RESULTS FOR
THE MACKAY-WHITSUNDAY-ISAAC
2018 REPORT CARD

ENVIRONMENTAL INDICATORS

HEALTHY RIVERS TO REEF PARTNERSHIP
MACKAY-WHITSUNDAY-ISAAC

Authorship statement

The Mackay-Whitsunday-Isaac Healthy Rivers to Reef Healthy Partnership (Partnership) Results for Environmental Indicators for the Mackay-Whitsunday-Isaac 2018 Report Card technical report was compiled by the Partnership's Technical Officers, Alysha Lee and Jessica Gillespie.

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HEALTHY RIVERS TO REEF PARTNERSHIP
MACKAY-WHITSUNDAY-ISAAC

1 Contents

Terms and Acronyms

Basin	An area of land where surface water runs into smaller channels, creeks or rivers and discharges into a common point and may include many sub-basins or sub-catchments. Also known as river basin or catchment
Chl-*a*	Chlorophyll-*a*: A measure of overall phytoplankton biomass. It is widely considered a useful proxy to measure nutrient availability and the productivity of a system
Climate	Climate refers to both climate variability and climate change
DDL	Declared Downstream Limit
DIN	Dissolved inorganic nitrogen
DO	Dissolved oxygen
Driver	An overarching cause of change in the environment
Ecosystem	A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit
Fish (as an index)	Fish community health is assessed and included in the ecosystem health assessments (coasters). Inclusion in the report card will contribute to an assessment of the health of local fish communities
Fish Barriers (as an indicator)	Fish barriers relate to any barriers which prevent or delay connectivity between key habitats which has the potential to impact migratory fish populations, decrease the diversity of freshwater fish communities and reduce the condition of aquatic ecosystems (Moore, 2015).
Flow (as an indicator)	Flow relates to the degree that the natural river flows have been modified in the Region's waterways. This is an important indicator due to its relevance to ecosystem and waterway health
FRP	Filterable reactive phosphorus
GBR	Great Barrier Reef
GBR report card	Great Barrier Reef Report Card developed under the Reef 2050 Water Quality Improvement Plan (2018)
GBRMPA	Great Barrier Reef Marine Park Authority
GV	Guideline Value
Impoundment (also impoundment length)	An indicator used in the 'in-stream habitat modification' indicator for freshwater basins in the Region. This index reports on the proportion (%) of the linear length of the main river channel inundated at the Full Supply Level of artificial in-stream structures such as dams and weirs

Index	Is generated by indicator categories (e.g. water quality made up of nutrients, water clarity, chlorophyll-*a* and pesticides)
Indicator	A measure of one component of an environmental dataset (e.g. particulate nitrogen)
Indicator category	Is generated by one or more indicators (e.g. nutrients made up of particulate nitrogen and particulate phosphorus)
Inshore (as a reporting zone)	Inshore is a reporting zone in the Mackay-Whitsunday report card that includes enclosed coastal, open coastal and mid-shelf waters.
In-stream Habitat Modification (as an indicator)	This basin indicator category is made up of two indicators; fish barriers and impoundment length
ISP	Independent Science Panel established under the Reef Plan, who have independently reviewed the methodologies involved in the report card assessments
LOR	Limit of reporting
Macroalgae (cover)	An indicator used in part to assess coral health. Macroalgae is a collective term used for seaweed and other benthic (attached to the bottom) marine algae that are generally visible to the naked eye. Increased macroalgae on a coral reef is often undesirable, indicating reef degradation (Diaz-Pulido and McCook, 2008)
Measure	A measured value that contributes to an indicator score for indicators that are comprised of multiple measures (e.g. flow, estuary fish barriers).
MMP	Marine Monitoring Program: the Great Barrier Reef Marine Park Authority's Marine Monitoring Program, which provided water quality data for the Central and Whitsunday reporting zones in the report card
ms-PAF	Multisubstance-Potentially Affected Fraction, derived using a concentration addition model which estimates the cumulative toxicity for contaminants with different modes of action.
NO_x	Oxidised nitrogen (nitrate and nitrite)
NQBP	North Queensland Bulk Ports Corporation Ltd
Offshore (reporting zone)	Offshore is a reporting zone in the Mackay-Whitsunday report card that includes mid-shelf and offshore water bodies.
Overall Score	The overall scores for each reporting zone used in the report card are generated by an index or an aggregation of indices

Pesticides (as an indicator)	Formerly limited to the PSII herbicides; now incorporating up to 22 herbicides and insecticides with different modes of action. A list of the relevant analytes is provided in Table 6.
Pesticide Risk Metric	Refers to the multisubstance-Potentially Affected Fraction (ms-PAF) methodology for estimation of ecological risk associated with pesticide pollution
Phys-chem	The physical-chemical indicator category that includes two indicators: dissolved oxygen (DO) and turbidity
PN	Particulate nitrogen
PONSE	Proportion of Native (fish) Species Expected
Ports	NQBP port authority
PP	Particulate phosphorus
PSII herbicides	Photosystem II inhibiting herbicides (Ametryn, Atrazine, Diuron, Hexazinone, Tebuthiuron, Bromacil, Fluometuron, Metribuzin, Prometryn, Propazine, Simazine, Terbuthylazine, Terbutryn)
PSII-HEq	Photosystem II herbicide equivalent concentrations, derived using relative potency factors for each individual PSII herbicide with respect to a reference PSII herbicide, Diuron.
QPSMP	Queensland Ports Seagrass Monitoring Program
RIMReP	Reef 2050 Integrated Monitoring and Reporting Program
Riparian Extent (as an indicator)	An indicator used in the assessments of both basin and estuarine zones in the pilot and 2015 report cards. This indicator uses mapping resources to determine the extent of the vegetated interface between land and waterways in the Region
Secchi	Secchi depth (m) – measure of water clarity
SF	Scaling factor. A value used to set scoring range limits for indicators
TSS	Total suspended solids

1. Introduction

1.1. Purpose of this Document

The purpose of this document is to provide detailed results to support the 2018 Mackay-Whitsunday-Isaac report card on waterway health. The results provided in this document pertain to the condition of environmental indicators. For human dimensions reporting including social and economic, agricultural and non-agricultural stewardship and cultural heritage, see the 'Results for the Mackay-Whitsunday-Isaac 2018 report card Human Dimensions' report[1].

This document presents indicator scores in their original scale along with standardised scores that (where relevant) were used for aggregation. Confidence in the results is also reported in this document.

Where practicable, the 2018 results are compared to 2017, 2016, 2015 and 2014 results that have been calculated using the same methods. Where this is not the case, previous results calculated using alternate methods are presented for reference. The data collection period is outlined with associated results.

This document describes:

- The 2018 condition assessments for environmental indicators;
- The confidence associated with 2018 results;
- Where practicable, comparison of 2017 results to 2016, 2015 and 2014 results; and
- Additional information associated with 2018 environmental results contained in Appendices.

1.2. General

The Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership (Partnership) was established in October 2014. The primary focus of the Partnership is to produce an annual report card on the ecological condition of the Region's waterways. Typically, the Mackay-Whitsunday-Isaac report cards have been released in October/November each year, reflecting the previous financial reporting year. In a commitment to provide the Mackay-Whitsunday-Isaac region with relevant data closer to the reporting period, the Partnership trialled an earlier release of the 2018 report card, approximately four months earlier to previous report card releases. The 2018 Mackay-Whitsunday-Isaac report card was released on the 18th July 2019.

The report card includes assessments of five freshwater basins, eight estuaries, four inshore marine zones and one offshore marine zone (to the eastern boundary of the Great Barrier Reef Marine Park). Different indicators are assessed to provide the overall scores for these reporting areas throughout the Mackay-Whitsunday-Isaac Region.

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

Since the release of the 2017 report card, the Program Design[1] outlining the guiding framework for the development and scope of the 2017 – 2022 report cards was finalised. Some changes to the scope of assessment (monitoring sites and methods) have occurred since the 2017 report card and are highlighted throughout this document where relevant. Otherwise, methods for developing the scores for the 2018 report card are consistent with those used in the previous report card.

For more detail on the methods used to produce the Mackay-Whitsunday-Isaac report card and for more information on the Partnership, refer to the Methods for the Mackay-Whitsunday-Isaac 2018 report card document[2] and the Mackay-Whitsunday-Isaac Report Card Program Design 2017 to 2022 document[3].

1.3. Terminology

The report card assesses different indicators of ecosystem health to report on overall condition. Scores for indicators are aggregated together depending on the aspect of the environment they are assessing, such as water quality, coral or fish. The terminology used in this document for defining the level of aggregation of indicators is as follows:

- Overall score is generated by the aggregation of indices or by a single index score;
- Index/indices (e.g. water quality) are generated by the aggregation of indicator categories;
- Indicator categories (e.g. nutrients) are generated by one or more related indicators; and
- An indicator is a component of the environment that can be measured or calculated (e.g. particulate nitrogen).

In the report card (Figure 1), overall scores and scores for indices are represented in the format of a coaster (Figure 1). Presentation of the coasters can be with or without the outer ring (i.e. indicator categories).

[1] https://healthyriverstoreef.org.au/wp-content/uploads/2018/12/mackay-whitsunday-report-card-program-design-2017-2022.pdf
[2] https://healthyriverstoreef.org.au/report-card/report-card-download/
[3] https://healthyriverstoreef.org.au/wp-content/uploads/2018/12/mackay-whitsunday-report-card-program-design-2017-2022.pdf

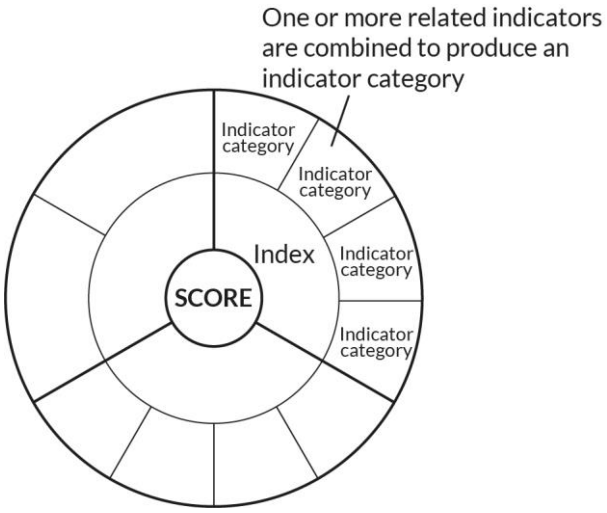

Figure 1. Terminology used for defining the level of aggregation of indicators and how they are displayed in the coasters in the report card.

1.4. General scoring of condition assessments

Ordinal categories are used to describe the scores for condition of indicators, indicator categories and the overall score. This follows a five-point scoring system:

Very Good (A), Good (B), Moderate (C), Poor (D), Very Poor (E).

All indicators have applicable scoring ranges and bandwidths which correspond to the five-point system. Individual scoring ranges are listed below the results tables presented throughout this document.

Results for indicators that had divergent scoring ranges and bandwidths were required to be translated into a common scoring range before aggregating (rolling up). The common scoring range used for reporting is based on that used by the Great Barrier Reef (GBR) report card (Table 1). Once standardised (where necessary), relevant scores were averaged to aggregate into the higher category.

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

- ≥ 50% of measured indicators to generate the indicator category score (where relevant);
- ≥ 60% of indicator categories to generate an index score; and
- Overall scores for reporting zones are presented in the report card, even if not all indicator categories are available.

Table 1. Overall range of scores within the report card.

Scoring range	Condition grade and colour code
81 to 100	Very Good
61 to <81	Good
41 to <61	Moderate
21 to <41	Poor
0 to <21	Very Poor

1.5. Data used in the 2018 report card

Results for indicators that are reported annually in the 2018 report card are largely based on data collected between July 1st 2017 and June 30th 2018. This includes:

- Water quality indicators;
- Habitat and hydrology (impoundment and flow) indicators;
- Coral indicators; and
- Seagrass indicators

This data collection period is not completely consistent for certain measures of water quality and coral in some of the marine zones. Where this occurs, it is identified within the document. Results for indicators that are reported less frequently are repeated from previous report cards and are based on data collected during:

- July 1st 2013 to June 30th 2014 for riparian, wetland and mangrove/saltmarsh extent indicators (updated every four years and was due for updating in the 2018 report card, however due to changes in catchment boundaries required further investigation before updates could be incorporated);
- July 1st 2014 to June 30th 2015 for fish barrier indicators (updated every four years, and due for updating in the 2019 report card)

1.6. Regional Setting

1.6.1. Drivers of condition assessments during the 2017 – 2018 reporting period

Climate, population and the economy are the key external forces that influence the condition of waterways in the Mackay-Whitsunday-Isaac region, either directly or by driving activities that put pressure on local waterways (Figure 2). Land use in the region is predominated by agricultural activities including sugarcane, grazing and horticulture, as well as other practices such as mining and urban development. As a result, the regions aquatic ecosystems can be subject to ingress of sediment, nutrient and contaminants, which become mobilised by surface water run-off. Increased loads of these pollutants are ultimately received by coastal waters through river discharge and move to offshore waterways (Figure 2).

In the reporting period from July 1st 2017 to June 30th 2018, anthropogenic drivers such as sediment, nutrient and pesticide loads within land-based run-off were anticipated to directly affect scores of some of the adopted indicators; environmental drivers such as climate variability, specifically rainfall,

and the residual impacts of Tropical Cyclone Debbie (TC Debbie) are captured in some report card indicators.

Figure 2. Conceptual diagram of the key drivers, pressures, and ecological processes in the Mackay-Whitsunday-Isaac Region.

1.6.2. Climate

Geographically, the Mackay-Whitsunday-Isaac region is situated in North Queensland, a torrid zone north of the Tropic of Capricorn circle of latitude and typified by a tropical to subtropical climate. Regionally, climate is characterised by two seasons; a wet (November to May) and a dry (April to October) season. During the wet season, the Mackay-Whitsunday-Isaac area may experience elevated rainfall, tropical lows and cyclones. Upon making landfall, cyclones may generate considerable rainfall and flooding.

Shifts in year-to-year weather and climate influence the frequency and severity of environmental events including drought, bushfires and floods within natural ecosystems. Such variability also extends to changes in modified environments, including agricultural land, and can dictate how land management activities evolve within and between seasons.

1.6.3. Rainfall

Rainfall across the reporting period from July 1st 2017 to June 30th 2018, indicated annual rainfall was generally low across all of the Mackay-Whitsunday-Isaac catchments and fell below the long-term average (1911-2016). This contrasted with the anomalously high levels recorded for the previous reporting period (Figure 3).

Rainfall across daily and monthly temporal scales followed typical wet season rainfall trends, with highest rainfall occurring between March and April 2018 across the Don, Proserpine, O'Connell, Pioneer and Plane Creek basins. The highest monthly rainfall across catchments occurred in March 2018 (Figure 3). This trend was generally consistent with rainfall reported in 2017 alongside Tropical Cyclone Debbie; however both ambient and acute rainfall event levels were higher within the previous reporting period (Figure 3).

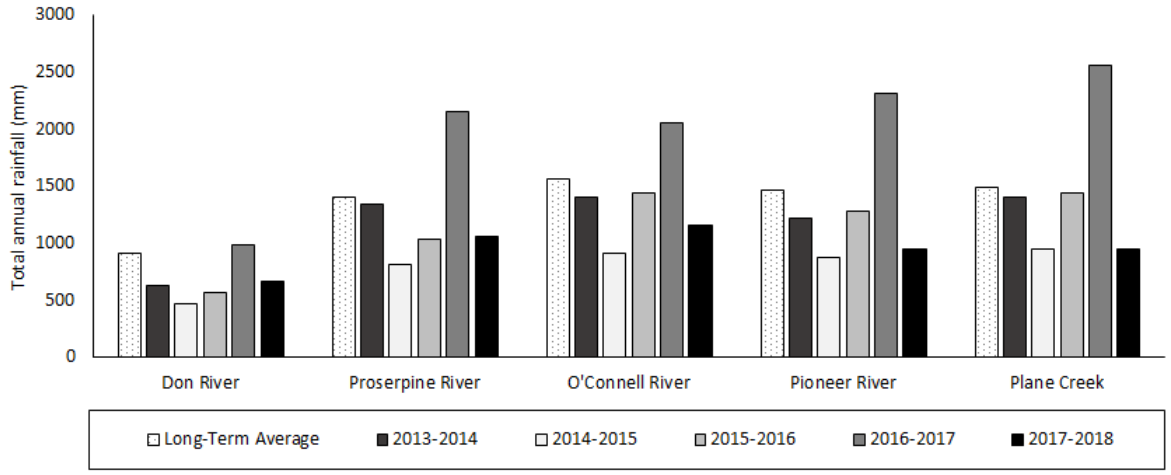

Figure 3.Total annual rainfall across the Mackay-Whitsunday-Isaac Region for the 2017-2018 reporting period compared to previous reporting periods and the long-term average (past 100 years). Data from the Australian Water Resources Assessment Modelling System, Bureau of Meteorology.

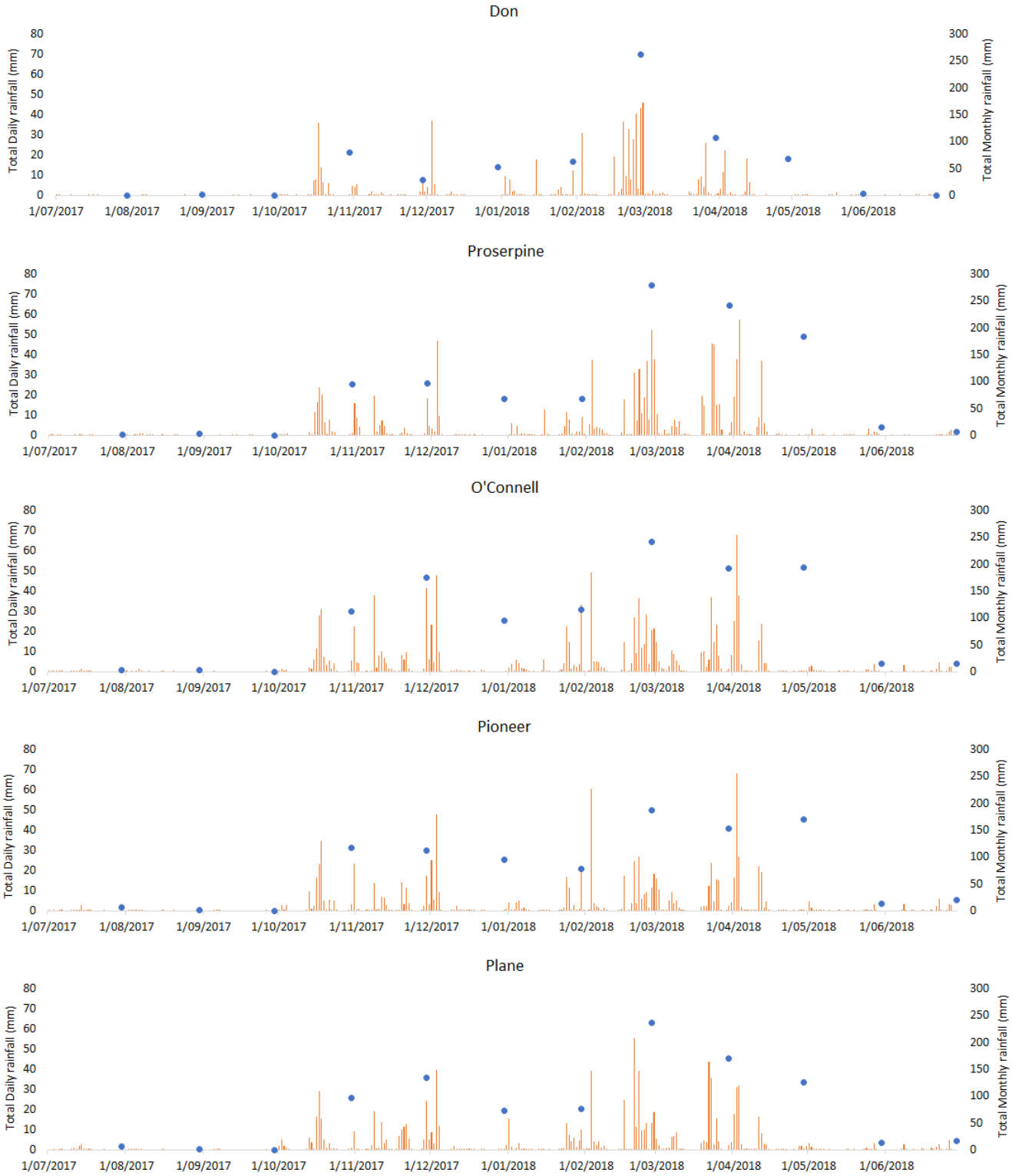

Figure 4. Total daily (orange bars) and monthly (blue dots) rainfall (mm) recorded from July 1st 2017 to June 30th 2018 in the five basins reported in the Mackay-Whitsunday report card. Data from the Australian Water Resources Assessment Modelling System, Bureau of Meteorology.

1.6.4. Cyclones

Tropical cyclone systems in the region develop from tropical lows, typically between November and April. It is anticipated that an average of 4.7 tropical cyclones affect the State of Queensland per year[1]. During the reporting period, no tropical cyclone systems made landfall over the Mackay-Whitsunday-Isaac region, however several systems developed within the Coral Sea to the east and remained localised offshore in the South Pacific (Figure 5).

Flow-on effects arising from Tropical Cyclone (TC) Debbie impacted some indicator scores within the 2018 report card, including coral and seagrass, despite occurring outside the reporting period. TC Debbie made landfall near Airlie Beach on Queensland's Whitsunday coast on Tuesday, 28th March 2017, after crossing the Whitsunday Islands as a large and powerful category 4 storm system (Figure 6; Figure 7). Shortly after crossing the coast, TC Debbie slowed down moving inland at only 7km/h, and locations such as Airlie Beach and Proserpine were exposed to the very destructive winds near the cyclone's eye for many hours. TC Debbie weakened below TC strength around 3:00am AEST on Wednesday, 29th March. The remnant low then turned southeast and produced a broad swathe of damaging winds and torrential rainfall from central Queensland to the southeast. Clarke Range, west of Mackay, received 986mm in the 48 hours to 9am Wednesday 29th March, and Mt Jukes, northwest of Mackay, recorded 635mm in the 24 hours to 9am Thursday, 30th March.[1]

Regionally, Cyclone Debbie impacted agricultural industries like sugarcane growers through wind and flood damage which resulted in a decline in yields. In turn, lower yields may have longer term flow on effects including:

- A reduction in canopy cover, leading to an increase in on ground weed cover that would need to be controlled following the harvest.
- A reduction in the amount of trash blanket remaining, a natural suppressor of weed growth, that would need to be accommodated through chemical applications.
- A reduction in the amount of trash blanket remaining, resulting in increased erosion risk of blocks during the wet season.

Anecdotal evidence provided by growers suggested that the greatest impact of TC Debbie was increased weed pressure, both abundance and type, suggesting there may have been a greater level of spraying than in pre-disturbance years.

[1] *Text source: Bureau of Meteorology* http://www.bom.gov.au/cyclone/history/database/Tropical-Cyclone-Debbie-Technical-Report-Final.pdf

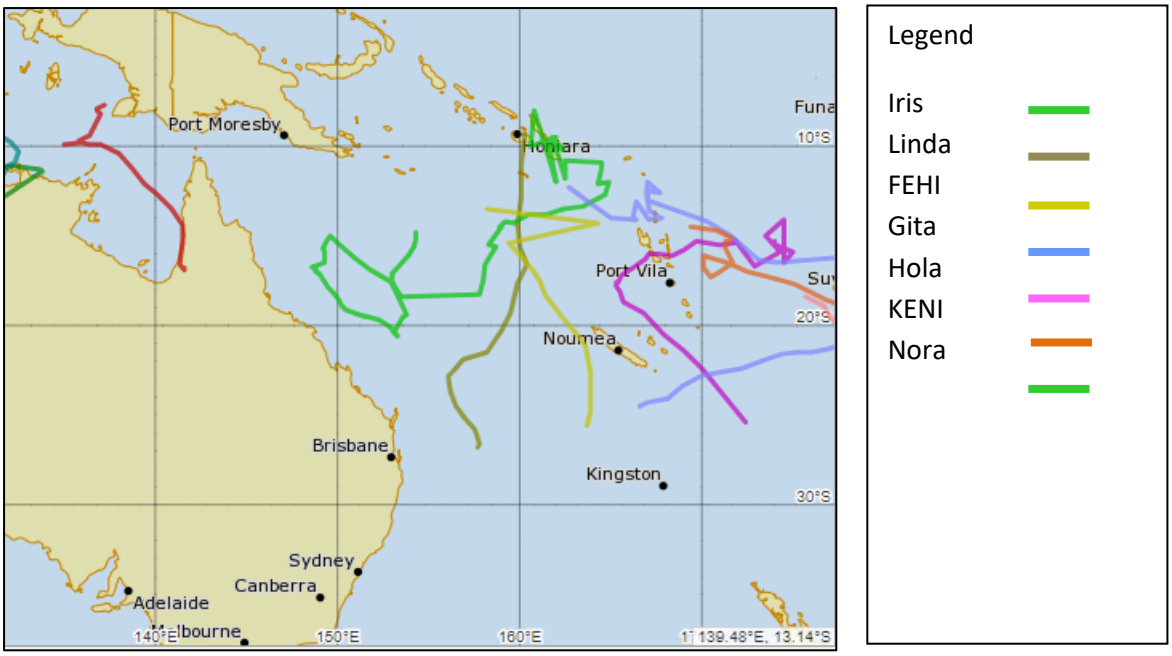

Figure 5. Southern Hemisphere Tropical Cyclone Data Portal, 2017/2018 Source: Bureau of Meteorology.

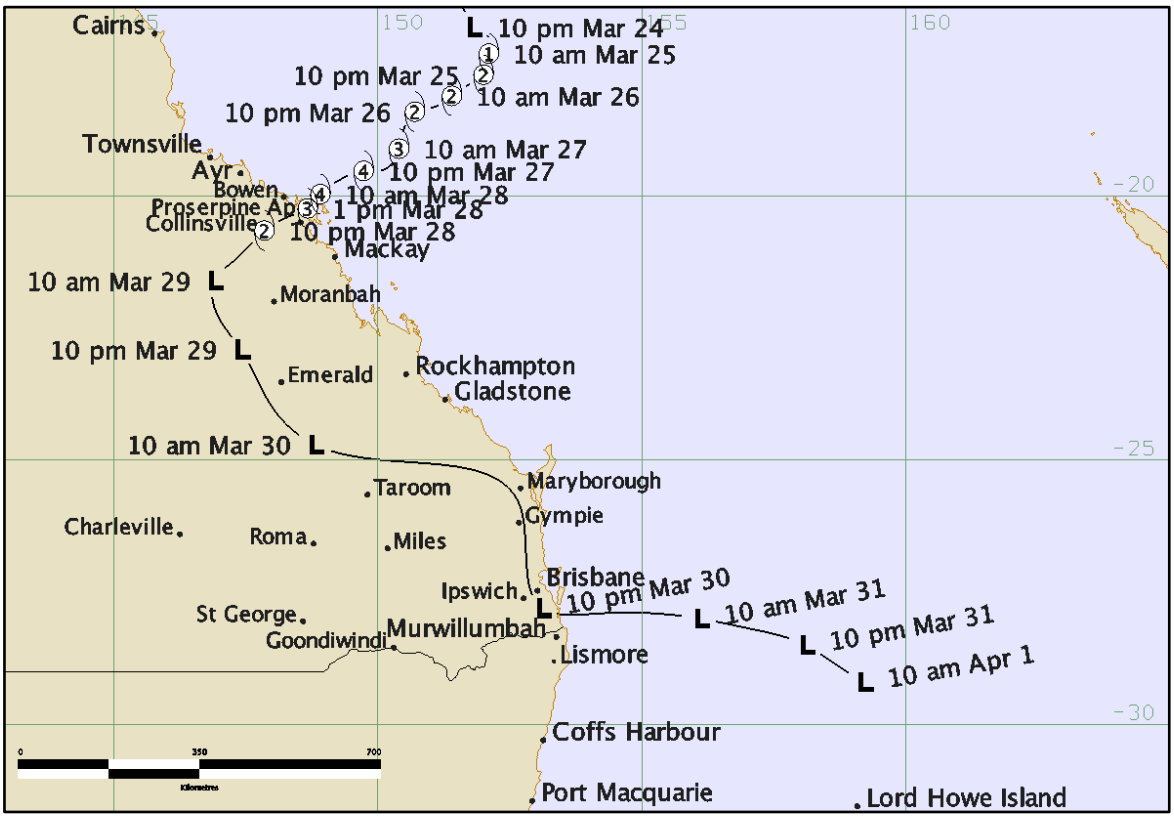

Figure 6. Tropical Cyclone Debbie track and intensity (all times in AEST). Source: Bureau of Meteorology.

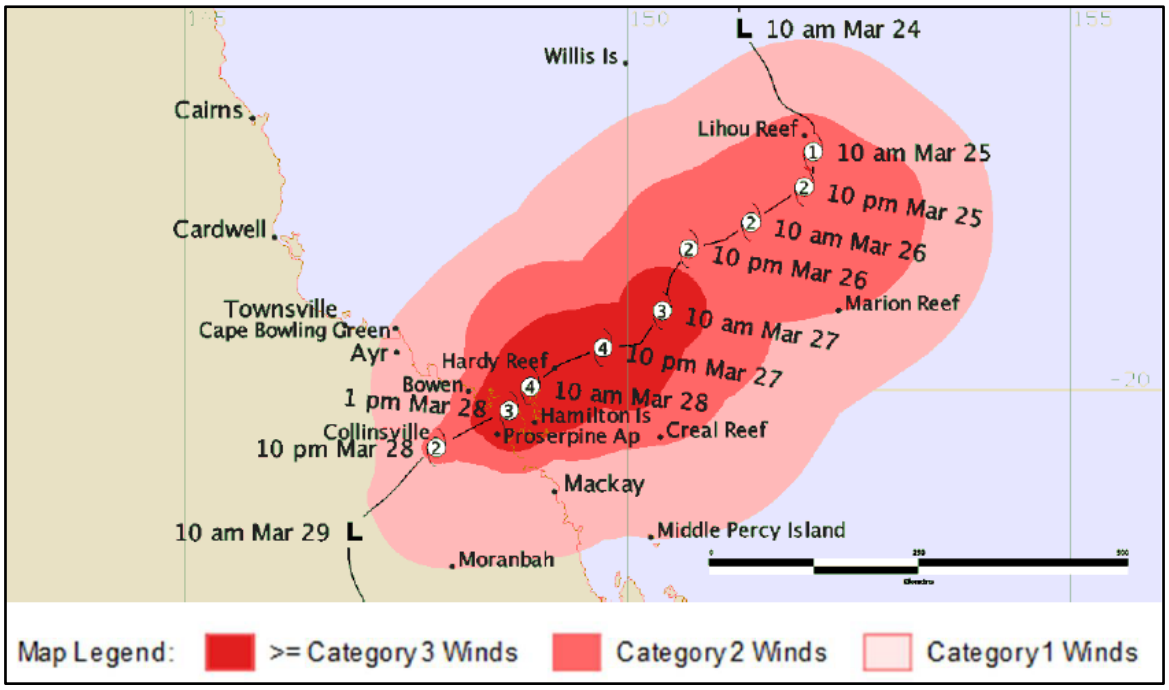

Figure 7. Tropical Cyclone Debbie track showing areas affected by very destructive (red), destructive (dark pink) and damaging (pink) winds produced by Tropical Cyclone Debbie (all times in AEST). Source: Bureau of Meteorology.

1.6.5. Climate change

Earth's climate has always been changing, from the end of ice ages to sea levels changing over millions of years. However, it is now certain the climate is changing at an unprecedented rate, with this change driven predominately by anthropogenic activities from increased carbon emissions[1].

Increases in sea surface temperature, ocean acidification, short-duration heavy rainfall, more frequent and severe cyclones, and a rising sea level are some of the variables highlighted for their potential to impact aquatic ecosystems within Australia, under a warming climate regime. More specifically, longer and more frequent periods of elevated sea surface temperatures, resulting in 'marine heatwaves', pose a major threat to the long-term health and resilience of coral reef ecosystems due to their propensity to result in widespread coral bleaching. Climate change is the primary factor affecting the health of the Great Barrier Reef (Great Barrier Reef Marine Park Authority 2019).

1.6.6. Coral Bleaching

Historically, global-scale coral bleaching has been associated with strong El Nino events and increases to global sea-surface temperatures (Great Barrier Reef Marine Park Authority 2017). During the summer of 2016, consistently high sea surface temperatures across the GBR triggered one of the worst mass coral bleaching events recorded on the GBR (Great Barrier Reef Marine Park Authority 2017). Following the record-breaking temperatures of 2016, sea surface temperatures on the GBR again exceeded long-term averages from January to March 2017, causing an unprecedented second consecutive year of bleaching (Thompson et al. 2018) (Figure 8). Patterns of bleaching intensity shifted from the northern reefs of the GBR in 2016 to the central reefs in 2017. Whilst coral bleaching in 2017 was observed in the Wet Tropics, Burdekin, Mackay-Whitsunday and Fitzroy regions, the impacts

[1] http://elibrary.gbrmpa.gov.au/jspui/bitstream/11017/3460/1/v0-Climate-Change-Position-Statement.pdf

varied. The most impacted reefs were located in the Wet Tropics and Burdekin regions (Thompson et al. 2018). Most of the southern thirds of the GBR escaped impact (Great Barrier Reef Marine Park Authority 2019) (Figure 8).

The Australian Institute of Marine Science (AIMS) Long-term Monitoring Program (LTMP) provides an annual summary of coral reef condition. AIMS divides the GBR into three regions for reporting purposes: Northern (last surveyed in 2017), Central and Southern (last surveyed 2018)[1]. As of May 2018, average coral cover in the Central region, encompassing the Mackay Whitsunday zone, had declined from 22% in 2016 to 14% in 2018 as a result of mass coral bleaching and crown-of-thorns starfish outbreaks. Survey results from the Marine Monitoring Program (MMP) showed average coral cover on inshore coral reefs in the Whitsundays was high prior to Cyclone Debbie; however, declined by more than half following the impact. The passage of TC Debbie damaged reefs in the Mackay-Whitsunday Region, confounding the ability to assess coral bleaching impacts within the same time period (Thompson et al. 2018).

