Shaw & Mueller, 2009). The most frequently detected pesticides in inshore waters include those herbicides that inhibit the photosynthetic pathway (PSII) of plants in an additive manner: diuron, atrazine, hexazinone, simazine and tebuthiuron (Haynes et al., 2000; Mitchell et al. 2005; Kapernick et al. 2006; Lewis et al. 2009; Packett et al. 2009). These PSII herbicides may also have a negative impact on non-target organisms such as algae, corals and seagrass (Magnusson et al., 2008; Jones and Kerswell, 2003; Haynes et al., 2000(b)).

An index has been developed using PSII herbicide equivalent concentrations to assess the potential combined toxicity of these pesticides relative to the Great Barrier Reef Water Quality Guidelines. The PSII herbicide equivalent concentration incorporates the relative potency and abundance of individual PSII herbicides compared to a reference PSII herbicide, diuron. For reporting purposes, the index has five categories: concentrations detected at the lowest category 5 levels are not expected to have an impact on seagrass or coral, while the highest category 1 levels correspond to the guideline for diuron set for the protection of 99 per cent of species (http://www.gbrmpa.gov.au/about-the-reef/how-the-reefs-managed/water-quality-in-the-great-barrier-reef/water-quality-guidelines-for-the-great-barrier-reef).

PSII Herbicide Equivalent (HEq) Index developed as an indicator for reporting of PSII herbicides across the reef

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 ≤ 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.

For categories 2 to 4:

- The published scientific papers indicate that this reduction in photosynthesis is reversible when the organism is no longer exposed to the pesticide.
- Detecting a pesticide at these concentrations does not necessarily mean that there will be an ecological effect on the plants and animals present.
- These categories have been included as they indicate an additional level of stress that plants and animals may be exposed to in the Marine Park. In combination with a range of other stressors (e.g. sediment, temperature, salinity, pH, storm damage and elevated nutrient concentrations) the ability of these plant and animal species to recover from impacts may be reduced.

Classifying the data into Index categories provides an indication of the extent and frequency of exposure to PSII herbicides at a given site (and the potential consequences for marine organisms). The PSII herbicide equivalent concentrations are calculated from diuron, hexazinone, atrazine and its breakdown products, tebuthiuron, ametryn, prometryn, simazine, metolachlor, terbutryn, flumeturon and imidacloprid, all of which are used to control weeds and other plant species in the Great Barrier Reef catchment and are regularly found in the Marine Park. Note that reference to pesticides in the report includes the all herbicides, insecticides and other chemicals used to treat pest or weed species.

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Scoring system

A standardised scoring system was developed for each of the key indicators in the report card. The scoring system is used to assess and communicate progress towards the goals and targets. The Reef Plan targets are considered ambitious. Therefore, progress that is equal to or exceeds the target is considered very good.

Management practice adoption – sugarcane, horticulture and grains
Target: 80 per cent of landholders adopt improved practices by 2013.

Score	Criteria for June 2011	Criteria for June 2012	Criteria for June 2013	Colour
Very poor progress towards target	0–9% adoption of improved management practices	0-14% adoption of improved management practices	0-20% adoption of improved management practices	Red
Poor progress towards target	10–19% adoption of improved management practices	15-29% adoption of improved management practices	21-40% adoption of improved management practices	Orange
Moderate progress towards target	20-29% adoption of improved management practices	30-44% adoption of improved management practices	41-60% adoption of improved management practices	Yellow
Good progress towards target	30-40% adoption of improved management practices	45-60% adoption of improved management practices	61-79% adoption of improved management practices	Light green
Very good progress towards target	Greater than 40% adoption	Greater than 60% adoption	Greater than 80% adoption	Dark green

Management practice adoption – grazing
Target: 50 per cent of landholders adopt improved practices by 2013.

Score	Criteria for June 2011	Criteria for June 2012	Criteria for June 2013	Colour
Very poor progress towards target	0 – 6% adoption of improved management practices	0-9% adoption of improved management practices	0 - 13% adoption of improved management practices	Red
Poor progress towards target	7 – 12% adoption of improved management practices	10-19% adoption of improved management practices	14- 25% adoption of improved management practices	Orange
Moderate progress towards target	13 - 18% adoption of improved management practices	20 - 28% adoption of improved management practices	26 - 37% adoption of improved management practices	Yellow
Good progress towards target	19 - 25% adoption of improved management practices	29 - 37% adoption of improved management practices	38 - 49% adoption of improved management practices	Light green
Very good progress towards target	Greater than 25% adoption	Greater than 37% adoption	Greater than 50% adoption	Dark green

Groundcover

Target: minimum 50 per cent late dry season groundcover by 2013.

Score	Criteria for June 2011	Colour
Very poor groundcover – "Well below the target"	Less than 30% groundcover	Red
Poor groundcover - "Below the target"	Between 30-39% average groundcover	Orange
Moderate groundcover – "Just below the target"	Between 40-49% average groundcover	Yellow
Good groundcover – "Above the target"	Between 50-69% average groundcover	Light green
Very good groundcover – "Well above the target"	Greater than 70% average groundcover	Dark green

Catchment pollutant loads – pesticides, nitrogen and phosphorus

Target: 50 per cent reduction in load by 2013.

Score	Criteria for June 2011	Criteria for June 2012	Criteria for June 2013	Colour
Very poor progress towards target – "Increase in the catchment load"	No reduction in load	0-5% reduction in load	5-12.5% reduction in load	Red
Poor progress towards target – "No or small increase in the catchment load"	0-5% reduction in load	5-12.5% reduction in load	12.5-25% reduction in load	Orange
Moderate progress towards target – "A small reduction in catchment load"	5-12.5% reduction in load	12.5-25% reduction in load	25 – 37.5% reduction in load	Yellow
Good progress towards target – "A significant reduction in catchment load"	12.5-25% reduction in load	25 – 37.5% reduction in load	37.5 - 49% reduction in load	Light green
Very good progress towards target – "A high reduction in catchment load"	Greater than 25% reduction in load	Greater than 37.5% reduction in load	Greater than 50% reduction in load	Dark green

Catchment pollutant loads – sediment

Target: 20 per cent reduction in load by 2020.

Score	Criteria for June 2011	Criteria for June 2012	Criteria for June 2013	Colour
Very poor progress towards target – "Increase in the catchment load"	No reduction in load	0-1% reduction in load	1-3% reduction in load	Red
Poor progress towards target – "No or small increase in the catchment load"	0-1% reduction in load	1-3% reduction in load	3-5% reduction in load	Orange
Moderate progress towards target – "A small reduction in catchment load"	1-3% reduction in load	3-5% reduction in load	5–7% reduction in load	Yellow
Good progress towards target – "A significant reduction in catchment load"	3-4% reduction in load	5 – 6% reduction in load	7-8% reduction in load	Light green
Very good progress towards target – "A high reduction in catchment load"	Greater than 4% reduction in load	Greater than 6% reduction in load	Greater than 8% reduction in load	Dark green

Marine

Score	Marine indicators				
	Corals	**Water quality**	**Seagrass**	**Overall**	
Very poor condition	Standardised scale (1-100)	Standardised scale (1-100)	Standardised scale (1-100)	Standardised scale (1-100)	Red
Poor condition					Orange
Moderate condition					Yellow
Good condition					Light green
Very good condition					Dark green