Results for Townsville Dry Tropics 2020-2021 Report Card (released in 2022)

Technical report

Dry Tropics Partnership for Healthy Waters

August 2022

Authorship statement

The technical report of the results of the Townsville Dry Tropics 2020-2021 Report Card (released in 2022) was compiled by the Partnership's Senior Technical Officer, Dr Tegan Whitehead, and finalised by the Partnership's Senior Technical Officer replacement Dinny Taylor and Technical Officer Adam Shand. Input was received from the Regional Report Cards Technical Working Group (TWG) members. Some content was also based on technical reports from the Wet Tropics and Mackay-Whitsunday-Isaac regional Report Cards.

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Executive Summary

This executive summary includes three summary sections covering:

- The Dry Tropics Partnership,
- The region's climate during 2020-2021,
- The state and condition of the environment, including scores and grades for each index for each environment (freshwater, estuarine, inshore marine, and offshore marine), and site-specific scores and grades for litter.

The Dry Tropics Partnership

The Dry Tropics Partnership for Healthy Waters (referred to as the Partnership) was formed in November 2017 and launched in January 2019. The current geographic scope of the Partnership covers the waterways (freshwater, estuarine and marine) in the Townsville region, from Crystal Creek in the north to Cape Cleveland in the south and east to the outer Great Barrier Reef (GBR) Marine Park. The Partnership released its Pilot Report Card in May 2019, reporting on data from the 2017-18 year and its first full Report Card in June 2020. The Partnerships' second full Report Card (data from 2019-2020) was released in June 2021, with an accompanying management response report highlighting the management actions by partners. The Partnerships' third full report card (data from 2020-2021), which is a summary of the results from this document, will be released in August 2022. This document is intended to be read in conjunction with the Townsville Dry Tropics Program Design and the Townsville Dry Tropics Methods document.

Climate

For the 2020-2021 period, annual rainfall in the Dry Tropics region was at or above the long-term mean, and significantly higher than the previous reporting year. However, monthly rainfall fluctuated significantly. The Ross Basin received 100% of the annual mean with a total of 1133 mm. The Black Basin received 126% of the annual mean with a total of 1980 mm (412 mm above the long-term mean). Only one month of rainfall was similar to the long-term average for each basin. July, December, January, March, and April recorded above average rainfall for both basins, and September was also above average for the Black basin. Rainfall in the lowest 1% of long-term records was also recorded for two months in the Ross basin, and three months in the Black basin.

Sea surface temperatures for the Dry Tropics inshore and offshore zones were slightly above long-term average summers but generally below those observed in previous years. Sea surface temperature anomalies were more even across the zones than previous years and the risk of severe thermal stress and coral bleaching events was lower than in 2016-17 and 2019-20.

Air temperatures for the Dry Tropics region were similar to the long-term average with a mean temperature of 25.2°C and no significant spikes.

State and condition of the environment

The results presented in this document describe the state and condition for freshwater, estuarine, inshore marine, and offshore marine environments. The freshwater and estuarine environments are divided into the Ross and Black zones, whilst the inshore marine environment is divided into Cleveland Bay and Halifax Bay. The offshore marine environment is one zone that encompasses all offshore waters from Palm Island to Cape Cleveland. The Townsville Dry Tropics 2020-2021 Report Card (henceforth referred to as the Report Card) reports mainly on data from the 2020-2021 year.

Within each of these environments (and zones), standardised scores and grades are produced for indicators, indicator categories and indices. Results from multiple indicators are aggregated into results for indicator categories, which are aggregated into results for indices. Within the four environments, there are different indices that are reported upon. Within the freshwater environment there are three indices, namely water quality, habitat and hydrology and fish. Within the estuarine environment, there are two indices, namely water quality, and habitat and hydrology. Within the inshore marine and offshore marine environments, water quality and habitat are the two indices scored although for 2020-2021 we were unable to access offshore water quality data. The habitat and hydrology index was referred to as biodiversity or habitat in the 2017-2018 and 2018-2019 report cards. The name was changed in the 2019-2020 report card to align with the terminology used by the other GBR regional report cards. Confidence levels associated with the results are also reported and are based on how data were collected and analysed.

The index and overall standardised scores and grades of each waterway environment for the 2020-2021 reporting period are presented in the Tables i - iv below for quick reference. Selected key messages are also provided.

Freshwater basins

Table i. Comparison of 2020-2021 weighted scores and grades for water quality, habitat and hydrology, and fish indices in the Ross and Black freshwater basins against previous years.

Zone	Weighted Score (Grade)								
	2020-2021			2019-2020			2018-2019		
	Water Quality	Habitat and hydrology*	Fish^	Water Quality	Habitat and hydrology	Fish	Water Quality	Habitat and hydrology	Fish
Ross freshwater	73 (B)	51 (C)	57 (C)	70 (B)	51 (C)	57 (C)	66 (B)	51 (C)	ND
Black freshwater	68 (B)	78 (B)	78 (B)	67 (B)	78 (B)	78 (B)	62 (B)	78 (B)	ND

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

* Habitat and Hydrology data is collected every four years. The scores for this index are identical between all years and will next be updated in 2022.

^ Fish data is collected every three years. The scores for this index are identical between all years in Table i and will next be updated in 2022.

Key messages: Freshwater basins

Water Quality

- Water Quality in the Ross and Black freshwater basins was graded as 'good' with scores of 74, and 68. Grades did not improve on previous years however scores in both zones slightly increased.
  - Nutrients in both basins were graded as 'good'. Eight of ten Black basin sites were graded as 'good' or 'very good', however Ross basin sites were highly variable: ranging from 'poor' to 'very good'.
  - Phys-chem properties in both basins were graded as 'good'. 12 of 13 independent sites were graded as 'good' or 'very good' for Turbidity and High DO indicators. However, Low DO was consistently graded 'moderate' to 'poor', in the Ross basin.
  - Most sites exhibited some increase in nutrient levels associated with high rainfall. Conversely, many rivers and creeks are seasonal and as they become shallow with low flow rates during the dry season, the dissolved oxygen within the river declines.

Habitat and Hydrology

- Data for the habitat and hydrology index is collected every four years (next update in 2021-2022 report). Scores and grades remain unchanged to previous years.
- Scores and grades are based on 2017 data and may not be representative of 2021 condition.

Fish

- Data for the Fish index is collected every three years (next update in 2021-2022 report). Scores and grades remain unchanged to previous years.
- Scores and grades are based on 2019-2020 data and may not be representative of 2020-2021 condition.

Estuarine basins

Table ii. Comparison of 2020-2021 weighted scores and grades for water quality, and habitat and hydrology indices in the Ross and Black estuarine zones against previous years.

Zone	Weighted Score (Grade)					
	2020-2021		2019-2020		2018-2019	
	Water Quality	Habitat*^	Water Quality	Habitat	Water Quality	Habitat
Ross estuarine zone	88 (A)	71 (B)	90 (A)	71 (B)	71 (B)	71 (B)
Black estuarine zone	66 (B)	77 (B)	64 (B)	77 (B)	67 (B)	77 (B)

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

* Habitat data is collected every four years. The scores for this index are identical between all years and will next be updated in 2022.

^This index is referred to as solely Habitat (not habitat and hydrology), as no hydrology indicators are measured.

Key messages: Estuarine zone

Water Quality

- Water Quality in the Ross and Black estuarine zones was graded as ‘very good’ and ‘good’, with scores of 88 and 66 respectively. Grades did not improve on the previous year, scores slightly decreased for the Ross zone and increased for the Black zone.
  - Nutrients were graded as ‘very good’ and ‘good’ in the Ross and Black estuarine zones with 10 of 13 sites graded as ‘good’ or ‘very good’.
  - Phys-chem properties were graded as ‘good’ in both estuarine zones with 11 of 13 sites graded as ‘good’ or ‘very good’.
  - Louisa Creek was the only site graded as ‘moderate’ for both indicator categories.

Habitat

- Data for the habitat index is collected every four years (next report update in 2022). Scores and grades remain unchanged to previous years.
- Scores and grades are based on 2017 data and may not be representative of 2021 condition.

Inshore marine zones

Table iii. Comparison of 2020-2021 weighted scores and grades for water quality, and habitat indices in Cleveland Bay and Halifax Bay against previous years.

Zone	Weighted Score (Grade)					
	2020-2021		2019-2020		2018-2019	
	Water Quality	Habitat^	Water Quality	Habitat	Water Quality	Habitat
Cleveland Bay	71 (B)	54 (C)	80 (B)	48 (C)	55 (C)	56 (C)
Halifax Bay	73 (B)	49 (C)	70 (B)	52 (C)	43 (C)	52 (C)

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

^This index is referred to as solely Habitat (not habitat and hydrology), as no hydrology indicators are measured.

Key messages: Inshore marine zone

Water Quality

- Water Quality in the Cleveland Bay and Halifax Bay inshore marine zones was graded as ‘good’. Grades did not improve on the previous year, however scores slightly increased for Halifax Bay and decreased for Cleveland Bay. Grades and scores remain above 2018-2019.
  - Nutrients in both bays were graded as ‘moderate’, with the total phosphorous indicator graded as ‘very good’ at all sites.
  - Phys-chem properties in both bays were graded as ‘good’, with all independent sites also receiving a ‘good’ grade.
  - Chlorophyll *a* in both bays was graded as ‘very good’, with all sites receiving a ‘good’ or ‘very good’ grade.
  - Although Cleveland Bay received a water quality grade of ‘good’, there is naturally high variability in the bay that can significantly influence results. Grades for NOx, TSS and Turbidity all ranged from ‘very good’ to ‘very poor’.

Habitat

- Habitat in the Cleveland Bay and Halifax Bay inshore marine zones was graded as ‘good’. The score in Cleveland Bay improved on last year, whilst the score in Halifax Bay declined.
  - Seagrass was only measured in Cleveland Bay. The indicator category received a ‘good’ grade, with 9 of 10 sites receiving ‘good’ or ‘very good’ grades for every indicator measured. Seagrass has recovered from the February 2019 floods and seagrass in meadow 17/18 has expanded significantly at the deeper margins, indicating there is sufficient water clarity to allow deeper growth.
  - Coral in both bays declined slightly from the previous year and was graded ‘poor’ and ‘moderate’ in Cleveland and Halifax Bay respectively. Coral cover increased in both bays, however this was outweighed by a decrease in the juvenile density and macroalgae indicators.

Offshore marine zone

Table iv. Comparison of 2020-2021 weighted scores and grades for the habitat index in the offshore marine zone against previous years.

Zone	Weighted Score (Grade)			
	2020-2021	2019-2020	2018-2019	2017-2018
	Habitat^	Habitat	Habitat	Habitat
Offshore	62 (B)	56 (C)	59 (C)	61 (B)

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

^This index is referred to as solely Habitat (not habitat and hydrology), as no hydrology indicators are measured.

Key messages: Offshore marine zone

Habitat

- The Habitat Index is comprised only of the coral indicator category.
- The Habitat Index in the Dry Tropics Offshore marine zone was graded as 'good' with a score of 62. The grade improved from the previous year, increasing from 'moderate' to 'good', however the score remained close to the borderline between these grades.
    - The overall coral indicator category was graded as 'moderate' or 'good' for all sites, and juvenile density was graded as 'very good' for 15 of 16 sites. Although 11 sites were graded 'poor' or 'very poor' for the coral cover indicator, the coral cover change indicator was graded 'moderate' or better for 10 sites.
    - Low levels of bleaching were observed in mid-2020 which was a legacy of the 2020 summer heat wave.
    - No active crown-of-thorns starfish outbreaks were recorded.

Litter

Litter is a recently developed metric and was first included in the 2019-2020 report card. The methodology has been updated from the previous year, and data collected from new sites. Data from the previous year has been updated using the new method however direct year-to-year comparison is limited. Zone scores are not yet achievable, thus only site-specific scores and grades are presented (Table v).

Table v. Comparison of 2020-2021 standardised scores and grades for litter within the Townsville Dry Tropics region against previous years.

Zone	Site	Standardised Scores (Grades)*	
		2020-2021	2019-2020
Black Estuarine Zone	Ollera Beach	NA	38 (HP)
	Toomulla Beach	NA	46 (MP)
Ross Freshwater	Aplin's Weir Rotary Park	**61 (LP)**	NA
	Queensland Country Bank Stadium	**44 (MP)**	NA
Ross Estuarine Zone	Shelly Cove, Cape Pallarenda Conservation Park	**82 (SP)**	31 (HP)
	Shelly Beach, Pallarenda	**27 (HP)**	83 (SP)
	Rowes Bay	**38 (HP)**	NA
	Strand Park, Townsville	**91 (SP)**	NA
Cleveland Bay (Magnetic Island)	Nelly Bay Beach, Magnetic Island	**61 (LP)**	37 (HP)
	Alma Bay, Magnetic Island	**60 (MP)**	72 (LP)
Halifax Bay	Picnic Bay, Orpheus Island	**3 (VHP)**	NA
	Fig Tree Beach, Orpheus Island	**7 (VHP)**	NA
	Yanks Jetty, Orpheus Island	**84 (SP)**	NA
	Big Rock Bay, Orpheus Island	**4 (VHP)**	6 (VHP)
	North East Bay, Great palm Island	NA	93 (SP)

Scoring range: ■ Very high pressure (VHP) = 0 to ≤20 | ■ High pressure (HP) > 20 to ≤40 | ■ Moderate pressure (MP) > 40 to ≤60 | ■ Low pressure (LP) > 60 to ≤80 | ■ Slight pressure (SP) > 80 to 100

* Data is not yet fully comparable across years due to variations in site selection, and limited temporal scale.

Key messages: Litter

- The number of sites where litter was collected (and thus graded) improved from eight to 12.
- Litter grades range from 'very high pressure' to 'slight pressure' with no trend to either way.
- Sites in more remote areas (e.g., Orpheus Island's bays and beaches) tended to be graded worse than sites in high traffic areas (e.g., Orpheus Island jetty, Strand Park).

1 Contents

Terms and Acronyms

AIMS	Australian Institute of Marine Science.
Alien species	Alien species are those species that are not native to Australia.
Artificial barriers (as an indicator)	Artificial barriers are any barriers which prevent or delay connectivity between key habitats and potentially impacting migratory fish populations, reducing diversity of aquatic species and communities and the condition of aquatic ecosystems (Moore, 2016).
Basin	Area of land where surface water runs into smaller channels, creeks or rivers discharging into a common point and may include many sub-basins or sub-catchments.
BOM	Bureau of Meteorology.
Catchment area	Area of land from which rainfall flows into a river, lake or reservoir and discharges into a common point.
Chlorophyll-*a*	Chlorophyll-*a* is an indicator of phytoplankton biomass and is widely considered a useful proxy of nutrient availability and system productivity.
Climate	In this Report Card, means both natural climate variability and climate change.
CVA	Conservation Volunteers Australia.
DES	Department of Environment and Science of the Queensland Government.
DHW	Degree Heating Weeks are an accumulated measurement of sea surface temperature (SST) that assesses the instantaneous bleaching heat stress during the prior 12-week period. (Significant coral bleaching usually occurs when the DHW value reaches 4 °C-weeks. By the time the DHW value reaches 8 °C-weeks, severe, widespread bleaching and significant mortality are likely).
DIN	Dissolved Inorganic Nitrogen. Comprised of nitrate plus nitrite and ammonium.
DO	Dissolved Oxygen.
DTPHW	Dry Tropics Partnership for Healthy Waters.
Ecosystem	A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.
Ecosystem Health	An ecological system is healthy and free from 'distress syndrome' if it is stable and sustainable. That is, if it is active and maintains its organization and autonomy over time and is resilient to stress. Ecosystem health is thus closely

	linked to the idea of sustainability, which is seen to be a comprehensive, multiscale, dynamic measure of system resilience, organization, and vigour.
Enclosed Coastal (EC)	An enclosed coastal (EC) water is a partially smooth, semi protected water body including shallow, enclosed waters near an estuary mouth and generally considered the interface between coastal and inland waters. Its boundaries depend on the local or regional authorities.
Environmental values (EV)	Characteristics or qualities of a natural system that supports viable natural communities and human uses.
eReefs	Integrated modelling system to visualise, communicate and report reef information for the GBR.
Floor rounding	Rounding decimal places down to the nearest integer, regardless of the value of the decimal. (E.g., 60.9 = 60).
Flow (as an indicator)	Flow is the degree that the natural river currents or stream flows have been modified, influencing waterways and ecosystem health.
FRP	Filterable Reactive Phosphorus.
GBR	Great Barrier Reef.
GBR Report Card	GBR Report Card under the Reef Water Quality Protection Plan (2013).
GBRMPA	Great Barrier Reef Marine Park Authority.
GBRMP	Great Barrier Reef Marine Park.
High DO	High Dissolved Oxygen. Excessively high dissolved oxygen in water can be a sign of significant algae growth and poor water quality.
Impoundment length	An indicator used in the 'in-stream habitat modification' indicator for freshwater basins in the region. The proportion (%) of the linear length of the main river channel when at the full capacity of artificial in-stream structures, such as dams and weirs.
Independent site	A monitoring site is deemed an independent site if there is more than one sampling site along the same watercourse and there is a substantial input into the waterway between the two sites, such as a tributary, storm water input or a sewage treatment plant. Independent sites are scored separately.
Index	Integration of one or more indicator categories (e.g., coral, seagrass and riparian extent are indicator categories of the habitat index).
Indicator	A measure of one component of an indicator category (e.g., coral composition (indicator) is a measure of coral (indicator category).

Indicator category	Integration of one or more indicators (e.g., the coral category comprises coral composition, change in coral cover, juvenile density, macroalgae cover and coral cover).
Inshore marine environment	Includes enclosed coastal (EC), open coastal (OC) and midshelf (MS) waters, extending east to the boundary with the offshore waters (Department of Environment and Science, 2018). The boundary is based on the delineation guidelines for the Burdekin (which includes the Townsville Dry Tropics region) and the Wet Tropics region. Waters north of Pelorus Island are based on the guidelines for the inshore boundary for the Wet Tropics region.
Inshore marine zone	Inshore marine zone is a reporting zone in the Townsville Dry Tropics Report Card that includes inshore marine environments.
ISP	Independent Science Panel.
Invasive species (same as non-indigenous species)	Invasive species (same as non-indigenous species) include both alien and translocated species. Alien species are those species that are not native to Australia, whilst translocated species are species that are native to Australia but not native to the waterway.
JCU	James Cook University.
Low DO	Low Dissolved Oxygen. Excessively low dissolved oxygen in water can result in anoxic waterways (i.e. depleted of oxygen) and poor water quality.
LTMP	Long Term Monitoring Program of GBR midshelf and offshore reef communities.
Macroalgae (cover)	Indicator used to assess coral health. Macroalgae includes seaweed and other visible benthic (attached to the bottom) marine algae.
MD	Moderate disturbed waters.
Midshelf waters	Midshelf waters are from 12 to 48 km offshore in the Burdekin region (waters south of approximately Pelorus Island) and 6 to 24 km offshore in the Wet Tropics region (waters north of Pelorus Island) (GBR, 2010).
MMP	Marine Monitoring Program of the inshore reef communities along Wet Tropics, Burdekin, Mackay, Whitsunday, and Fitzroy regions of the GBR.
Non-independent site (or monitoring location)	Non-independent site (or monitoring location) is if there is more than one sampling site along the same watercourse and there is a no substantial input into the waterway between the two sites, such as a tributary, storm water input or a sewage treatment plant. Data from the non-independent sites are combined into one independent site and one score is produced for each site.