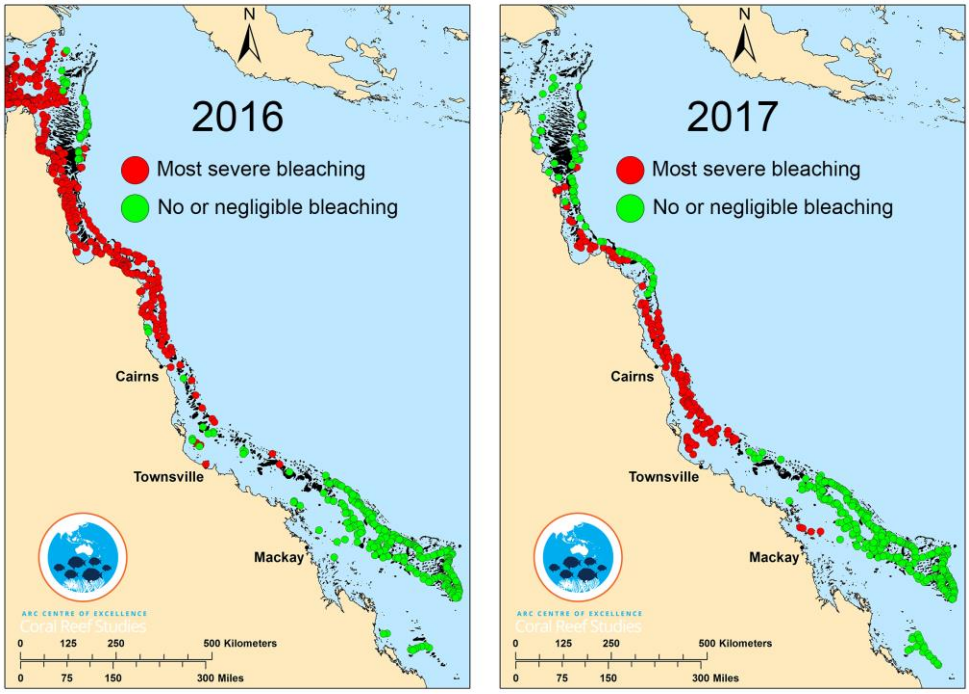

Figure 8. Composite map of surveyed corals across the 2016 and 2017 bleaching events. Only reefs at each end of the spectrum are shown: Red circles indicate reefs undergoing most severe bleaching (60% or more of corals visible to aerial surveys bleached). Green circles indicate reefs with no or minimal bleaching (10% or less of corals bleached). Source: Thompson et al. (2018) courtesy of ARC Centre of Excellence Coral Reef Studies. Summarised from the GRMPA Reef Health website. Source: http://www.gbrmpa.gov.au/the-reef/reef-health[5].

[1] Marine Monitoring Program: Annual report for inshore coral reef monitoring 2016-2017

2. Freshwater basin results

The indicators, relevant indicator categories and overall indices that are assessed for the basins are presented in Figure 9.

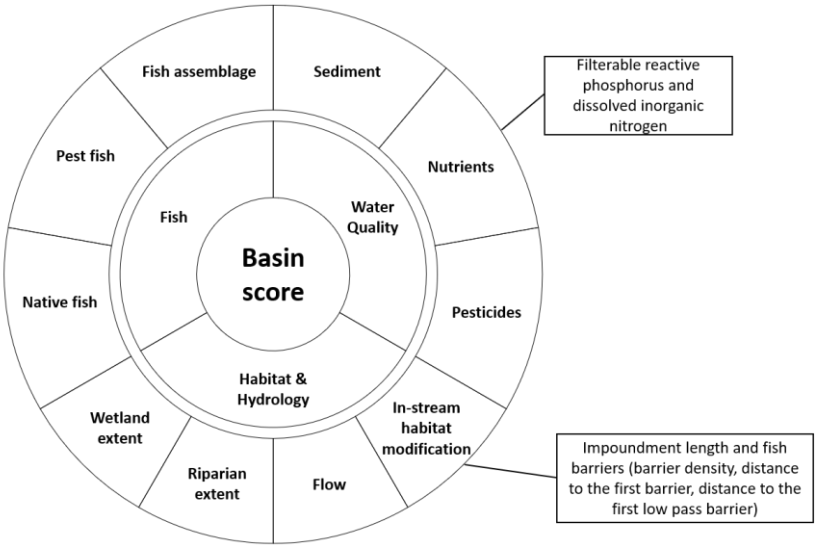

Figure 9. Indicator categories (outer ring) and indices (inner ring) that contribute to overall basin scores. Where multiple indicators are aggregated to determine the indicator category, these are listed in break-out boxes.

2.1. Key findings in freshwater basins

- Overall scores for freshwater basins in the Mackay-Whitsunday-Isaac region graded moderate and good for the 2018 report card. Overall scores changed for the Proserpine, O'Connell and Pioneer basins compared to the 2017 report card, with the Proserpine and O'Connell shifting from moderate to good, and the Pioneer from poor to moderate.
- Additional freshwater basin sites in the O'Connell and Plane basins were incorporated into the 2018 report card for the first time, resulting in two sites for the aforementioned basins contributing to water quality scores. The incorporation of new monitoring sites has been undertaken in order to improve the spatial representativeness of basin monitoring programs and, therefore, our understanding of local waterways.
- Pesticide condition in freshwater basins for the 2018 report card were based on monitored concentrations of 22 pesticides. In comparison, previous report card scores were based on 13 Photosystem ll (PSII) herbicides only. The incorporation of additional pesticides allows for improved understanding of contaminant profiles and levels within the regions catchments.
- Scores ranged from good to very poor for pesticides in the 2018 report card. The Don and O'Connell scored good and moderate respectively, whilst the Proserpine, Pioneer and Plane scored very poor, highlighting the on-going pesticide issue in the Mackay-Whitsunday-Isaac region.
- Scores for the habitat and hydrology indicators riparian and wetland extent are based on repeated data from the 2014-2017 report cards. Due to changes in some catchment boundaries used for calculating habitat extent, further investigation of the catchment boundaries and methods is required alongside the report card's Technical Working Group

(TWG), to ensure updated data can be reasonably incorporated. As a result, wetland and riparian extent indicators are to be updated in future report cards (estimated 2020).

- Freshwater flow is a positive indicator for habitat health and species diversity and was assessed for the first time in the O'Connell and Pioneer basins. Whilst the score for flow was in a good condition for the O'Connell, unseasonably low freshwater flows were recorded between July and November 2018. Whilst falls outside of the 2018 reporting year, this will likely be reflected in 2019 scores released in 2020.
- Impoundment scores, part of the habitat and hydrology indicator, were updated for the 2018 report card, reflecting their three-year cycling period.
- Any changes to the habitat and hydrology index are as a result of indicator updates to impoundment or the addition of flow for the 2018 report card.
- The freshwater fish indicator was updated in the 2018 report card reflecting the three-year reporting frequency and includes reporting of fish in the Proserpine Basin for the first time. All basins monitored scored good or very good, highlighting the importance of preventing pest fish incursions within Mackay-Whitsunday waterways.

Table 2. Condition grades of freshwater basins for the 2018 report card in comparison to 2017, 2016, 2015 and 2014 report card scores.

	2018 report card					*2017	^2016	^2015	^2014
Freshwater basin	Water quality	Habitat and hydrology	Fish	Basin score and grade		Basin score	Basin score	Basin score	Basin score
Don	64	48		**56**	**C**	47	48	48	54
Proserpine		52	79	**66**	**B**	53	53	53	52
O'Connell	53	53	92	**66**	**B**	54**	58	57	52
Pioneer	42	37	82	**54**	**C**	40	41	41	34
Plane	32	39	79	**50**	**C**	50**	52	51	35

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

*2017 scores have been back-calculated to incorporate updates to freshwater pesticides made in the 2018 report card.

**2017 scores do not incorporate additional sites that were included for the first time in the 2018 report card.

^ 2016-2014 report card scores do not include back-calculated pesticide updates that were established for the 2018 report card.

2.2. Water quality in freshwater basins

Water quality condition scores were derived from end of catchment loads monitoring sites; one in each of the Don and Pioneer Basins, and two at the O'Connell and Plane Basins. These sites were at the Don River in Bowen, the O'Connell River at the Caravan Park, the O'Connell River at Staffords Crossing, the Pioneer River at Dumbleton Pump Station, Sandy Creek at Homebush and Plane Creek at Sucrogen Weir, as depicted in Figure AA 4, Appendix 1. This is the first year that additional sites were incorporated into the report card for the O'Connell and Plane Basins (O'Connell River at Staffords Crossing and Plane Creek at Sucrogen Weir, respectively). These additional sites are incorporated into an overall score weighted by the proportion of catchment area relevant to the site. A review of the methodology for combining multiple sites in assessing condition of freshwater basins was undertaken by the report card's Technical Working Group (TWG). For further information on combining additional

water quality sites, see the Methods for the Mackay-Whitsunday-Isaac 2018 report card document[1]. Both overall and site related scores are provided for the O'Connell and Plane basins. The addition of these sites is an important step towards improving the understanding and confidence in water quality reporting in the Mackay-Whitsunday-Isaac region and demonstrates the Partnerships commitment to continuously improve the waterway health report card.

This is the second year that water quality in the Don basin has been reported, with a monitoring site established on the Don River in November 2016. The Don River is an ephemeral system, with surface flow occurring following heavy rainfall. As a result, water quality monitoring is limited to during the wet season or after rainfall events when water levels are sufficient to facilitate sampling procedures. It is likely the number of samples collected during each reporting period will fluctuate depending on relative water levels within the system at the time of sampling. In the 2018 report card, water quality scores for the Don Basin were developed using data collected from August 2017 to May 2018. Conversely, scores for the Don in the 2017 report card were developed using data collected from January 2017 to June 2017, capturing predominantly wet season conditions. This limitation should be acknowledged when interpreting change in condition between monitoring years.

Water quality condition within the Proserpine basin remains a data gap in the Mackay-Whitsunday-Isaac report card. Although data is collected from the Proserpine River (at Glen Isla), as a component of the GBR Catchment Loads Monitoring Program (CLMP), the monitoring site was deemed unsuitable for the purpose of basin reporting within the report card. The site is located at the hydrological boundary of the freshwater catchment and estuary system, where sediment concentrations may be influenced by tidal movements. The site was also deemed provisionally unsuitable to report on nutrient conditions until further investigation was conducted (Appendix D). Opportunistic monitoring is occurring in Myrtle Creek, upgradient of the Glen Isla monitoring site and which joins the Proserpine River near Mount Julian, in order to assess the impacts associated with tidal exchange on nutrient levels, through comparison. It is expected that a summary of these findings will be available for the 2019 report card. A preliminary assessment of the Glen Isla monitoring site data is provided in Appendix D.

Pesticide data was reported on from the Proserpine at Glen Isla in the 2018 report card, similar to the 2017 report card, as it provides a good estimate of pesticide pressure from the freshwater catchment; where the tidal inflow of seawater is not anticipated to dilute the magnitude of the pesticide risk score substantially, and a pesticide risk score calculated above the tidal zone would not necessarily provide a better representation of the pesticide pressures in the catchments, as it would likely miss some of the land based inputs (Appendix D).

2.2.1. Sediments

The sediment indicator (reported from Total Suspended Solids (TSS)) scores were all reported in a moderate condition across the basins for the 2018 report card (Table 3). The moderate score for the Don basin was an improvement from the 2017 report card which reported a poor condition. However, it is acknowledged that this improvement in score may be attributed to increased temporal representativeness in the 2018 monitoring program, rather than true improvement in ambient sediment conditions. This is the fifth consecutive year that the O'Connell and Pioneer basins have

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

been in a moderate condition for sediments. Similar to previous report cards, data is unavailable to report on sediments in the Proserpine basin and is still a current knowledge gap.

Table 3. Results for the sediment indicator category (based on a measure of TSS) score for water quality in freshwater basins for the 2018 report card (2017-18 data) in comparison to 2017, 2016, 2015 and 2014 scores. Scores for 2018 include combined additional sites in the O'Connell and Plane basins.

Freshwater Basin	2018 report card Sediment	2017 Sediment	2016 Sediment	2015 Sediment	2014 Sediment
Don (Don River)	60	29			
Proserpine					
O'Connell (O'Connell River)	53	57	55	58	55
Pioneer (Pioneer River)	54	60	59	59	53
Plane	55	55	54	61	51

Sediment: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

Additional freshwater sites were incorporated into the 2018 report card for the first time. Scores for specific freshwater sites in the O'Connell and Plane are provided in Table 4.

Table 4. Results for the sediment indicator category (based on a measure of TSS) for sites in O'Connell and Plane basins for water quality in freshwater basins for the 2018 report card (2017-18 data).

Freshwater Basin	2018 report card Sediment
O'Connell basin	
O'Connell River (Caravan Park)	56
O'Connell River (Staffords Crossing)	48
Plane basin	
Plane (Sandy Creek)	54
Plane (Plane Creek)	58

Sediment: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

2.2.2. Nutrients

The nutrients indicator category (derived from DIN and FRP indicator categories) reported poor to good condition across the basins (Table 5). The Don basin was the only basin that shifted grading in the 2018 report card from poor to good. This was driven by changes in the FRP indicator, which shifted from a poor to good grade. All other basins (the O'Connell, Pioneer and Plane basins) remained at the same grading, similar to the two previous report cards. Whilst the score remained the same for the Plane basin, scores for the 2018 report card were derived from two water quality monitoring sites, compared to previous report cards, where the score was derived from the Sandy Creek monitoring site only. A review of the results reported for Sandy Creek in 2017 and 2018 showed nutrient scores had declined at this site, shifting from poor to very poor. This was driven by a decline in the DIN indicator, which shifted from a poor to very poor grade. There was no change in the nutrient indicator or indicator category scores observed at the O'Connell Caravan Park monitoring site between 2017 and 2018.

Table 5. Results for DIN and FRP indicators and overall nutrients indicator category scores for water quality in freshwater basins for the 2018 report card (2017-18 data) in comparison to 2017, 2016, 2015 and 2014 report card scores. Scores for 2018 include combined additional sites in the O'Connell and Plane basins.

Freshwater Basin	2018 report card			2017	2016	2015	2014
	DIN	FRP	Nutrients	Nutrients	Nutrients	Nutrients	Nutrients
Don	55	69	**62**	**33**			
Proserpine							
O'Connell	59	59	**59**	**60**	60	90	55
Pioneer	46	61	**53**	**45**	52	53	46
Plane	23	25	**24**	**24**	39	27	16

DIN and FRP: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = assigned 90 | ■ No score/data gap

Nutrients: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

Additional freshwater sites were incorporated into the 2018 report card for the first time. Scores for specific freshwater sites in the O'Connell and Plane are provided in Table 6, below.

Table 6. Results for the nutrients indicator category (based on a measure of DIN and FRP) for sites in O'Connell and Plane basins for water quality in freshwater basins for the 2018 report card (2017-18 data).

Freshwater Basin	DIN	FRP	2018 report card Nutrients
O'Connell basin			
O'Connell River (Caravan Park)	59	59	59
O'Connell River (Staffords Crossing)	59	59	59
Plane basin			
Plane (Sandy Creek)	12	15	14
Plane (Plane Creek)	61	61	61

DIN and FRP: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = assigned 90 | ■ No score/data gap

Nutrients: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

2.2.3. Pesticides

The 2018 report card was the first year that the results for pesticides in freshwater basins were based on 22 pesticides, including herbicides and insecticides. The pesticide concentration data are represented as the percentage of aquatic species protected from the potential harmful effects of the mixture of pesticides present in the water, alongside the pesticide score for the report card. Previous report cards (2017 and 2016) reported Pesticide Risk Metric scores (previously referred to as the multisubstance-Potentially Affected Fraction (ms-PAF)) for only 13 photosystem II (PSII) herbicides.

The inclusion of additional pesticides into the Pesticide Risk Metric aligns with the Queensland Government's Reef 2050 Water Quality Improvement Plan; the draft *Paddock to Reef Integrated Monitoring, Modelling and Reporting (Paddock to Reef) Program Design, 2018-2022,* and lists the same 22 pesticides as reference pesticides for reporting against Reef 2050 Water Quality Improvement Plan pesticide target. A list of the pesticides assessed within the 2018 report card is detailed in Table 9, below. For further information on the methodology adopted for calculation of the

Pesticide Risk Metric, refer to the 'Methods for the Mackay-Whitsunday-Isaac 2018 Report Card' document[1].

Three out of five basins for the 2018 report card were very poor for freshwater pesticides: the Proserpine, Pioneer and Plane. The Don remained in good condition when compared to the 2017 report card, and the O'Connell was in a moderate condition (Table 7). Additional sites were incorporated into the report card for the first time in 2018 for the O'Connell and Plane basins, with scores relating to these sites presented in Table 8. As indicated in the 2017 report card, including additional pesticides into the report card was highlighted as likely resulting in a downgrading of pesticide scores, due to the additive nature of the Pesticide Risk Metric method. Scores for 2017 freshwater pesticides were back-calculated using the updated method to allow for comparability between the two years (Table 7). Previously reported freshwater pesticide scores are presented in Appendix A.

When comparing scores between the two years, scores improved in the O'Connell basin from poor to moderate in 2018, whilst scores dropped in the Pioneer from poor to very poor. The Proserpine and Plane basins remained in a very poor condition.

The very poor results across three out of five Mackay-Whitsunday-Isaac basins highlight the ongoing pesticide issue in the region and captures the impact of additional pesticides not previously assessed in preceding report cards.

During the reporting period from July 1st 2017 to June 30th 2018, the Mackay-Whitsunday-Isaac region experienced low rainfall and residual environmental pressures in the aftermath of TC Debbie. Three exceedance notices were issued throughout the reporting period, following the identification of elevated pesticide concentrations at the Proserpine River, O'Connell River, Pioneer River and Sandy Creek. Notices related to events in late November to early December (2017), early February (2018) and late February to early April (2018), respectively. On each occasion, the contaminants of concern were Diuron and Metachlor with levels consistently exceeding the adopted guideline for the protection of ecosystems (ANZECC and ARMCANZ 2000). Intermittent exceedances of the adopted guidelines for the protection of water quality for Irrigation were also identified.

Table 7. Results for the Pesticide Risk Metric indicator accounting for 22 pesticides, reporting aquatic species protected (%) and overall standardised pesticide score for freshwater basins for the 2018 report card compared to 2017.

Pesticides	2018 report card		*2017 report card
Basin	% species protected	Pesticides	Pesticides
Don	97	70	75
Proserpine	71	18	19
O'Connell	92	48	36
Pioneer	74	19	26
Plane	66	17	15

Species protected scoring range: Very Poor = <80% | Poor = <90 to 80% | Moderate = <95 to 90% | Good = <99 to 95% | Very Good = ≥99% | No score/data gap

Pesticides: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

* 2017 pesticides scores have been back-calculated to incorporate changes in pesticide method that occurred for the first time for the 2018 report card.

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

Additional freshwater sites were incorporated into the 2018 report card for the first time. Scores for specific freshwater sites in the O'Connell and Plane are provided in Table 8.

Table 8. Results for the pesticides indicator category (based on a measure of 22 pesticides) for sites in O'Connell and Plane basins for water quality in freshwater basins for the 2018 report card (2017-18 data).

Freshwater Basin	% species protected	Pesticides
O'Connell basin		
O'Connell River (Caravan Park)	59	59
O'Connell River (Staffords Crossing)	59	59
Plane basin		
Plane (Sandy Creek)	12	15
Plane (Plane Creek)	61	61

Species protected scoring range: Very Poor = <80% | Poor = <90 to 80% | Moderate = <95 to 90% | Good = <99 to 95% | Very Good = ≥99% | No score/data gap

Pesticides: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

* 2017 pesticides scores have been back-calculated to incorporate changes in pesticide method that occurred for the first time for the 2018 report card.

Table 9. List of pesticides (herbicides and insecticides) assessed in the calculation of the Pesticide Risk Metric, in the 2018 report card. The relevant Mode of Action (MoA) is also listed for each analyte and describes the way in which pesticides exert their toxicity within the ecosystem.

Reference pesticide	Pesticide type	Mode of Action
Chlorpyrifos	Insecticide	Acetylcholine esterase (AChE) inhibitor
Fipronil	Insecticide	Gamma-aminobutyric acid (GABA) gated chloride channel blocker
Imidacloprid	Insecticide	Nicotinic receptor agonist
Haloxyfop	Herbicide	Acetyl-coenzyme A carboxylase (ACCase) inhibitor
Imazapic	Herbicide	Acetolactate synthase (ALS) inhibitor
Metsulfuron-methyl	Herbicide	
Pendimethalin	Herbicide	Microtubule synthesis inhibitor
Metolachlor	Herbicide	Acetolactate synthase (ALS) inhibitor
Ametryn	Herbicide	PSII inhibitor
Atrazine	Herbicide	
Terbuthylazine	Herbicide	
Tebuthiuron	Herbicide	
Simazine	Herbicide	
Diuron	Herbicide	
Terbutryn	Herbicide	
Hexazinone	Herbicide	
Metribuzin	Herbicide	
2,4-D	Herbicide	Auxin mimic (Phenoxy-carboxylic acid auxins)
MCPA	Herbicide	
Fluroxypyr	Herbicide	Auxin mimic (Pyridine-carboxylic acid auxins)
Triclopyr	Herbicide	
Isoxaflutole	Herbicide	4-hydroxyphenylpyruvate dioxygenase (4-HPPD) inhibitor

2.2.4. Water quality index scores and confidence

The overall water quality index for the Plane basin graded poor, the O'Connell and Pioneer basin moderate and the Don basin good for the 2018 report card Table 10). Based on the rules for minimum proportion of information required to generate overall scores, a final water quality score could not be calculated for the Proserpine Basin.

Ambient water quality did not change substantially from the 2017 report card despite the very poor pesticide scores recorded across three of the five basins. The exception to this was the Don, which shifted from moderate grading in the 2017 report card to good. Additional temporal samples collected within the Don Basin in the 2017-18 reporting year better capture ambient conditions across the wet and dry seasons, compared to the previous monitoring year where sampling was limited to early 2017 (predominantly wet season).

The incorporation of additional pesticides in the 2018 report card for the first time (shifting from 13 pesticides reported in previous report cards to up to 22) highlights that there is a considerable pesticide issue in the Mackay-Whitsunday-Isaac region, and presents a key water quality concern in freshwater basins.

Table 10. Results for water quality indicator categories and final water quality index scores in freshwater basins for the 2018 report card (2017-19 data) in comparison to 2017 2016, 2015 and 2014 report cards.

Water quality index	2018 report card				*2017	^2016	^2015	^2014
Basin	Sediment	Nutrients	Pesticides	Water quality	Water quality	Water quality	Water quality	Water quality
Don	60	62	70	**64**	46			
Proserpine			18					
O'Connell	53	59	48	**53**	51	63	63	59
Pioneer	54	53	19	**42**	44	48	48	40
Plane	55	24	17	**32**	31	37	35	28

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*2017 scores have been back-calculated to incorporate updates to freshwater pesticides made in the 2018 report card. 2017 scores do not incorporate additional sites that were included for the first time in the 2018 report card.

^ 2016-2014 report card scores do not include back-calculated pesticide updates that were established for the 2018 report card.

The report card scores were rated in terms of the confidence and uncertainty surrounding the methods of assessment and data used in the development of each score. To achieve this, five criteria relating to data confidence are assessed for each indicator in each reporting area, including maturity of methodology, validation, representativeness, directness, and measure error. This information is used to provide a qualitative assessment of confidence for all grades generated in the report card. A detailed summary of confidence methods and scoring are provided in Section 5.1 of the methods report[1].

Confidence in water quality scores for the four basins is presented in Table 11.

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

Table 11. Confidence associated with water quality index results in freshwater basins in the 2018 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Unless specified, confidence in results is the same across basins.

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Sediment	3	3	1	3	2	8.8	3
Nutrients	3	3	1	3	2	8.8	3
Pesticides	1	2	1	2	2	6.6	2
					Water quality index	**8.8**	**3**

Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

2.3. Habitat and Hydrology in freshwater basins

Results for indicators and indicator categories that contribute to the habitat and hydrology index are presented below. The flow indicator was incorporated into freshwater basins for the 2018 report card for the first time. Impoundment length scores were updated for the 2018 report card, reflecting the three-year reporting frequency for this indicator.

2.3.1. In-stream habitat modification

Fish barrier indicator scores for the 2018 reporting period are shown in Table 12. In accordance with the reporting frequency of these indicators being every four years, these scores reflect those outlined in the previous three report cards. This reporting cycle has been adopted based on the gradual nature of change associated with these indicators. Since the fish barrier indicator was last assessed, the Mackay Regional Council have been progressively working to install fish ways and remove a number of high priority barriers. Impacts associated with these changes are expected to be captured when fish barrier indicators are updated in the 2019 report card (released in 2020).

Based on the results, northern freshwater basins; Don, O'Connell and the Proserpine recorded higher fish barrier condition ratings when compared to southern freshwater basins Plane and Pioneer, which both graded poor. The Plane and Pioneer freshwater basins comprise the two largest population centres in the region (Mackay and Sarina) and land use includes urban developments and high levels of intensive agriculture. To support these activities construction of road crossings, infrastructure and irrigation is often required, forming barriers to fish passage. These factors may have contributed to the poor barrier condition ratings in the Pioneer and Plane freshwater basins (Moore 2016).

Table 12. Results for fish barrier indicators in freshwater basins in the 2018 report card (2014-15 data). Indicators were assessed on Stream Orders (SO) ≥3 or ≥4 as indicated. *Insufficient data was available regarding barrier "passability" in the Don basin, so the score was based on expert opinion rather than measured.

	Barrier density		Stream to the 1st barrier		Stream to the 1st low "passability" barrier		Fish barriers	
Basin	km per barrier on SO ≥3	Score	% of stream before first barrier on SO ≥3	Score	% of stream before first low pass barrier on SO ≥4	Score	Total score	Fish barriers (standardised)
Don	10.5	4	23.7	2	*	4	10	**60**
Proserpine	2.7	2	38.5	3	91.4	4	9	**50**
O'Connell	5.3	3	33.4	3	85.3	4	10	**60**
Pioneer	5.6	3	0.1	1	0.5	1	5	**21**
Plane	2.4	2	27.9	2	70.5	3	7	**40**

Barrier density (km): Very Poor/score of 1 = 0 to 2km | Poor/score of 2 = >2 to 4km | Moderate/score of 3 = >4 to 8km | Good/score of 4 = >8 to 16km | Very Good/score of 5 = >16km | No score/data gap

Stream to 1st barrier (%): Very Poor/score of 1 = 0 to <10% | Poor/score of 2 = 10 to <30% | Moderate/score of 3 = 30 to <50% | Good/score of 4 = 50 to <100% | Very Good/score of 5 = 100% | No score/data gap

Stream to 1st low "passability" barrier (%): Very Poor/score of 1= 0 to 50% | Poor/score of 2 = >50 to 60% | Moderate/score of 3 = >60 to 70% | Good/score of 4 = >70 to 95% | Very Good/score of 5= >95% | No score/data gap

Total score: Very Poor = 3 to 4 | Poor = 5 to 7 | Moderate = 8 to 10 | Good = 11 to 13| Very Good = 14 to 15 | No score/data gap

Fish barriers (standardised): Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

The impounded stream indicator was re-assessed for the 2018 report card, aligning with its four year reporting cycle (Table 13).A permitted sand dam on the Proserpine River, impounding approximately 4km of linear stream length, was incorporated in the impoundment assessment for the first time in the 2018 report card. The presence of this sand dam was of concern as water impoundment may result in extended inundation of riparian vegetation contributing to potential increased erosion if submerged vegetation dies. This impoundment may also affect the fish way, which enables migratory fish to travel upstream. The inclusion of the sand dam shifted scores in the Proserpine basin from moderate to poor.

The Pioneer Basin also graded poor with 9.8% of the total length of streams of order three or higher impounded by artificial structure. There were no impoundments on streams (of order three or higher) in the Don Basin, giving it a condition score of very good. All basins, excluding the Proserpine, remained at similar condition for the 2018 report card, indicating here has been little change in the net proportion of ponded channel habitat within each basin since the last assessment conducted in 2015.

Table 13. Results for the impounded stream indicator in freshwater basins in the 2018 report card (2017-18 data).

Basin	Not impounded (km)	Impounded (km)	Total (km)	% total	Standardised impoundment
Don	954	0	954	0.0	**100**
Proserpine	524	41	565	7.3	**39**
O'Connell	598	16	614	2.6	**70**
Pioneer	498	54	552	9.8	**22**
Plane	671	28	698	4.0	**60**

Impoundment (% total): Very Poor = ≥10% | Poor = 7 to <10% | Moderate = 4 to <7% | Good = <4 to 1% | Very Good <1% | No score/data gap

Standardised impoundment: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

The Impoundment and fish barrier indicators are aggregated up to form the in-stream habitat modification indicator category. In-stream habitat modification scores and grades are provided in Table 14. The Don and O'Connell basins scored good, the Proserpine and Plane basins scored moderate, and the Pioneer basin scored poor (Table 14). Despite the addition of the sand dam into the impoundment assessment for the Proserpine basin, the overall in-stream habitat modification grade remained as moderate.

Table 14. Results for in-stream habitat modification indicator category in freshwater basins in the 2018 report card.

Basin	Impoundment	Fish barriers	In-stream habitat modification
Don	100	60	**80**
Proserpine	39	50	**44**
O'Connell	70	60	**65**
Pioneer	22	21	**21**
Plane	60	40	**50**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

2.3.2. Riparian and wetland extent

In the 2018 report card, the same data was used for percentage loss of riparian extent and wetland extent (palustrine wetlands only) as in the preceding 2017, 2016, 2015 and 2014 report cards. Due to changes in some of the catchment boundaries used for calculating riparian and wetland extent, reporting methods for this year do not directly align with those previously employed. To ensure updated data can be reasonably incorporated, further investigation of the catchment boundaries and methods is required alongside the report card's TWG. As result, wetland and riparian extent indicators are to be updated in future report cards (estimated 2020).

All basins graded moderate for the riparian extent indicator (Table 15), whilst scores for the wetland extent varied between reporting areas. The Proserpine basin was the only basin in good condition for wetland extent. The remaining basins graded poor to very poor for wetland extent (Table 15).

Table 15. Results for riparian and wetland (palustrine wetlands only) extent loss since pre-development (%) and standardised riparian and wetland extent in freshwater basins in the 2018 report card (2013-14).

Basin	Riparian extent (% loss since pre-development)	Wetland extent (% loss since pre-development)		Standardised riparian extent	Standardised wetland extent
Don	30	48		41	22
Proserpine	23	14		50	62
O'Connell	22	56		51	18
Pioneer	20	83		54	7
Plane	30	45		41	25

Riparian and wetland extent (% loss): Very Poor = >50% | Poor =>30 to 50% | Moderate = >15 to 30% | Good = >5 to 15% | Very Good ≤5% | No score/data gap

Standardised riparian and wetland extent: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

2.3.3. Flow

Flow was incorporated into the habitat and hydrology index of the 2018 report card for the first year using the newly developed flow indicator (Stewart-Koster et al. 2018). Flow is assessed upon the 30th percentile value from 10 indicator categories at each assessment site. The indicator for flow at the O'Connell and Pioneer basins were both graded in a good condition (Table 16). The O'Connell basin indicator was assessed from three flow monitoring stations, and the Pioneer basin from four available stations (Table AA2 (Appendix A)). Whilst the grade for flow was good for the O'Connell, unseasonably low flows were recorded from July to August 2018. This period of time falls outside of the 2018 reporting cycle and will likely be captured in the 2019 report card.

Flow could not be assessed for the Don, Proserpine or Plane basins due to lack of either pre-development modelled data or availability of open gauging stations (Table 16). Solutions to fill this data gap will be explored by the TWG, in order to report on flow in these basins in future report cards. Further information on the methods employed for the new flow indicator are available in the Mackay-Whitsunday-Isaac 2018 methods report[1].

Table 16. Results for the flow indicator for freshwater basins for the 2018 report card.

Flow	2018 report card
Basin	Flow
Don	
Proserpine	
O'Connell	78
Pioneer	66
Plane	

Standardised flow scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

2.3.4. Habitat and hydrology index scores and confidence

The overall habitat and hydrology index scores for the 2018 report card show that the Don, Proserpine and O'Connell basins were in moderate condition, and the Pioneer and Plane basins were in poor condition (Table 17). As data for the habitat and hydrology index includes repeated data from 2013-14 (fish barriers, wetland extent and riparian extent), these scores do no not fully capture changes in

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

condition associated with climatic events, including Cyclone Debbie, or potential anthropogenic impacts which may have occurred between 2014 and 2018.

On-ground observations and aerial imagery of the region demonstrate changes to stream banks and in-stream morphology at certain locations as a result of Cyclone Debbie.

The flow indicator was incorporated within the report card framework for the first time. Flow in the O'Connell and Pioneer basins were graded as good and resulted in a shift in grade of the underlying habitat and hydrology scores for these basins, although this did not translate to a shift in the overall grade (Table 17).

Impoundment length (which forms part of the in-stream habitat modification indicator category) was updated in the 2018 report card, with an impounded structure in the Proserpine River included in scoring for the first time.

Habitat and hydrology indicators, riparian and wetland extent were due to be updated for the 2018 report card, however further exploration of the data is required by the report card's TWG and is expected to be updated in future report cards.

Table 17. Results for habitat and hydrology indicator categories and the aggregated index in freshwater basins in the 2018 report card (using data repeated from 2016, 2015 and 2014 report cards, except flow, which are based on 2017-18).

	2018 report card					2017
Basin	In-stream habitat modification	Flow	Riparian extent	Wetland extent	Habitat and hydrology	Habitat and hydrology
Don	80		41	22	**48**	**48**
Proserpine	44		50	62	**52**	**53**
O'Connell	65	78	51	18	**53**	**45**
Pioneer	21	66	54	7	**37**	**27**
Plane	50		41	25	**39**	**39**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

Confidence scoring for habitat and hydrology is provided in Table 18.

Table 18. Confidence associated with habitat and hydrology index results in freshwater basins for the 2018 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Where confidence in results for the Don basin differ to the other basins, the relevant confidence score for the Don is presented in square parenthesis. Unless otherwise specified, confidence in results is the same across basins.

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
In-stream habitat modification[1]						10.4 [7.7]	4 [2]
Riparian extent	2	2	2	2	2	9	3
Wetland extent	2	2	2	2	2	9	3
Flow	1	1	2	2	1	7.2	2
					Habitat and hydrology index	**9**	**3**
Impoundment	2	2	3	2	1	10.3	4
Fish barriers	1	2 [1]	3 [1]	2	2 [1]	10.6 [5.2]	4 [1]

[1]The in-stream habitat modification rank is based on the median final score of impoundment and fish barriers indicators.
Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

2.4. Fish in freshwater basins

Assessments of fish in freshwater basins are updated every three years and were updated for the 2018 report card. Scores for freshwater fish in the Proserpine basin were reported on for the first time (Table 19). Results for freshwater fish assessments were based on electrofishing, which was used to identify the fish species present at 46 randomly selected sampling sites. The majority of Australian freshwater fish are small, e.g. less than 10-15 cm in length, therefore results presented here do not necessarily reflect the expected catch from line-fishing.

Fish survey results were expressed as the Proportion of Native Species Expected (PONSE), which is the number of native fish species caught in relation to the number predicted to occur, based on a numeric model. Median values of PONSE across Mackay-Whitsunday-Isaac basins ranged from very good to moderate. The O'Connell basin was in very good condition, whilst those for the Proserpine and Pioneer basins were rated as good. Results for the Plane basin were considered to represent freshwater fish communities in moderate condition.

The proportion of alien (pest) fish in catches were graded as very good across all of the basins assessed, which was an improvement to 2017 results (repeated from 2015 report card due to reporting frequency), for which only the Plane was in a very good condition. The very good scores for the relative abundance of pest fish abundance in the Mackay-Whitsunday-Isaac region are encouraging and highlight the importance of minimising the impact of pest fish through management and eradication programs. Of note, is that the Mackay-Whitsunday-Isaac region has fewer introduced fish than other parts of Queensland such as South East Queensland and at least some basins within the Wet Tropics.

Unfortunately, a small number of Peacock Bass have recently been caught from the Pioneer River and The Gooseponds at Mackay. Peacock Bass are a voracious predator native to central South America

[1] In-stream habitat modification is the median of impoundment and fish barrier final scores.

and have the potential to spread and cause major impacts on the region's local waterways. Pest fish may affect aquatic plants and animals through direct competition for food and space, predation, driving habitat changes and the introduction of exotic diseases and parasites. For this reason, it is important to prevent the introduction of pest fish into local waterways and eradicate new incursions wherever possible. Continuing the management of existing pest fish populations such as Tilapia and Peacock Bass are critical to reduce threats to native fish species.

Overall, results for the 2017-18 reporting period indicated that local freshwater fish communities, at a catchment scale, are generally in good to very good condition, with results for the Pioneer and O'Connell basins improving from the previous monitoring year to very good, and the Plane maintaining a stable score of good (Table 19).

On face value, the good to very good fish scores appear to be inconsistent with the scores for freshwater pesticides, which are very poor in three of the five basins (Table 7). However, it is important to note that the fish and pesticide scores represent two quite different measures.

The fish indicators used to produce these scores were improved from the 2015 reporting period.

Table 19. Results for fish indicators in freshwater basins in the 2018 report card (2017-18 data).

	2018 report card			2017 (repeated from 2016 & 2015 report card)
Basin	**Native fish richness (PONSE)**	**Pest fish (proportion of sample)**	**Fish (standardised)**	**Fish (standardised)**
Don				
Proserpine	70	89	79	
O'Connell	84	100	**92**	**65**
Pioneer	65	100	**82**	**48**
Plane	59	100	**79**	**79**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

Confidence for freshwater fish is presented in Table 20, below.

Table 20. Confidence associated with fish index results in freshwater basins for the 2018 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Unless otherwise specified, confidence in results is the same across basins.

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Native richness	2	2	2	2	2	9.0	3
Pest fish abundance	2	2	2	2	2	9.0	3
					Fish index	**9.0**	**3**

Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

3. Estuary results

The indicators, relevant indicator categories and overall indices that are assessed for estuaries are presented in Figure 10.

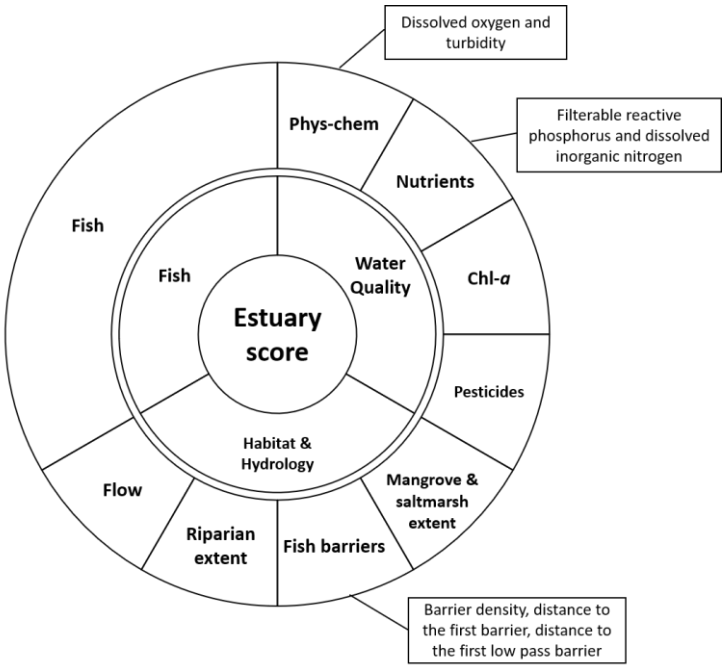

Figure 10. Indicator categories (outer ring) and indices (inner ring) that contribute to overall estuary scores. Where multiple indicators are aggregated to determine the indicator category, these are listed in break-out boxes.

3.1. Key findings for estuaries

- Overall, estuaries in the Mackay-Whitsunday-Isaac region ranged from very good to moderate for the 2018 report card (Table 21).
- The Gregory was the only estuary to grade very good in the 2017-18 reporting year, with Vines, Plane, Rocky Dam and Carmila grading good, and O'Connell, St Helens/Murray and Sandy grading moderate.
- Pesticides were not reported on in the 2018 report card, due to lack of data. Pesticides are expected to be reported on again in the 2019 report card (released in 2020).
- With the exception of the Carmila, estuaries in the Mackay-Whitsunday-Isaac region have remained in relatively consistent condition across reporting years as reflected in the overall scores reported across 2015 – 2018
- Water quality within the Carmila estuary graded poor for the second consecutive year. This score was driven primarily by super saturated concentrations of DO which exceeded the guideline values and, to a lesser degree, high levels of chlorophyll-*a* reported in the 2018 report card. Further investigation is crucial to understanding the ecological processes that are occurring in the Carmila estuary.
- Scores for habitat and hydrology indicators riparian and mangrove/saltmarsh extent are based on repeated data from the 2014 report card. These scores were due to be updated and presented in the 2018 report card, however, due to changes in some parameters comprising the habitat and hydrology indicators, further investigation of the data and methods is required alongside the report cards' TWG. As a result, riparian and mangrove/saltmarsh extent are to be updated in future report cards (estimated 2020).

Table 21. Condition grades of estuaries for the 2018 report card in comparison to 2017, 2016 and 2015* report card scores. *Data from 2015 report card is repeated from the 2014 report card.

Estuary	2018 report card					2017	2016	2015
	Water quality	Habitat and hydrology	Fish	Estuary score and grade		Estuary score	Estuary score	Estuary score
Gregory	81	83		82	A	79	80	79
O'Connell	44	58		51	C	61	54	57
St Helens/Murray	53	61		57	C	61	61	63
Vines	69	68		68	B	64	72	73
Sandy	66	50		58	C	52	50	52
Plane	80	57		68	B	67	59	61
Rocky Dam	78	74		76	B	70	73	70
Carmila	39	96		67	B	66	73	79

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

3.2. Water quality in estuaries

Water quality scores are derived from monthly grab sample data taken at one, two or three monitoring sites, per estuary. Monitoring sites used to calculate scores for the 2018 report card are consistent with those used for reporting water quality in estuaries for the 2017 report card. Similar to the 2017 report card, DIN and FRP data for the O'Connell River estuary only were taken from the freshwater basin CLMP site, O'Connell River at Caravan Park, as no data for DIN or FRP are available through the estuary program.

3.2.1. Nutrients

Scores for the indicator category nutrients, which are generated by the indicators DIN and FRP, are presented in Table 22, below. All estuaries graded moderate for DIN, indicating that median annual conditions exceeded the water quality guideline for this indicator, across the systems assessed. Conversely, all eight estuaries assessed were graded good or very good for the FRP indicator. The final nutrient indicator category scores were similar to the 2017 report, with estuaries grading moderate or good for the 2018 report card. The only observed change in grading occurred at Vines Creek, which improved from moderate to good as a result of improvements to both DIN and FRP. Further, nutrient scores have remained relatively stable across reporting years with half of the estuaries assessed showing no change in grading between 2015 and 2018, as well as being in good condition.

Table 22. Results for DIN and FRP indicators and nutrient indicator category in estuaries for the 2018 report card in comparison to 2017, 2016 and 2015* report card scores. *Data from 2015 report card is repeated from the 2014 report card.

Estuary	2018 report card			2017	2016	2015
	DIN	FRP	Nutrients	Nutrients	Nutrients	Nutrients
Gregory	59	90	**74**	78	78	90
O'Connell^	57	90	**73**	74	75	78
St Helens/Murray	47	65	**56**	54	60	62
Vines	45	90	**67**	50	61	64
Sandy	43	65	**54**	49	46	41
Plane	59	90	**74**	75	74	74
Rocky Dam	46	90	**68**	66	66	66
Carmila	59	90	**74**	69	63	65

DIN and FRP: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = assigned 90 | No score/data gap

Nutrients: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

^ DIN and FRP from the O'Connell estuary are taken from the basin score.

Chlorophyll-*a*

The scores for chlorophyll-*a* for the 2018 report card are presented in Table 23, below. Grades for chlorophyll-*a* ranged from very good to moderate. The Gregory River was the only estuary that scored a very good for chlorophyll-*a* and this has remained consistent for the past three reporting years. Whilst Carmila estuary improved in score from very poor to moderate for the chlorophyll-*a* indicator, further investigation is still required to understand the processes occurring in this system, where scores have fluctuated considerably between reporting years. Slight shifts in grading were also observed in the O'Connell River, Vines Creek and Sandy Creek estuary.

Table 23. Results for Chlorophyll-*a* indicator for the 2018 report card in comparison to the 2017, 2016 and 2015 report card scores.

	2018 report card	2017	2016	2015
Estuary	**Chlorophyll-*a***	**Chlorophyll-*a***	**Chlorophyll-*a***	**Chlorophyll-*a***
Gregory	90	90	90	90
O'Connell	58	63	**33**	
St Helens/Murray	52	58	54	62
Vines	62	55	74	90
Sandy	66	51	60	63
Plane	77	75	69	69
Rocky Dam	76	65	58	90
Carmila	43	0	0	62

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

3.2.2. Physio-chemical

The indicator category physio-chemical, which is generated by aggregation of the turbidity and dissolved oxygen (upper and lower (DO)) indicators, are presented in Table 24, below. Scores for the physio-chemical indicator category varied across the region for estuaries, with the Gregory River, Plane and Rocky Dam grading very good, and O'Connell River and Carmila Creek grading very poor.

Carmila Creek graded very poor for physio-chemical for the second consecutive year, driven by super-saturated concentrations of dissolved oxygen impacting the upper DO indicator. To understand this system, the mechanisms driving super saturation of dissolved oxygen within the Carmila are currently being explored through a desktop review of existing data, however, it is possible a more detailed investigation would be required to delineate this. The O'Connell River also graded as very poor as a result of high concentrations of dissolved oxygen and high levels of turbidity. This is a substantial shift from the 2017 report card where the O'Connell Estuary was graded as good.

Turbidity scores for the report card are compared to draft guidelines for Mackay-Whitsunday-Isaac estuaries (Newham et al. 2017)[1]. A turbidity score was not calculated for the four estuaries south of Mackay (Sandy Creek, Plane Creek, Rocky Dam Creek and Carmila Creek estuaries) as the draft guidelines for Mackay-Whitsunday-Isaac estuaries listed turbidity as too variable to derive a guideline.

[1] https://www.ehp.qld.gov.au/water/policy/pdf/don-haughton-mackay-whitsunday-main-report.pdf

Table 24. Results for DO and turbidity indicators and the phys-chem indicator category (this is calculated by averaging the poorer DO score with the turbidity score, or where there is no turbidity score the poorer DO score is used as the phys-chem score) for the 2018 report card in comparison to 2017, 2016 and 2015* report card scores. *Data from 2015 report card is repeated from the 2014 report card.

	2018 report card				2017	2016	2015
Estuary	Turbidity	lower DO	upper DO	Phys-Chem	Phys-Chem	Phys-Chem	Phys-Chem
Gregory	90	69	90	**79**	84	84	85
O'Connell	4	90	0	**2**	63	18	53
St Helens/Murray	9	90	90	**49**	60	52	81
Vines	64	90	90	**77**	64	90	84
Sandy		78	90	**78**	90	77	90
Plane		90	90	**90**	90	68	67
Rocky Dam		90	90	**90**	90	90	90
Carmila		90	0	**0**	0	90	65

DO and turbidity: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = assigned 90 | No score/data gap

Phys-chem: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

3.2.3. Pesticides

Reporting of pesticides in the Mackay-Whitsunday-Isaac estuaries follow similar methods to those adopted for freshwater basins. Previous Mackay-Whitsunday-Isaac report cards have been able to provide scores on estuary pesticide conditions, however during the 2017-18 reporting year, insufficient data was available. Pesticide scores are expected to be developed for the region's estuaries in the 2019 report card (released in 2020).

3.2.4. Water quality index scores and confidence

Overall, water quality in estuary systems of the Mackay-Whitsunday-Isaac region ranged from very good to poor (Table 25). The Gregory and Sandy estuaries improved in water quality grading, shifting from good and moderate to very good and good, respectively. It should be noted, however, that the 2018 report card scores for estuaries do not consider the impacts of pesticides, which may confound interpretation of improvements observed between reporting years. Despite this, the condition of estuaries in the Mackay-Whitsunday-Isaac region have remained relatively consistent over reporting years.

Carmila Creek was the only estuary that was graded in poor condition for water quality, for the second consecutive year. Of note, is that the Carmila estuary scores are based upon the lower DO and upper DO indicators only, in the absence of a suitable guideline to assess turbidity levels. In the 2018 report card, the Upper DO indicator remained very poor, resulting in the physio-chemical indicator category remaining very poor for the second consecutive year. Chlorophyll-*a* improved in score from very poor in the 2017 and 2016 report cards, to moderate in the 2018 report card with the median chlorophyll-*a* concentration reported at 8.5 and 5.9 µg/L, respectively. As highlighted in the 2017 report card, it is anticipated that these water quality anomalies are a product of natural system processes, with the Carmila estuary operating differently to other estuaries in the region, as there are no apparent substantial anthropogenic pressures on this estuary. Visual observations of Carmila estuary suggest algal blooms may present an issue in this estuary with big tidal movements potentially operating as a source input for algal material (pers comm, A. Moss 12/03/2019). Scores in the 2018 report card highlight, once again, that the relationship between nutrients, phys-chem properties and chlorophyll-a concentrations within the Carmila estuary has not yet been clarified. In addition, further

investigation is required to assist in understanding the ecological impacts of high dissolved oxygen and chlorophyll-*a* in this estuary.

Table 25. Results for water quality indicator categories and final water quality index scores in estuaries for the 2018 report card (2017-18 data) in comparison to 2017, 2016 and 2015* scores. *Data from 2015 report card is repeated from the 2014 report card.

	2018 report card					2017	2016	2015
Estuary	Phys-chem	Nutrients	Pesticides	Chlorophyll-*a*	Water Quality	Water quality	Water quality	Water quality
Gregory	79	74		90	**81**	75	76	75
O'Connell	2	73		58	**44**	65	50	57
St Helens/Murray	49	56		52	**53**	62	61	66
Vines	77	67		62	**69**	61	75	79
Sandy	78	54		66	**66**	54	51	53
Plane	90	74		77	**80**	78	62	66
Rocky Dam	90	68		76	**78**	65	71	66
Carmila	0	74		43	**39**	37	50	63

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

Confidence in water quality index scores in estuaries is shown in Table 26, below. Lower confidence in the O'Connell, Vines and Carmila Creek estuary water quality scores is due to data collection occurring at only one sample site. In other estuaries, there is higher confidence in water quality scores as data is collected at either two or three monitoring sites, resulting in scores which are more spatially representative.

Table 26. Confidence associated with water quality index results in estuaries for the 2018 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Where confidence in results for the O'Connell, Vines and Carmila Creek estuaries differ from the other estuaries, the relevant confidence scores for these estuaries are presented in square parenthesis. Unless otherwise specified, confidence in results is the same across estuaries. *Pesticides were not incorporated into report card scores for the 2018 report card.

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Phys-chem	3	3	2 [1]	3	1	10.1 [8.1]	4 [2]
Nutrients	3	3	2	3	1	10.1 [8.1]	4 [2]
Chl-a	3	3	2	3	1	10.1 [8.1]	4 [2]
Pesticides*	3	3	1	3	2	8.8	3
					Water quality index	**10.1 [8.1]**	**4 [2]**

Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

3.3. Habitat and hydrology in estuaries

Habitat and hydrology assessments in the estuaries are distinct from those in the basins, comprising only four indicators including fish barriers, vegetation (riparian and mangrove/saltmarsh) extent and flow. Impoundments are not assessed as a component of the estuaries. Vegetation assessments also differ from those conducted in the basins, which are taken from the GBR Reef Water Quality Report Card programs for evaluating riparian vegetation extent within the GBR lagoon catchments. To assess vegetation condition in the estuaries, the same broad principles of assessment are applied within the assessment area which included from the estuary mouth, upstream to the tidal limit.

Results for indicators and indicator categories that contribute to the habitat and hydrology index are presented in Section 3.3.1, below.

3.3.1. Fish barriers

Similar to freshwater basins, estuary fish barrier indicators are updated every four years, therefore, data used in the 2018 report card was the same that is used for the preceding 2017, 2016 and 2015 report card scores (Table 27). This reporting frequency reflects the expected gradual nature of change associated with these indicators. Fish barrier indicators are due to be updated in the 2019 report card (released in 2020).

Carmila creek estuary assessment area comprised no fish barriers to fish passage, scoring a condition rating of very good. Fish barriers in Carmila Creek are primarily located in the middle and upper river reaches, falling outside the estuary extent (18.5 m above the DDL). Plane Creek estuary recorded the lowest fish barrier condition rating of poor. Plane Creek flows through Sarina, a large population centre. Plane Creek catchment comprises a high proportion of sugar cane, including a sugar mill located adjacent to the creek. Several low "passability" fish barriers have been constructed in the lower reaches of Plane Creek to provide drinking water for the Sarina community and irrigation supplies for the sugar mill. These large low "passability" barriers contributed to the poor score recorded for the Plane Creek estuary. Vines Creek and the O'Connell and Gregory River estuary assessment areas all received barrier condition ratings of good where systems comprise large areas of connected stream habitats upstream from the estuary mouth, with only a few fish barriers located on smaller tributaries and no low "passability" barriers (Moore, 2016).

Table 27. Results for fish barrier indicators in estuaries in the 2018 report card (2014-15 data). Indicators assessed on Stream Order (SO) ≥3 or ≥4 as indicated. NB: no barriers, NLPB: no low "passability" barriers.

	Barrier density		Stream (%) to the first barrier		Stream (%) to 1st low "passability" barrier		Fish barriers	
Estuary	km per barrier on SO ≥3	Score	% of stream before first barrier on SO ≥3	Score	% of stream before 1st low pass barrier on SO ≥4	Score	Total score	Fish barriers (standardised)
Gregory	34.8	5	96.1	4	97.0	4	13	**80**
O'Connell	4.7	3	85.0	4	NLPB	5	12	**70**
St Helens/Murray	3.6	2	65.1	3	83.1	3	8	**41**
Vines	13.4	4	96.4	4	NLPB	5	13	**80**
Sandy	3.1	2	43.6	2	90.1	4	8	**41**
Plane	2.0	1	48.2	2	75.8	2	5	**21**
Rocky Dam	4.9	3	73.9	3	NLPB	5	11	**61**
Carmila	NB	5	NB	5	NLPB	5	15	**100**

Barrier density (km): Very Poor/score of 1 = 0 to 2km | Poor/score of 2 = >2 to 4km | Moderate/score of 3 = >4 to 8km | Good/score of 4 = >8 to 16km | Very Good/score of 5 = >16km | No score/data gap

Stream to 1st barrier (%): Very Poor/score of 1 = 0 to <40% | Poor/score of 2 = 40 to <60% | Moderate/score of 3 = 60 to <80% | Good/score of 4 = 80 to <100% | Very Good/score of 5 = 100% | No score/data gap

Stream to 1st low "passability" barrier (%): Very Poor/score of 1 = 0 to 60% | Poor/score of 2 = >60 to 80% | Moderate/score of 3 = >80 to 90% | Good/score of 4 = >90 to <100% | Very Good/score of 5 = 100% | No score/data gap

Total score: Very Poor = 3 to 4 | Poor = 5 to 7 | Moderate = 8 to 10 | Good = 11 to 13| Very Good = 14 to 15 | No score/data gap

Fish barriers (standardised): Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

3.3.2. Riparian and mangrove/saltmarsh extent

For the 2018 report card, the same data is used to calculate percentage loss of riparian extent and mangrove/saltmarsh extent as in the preceding 2017, 2016, 2015 and 2014 report cards. Mangrove/saltmarsh and riparian extent indicators were due to be updated for the 2018 report card, however, due to changes in some of the catchment boundaries used for calculating riparian vegetation extent within the catchments, estuary reporting methods for this year do not directly align with those previously employed. To ensure updated data can be reasonably incorporated, further investigation of the reporting boundaries and methods is required, alongside the report card's TWG. As result, riparian and mangrove/saltmarsh extent indicators are to be updated in future report cards (estimated 2020).

All estuaries were in good or very good condition with respect to mangrove/saltmarsh extent, while riparian extent varied from very poor in the O'Connell River estuary to very good in the Gregory River, Rocky Dam Creek and Carmila Creek estuaries (Table 28).

Table 28. Results for riparian and mangrove/saltmarsh extent loss since pre-development (%) and standardised riparian and mangrove & saltmarsh extent in estuaries in the 2018 report card (2013-14 data).

	2018 report card (repeated data)		2018 report card (repeated data)	
Estuary	Mangrove/saltmarsh extent (% loss since pre-development)	Riparian extent (% loss since pre-development)	Standardised mangrove/ saltmarsh extent	Standardised riparian extent
Gregory	3	4	88	81
O'Connell	3	62	87	16
St Helens/Murray	1	26	96	46
Vines	12	18	67	56
Sandy	6	39	79	31
Plane	2	17	91	58
Rocky Dam	5	4	81	82
Carmila	3	0	88	100

Riparian and mangrove/saltmarsh extent (% loss): Very Poor = >50% | Poor =>30 to 50% | Moderate = >15 to 30% | Good = >5 to 15% | Very Good ≤5% | No score/data gap

Standardised riparian and mangrove/saltmarsh extent: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

3.3.3. Flow

A newly developed flow tool for the Mackay-Whitsunday-Isaac and Wet tropics regional report cards (Stewart-Kosher et al. 2018) was able to be utilised for the first time in the 2018 report card to report on flow in freshwater basins. Due to minimal data availability, scores for flow were not able to be developed across the majority of estuaries. Further review of the flow tool is scheduled to occur with the report cards Technical Working Group prior to the release of the 2019 report card, with the aim of resolving data gaps in order to develop scores for flow in estuaries and additional freshwater basins.

3.3.4. Habitat and hydrology index scores and confidence

The overall habitat and hydrology index scores for estuaries for the 2018 report card ranged from moderate to very good across the Mackay-Whitsunday-Isaac region (Table 29). Due to the reporting frequency, results do not reflect potential impacts to these indicators from TC Debbie. On-ground observations and aerial imagery of the region have identified localised impacts to mangroves, stream banks and in-stream morphology as a result of TC Debbie. This includes a loss of mangroves at the St Helens Creek and Murray Creek estuary which has resulted in these systems intersecting further upstream than they did previously (P. Trendell 2018. pers. Comm 19/10/2018). Changes like this may

be captured in mangrove/saltmarsh extent indicators, which are expected to be updated in the 2019 report card (released in 2020).

Table 29. Results for habitat and hydrology indicator categories and index in estuaries for 2018 report card (data repeated from 2017, 2016, 2015 and 2014 report cards).

Estuary	2018 report card			2018 report card (repeated data)
	Mangrove/ saltmarsh extent*	Riparian extent*	Fish barriers*	Habitat and hydrology
Gregory	88	81	80	**83**
O'Connell	87	16	70	**58**
St Helens/Murray	96	46	41	**61**
Vines	67	56	80	**68**
Sandy	79	31	41	**50**
Plane	91	58	21	**57**
Rocky Dam	81	82	61	**74**
Carmila	88	100	100	**96**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

*Data for mangrove/saltmarsh extent, riparian extent and fish barriers is repeated data.

Confidence in habitat and hydrology scores for estuaries are shown in Table 30.

Table 30. Confidence associated with habitat and hydrology index results in estuaries for the 2018 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Unless otherwise specified, confidence in results is the same across estuaries.

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Fish barriers	1	2	3	2	1	9.9	4
Riparian extent	2	2	2	1	2	8.3	3
Mangrove & saltmarsh extent	2	2	2	1	2	8.3	3
					Habitat and hydrology index	**8.3**	**3**

Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

3.4. Fish in estuaries

There is no score for condition of fish in estuaries. Identification of appropriate indicators and development of methodology are required to progress assessment of fish community condition in estuaries. Development of these indicators is anticipated to occur in collaboration with RIMReP, TWG and other regional report card Partnerships.

4. Inshore and offshore marine results

The indicators, relevant indicator categories and overall indices that are assessed for the inshore and offshore marine zones are presented in Figure 11.

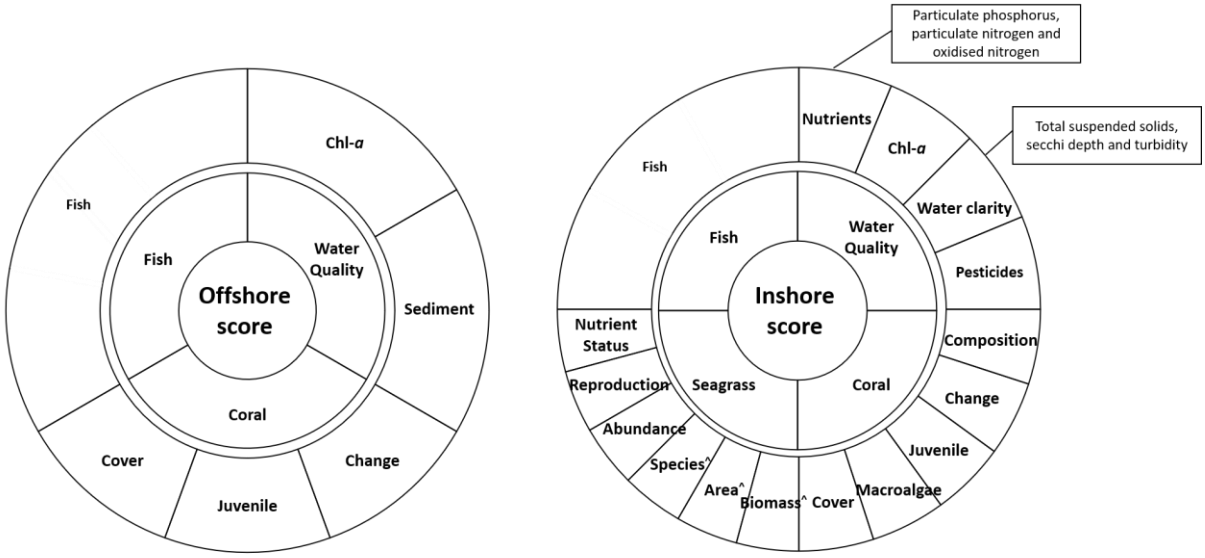

Figure 11. Indicator categories (outer ring) and indices (inner ring) that contribute to overall offshore and inshore marine scores for each zone. Where multiple indicators are aggregated to determine the indicator category, these are listed in break-out boxes.

4.1. Key findings for inshore and offshore marine

- Overall marine zone grades were good and poor for the 2018 report card, with the marine offshore zone scoring good, and all inshore marine zones scoring poor (Table 31).
- Water quality scores for inshore marine zones graded moderate and poor for the 2018 report card.
- Offshore water quality remained in a very good condition for the fifth consecutive year.
- An overall score was produced for the southern inshore marine zone reporting on the water quality indicator for the first time in the 2018 report card. This was captured through the successful development of a monitoring program established in the zone for water quality, coral and seagrass. This highlights the Partnership's commitment to improve report card data and ultimately understanding of ecosystem health in the Mackay-Whitsunday-Isaac region.
- Coral and seagrass indicators are expected to be reported in future report cards for the Southern inshore marine zone.
- Additional pesticides were assessed in the inshore marine zones for the first time in the 2018 report card, shifting from 13 to up to 19 pesticides. The incorporation of additional pesticides aligned with a change in methods and reflects pesticide methods used to assess water quality in freshwater basins.
- Coral condition was moderate and poor across inshore and offshore zones for the 2018 report card, respectively.
- Tropical Cyclone Debbie caused considerable damage to coral in the Mackay-Whitsunday-Isaac inshore region when it crossed the coast on 28th March 2017. There was little evidence of recovery in 2018 on inshore reefs. Low densities of juvenile corals, high cover of macroalgae

and historically low rates of increase in coral cover suggest recovery of coral communities will be slow.

- Coral in the offshore zone remained in a moderate condition for the fifth consecutive year. The full impact of Tropical Cyclone Debbie is yet to be fully captured in the offshore zone, as coral scores for several reefs are yet to be updated to include post cyclone observations.
- Seagrass condition was moderate to very poor among inshore marine zones for the 2018 report card.
- Tropical Cyclone Debbie was the most likely driver for seagrass condition declines recorded for many meadows/sites and zones in the region compared with the previous year (2016-17 reporting)
- Seagrass meadows sustained high rainfall, flood plumes, increased wave height, and strong winds during Tropical Cyclone Debbie. These conditions severely impact seagrass physically (e.g. burial, scouring, and direct removal of plants and seed banks), and physiologically (light limitation, excess nutrients and herbicides, and changes in salinity).
- Scores for new seagrass sites/locations were incorporated in the 2018 report card scores for the first time in the Whitsunday zone: Lindeman Island (MMP); and the central zone: Dudgeon Point (QPSMP), St Bees Island (QPSMP), Keswick Island (QPSMP) and a citizen science Seagrass Watch site at St Helens.

Table 31. Results for indices and overall marine scores for inshore and offshore zones reported in the 2018 report card (2017-18 data) in comparison to final scores in the 2017, 2016, 2015 and 2014 report cards. *Offshore coral scores have been amended since previous report cards which has impacted the overall scores for the offshore zone 2014-2016 (see Appendix C for score comparison).

	2018 report card						*2017	^2016	^2015	^2014
Zone	Water quality	Coral index	Seagrass	Fish	Marine score and grade		Marine score	Marine score	Marine score	Marine score
Northern	55	25	25		**35**	**D**	44	43	21	40
Whitsunday	28	42	13		**27**	**D**	27	47	39	28
Central	44	23	45		**37**	**D**	31	41	51	25
Southern	22				**22**	**D**				
Offshore	99	56			**77**	**B**	76	77**	77**	74**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap| ■ Not applicable

*2017 overall marine score results have been back-calculated to incorporate changes to methods for pesticides and seagrass that were applied in the 2018 report card. 2016-2014 scores have not been back-calculated.

^2016-2014 report card scores do not include back-calculated pesticide updates that were established for the 2018 report card.

**Offshore coral scores have been amended due to error in methods.

4.2. Water quality in inshore and offshore marine ecosystems

Following the Marine Monitoring Program (MMP) approach for scoring and reporting *in-situ* water quality data, the condition scores for nutrients, chlorophyll-*a* and water clarity were derived for the inshore zone. For the pesticide indicator category, data obtained from passive sampler deployments were used to derive pesticide condition scores for the inshore zone. Condition of water quality in the offshore marine zone is assessed based on two indicators, chlorophyll- *a* and TSS. Water quality (chlorophyll-*a* and TSS) condition in the offshore zone is assessed using available remote sensing data sourced from the Bureau of Meteorology. This contrasts water quality reporting across other zones, areas and sites within the report card, which are based on monitoring data collected in-situ.

To assess water quality, scheduled guideline values that are more localised to the marine waters in the Mackay-Whitsunday-Isaac Region (DES 2013) as per the Environmental Protection (Water) Policy 2009 (DES 2009) were adopted in the Whitsunday and Central inshore marine zones, however, these do not extend to the Northern inshore zone. Localised guidelines for the coastal waters of the Haughton, Burdekin and Don Basins region are in draft (Newham et al. 2017)[1]. To remain consistent with reporting in the 2016 report card, the current GBRMPA (2010) guidelines were used for marine waters in the Northern inshore zone until localised guidelines have been developed. For further details on the adopted guidelines, refer to the Methods for the Mackay-Whitsunday-Isaac 2018 report cards document[2].

Conceptually, inshore marine water quality in the Mackay-Whitsunday-Isaac region is influenced by five major river basins; the Proserpine, O'Connell, Pioneer, Plane and Fitzroy Basins. More specifically, the Pioneer and Fitzroy Rivers appear to have the greatest influence on the Whitsundays region. Under strong discharge conditions, the Pioneer dominates the waters inshore of Whitsundays Island with the offshore coast of Whitsundays Islands being influenced by the Fitzroy (Baird et al 2018). The region is also potentially influenced by run-off from the Burdekin Basin during extreme events or through longer-term transport and mixing. The region is typified by higher variability in discharge and loads compared to surrounding regions such as the Wet Tropics Basins (Waterhouse et. al 2018).

4.2.1. Nutrients, chlorophyll-*a* and water clarity

Nutrient scores are based upon reported concentrations of oxidised nitrogen (NOx), particulate phosphorus (PP) and particulate nitrogen (PN), while Secchi depth, Total Suspended Solids (TSS) and turbidity inform the water clarity indicator category.

Condition scores are calculated by comparing annual means or medians to guideline values (with the appropriate statistic identified within the guidelines), for each indicator at each site within a zone. Preliminary scores are aggregated across sites and indicators to produce the final nutrients, chlorophyll-*a* and water clarity indicator category scores within a zone.

In the 2018 report card, nutrients, chlorophyll-*a* and water clarity scores ranged from good to very poor across the inshore marine waters assessed within the Mackay-Whitsunday-Isaac region (Table 32). Changes in these water quality indicators were evident between the 2017 and 2018 reporting years across the Northern and Whitsunday zone. In the Northern zone, chlorophyll-*a* and water clarity scores declined, shifting from very good and moderate, to good and very poor, respectively. Nutrient scores have not been calculated in the northern zone since 2014, inhibiting any interpretation of change between years; however, scores were rated as very good for this indicator. Between the 2017 and 2018 reporting years, there was an overall increase in score for nutrients, chlorophyll-*a* and water clarity within the Whitsunday zone; in the case of nutrients and chlorophyll-*a* this translated to a shift from very poor to poor grading, suggesting concentrations of these pollutants were lower than the previous reporting period at the time of sampling. Conditions for chlorophyll-*a* and water clarity remained poor within the Central inshore marine zone, whilst nutrient scores shifted from moderate to good.

[1] https://www.ehp.qld.gov.au/water/policy/pdf/don-haughton-mackay-whitsunday-main-report.pdf
[2] https://healthyriverstoreef.org.au/report-card/report-card-download/

Notably, NOx and TSS did not contribute consistently to the final indicator scores within the Northern, Central and Southern zones due to limited data availability. Likewise, considerable gaps in the turbidity data were identified for sites within the Northern, Central and Southern zones across the wet season, therefore, turbidity scores may underestimate system conditions. Despite this, condition associated with water clarity was poor to very poor across all inshore marine zones.

Scores within the Southern inshore marine zone are presented for the first time within the Mackay-Whitsunday-Isaac report card and reflected very poor scores for chlorophyll-*a* and water clarity, whilst median values for nutrients were moderate.

Table 32. Results for inshore water quality indicator categories for the 2018 report card (2017-18 data) compared to 2017, 2016 and 2015 report cards. Scores in italics should be treated with caution due to lack of temporal representativeness (n=2).

Inshore zone	2018			2017			2016			2015		
	Nutrients	Chl-a	Water clarity	Nutrients	Chl-a	Water clarity	Nutrients	Chl-a	Water clarity	Nutrients	Chl-a	Water clarity
Northern	88	61	17		89	50		89	40			
Whitsunday	32	22	30	1	0	21	28	53	38	32	49	47
Central	63	27	30	55	29	25	36	38	52	64	52	32
Southern	49	18	0									

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

Data from grab samples is used to develop water quality scores, with the exception of turbidity which is recorded in 15-minute intervals using data loggers. A summary of the grab sampling program is detailed below (Table 33).