Non-indigenous species	Non-indigenous species (same as invasive species) are species that include both alien and translocated species. Alien species are those species that are not native to Australia, whilst translocated species are species that are native to Australia but not native to the waterway.
NOx	Generic term for nitrogen oxides such as mixtures of nitrites and nitrates.
NRM	Natural resource management.
NTU	Nephelometric Turbidity Unit. The unit of measure that turbidity is recorded in.
OGBR	Office of the Great Barrier Reef of the Queensland Government.
Offshore waters	Offshore waters extend 48 to 180 km in the Burdekin region (waters south of approximately Pelorus Island) and 24 to 170 km offshore in the Wet Tropics region (waters north of Pelorus Island) (GBR, 2010).
Offshore zone	Offshore is a reporting zone in the Townsville Dry Tropics Report Card that includes offshore waters.
Open coastal (OC)	Open coastal waterbodies being at the seaward limit and extends 12 km offshore in the Burdekin region (waters south of approximately Pelorus Island) and 6 km offshore in the Wet Tropics region (waters north of Pelorus Island) (GBR, 2010).
Palustrine wetlands	Vegetated, non-riverine or non-channel systems that include billabongs, swamps, bogs, springs, soaks etc and have more than 30% emergent vegetation (Department of Environment and Science, 2013).
Physical-chemical properties	(Phys-chem properties). Indicator category that includes dissolved oxygen and turbidity.
PN	Particulate Nitrogen.
POTL	Port of Townsville Limited.
PP	Particulate Phosphorus.
QA/QC	Quality Assurance / Quality Control.
QPSMP	Queensland Ports Seagrass Monitoring Program.
RE	Regional Ecosystem.
Reef 2050 Plan	The overarching framework of the Australian and Queensland governments for protecting and managing the reef until 2050.
REMP	Receiving Environment Monitoring Program. A REMP provides a basis for evaluating whether the discharge limits or other conditions imposed upon an

	activity have been successful in maintaining or protecting receiving environment values over time.
Resilience (seagrass)	A multivariate metric developed by the MMP to measure the capacity of seagrass to cope with disturbances (Collier et al., 2021). The resilience metric better accommodates differences in recovery strategies between species in comparison to previous indicators.
Riparian extent	Vegetation with a 50 m buffer from a watercourse.
RIMReP	Reef 2050 Integrated Monitoring and Reporting Program.
Secchi	Secchi depth. A measure used to gauge the transparency (clarity) of water.
TCC	Townsville City Council.
Translocated species	Translocated species are species that are native to Australia but not native to the waterway.
TP	Total Phosphorus.
TSS	Total Suspended Solids.
Turbidity	A measure of how cloudy/opaque water is, recorded in NTU.
WQO	Water Quality Objectives. Defined for specific regions, these values act as a management target. They do not necessarily reflect 'natural' condition but rather a state that is considered acceptable considering environmental, social, and economic factors.
WQGV	Water Quality Guideline Values. Defined for broad scale regions, these values act as an 'earliest baseline' and ideally reflect the natural state of the environment pre-European/pre-developed settlement (or pre-land clearing). They allow managers to assess how water quality has changed from 'natural' condition.

List of Tables

List of Figures

2 Introduction

2.1 Overview

The Dry Tropics Partnership for Healthy Waterways (referred to as the Partnership) was launched in January 2019, with a focus of the Partnership being to produce an annual Report Card. The 'Pilot Report Card' was released in May 2019 and reported on data mainly from the 2017-18 year. Each year an annual report card is produced, with the current Report Card reporting on data mainly from the 2020-2021 year. In some cases where a seasonal monitoring program extends outside of the year period, such as inshore coral, data from the whole monitoring period are included. For monitoring programs that collect data less frequently than annually (e.g., wetland and riparian extent) then the most recent data set is included.

The key deliverable for the Report Card is an assessment of the state of the environment. The Report Card focuses on three indices; Water Quality, Habitat and Hydrology, and Fish, that are directly dependent on waterway health. Indices are scored and graded for the freshwater, estuarine, inshore marine, and offshore marine environments within the Townsville Dry Tropics region, however not all indices are scored and graded for each environment (for example, fish is only scored within the freshwater environment). The site-specific results for the Townsville zones are included.

To allow comparison between the report cards, where appropriate, the summary results for each index from 2020-2021, 2019-2020, 2018-2019, and 2017-2018 are presented alongside the detailed results. For some indicators, the methodology used has changed between years and therefore only data after the methodology change is compared to current results.

2.2 Report Card zones

The results presented in the 2020-2021 Report Card cover seven zones. The zones are:

- Two freshwater zones, called Ross freshwater basin and Black freshwater basin.
- Two estuarine zones, called Ross estuarine zone and Black estuarine zone.
- Two inshore marine zones, called Cleveland Bay/Ross inshore marine zone (referred to as Cleveland Bay) and Halifax Bay/Black inshore marine zone (referred to as Halifax Bay).
- One offshore marine zone.

The reporting area for the Townsville Dry Tropics is shown in Figure 1.

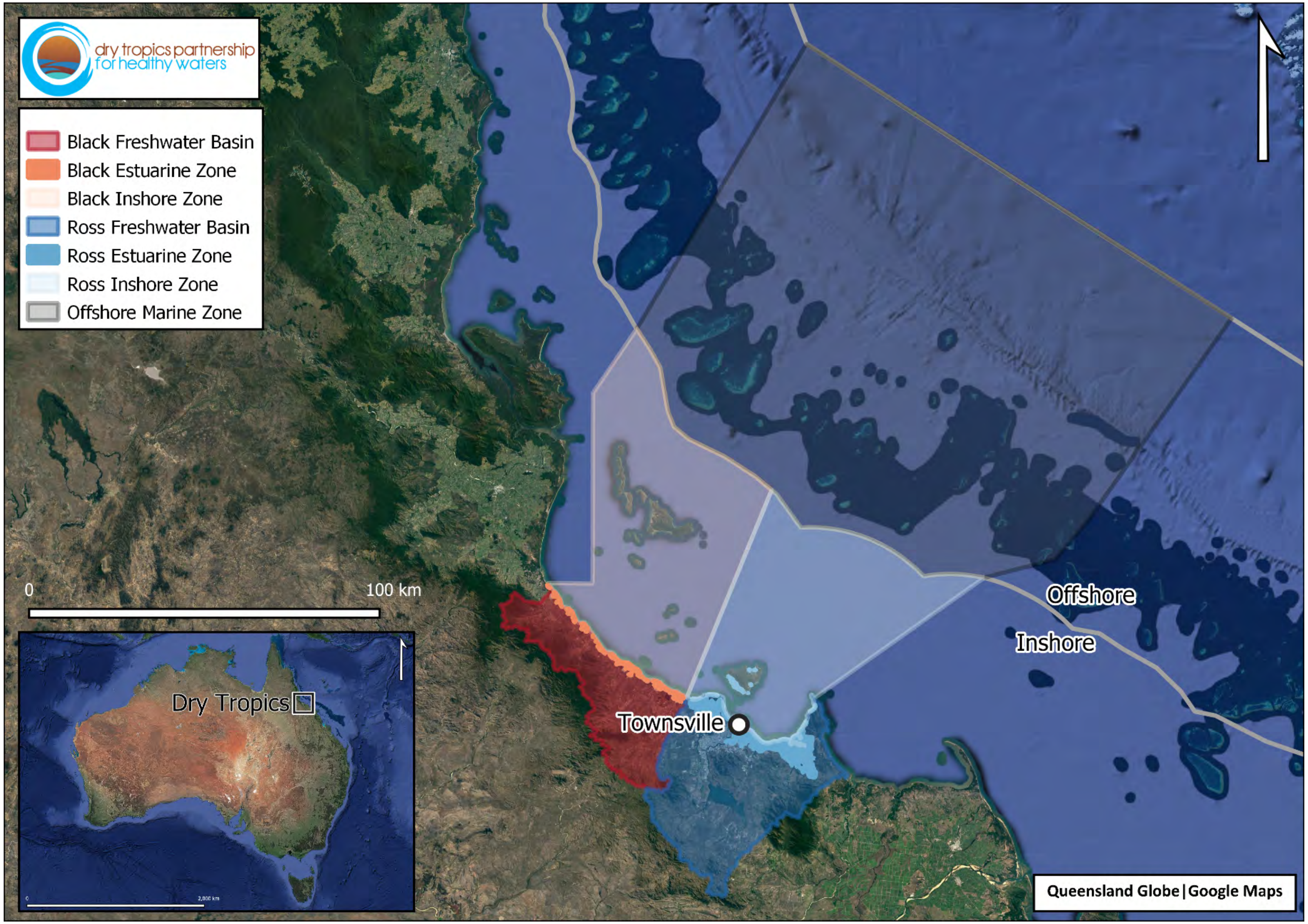


Figure 1. Geographic boundary of the zones reported upon by the Dry Tropics Partnership.

2.3 Purpose of this document

The purpose of this document is to provide detailed results on the condition of freshwater basins, estuaries, and the inshore and offshore marine environments within the Townsville Dry Tropics region. This document presents scores and grades for indicators, indicator categories and indices for each of the seven zones. Key messages about each index are presented within the main result section of this document, with the summarised key messages for each environment and zone presented in the executive summary. Confidence scores are also presented within the main results.

This document supports the 2020-2021 Report Card and provides a summary of the results. For further details on the design of the Report Card program, including reporting zones and reasoning for selecting the indicators, refer to the Townsville Dry Tropics Program Design (Whitehead, 2019a).

3 Methods and terminology

The methods used are presented in detail in the 'Methods for the Townsville Dry Tropics Annual Report Cards' document (Whitehead, 2021). Key components required to understand the Technical Report are presented in sections 3.1 to 3.4 below.

3.1 Terminology

There are multiple levels of aggregation of data used within this report. These levels are "indicator", "indicator category", and "index", and are summarised in Table 1 with examples at each level.

Table 1. Levels of aggregation used within the Townsville Dry Tropics Report Card.

Indicator (Level 1)	Indicator Category (Level 2)	Index (Plural = Indices) (Level 3)
NOx	Nutrients	Water Quality
Total Phosphorus		
Turbidity	Physical-Chemical Properties	
Total Suspended Solids		

There are three indices scored and graded in the report card, these are Water Quality, Habitat and Hydrology, and Fish. Indicators that measure a similar aspect of the condition of the environment are grouped together and their scores are aggregated multiple times to produce an average (overall) score and grade for each of the three indices. Aggregation is detailed in section 3.2.

Some indicators are only measured in certain zones; for each zone the specific indicators used are detailed. For example, the Habitat and Hydrology index is referred to as solely Habitat for the inshore and offshore marine zones as hydrology indicators such as water flow are not included or planned to be included for future report cards.

For the Report Card, grades for each indicator, indicator category, and index are presented in a coaster. Each of the seven zones in the Dry Tropics region (Figure 1) receives its own coaster. An example of a coaster is shown in Figure 2, subject to artist change.

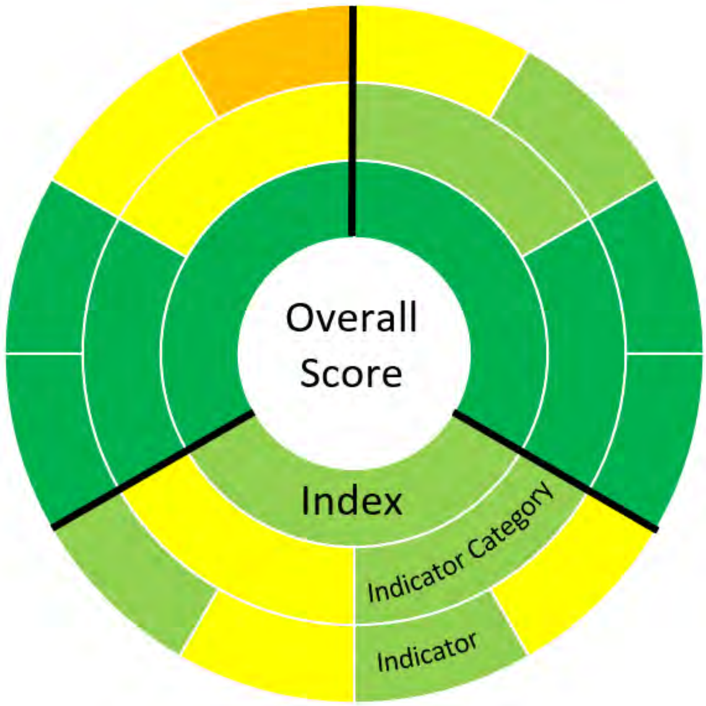


Figure 2. Terminology used to define the levels of aggregation for indicators, and how they are displayed in coasters for the report card.

3.2 Scoring categories

All indicators were graded using five ordinal values commonly used in Report Cards, 'very good' (A) to 'very poor' (E), as shown in Table 2.

Table 2. Standardised scoring range and corresponding grades used in the Technical Report.

Scoring Range	Grade and colour code
81 to 100	Very Good (A)
61 to <81	Good (B)
41 to <61	Moderate (C)
21 to <41	Poor (D)
0 to <21	Very Poor (E)

Each indicator was scored on a scale that was appropriate for the variable being measured and thus some indicators had different scoring ranges. To ensure results for all indicators were comparable, all scores were converted (if required) into a standardised score. The standardised score has a scoring range of between 0 and 100, as shown in Table 2.

Scores for each indicator were aggregated into an indicator category, then into an index, and then an overall score. Scores can only be aggregated to the next level if they meet the 'minimum information rules for aggregating data'. These rules are:

1. ≥50% of indicators are required to aggregate to an indicator category,
2. ≥60% of indicator categories are required to aggregate to an index.

3.3 Confidence measure

The results for each index are given a qualitative confidence measure. Confidence scores are based on the accuracy and appropriateness of the data used in the analysis. Confidence scores range from 4.5 (very low, with a rating of 1) to 13.5 (very high, with a rating of 5) and were calculated using five criteria (Table 3).

Table 3. The criteria, score, and weighting used to generate confidence scores for indices.

Criteria	Score	Weighting
Maturity of Methodology	New = 1; Developed = 2; Established = 3	0.36
Validation	Limited = 1; Not comprehensive = 2; Comprehensive = 3	0.71
Representativeness	Low = 1; Moderate = 2; High = 3	2
Directness	Conceptual = 1; Indirect = 2; Direct = 3	0.71
Measured error	>25% = 1; Between 10% and 25% = 2; <10% = 3	0.71

Each criterion was firstly scored from 1 (lowest) to 3 (highest) following the set of rules discussed in the Methods for the Dry Tropics Partnership for Healthy Waters Annual Report Cards. This score was then weighted using the weightings shown in column three of Table 3. The weightings reflect the importance of each criterion.

3.4 Baselines for scoring data

Indicators were compared against either water quality objectives, ecosystem condition measures, or the earliest available data/baseline. Water quality objectives and ecosystem condition measures are used to assess whether actions positively or negatively influence the environment with respect to the objective or measure. The objective or measure may not reflect the 'natural' (pre-development) state of environment, but rather a state that is considered acceptable considering environmental, social, and economic factors. Earliest baselines ideally reflect the natural state of the environment pre-European/pre-developed settlement (or pre-land clearing). Comparing indicators against the earliest baseline is important to show how the environment has changed from a 'natural' environment.

Although earliest baselines are ideal, for some indicator categories in this report card there is no known data available that accurately describes the state of the environment pre-development. The use of objectives, measures, or earliest baselines for each indicator category are shown in Table 4.

Table 4. Summary of baselines each indicator category was scored against in the 2020-2021 Report Card.

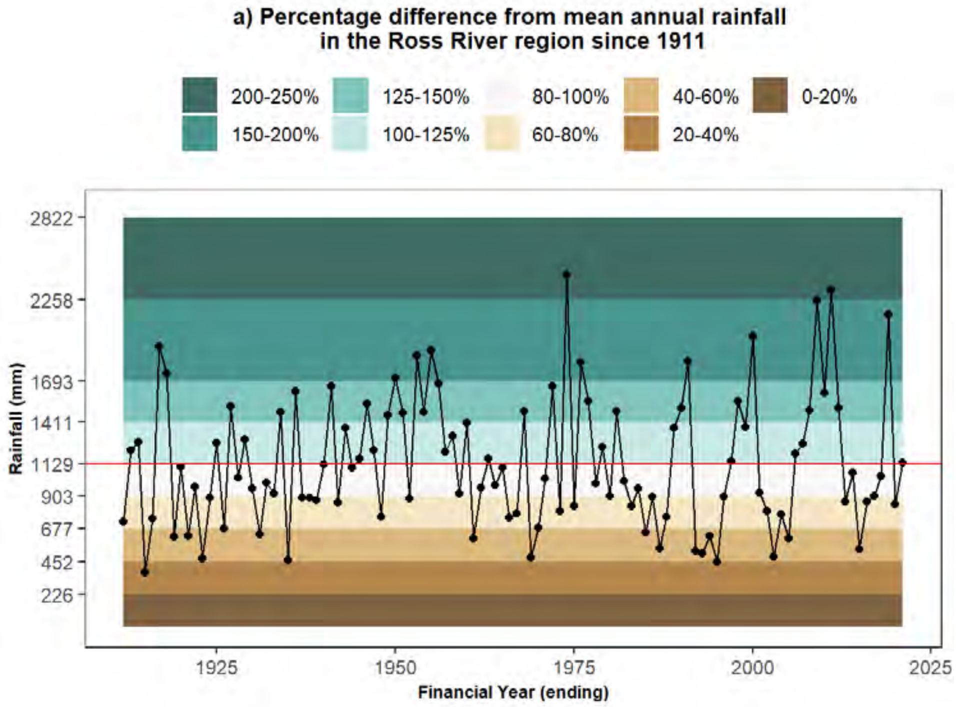
Index	Zone	Indicator categories	Baseline that data was compared against
Water Quality	All zones	Nutrients and phys-chem properties	Water quality objective
	Inshore marine	Chlorophyll *a*	Water quality objective
Habitat and hydrology	Freshwater and estuarine	Habitat extent	Ecosystem condition measure
	Freshwater	Artificial barriers	Earliest baseline
	Inshore marine	Seagrass condition	Earliest baseline
	Inshore and offshore marine	Coral condition (Juvenile density and coral cover)	Ecosystem condition measure
		Coral condition (Composition and cover change)	Earliest baseline
		Coral condition (macroalgae)	Ecosystem condition measure, earliest baseline
Fish	Freshwater	Indigenous (native) species expected (POISE) within waterways (excluding translocated species)	Earliest baseline
		The proportion of Indigenous (native) fish	

4 Climatic influences on the Townsville Dry Tropics region

Climate change and extreme weather, land use, urban lifestyles, and economic growth are the key drivers that impact upon the condition of the waterways within the Townsville Dry Tropics region. A summary of the climatic conditions between 1st July 2020 and 30th June 2021 are outlined below. A description of the Townsville urban environment is also provided.

4.1 Rainfall

The amount of rainfall within a catchment can influence the amount of nutrients and sediments washed into waterways (Department of Environment and Science, 2018). This is especially applicable to the urban environment, where stormwater drains channel water straight into the waterways (Department of Environment and Science, 2018). As depicted in Figure 3a, and Figure 3b, in the 2020-2021 year, the Ross and Black basins received 100% and 126% of the annual year mean rainfall respectively. In 2020-2021 rainfall across Queensland was varied, with the tropics and parts of western Queensland receiving average to above average rainfall, and central Queensland receiving below average rainfall (Figure 4).



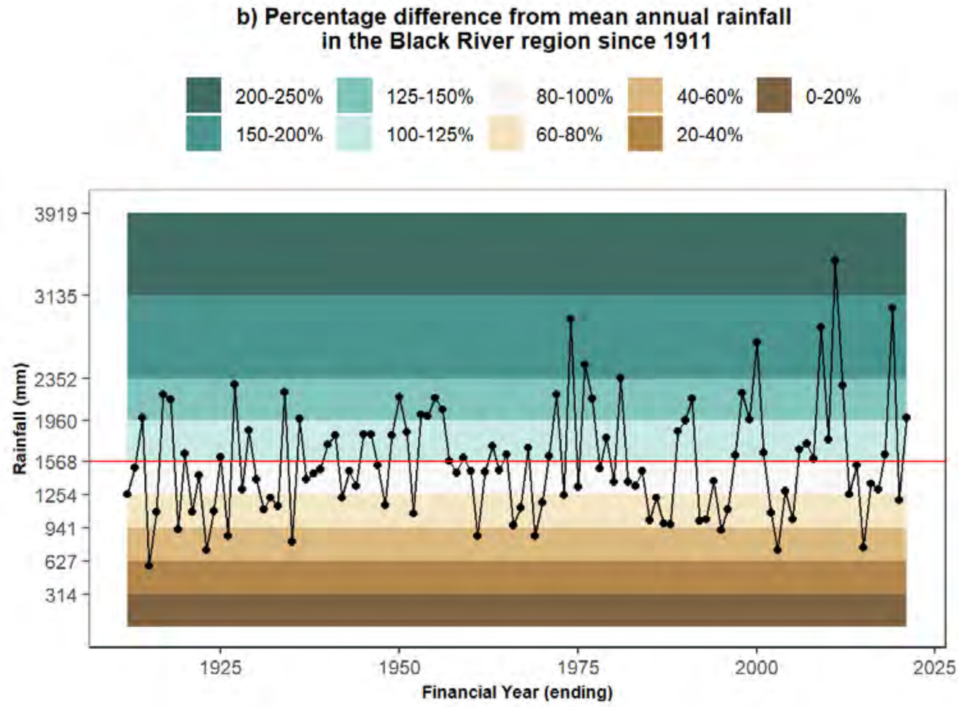


Figure 3. Percentage difference in the annual rainfall from the annual mean rainfall from 1911 to 2021 for (a) the Ross Basin, and (b) the Black Basin.

The red line represents the long-term mean. The long-term mean is represented as 100% and the percentage difference from this value calculated. The long-term mean was based upon historical rainfall records from July 1911 to June 2021 supplied by the Bureau of Meteorology (2022).