Table 33. Dates that grab samples were taken in the inshore marine zones and parameters sampled

Northern		Whitsunday		Central		Southern	
Date sampled	Parameters analysed	Date sampled	Parameters analysed	Date sampled	Parameters analysed	Date sampled	Parameters analysed
Aug-2017	Chl-*a*	Sep-2017	NOx, PP, PN, Chl-*a*, Secchi, TSS	Jul-2017	PP, PN, Chl-*a*, Secchi	Sep-2017	PP, PN, Chl-*a*, NOx
Nov-2017	PN, PP, Chl-*a*, Secchi	Jan-2018	NOx, PP, PN, Chl-*a*, Secchi, TSS	Sep-2017	PP, PN, Chl-*a*, Secchi, NOx, TSS	Oct-2017	PP, PN, Chl-*a*, NOx
Dec-2017	PN, PP, Chl-*a*, Secchi	Feb-2018	NOx, PP, PN, Chl-*a*, Secchi, TSS	Oct-2017	PP, PN, Chl-*a*, Secchi	Dec-2017	PP, PN, Chl-*a*, NOx
Feb-2018	PN, PP, Chl-*a*, Secchi	Apr-2018	NOx, PP, PN, Chl-*a*, Secchi, TSS	Dec-2017	PP, PN, Chl-*a*, Secchi	Apr-2018	PP, PN, Chl-*a*, NOx
Apr-2018	PN, PP, Chl-*a*, Secchi	Jun-2018	NOx, PP, PN, Chl-*a*, Secchi, TSS	Jan-2018	PP, PN, Chl-*a*, Secchi, NOx, TSS	Jun-2018	PP, PN, Chl-*a*, NOx

Table 33. continued

Jun-2018	PN, PP, Chl-*a,* Secchi		Feb-2018	PP, PN, Chl-*a,* Secchi, NOx, TSS	
			Apr-2018	PP, PN, Chl-*a,* Secchi, NOx, TSS	
			Jun-2018	PP, PN, Chl-*a,* Secchi, NOx, TSS	

4.2.2. Pesticides

Pesticides in the inshore marine zone were reported using the Pesticide Risk Metric for the first time in the 2018 report card (Table 35). This method was adopted to align pesticide reporting with that of freshwater basins. The Pesticide Risk Metric approach is able to consider pesticides with different Modes of Action (MoA) which exert their toxicity by different means, increasing the number of chemicals which can be incorporated to inform water quality assessment. As a result, the impacts to the marine environment through land-based run-off are captured for a greater number of pollutants.

In the 2018 report card, 19 pesticides were reported on in the inshore marine zone. However, it is expected that additional pesticides will be included in future report cards to align reporting with Reef 2050 WQIP pesticide targets. The additive nature of the Pesticide Risk Metric calculations may result in scores for pesticides getting worse in subsequent years as more pesticides are assessed.

Previous Mackay-Whitsunday-Isaac report cards have reported pesticides in the inshore marine zone using the PSII-HEq (PSII Herbicide Equivalent Concentration) method, which can only assess a maximum of 13 herbicides. Previously reported PSII-HEq scores for in inshore marine pesticides are provided in Table AC 20 (Appendix C).

Pesticide data for the 2018 report card were collected using a combination of passive samplers and grab samples. Passive samplers were deployed as part of the MMP to assess long-term trends in pesticide concentrations and are currently installed at locations within the Central zone only. A single monitoring event, including collection of one grab sample from each monitoring site, was conducted at Abbot Point, Mackay and Hay Point, as commissioned by North Queensland Bulk Ports Corporation Ltd (NQBP) in the Northern and Central zones. As the report card endeavours to assess ambient water quality, only passive sampler data from the MMP were employed to derive pesticide scores, resulting in a score within the Central Zone only.

Passive sampler deployments record a time-averaged estimate of pesticide concentrations (approximately a monthly average) and the maximum % species affected for the site was adopted for calculation of the Pesticide Risk Metric. For the purpose of reporting, the % species protected (the inverse of % species affected) is reported alongside the final Pesticide Risk Metric score.

The overall score for pesticides in the Central zone was produced by averaging maximum % species affected values from sites at Repulse Bay, Round Top, Sandy Creek and Sarina (Table 34). The moderate score in the Central zone was driven primarily by the very high risk scores observed at Round Top monitoring site, which scored a very poor for the third consecutive year. The passive sampler deployed at Round Top during November/December yielded the highest pesticide risk observed

throughout the monitoring period. A review of pesticide grades within upgradient or cross-gradient catchments from Round Top, including the Pioneer River and Plane Creek, indicated they rated very poor for the 2018 report card. The November – December spike in pesticide concentration aligned with reported shifts in harvest practices for 2017 (pers comm, P. Trendell 2018) and are reflected in *Department of Environment and Science Exceedance notice No.3 and No.5,* however a more detailed investigation of land-based pesticide inputs and prevailing oceanographic conditions is required to understand ecological risk within this area.

Of note, is that monitoring at Sandy Creek was limited, where analysis of only two passive samplers were available, capturing pesticide concentration levels between 25/05/2017-7/11/2017. This falls outside of the peak spray and rainfall season, therefore, scores may underestimate the maximum % species affected by pesticides at this site.

A monitoring program was established in the Southern zone in 2017 (for water quality, coral and seagrass indices) and water quality indicators have been reported on for the first time in the 2018 report card. The collection of pesticide data has recently been added into the monitoring program and is expected to be reported on in the 2019 report card (released in 2020).

Table 34. Results for the Pesticide Risk Metric indicator accounting for 22 pesticides, reporting aquatic species protected (%) and overall standardised pesticide score for inshore marine zones for the 2018 report card compared to the 2017. The Pesticide Risk Metric reported for each passive sampler site is the maximum % species affected value out of n deployments per site.

2018 report card							^2017 report card
Zone	**Sample**	**Program**	**Site/s**	**Value obtained**	**% species protected**	**Pesticide score**	
Northern							
Whitsunday							
Central	Passive (monthly average)	MMP	Repulse 10/10/2017 - 15/03/2018 n = 3	max	99	54	50
			Round Top 10/10/2017 - 12/04/2018 n = 6	max	78		
			Sandy Creek 25/05/2017 - 7/11/2017 n =2	max	99		
			Sarina 10/05/2017- 5/05/2018 n = 6	max	98		
Southern							

Species protected scoring range: Very Poor = <80% | Poor = <90 to 80% | Moderate = <95 to 90% | Good = <99 to 95% | Very Good = ≥99% | No score/data gap

Pesticides: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

^ A comparison of Pesticide risk metric method scores for the 2018 and 2017 report card is presented in Appendix D. Previous report card scores (2016, 2015, and 2014) have not been back-calculated to reflect method updates to inshore marine pesticides

4.2.3. Water quality index scores and confidence

Overall, the Whitsunday and Central inshore marine zones were in poor and moderate condition, respectively, for water quality in the 2018 report card (Table 35). Index scores have increased in these zones for overall water quality between the 2017 and 2018 report cards. Due to limited data availability, a pesticide score was not derived for the Northern, Whitsunday or Southern zone. A water quality score was reported for the first time in the northern zone since 2014 and was in a moderate condition. Water quality in the Southern inshore marine zone was reported for the first time, following the development of a monitoring program for this zone in 2017.

Water quality within the offshore zone scored very good the fourth consecutive year (Table 35).

Table 35. Final 2018 report card score for water quality index scores for Mackay-Whitsunday marine zones and final scores compared to 2017, 2016, 2015 and 2014 report cards. Scores from 2015 and 2014 report cards have been back-calculated to exclude pesticide scores in the Whitsunday zone so that they are directly comparable to 2016 and 2017 scores.

Inshore zone	Nutrients	Chl-a	Water clarity	Pesticides	Water quality index 2018	Water quality index 2017	Water quality index 2016	Water quality index 2015	Water quality index 2014
Northern	88	61	17		55				40
Whitsunday	32	22	30		28	7	4	42	4
Central	63	27	30	54	44	39	44	54	
Southern	49	18	0		22				
Offshore		99	99		99	92	93	94	95

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap | ■ Not applicable

Confidence in water quality index scores generated for inshore and offshore marine zones is shown in Table 36, below. The low confidence in the water quality index for the offshore zone (Table 36) was due to the use of remote sensing data to inform indicator scores.

Table 36. Confidence associated with water quality index results in marine zones for the 2018 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level.

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Nutrients	3	3	1	3	3	9.5	3
Chl-a	3	3	1	3	3	9.5	3
Water clarity	3	3	1	3	3	9.5	3
Pesticides	2	2	1	2	1	6.3	1
					Inshore water quality index	**9.5**	**3**
Offshore chl-a	3	2	2	1	1	7.9	2
Offshore TSS	3	2	2	1	1	7.9	2
					Offshore water quality index	**7.9**	**2**

Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

4.3. Coral in inshore and offshore marine zones

Coral reef assessment is undertaken with the general understanding that healthy and resilient coral communities exist in a dynamic equilibrium, following a cycle of recovery punctuated by acute

disturbance events. Disturbance events may include cyclones, thermal bleaching and outbreaks of crown-of-thorns starfish (COTS) (Thompson *et al* 2018). The condition of coral indicators for the inshore and offshore zones for the 2018 report card are presented in Table 37.

The offshore coral index remained in a moderate condition for the fifth consecutive year (Table 37), although the underlying assessment score in 2018 has declined. This decline largely reflects the impacts of Cyclone Debbie that were partially captured in this year's report card. Of note, is that six of the sixteen reefs monitored in the offshore zone have not been revisited since the passage of Cyclone Debbie. These reefs are scheduled for survey in early 2019 and will capture the full extent of the damage. Coral cover declined and remained as poor and coral change as moderate, whilst the juvenile indicator score declined slightly it remained very good. The juvenile coral indicator, which assesses the abundance of hard coral recruits, scored very good. Coral recruits require space amongst a coral reef on which to settle and are susceptible to poor water quality, therefore a very good juvenile score suggests there was no considerable environmental limitation to hard coral recruitment within the offshore marine zone during the monitoring period.

Notably, higher numbers of coral-eating Crown-of-Thorns Starfish (COTS) were reported within the offshore zone. The crown-of-thorns starfish is a voracious native predator of live coral on the Great Barrier Reef. Populations can reach ''outbreak'' densities rapidly, causing significant damage to coral reefs. The incidence of outbreaks is influenced by multiple factors, including major flooding events which may coincide with cyclonic activity[1]. The presence of COTS is anticipated to compound impacts attributed to Cyclone Debbie causing further loss of coral cover at reefs where they occur and so supressing recovery processes.

The coral index ranged from moderate to poor across inshore marine waters within the Mackay-Whitsunday-Isaac Region (Table 37). There was no change in coral index grades between the 2017 and 2018 report cards, although there was a reduction in the value of scores within the Northern and Whitsunday zones, indicating limited recovery has occurred since Cyclone Debbie. While initial recovery of coral communities following severed disturbance is often slow the poor to very poor scores for juvenile densities, coral cover and the coral change indicator within each of the inshore marine zones, suggest a protracted recovery from damage caused by TC Debbie is likely. Where reefs are isolated from surviving coral communities and have low scores for the macroalgae indicator the rate of recovery is likely to be further reduced (pers comm, A. Thompson 2018).

For the macroalgae indicator, a considerable decline in score was evident within the Whitsunday zone and resulted in a shift from very good to moderate grade. Low macroalgae cover previously reported for the Whitsunday and Northern zone in the 2017 report card was likely to have occurred in response to high wave action associated with TC Debbie, stripping the reefs of macroalgae, or, as a result of high turbidity in the aftermath (Thompson et al. 2018). A reduction in indicator score values in the 2018 report card within the Whitsunday and Northern zone demonstrate that macroalgae has rapidly re-established.

[1] http://www.gbrmpa.gov.au/our-work/our-programs-and-projects/crown-of-thorns-starfish-control-program

The report card has started to capture the impacts of Tropical Cyclone Debbie, however the full impacts, particularly in the offshore zone, are yet to be fully captured in the Mackay-Whitsunday-Isaac region. Future monitoring will continue to show how challenging environmental conditions influence the recovery of coral communities.

Table 37. Results for inshore and offshore coral indicators for marine zones reported in the 2018 report card (2017-18 data) in Mackay-Whitsunday-Isaac compared to 2017, 2016 2015 and 2014 report cards. *Offshore coral scores are not directly comparable to previously reported values, due to revision of the coral change metric, scores presented are back calculated using the revised method.

	2018 report card						2017	2016	2015	2014
Zone	Cover	Macroalgae	Juvenile	Change	Composition	Coral index	Coral index	Coral index	Coral index	Coral index
Northern	12	61	7	20		**25**	31	45		
Whitsunday	32	60	32	37	47	**42**	52	61	58	56
Central	36	0	16	39		**23**	23	31		
Southern										
Offshore	33		93	41		**56**	60	57*	57*	54*

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap | Not applicable

Confidence in scores for coral indicators is high and presented in Table 38.

Table 38. Confidence associated with coral index results in marine zones for the 2018 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Unless otherwise specified, confidence in results is the same across marine zones where relevant.

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Cover	3	3	2	3	2	10.8	4
Change	3	3	2	3	2	10.8	4
Juvenile	3	3	2	3	2	10.8	4
Macroalgae	3	3	2	3	2	10.8	4
Composition	3	3	2	3	2	10.8	4
					Inshore coral index	**10.8**	**4**
Cover	3	3	1	3	1	8.1	2
Change	3	3	1	3	1	8.1	2
Juvenile	3	3	1	3	1	8.1	2
					Offshore coral index	**8.1**	**2**

Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

4.4. Seagrass in inshore marine zones

Seagrass condition for the 2018 report card assessment was based on indicators measured as part of either the Marine Monitoring Program (MMP) and/or the Queensland Ports Seagrass Monitoring Program (QPSMP), depending on which zone is assessed. Different indicators are used across the two programs, with MMP-associated indicators being abundance (percent cover), reproductive effort and tissue nutrient status, while the QPSMP-associated indicators are area, biomass and species composition. To combine these programs, the seagrass index score is derived from averaging

site/meadow scores from within a zone, as opposed to averaging the indicator scores within a zone. This is because there is a key difference between the two programs in how they derive site/meadow scores; the MMP takes the average of the indicator scores while the QPSMP takes a conservative approach and allocates the lowest of the indicator scores to the site/meadow. In 2018, a method update was applied for the QPSMP where if species composition drives the score because it is the lowest indicator, it is given a 50% weighting.

The method for calculating zone scores was updated for seagrass for the 2018 report card to remove a weighting bias due to the different approaches between the programs. Overall scores for seagrass have been back-calculated and are provided in Table 39, with previously reported scores provided in Appendix C. Further information on seagrass methods are presented in the Methods for the Mackay-Whitsunday-Isaac 2018 Report Card[1].

Seagrass condition was moderate to very poor among zones in the 2018 report card (Table 39).

Tropical Cyclone Debbie severely impacted the region in March 2017 and was the likely driver for seagrass condition declines across many of the meadows in the Mackay-Whitsunday-Isaac Region, compared with previous reporting years. Events such as Tropical Cyclone Debbie create conditions where seagrass meadows sustain high rainfall, flood plumes, increased wave height and strong winds. These conditions can severely impact seagrass condition through physical disturbance (burial, scouring and direct removal of plants and seed banks), and physiologically through light limitations, excess nutrient loads and herbicides, and changes in salinity. The extreme weather event in January 2019 that resulted in substantial flooding in Townsville, and high rainfall and flash flooding in Mackay-Whitsunday-Isaac region, will likely be reflected in the in the 2019 report card (due for release in 2020).

Seagrass condition in the Northern zone is derived from data entirely from the QPSMP. Overall seagrass condition declined from moderate in 2017 to poor in 2018. This was driven by a decline in all seagrass meadow indicators measured in this region (biomass, area and species composition). Seagrass condition declined across both shallow and deep-water meadows as a result of declines in biomass in deep-water meadows, and the disappearance of two meadows in the shallow zones. This was coupled with declines in area and biomass in some monitoring meadows. Cyclone Debbie impacts in this region were associated with high rainfall and flooding of the Don River which caused a reduction in benthic light below light requirements suitable to support seagrass growth and survival.

Seagrass condition in the Whitsunday zone is derived from MMP and Seagrass Watch (a citizen science program active in the region) sites, from five locations. Overall condition of seagrass in the Whitsunday zone shifted from poor to very poor. Seagrass abundance in this zone also was affected by Tropical Cyclone Debbie at sites near and south of Airlie Beach (McKenzie et al. 2018). Of note, is that abundance (percent cover) is the only indicator reported in three of the five locations in the Whitsunday zone. Abundance decreased in Hydeaway, Tongue and Pioneer bays, whilst abundance at

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

Hamilton Island remained zero. Lindeman Island was added to the MMP for the first time in 2017-2018; seagrass was in poor condition at this location.

Seagrass in the Central zone is derived from a combination of QPSMP, MMP and Seagrass Watch sites. Previous report cards have typically reported on three MMP sites (Midge Point, Newry Bay and Sarina Inlet) and one QPSMP deep-water meadow site (Hay Point). Additional seagrass data were available to report in 2018 from both seagrass monitoring programs. This includes St Helens Beach, a Seagrass Watch citizen science monitoring site, additional QPSMP meadows at Dudgeon Point, St Bees and Keswick Island, and an area score for the deep-water Hay Point meadow. Despite impacts associated with Tropical Cyclone Debbie in this zone, including high wave action, high rainfall and flooding of the Pioneer River, and likely reduced available light below levels suitable for seagrass growth and survival, seagrass condition in the central zone improved from poor to moderate. However, the improved score was largely driven by the addition of new QPSMP meadows which were in generally better condition than existing monitoring locations

An active citizen science Seagrass Watch program is currently underway in the Southern inshore zone which was able to provide some insight into seagrass abundance condition in this zone for the 2018 report card. Whilst an overall seagrass score is not produced for the Southern inshore zone using the Seagrass Watch program data, the abundance score from the Seagrass Watch citizen science program for Clairview (Southern inshore zone) is provided for the first time in Appendix C. The Mackay-Whitsunday-Isaac report card recognises and acknowledges the valuable input from active citizen science programs in monitoring ecosystem health in the Mackay-Whitsunday Region. The Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership are currently funding a seagrass program in the Southern inshore zone, which is expected to report on seagrass condition in the 2021 report card.

Table 39. Results for inshore seagrass indicators for marine zones reported in the 2018 report card (2017-18 data) in Mackay-Whitsunday-Isaac compared to 2017, 2016, 2015 and 2014 report cards. Indicators are based on data collected from the Marine Monitoring Program (MMP) or the Queensland Ports Seagrass Monitoring Program (QPSMP).

2018 report card								2017#	2016#	2015#	2014*#
Zone	Abundance	Reproductive effort	Nutrient status	Biomass	Area	Species Composition	Seagrass Index	Seagrass index	Seagrass Index	Seagrass index**	Seagrass index**
Program	*MMP*			*QPSMP*							
Northern				28	48	57	**25^**	**58^**	42	21	
Whitsunday	14	4	13				**13^**	**24^**	34	18	24
Central	45	13	38	55	65	98	**45^**	**30^**	50	39	26
Southern											

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap | ■ Not applicable

^To derive the seagrass index an average of *site/meadow* scores is calculated, not an average of indicator. To determine a site/meadow score the MMP takes the average of the indicator scores and QPSMP take the lowest of the indicator scores. This can sometimes lead to overall seagrass index scores and ratings appearing to contradict the indicator scores.
*Seagrass scores from 2014 are only from MMP.
**Seagrass scores in 2015 and 2014 do not account for subtidal sites in the MMP.
#Seagrass scores have been back-calculated in 2018 report card to reflect updates to method changes relating to MMP.

Confidence for seagrass condition indicators associated with the MMP and QPSMP and the overall seagrass condition index are shown in Table 40.

Table 40. Confidence associated with seagrass index results in marine zones for the 2018 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level.

Indicator category	Maturity of methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final	Rank
Abundance	3	3	1	3	2	8.8	3
Reproductive effort	3	3	1	3	2	8.8	3
Nutrient status	3	3	1	3	2	8.8	3
Biomass	3	3	1	3	2	8.8	3
Area	3	3	1	3	2	8.8	3
Species composition	3	3	1	3	2	8.8	3
					Seagrass index	**8.8**	**3**

Rank based on final score: 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5

4.5. Fish in inshore and offshore marine zones

There is no score for condition of fish in inshore and offshore marine zones. Identification of appropriate indicators and development of methodology are required for progressing fish assessment indicators in inshore and offshore marine zones. Development of these indicators is planned to occur in collaboration with RIMReP, TWG and other regional report card Partnerships.

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Appendix A: Freshwater basins

Boxplots of monthly medians presented for DIN, FRP and TSS indicators, previously reported Ms-PAF indicator scores and freshwater flow values for freshwater basins are presented below.

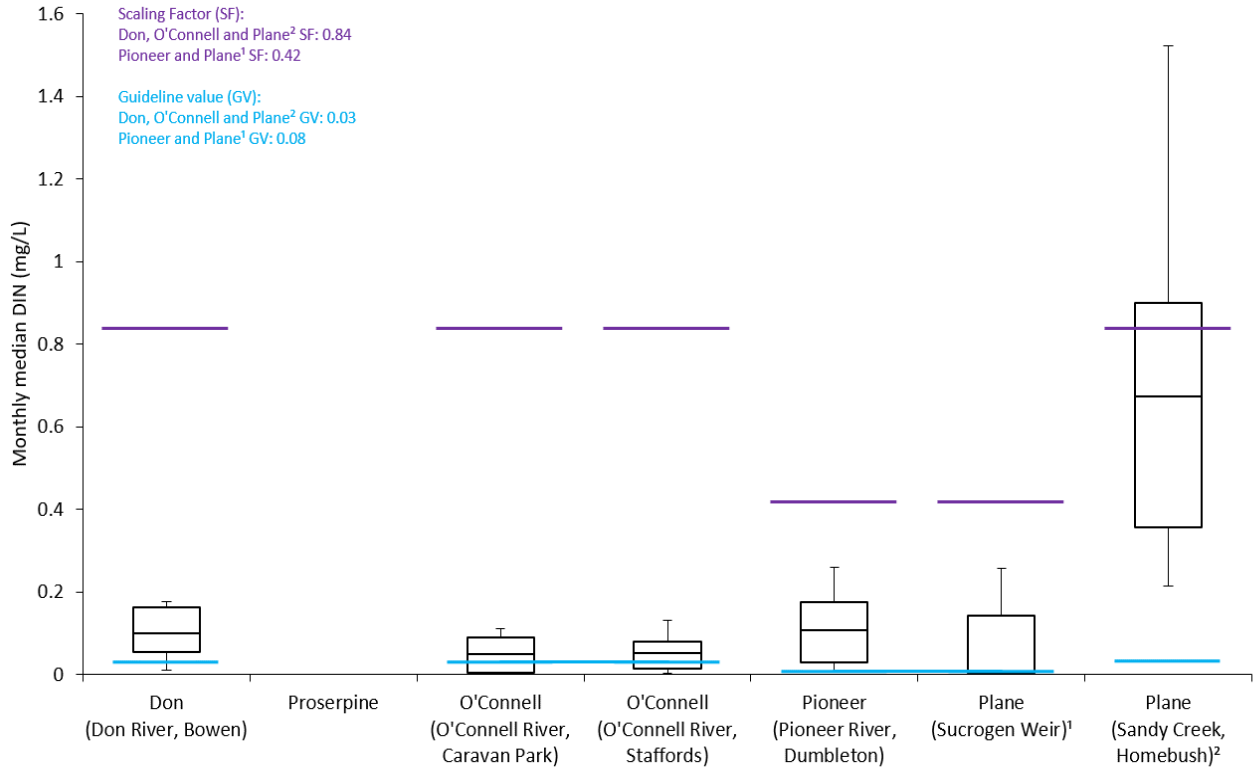


Figure AA 1. Box and whiskers plot (box 20th, 50th and 80th percentiles, whiskers 1.5x interquartile range [IQR]) of monthly median concentrations of dissolved inorganic nitrogen (DIN) in the Mackay-Whitsunday freshwater basins for 2017-18, with scaling factors (SF) and guideline values (GV) for each basin reported. Outliers (>1.5x IQR) are also pictured. SF provides the lower boundary for the report card scoring framework within which scores are calculated for the grades of moderate, poor and very poor. SF is nominally defined as the 90th (or 10th) percentile.

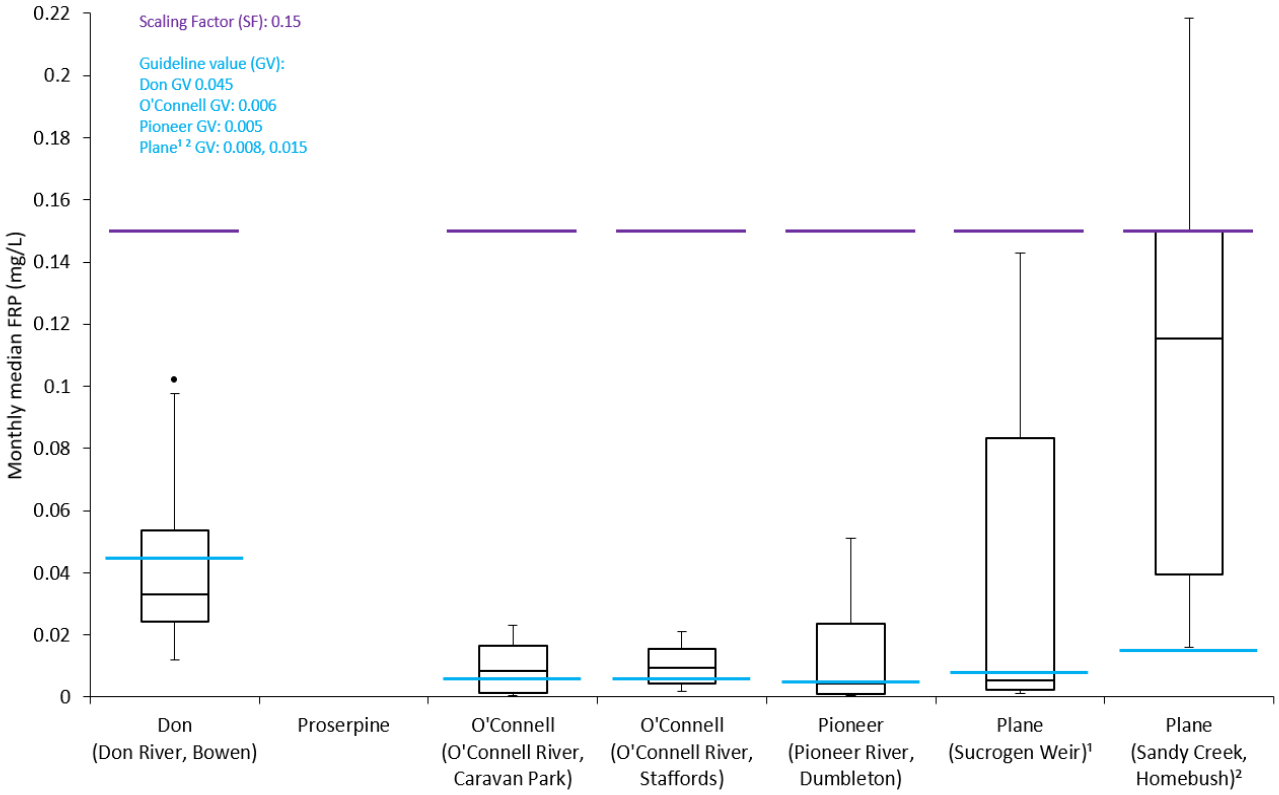


Figure AA 2. Box and whiskers plot (box 20th, 50th and 80th percentiles, whiskers 1.5x interquartile range [IQR]) of monthly median concentrations of filterable reactive phosphorus (FRP) in the Mackay-Whitsunday freshwater basins for 2017-18, with scaling factors (SF) and guideline values (GV) for each basin. Outliers (>1.5x IQR) are also pictured. SF provides the lower boundary for the report card scoring framework within which scores are calculated for the grades of moderate, poor and very poor. SF is nominally defined as the 90th (or 10th) percentile.

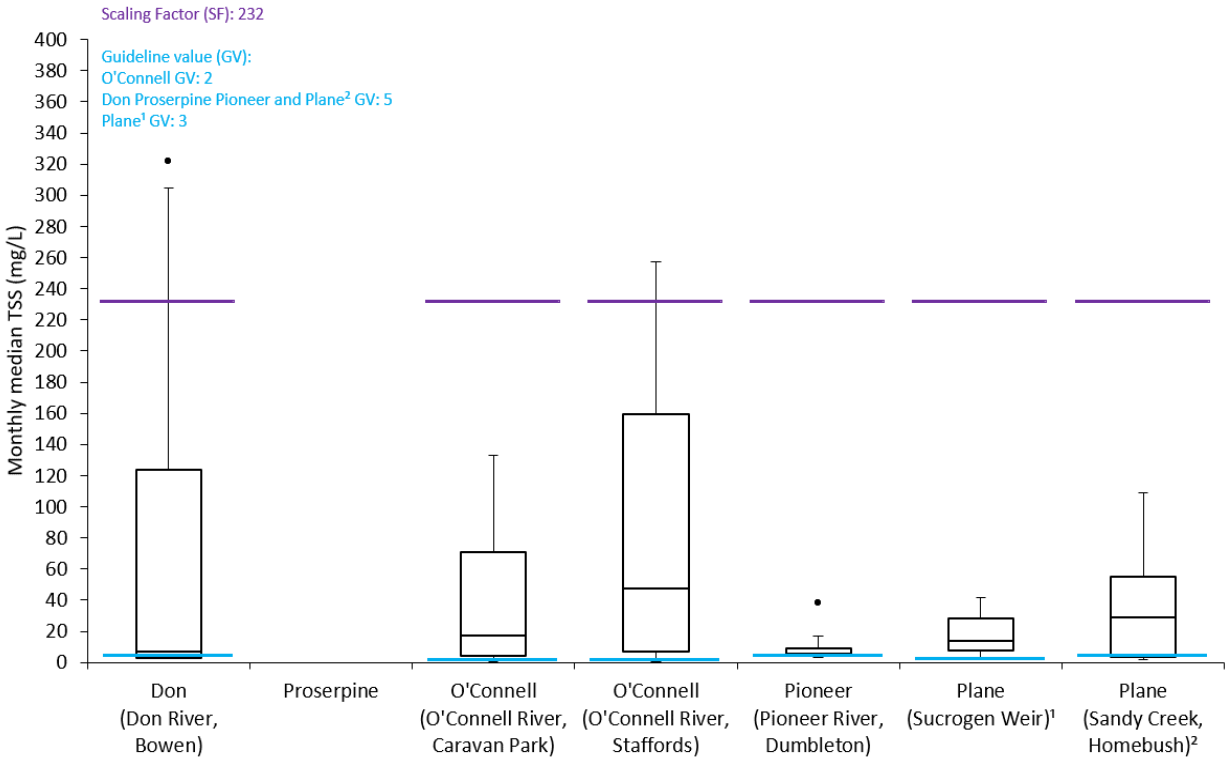


Figure AA 3. Box and whiskers plot (box 20th, 50th and 80th percentiles, whiskers 1.5x interquartile range [IQR]) of monthly median concentrations of total suspended solids (TSS) in the Mackay-Whitsunday freshwater basins for 2017-18, with scaling factors (SF) and guideline values (GV) for each basin. Outliers (>1.5x IQR) are also pictured. SF provides the lower boundary for the report card scoring framework within which scores are calculated for the grades of moderate, poor and very poor. SF is nominally defined as the 90th (or 10th) percentile.

Table AA 1. Previously reported ms-PAF indicator (accounting for 13 or 5* pesticides), equivalent aquatic species protected (%) and overall standardised pesticide scores for freshwater basins for the 2017, 2016, 2015 and 2014 report cards. *The 2014 report card score accounted for 5 pesticides only. Additional pesticides were included in the 2018, reporting on 22 pesticides.

	2017 report card		Pesticides	Pesticides	Pesticides
Basin	ms-PAF (%)	Pesticides	2016	2015	2014*
Don	0 (100% species protected)	**100**			
Proserpine	15 (85% species protected)	**30**			
O'Connell	5 (95% species protected)	**61**	74	40	66
Pioneer	15 (85% species protected)	**30**	35	31	19
Plane	22 (78% species protected)	**20**	19	16	16

Species protected scoring range: Very Poor = <80% | Poor = <90 to 80% | Moderate = <95 to 90% | Good = <99 to 95% | Very Good = ≥99% | No score/data gap

Pesticides: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

Table AA 2. Indicator scoring for freshwater flow values across the Mackay-Whitsunday region, based on catchment area, for 2017-18 reporting year.

	Gauging station #	MDF: '%benchmark	CTF: Duration	CTF: Frequency	Below 10%ile: Duration	Below 10%ile: Frequency	Ratio dry/total	CV dry season	Above 50%ile: Duration	Above 50%ile: Frequency	Above 90%ile: Duration	Above 90%ile: Frequency	30th percentile	Standardised score	Gauge catchment (km^2)	Adjusted catchment (km^2)	Proportion (based on using gauged catchment area) (for Basins)		**Aggregated basin score**
																			78.95
AndromaheR@Jochheims	124003A	0.49	5	5	5	5	4	4	5	5	5	5	5	95	230	230	0.40	38.20	
OConnellR@StaffordsCrossing	124001B	0.85	5	5	5	5	4	5	4	5	5	4	4.7	75	342	175	0.31	22.95	
OConnellR@ForbesRd	124005A	1.83	5	5	5	5	4	4	4	5	5	4	4	61	167	167	0.29	17.81	
																			66.69
CattleCk@Gargett	125004B	1.03	5	5	4	4	5	5	5	5	5	5	5	95	326	326	0.17	15.90	
BlacksCk@Whitefords	125005A	0.30	4	4	5	5	4	5	3	5	5	5	4	61	509	702	0.36	21.98	
FinchHattonCk@GorgeRd	125006A	1.47	4	4	5	5	5	4	5	4	5	5	4	61	35	35	0.02	1.10	
PioneerR@MiraniWeirTW	125007A	0.59	4	4	5	5	4	5	5	3	5	5	4	61	1211	885	0.45	27.71	

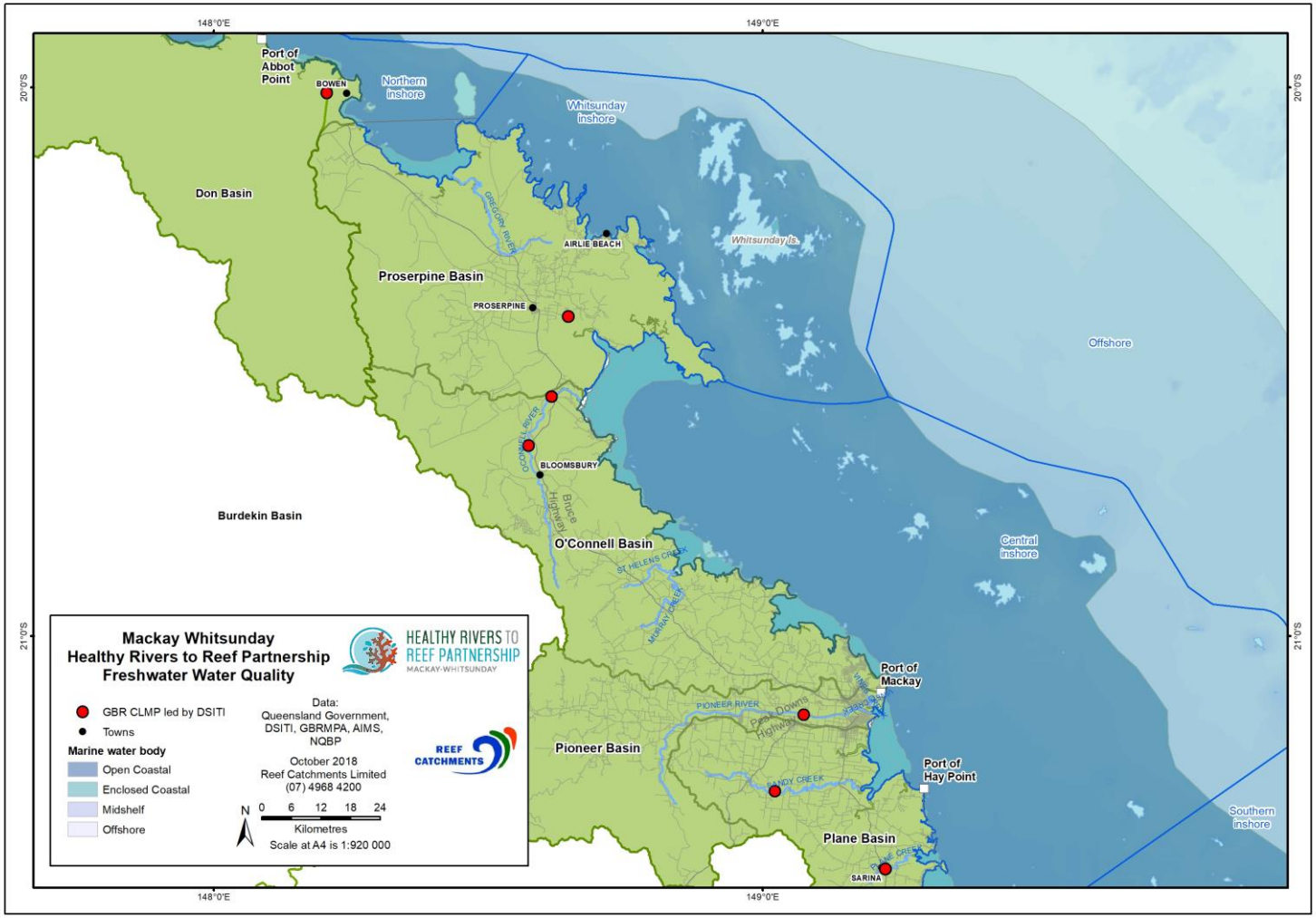


Figure AA 4. Basin water quality monitoring sites in the Mackay-Whitsunday Region for the 2018 report card

Appendix B: Estuaries

Boxplots of monthly medians are presented for chl-*a,* DIN, FRP, DO and turbidity indicators.

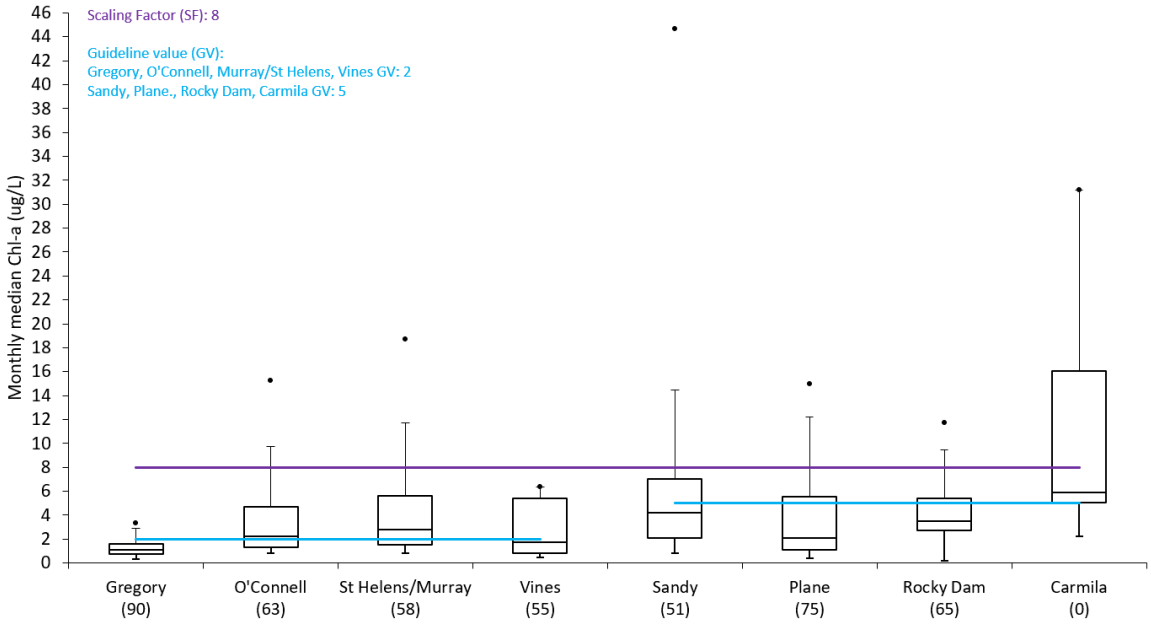


Figure AB 1. Box and whiskers plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5x interquartile range [IQR]) of monthly concentrations of chlorophyll-*a* in the Mackay-Whitsunday estuaries for 2017-18, with scaling factors (SF) and guideline values (GV) for relevant estuaries. Outliers (>1.5x IQR) are also pictured. Following estuary names are the calculated indicator scores. SF provides the lower boundary for the report card scoring framework within which scores are calculated for the grades of moderate, poor and very poor. SF is nominally defined as the 90th (or 10th) percentile.

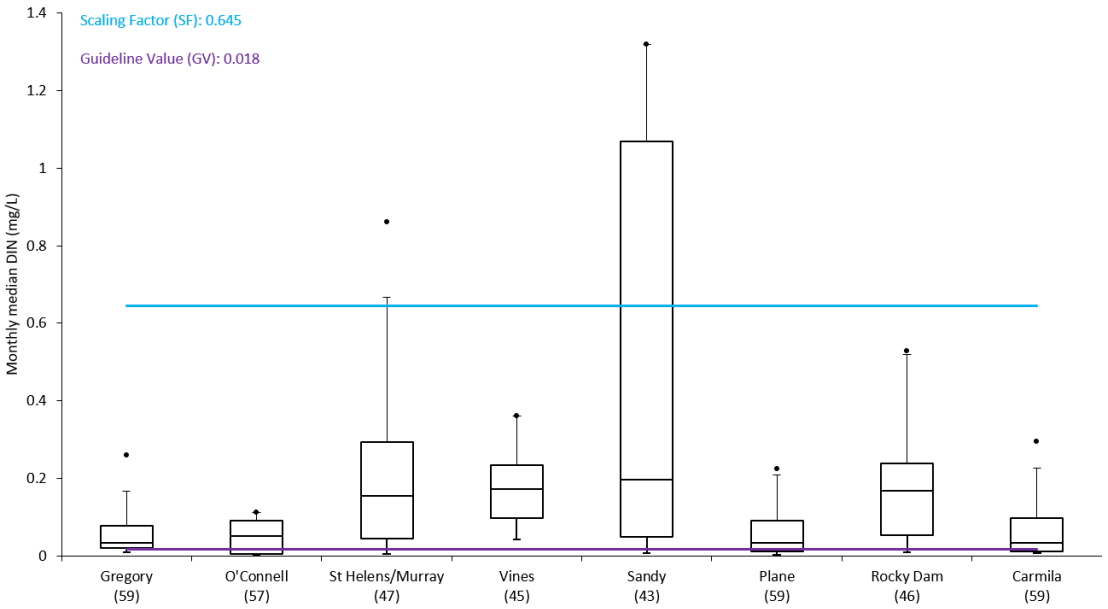


Figure AB 2. Box and whiskers plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5x interquartile range [IQR]) of monthly concentrations of dissolved inorganic nitrogen (DIN) in the Mackay-Whitsunday estuaries for 2017-18, with scaling factors (SF) and guideline values (GV) for relevant estuaries. Outliers (>1.5x IQR) are also pictured. Following estuary names are the calculated indicator scores. SF provides the lower boundary for the report card scoring framework within which scores are calculated for the grades of moderate, poor and very poor. SF is nominally defined as the 90th (or 10th) percentile.

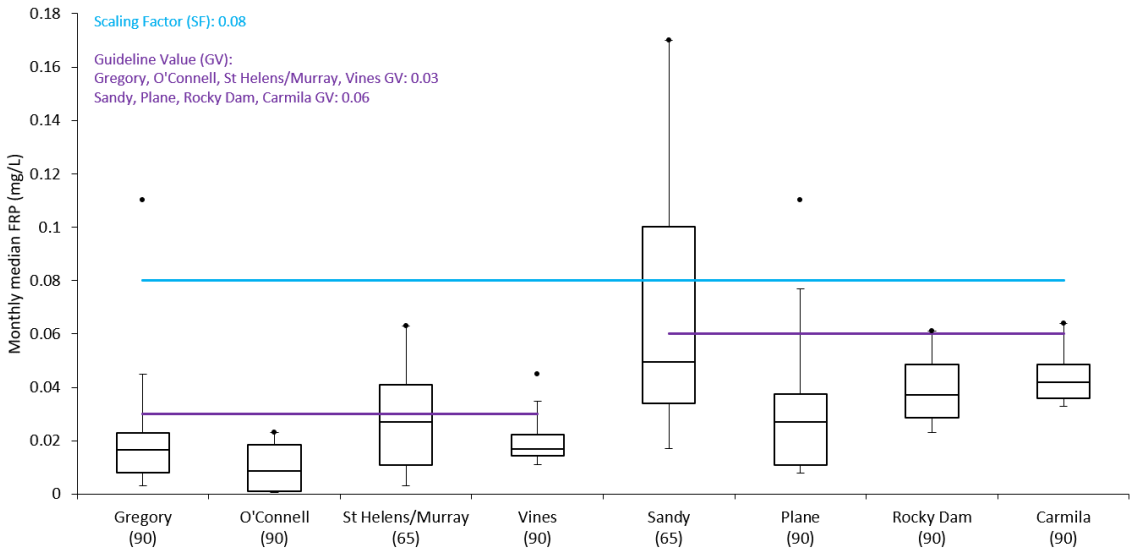


Figure AB 3. Box and whiskers plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5x interquartile range [IQR]) of monthly concentrations of filterable reactive phosphorus (FRP) in the Mackay-Whitsunday estuaries for 2017-18, with scaling factors (SF) and guideline values (GV) for relevant estuaries. Outliers (>1.5x IQR) are also pictured. Following estuary names are the calculated indicator scores. SF provides the lower boundary for the report card scoring framework within which scores are calculated for the grades of moderate, poor and very poor. SF is nominally defined as the 90th (or 10th) percentile.

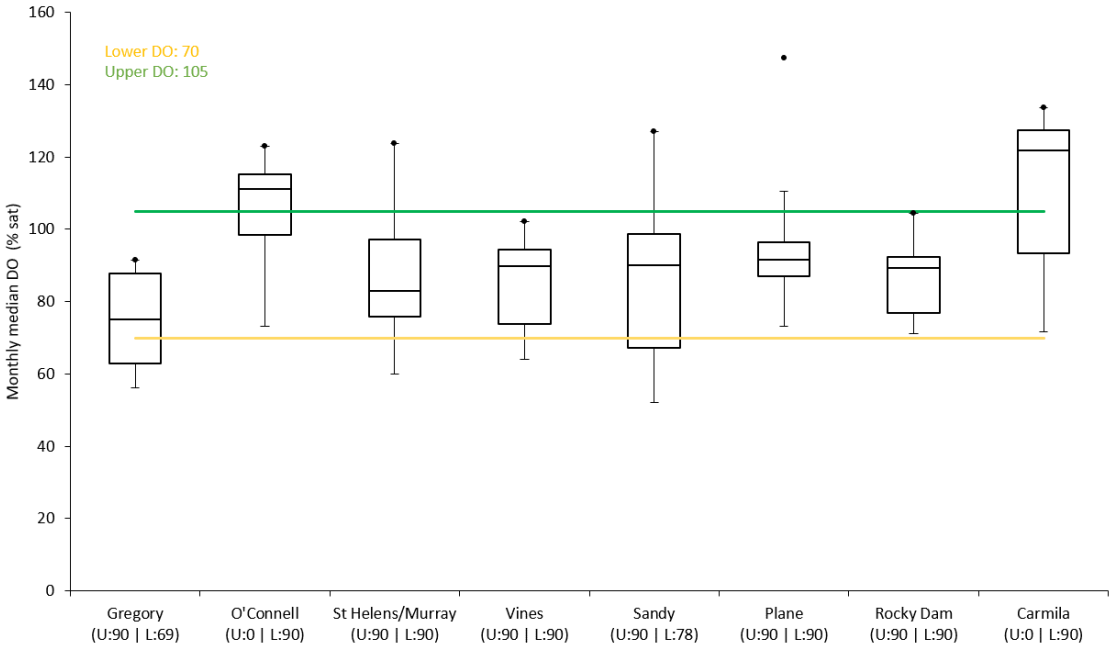


Figure AB 4. Box and whiskers plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5x interquartile range [IQR]) of monthly concentrations of dissolved oxygen (DO) in the Mackay-Whitsunday estuaries for 2017-18, with upper and lower guideline values (GV) for relevant estuaries. Outliers (>1.5x IQR) are also pictured. Following estuary names are the calculated indicator scores calculated by comparing to the upper (U) and lower (L) guidelines for DO. SF provides the lower boundary for the report card scoring framework within which scores are calculated for the grades of moderate, poor and very poor. SF is nominally defined as the 90th (or 10th) percentile.

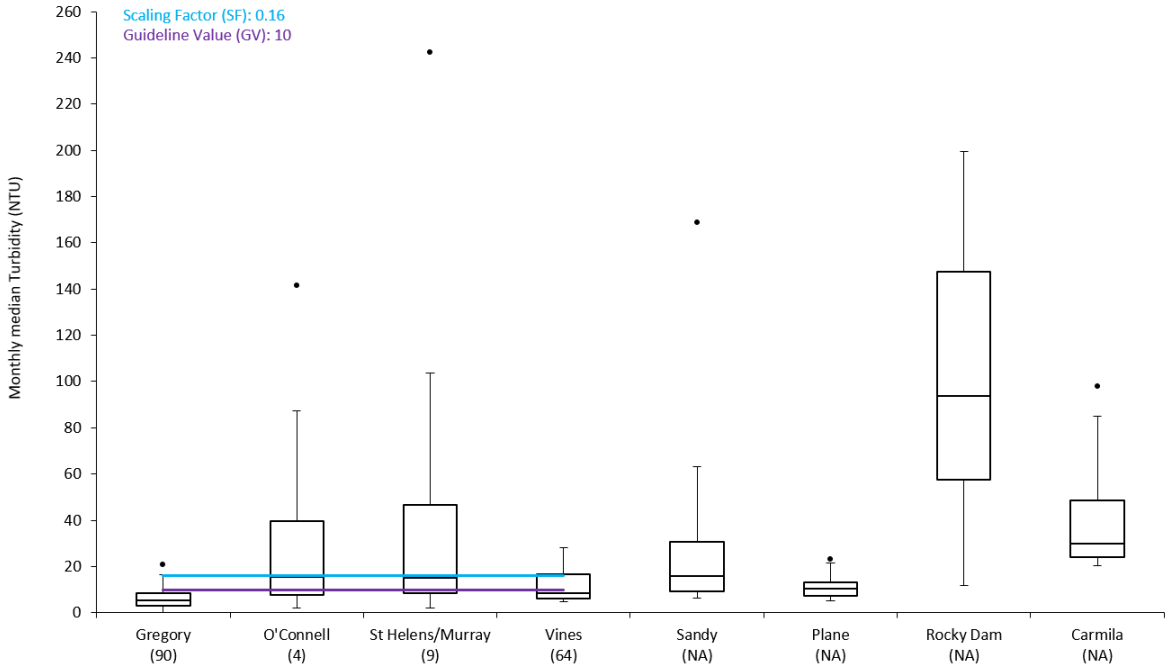


Figure AB 5. Box and whiskers plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5x interquartile range [IQR]) of monthly concentrations of turbidity in the Mackay-Whitsunday estuaries for 2017-18, with scaling factors (SF) and guideline values (GV) for relevant estuaries (no guidelines for Sandy, Plane, Rocky Dam or Carmila Creek estuaries, so no score calculated). Outliers (>1.5x IQR) are also pictured. Following estuary names are the calculated indicator scores where relevant. SF provides the lower boundary for the report card scoring framework within which scores are calculated for the grades of moderate, poor and very poor. SF is nominally defined as the 90th (or 10th) percentile.

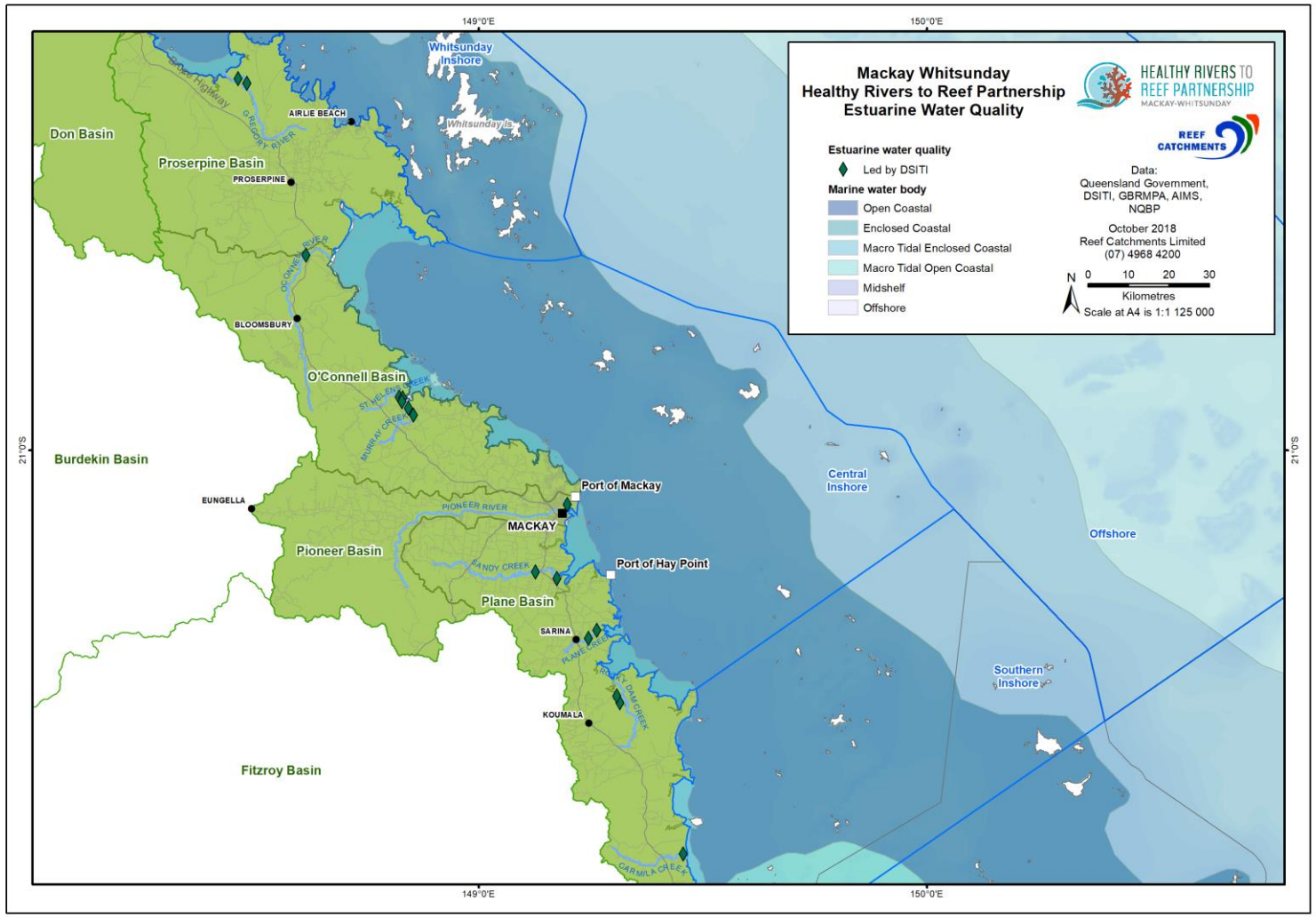


Figure AB 6. Estuary water quality monitoring sites in the Mackay-Whitsunday Region for the 2018 report card.

Appendix C: Marine environment

The scores presented below are inshore zone site scores for the Mackay-Whitsunday 2018 report card. Boxplots are presented for water quality indicators and summary statistics are tabulated for individual sites. Locations of monitoring sites for inshore marine zones are also presented.

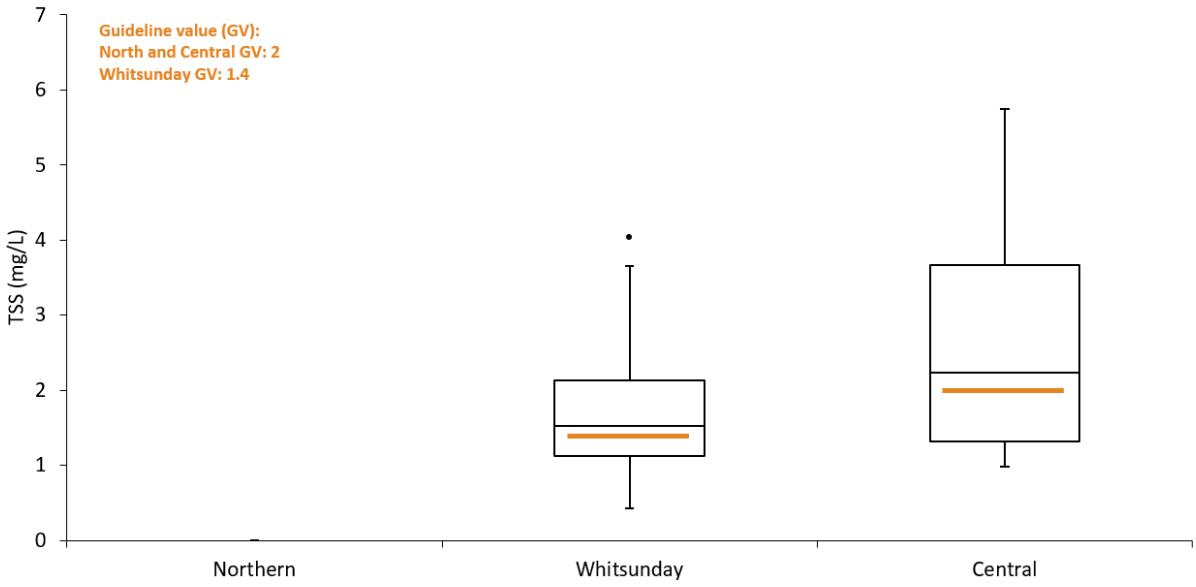


Figure AC 1. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all total suspended solids (TSS) samples taken from relevant inshore zones in the Mackay-Whitsunday Region for 2017-18. Outliers (>1.5x IQR) are also pictured. Guideline values (GV) for each zone are pictured, where multiple guideline values are scheduled within a zone, the most conservative level was adopted for the purpose of graphical presentation.

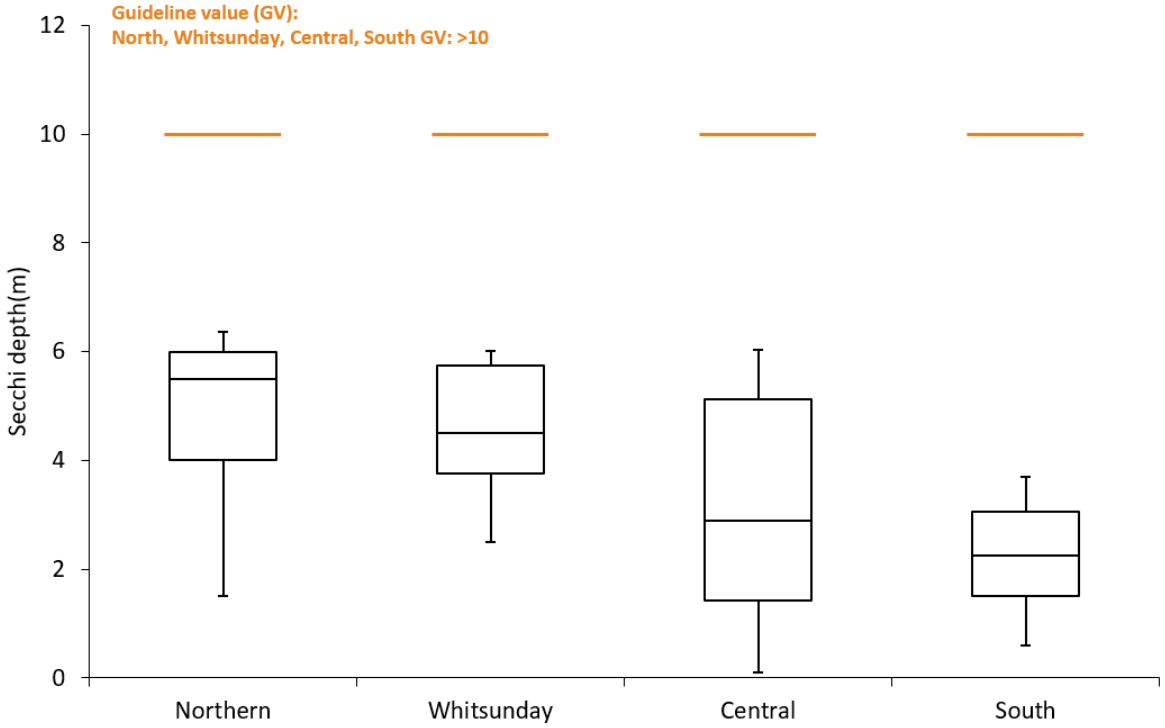


Figure AC 2. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all secchi depth samples taken from relevant inshore zones in the Mackay-Whitsunday Region for 2017-18. Outliers (>1.5x IQR) are also pictured. Guideline values (GV) for each zone are pictured. Higher secchi depth values relate to higher water clarity.

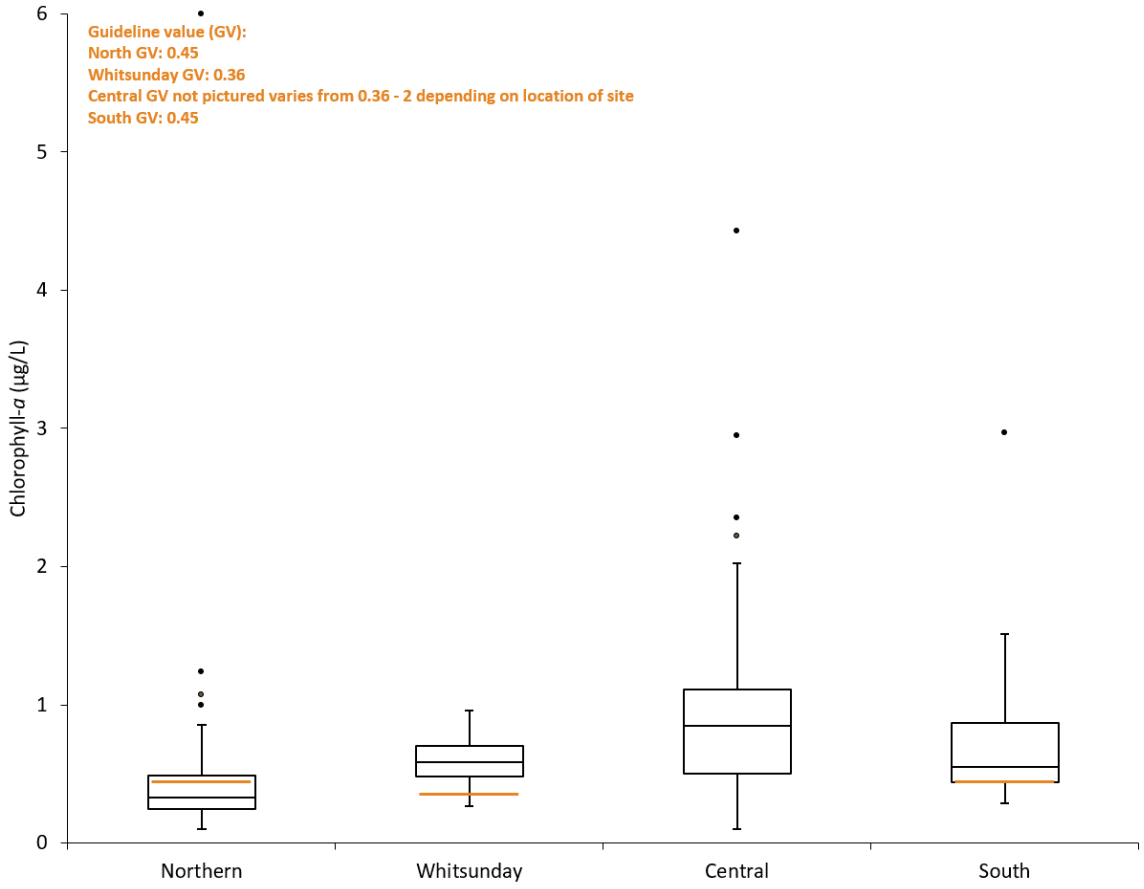


Figure AC 3. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all chlorophyll-*a* samples taken from relevant inshore zones in the Mackay-Whitsunday Region for 2017-18. Outliers (>1.5x IQR) are also pictured. Guideline values (GV) for each zone are pictured; where multiple guideline values are scheduled within a zone, the most conservative level was adopted for the purpose of graphical presentation.

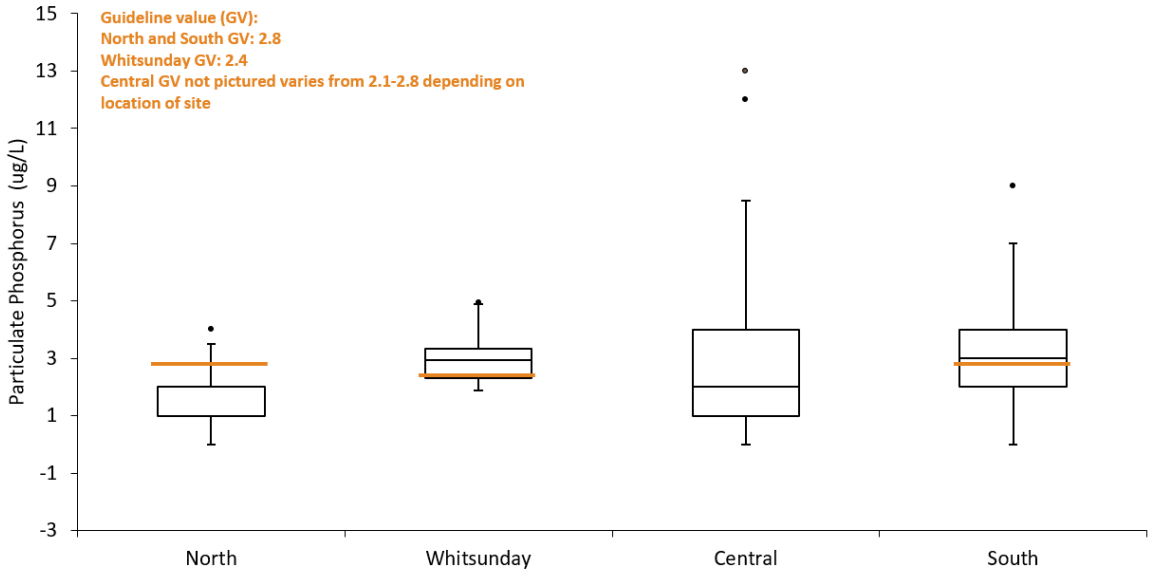


Figure AC 4. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all particulate phosphorus samples taken from relevant inshore zones in the Mackay-Whitsunday Region for 2017-18. Where relevant outliers (>1.5x IQR) are also pictured. Guideline values (GV) for each zone are pictured; where multiple guideline values are scheduled within a zone, the most conservative level was adopted for the purpose of graphical presentation.

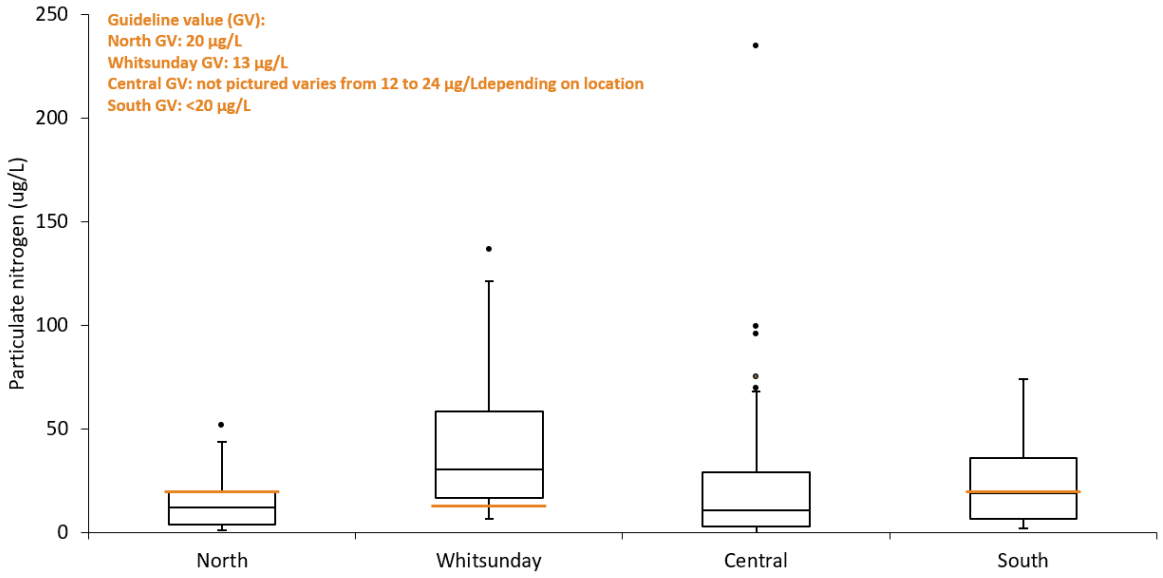


Figure AC 5. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all particulate nitrogen samples taken from relevant inshore zones in the Mackay-Whitsunday Region for 2017-18. Where relevant outliers (>1.5x IQR) are also pictured. Guideline values (GV) for each zone are pictured; where multiple guideline values are scheduled within a zone, the most conservative level was adopted for the purpose of graphical presentation.