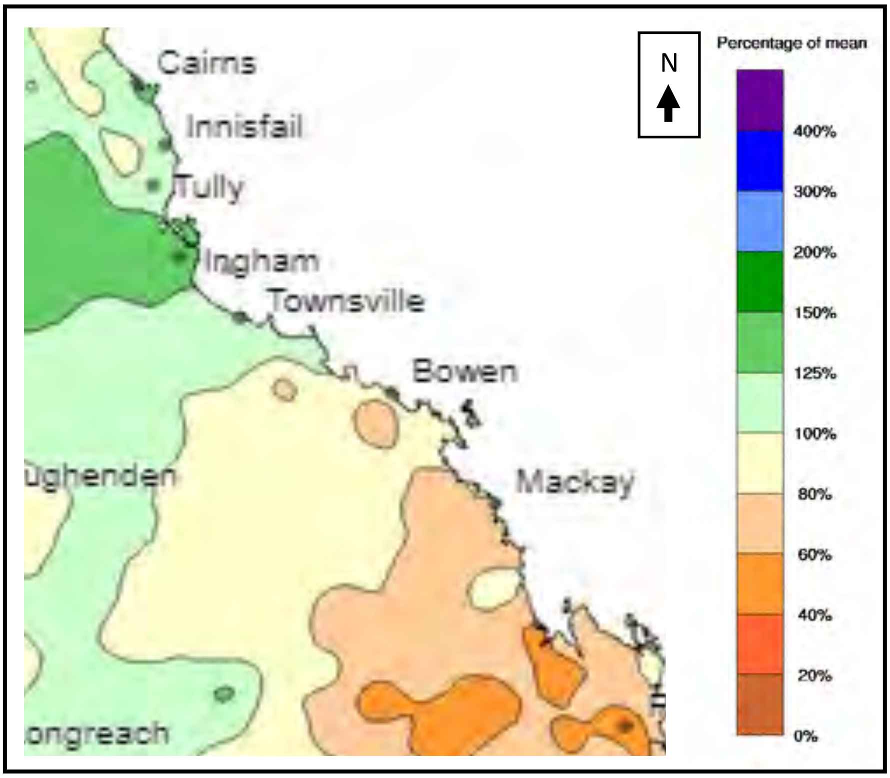


Figure 4. Percentage difference in the annual mean rainfall (2020 - 2021) from the long-term mean annual rainfall for the Townsville Dry Tropics and surrounding regions.

The long-term mean is represented as a "difference from mean rainfall" of 100% and was based upon historical rainfall records from July 1961 to 2021 supplied by the Bureau of Meteorology (2022).

As shown in Table 5, a total of 1133 mm of rain was recorded across the Ross freshwater basin, which was similar to the long-term mean (Bureau of Meteorology, 2022). In the Black freshwater basin, a total of 1980 mm of rain was recorded across the basin, which was 412 mm above the long-term mean of 1568 mm. The long-term mean was calculated from data for 1911-2021 supplied by the Bureau of Meteorology (2022).

Table 5. Annual rainfall statistics for basin areas of the Dry Tropics.

Basin	Total (mm)	Long-term mean (mm)	Decile*	Anomaly (+/- long term mean)	Percentage long term mean (%)
Ross	1133	1129	5-6	+4	100.4%
Black	1980	1568	8-9	+412	126.3%

*Decile ranking category descriptions are shown in Table 6.

When assessing rainfall by months, July, December, January, March, and April recorded above average rainfall for both the Ross and Black basins (decile 7-9) (Table 6). Lower than average rainfall was recorded for four months in the Black basin and for two months in the Ross basin (decile 1-3). Rainfall was similar to the long-term average for five months in the Ross basin, and three months in the Black basin.

Table 6. Monthly rainfall deciles for the Ross and Black Basins (2020-2021).

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Ross	9	4	5	6	1	7	7	4	7	9	1	4
Black	7	1	6	3	1	9	8	5	7	9	1	6

Decile Rankings	1	2	3	4	5	6	7	8	9
	Lowest ≤10 percentile	----------------------------			Average	---------------------------------			Highest ≥90 percentile

Source: [AWO BOM Precipitation]

4.2 Air temperature

Annual mean air temperature within the Dry Tropics region for 2020-2021 was 25.2°C, which is similar to the long-term average. For the reporting period, Townsville and most of the surrounding region experienced average temperatures throughout the year with pockets of cooler temperatures inland of Innisfail and Mackay (Figure 5).

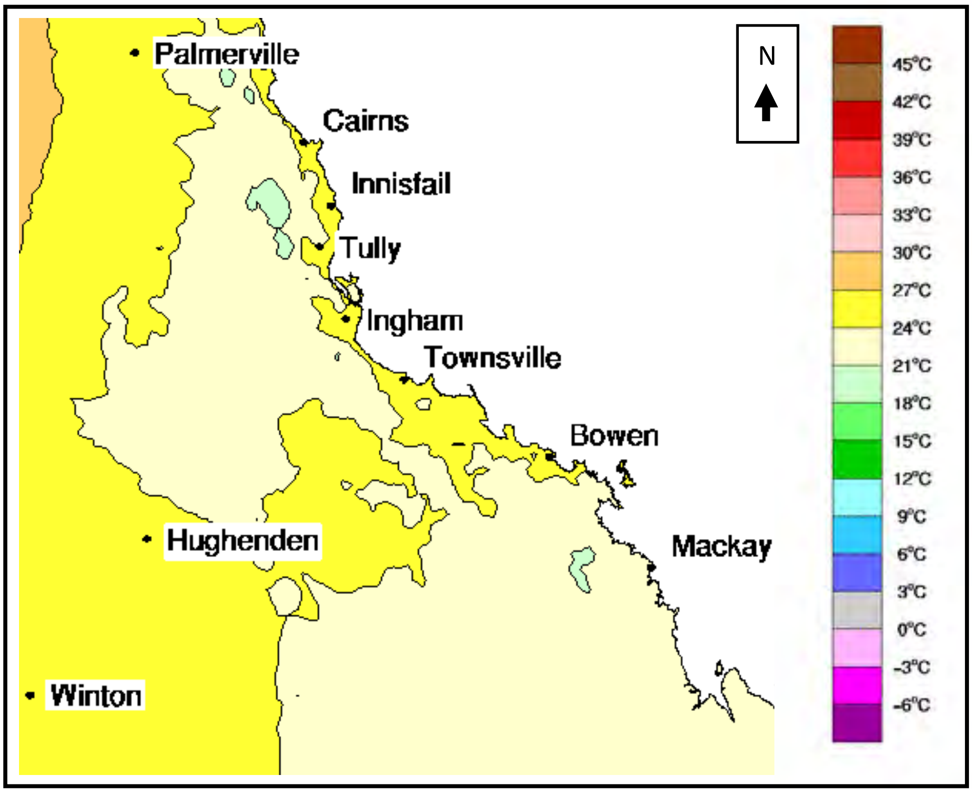


Figure 5: Twelve-month mean temperature for the Dry Tropics Region (2020-2021).

Map source: (Bureau of Meteorology, 2022) [BOM 2021 Air Temperature Map]

Additional data source: (Bureau of Meteorology, 2022) [BOM 2021 Air Temperature Data]

4.3 Sea surface temperature

During 2020-2021 sea surface temperatures for the Dry Tropics inshore and offshore zones were slightly above long-term average summer maximums but well below those observed in 2019-20 (Figure 6). Sea surface temperature anomalies were more even across the zones than previous years and the risk of severe thermal stress and coral bleaching events was lower than in 2016-17 and 2019-20.

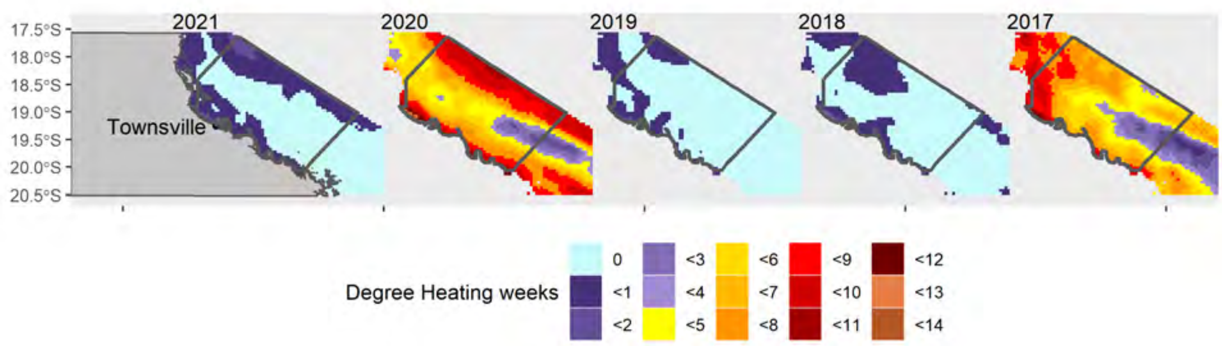


Figure 6. Annual degree heating weeks estimates for the Reef for the Townsville region from 2021 - 2017.

Data are the annual maximum degree heating week estimates for each ~25 km2 pixel (Thompson, et al., 2021).

Source: NOAA Coral Reef Watch Satellite and Information Service (2021). [NOAA Coral Reef Watch]

4.4 Urban environment

The Townsville Dry Tropics region includes the largest city in regional Queensland, with residential and services being substantial land uses within the region (see Figure 7). Urban development is a major driver of environmental change, with new residential developments occurring in outer suburbs of Townsville and existing developments continuing to expand. The conversion or degradation of natural ecosystems in urban areas has immediate impacts upon biodiversity (Department of Agriculture, Water and the Environment, 2016). Additionally, urban development impacts water quality and changes the flow of water (McGrane, 2016). This often results in a high proportion of the catchment containing impervious surfaces, the construction of artificial barriers and changes to watercourses, all of which can detrimentally impact water quality and the natural flow of water (McGrane, 2016).

Within the Townsville Dry Tropics, the Ross Basin is more developed than the Black Basin, although most developments within the Ross Basin are restricted to the lower half of the catchment. The upper catchment is predominately used for grazing on native vegetation, with nature conservation and production forestry the next largest land uses within the upper catchment. The Ross Basin also contains four major impoundments: Ross River Dam and three weirs, Black School weir (referred to as Black weir), Gleeson weir and Aplin's weir. These impoundments have a large impact upon the water flow within the Ross River. During the wet season, heavy rainfall can result in flow overtopping the impoundments, providing connectivity from the headwaters to the coast. During most of the dry season, surface waters within the weirs and Ross Dam are generally separate water bodies.

A large proportion of the Black Basin is grazing on native vegetation, especially within the eastern half of the basin. Nature conservation is the second largest land use within the Black Basin, with less amounts of production forestry and a minor amount of intensive horticulture (e.g., pineapple farming). Although residential land use is not currently a major land use within the basin, many new residential developments are occurring within the Black Basin, with developments since 2017 not shown in Figure 7.

Key messages: Climate

- The Ross Basin received 100% of the annual mean rainfall with a total of 1133 mm. The Black Basin received 126% of the annual mean rainfall with a total of 1568 mm.
- Sea Surface Temperature for the Dry Tropics Region was slightly above the long-term average, but well below temperatures of recent coral stress events.
- Annual air temperature for the Dry Tropics Region was 26℃, which is slightly above average.
- Land use in Townsville remains consistent with previous years, with no significant changes.
- The overall climate for the Dry Tropics Region was similar to the long-term average, and for some measures, similar to the climate of the previous year.

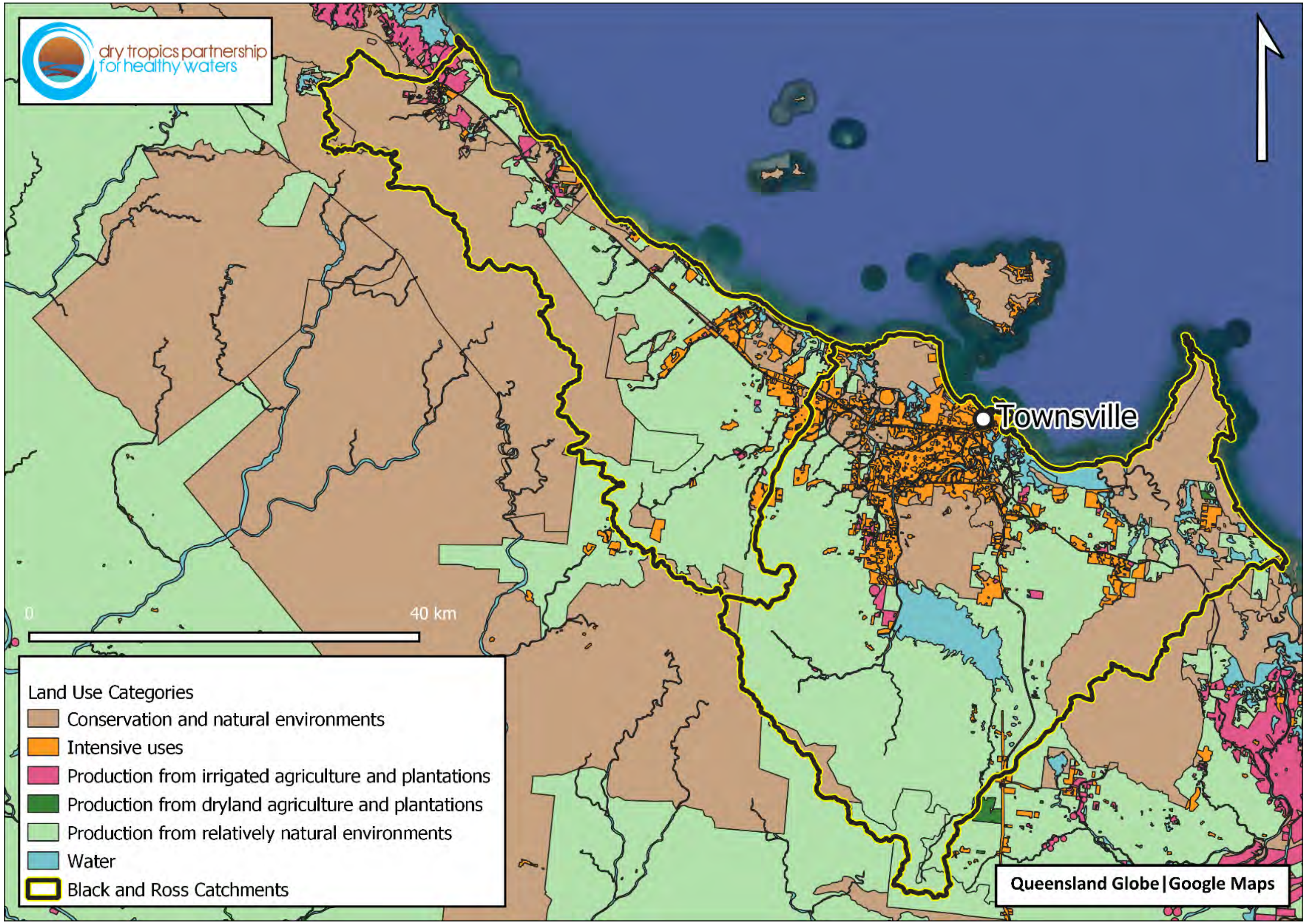


Figure 7. Land Use Categories in the Townsville Dry Tropics region.

Land use map layer provided by Queensland Globe here: [Land Use Categories]. Raw data listed in Appendix L.

5 Freshwater basins

Within the freshwater basins, water quality, habitat and hydrology, and fish are the three indices scored. The results are presented in separate sections below.

5.1 Water quality

5.1.1 Monitoring sites

Monitoring occurred at three independent sites within the Ross freshwater basin and 10 independent sites within the Black freshwater basin.

The freshwater monitoring sites within the Ross freshwater basin are:

- Bohle River, comprising two non-independent sites, which are the mid- and far-field Receiving Environment Monitoring Programme (REMP) sites for the Condon Sewage Treatment Plant.
- Lower Ross River, comprising three non-independent sites, which are Aplin's, Gleeson's and Black School (Black) weirs.
- Upper Ross River (Ross River Dam), comprising seven non-independent sites.

The position of monitoring sites within the Ross freshwater basin are shown in Figure 8.

Monitoring occurs at 10 independent sites within the Black freshwater basin. These sites are listed below:

- Black River
- Althaus Creek
- Bluewater Creek
- Sleeper Log Creek
- Leichhardt Creek
- Saltwater Creek
- Rollingstone Creek
- Ollera Creek
- Crystal Creek
- Paluma Dam

The position of monitoring sites within the Black freshwater basin are shown in Figure 9.

In the Ross Basin, monthly grab samples were collected for the period July 2020 to June 2021. All grab samples were collected for Upper Ross River. Samples from Bohle River sites were not collected for November 2020; however, an additional sample was collected at a fortnightly spacing in December 2020. Samples from Lower Ross River sites were not collected for December 2020, no additional sampling was conducted.

In the Black Basin, between five and eleven monthly samples were collected between August 2020 and June 2021 for each site. The number of samples collected varied due to seasonal flow of some sites such as Althaus Creek. The number of months each site was sampled is shown in Appendix A.

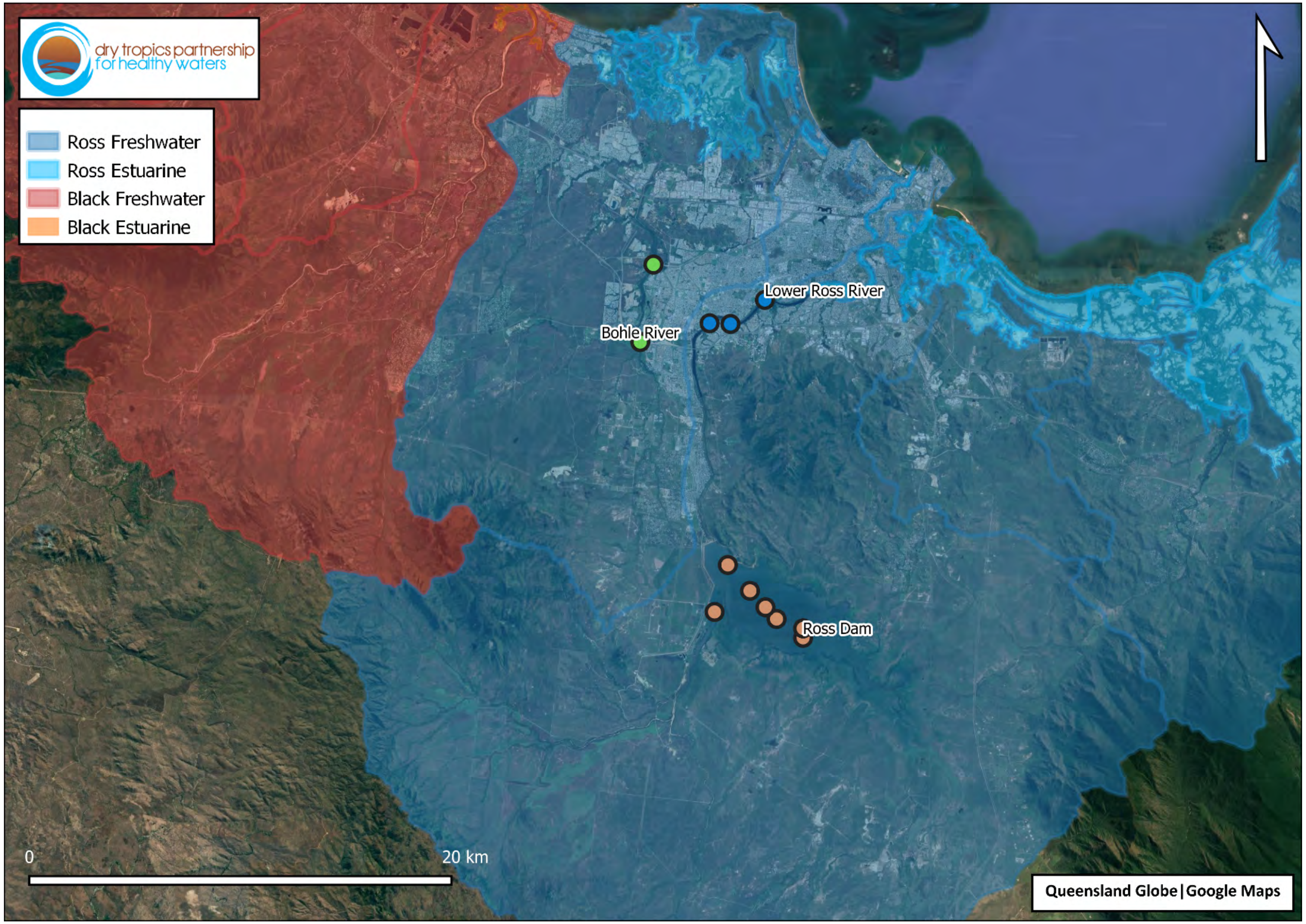


Figure 8. Independent and non-independent sites within the Ross freshwater basin.

There are seven non-independent sites comprising the Ross Dam site denoted by brown, two non-independent sites comprising the Bohle River site denoted by green, and three non-independent sites for the Lower Ross River denoted by blue.

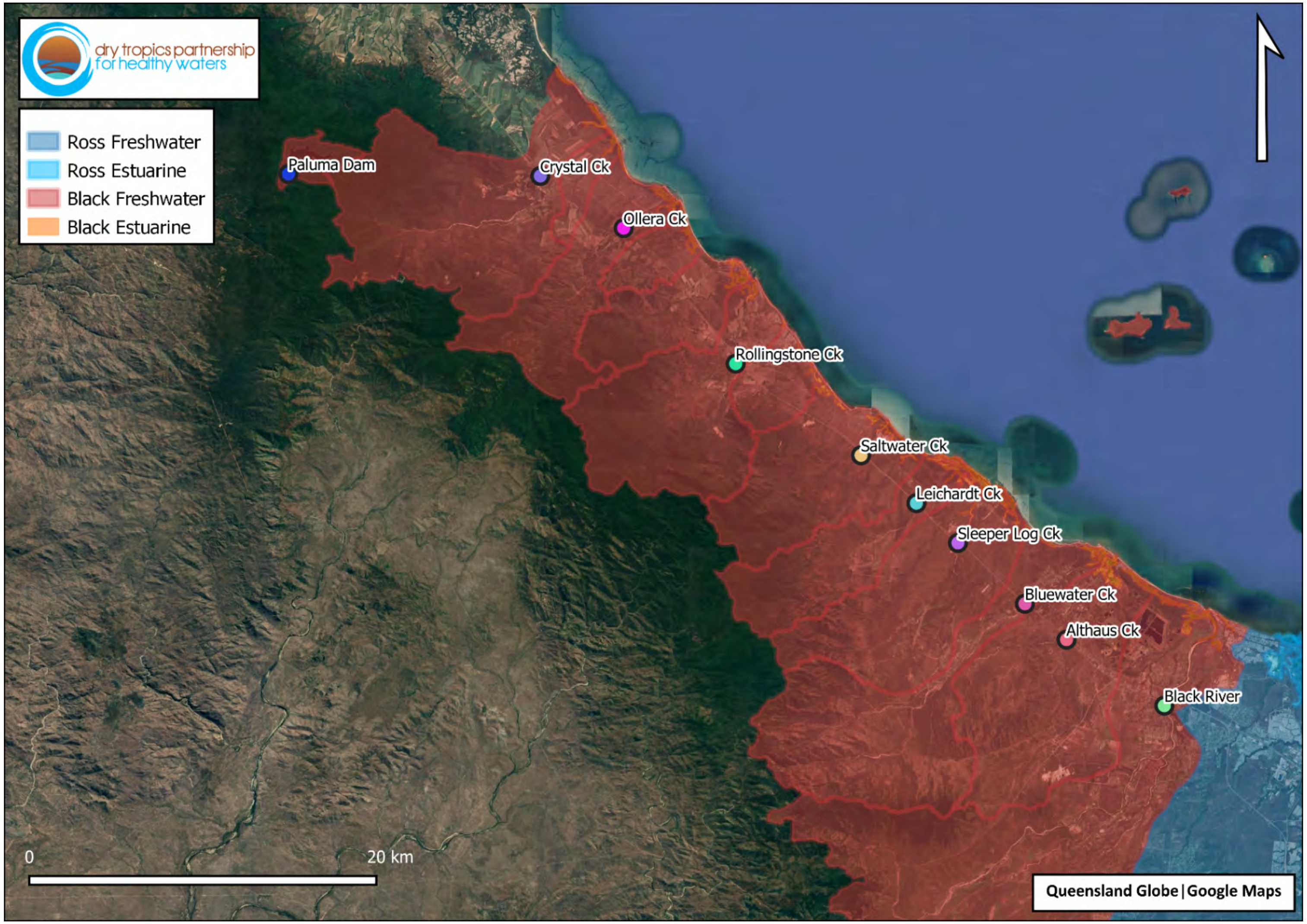


Figure 9. Independent monitoring sites within Black freshwater basin.

Each independent site is denoted by a different colour.

5.1.2 Results

The overall water quality score for each freshwater basin was based on five indicators and the two indicator categories they make up: nutrients, and physical and chemical (phys-chem) properties. Independent sites were weighted by the proportion of the catchment area that each site represents (that is, the catchment area that drains into where the sampling site was located). Scores were then aggregated based on the weighted scores. The distributions of data for each indicator are presented as boxplots in Appendix B. The values used to calculate the scores are presented in Appendix A. The parameters used to calculate the scores were the:

- Water quality objectives (WQOs) (the values that the raw data are compared against),
- Scaling factors (used to scale the scores),
- Annual medians, derived from the monthly medians, and
- 80th percentile of the monthly medians (or 20th percentile for low dissolved oxygen).

5.1.2.1 *Nutrients*

The scores for nutrients were averaged from the scores for two indicators, which are total phosphorus (TP) and dissolved inorganic nitrogen (DIN). The scores and grades for the Ross and Black freshwater basins are shown in Table 7.

Overall, the nutrient indicator category for the Ross River freshwater basin was graded as 'good' with a weighted score of 73, as shown in Table 7. The Upper Ross River (Ross River Dam) and the Lower Ross River were in a 'very good' and 'good' condition respectively. The Bohle River was in a 'poor' condition and contained high levels of total phosphorus (TP) and dissolved inorganic nitrogen (DIN) relative to their WQOs. Within the Bohle River catchment there are several possible sources for this including, the Condon Sewage Treatment Plant, turf and chicken farming, aquaculture, and a golf course. These diffuse and point source inputs along with ongoing residential development and road infrastructure upgrades may account for the 'poor' scores for Bohle River. The Bohle River only represents 12% of the Ross Basin and has a low weighting compared to the Upper and Lower Ross River. Therefore the 'poor' grades had minimal impact upon the overall grade for the Ross freshwater basin. The Lower Ross River sites showed higher concentrations of DIN associated with rainfall-runoff during the wet season (January-May). The same sites were within the WQO during the dry season except for Aplin's Weir in September 2020. Sampling of Upper Ross River was limited to surface sampling only (within the surface 1m depth) to align with sampling from all other sites that also only collected surface water. Without deeper sampling the holistic condition of Ross Dam cannot be commented on.

Table 7. Scores and grades for total phosphorus (TP), dissolved inorganic nitrogen (DIN) and the overall nutrients for freshwater sites.

Site	Non-weighted Score (Grade)			Catchment Area		Weighted Score (Grade) and contribution to final score#		
	DIN	TP	Nutrients*	Catchment area (km^2)	Proportion of catchment area	DIN	TP	Nutrients
Upper Ross River (Ross River Dam)	90 (A)	90 (A)	90 (A)	458	0.32	28	28	28
- Black Weir^	61 (B)	90 (A)	75 (B)	786	0.56	33	50	42
- Gleeson Weir	62 (B)	ND	62 (B)					
- Aplin's Weir	59 (C)	ND	59 (C)					
Lower Ross River	60 (C)	90 (A)	75 (B)					
- Bohle far-field	66 (B)	0 (E)	33 (D)	169	0.12	6	0	3
- Bohle mid-field	43 (C)	0 (E)	21 (D)					
Bohle River	54 (C)	0 (E)	27 (D)					
Ross freshwater basin+	**68 (B)**	**60 (C)**	**64 (B)**	**1413**	**1**	**67 (B)**	**78 (B)**	**73 (B)**
Black River	61 (B)	54 (C)	58 (C)	250	0.37	22	20	21
Althaus Creek	67 (B)	90 (A)	78 (B)	35	0.05	3	4	3
Bluewater Creek	63 (B)	73 (B)	68 (B)	86	0.13	8	9	8
Sleeper Log Creek	74 (B)	90 (A)	82 (A)	41	0.06	4	5	4
Leichhardt Creek	74 (B)	76 (B)	75 (B)	38	0.06	4	4	4
Saltwater Creek	70 (B)	90 (A)	80 (B)	36	0.05	3	4	3
Rollingstone Creek	0 (E)	90 (A)	45 (C)	71	0.10	0	9	4
Ollera Creek	66 (B)	90 (A)	78 (B)	39	0.06	4	5	4
Crystal Creek	90 (A)	90 (A)	90 (A)	77	0.11	9	9	9
Paluma Dam	63 (B)	90 (A)	76 (B)	2	0.00	0	0	0
Black freshwater basin	**63 (B)**	**83 (A)**	**73 (B)**	**675**	**1**	**60 (C)**	**73 (B)**	**66 (B)**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 90 (scores are capped at 90) | ■ No data (ND)

* The overall nutrient score was calculated by averaging the scores for DIN, and TP.

^ Independent site names are written in black, non-independent site names are written in brown. Non-independent site indicator scores are averaged for non-independent indicator category scores. Non-independent site scores are averaged by indicator to create independent site scores, and the independent site indicator category is the average of its indicator scores.

+ Zone/basin names are written in bold. Independent site scores for each indicator are averaged to create zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.

< When values don't appear to add up correctly this is due to floor rounding. Significant figures differ where appropriate to show very small numbers.

\# Scores are weighted based on the proportion of measured catchment area. Weighted scores are summed to create the overall score for each zone/basin.

Overall, the nutrient indicator category for the Black freshwater basin was in a 'good' condition with a weighted score of 66. Eight of ten rivers sampled were in a 'good' or 'very good' condition with respect to overall nutrients and individually for both DIN and TP (Table 7). However, Rollingstone Creek and Black River were both graded 'moderate' for nutrients, scoring 45 and 58 respectively. The wet and dry seasons had a notable impact on the indicators, with DIN in particular, increasing in most creeks associated with the wet season and the subsequent runoff. In Rollingstone Creek, DIN measurements were higher than the WQO from January-May which may be due to high levels of surrounding horticulture. In Black River high levels of nutrients may stem from the use of septic and on-site sewage treatment systems rather than municipal sewage treatment plants. TP concentrations in the Black River were consistently at, or above, the WQOs. Very high concentrations were recorded in February-March associated with high rainfall and increased runoff. Additional sampling locations along these waterways and further investigation is required before a definitive source can be isolated.

Key messages: Nutrients

- Overall, nutrients in the Ross freshwater basin were graded as 'good'.
- The Bohle River scored 'poor' for nutrients due to high levels of DIN and TP in relation to the WQOs.
- Eight of ten sites in the Black freshwater basin were graded as 'good' or 'very good' for nutrients.
- Most sites exhibited some increase in nutrient levels associated with high rainfall in February-March
- The Black River had consistently higher phosphorus levels than other creeks even in dry weather. Further sampling and analysis is required to determine the root cause.

5.1.3 Physical-chemical properties

The results for the phys-chem index were derived by averaging the scores for turbidity and the lower of the scores for either high dissolved oxygen (DO) or low dissolved oxygen (DO). The results are presented in Table 8.

Overall, both the Ross and Black freshwater basins were in a 'good' condition with respect to phys-chem properties, with weighted scores of 74 and 70 respectively. Apart from Althaus Creek, all sites, across both basins, were in a 'moderate' to 'very good' condition. Turbidity at all sites received a 'good' or 'very good' grade, except for Althaus Creek which received a 'very poor' grade for turbidity. Sampling only occurred during the wet season (January-May 2020) which may have influenced the results. All samples with turbidity readings above the WQO were associated with rainfall events.

All sites, except Black River, received 'good' or 'very good' grades for the high DO indicator. Conversely, low DO had the worst performance of the three indicators, with several sites scoring 'moderate' or worse. (Both high DO and low DO are measured as very high DO is associated with excessive algal growth, whilst very low DO is associated with anoxic waterways). The Bohle River had an unweighted score of 18 and grade of 'poor', the Lower Ross River, a score of 50 and grade of 'moderate', and Ollera Creek, a score of 59 and grade of 'moderate'. Additionally, the Black Weir non-independent site within the Lower Ross River had a score of 26 and grade 'poor'. The low dissolved oxygen levels in the Bohle River and Ollera Creek may be caused by the seasonal nature of the watercourses, as the rivers have very low water levels during the dry season. Although samples are always collected in running waters, water levels can drop significantly during the dry season resulting in very low flow rates which can result in low dissolved oxygen levels. The method to score dissolved oxygen does not take into consideration the seasonal nature of watercourses within the Dry Tropics, which can cause the indicator to receive a 'poor' or 'very poor' grade.

Table 8. Scores and grades for turbidity, low Dissolved Oxygen (DO), high DO and the overall physical-chemical (phys-chem) properties for freshwater sites.

Site	Non-weighted Score (Grade)				Catchment Area		Weighted Score (Grade) and contribution to final score[#]			
	Turbidity	High DO	Low DO	Phys-chem properties*	Catchment area (km^2)	Proportion catchment area	Turbidity	High DO	Low DO	Phys-chem properties
Upper Ross River (Ross River Dam)	90 (A)	90 (A)	90 (A)	90 (A)	458	0.32	28	28	28	28
- Black Weir[^]	90 (A)	90 (A)	26 (D)	58 (C)	786	0.56	50	50	28	39
- Gleeson Weir	90 (A)	90 (A)	50 (C)	70 (B)						
- Aplin's Weir	90 (A)	90 (A)	74 (B)	82 (A)						
Lower Ross River	90 (A)	90 (A)	50 (C)	70 (B)						
- Bohle far-field	90 (A)	90 (A)	37 (D)	63 (B)	169	0.12	10	10	2	6
- Bohle mid-field	90 (A)	90 (A)	0 (E)	45 (C)						
Bohle River	90 (A)	90 (A)	18 (D)	54 (C)						
Ross freshwater basin[+]	**90[<] (A)**	**90 (A)**	**52 (C)**	**71 (B)**	**1413**	**1**	**90 (A)**	**90 (A)**	**59 (C)**	**74 (B)**
Black River	69 (B)	53 (C)	90 (A)	61 (B)	250	0.37	25	19	33	22
Althaus Creek	12 (E)	69 (B)	90 (A)	40 (D)	35	0.05	0	3	4	2
Bluewater Creek	90 (A)	90 (A)	77 (B)	83 (A)	86	0.13	11	11	10	10
Sleeper Log Creek	90 (A)	90 (A)	76 (B)	83 (A)	41	0.06	5	5	4	5
Leichhardt Creek	90 (A)	90 (A)	61 (B)	75 (B)	38	0.06	5	5	3	4
Saltwater Creek	90 (A)	90 (A)	66 (B)	78 (B)	36	0.05	4	4	3	3
Rollingstone Creek	90 (A)	90 (A)	74 (B)	82 (A)	71	0.10	9	9	7	8
Ollera Creek	90 (A)	90 (A)	59 (C)	74 (B)	39	0.06	5	5	3	4
Crystal Creek	90 (A)	90 (A)	73 (B)	81 (A)	77	0.11	9	9	8	8
Paluma Dam	90 (A)	90 (A)	90 (A)	90 (A)	2	0.00	0	0	0	0
Black freshwater basin	**80 (B)**	**84 (A)**	**75 (B)**	**75 (B)**	**675**	**1**	**77 (B)**	**74 (B)**	**78 (B)**	**70 (B)**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 90 (scores are capped at 90)

* The overall phys-chem properties score was calculated by averaging the scores for Turbidity, and the worse score of High DO and Low DO. Only the worse DO score is used as the measures are inversely related: if high DO scores perfectly, low DO scores terribly, and vice versa. Using both scores would mask poor DO scores.

^ Independent site names are written in black, non-independent site names are written in brown. Non-independent site scores are averaged to create independent site scores.

+ Zone/basin names are written in bold. Independent site scores for each indicator are averaged to create zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.

< When values don't appear to add up correctly this is due to floor rounding. Significant figures differ where appropriate to show very small numbers.

Scores are weighted based on the proportion of measured catchment area. Weighted scores are summed to create the overall score for each zone/basin.

Key messages: Physical-chemical properties

- Phys-chem properties for both Ross and Black freshwater basins were graded as ‘good’.
- Turbidity and high DO were graded as ‘good’ or ‘very good’ for 12 of the 13 independent sites sampled.
- Low DO was the lowest scoring indicator, with Bohle River scoring as ‘poor’.
- Low DO is affected by natural variation and hydrology of the system, as well as anthropogenic influence. Many rivers and creeks within the Townsville Dry Tropics are seasonal and as they become shallow with low flow rates during the dry season, the dissolved oxygen within the river declines.

5.1.3.1 *Overall water quality*

As shown in Table 9, overall water quality was in a ‘good’ condition for both the Ross and Black freshwater basins. The Bohle River had ‘poor’ overall water quality, Black River and Althaus Creek had ‘moderate’ overall water quality, while all other rivers had ‘good’ to ‘very good’ water quality (Table 9).

Table 9. Scores and grades for nutrients, phys-chem properties, and overall water quality for freshwater sites.

Site	Non-weighted Score (Grade)			Weighted Score (Grade) and contribution to final score[#]		
	Nutrients	Phys-chem	Water quality*	Nutrients	Phys-chem	Water quality
Upper Ross River (Ross River Dam)	90 (A)	90 (A)	90 (A)			
- Black Weir[^]	75 (B)	58 (C)	66 (B)			
- Gleeson Weir	62 (B)	70 (B)	66 (B)			
- Aplin’s Weir	59 (C)	82 (A)	70 (B)			
Lower Ross River	75 (B)	70 (B)	72 (B)			
- Bohle far-field	33 (D)	63 (B)	48 (C)			
- Bohle mid-field	21 (D)	45 (C)	33 (D)			
Bohle River	27 (D)	54 (C)	40(D)			
Ross freshwater basin[+]	**64[<] (C)**	**71 (B)**	**67 (B)**	**73 (B)**	**74 (B)**	**73 (B)**
Black River	58 (C)	61 (B)	59 (C)			
Althaus Creek	78 (B)	40 (D)	59 (C)			
Bluewater Creek	68 (B)	83 (A)	76 (B)			
Sleeper Log Creek	82 (A)	83 (A)	82 (A)			
Leichhardt Creek	75 (B)	75 (B)	75 (B)			
Saltwater Creek	80 (B)	78 (B)	79 (B)			
Rollingstone Creek	45 (C)	82 (A)	63 (B)			
Ollera Creek	78 (B)	74 (B)	76 (B)			
Crystal Creek	90 (A)	81 (A)	85 (A)			
Paluma Dam	76 (B)	90 (A)	83 (A)			
Black freshwater basin	**73 (B)**	**75 (B)**	**74 (B)**	**66 (B)**	**70 (B)**	**68 (B)**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 90 (scores are capped at 90)

* The overall water quality score was calculated by averaging the scores for nutrients and phys-chem properties.

^ Independent site names are written in black, non-independent site names are written in brown. Non-independent site scores are averaged by indicator to create independent site indicator scores. Independent site indicator scores are averaged to obtain the indicator category score.

[+] Zone/basin names are written in bold. Independent site scores for each indicator are averaged to obtain zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.
[<] When values don't appear to add up correctly this is due to floor rounding.
[#] Scores are weighted based on the proportion of measured catchment area. Weighted scores are summed to create the overall score for each zone/basin.

5.1.3.2 *Confidence scores*

There was low confidence in the water quality scores for the Ross freshwater basin. This was due to limited spatial sampling in the basin, with only two rivers and the Ross Dam sampled. There was a moderate confidence in the water quality scores for the Black freshwater basins, with most major rivers (9 rivers and Paluma Dam) monitored. The score for each criterion is shown in Table 10.

Table 10. Confidence scores for nutrients, phys-chem properties, and overall water quality for the Ross and Black freshwater basins.

Basin	Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Ross Basin	Nutrients	2	3	1	3	1	7.6	Low (2)
	Phys-chem	2	3	1	3	1	7.6	Low (2)
	Water quality index						**7.6**	**Low (2)**
Black Basin	Nutrients	2	3	1.5	3	1	8.6	Moderate (3)
	Phys-chem	2	3	1.5	3	1	8.6	Moderate (3)
	Water quality index						**8.6**	**Moderate (3)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.
Confidence criteria were scored 1-3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

5.1.3.3 *Comparing scores for water quality between years*

The results for 2020-2021, 2019-2020 and 2018-2019 are shown in Table 11, with site specific results for the last two years shown (2020-2021 and 2019-2020) in Appendix C. The results from the 2017-2018 Pilot Report Card were not included in the comparison because a different methodology was used to calculate the scores and fewer sites were sampled.

Table 11. Comparison of water quality scores between 2020-2021, 2019-2020, and 2018-2019 for the Ross and Black freshwater basins.

Measure	2020-2021		2019-2020		2018-2019	
	Ross Basin	Black Basin	Ross Basin	Black Basin	Ross Basin	Black Basin
Nutrients	73 (B)	66 (B)	60 (C)	67 (B)	66 (B)	52 (C)
Phys-chem properties	74 (B)	70 (B)	80 (B)	67 (B)	68 (B)	71 (B)
Water quality*	**73 (B)**	**68 (B)**	**70 (B)**	**67 (B)**	**66 (B)**	**62 (B)**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

*Scores for the Water Quality index are calculated by averaging the scores for nutrients and phys-chem properties for each zone.