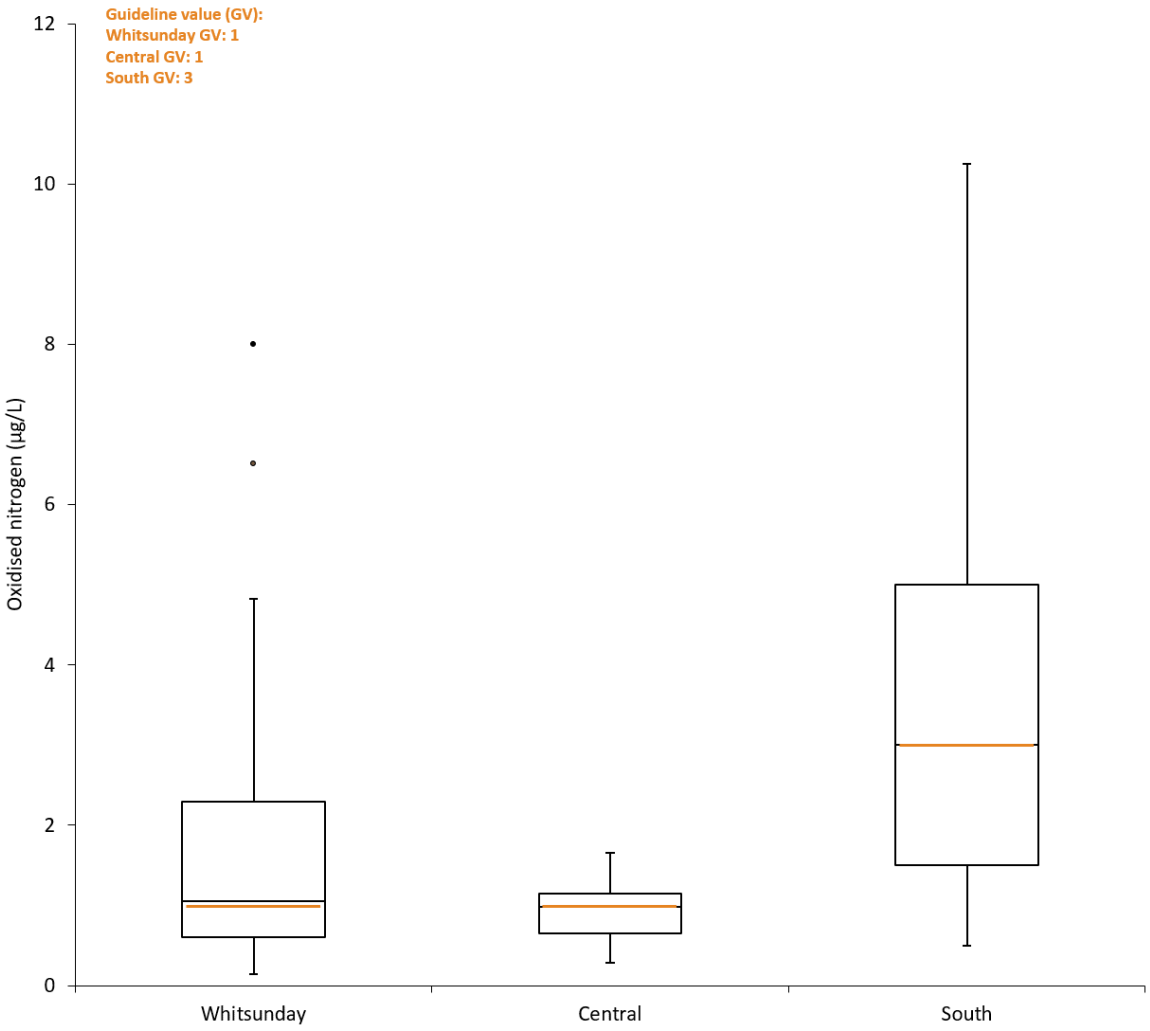


Figure AC 6. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all oxidised nitrogen samples taken from relevant inshore zones in the Mackay-Whitsunday Region for 2017-18. Outliers (>1.5x IQR) are also pictured. Guideline values (GV) for the assessed zones pictured; where multiple guideline values are scheduled within a zone, the most conservative level was adopted for the purpose of graphical presentation.

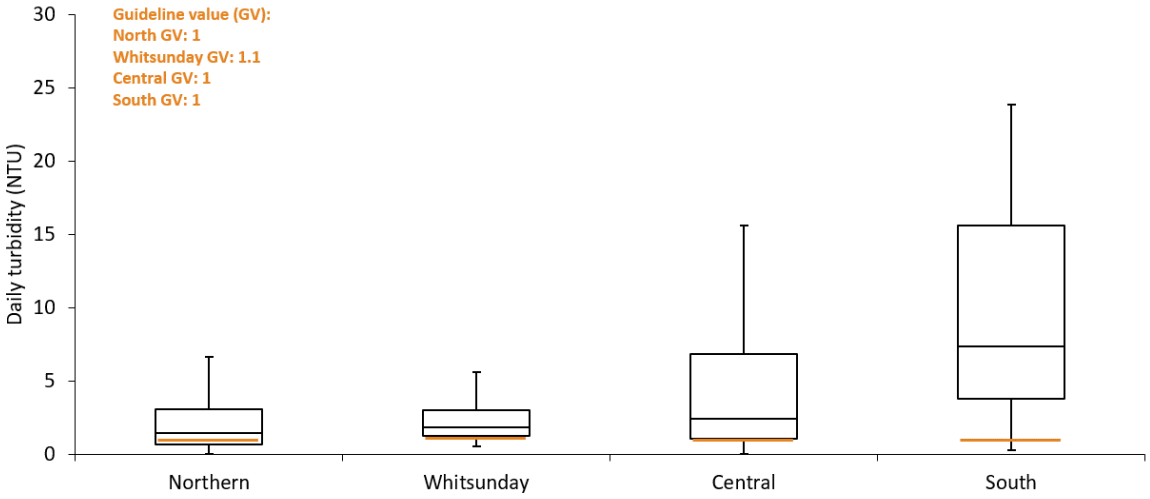


Figure AC 7. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range) for daily turbidity taken from relevant inshore zones in the Mackay-Whitsunday Region for 2017-18. Guideline values (GV) for the Northern, Whitsunday and Southern zone are pictured; Central GV vary from 1 – 12 NTU depending on site location and season (wet vs dry); where multiple guideline values are scheduled within a zone, the most conservative level was adopted for the purpose of graphical presentation. NB outliers (>1.5x IQR) are not pictured due to excessive quantity (n=150 for Northern, n = 72 for Whitsunday and n = 241 for Central), however, maximum turbidity values per site can be seen in tables below.

Table AC 1. 2017-18 indicator scores for Northern inshore marine sites (Abbot Point Program). *NOx or TSS was not included in calculations for the 2018 report card due to only 1 or 2 sampling points collected.

	Nutrients			Chl-a	Water clarity		
Site	**PN**	**PP**	**NOx***	**Chl-a**	**TSS***	**Turbidity**	**Secchi**
Amb1	1.00	1.00		0.35		-0.07	-0.99
Amb 2	0.42	0.64		0.27		-1.00	-1.00
Amb 3	1.00	0.81		0.02		-0.81	-0.99
Amb 4a	0.56	0.64		-1.00		-0.40	-1.00
Amb 5	-0.14	1.00		0.41		0.01	-0.85

Scoring range: Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

Table AC 2. 2017-18 indicator category scores for Northern inshore marine sites (Abbot Point Program) compared to indicator category scores for the Northern inshore marine zone in 2017, 2016, 2015 and 2014 report cards.

Site	**Nutrients**	**Chl-a**	**Water clarity**
Amb1	1.00	0.35	-0.53
Amb 2	0.53	0.27	-1.00
Amb 3	0.90	0.02	-0.90
Amb 4a	0.60	-1.00	-0.70
Amb 5	0.43	0.41	-0.42
Northern 2018	0.69	0.01	-0.71
Northern 2017		0.72	-0.18
Northern 2016		0.74*	-0.35*
Northern 2015			
Northern 2014	-0.96^	-0.95	-0.11

*Scores for chl-a and TSS are based on only one sample (taken in May 2016).

^For the 2014 pilot report card only, the indicator score for NOx was used on its own for the nutrients score.

Scoring range: Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

Table AC 3. Summary statistics for water quality indicators in the Northern inshore marine sites from July 2017 to June 2018. Presented alongside statistics that were compared to guideline values. For all indicators except secchi, to meet the guideline the relevant statistic must be lower compared to the guideline (secchi must be higher than the guideline).

					Guidelines	
Site	**Indicator**	n	**Mean**	**Median**	**Comparison**	**Guideline value**
Amb1	NOx (µg/L)	2	18.50	18.50	mean	3
	PN (µg/L)	5	9.60	5.00	mean	20
	PP (µg/L)	5	1.40	2.00	mean	2.8
	Chl-*a* (µg/L)	5	0.35	0.33	mean	0.45
	TSS (mg/L)	2	2.25	2.25	mean	2
	Secchi (m)	5	5.04	6.00	mean	10
	Turb (NTU)	181*	2.89	1.05	median	1
Amb2	NOx (µg/L)	2	0.10	0.10	mean	3
	PN (µg/L)	5	15.00	12.00	mean	20
	PP (µg/L)	5	1.80	1.00	mean	2.8
	Chl-*a* (µg/L)	6	0.37	0.29	mean	0.45
	TSS (mg/L)	2	1.50	1.50	mean	2
	Secchi (m)	5	4.74	5.00	mean	10
	Turb (NTU)	200*	3.88	2.13	median	1
Amb3	NOx (µg/L)	2	0.10	0.10	mean	3
	PN (µg/L)	5	8.00	4.00	mean	20
	PP (µg/L)	5	1.60	1.00	mean	2.8
	Chl-*a* (µg/L)	5	0.44	0.33	mean	0.45
	TSS (mg/L)	2	0.75	0.75	mean	2
	Secchi (m)	5	5.02	5.00	mean	10
	Turb (NTU)	195*	10.42	1.75	median	1
Amb4	NOx (µg/L)	2	1.55	1.55	mean	3
	PN (µg/L)	5	13.60	11.00	mean	20
	PP (µg/L)	5	1.80	2.00	mean	2.8
	Chl-*a* (µg/L)	5	1.44	0.52	mean	0.45
	TSS (mg/L)	2	2.00	2.00	mean	2
	Secchi (m)	5	4.30	4.00	mean	10
	Turb (NTU)	197*	1.85	1.32	median	1
Amb5	NOx (µg/L)	2	434.50	434.50	mean	3
	PN (µg/L)	5	22.00	20.00	mean	20
	PP (µg/L)	5	1.00	1.00	mean	2.8
	Chl-*a* (µg/L)	5	0.34	0.39	mean	0.45
	TSS (mg/L)	2	2.00	2.00	mean	2
	Secchi (m)	5	5.54	6.00	mean	10
	Turb (NTU)	175*	8.90	0.99	median	1

*While turbidity loggers were deployed for the entire 2017/2018 reporting period (365 days), sample size is based on daily averages from *validated* data recovered from this period. Some data points maybe lost due to unforeseen device malfunction or damage.

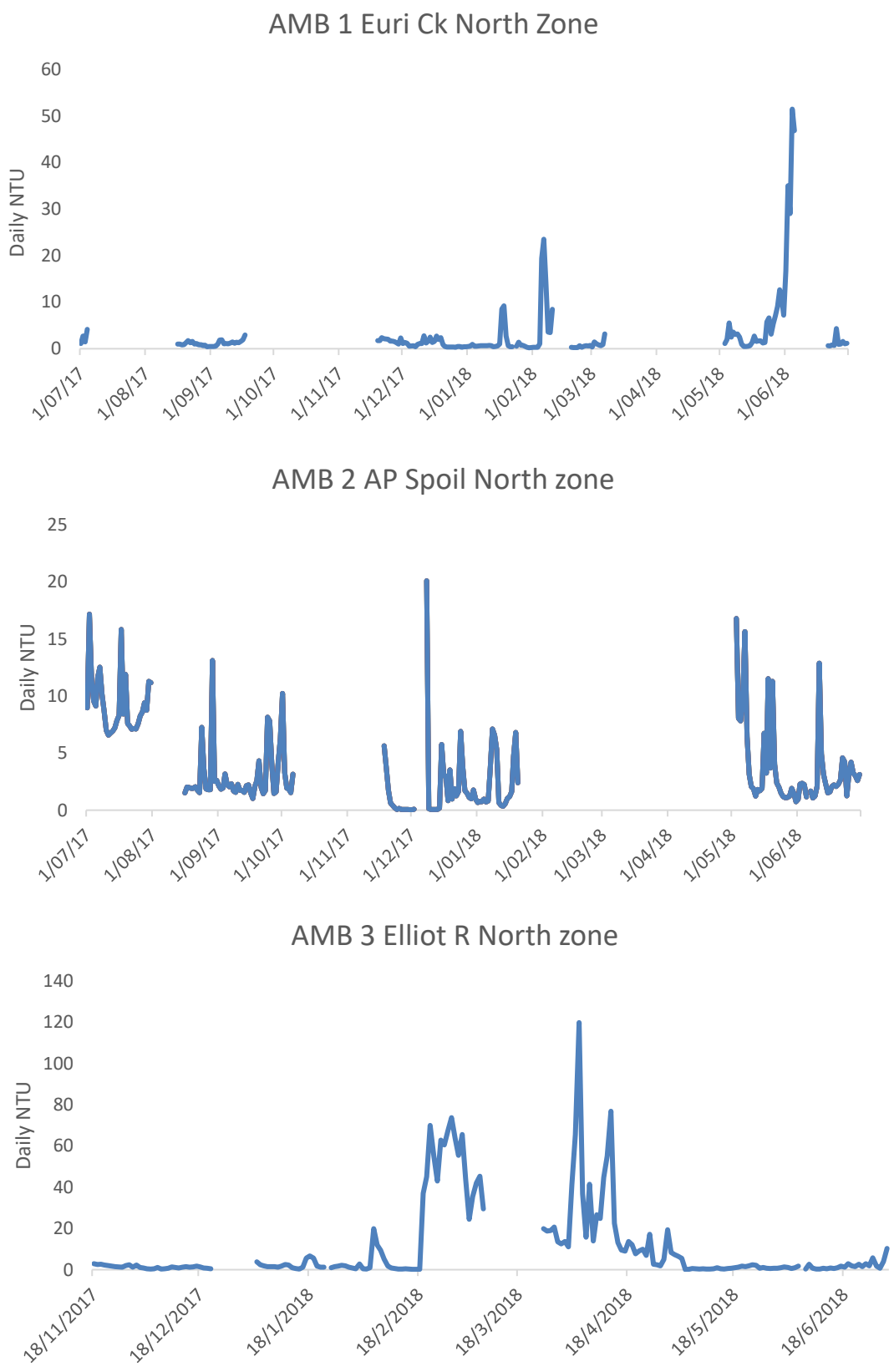


Figure AC 8. Daily turbidity (NTU) from 2017-18 reporting year for Northern inshore marine (Abbot Point) loggers.

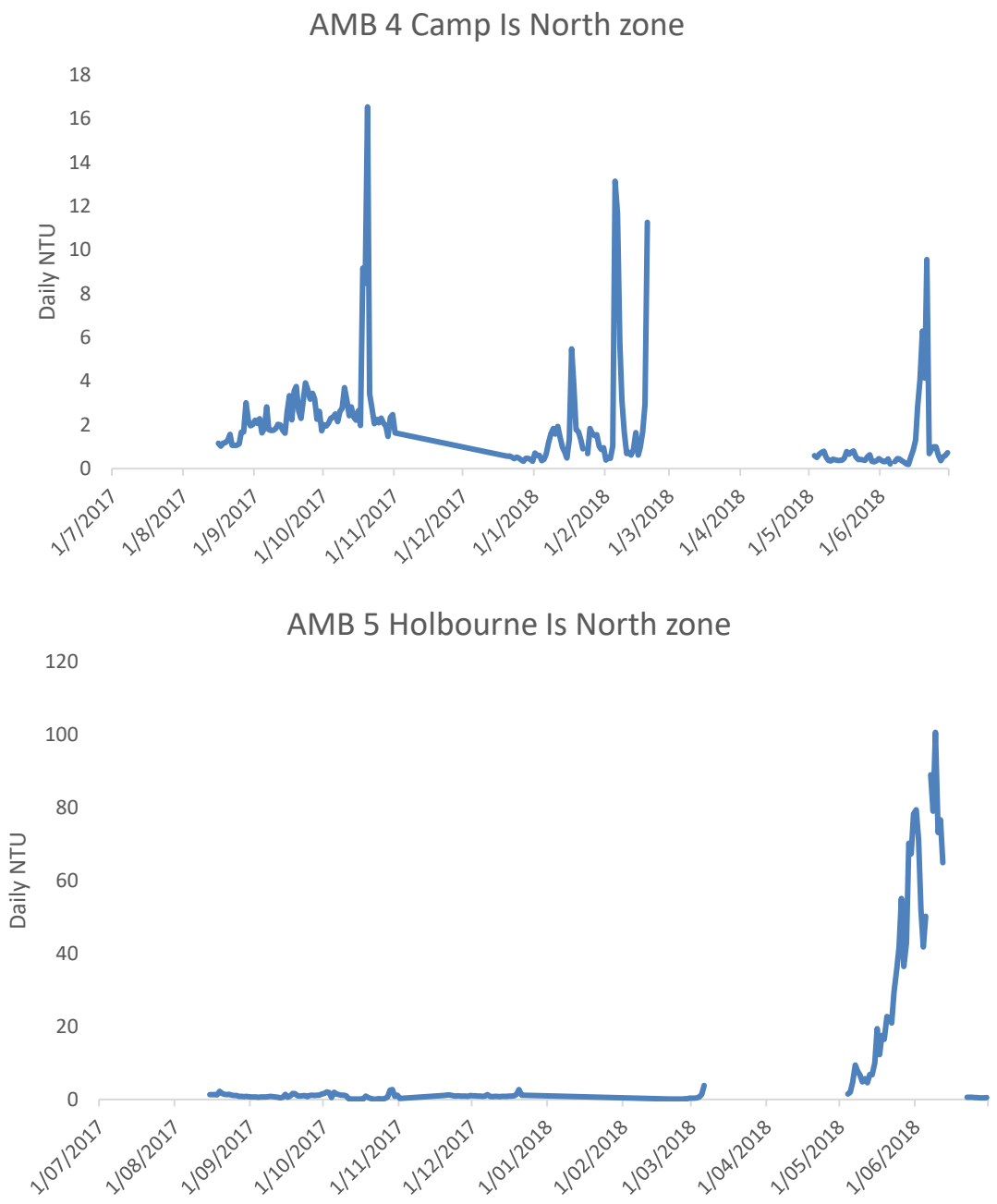


Figure AC 9. Daily turbidity (NTU) for 2017-18 reporting year from Northern inshore marine (Abbot Point) loggers.

Table AC 4. 2017-18 indicator scores for Whitsunday inshore marine sites (Marine Monitoring Program).

	Nutrients			Chl-a	Water clarity		
Site	NOx	PN	PP	Chl-a	TSS	Secchi	Turbidity
Double Cone Island	-1.00	-1.00	-0.22	-0.87	0.65	-0.86	-0.43
Pine Island	0.06	-0.48	-0.50	-0.51	-0.21	-1.00	-1.00
Seaforth Island	-0.08	-1.00	-0.07	-0.52	-0.12	-1.00	-0.53

Scoring range: Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

Table AC 5. 2017-18 indicator category scores for Whitsunday inshore marine sites (Marine Monitoring Program) compared to indicator category scores for the Whitsunday inshore marine zone in 2017, 2016, 2015 and 2014 report cards.

Site	Nutrients	Chl-a	Water clarity
Double Cone Island	-0.74	-0.87	-0.21
Pine Island	-0.31	-0.51	-0.74
Seaforth Island	-0.38	-0.52	-0.55
Whitsunday 2018	-0.48	-0.63	-0.50
Whitsunday 2017	-0.99	-0.99	-0.66
Whitsunday 2016	-0.54	-0.12	-0.38
Whitsunday 2015	-0.48	-0.20	-0.23
Whitsunday 2014	-0.88	-1.00	-0.88

Scoring range: Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

Table AC 6. Summary statistics for water quality indicators in the Whitsunday inshore marine sites from July 2017 to June 2018. Presented alongside statistics are guideline values, including the statistic that was compared to the guideline (where three values are listed, the median is compared to the middle of the listed values). For all indicators except secchi, to meet the guideline the relevant statistic must be lower compared to the guideline (secchi must be higher than the guideline).

Site	Indicator	n	Mean	Minimum	25th %tile	Median	75th %tile	Maximum	Guidelines	
									Comparison	Guideline value
Double Cone	NOx (µg/L)	5	1.76	0.35	0.59	2.10	2.49	3.30	median	0-1-2
	PN (µg/L)	5	48.81	17.30	17.74	37.16	76.42	95.46	median	12-13-15
	PP (µg/L)	5	2.69	1.98	2.40	2.79	3.12	3.15	median	1.8-2.4-2.8
	Chl-*a* (µg/L)	5	0.58	0.29	0.59	0.66	0.68	0.68	median	0.25-0.36-0.54
	TSS (mg/L)	5	1.19	0.43	0.75	0.89	1.56	2.31	median	0.9-1.4-2.3
	Secchi (m)	5	5.50	4.00	4.00	5.00	7.00	7.50	mean	10
	Turb (NTU)	365*	1.85	0.55	1.08	1.50	2.17	11.68	median	0.7-1.1-2.1
Pine Island	NOx (µg/L)	5	2.33	0.35	0.65	0.96	1.68	8.00	median	0-1-2
	PN (µg/L)	5	30.92	6.70	16.43	18.08	34.01	79.36	median	12-13-15
	PP (µg/L)	5	3.51	2.27	3.07	3.40	3.87	4.93	median	1.8-2.4-2.8
	Chl-*a* (µg/L)	5	0.63	0.44	0.46	0.51	0.81	0.92	median	0.25-0.36-0.54
	TSS (mg/L)	5	2.17	1.36	1.53	1.62	2.33	4.03	median	0.9-1.4-2.3
	Secchi (m)	5	3.80	2.50	2.50	2.50	5.00	6.50	mean	10
	Turb (NTU)	364*	3.70	0.65	1.83	2.98	4.90	16.90	median	0.7-1.1-2.1
Seaforth	NOx (µg/L)	5	1.91	0.14	0.63	1.06	1.22	6.51	median	0-1-2
	PN (µg/L)	5	47.83	14.88	15.63	30.75	41.00	136.91	median	12-13-15
	PP (µg/L)	5	2.17	0.00	1.89	2.28	2.76	3.92	median	1.8-2.4-2.8
	Chl-*a* (µg/L)	5	0.59	0.26	0.50	0.52	0.72	0.96	median	0.25-0.36-0.54
	TSS (mg/L)	5	1.60	0.71	1.41	1.52	1.96	2.41	median	0.9-1.4-2.3
	Secchi (m)	5	4.90	3.50	4.50	4.50	5.00	7.00	mean	10
	Turb (NTU)	365*	1.92	0.63	1.23	1.60	2.41	8.64	median	0.7-1.1-2.1

*While turbidity loggers were deployed for the entire 2017/2018 reporting period (365 days), sample size is based on daily averages from *validated* data recovered from this period. Some data points maybe lost due to unforeseen device malfunction or damage.

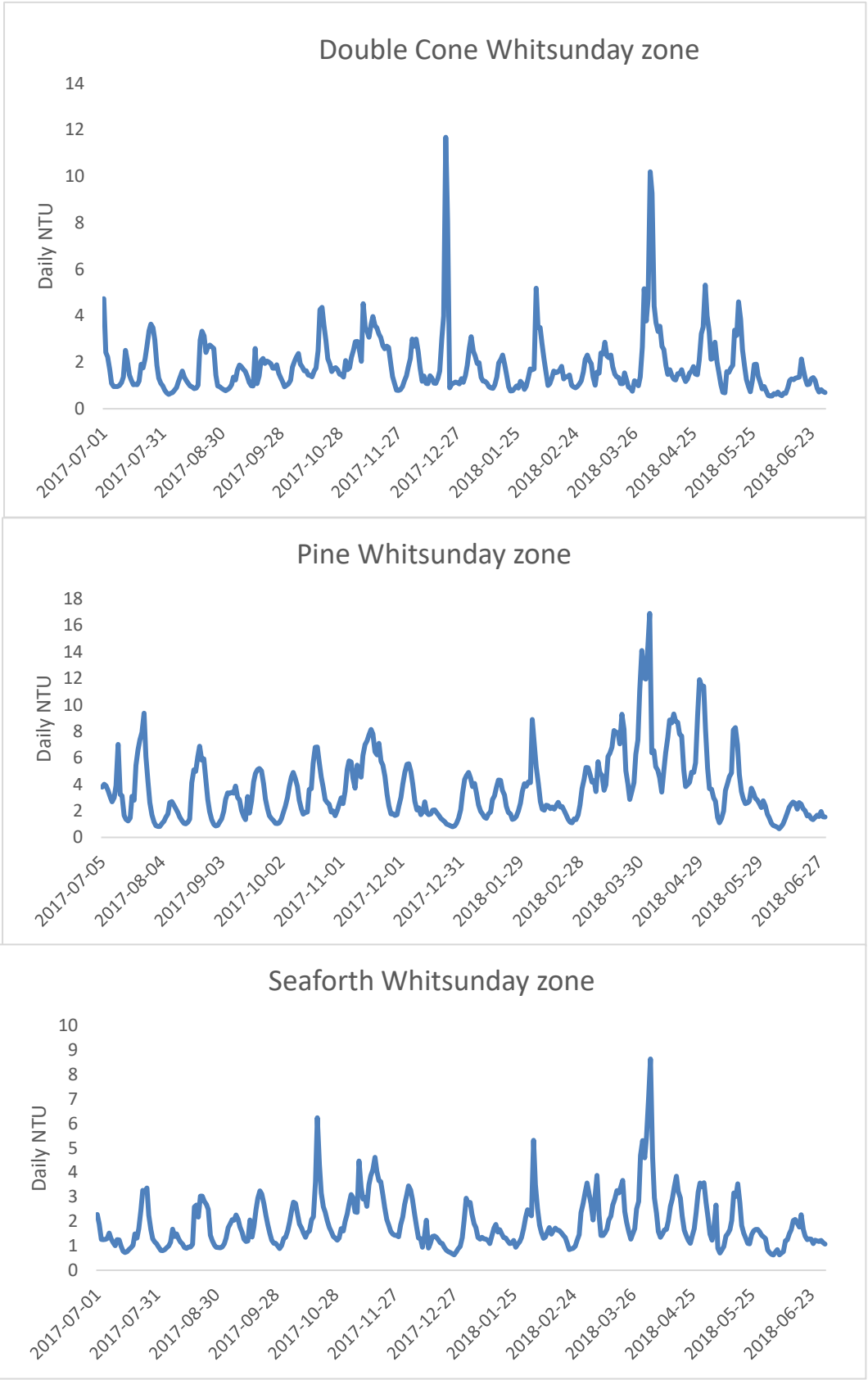


Figure AC 10. Daily turbidity (NTU) for 2017-18 reporting year for Whitsunday inshore marine loggers.

Table AC 7. 2017-18 indicator scores for Central inshore marine sites (Hay Point Ports Program and Marine Monitoring Program). For two sites guideline values for turbidity were scored for the wet (Nov-Apr) and dry (May-Oct) season; the average of these scores is used for the turbidity score in the water clarity index.

	Nutrients			Chl-a	Water clarity			Turbidity	
Site	NOx	PN	PP	Chl-a	TSS	Secchi	Turbidity	Dry	Wet
O'Connell River mouth	1.00			0.46					
Repulse Islands dive mooring	-0.16	-1.00	-1.00	-0.87	-0.93	-1.00	-1.00		
AMB 1		1.00	1.00	-0.79		-1.00	-1.00		
AMB 2		-0.39	-0.61	-1.00		-1.00	0.73	0.46	1.00
AMB 3B		-0.28	-0.10	-1.00		-1.00	-0.11		
AMB 5		0.03	-0.51	-1.00		-1.00	1.00	1.00	1.00
AMB 6B		-0.28	-0.23	-1.00		-1.00			
AMB 8		-0.96	0.21	-1.00		-1.00	1.00	1.00	1.00
AMB 10		1.00	1.00	-0.77		-1.00	-1.00		
AMB 11				1.00		0.81			
AMB 12		1.00	1.00	-0.20		-0.90	0.22		

Scoring range: Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

Table AC 8. 2017-18 indicator category scores for Central inshore marine sites (Hay Point Ports Program and Marine Monitoring Program) compared to indicator category scores for the Central inshore marine zone in 2017, 2016, 2015 and 2014 report cards.

Site	Nutrients	Chl-a	Water clarity
O'Connell River mouth		0.46	
Repulse Islands dive mooring	-0.72	-0.87	-0.98
AMB 1	1.00	-0.79	-1.00
AMB 2	-0.50	-1.00	-0.13
AMB 3B	-0.19	-1.00	-0.56
AMB 5	-0.24	-1.00	0.00
AMB 6B	-0.26	-1.00	
AMB 8	-0.38	-1.00	0.00
AMB 10	1.00	-0.77	-1.00
AMB 11		1.00	
AMB 12	1.00	-0.20	-0.34
Central 2018	0.08	-0.56	-0.50
Central 2017	-0.10	-0.53	-0.59
Central 2016	-0.41	-0.38	-0.14
Central 2015	0.10	-0.15	-0.47
Central 2014			

Scoring range: Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

Table AC 9. Summary statistics for water quality indicators in the Central inshore marine sites from July 2017 to June 2018. Presented alongside statistics are guideline values, including the statistic that was compared to the guideline (where three values are listed, the median is compared to the middle of the listed values). For all indicators except secchi, to meet the guideline the relevant statistic must be lower compared to the guideline (secchi must be higher than the guideline).

Site	Indicator	n	Mean	Minimum	25th %ile	Median	75th %ile	Maximum	Guidelines	
									Comparison	Guideline value
O'Connell River mouth	NOx (µg/L)	5	0.69	0.28	0.42	0.63	0.91	1.19	median	2-4-10
	PN (µg/L)	5	53.78	28.19	39.06	56.83	69.54	75.28		
	PP (µg/L)	5	5.90	3.85	5.34	5.87	7.02	7.42		
	Chl-*a* (µg/L)	5	0.97	0.60	0.93	0.95	1.07	1.30	median	0.8-1.3-2
	TSS (mg/L)	5	2.82	1.27	1.49	1.80	3.79	5.75		
	Secchi (m)	5	3.10	1.50	1.50	3.00	4.50	5.00		
	Turb (NTU)									
Repulse Islands dive mooring	NOx (µg/L)	5	1.14	0.72	1.05	1.12	1.15	1.66	median	0-1-2
	PN (µg/L)	5	43.94	17.17	17.97	28.27	56.94	99.34	median	12-13-15
	PP (µg/L)	5	4.41	2.18	4.26	5.00	5.04	5.57	median	1.8-2.4-2.8
	Chl-*a* (µg/L)	5	0.74	0.40	0.51	0.66	0.97	1.15	median	0.25-0.36-0.54
	TSS (mg/L)	5	2.42	0.99	1.14	2.68	3.58	3.71	median	0.9-1.4-2.3
	Secchi (m)	5	3.50	2.00	2.50	4.00	4.00	5.00	mean	10
	Turb (NTU)	368*	5.41	1.01	2.39	4.43	7.25	33.95	median	0.7-1.1-2.1
AMB 1	NOx (µg/L)			0.00				0.00		
	PN (µg/L)	7	8.00	1.00	2.50	4.00	6.50	33.00	mean	<20
	PP (µg/L)	7	1.14	0.00	1.00	1.00	1.50	2.00	mean	<2.8
	Chl-*a* (µg/L)	7	0.78	0.32	0.54	0.75	0.96	1.39	mean	<0.45
	TSS (mg/L)	0		0.00				0.00	mean	<2.0
	Secchi (m)	7	2.44	0.67	1.40	2.50	2.95	5.20	mean	>10
	Turb (NTU)	296*	20.00	0.13	1.57	4.79	23.77	324.98	median	<1
AMB 2	NOx (µg/L)	0		0.00				0.00		
	PN (µg/L)	7	26.29	5.00	9.00	34.00	38.50	50.00	mean	<20
	PP (µg/L)	7	4.29	0.00	2.00	3.00	5.50	12.00	mean	<2.8
	Chl-*a* (µg/L)	7	0.92	0.39	0.61	1.04	1.16	1.47	mean	<0.45
	TSS (mg/L)	0		0.00				0.00	mean	<2.0
	Secchi (m)	7	2.34	1.00	1.10	1.20	3.25	5.50	mean	>10
	Turb (NTU)	170*	6.06	0.02	1.01	2.13	4.70	78.86	median	D1-2-8 W5-12-33
AMB 3B	NOx (µg/L)	0		0.00				0.00		
	PN (µg/L)	7	24.29	1.00	7.00	13.00	23.00	96.00	mean	<20
	PP (µg/L)	7	3.00	0.00	1.00	1.00	5.00	8.00	mean	<2.8
	Chl-*a* (µg/L)	6	0.98	0.49	0.62	0.97	1.03	1.89	mean	<0.45
	TSS (mg/L)	0		0.00				0.00	mean	<2.0

Site	Indicator	n	Mean	Minimum	25th %ile	Median	75th %ile	Maximum	Guidelines	
									Comparison	Guideline value
	Secchi (m)	7	3.71	1.60	3.00	4.20	4.35	5.50	mean	>10
	Turb (NTU)	215*	2.17	0.15	0.61	1.08	1.97	31.63	median	<1
AMB 5	NOx (µg/L)	0		0.00				0.00		
	PN (µg/L)	7	19.57	0.00	6.00	13.00	34.00	44.00	mean	<20
	PP (µg/L)	7	4.00	0.00	2.00	3.00	4.50	12.00	mean	<2.8
	Chl-*a* (µg/L)	6	1.05	0.36	0.54	1.00	1.18	2.35	mean	<0.45
	TSS (mg/L)	0		0.00				0.00	mean	<2.0
	Secchi (m)	6	2.87	1.00	1.68	2.60	3.38	6.00	mean	>10
	Turb (NTU)	242*	13.72	0.14	0.80	1.66	5.42	570.14	median	D1-2-8 W5-12-33
AMB 6B	NOx (µg/L)	0		0.00				0.00		
	PN (µg/L)	7	24.29	2.00	6.00	26.00	35.00	60.00	mean	<20
	PP (µg/L)	7	3.29	0.00	0.50	1.00	4.50	12.00	mean	<2.8
	Chl-*a* (µg/L)	7	1.19	0.37	0.69	1.11	1.63	2.22	mean	<0.45
	TSS (mg/L)	0	1.19	0.37	0.69	1.11	1.63	2.22	mean	<2.0
	Secchi (m)	6	1.37	0.10	0.55	0.95	1.80	3.70	mean	>10
	Turb (NTU)									
AMB 8	NOx (µg/L)	0		0.00				0.00		
	PN (µg/L)	7	38.86	0.00	0.50	11.00	12.50	235.00	mean	<20
	PP (µg/L)	7	2.43	0.00	0.50	1.00	1.00	13.00	mean	<2.8
	Chl-*a* (µg/L)	7	1.32	0.36	0.45	0.57	1.49	4.43	mean	<0.45
	TSS (mg/L)	0		0.00				0.00	mean	<2.0
	Secchi (m)	7	4.59	1.80	3.80	5.20	5.75	6.00	mean	>10
	Turb (NTU)	232*	5.09	0.10	0.73	1.37	2.80	87.80	median	D1-2-8 W5-12-33
AMB 10	NOx (µg/L)	0		0.00				0.00		
	PN (µg/L)	7	8.14	1.00	2.50	5.00	8.50	29.00	mean	<20
	PP (µg/L)	7	1.14	0.00	0.50	1.00	1.50	3.00	mean	<2.8
	Chl-*a* (µg/L)	7	0.77	0.10	0.64	0.85	1.01	1.11	mean	<0.45
	TSS (mg/L)	0		0.00				0.00	mean	<2.0
	Secchi (m)	7	2.76	1.00	2.00	2.10	3.10	6.00	mean	>10
	Turb (NTU)	271*	15.07	0.02	1.96	4.88	18.77	145.54	median	<1
AMB 11	NOx (µg/L)	0		0.00				0.00	median	<10
	PN (µg/L)	7	12.71	1.00	4.00	7.00	14.00	45.00		
	PP (µg/L)	7	1.71	0.00	1.00	1.00	1.50	6.00		
	Chl-*a* (µg/L)	7	1.26	0.69	0.76	0.95	1.37	2.95	median	<2.0
	TSS (mg/L)	0		0.00				0.00		
	Secchi (m)	6	1.87	0.40	0.85	1.75	2.88	3.50	median	>1

Site	Indicator	n	Mean	Minimum	25th %ile	Median	75th %ile	Maximum	Guidelines	
									Comparison	Guideline value
	Turb (NTU)									
AMB 12	NOx (µg/L)	0		0.00				0.00	median	0-0-1
	PN (µg/L)	7	7.29	1.00	2.00	3.00	9.50	24.00	median	14-18-24
	PP (µg/L)	7	1.71	0.00	0.50	1.00	3.00	4.00	median	1.6-2.1-3
	Chl-*a* (µg/L)	7	0.52	0.23	0.37	0.59	0.62	0.83	mean	≤0.45
	TSS (mg/L)	0	0.52	0.23	0.37	0.59	0.62	0.83	median	1.1-1.6-2.4
	Secchi (m)	7	5.36	3.50	5.50	5.50	5.75	6.00	mean	10
	Turb (NTU)	334*	4.70	0.20	0.53	0.86	1.68	173.21	median	<1

*While turbidity loggers were deployed for the entire 2017/2018 reporting period (365 days), sample size is based on daily averages from *validated* data recovered from this period. Some data points maybe lost due to unforeseen device malfunction or damage. Turbidity data was not available for monitoring sites AMB6 and AMB11. Some data was lost at AMB3B, Oct-Nov 2017; AMB8, Mar-May 2018; AMB5, Mar-May; and AMB2, Jan-Apr.