There is inherent natural variation in river systems due to climatic events, such as rainfall and the associated increase in flow. The natural variation combined with the limited spatial and temporal sampling, means that any reliable trends cannot be deduced until there is more data. However, differences in scores are still noted for interest. Between 2019-2020 and 2020-2021, the results were very similar within the basins, which may be attributed to similar rainfall and climatic conditions between these two years. More data is required before accurate trends and potential reasons for trends can be reported. The lower grade for nutrients in the Black freshwater basin in 2018-2019 was based on between one and three samples collected April-June 2019 at each of the 9 creek/river sites, as this was the commencement of this monitoring programme. The Black River (37% of catchment), Bluewater Creek (13% of catchment), and Rollingstone Creek (10% of catchment) were graded 'poor', 'moderate', and 'moderate' respectively for nutrients across these samples, with the remainder of the creeks grading 'good' or 'very good'. The nutrient load may be associated with nutrients and debris washed from peri-urban and agricultural catchments during the February 2019 flood.

5.2 Habitat and hydrology

Within the freshwater basin, habitat and artificial barriers were the two indicator categories scored within the habitat and hydrology index. The results for each index are presented in three separate sections. The 2020-2021 results for habitat and artificial barriers are the same as presented in the 2019-2020 and 2018-2019 report cards, as the results are only updated when new data are available, with the last available data between from 2013-2017.

5.2.1 Habitat

Riparian and palustrine wetland extent were the two indicators measured within the freshwater zone for the habitat index. Data was prepared by the Queensland Herbarium, using information obtained through Google Earth and the Queensland Herbarium's Regional Ecosystem mapping (version 5 for wetland extent and version 11 for riparian) (Neldner, et al., 2017). Scores were based on the four yearly change in habitat extent between 2014 and 2017, with change compared against a pre-clearing – 1988 baseline for riparian vegetation. The scores for riparian and wetland extent were aggregated to produce an overall score for the habitat index.

5.2.1.1 *Wetland and riparian extent results*

Overall, there was 'moderate' grade for the habitat index within both the Ross and Black freshwater basins, as shown in Table 12.

Table 12. Scores and grades for riparian extent, wetland extent and the habitat index for the Ross and Black freshwater basins.

Basin	Raw data		Standardised Score (Grade)		
	Riparian extent (% change for 2013)*	Wetland extent (% change for 2017)#	Riparian extent	Wetland extent	Habitat index^
Ross Basin	0.45% lost (135 ha lost)	0.15% lost (< 1 ha lost)	44 (C)	59 (C)	**51< (C)**
Black Basin	0.20% lost (52 ha lost)	0.22% lost (<1 ha lost)	56 (C)	55 (C)	**56 (C)**

Scoring range: Very Poor (E) = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 to 100

Loss of riparian extend over four years: Very Poor (E) > 1% loss| Poor (D) = 0.51-1.0% loss | Moderate (C) = 0.11-0.5% loss | Good (B) = 0-0.1% loss | Very Good (A) = increase in vegetation

Loss of wetland: Very Poor (E) = >3% loss | Poor (D) = 0.51-3.0% loss | Moderate (C) = 0.11-0.5% loss | Good (B) = 0-0.1% loss | Very Good (A) = increase in wetland area

* Riparian extent % change was determined by comparing current (2013) riparian extent to pre-development (1988) riparian extent. Scores for this indicator category have not been updated since 2013.

\# Wetland extent % change was determined by comparing current (2017) wetland extent to pre-development (2001) wetland extent. Scores for this indicator category have not been updated since 2017.

^ Habitat scores were calculated by averaging the scores for riparian extent and wetland extent.

< When values don't appear to add up correctly this is due to floor rounding.

Source: Queensland Government (2019) Reef Water Quality Report Card 2017 and 2018.

Wetland extent received a 'moderate' grade in both basins, with less than one hectare lost from both basins. This equated to a 0.15% and 0. 22% loss of wetlands from the Ross and Black freshwater basins, respectively. Riparian vegetation was lost from both the Ross and Black freshwater basins (0.45% and 0.20% loss respectively), resulting in both zones receiving 'moderate' grades. However, the method for measuring riparian extent likely underestimates the amount of habitat lost, resulting in better scores than actual (A. Healy, pers. comm., 3rd February 2021). A more accurate method to estimate habitat extent is currently being developed, with updated results to be included in the 2021-2022 Report Card.

Key messages: Wetland and riparian extent

- There was a 0.15% and 0.22% loss of wetland extent and a 0.45% and 0.20% loss of riparian habitat from the Ross and Black freshwater basins respectively, equating to a 'moderate' grading.
- Scores are based on 2017 data and may not be representative of 2021 condition.

5.2.2 Artificial barriers

The artificial barriers indicator category is comprised of two indicators, which are impoundment length and fish barriers. Both indicators were only scored against the earliest baseline of no barriers. Artificial in-stream barriers, such as weirs and dams, are generally built for flood mitigation and to store water for later use (Department of Environment, Land, Water and Planning, n.d.). However, these barriers often have a profound impact upon stream ecology and connectivity (Faulks, et al., 2011).

5.2.2.1 *Impoundment length*

Impoundment length describes how much "natural" channel habitat remains within a waterway. Impoundment length was calculated as the linear length of the stream that is impounded proportional to the total linear length of the watercourse. The length of impounded channel varies according to attributes, such as the height of the constructed in-stream barrier and landscape features, such as gradient of the channel (Department of Environment, Land, Water and Planning, n.d.). Scores for the 2020-2021 Report Card were based on 2019 data, as data are only updated every four years.

Impoundment length was assessed within watercourses that were classified as major or high importance for fish movement and fish species communities. The Ross freshwater basin received a 'poor' grade, with 8.1% of watercourses impounded (see Table 13). This 'poor' grade was due to the presence of the Ross River Dam and the three weirs (Black, Gleeson and Aplin's weirs) within the lower section of the Ross River. No watercourses within the Black freshwater basin were impounded, resulting in a 'very good' grade (see Table 13).

Table 13. Scores and grades associated with impoundment length for the Ross and Black freshwater basins.

Basin	non-impounded watercourse (km)	impounded watercourse (km)	Total watercourse (km)	% Of watercourse impounded	Standardised Score (Grade)
Ross Basin	817	72	888	8.1%	**34 (D)**
Black Basin	659	0	659	0	**100 (A)**

Impoundment (% total): ■ Very Poor = ≥10% | ■ Poor = 7 to <10% | ■ Moderate = 4 to <7% | ■ Good = <4 to 1% | ■ Very Good <1%.
Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100
The scores are based on spatial analysis of imagery from 2019. Only streams of high or major importance in relation to fish movement were included in the assessment. Scores have been rounded to nearest whole number.

Key messages: Impoundment length

- In the Ross freshwater basin, 8.1% of watercourses are impounded due to the presence of three weirs and the Ross River Dam.
- No watercourses within the Black freshwater basin are impounded.

5.2.2.2 *Fish barriers*

Fish barriers are an important indicator to include due to their links to ecosystem health. Additionally, the community places a high level of importance on the presence of freshwater fish species. The ability of commercial species to migrate into freshwaters and spawn is also important for the local economy. Fish barriers were identified based on a 2018-2019 desktop analysis of spatial imaging in Google Earth Pro and Esri ArcGIS mapping software. Barriers were classified as either passable (a physical barrier that does not prevent fish movement) or impassable (a physical barrier that prevents fish movement). The raw scores for each of the indicators, shown in Table 14, are the same as the 2018-2019 Report Card, as results are only updated every four years. The standardised score is provided for the Fish Barriers Indicator Category.

Within the Ross freshwater basin, there were 12 barriers along the five measured watercourses. The only impassable barriers were the three weirs and the Ross River Dam wall, all of which are along the Ross River. Overall, the Ross freshwater basin received a 'good' grade for the fish barriers indicator category. The 'poor' grade for the Ross River was offset by the 'very good' grade for Whites Creek (see Table 14). It is noted that Whites Creek is smaller than the Ross River and therefore averaging the two results may not be the best approach.

No barriers were present along Black River, with the river receiving a 'very good' grade (see Table 14). The Black River was the only watercourse assessed within the Black freshwater basin.

Key messages: Fish barriers

- The Ross freshwater basin received a 'good' grade with respect to fish barriers.
- Of the 12 barriers in the Ross freshwater basin only four prevented fish movement, which were the three weirs along the Ross River and the Ross River Dam.
- The Black freshwater basin received a 'very good' grade as no barriers were present.

Table 14. Standardised score and grade for the fish barriers indicator, and raw data that comprise the indicator, in the Ross and Black freshwater basins.

Basin	Watercourse	Raw data used to generate scores for indicators						Unstandardised scores for each indicator			Standardised score (Grade)
		Total watercourse (km)	# Barriers on watercourse	# Passable barriers	# Impassable barriers	Length to first barrier (km)	Length to first impassable barrier (km)	Barrier density (km/barrier)	% Of stream to first barrier	% Of stream to impassable barrier	Fish barriers indicator category
Ross Basin	Ross River	263.6	4.0	0.0	4.0	1.0	1.0	65.9km	0.4%	0.4%	40 (D)
	Bohle River	51.1	2.0	2.0	0.0	7.2	51.1	25.5km	14.1%	100%	61 (B)
	Stuart Creek	17.5	5.0	5.0	0.0	11.9	17.5	3.5km	68.2%	100%	60 (C)
	Alligator Creek	13.7	1.0	1.0	0.0	0.7	13.7	13.7km	5.2%	100%	60 (C)
	Whites Creek	11.1	0.0	0.0	0.0	11.1	11.1	No barriers	100%	100%	100 (A)
	Ross freshwater basin	71.4	2.4	1.6	0.8	6.4	18.9	27.2km	37.6%	80.1%	65 (B)
Black Basin	Black River	92.0	0.0	0.0	0.0	0.0	92.0	No barriers	No barriers	No barriers	100 (A)

Barrier density (km): ■ Very Poor = 0 to 2km | ■ Poor = >2 to 4km | ■ Moderate = >4 to 8km | ■ Good = >8 to 16km | ■ Very Good >16km.
Percent stream length to first barrier: ■ Very Poor = 0 to <40% | ■ Poor = 40 to <60% | ■ Moderate = 60 to <80% | ■ Good = 80 to <100% | ■ Very Good 100%
Percent stream length to impassable barrier: ■ Very Poor = 0 to 60% | ■ Poor = >60 to 80% | ■ Moderate = >80 to 90% | ■ Good = >90 to <100% | ■ Very Good 100%
Standardised scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100
The unstandardised scores for each indicator are standardised and then averaged with equal weighting to calculate the standardised score for the fish barriers indicator category.

5.2.2.3 *Overall results for the artificial barriers index*

Overall, the Ross freshwater basin received a 'moderate' grade for artificial barriers, whilst the Black freshwater basin received a 'very good' grade (see Table 15).

Table 15. Standardised scores and grades for the artificial barriers indicator category in the Ross and Black freshwater basins.

	Standardised Scores (Grades) for Report Card		
Freshwater Basin	**Impoundment length**	**Fish barrier**	**Artificial barriers**
Ross Basin	34 (D)	65 (B)	**50 (C)**
Black Basin	100 (A)	100 (A)	**100 (A)**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100
The score and grade for the artificial barrier's indicator category is the average of impoundment length and fish barrier. Scores have been rounded to nearest whole number.

5.2.3 Overall habitat and hydrology score

Overall, the Ross freshwater basin received a 'moderate' grade for the habitat and hydrology index, whilst the Black freshwater basin was graded as 'good' (see Table 16).

Table 16. Score and grades for the habitat and hydrology index in the Ross and Black freshwater basins.

Basin	Scores (Grades)		
	Habitat	**Artificial barriers**	**Habitat and hydrology**
Ross freshwater basin	51 (C)	50 (C)	**51 (C)**
Black freshwater basin	56 (C)	100 (A)	**78 (B)**

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100
The score and grade for the artificial barrier's indicator category is the average of impoundment length and fish barrier. Scores have been rounded to nearest whole number.

5.2.4 Confidence scores for habitat and hydrology

There was a 'moderate' confidence in the overall scores for the habitat and hydrology index (Table 17).

The confidence score for impoundment length, shown in Table 17, was based on all watercourses being assessed and therefore the representativeness score (which has the highest weighting) was a three. This resulted in the overall confidence score being high for impoundment length. For fish barriers, there was low confidence, as it is unlikely that all potential barriers were identified (representativeness), ground truthing of barriers was unknown (validation) and there was no known measured error. Additionally, not all watercourses were assessed for the fish barriers indicator. As a result, there was very low confidence in the scores for fish barriers.

There was a very low confidence in the results for riparian and wetland extent, with the overall rank and scores for each confidence criterion presented in Table 17. The representativeness was very low, due to the current method to estimate habitat extent likely underestimating the amount of habitat lost. A new, more accurate method is currently being devised.

Table 17. Confidence scores for the habitat and hydrology index in the Ross and Black (combined) freshwater basins.

<table>
<tr><th></th><th>Maturity of method (x0.36)</th><th>Validation (x0.71)</th><th>Representativeness (x2)</th><th>Directness (x0.71)</th><th>Measured error (x0.71)</th><th>Final score</th><th>Rank</th></tr>
<tr><td>Impoundment length</td><td>2</td><td>2</td><td>3</td><td>2</td><td>1</td><td>10.3</td><td>High (4)</td></tr>
<tr><td>Fish barriers</td><td>2</td><td>1</td><td>1</td><td>2</td><td>1</td><td>5.6</td><td>Very Low (1)</td></tr>
<tr><td colspan="6">Artificial barriers indicator category</td><td>8.0</td><td>Low (2)</td></tr>
<tr><td>Riparian extent</td><td>2</td><td>2</td><td>1</td><td>2</td><td>1</td><td>6.3</td><td>Very low (1)</td></tr>
<tr><td>Wetland extent</td><td>2</td><td>2</td><td>1</td><td>2</td><td>1</td><td>6.3</td><td>Very low (1)</td></tr>
<tr><td colspan="6">Habitat extent indicator category</td><td>6.3</td><td>Very low (1)</td></tr>
<tr><td colspan="6">Habitat and Hydrology index</td><td>7.1</td><td>Low (2)</td></tr>
</table>

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

Scores are rounded to one decimal place. Confidence criteria were scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

5.3 Fish

In future, fish may be reported on as one part of a broader "Biota index" based on data for several groups of ("freshwater") aquatic organisms, but fish are presently the only aquatic fauna for which consistent data are available. Fish monitoring results are updated every third year, with the last update being made for the 2019-2020 Report Card, so the results for this year remain unchanged.

The assessment of freshwater fish communities is based on two indicator categories, which are the Proportion of Indigenous Species Expected within inland waterways (excluding translocated species) and the Proportion of Non-Indigenous Fish, with the latter consisting of two separate measures: 1) the Proportion of Translocated Fish and 2) the Proportion of Alien Fish. The distinction between each classification of fish is covered in Table 18.

Table 18. The division between Indigenous, Translocated, and Alien fish species.

<table>
<tr><td>Index:</td><td colspan="3">Fish</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Native to Australia</td><td>Not Native to Australia</td></tr>
<tr><td>Native to Waterway</td><td colspan="2">Not Native to Waterway</td></tr>
<tr><td>Indicator category:</td><td>proportion of Indigenous species expected (POISE) within waterways</td><td colspan="2">proportion of non-Indigenous fish</td></tr>
<tr><td>Indicator:</td><td>"Indigenous"</td><td>"Translocated"</td><td>"Alien"</td></tr>
</table>

The fish index is designed to provide a basic description of how similar regional fish communities are to the best available estimate of their natural state. Condition ratings are based on the median result across multiple sites within each basin, with each site generally being assessed on a single occasion. Fish were sampled at each site using backpack electrofishing, which is highly effective, but not all the species present at a site are captured, and condition ratings take this into account.

5.3.1 Assessment sites

Assessment sites were selected using an objective randomised design. Within the Ross freshwater basin fish were assessed at 11 sites on nine different waterways (Alligator Creek was assessed at three locations) (Figure 10). Within the Black freshwater basin, fish were assessed at 13 sites on 11 different waterways (the Alice River and Crystal Creek were each assessed at two locations) (Figure 11). Electrofishing was undertaken during 19-23 August 2019.

Four sites in the upper Ross River catchment (i.e., upstream of the Ross River Dam wall) could not be sampled due to access constraints, and one site within the Black Weir pool could not be sampled due to resource constraints. These sites were moved elsewhere in accordance with the site selection method. A lack of sampling within the upper catchment and weir pool may have influenced results, however the current result is still considered reasonable in relation to other basins.

5.3.2 Results

Thirty-three species were caught during sampling across the Townsville Dry Tropics region, with 26 and 23 species recorded in the Ross and Black freshwater basins, respectively. The species present within the Ross and Black freshwater basins area shown in Table 20 and Table 21, respectively.

Fish sampling yielded 7,411 fish, of which 110 were retained for laboratory confirmation of identification, 968 were introduced species that were euthanised, and the remainder were released unharmed. Twenty-six species (23 indigenous, 3 non-indigenous) were recorded within the Ross freshwater basin, whilst 23 species (20 indigenous, 3 non-indigenous) were recorded within the Black freshwater basin. Non-indigenous species include both alien and translocated species. Alien species are those species that are not native to Australia, whilst translocated species are species that are native to Australia but not native to the waterway. Three indigenous species (Giant Mottled Eel, Bunaka and Scaleless Goby) were recorded (Table 21) for the first time in the Dry Tropics region.

Overall, fish communities were in a ‘moderate’ condition within the Ross Basin and ‘good’ condition within the Black Basin. The scores for the indicator categories and the overall fish index are shown in Table 22, whilst the raw values are shown in Table 23, and appendices D1 and D2. The Proportion of Non-Indigenous Species Expected within sampled waterways was graded as ‘moderate’ (0.62 or 62% of expected species present) within the Ross Basin and ‘good’ (0.70 or 70% of expected species present) within the Black Basin (Table 22, Table 23). Across all sites within the Ross and Black basins, non-indigenous fish comprised proportions of 0.051 (5.1%) and 0.012 (1.2%) of fish catch within waterways within each basin respectively. This translated to a ‘moderate’ and ‘very good’ grade for the Ross and Black basins respectively for the Proportion of Non-Indigenous Fish indicator category.

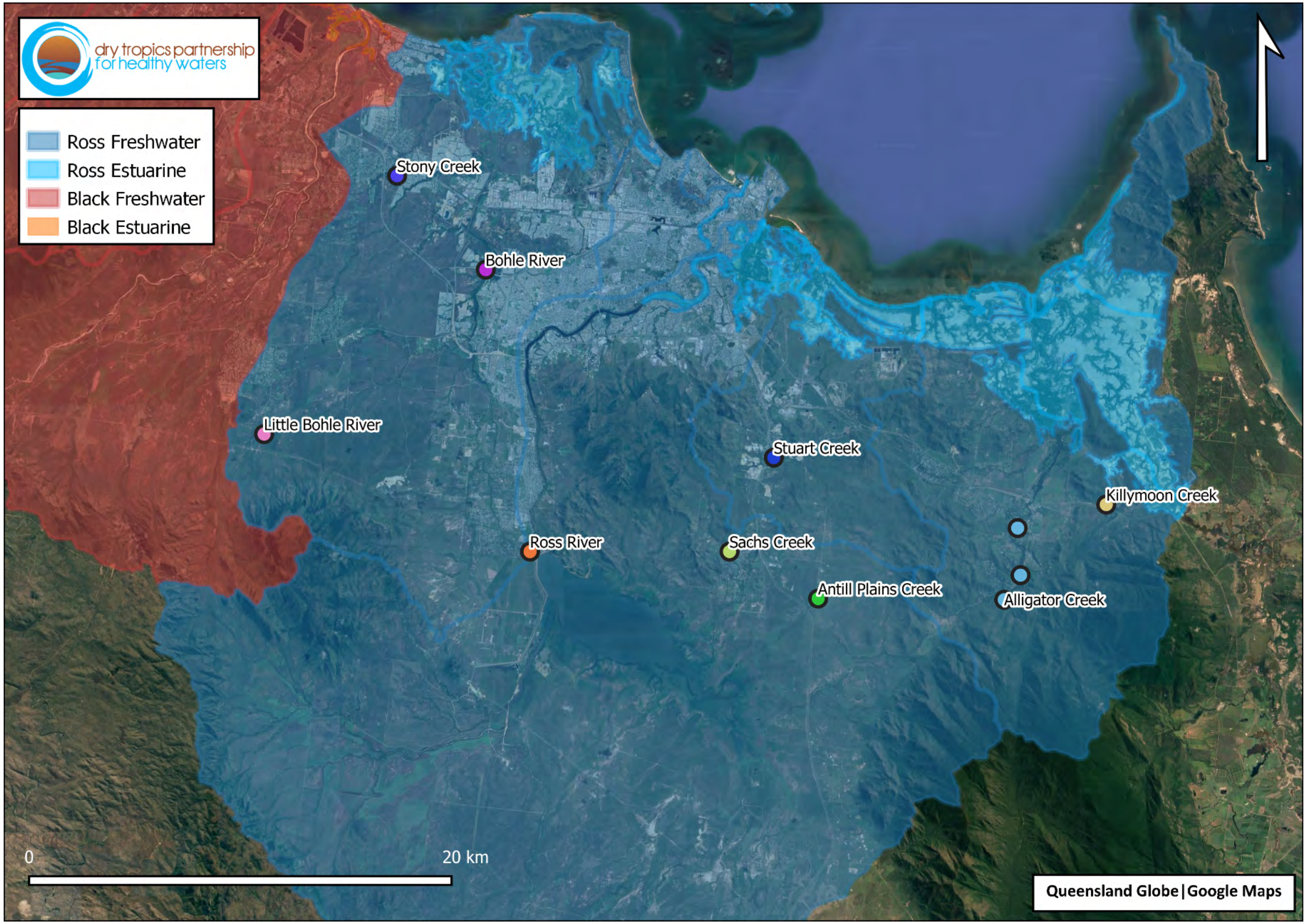


Figure 10: Location of fish sampling sites within the Ross freshwater basin.

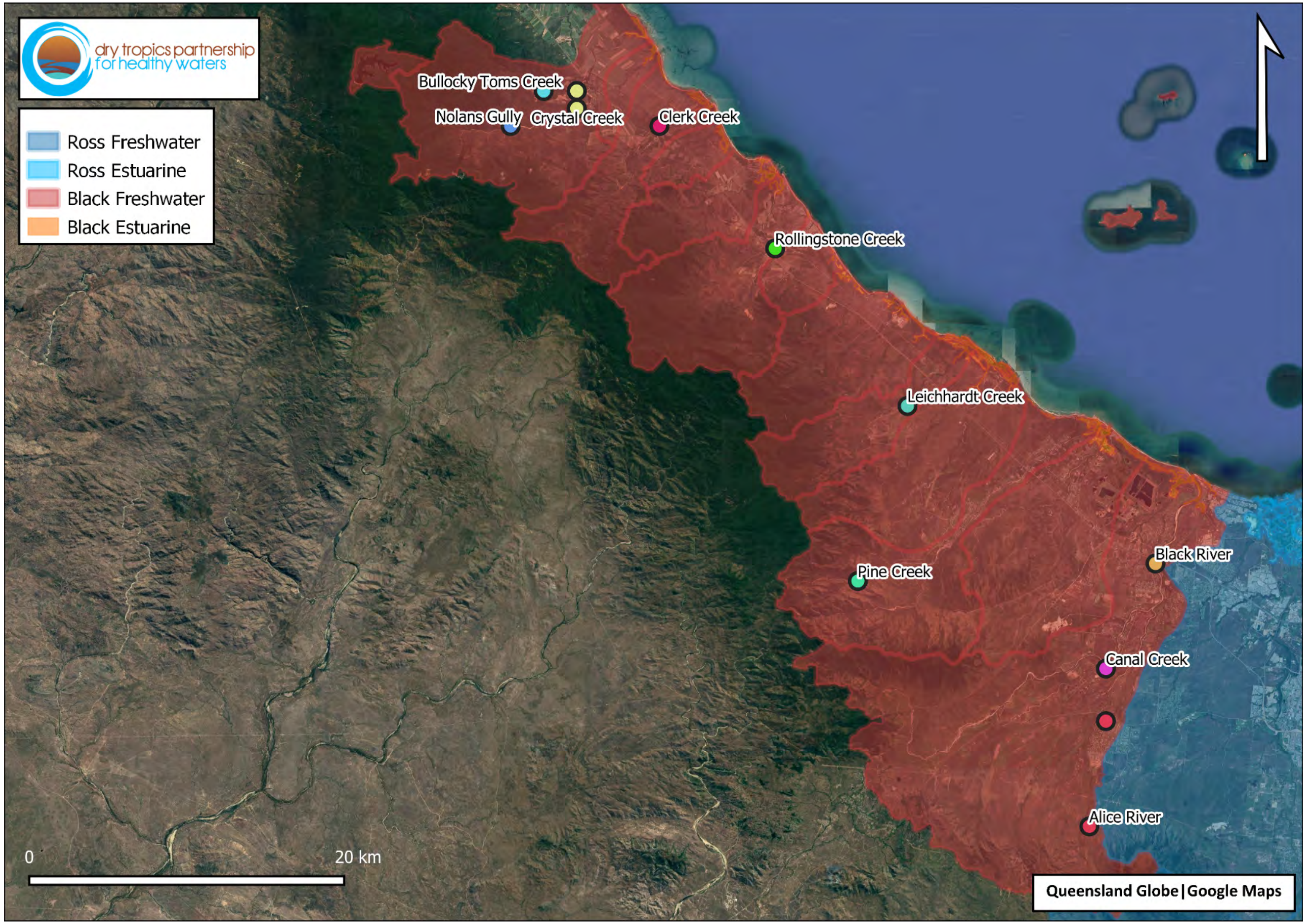


Figure 11. Location of fish sampling sites within the Black freshwater basin.

Table 19. Key used to determine species in Table 20 and Table 21.

Key	Species	Basin (Ross, Black, Both)	Species Category
1	Northern perchlet	Both	Indigenous
2	Barred grunter	Ross	
3	Long-finned eel	Both	
4	Roman-nose goby	Both	
5	Fly-specked hardyhead	Both	
6	Mouth almighty	Both	
7	Empire gudgeon	Both	
8	Northern carp gudgeon (undescribed)	Ross	
9	Jungle perch	Both	
10	Barramundi	Both	
11	Spangled perch	Both	
12	Indo-Pacific tarpon	Ross	
13	Eastern rainbowfish	Both	
14	Southern, purple-spotted gudgeon	Both	
15	Bony bream	Ross	
16	Butter jew	Ross	
17	Hyrtl's tandan	Both	
18	Swamp eel	Both	
19	Greenback mullet	Ross	
20	Rendahl's tandan	Ross	
21	Speckled goby	Ross	
22	Seven-spot archerfish	Ross	
23	Giant mottled eel	Black	
24	Bunaka	Black	
25	Silver biddy	Black	
26	Snake-head gudgeon	Black	
27	False Celebes goby	Black	
28	Mangrove jack	Black	
29	Scaleless goby	Black	
30	Gambusia	Both	Alien
31	Guppy	Both	
32	Mozambique tilapia	Both	
33	Sleepy cod	Ross	Translocated

Table 20. Fish species present within waterways in the Ross freshwater basin

Waterway	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	30	31	32	33
Little Bohle River	1	0	1	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1	0	1	0
Bohle River	1	0	1	1	1	0	1	0	1	1	1	0	1	0	0	0	0	0	1	0	0	0	1	0	1	0
Sachs Creek	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0
Killymoon Creek	1	0	1	0	0	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Alligator Creek	1	1	1	0	1	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0
- Site 1^	1	0	1	0	1	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
- Site 2	0	1	1	0	1	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0
- Site 3	1	0	1	0	1	1	1	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Stuart Creek	1	0	1	0	1	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	1	0	1	0
Ross River	1	1	1	0	1	1	0	0	0	0	1	0	1	1	1	1	1	1	0	1	1	1	1	0	1	1
Stony Creek	1	0	0	0	0	0	1	1	0	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0	1	0
Antill Plains Creek	1	0	0	0	1	1	0	1	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	1

1 represents present, 0 indicates absence.

^Independent site names are written in black, non-independent site names are written in brown. Non-independent site scores are averaged to create independent site scores.

Table 21. Fish species present within waterways in the Black freshwater basin.

Waterway	1	23	3	4	24	5	25	26	6	27	7	9	10	11	28	13	14	17	18	29	30	31	32
Pine Creek	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0
Black River	0	0	1	1	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	1	0	1
Rollingstone Creek	1	0	1	0	0	1	0	0	0	1	1	1	0	1	0	1	1	1	0	0	0	0	1
Healy Creek	1	0	1	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	1	0	0
Canal Creek	1	0	1	0	0	0	0	0	0	1	1	0	0	1	0	1	1	0	0	0	1	1	1
Crystal Creek	0	1	1	1	0	1	1	0	0	1	1	1	1	0	1	1	1	0	1	1	1	0	0
- Site 1^	0	0	1	1	0	1	0	0	0	1	1	1	0	0	1	1	1	0	0	0	1	0	0
- Site 2	0	1	1	1	0	1	1	0	0	1	1	1	1	0	1	1	0	0	1	1	0	0	0
Leichhardt Creek	1	0	1	1	1	1	0	1	1	0	1	0	0	1	0	1	1	1	0	0	0	0	1
Bullocky Toms Creek	0	0	1	1	0	1	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0
Alice River	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	0	1	1
- Site 1^	0	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1
- Site 2	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	0	1	1
Nolan's Gully	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0
Clerk Creek	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	1	0	0

1 represents present, 0 indicates absence. No translocated Australian fish species were recorded in catches.

^Independent site names are written in black, non-independent site names are written in brown. Non-independent site scores are averaged to create independent site scores.

Table 22. Scores and grades for the Proportion of Indigenous Species Expected, and Proportion of Indigenous Fish indicator categories, which comprise the overall fish index.

Basin	Scores (Grades)		
	Proportion of Indigenous species expected	Proportion of non-Indigenous Fish	Fish index
Ross freshwater Basin	54 (C)	60 (C)	**57 (C)**
Black freshwater Basin	66 (B)	91 (A)	**78 (B)**

Scoring range: Very Poor I = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 to 100
The fish index is the average of the scores for the Proportion of Indigenous Species Expected and the Proportion of Indigenous Fish. Scores have been rounded to nearest whole number.

Table 23. Raw scores for the Proportion of Indigenous Species Expected, and Proportion of Indigenous Fish indicator categories, which comprise the overall fish index.

Basin	Proportion of Indigenous species expected	Proportion of non-Indigenous Fish		
		Proportion of translocated fish	Proportion of alien fish	Proportion of non-Indigenous Fish index
Ross freshwater Basin	0.62	0.0	0.037	0.051
Black freshwater Basin	0.70	0.0	0.012	0.012

Scoring range for the proportion of Indigenous species expected: Very Poor I = 0 to <0.40| Poor (D) = 0.40 to <0.53| Moderate (C) = 0.53 to <0.67 | Good (B) = 0.67 to <0.80 | Very Good (A) = 0.80 to 1
Scoring range for the proportion of non-Indigenous species: Very Poor I = >0.20 to 1| Poor (D) = >0.1 to 0.2 | Moderate (C) = >0.05 to 0.1 | Good (B) = >0.03 to 0.05 | Very Good (A) = 0 to 0.3
The Proportion of Indigenous fish indicator category comprises of two indicators, which are the proportion of translocated fish and the proportion of invasive (alien) fish. All proportions are calculated by deriving the median based on all sites monitored. The index is calculated at the site level and the medians reported here are derived from those. Significant figures differ for ease of presentation. All values are floor rounded.

The Proportion of Non-Indigenous Fish was highly variable in the Ross basin (Table 23), with fish communities generally improving in this respect away from the urban centre. The total number of fish of non-indigenous species caught within the Black and Ross basins were similar between the two basins. For example, there were 122 gambusia caught in the Black and 124 in the Ross basins, whilst there were 319 Mozambique tilapias caught in the Black Basin and 395 caught in the Ross Basin. In total, there were only 8 guppies caught within the two basins.

Key messages: Fish

- The Ross and Black basins were in a 'moderate' and 'good' condition for fish communities.
- 33 species were found in the Dry Tropics Region (30 native, three non-indigenous), with three indigenous species recorded for the first time (Giant Mottled Eel, Bunaka and Scaleless Goby).
- Non-indigenous fish comprised a median of only 5.1% and 1.2% of catch in the Ross and Black basins.

5.3.3 Confidence scores for the fish index

There was 'moderate' confidence in the results. The research and associated results are relatively new to Northern Queensland. Over time sampling plans and analysis can be improved and temporal trends established.

Table 24. Confidence scores for the fish index in the (combined) Ross and Black estuarine zone.

	Maturity (0.36)	Validation (0.71)	Representativeness (2)	Directness (0.71)	Measured error (0.71)	Final score	Rank
Fish index	2	2	2	3	1	**9**	**Moderate (3)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.
Confidence criteria were scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

6 Estuarine zones

Within the estuarine zone, water quality and habitat and hydrology are the two indices scored, with the results presented in separate sections below.

6.1 Water quality

6.1.1 Monitoring sites

Seven estuaries were monitored within the Ross estuarine zone and eight within the Black estuarine zone. Monthly grab samples were taken at one to five sites per estuary. The estuary names and number of sites sampled per estuary are shown in Table 25. The locations of the sites are shown in Figure 12 and Figure 13.

6.1.2 Results

Water quality scores for estuarine zones were derived from five indicators and two indicator categories, which are nutrients and physical-chemical (phys-chem) properties. The distributions of the raw data for each indicator are presented as boxplots in Appendix F. The values used to calculate the scores are presented in Appendix G. The parameters used to calculate the scores are:

- Water quality objectives (WQOs),
- Scaling factors, which are used to scale the scores,
- Annual median, calculated from the monthly medians,
- 80th percentile for nutrients, turbidity, and high dissolved oxygen, and
- 20th percentile for low dissolved oxygen.

Table 25. Estuaries and number of monitoring sites per estuary within the Ross and Black estuarine zones.

Zone	Estuary name	# of monitoring sites
Ross estuarine zone	Bohle River Estuary	1
	Louisa Creek Estuary	3
	Ross Creek Estuary	2
	Ross River Estuary	1
	Stuart Creek Estuary	1
	Sandfly Creek Estuary	6
	Alligator Creek Estuary	1
Black estuarine zone	Althaus/Deep Creek Estuary	1
	Bluewater Creek Estuary	1
	Sleeper Log Creek Estuary	1
	Camp Oven Creek Estuary	3
	Saltwater Creek Estuary	3
	Rollingstone Creek Estuary	1
	Crystal Creek Estuary	1

6.1.2.1 *Nutrients*

The scores for nutrients were derived by averaging the scores of two indicator categories, which are total phosphorus (TP) and dissolved inorganic nitrogen (DIN). The results for nutrients are presented in Table 26. Nutrients were graded as ‘very good’ and ‘good’ in the Ross and Black estuarine zones, respectively. The Louisa Creek Estuary within the Ross estuarine zone was in ‘poor’ condition with respect to TP due to the median concentration being above the water quality objective and the 80th percentile being above the scaling factor at the two upper catchment sites. The scores for the 2020-2021 Report Card were very similar to the scores in 2019-2020, with the comparisons of scores between the years shown in Appendix H.

The Crystal Creek Estuary in the Black estuarine zone was in ‘moderate’ condition with DIN scoring ‘poor’ with the annual median exceeding the water quality objective and the 80th percentile exceeding the scaling factor. The Rollingstone Creek Estuary similarly had DIN concentrations where the annual median exceeded the water quality objective and the 80th percentile exceeded the scaling factor, though not to the same extent as in Crystal Creek Estuary. The Bluewater Creek Estuary was graded ‘moderate’ for DIN with the annual median exceeding the water quality objective. The sources of nutrients in these estuaries requires further investigation, as there is a consistent source of DIN as can be seen by comparison with the 2019-2020 data (‘moderate’ condition for DIN) and 2018-2019 data (‘poor’ condition for DIN) refer to Appendix G.

All other estuaries in both the Ross and Black estuarine zones were in a ‘good’ or ‘very good’ condition overall.

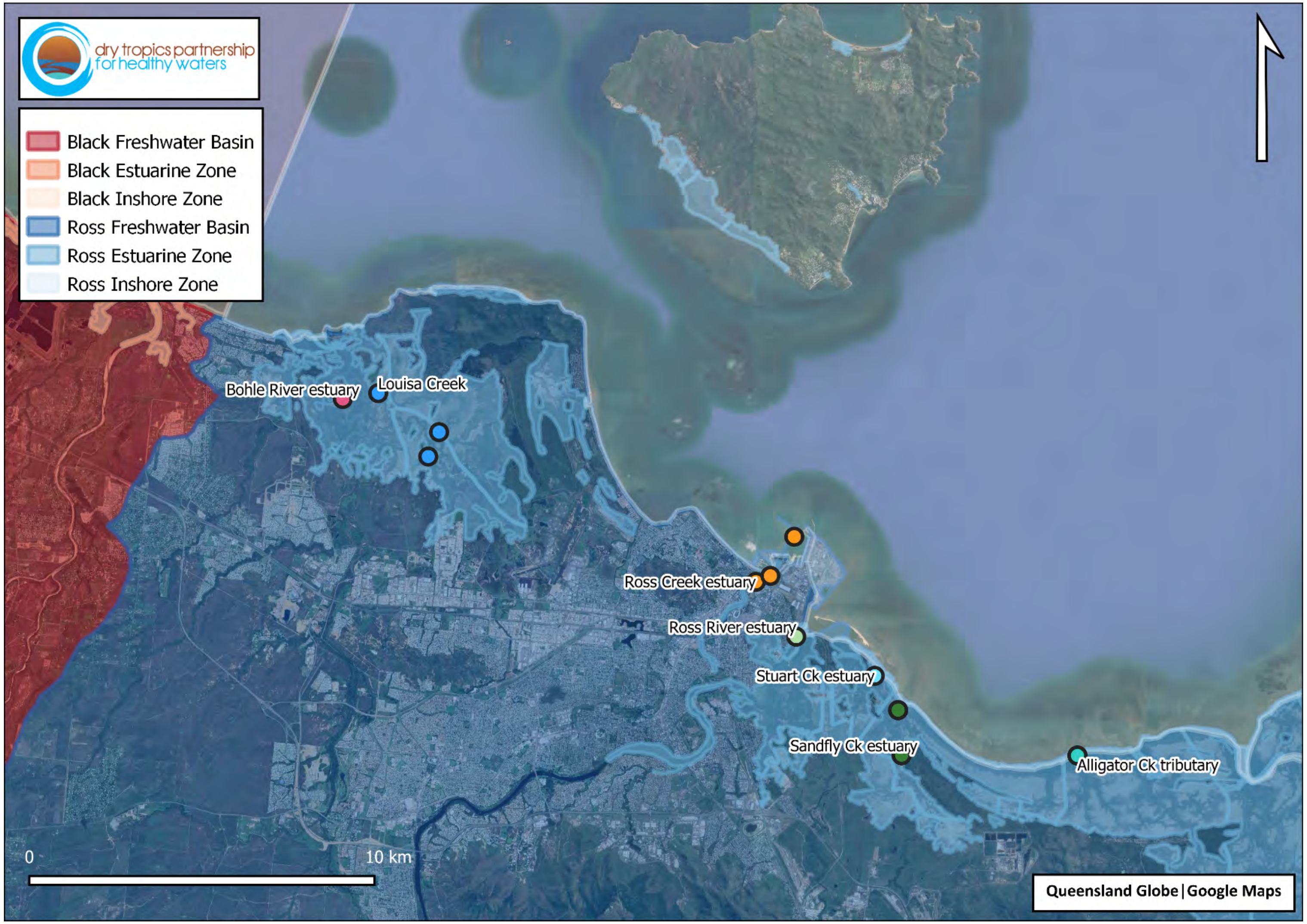


Figure 12. Monitoring sites within the Ross estuarine zones.

Estuarine zone map layer provided by DES here: [Queensland Globe Water Type Layer]. Each estuary is denoted by a different colour. Where non-independent sites are combined for the estuary, these are shown as separate points of the same colour.

Figure 13. Monitoring sites within the Black estuarine zone.

Each estuary is denoted by a different colour. Where non-independent sites are combined for the estuary, these are shown as separate points of the same colour.

Key messages: Nutrients

- Overall, nutrients were graded as 'very good' and 'good' in the Ross and Black estuarine zones.
- Nutrient (total phosphorus and dissolved inorganic nitrogen) were rated as 'good' or 'very good' in over 77% of monitored estuaries (10 out of 13 estuaries) in relation to the water quality objectives (WQOs).
- Louisa Creek Estuary was in a 'moderate' condition due to total phosphorus being higher than the WQO.
- Crystal Creek Estuary was in 'moderate' condition due to DIN being higher than the WQO.
- Rollingstone Creek Estuary and Bluewater Creek Estuary were in 'good' condition overall but had annual median DIN higher than the WQO.

6.1.2.2 *Physical-chemical (phys-chem) properties*

The results for the phys-chem index were derived by averaging the scores of the turbidity indicator and the lower of the two dissolved oxygen (DO) measures. The scores and grades for the sampled estuaries are presented in Table 27. Overall, the Ross and Black estuarine zones were in a 'good' condition in relation to phys-chem properties, with most estuaries sampled in a 'good' or 'very good' condition. All estuaries sampled within the Ross estuary were in a 'very good' condition, except for Louisa Creek estuary, which was in a 'moderate' condition. This was due to two monitoring sites within Louisa Creek Estuary receiving 'very poor' grades for low DO. The relationship between DO and nutrients is well established, and thus the low DO is not surprising given the TP concentrations measured in the upper reaches of the estuary.

Within the Black estuarine zone, Althaus Creek Estuary was in a 'moderate' condition, due to higher turbidity levels than the water quality objective (WQO). Turbidity within the freshwater section of the creek was 'very poor', which indicates the issues in the estuary may be caused by disturbances upstream.