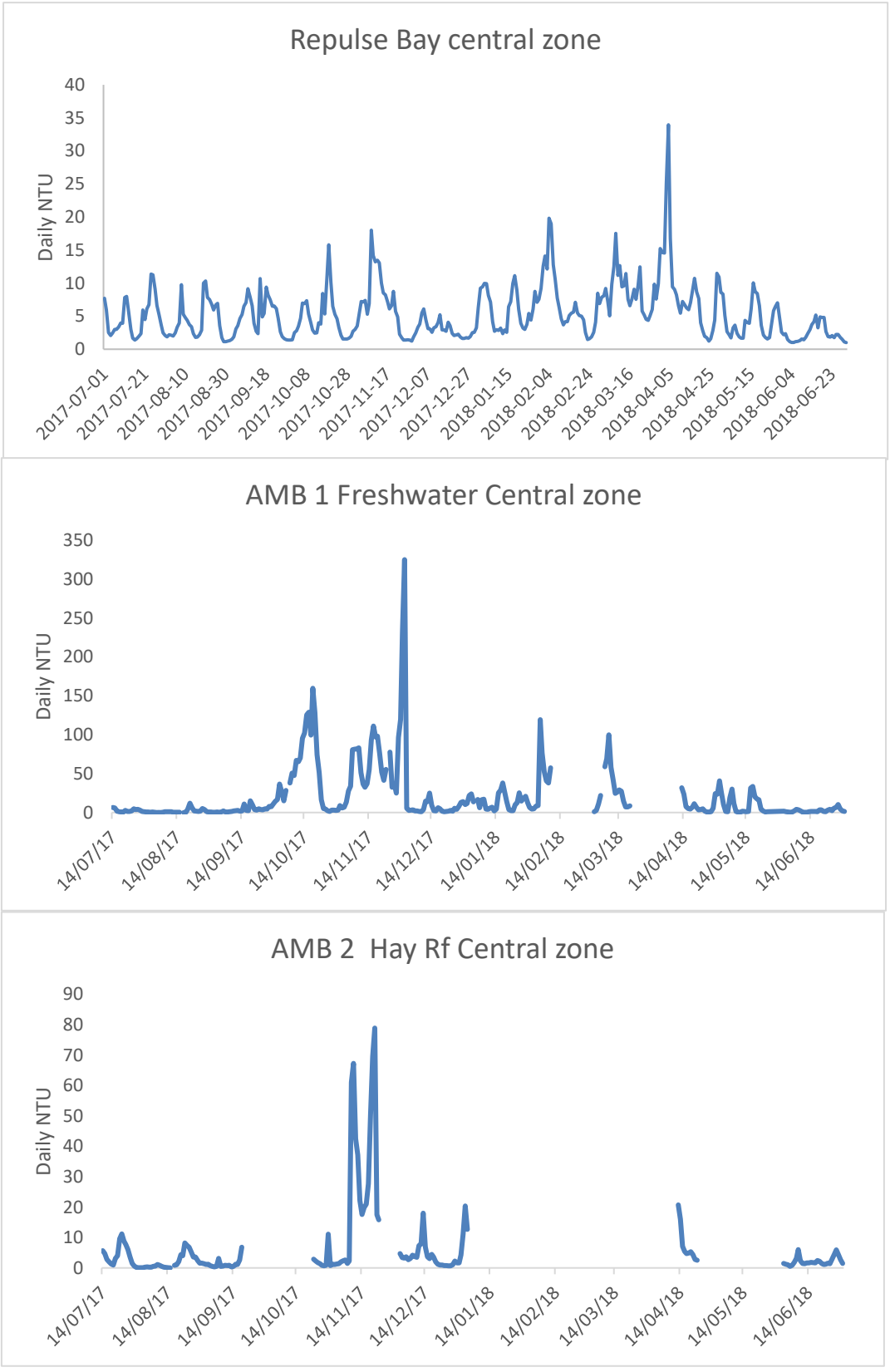


Figure AC 11. Daily turbidity (NTU) for 2017-18 reporting year for three Central inshore marine loggers.

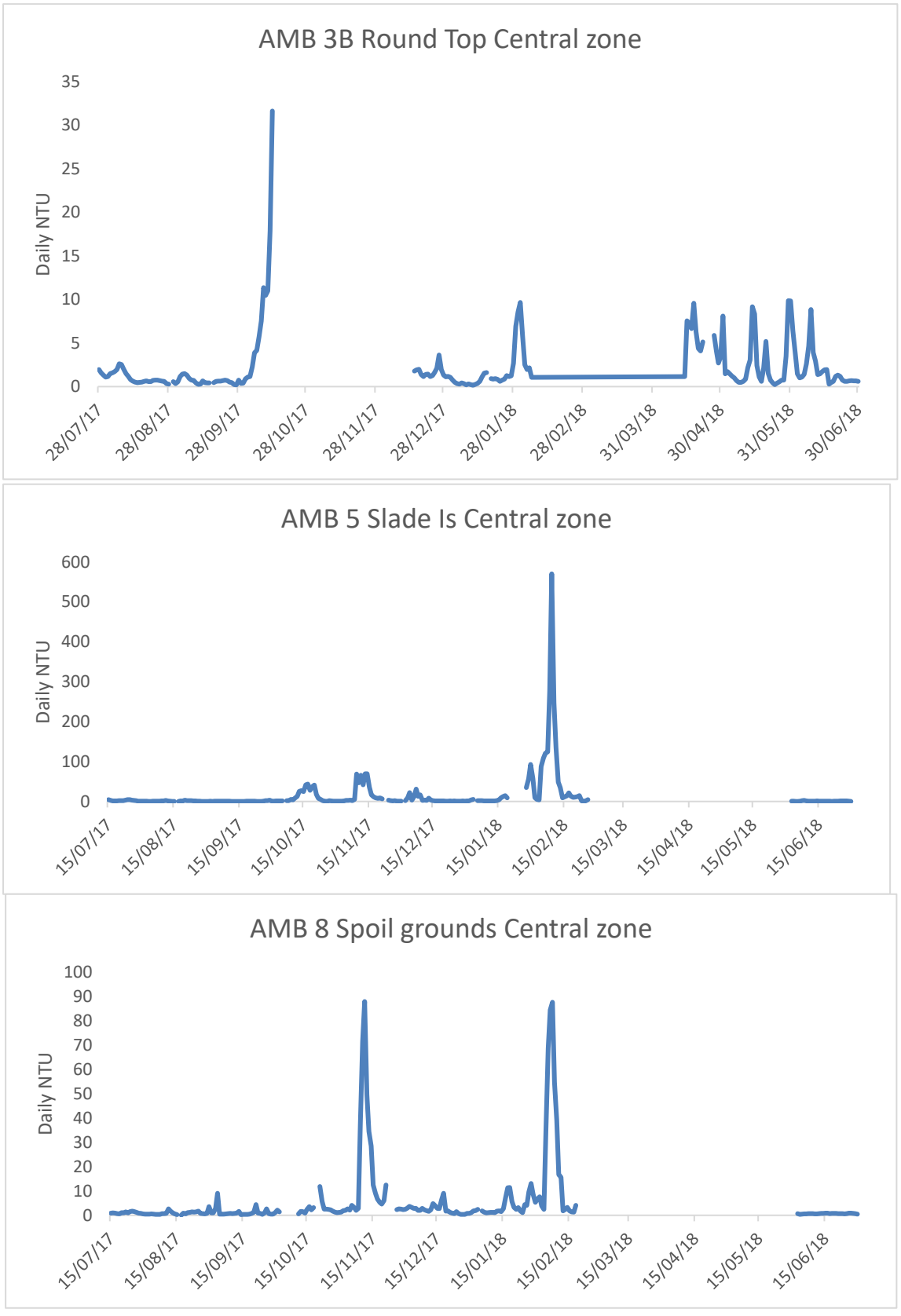


Figure AC 12. Daily turbidity (NTU) for 2017-18 reporting year from three Central inshore marine loggers.

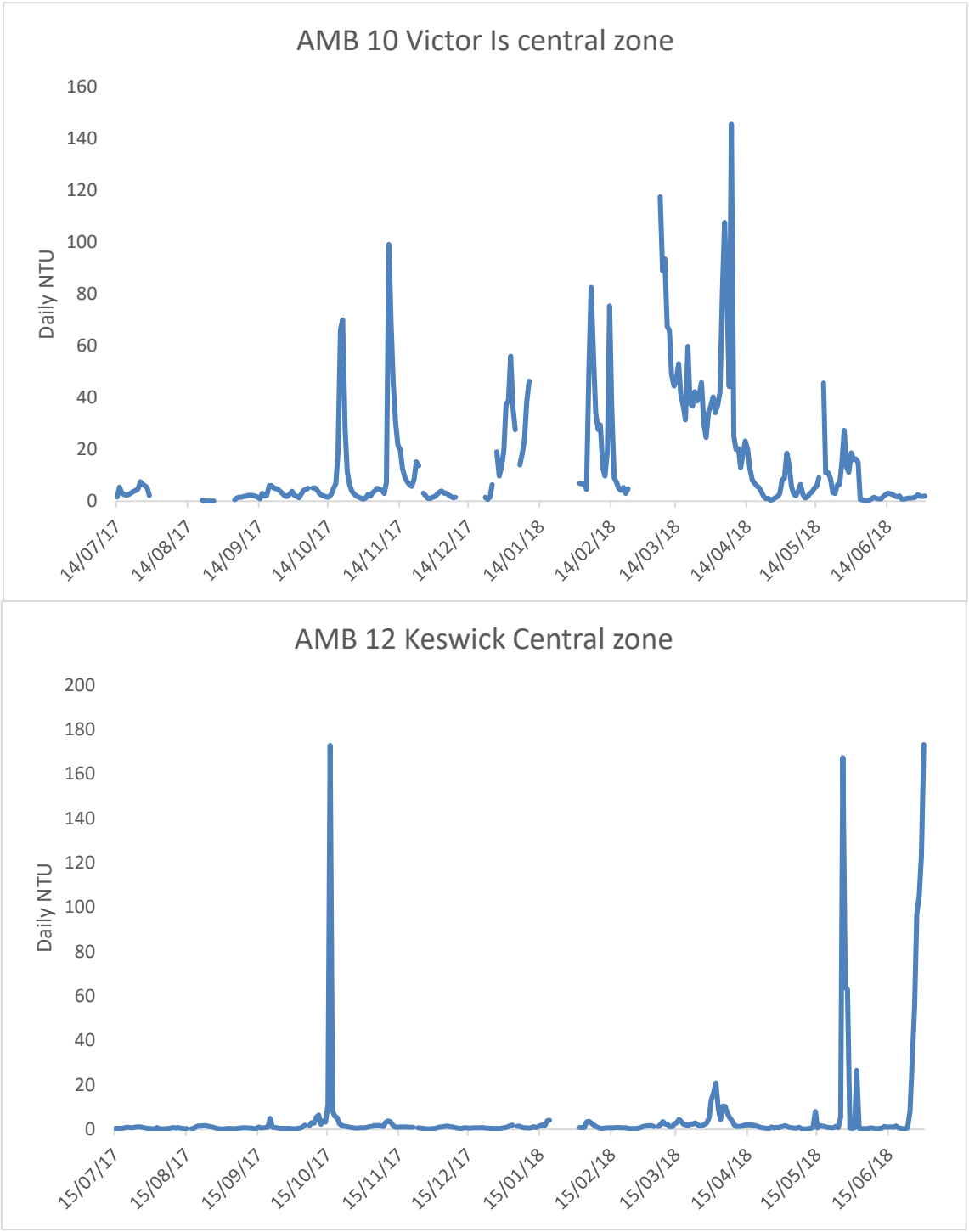


Figure AC 13. Daily turbidity (NTU) for 2017-18 reporting year from two Central inshore marine loggers.

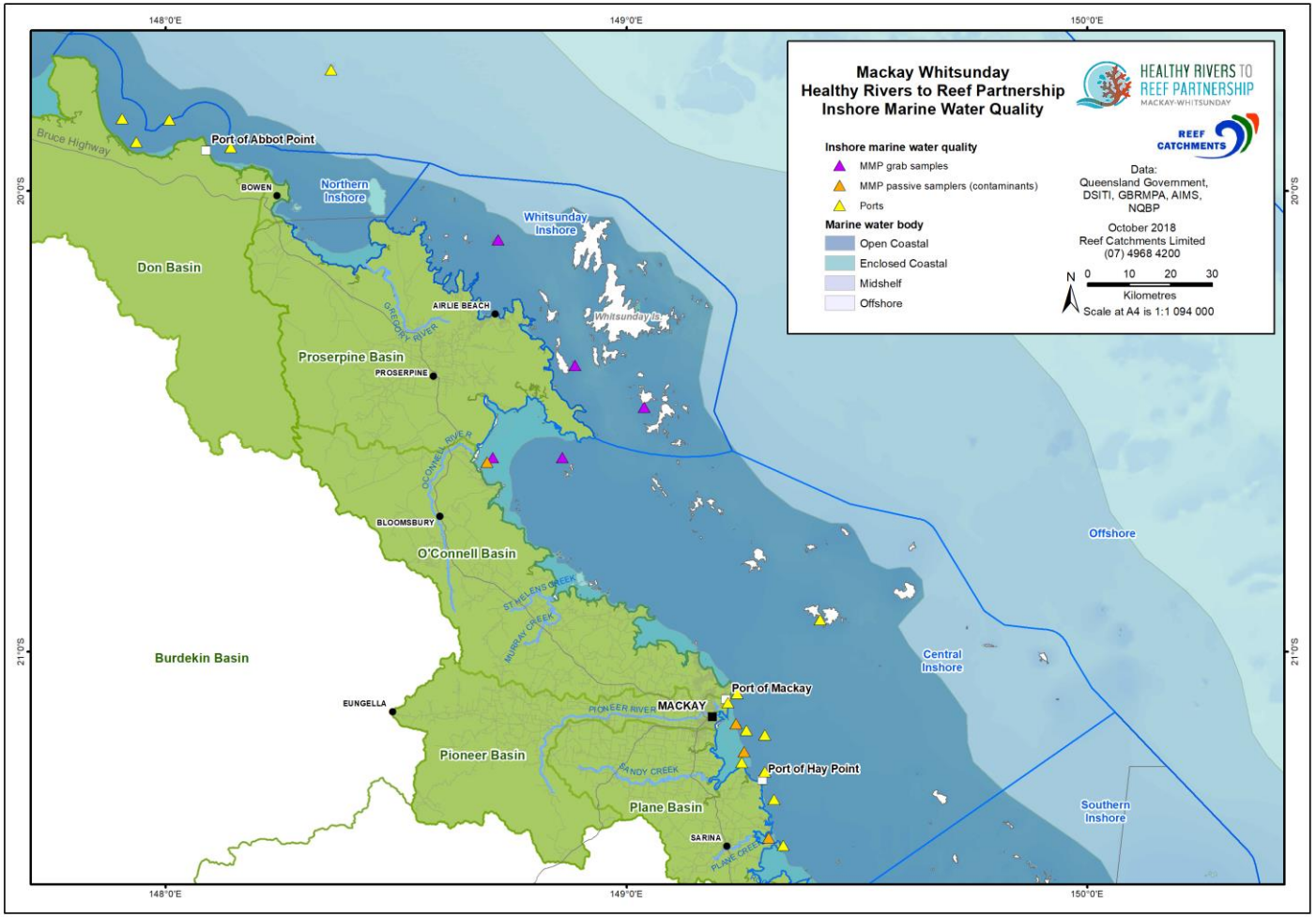


Figure AC 14. Inshore marine water quality monitoring sites in the Mackay-Whitsunday Region for the 2018 report card.

Table AC 10. Southern inshore water quality indicator scores for the 2017-18 report card.

	Nutrients			Chl-a	Water clarity		
Site	NOx	PN	PP	Chl-a	TSS	Secchi	Turbidity
Mky_Cam 1	0.58	-0.40	-0.28	-0.79		-1.00	-1.00
Mky_Cam 2	-0.42	-0.70	-0.28	-1.00		-1.00	
Mky_Cam 3	-0.74	0.64	-0.10	-0.31		-1.00	

Table AC 11. Southern inshore water quality indices for the 2017-18 report card

Site	Nutrients	Chl-a	Water clarity
Mky_Cam 1	-0.03	-0.79	-1.00
Mky_Cam 2	-0.46	-1.00	
Mky_Cam 3	-0.06	-0.31	
Southern 2018	-0.19	-0.70	-1.00

Table AC 12. Summary statistics for water quality indicators in the Southern zone for marine sites from July 2017 to June 2018. Presented alongside statistics are guideline values, including the statistic that was compared to the guideline (where three values are listed, the median is compared to the middle of the listed values). For all indicators except secchi, to meet the guideline the relevant statistic must be lower compared to the guideline (secchi must be higher than the guideline).

									Guidelines	
Site	Indicator	n	Mean	Minimum	25th %ile	Median	75th %ile	Maximum	Comparison	Guideline value
Mackay Cam 1	NOx (µg/L)	5	3	1	1	2	3	8	median	3.0
	PN (µg/L)	5	26	10	19	20	36	47		<20
	PP (µg/L)	5	3	1	3	4	4	5		<2.8
	Chl-*a* (µg/L)	5	1	1	0.56	1	0.94	1	median	<0.45
	TSS (mg/L)									2.0
	Secchi (m)	6	2.11	1	1.2	2	2.58	4		>10
	Turb (NTU)	199*	30.70	0.30	4.65	10.89	17.51	1952.67		<1
Mackay Cam 2	NOx (µg/L)		4	2	3	4	5	6	median	3.0
	PN (µg/L)	5	32	2	5	33	48	74	median	<20
	PP (µg/L)	5	3	1	3	4	4	5	median	<2.8
	Chl-*a* (µg/L)	5	1	0	0.42	0	0.49	3	median	<0.45
	TSS (mg/L)								median	2.0
	Secchi (m)	6	2.47	1.4	1.95	2.15	3.45	3.9	mean	>10
	Turb (NTU)								median	<1
Mackay Cam 3	NOx (µg/L)		5.7	0.5	1	5	5	17		3.0
	PN (µg/L)	5	13	2	3	8	15	36	mean	<20
	PP (µg/L)	5	3	0	0	3	3	9	mean	<2.8
	Chl-*a* (µg/L)	5	1	0	0.39	1	0.59	1	mean	<0.45
	TSS (mg/L)								mean	2.0
	Secchi (m)	6	2.52	0.6	1.7	2.4	3.03	5	mean	>10
	Turb (NTU)								median	<1

*While turbidity loggers were deployed for the entire 2017/2018 reporting period (365 days), sample size is based on daily averages from *validated* data recovered from this period. Some data points maybe lost due to unforeseen device malfunction or damage. Due to the recent development of the monitoring program within the Southern Inshore Zone, a turbidity logger has only been established at Mackay Cam 1 site, 'Aquilla'.

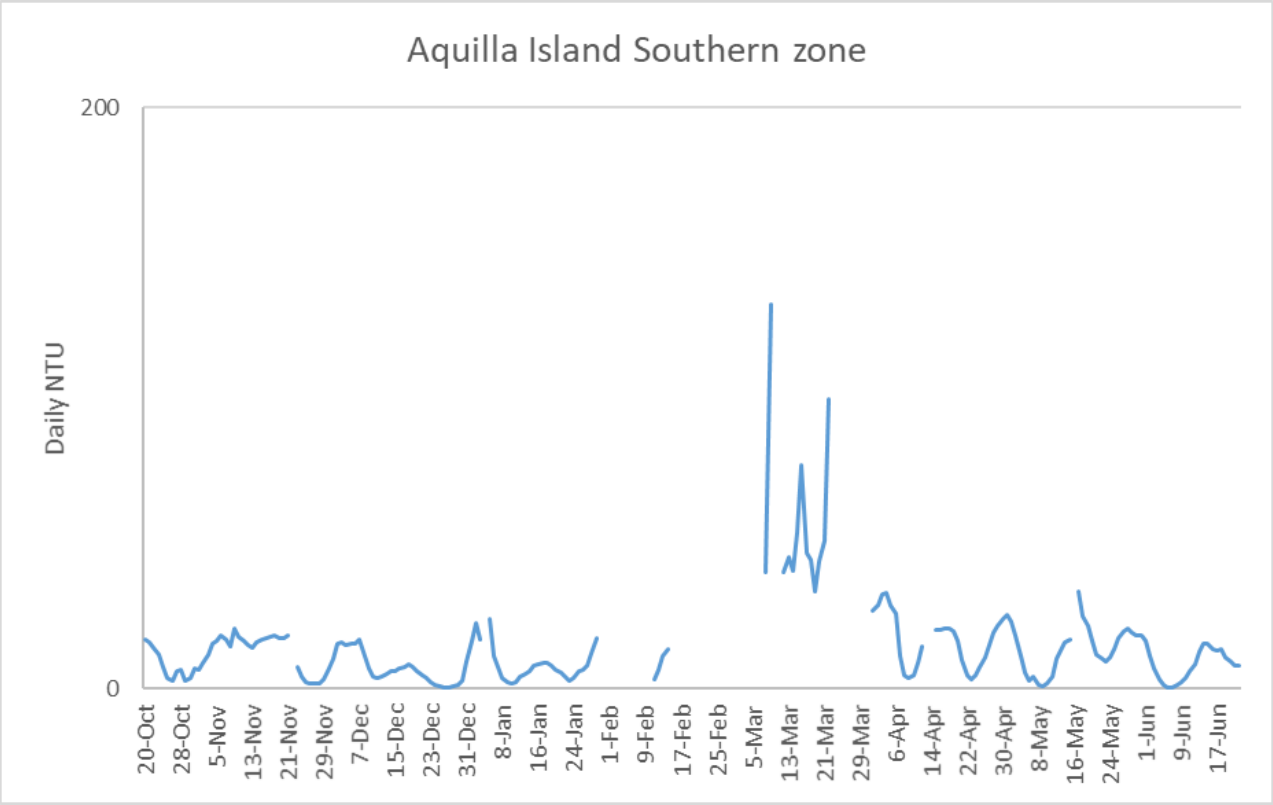


Figure AC 15. Daily turbidity (NTU) for 2017-18 reporting year from Southern inshore zone marine logger.

Table AC 13. Coral indicator scores for 2018 in the Northern inshore marine sites (Abbot Point coral monitoring program). Coral change was reported on for the first time.

Zone	Reef ID	Depth	Cover	Macroalgae	Juvenile	Change*	Composition	Coral index
Northern	Camp East	2	0.13	0.00	0.03	0.00		**0.04**
	Camp West	2	0.33	0.00	0.17	0.40		**0.22**
	Holboune East	2	0.04	1.00	0.03	0.33		**0.35**
	Holbourne East	5	0.12	0.99	0.04	0.00		**0.29**
	Holbourne West	2	0.02	1.00	0.05	0.48		**0.39**
	Holbourne West	5	0.11	0.70	0.07	0.00		**0.22**
2018 Report card score: Poor			**0.12**	**0.61**	**0.07**	**0.20**		**0.25**
2017 Report card score: Moderate			0.14	0.67	0.12			**0.31**
2016 Report card score: Moderate			0.40	0.67	0.29			**0.45**
2015 Report card score: no data								
2014 Report card score: no data								

Scoring range: Very Poor = 0 to <0.21 | Poor = 0.21 to <0.41 | Moderate = 0.41 to <0.61 | Good = 0.61 to <0.81 | Very Good = 0.81 – 1 | No score/data gap

Table AC 14. Coral indicator scores for 2018 in the Whitsunday inshore marine sites (MMP coral monitoring program).

Zone	Reef ID	Reef	Depth	Cover	Macroalgae	Juvenile	Change	Composition	Coral index
Whitsunday	W1	Border	5	0.85	1.00	1.00	0.47	1.00	0.86
	W2		2	0.01	0.00	0.20	0.43	0.00	0.13
	W3	Daydream	5	0.04	0.19	0.19	0.39	0.00	0.16
	W4		2	0.47	1.00	0.10	0.65	0.00	0.44
	W5	Dent	5	0.48	1.00	0.14	1.00	0.50	0.62
	W6	Double	2	0.01	0.00	0.02	0.31	0.00	0.07
	W7	Cone	5	0.25	0.00	0.10	0.24	0.50	0.22
	W8	Hayman	5	0.69	1.00	1.00	0.16	0.50	0.67
	W9		2	0.09	0.93	0.08	0.28	0.00	0.28
	W10	Hook	5	0.30	0.81	0.14	0.13	0.50	0.38
	W11	Langford	5	0.60	1.00	0.78	0.00	0.50	0.58
	W12		2	0.15	0.00	0.10	0.33	1.00	0.31
	W13	Pine	5	0.22	0.59	0.15	0.22	0.00	0.23
	W14		2	0.24	0.00	0.39	0.41	0.50	0.31
	W15	Seaforth	5	0.20	0.82	0.42	0.00	1.00	0.49
	W16	Shute	2	0.59	1.00	0.31	0.85	1.00	0.75
	W17	Harbour	5	0.25	0.79	0.40	0.46	1.00	0.58
2018 Report card score: Moderate				**0.32**	**0.60**	**0.32**	**0.37**	**0.47**	**0.42**

2017 Report card score: Moderate	0.37	0.93	0.34	0.43	0.53	**0.52**
2016 Report card score: Good	0.68	0.76	0.62	0.40	0.59	**0.61**
2015 Report card score: Moderate	0.64	0.74	0.60	0.40	0.53	**0.58**
2014 Report card score: Moderate	0.61	0.74	0.61	0.39	0.44	**0.56**

Scoring range: Very Poor = 0 to <0.21 | Poor = 0.21 to <0.41 | Moderate = 0.41 to <0.61 | Good = 0.61 to <0.81 | Very Good = 0.81 – 1 | No score/data gap

Table AC 15. Coral indicator scores for 2018 in the Central inshore marine sites (Hay Point coral monitoring program).

Zone	Reef ID	Cover	Macroalgae	Juvenile	Change	Composition	Coral index
Central	Keswick	0.52	0.00	0.06	0.41		0.25
	Round	0.37	0.00	0.22	0.44		0.26
	Slade	0.29	0.00	0.26	0.42		0.24
	Victor	0.26	0.00	0.11	0.30		0.17
2018 Report card score: Poor		**0.36**	**0.00**	**0.16**	**0.39**		**0.23**
2017 Report card score: Poor		0.35	0.01	0.18	0.40		**0.23**
2016 Report card score: Poor		0.44	0.00	0.15	0.64		**0.31**
2015 Report card score: no score		0.42		0.39			
2014 Report card score: no data							

Scoring range: Very Poor = 0 to <0.21 | Poor = 0.21 to <0.41 | Moderate = 0.41 to <0.61 | Good = 0.61 to <0.81 | Very Good = 0.81 – 1 | No score/data gap

Table AC 16. Coral indicator scores for 2018 in the offshore marine zone (Long-Term Monitoring Program monitoring program) compared to amended indicator scores from 2017, 2016, 2015 and 2014. Also presented are original scores for 2014 – 2016 report cards, presented in the 2016 report card (and associated documents) that were calculated using erroneous methodology.

Year	Cover	Macroalgae	Juvenile	Change	Coral index
New methods 2018 (accounting for detection of erroneous method)					
2018	33		93	41	**56**
2017	39		95	45	**60**
2016	34		95	41	**57**
2015	38		99	33	**57**
2014	36		97	28	**54**
Old Methods 2016 (updated analysis approach)					
2016	32		95	42	**57**
2015	34		87	38	**53**
2014	32		68	33	**44**
Old Methods (2014 and 2015)					
2015	28	31	88		**49**
2014	25	22	69		**39**

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100 | No score/data gap | Not applicable

Table AC 17. Final offshore scores and indices for 2018 compared to amended scores from 2017, 2016, 2015 and 2014. Also presented are original scores for 2014 – 2016 report cards, presented in the 2016 report card (and associated documents) that were calculated using erroneous offshore coral scoring methodology.

Year	Water quality	Coral index	Seagrass	Fish	Final
New methods 2018 (accounting for detection of erroneous method)					
2018	99	56			77
2017	92	60			76
2016	93	57			75
2015	94	57			76
2014	95	54			74
Original scores (using erroneous method)					
2016	93	56			74
2015	94	53			73
2014	95	44			69

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100 | No score/data gap | Not applicable

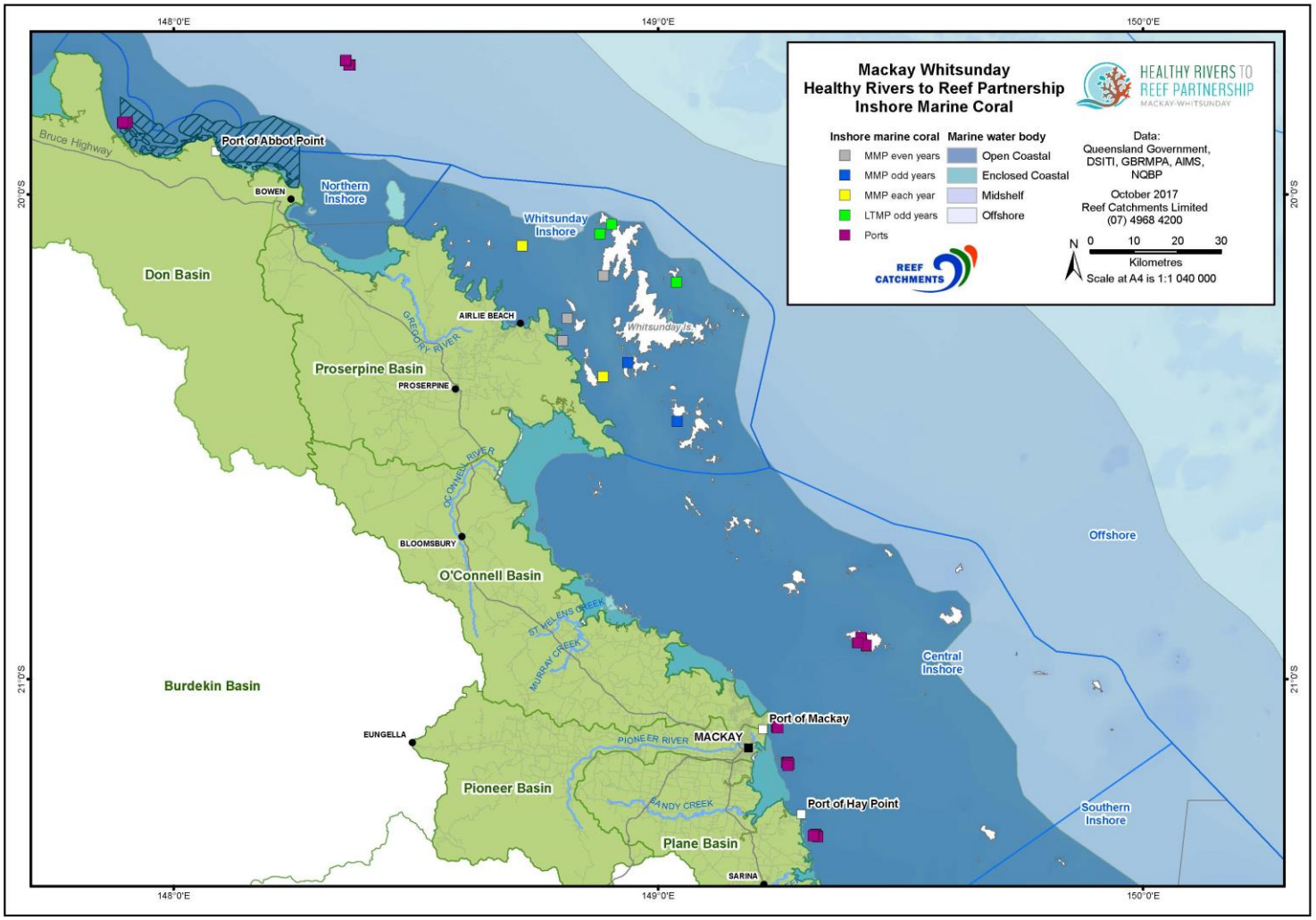


Figure AC 16. Inshore marine coral monitoring sites in the Mackay-Whitsunday Region for the 2018 report card.