Key messages: Phys-chem properties

- Ross and Black estuarine zones were in a 'good' condition with respect to physical-chemical properties (turbidity and dissolved oxygen).
- 85% of estuaries monitored (11 out of 13 estuaries) were in a 'good' or 'very good' condition.

Table 26. Scores and grades for total phosphorus (TP), dissolved inorganic nitrogen (DIN) and the overall nutrients for estuarine sites.

Site	Unweighted Score (Grade)			Catchment Area		Weighted Score (grade)#		
	DIN	TP	Nutrients*	Area (km²)	Proportion of basin	DIN	TP	Nutrients
- Louisa Creek upstream^	66 (B)	0 (E)	33 (D)	52	0.0422	3	1	2
- Town Common downstream	72 (B)	0 (E)	36 (D)					
- Louisa Creek downstream	90 (A)	90 (A)	90 (A)					
Louisa Creek Estuary	76 (B)	30 (D)	53 (C)					
Bohle River Estuary	90 (A)	90 (A)	90 (A)	296	0.2376	21	21	21
Ross Creek Estuary	90 (A)	90 (A)	90 (A)	21	0.0167	1	1	1
Ross River Estuary	90 (A)	90 (A)	90 (A)	843	0.6774	61	61	61
Sandfly Creek Estuary	90 (A)	90 (A)	90 (A)	28	0.0223	2	2	2
Alligator Creek Estuary	90 (A)	90 (A)	90 (A)	5	0.0039	0.3	0.3	0.3
Ross Estuarine Zone+	**87 (A)**	**80 (B)**	**83 (A)**	**1244**	**1**	**89 (A)<**	**87 (A)**	**88 (A)**
Althaus Creek Estuary	69 (B)	90 (A)	79 (B)	101	0.1729	12	15	13
Bluewater Creek Estuary	53 (C)	90 (A)	71 (B)	105	0.1811	9	16	13
Sleeper Log Creek Estuary	90 (A)	90 (A)	90 (A)	72	0.1232	11	11	11
- Camp Oven Creek upstream	ND	90 (A)	90 (A)	10	0.0171	0	1	0.8
- Camp Oven Creek confluence	ND	90 (A)	90 (A)					
- Camp Oven Creek downstream	ND	90 (A)	90 (A)					
Camp Oven Creek Estuary	ND	90 (A)	90 (A)					
- Saltwater Creek midstream	ND	90 (A)	90 (A)	47	0.0808	7	7	7
- Saltwater Creek Estuary 0.6km from mouth	90 (A)	90 (A)	90 (A)					
- Saltwater Creek downstream	ND	90 (A)	90 (A)					
Saltwater Creek Estuary	90 (A)	90 (A)	90 (A)					
Rollingstone Creek Estuary	36 (D)	90 (A)	63 (B)	78	0.1345	4	12	8
Crystal Creek Estuary	27 (D)	90 (A)	58 (C)	119	0.2043	5	18	12
Black Estuarine Zone	**61 (B)**	**90 (A)**	**77 (B)**	**582**	**1**	**50 (C)**	**82 (A)**	**66 (B)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 90 (scores are capped at 90)

* The overall nutrient score was calculated by averaging the scores for DIN and TP.

^ Independent site names are written in black, non-independent site names are written in brown. Non-independent site scores are averaged to create independent site scores.

+ Zone/basin names are written in bold. Independent site scores for each indicator are averaged to create zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.

< When values don't appear to add up correctly this is due to floor rounding. Significant figures differ where appropriate to show very small numbers

Scores are weighted based on the proportion of measured catchment area. Weighted scores are summed to create the overall score for each zone/basin.

Table 27. Scores and grades for turbidity, low Dissolved Oxygen (DO), High DO and the overall physical-chemical (phys-chem) properties for estuarine sites.

Site	Unweighted Score (Grade)				Catchment Area		Weighted Score (grade)#			
	Turbidity	High DO	Low DO	Phys-Chem Properties*	Area (km^2)	Proportion of basin	Turbidity	High DO	Low DO	Phys-Chem Properties
- Louisa Creek upstream^	63 (B)	90 (A)	0 (E)	31 (D)	52	0.0422	2	3	1	2
- Town Common downstream	65 (B)	90 (A)	0 (E)	32 (D)						
- Louisa Creek downstream	76 (B)	90 (A)	90 (A)	83 (A)						
Louisa Creek Estuary	68 (B)	90 (A)	30 (D)	49 (C)						
Bohle River Estuary	76 (B)	90 (A)	90 (A)	83 (A)	296	0.2376	18	21	21	19
Ross Creek Estuary	90 (A)	90 (A)	90 (A)	90 (A)	21	0.0167	1	1	1	1
Ross River Estuary	90 (A)	90 (A)	90 (A)	90 (A)	843	0.6774	61	61	61	1
Sandfly Creek Estuary	77 (B)	90 (A)	90 (A)	83 (A)	28	0.0223	1	2	2	61
Alligator Creek Estuary	77 (B)	90 (A)	90 (A)	83 (A)	5	0.0039	0.3	0.3	0.3	0.3
Ross Estuarine Zone+	**79** (B)	90 (A)	**80** (B)	**79** (B)	**1244**	**1**	**86 (A)<**	**90 (A)**	**88 (A)**	**86.5 (A)**
Althaus Creek Estuary	0 (E)	68 (B)	90 (A)	34 (D)	101	0.1729	0	12	16	5
Bluewater Creek Estuary	90 (A)	73 (B)	90 (A)	81 (A)	105	0.1811	16	13	16	14
Sleeper Log Creek Estuary	90 (A)	90 (A)	90 (A)	90 (A)	72	0.1232	11	11	11	11
- Camp Oven Creek upstream	90 (A)	90 (A)	46 (C)	68 (B)	10	0.0171	1	1	1	1
- Camp Oven Creek confluence	65 (B)	90 (A)	72 (B)	68 (B)						
- Camp Oven Creek downstream	61 (B)	90 (A)	77 (B)	69 (B)						
Camp Oven Creek Estuary	72 (B)	90 (A)	65 (B)	68 (B)						
- Saltwater Creek midstream	90 (A)	90 (A)	90 (A)	90 (A)	47	0.0808	6	7	7	6
- Saltwater Creek Estuary 0.6km from mouth	76 (B)	90 (A)	90 (A)	83 (A)						
- Saltwater Creek downstream	65 (B)	90 (A)	90 (A)	77 (B)						
Saltwater Creek Estuary	77 (B)	90 (A)	90 (A)	83 (A)						
Rollingstone Creek Estuary	65 (B)	90 (A)	90 (A)	77 (B)	78	0.1345	8	12	12	10
Crystal Creek Estuary	68 (B)	90 (A)	90 (A)	79 (B)	119	0.2043	14	18	18	16
Black Estuarine Zone	**66** (B)	**84 (A)**	**89** (A)	**73** (B)	**582**	**1**	**58 (C)**	**75 (B)**	**82 (A)**	**66.3 (B)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 90 (scores are capped at 90)

* The overall phys-chem properties score was calculated by averaging the scores for Turbidity, and the worse score of High DO and Low DO. Only the worse DO score is used as the measures are inversely related: if high DO scores perfectly, low DO scores terribly, and vice versa. Using both scores would mask poor DO scores.

^ Independent site names are written in black, non-independent site names are written in brown. Non-independent site scores are averaged to create independent site scores.

+ Zone/basin names are written in bold. Independent site scores for each indicator are averaged to create zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.

< When values don't appear to add up correctly this is due to floor rounding. Significant figures differ where appropriate to show very small numbers.

Scores are weighted based on the proportion of measured catchment area. Weighted scores are summed to create the overall score for each zone/basin.

6.1.2.3 *Overall water quality*

Overall water quality within the Ross estuarine zone was 'very good', as shown in Table 28. All sites had 'very good' water quality, except for Louisa Creek Estuary, which was in a 'moderate' condition.

Overall, the Black estuarine zone was graded as being in a 'good' condition. Althaus Creek Estuary was in a 'moderate' condition overall due to the high turbidity levels. The sources of DIN require investigation in Bluewater Creek Estuary, Rollingstone Creek Estuary, and Crystal Creek Estuary.

Natural variability, such as geography, vegetation, and climate, may cause differences in results between estuaries. Differences in the depth of the site may also affect the results, with shallower sites generally being more turbid. Whilst sampling is generally on the outgoing tide, differences in when sampling was done, in terms of the closeness to the high or low tide, and the distance that the sampling site was from the estuary mouth could also influence the results.

Table 28. Scores and grades for nutrients, phys-chem properties and overall water quality for estuarine sites.

Site	Unweighted Score (Grade)			Weighted Score (grade)#		
	Nutrients	Phys-Chem Properties	Water Quality*	Nutrients	Phys-Chem Properties	Water Quality
- Louisa Creek upstream^	33 (D)	31 (D)	32 (D)			
- Town Common downstream	36 (D)	32 (D)	34 (D)			
- Louisa Creek downstream	90 (A)	83 (A)	86 (A)			
Louisa Creek Estuary	53 (C)	49 (C)	51 (C)			
Bohle River Estuary	90 (A)	83 (A)	86 (A)			
Ross Creek Estuary	90 (A)	90 (A)	90 (A)			
Ross River Estuary	90 (A)	90 (A)	90 (A)			
Sandfly Creek Estuary	90 (A)	83 (A)	86 (A)			
Alligator Creek Estuary	90 (A)	83 (A)	86 (A)			
Ross Estuarine Zone+	**83 (A)<**	**79 (B)**	**81 (A)**	**88 (A)**	**86 (A)**	**87 (A)**
Althaus Creek Estuary	79 (B)	34 (D)	57 (C)			
Bluewater Creek Estuary	71 (B)	81 (A)	76 (B)			
Sleeper Log Creek Estuary	90 (A)	90 (A)	90 (A)			
- Camp Oven Creek upstream	90 (A)	68 (B)	79 (B)			
- Camp Oven Creek confluence	90 (A)	68 (B)	79 (B)			
- Camp Oven Creek downstream	90 (A)	69 (B)	79 (B)			
Camp Oven Creek Estuary	90 (A)	68 (B)	79 (B)			
- Saltwater Creek midstream	90 (A)	90 (A)	90 (A)			
- Saltwater Creek Estuary 0.6km from mouth	90 (A)	83 (A)	86 (A)			
- Saltwater Creek downstream	90 (A)	77 (B)	83 (A)			
Saltwater Creek Estuary	90 (A)	83 (A)	86 (A)			
Rollingstone Creek Estuary	63 (B)	77 (B)	70 (B)			
Crystal Creek Estuary	58 (C)	79 (B)	68 (B)			
Black Estuarine Zone	**77 (B)**	**73 (B)**	**75 (B)**	**66 (B)**	**66 (B)**	**66 (B)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

* The overall water quality score was calculated by averaging the scores for nutrients and phys-chem properties.

^ Independent site names are written in black, non-independent site names are written in brown. Non-independent site scores are averaged to create independent site scores.

[+] Zone/basin names are written in bold. Independent site scores for each indicator are averaged to create zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.
[<] When values don't appear to add up correctly this is due to floor rounding.
[#] Scores are weighted based on the proportion of measured catchment area. Weighted scores are summed to create the overall score for each zone/basin.

6.1.2.4 *Confidence scores for nutrients, physical-chemical properties, and overall water quality*

There was a 'moderate' confidence in the water quality scores for the Ross and Black estuarine zone. The score for each criterion is shown in Table 29.

Table 29. Confidence score for nutrients, phys-chem properties and overall water quality for the Ross and Black estuarine zones.

Basin	Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Representa-tiveness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Ross estuarine zone	Nutrients	2	3	2	3	1	9.6	Moderate (3)
	Phys-chem	2	3	2	3	1	9.6	Moderate (3)
	Water quality index						**9.6**	**Moderate (3)**
Black estuarine zone	Nutrients	2	3	2	3	1	9.6	Moderate (3)
	Phys-chem	2	3	2	3	1	9.6	Moderate (3)
	Water quality index						**9.6**	**Moderate (3)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.
Confidence criteria were scored 1-3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

6.1.2.5 *Comparing scores for water quality between years*

Results were compared between 2020-2021, 2019-2020, and 2018-2019 with the scores shown in Table 30.

Table 30. Comparison of estuarine water quality scores and (grades) between 2020-2021, 2019-2020, and 2018-2019.

Measure	2020-2021		2019-2020		2018-2019	
	Ross basin	Black basin	Ross basin	Black basin	Ross basin	Black basin
Nutrients	88 (A)	67 (B)	90 (A)	78 (B)	54 (C)	63 (B)
Phys-chem properties	87 (A)	66 (B)	90 (A)	49 (C)	87 (A)	70 (B)
Water quality	89 (A)	66 (B)	**90** (A)	**64** (B)	**71** (B)	**67** (B)

Scoring range: Very Poor I = 0 to <21 | Poor (D) = 21 to <41 | Moderate (C) = 41 to <61 | Good (B) = 61 to <81 | Very Good (A) = 81 to 90 (scores are capped at 90)
Overall water quality is the average of the scores for nutrient and physical-chemical (phys-chem) properties. Scores have been rounded to nearest whole number.

A comparison of the results for each site for 2020-2021, 2019-2020 and 2018-2019 are shown in Appendix H. Results from the 2017-2018 Pilot Report Card were not included in the comparison. This is because the method for calculating scores changed between the 2017-2018 and the 2018-2019 report card. Comparing between three years of data (from 2018-2019 until 2020-2021) is not sufficient to assess trends over time and more data are required to establish accurate trends and potential reasons for any trends. However, it is still interesting to look at the differences between the years.

There were higher concentrations of nutrients (equating to poorer scores) within the Ross estuarine zone in 2018-2019 than in 2019-2020. This is likely due to the flood event and higher rainfall in 2018-2019, which may have washed more nutrients into the waterways compared to the drier 2019-2020 year. Overall, the water quality was stable.

In the Black estuarine zone, the grades were very similar between 2020-2021 and 2019-2020, with the exception being that phys-chem properties were a grade higher this year (up from 'moderate' to 'good').

6.2 Habitat

The results for 2021-2020 are the same as the 2019-2020 and the 2018-2019 Report Card, as the data has not been updated since 2017.

6.2.1 Habitat extent

Habitat extent (mangrove and saltmarsh extent combined) is the only indicator measured within the habitat indicator category within the estuarine zone.

6.2.1.1 *Mangrove and saltmarsh results*

Based on spatial sampling, 6 ha (0.05%) and less than one ha (0.02%) of estuarine habitat (mangrove and saltmarsh extent combined) were lost from the Ross and Black estuarine zones respectively, giving both zones a 'good' grade (Table 31). Although the percentages of habitat lost were relatively small, mangroves and saltmarshes are habitats of critical ecological value. They provide breeding grounds for fish, invertebrates, and birds, act as filters for nutrients and sediments, reduce erosion, and help to maintain water quality (Department of the Environment and Energy, 2016).

Table 31. Scores and grades for mangroves and saltmarsh for the Ross and Black estuarine zones.

Zone	Raw data (2013-2017 data)*	Standardised Score (Grade)
	Mangrove and saltmarsh extent (% change)	Habitat
Ross estuarine zone	0.05% loss (6 ha)	**71** (B)
Black estuarine zone	0.02% loss (0.3 ha)	**77** (B)

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

Loss of mangrove or saltmarsh: ■ Very Poor (E) = >3% loss | ■ Poor (D) = 0.51-3.0% loss | ■ Moderate (C) = 0.11-0.5% loss | ■ Good (B) = 0-0.1% loss | ■ Very Good (A) = increase in mangrove or saltmarsh area

*Scores and grades were based on the percent (%) loss and percent remaining from 2013 to 2017. Scores have been rounded to nearest whole number.

Data source: [Reef 2050 Burdekin Wetland Extent]

Key messages: Mangrove and saltmarsh

- Six ha (0.05%) and less than one ha (0.02%) of mangrove and saltmarsh extent (combined) were lost from the Ross and Black estuarine zones, giving both zones a 'good' grade.
- Mangroves and saltmarshes are ecologically important habitats and thus a loss of these habitats may negatively impact the environment.
- The method for measuring mangrove and saltmarsh extent likely underestimates the amount of habitat lost, resulting in a higher score. A new, more accurate method will be used to assess and score the data in the future.

6.2.1.2 *Confidence scores*

There was very low confidence in the results for mangrove and saltmarsh extent, with the overall rank and the scores for each confidence criterion presented in Table 32. The representativeness was very low due to the method likely underestimating the amount of habitat lost.

Table 32. Confidence scores for mangrove and saltmarsh extent for the (combined) Ross and Black estuarine zones.

	Maturity (0.36)	Validation (0.71)	Represent-ativeness (2)	Directness (0.71)	Measured error (0.71)	Final score	Rank
Mangrove and saltmarsh extent	2	2	1	2	1	6.3	Very low (1)
Habitat						**6.3**	**Very low (1)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.
Confidence criteria were scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

7 Inshore marine zones

Within the inshore marine zones, water quality and habitat are the two indices scored, with the results presented in separate sections below.

7.1 Water quality

7.1.1 Monitoring sites

There are two inshore marine bays (associated with upstream freshwater and estuarine basins), which are Cleveland Bay and Halifax Bay. Monitoring occurred within the enclosed coastal, open coastal, and Magnetic Island waters (zones) in Cleveland Bay and the enclosed coastal and open coastal waters in Halifax Bay. The enclosed coastal and open coastal waters of Cleveland Bay are further separated into the inside Port sub-zone, and outside Port sub-zone. Monitoring locations are presented in Figure 14 and Figure 15.

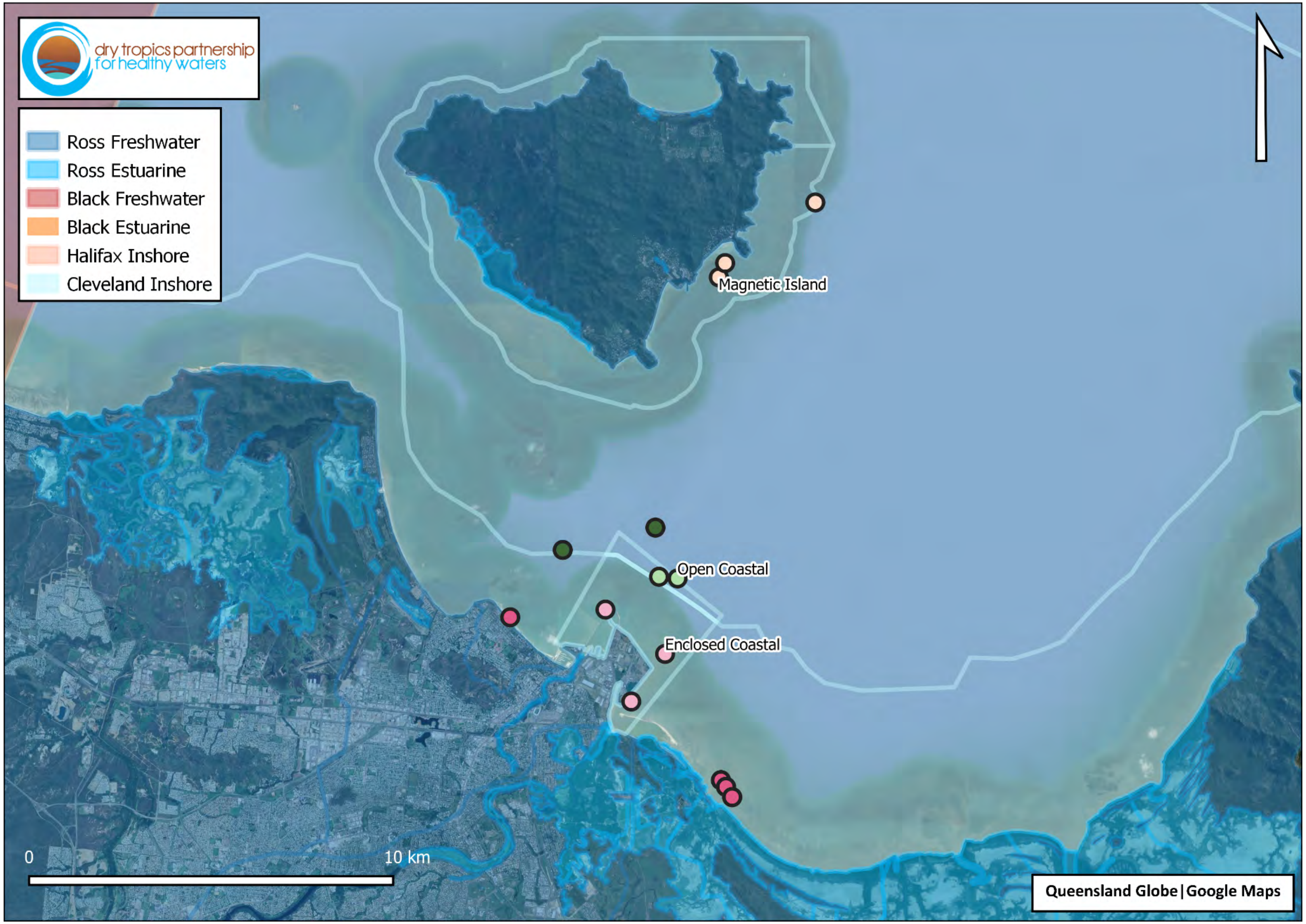


Figure 14. Monitoring sites within Cleveland Bay.