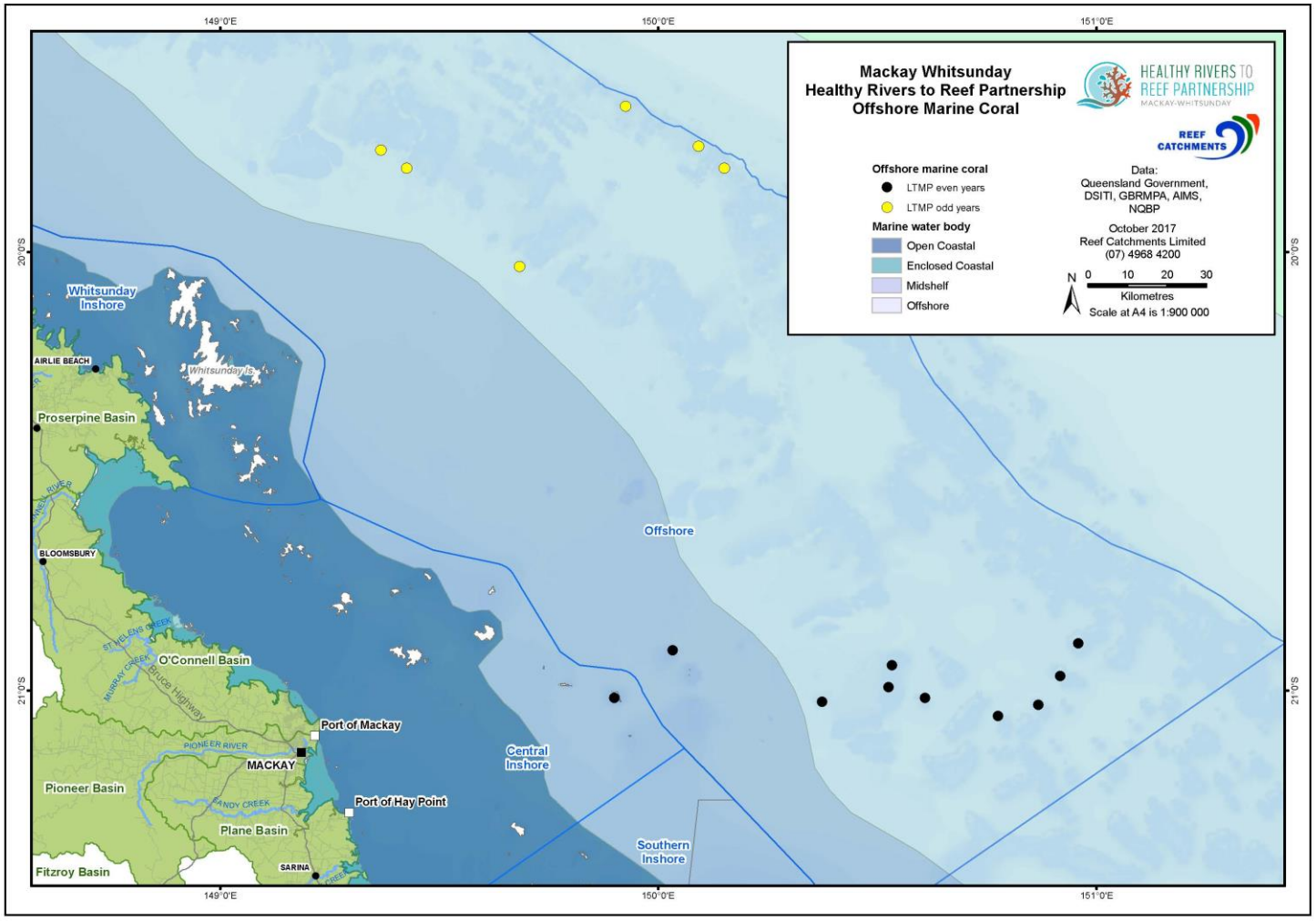


Figure AC 17. Offshore marine coral monitoring sites in the Mackay-Whitsunday Region for the 2018 report card

Table AC 18. Results for seagrass indicators, based on 2017-18 data. Indicators are based on data collected from the Marine Monitoring Program (MMP) or the Queensland Ports Seagrass Monitoring Program (QPSMP) and black cells indicate an indicator does not contribute to a reporting zone. Seagrass Watch sites that contribute to the MMP are indicated (SW). NB site scores for QPSMP are determined from the lowest indicator score. If species comp drives the overall score, it is given a 50% weighting; for MMP site scores are an average of indicators.

					MMP	MMP	MMP	Ports	Ports	Ports		
Zone	Habitat	Depth	Location/Meadow	Meadow/site	Abundance	Reproductive effort	Nutrient status	Biomass	Area	Sp. Composition	Overall site/meadow score	Overall zone score
Inshore Marine Northern	coastal	inshore	Abbot Pt.	API3				88	82	62	72	25
				API5				0	0	0	0	
				API7				78	87	72	75	
				API8				0	0	0	0	
				API9				83	71	100	71	
		subtidal		APD1				0		0	0	
				APD2				1		80	1	
				APD3				2		97	2	
				APD4				1		100	1	
Inshore Marine Whitsunday	reef	intertidal	Hydeaway Bay	HB1 and 2*	31						31	13
			Hamilton Is. 1	HM1	0	0	0.4				0.1	
			Hamilton Is. 2	HM2	0	0					0	
		subtidal	Tongue Bay	TO1 and 2^	0						0	
			Lindeman Island	LN1 and 2	25	13	25				21	
	coastal	intertidal	Pioneer Bay	PI2 and 3*	25						25	
Inshore Marine Central	coastal	intertidal	Midge Point	MP2 and 3	94	25	49				56	45
			St Helens Beach	SH1*#	38						38	
		subtidal	Newry Bay	NB1 and 2^	38						38	
	estuarine	intertidal	Sarina Inlet	SI1 and 2	13	0	27				13	
	coastal	intertidal/subtidal	Dudgeon Pt	DP1				74	65	95	65	
		subtidal	St Bees Island	SB10				52	84	97	52	
			Keswick Island	KW14				50	53	100	50	
			Hay Point	HPD1				45	57	100	45	
Inshore Marine Southern	coastal	intertidal	Clairview	CV1 and 2*	37.5						37.5	not used

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 – 100 | No score/data gap | Not applicable

* Seagrass-Watch sites ^Queensland Parks and Wildlife Service (QPWS) drop-camera # Not used in GBR-wide report card

New to MMP in 2017-18 New to Ports in 2017-18 Not used

Table AC 19. Seagrass scores for the 2017, 2016, 2015 and 2014 report card scores using previous seagrass methods. Method was updated for the 2018 report card.

	2017	2016	2015	2014*
Zone	**Seagrass index**	**Seagrass index**	**Seagrass index****	**Seagrass index****
Northern	**58^**	42	21	
Whitsunday	**29^**	42	16	24
Central	**34^**	50	49	26
Southern				

Scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap | Not applicable

^To derive the seagrass index an average of *site/meadow* scores is calculated, not an average of indicator. To determine a site/meadow score the MMP takes the average of the indicator scores and QPSMP take the lowest of the indicator scores. This can sometimes lead to overall seagrass index scores and ratings appearing to contradict the indicator scores.
*Seagrass scores from 2014 are only from MMP.
**Seagrass scores in 2015 and 2014 do not account for subtidal sites in the MMP.

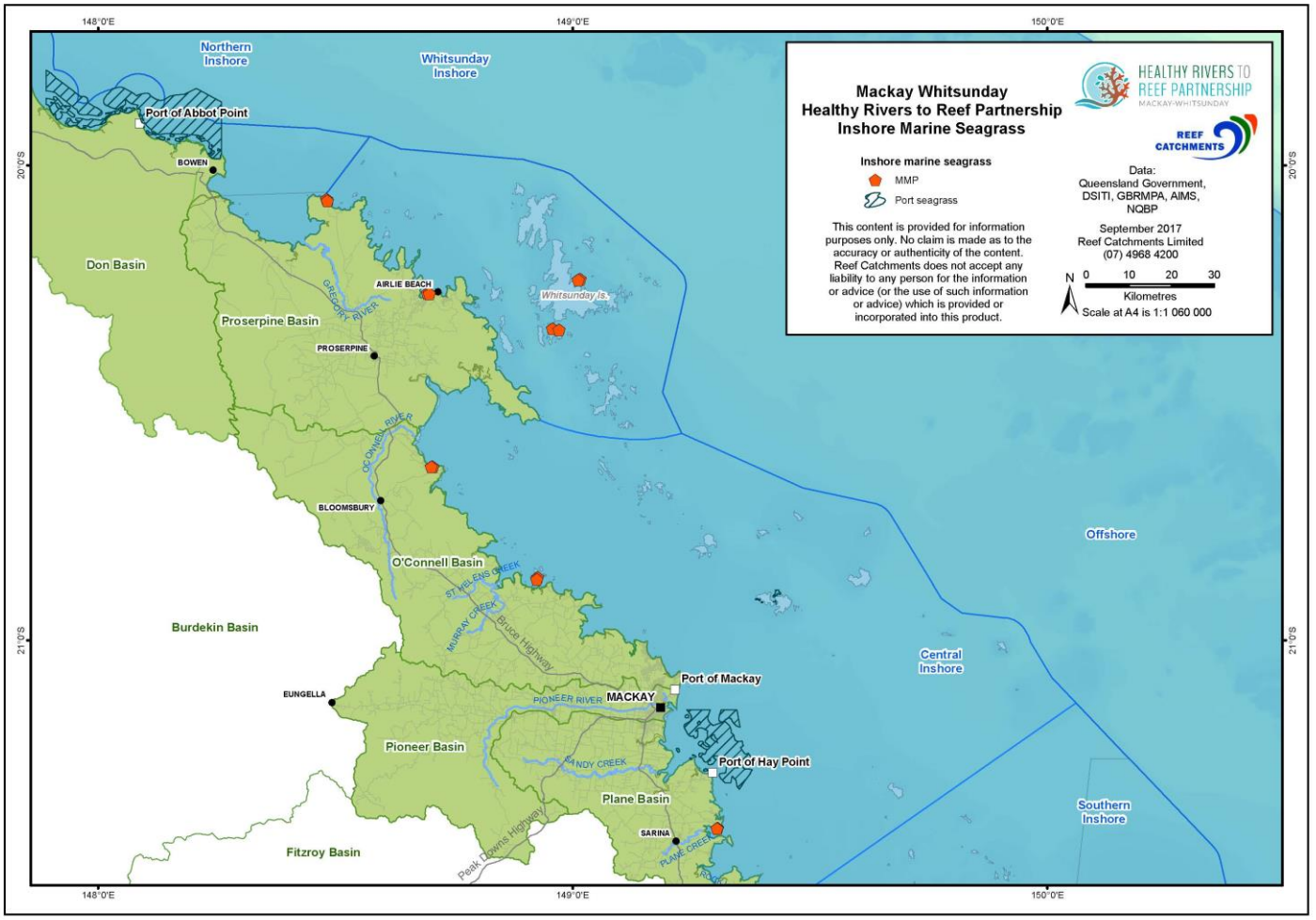


Figure AC 18. Inshore marine seagrass QPSMP and MMP monitoring sites in the Mackay-Whitsunday Region for the 2018 report card

Table AC 20. Previously reported scores for Mackay-Whitsunday-Isaac pesticides in the inshore marine zone. Scores for inshore marine pesticides in the 2014-2017 report card were reported using the PSII-HEq method. Pesticides scores in the inshore marine zone for the 2018 report card were scored using the Pesticide Risk Metric (ms-PAF) with 19 pesticides.

Zone	Sample	Program	Standardised score 2017	Standardised score 2016	Standardised score 2015	Standardised score 2014
Northern	Grab	Ports				100
Whitsunday					93	91
Central	Passive	MMP	39	51	68	68
	Grab	Ports	Used for validation only			
Southern						

PSII-HEq (ng/L) scoring range: Very Poor >900 | Poor 250 to 900 | Moderate = 50 to 250 | Good = 10 to 50 | Very Good = <10 | No score/data gap

Standardised scoring range: Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

Appendix D: Proserpine water quality monitoring

Following a review of the 2016-2017 water quality results received for the Proserpine Basin, concerns were raised by the TWG regarding elevated levels of TSS and Conductivity observed. Of note was that intermittent levels were anomalously high and may not adequately represent system conditions within the broader Proserpine Basin. It was recognised that the data more likely represented estuary concentrations during periods of low flow. A desktop review of the Declared Downstream Limit, as defined by the Water Act 2000 supported these

Estuary influences on sediment and nutrient concentrations could not be confidently identified within or separated from the dataset without analysis of the associated hydrograph, salinity data and historical information. Due to time limitations, this exploration of data could not be conducted in fulfilment of the 2017 report card. Since, a provisional assessment of the relationship between conductivity and nutrient levels has been conducted and is presented below.

Pesticide data exploration

Despite being located in the estuary, pesticides were still reported for the Proserpine basin in the 2017 and 2018 report card using data from this site. This was based on the below observations and exploration for the 2017 report card:

- The monitoring location, although in a tidal section of the Proserpine River, is suitably located to capture pesticide inputs from the majority of agriculture that flows to the Proserpine River (Figure AD 1).

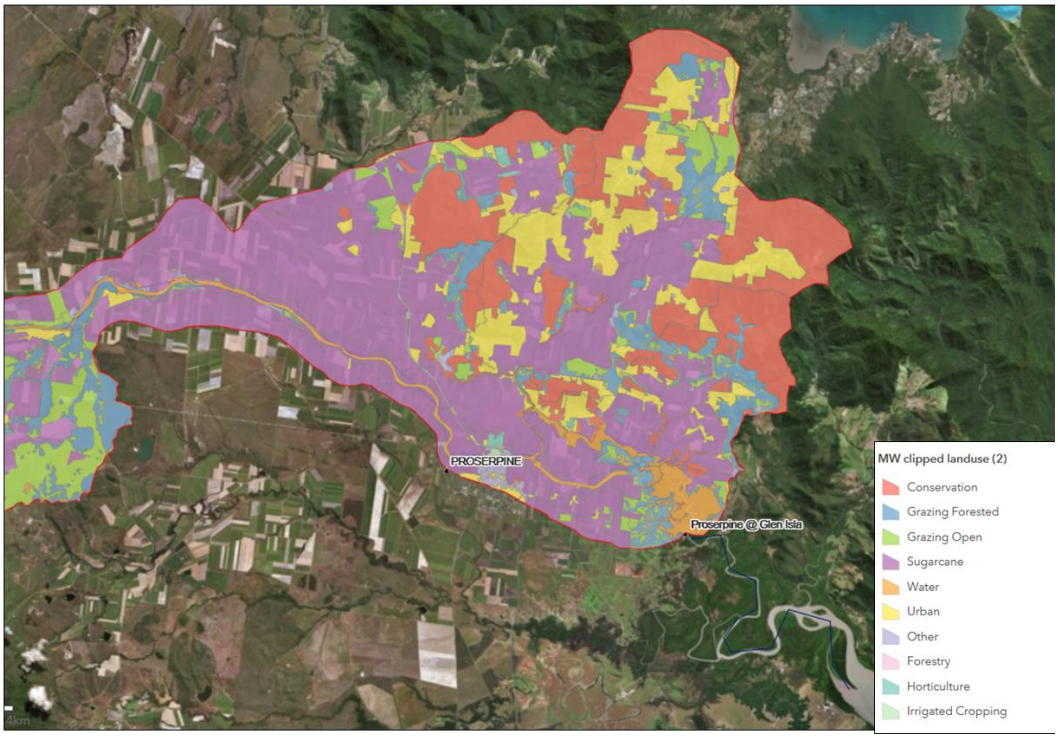


Figure AD 1. Land use upstream of the Proserpine River GBRCLMP site.

- The monitoring period for the 2017 report card (beginning of November 2016 to end of April 2017[1]) captured the majority of freshwater (event) flows. The conductivity trace (conductivity data was only available from January 2017) illustrated that the Proserpine River site was dominated by freshwater for a significant proportion of this six-month period (Figure AD 2). In Figure AD 2 all the event samples (shown as red dots) and a large proportion of the weekly ambient samples (not shown) would have been relatively representative of fresh water.

[1] The wet season monitoring period is not fixed. It depends on the first rainfall even that causes the first flush of nutrients into waterways. Therefore the wet season can start earlier than stated.

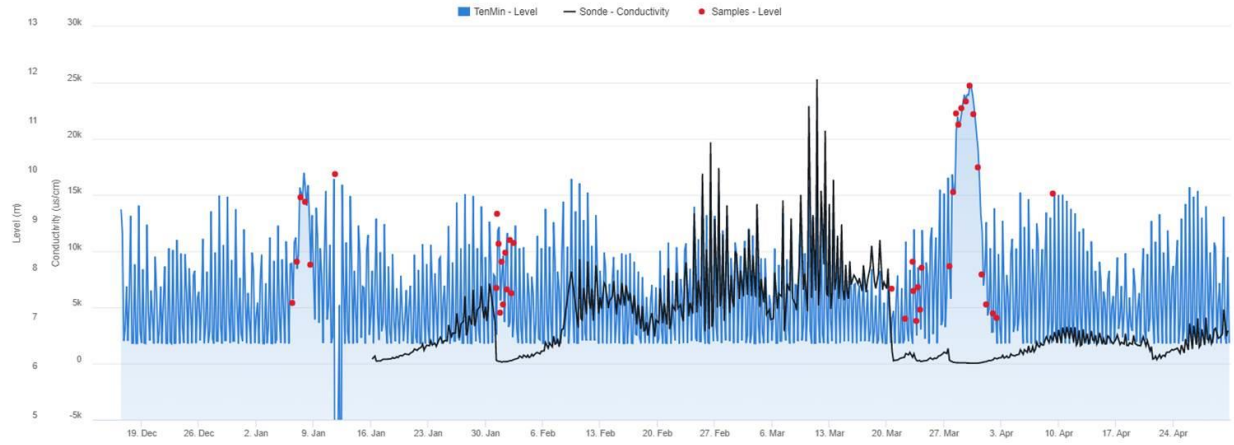


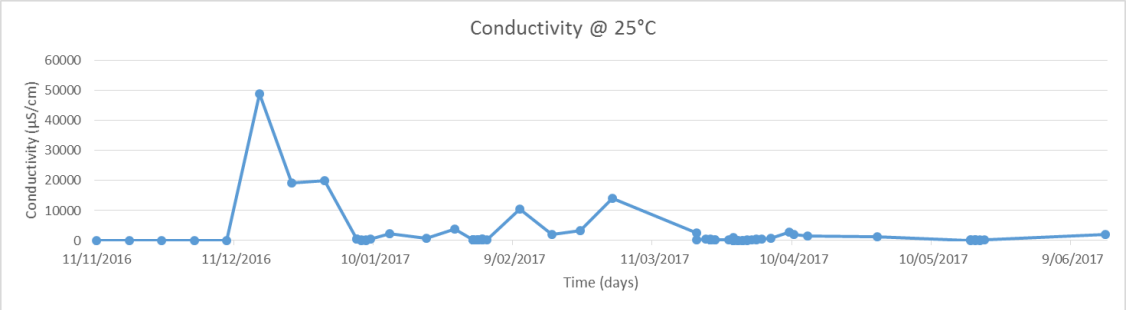
Figure AD 2. Conductivity, stream height and pesticide sampling times in the Proserpine River GBRCLMP site.

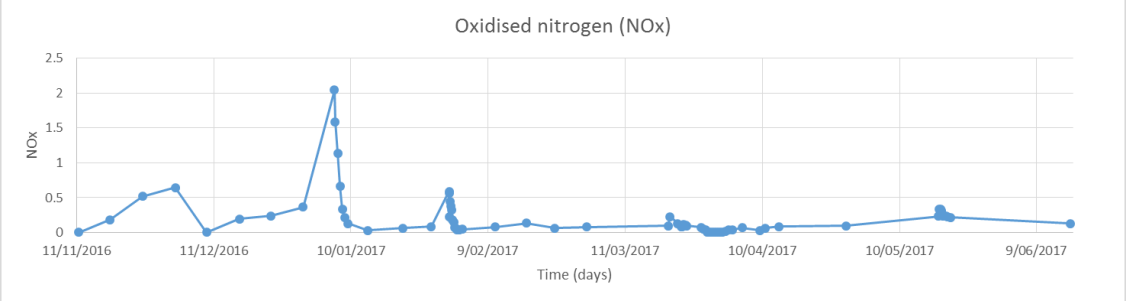
It was therefore recommended that data from the Proserpine River GBRCLMP site provided a reasonable estimate of the pesticide pressures in the freshwater catchment, where tidal inflow of marine waters was not likely to dilute the magnitude of the ms-PAF score substantially. Further, an ms-PAF score calculated above the tidal zone would not necessarily provide a more accurate picture of the pesticide pressures in the catchment because it would miss some of the land based inputs. These same assumptions were applied to the 2018 report card scores for pesticides.

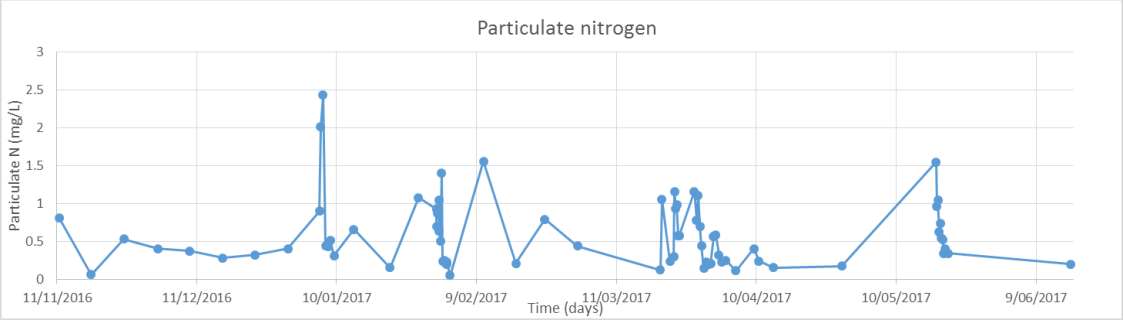
Sediment and nutrient data exploration

To explore the sediment and nutrients data for the Proserpine site, TWG reviewed the data provided which comprised samples collected during the wet season, from November 2016 – May 2017. Anomalously high values were identified within the conductivity dataset, indicating the water type was periodically characterised by more saline waters. A comparison between these values and the broader water quality data set (eight estuaries in total) showed that elevated conductivity values at the Glen Isla monitoring site were in the same order of magnitude as those reported for estuaries.

To assess whether variance in conductivity correlated with detectable variance in TSS and nutrient loads, Figure AD 3 was plotted. This provisional review showed no clear relationship between changes in conductivity and NOx, TSS, particulate N and particulate P; however, it was noted that sediment and particulate nutrient loads appeared correlated. A more detailed assessment would be required to delineate this relationship.







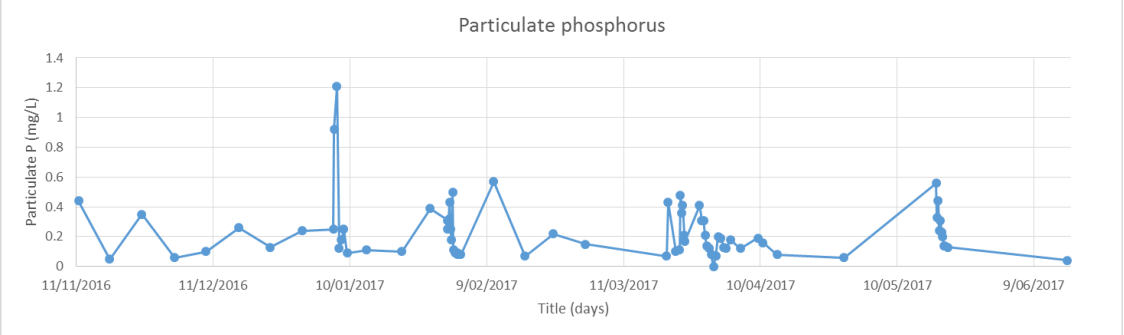


Figure AD 3. Results for event monitoring for water quality parameters measured at the Proserpine basin, Glen Isla site from 2016-17.

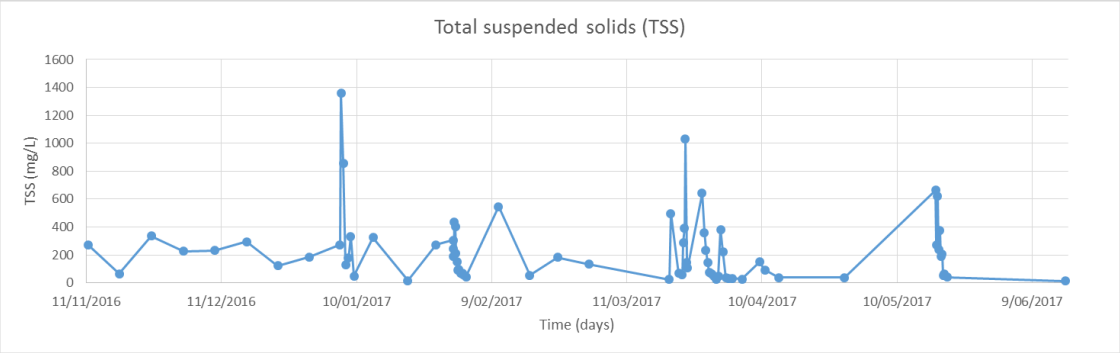


Figure AD 3. Continued. Results for event monitoring for water quality parameters measured at the Proserpine basin, Glen Isla site from 2016-17

Further liaison with data providers and TWG representatives provided the following information:

- Fluctuations in conductivity values across the grab sample monitoring period, of that level, suggested the location is subject to tidal influence. Tidal influence can affect TSS through physical resuspension of sediment during tidal exchange, therefore, the TSS values obtained from this site do not adequately represent the concentration of suspended sediments within catchment water through as result of natural or anthropogenic inputs.
- Variance in conductivity appeared to be correlated with variance in turbidity (a function of sediment loads). A copy of example graphs provided by DES are included below. These graphs were plotted using 2017-2018 data.
- *Figure AD 4* shows that from May 2017 – September 2017, during the dry season, conductivity values rose from <5,000 (during wet season where freshwater flows are expected to extend further downstream) to 55,000 µS/cm. Conductivity values of this magnitude under low flow conditions suggests the monitoring location is situated within the estuary.
- *Figure AD 5* shows conductivity and turbidity values from July to November (data year not known), which appear to link strongly with water level.
- *Figure AD 6* shows changes in water level, turbidity and conductivity over one tidal cycle. It is evident that conductivity increased in accordance with increases in water level. Likewise, conductivity decreased in accordance with decreases in water level, following peak high tide.
- *Note* that pesticide concentrations were not plotted against any other parameters for water quality, nor were soluble nutrient loads.

The information provided suggests that turbidity values were affected by tidal events, indicating TSS concentrations at Glen Isla may not be representative of catchment conditions; rather, they appear to capture the effects of tidal exchange.

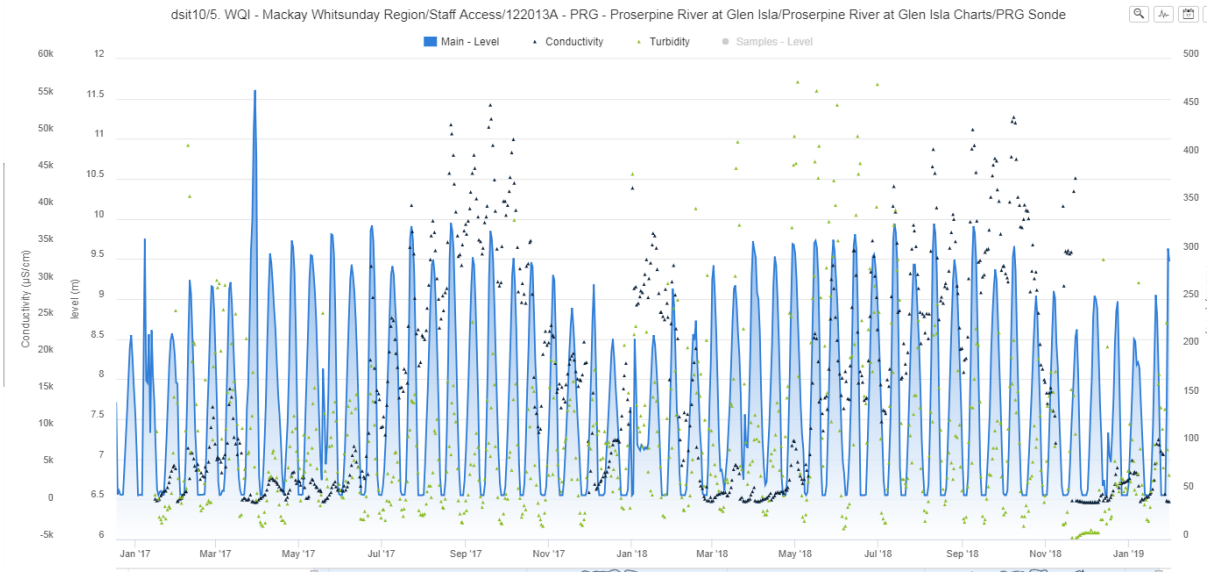


Figure AD 4. Water level, conductivity and turbidity reported at monitoring station 122013A, Jan'17 to Jan19. Blue line represents water level (m), black triangles represent conductivity (µs/cm) values and green triangles represent turbidity (NTU) values. Graph picture supplied by DES.

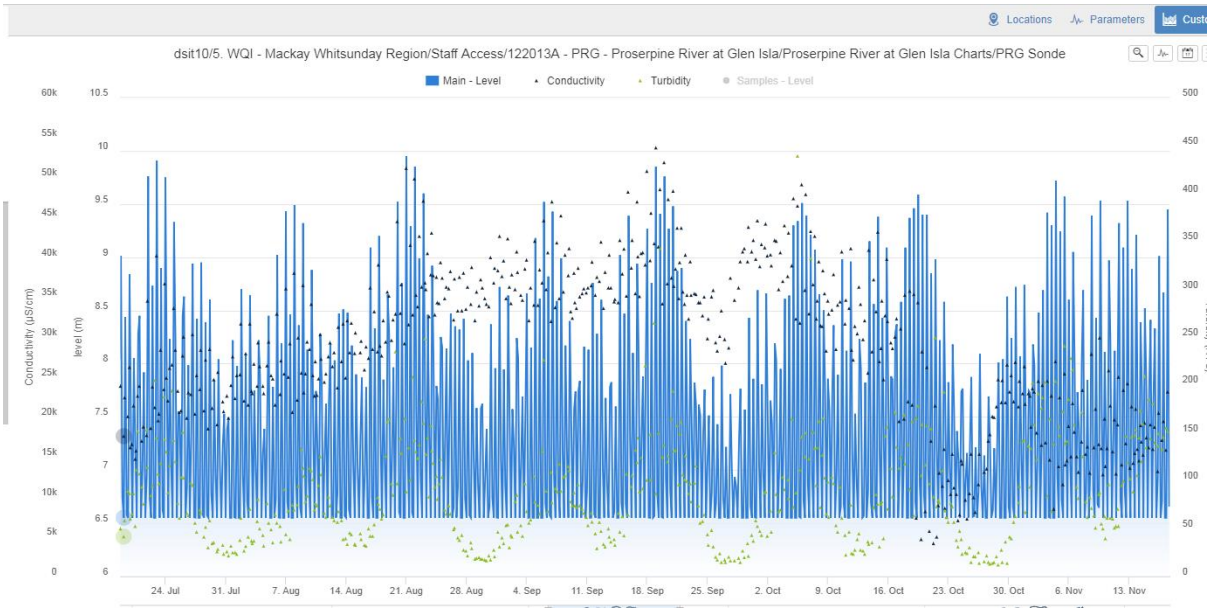


Figure AD 5. An example of water level, conductivity and turbidity reported at monitoring station 122013A. Blue line represents water level (m), black triangles represent conductivity (µs/cm) values and green triangles represent turbidity (NTU) values Graph picture supplied by DES.

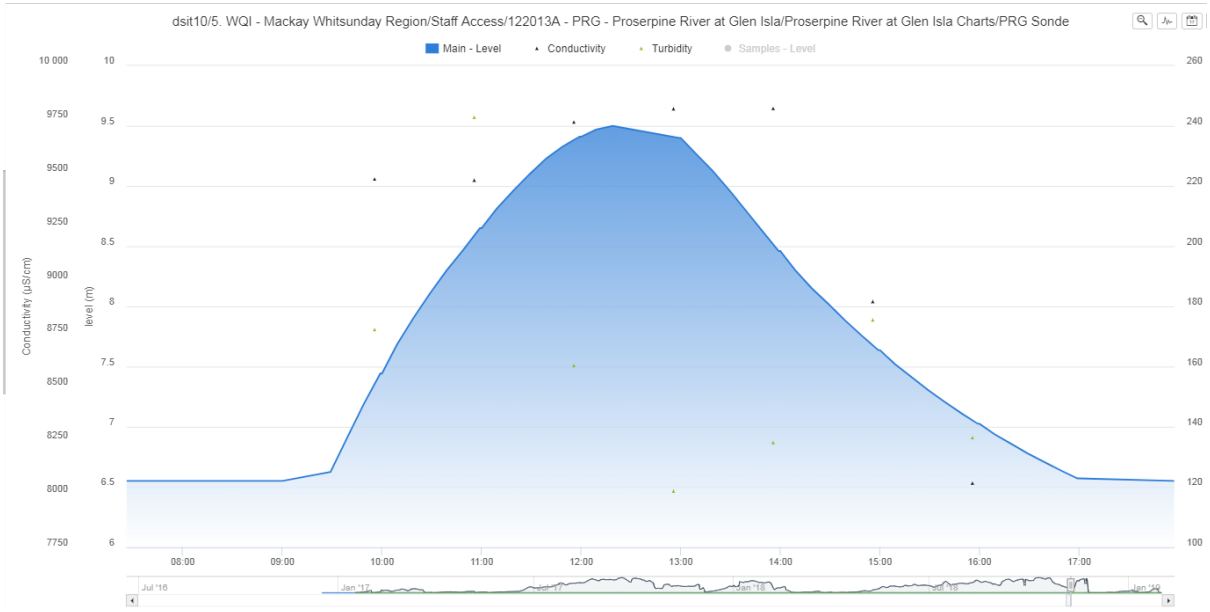


Figure AD 6. Example of water level, conductivity and turbidity reported at monitoring station 122013A across one tidal event. Blue line represents water level (m), black dots represent conductivity (µs/cm) values, and green dots represent turbidity (NTU) values. Graph picture supplied by DES.

Conclusion

As indicted by the desktop review outline above, the Glen Isla monitoring site is likely located within the estuary. The observed TSS values are considered confounded by sediment re-suspension processes within the tidal limit. It is acknowledged that local sediment re-suspension is a component of riverine systems and micro hydrology; however, the results suggest turbidity values correlate strongly with tidal events and, therefore, are not representative of catchment process or conditions. Further, a strong correlation between TSS, particulate P and particulate N is evident within Figure AD 3, suggesting nutrient concentrations may also be confounded at the monitoring site.

Findings of TWG for 2018 report card

Based on the desktop review conducted above, the following was ascertained for the development of this year's report card:

- Sediment and nutrients are not reported based on findings and options for an alternate monitoring site is being explored
- The pesticide indicator is reported
- Due to minimum information rules, no water quality index score is calculated

Looking to the future, the TWG ascertained that the marginal location of the Glen Isla site, situated within the lower reaches of the estuary, made it an undesirable estuary site too. For comparison, all other CLMP sites are situated within the middle of the estuary extent.

The Partnership is currently exploring alternate monitoring sites in an effort to better represent the freshwater extent of the Proserpine River and, ultimately, the Proserpine Basin.