Each zone is denoted by a colour. Inside Port sub-zone are denoted by a light shade and outside Port sub-zone are denoted by a dark shade.

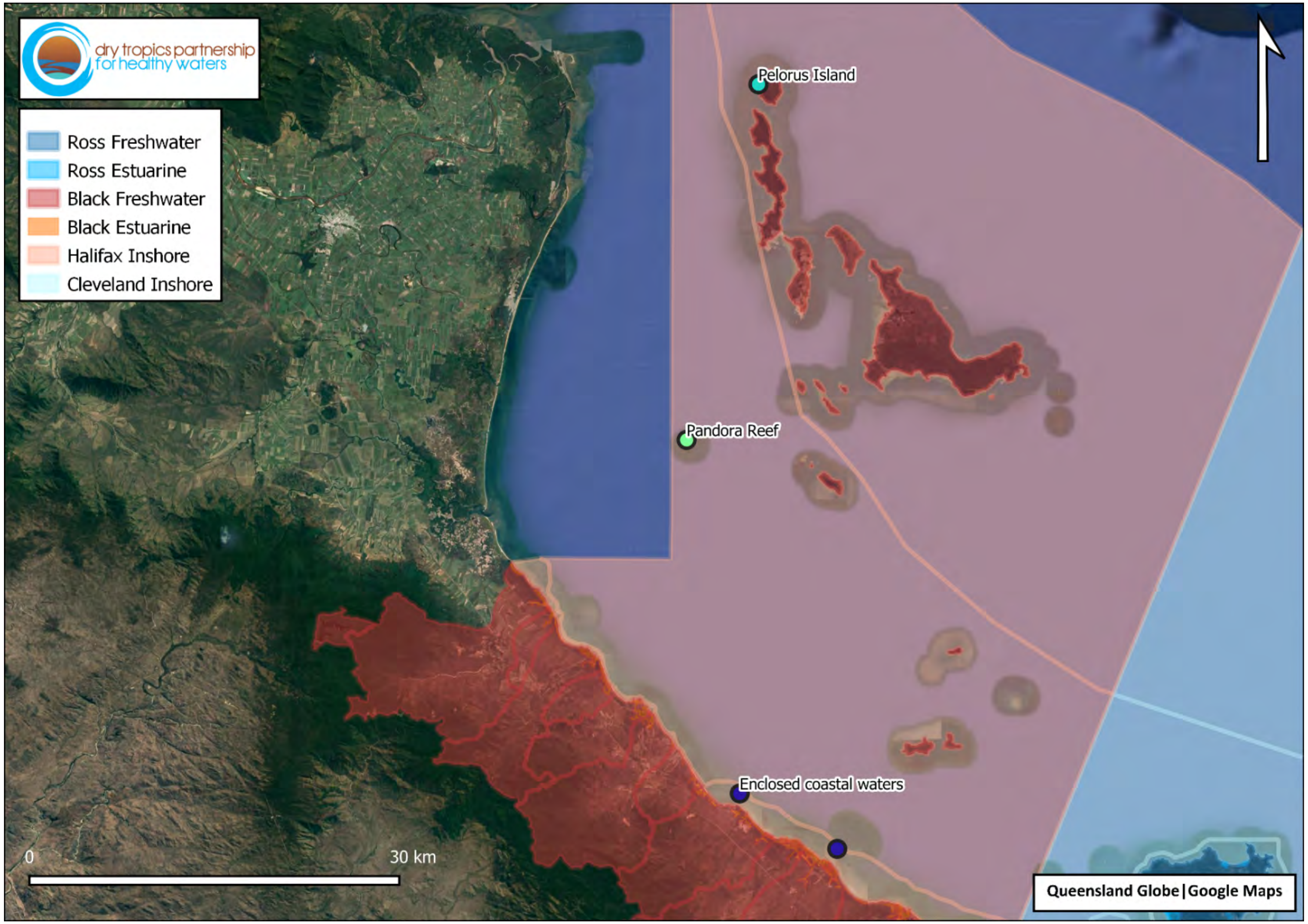


Figure 15. Monitoring sites within Halifax Bay

Sample sites in each zone are denoted by a different colour.

7.1.2 Results

Water quality scores for the two inshore marine bays were derived from three indicator categories that were calculated from eight indicators. The indicator categories are nutrients, physical-chemical (phys-chem) properties and chlorophyll *a*. The indicator category scores for each site were equally weighted. The distributions of the raw data for each indicator are presented as boxplots in Appendix I.

7.1.2.1 *Nutrients*

The scores for nutrients were derived from the average of total phosphorus (TP), particulate phosphorus (PP), particulate nitrogen (PN) and oxidised nitrogen (NOx). The results for these indicators are presented in Table 33. There is a minimum data requirement of 50% of indicators for inclusion in the scoring.

Table 33. Scores and grades for TP, PP, PN, NOx, and nutrients in the Cleveland and Halifax Bay inshore marine zones.

Zone	Score (Grade)				
	TP	PP	PN	NOx	Nutrients*
- Inside port sub-zone[^]	100 (A)	ND	ND	100 (A)	**100 (A)**
- Outside port sub-zone	100 (A)	ND	ND	0 (E)	**50 (C)**
Enclosed coastal waters Cleveland Bay	100 (A)	ND	ND	50 (C)	**75 (B)**
- Inside port sub-zone	100 (A)	ND	ND	100 (A)	**100 (A)**
- Outside port sub-zone	100 (A)	ND	ND	100 (A)	**100 (A)**
Open coastal waters Cleveland Bay	100 (A)	ND	ND	100 (A)	**100 (A)**
Magnetic Island	ND	46 (C)	27 (D)	0 (E)	**24 (D)**
Cleveland Bay[+]	**100 (A)**	**46[<] (C)**	**27 (D)**	**50 (C)**	**55 (C)**
Enclosed coastal waters Halifax Bay	100 (A)	ND	ND	22 (D)	**61 (B)**
Open Coastal (Pandora Reef) + Midshelf (Pelorus Island)[#]	ND	61 (B)	44 (C)	44 (C)	**50 (C)**
Halifax Bay	**100 (A)**	**61 (B)**	**44 (C)**	**33 (C)**	**59 (C)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND)

* The overall nutrient score was calculated by averaging the scores for TP, PP, PN, and NOx.

^ Zone names are written in black, sub-zone names are written in brown. Sub-zone scores are averaged to produce zone scores.

+ Bay names (associated with upstream basins) are written in bold. Zone scores for each indicator are averaged to produce zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.

< All scores are floor rounded.

Due to the shared sites, data for the Open Coastal (Pandora) and Midshelf (Pelorus) sites were sourced from the Wet Tropics Report Card: [Wet Tropics Technical Report 2021]

Overall, Cleveland Bay was graded as being in a 'moderate' condition with respect to nutrients. Within Cleveland Bay, enclosed coastal and open coastal waters were in a 'good', and 'very good' condition respectively, with total phosphorus and oxidised nitrogen both graded as 'very good' for 3 of 4 monitoring sites. The 4^{th} monitoring site (enclosed coastal waters outside the port sub-zone) had 'very poor' oxidised nitrogen. This was most likely caused by the combination of two factors: the proximity of a monitoring site to the Cleveland Bay Sewage Treatment Plant and variations in sampling time with respect to tidal flow for that point. At this monitoring site two samples throughout the 2020-2021 period were collected much later than the peak of high tide, and thus a greater proportion of the total tidal flow is sourced from the Sewage Treatment Plant. Magnetic Island (Geoffrey Bay) was graded ‘poor’ with respect to nutrients. Both particulate phosphorous and particulate nitrogen were consistently just above (worse) the water quality guidelines throughout the year and were graded ‘moderate’ and ‘poor’ respectively as a result. Oxidised nitrogen was also consistently above guidelines however showed more variability, peaking during the wet season, and grading ‘very poor’. The water quality guidelines for this measure are also more stringent than at any other site (see Table 34).

Overall, the nutrient grade in Halifax Bay was ‘moderate’. Nutrients in the enclosed coastal waters of Halifax were ‘good’ with total phosphorus scoring ‘very good’ and oxidised nitrogen scoring ‘poor’. For 9 of 11 months sampled, oxidised nitrogen was at or below water quality objectives. In January 2021 concentrations slightly exceeded objective concentrations and in February spiked to approximately 10x above objective levels at all sites. Particulate phosphorus grades in the open coastal (pandora) and Midshelf (pelorus) were ‘good’, particulate nitrogen, NOx, and the nutrient indicator category all graded ‘moderate’. Data for the open coastal and midshelf sites were provided by the Wet Tropics partnership team, detailed data and analysis is provided in their technical report [Wet Tropics Technical Report 2021] and methods document [Wet Tropics Methods 2021].

It is important to note that the WQOs substantially varied between zones and sub-zones at Halifax Bay and Cleveland Bay. Scores are determined by comparing site specific measurements to their respective WQOs. Comparing raw measurements between zones/sub-zones without first considering their WQOs can make them appear better/worse than they should be. Mean (or median) concentrations for TP, PP, PN, and NOx and their WQOs for each zone/sub-zone are shown in Table 34 and raw distributions are shown in Appendix I. The use of mean or median is determined by the WQOs.

Key messages: Nutrients

- Nutrients in Cleveland Bay and Halifax Bay were graded as ‘moderate’.
- Total phosphorous at all zones was graded as ‘very good’.
- Magnetic Island was graded as ‘poor’ as PP, PN and NOx were all consistently above WQOs.

Table 34. Comparison of annual mean and median values against water quality objectives for TP, PP, PN, and NOx in the Cleveland and Halifax Bay inshore marine zones.

Zone	Site	TP		PP		PN		NOx	
		Median*	WQO (mg/L)	Mean	WQO (mg/L)	Mean	WQO (mg/L)	Mean	WQO (mg/L)
Cleveland Bay	- Inside Port Sub-zone	0.002^	0.03	ND	NA	ND	NA	0.001	0.009
	- Outside Port Sub-zone	0.005	0.03	ND	NA	ND	NA	0.489	0.009
	Enclosed Coastal Cleveland								
	- Inside Port Sub-zone	0.002	0.03	ND	NA	ND	NA	0.001	0.009
	- Outside Port Sub-zone	0.002	0.02	ND	NA	ND	NA	0.001	0.002
	Open Coastal Cleveland								
	Geoffrey Bay	ND	NA	0.0030	0.0028	0.030	0.021	0.005	0.001
Halifax Bay	Enclosed coastal Halifax	0.002	0.02	ND	NA	ND	NA	0.008	0.003
	Open Coastal (Pandora Reef) + Midshelf (Pelorus Island)#	ND	NA	0.0028	0.0028	0.02	0.02	0.002	0.002

Colour key: ■ Annual median/mean is higher (worse) than the WQO | ■ Annual median/mean is lower (better) than the WQO | ■ No data (ND) indicating that the indicator is not scored for that site.

* WQOs for TP are given as a median while all other WQOs listed are given as means. Measured values are therefore provided in the associated statistic.

^ Significant figures for measured values are rounded to match the relevant WQO. If this would result in falsely reporting measured values as zero, additional significant figures are included.

Due to the shared sites, data for the Open Coastal (Pandora) and Midshelf (Pelorus) sites were sourced from the Wet Tropics Technical Report: [Wet Tropics Technical Report 2021]

7.1.2.2 *Physical-chemical properties*

The scores for physical-chemical properties were derived from the average of total suspended solids (TSS), secchi depth (Secchi), and turbidity. The results for these indicators and indicator category are presented in Table 35.

Table 35. Scores and grades for turbidity, total suspended solids (TSS), secchi depth and the overall physical-chemical (phys-chem) index within Cleveland and Halifax Bay inshore marine zones.

Site	Score (Grade)			
	TSS	Secchi	Turbidity	Phys-chem*
- Inside port sub-zone^	89 (A)	91 (A)	86 (A)	89 (A)
- Outside port sub-zone	15 (E)	96 (A)	0 (E)	37 (D)
Enclosed coastal waters Cleveland Bay	52< (C)	94 (A)	43 (C)	**63 (B)**
- Inside port sub-zone	95 (A)	100 (A)	100 (A)	98 (A)
- Outside port sub-zone	66 (B)	45 (C)	16 (E)	42 (C)
Open coastal waters Cleveland Bay	81 (A)	72 (B)	58 (C)	**70 (B)**
Magnetic Island	86 (A)	77 (B)	55 (C)	**73 (B)**
Cleveland Bay+	**70 (B)**	**82 (A)**	**51 (C)**	**68 (B)**
Enclosed coastal Halifax Bay	81 (A)	ND	100 (A)	**91 (A)**
Open Coastal (Pandora Reef) + Midshelf (Pelorus Island)#	76 (B)	ND	67 (B)	**71 (B)**
Halifax Bay	**78 (B)**	**ND**	**83 (A)**	**80 (B)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND)

* The overall phys-chem score was calculated by averaging the scores for turbidity, TSS and secchi depth.

^ Zone names are written in black, sub-zone names are written in brown. Sub-zone scores are averaged to produce zone scores.

+ Bay/basin names are written in bold. Zone scores for each indicator are averaged to produce zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.

< All scores are floor rounded.

Due to the shared sites, data for the Open Coastal (Pandora) and Midshelf (Pelorus) sites were sourced from the Wet Tropics Report Card: [Wet Tropics Technical Report 2021]

Overall, Cleveland Bay, and each of its zones were in a 'good' condition with respect to phys-chem properties. However, the open coastal outside port sub-zone was graded 'very poor' for turbidity. This may be caused by the proximity of a monitoring logger to the sea channel, with wind resuspension, current, and boat traffic contributing to increased turbidity. Similarly, turbidity at the Magnetic Island site received a 'moderate' grade, whilst secchi depth received 'good' and TSS received 'very good'. This is due to the turbidity being sourced from a continuous monitoring logger whilst TSS and secchi depth is the average of 10 samples collected over the reporting period. The turbidity for the same times as the 10 samples averages to a grade of 'very good'.

The enclosed coastal outside port sub-zone was graded 'very poor' for TSS and Turbidity, however, was graded 'very good' for Secchi. The difference in these results is due to Secchi depth not being monitored at all sample sites.

Overall, the phys-chem properties indicator category for Halifax Bay was graded 'good', with the enclosed coastal zone grading 'very good' for every indicator and indicator category, and the open coastal and midshelf zones scoring 'good' (Table 35).

It is important to note that the WQOs substantially varied between zones and sub-zones at Halifax Bay and Cleveland Bay. Scores are determined by comparing monitoring sites measurements to their respective WQOs. Comparing raw measurements between zones/sub-zones without first considering their WQOs can make them appear better/worse than they should be. Mean concentrations for TSS, mean depth for Secchi Depth, and median Turbidity and their WQOs for each site are shown in Table 36 and raw distributions are shown in Appendix I.

Key messages: Physical-chemical properties

- Phys-chem properties in Cleveland Bay and Halifax Bay were graded as 'good', all zones also received a 'good' grade.
- Turbidity and TSS grades ranged from 'very good' to 'very poor' within Cleveland Bay.
- There is naturally, highly variable water quality within Cleveland Bay that can significantly influence the results.

Table 36. Comparison of annual mean and median values and water quality objectives for TSS, Secchi, and Turbidity in the Cleveland and Halifax Bay inshore marine zones.

Zone	Site	TSS		Secchi		Turbidity	
		Mean	WQO (mg/L)	Mean	WQO (m)	Median *	WQO (NTU)
Cleveland Bay	- Inside Port Sub-zone	13.3^	22	1.7	1	3.1	4.9
	- Outside Port Sub-zone	25.1	15	1.9	1	11.9	4.9
	Enclosed Coastal Cleveland						
	- Inside Port Sub-zone	11.9	22	2.3	1	2.1	4.9
	- Outside Port Sub-zone	8.9	10	2.5	3	5.0	3
	Open Coastal Cleveland						
	Geoffrey Bay	2.89	3.7	4.0	3	2.9	2.7
Halifax Bay	Enclosed coastal Halifax	10.4	15	ND	NA	2.4	6
	Open Coastal (Pandora Reef) + Midshelf Coastal (Pelorus Island)#	1.6	2	ND	NA	1.4	1.5

Colour key: ■ Annual median/mean is higher (worse) than the WQO | ■ Annual median/mean is lower (better) than the WQO, except for secchi, where annual medians being higher than the WQO is better | ■ No data (ND), indicating that the indicator is not scored for that site.

* WQOs for Turbidity are given as a median while all other WQOs listed are given as means. Measured values are therefore provided in the associated statistic.

^ Measured values are rounded to one significant figure.

Due to the shared sites, data for the Open Coastal (Pandora) and Midshelf (Pelorus) sites were sourced from the Wet Tropics Report Card: [Wet Tropics Technical Report 2021]

7.1.2.3 *Chlorophyll a*

Chlorophyll *a* was graded as 'very good' within Cleveland Bay and Halifax Bay, with all Cleveland zones graded as 'very good', and all Halifax zones graded as 'good' or 'very good'. The results are presented in Table 37, as well as the annual means and WQOs for chlorophyll *a*.

Table 37. Scores, grades, mean, and water quality objectives for Chlorophyll-*a* in the Cleveland and Halifax Bay inshore marine zones.

Site	Score (Grade)	Mean	WQO (ug/L)
- Inside port sub-zone^	ND	NA	NA
- Outside port sub-zone	95 (A)	1.4	2.6
Enclosed coastal waters Cleveland Bay	95 (A)		
- Inside port sub-zone	ND	NA	NA
- Outside port sub-zone	ND	NA	NA
Open coastal waters Cleveland Bay	ND		
Magnetic Island	82 (A)	0.58	0.84
Cleveland Bay+	**88< (A)**		
Enclosed coastal Halifax Bay	100 (A)	0.85	2.0
Open Coastal (Pandora Reef) + Midshelf (Pelorus Island)#	64 (B)	0.11	0.45
Halifax Bay	**82 (A)**		

Scoring range for scores and grades: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND).

Colour key for mean and WQOs: ■ Annual mean is higher (worse) than the WQO | ■ Annual mean is lower (better) than the WQO | ■ No data (ND), indicating that the indicator is not scored for that site.

^ Zone names are written in black, sub-zone names are written in brown. Sub-zone scores are averaged to calculate zone scores.

+ Bay/basin names are written in bold. Zone scores for each indicator are averaged to calculate zone indicator scores. Zone indicator scores are averaged to calculate zone indicator category scores.

< All scores are floor rounded.

Due to the shared sites, data for the Open Coastal (Pandora) and Midshelf (Pelorus) sites were sourced from the Wet Tropics Report Card: [Wet Tropics Technical Report 2021]

Key messages: Chlorophyll *a*

- Chl *a* in Cleveland Bay, Halifax Bay, and all zones was graded as 'good' or 'very good'.
- Chl *a* is currently not measured at all locations.

7.1.2.4 *Overall water quality*

Overall, Cleveland Bay and Halifax Bay both had 'good' water quality grades. Summary scores and grades for water quality are presented in Table 38.

Table 38. Scores and grades for nutrients, phys-chem properties and overall water quality in the Cleveland and Halifax Bay inshore marine zones.

Site	Scores (grades)			
	Nutrients	Phys-chem	Chl *a*	Water Quality*
- Inside port sub-zone^	100 (A)	89 (A)	ND	**94 (A)**
- Outside port sub-zone	50 (C)	37 (D)	95 (A)	**60 (B)**
Enclosed coastal Cleveland Bay	75 (B)	63 (B)	95 (A)	**77 (B)**
- Inside port sub-zone	100 (A)	98 (A)	ND	**99 (A)**
- Outside port sub-zone	100 (A)	42 (C)	ND	**71 (B)**
Open coastal Cleveland Bay	100 (A)	70 (B)	ND	**85 (A)**
Magnetic Island	24 (D)	73 (B)	82 (A)	**59 (C)**
Cleveland Bay+	**58< (C)**	**68 (B)**	**88 (A)**	**71 (B)**
Enclosed coastal Halifax Bay	61 (B)	91 (A)	100 (A)	**84 (A)**
Open Coastal (Pandora Reef) + Midshelf (Pelorus Island)#	50 (C)	71 (B)	64 (B)	61 (B)
Halifax Bay	**59 (C)**	**80 (B)**	**82 (A)**	**73 (B)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND)

* The overall water quality score was calculated by averaging the scores for nutrients and phys-chem properties.

^ Zone names are written in black, sub-zone names are written in brown. Sub-zone scores are averaged to calculate zone scores.

+ Bay/basin names are written in bold. Zone scores for each indicator are averaged to calculate zone indicator scores. Zone indicator scores are averaged to calculate zone indicator category scores.

< When values don't appear to add up correctly this is due to floor rounding.

Due to the shared sites, data for the Open Coastal (Pandora) and Midshelf (Pelorus) sites were sourced from the Wet Tropics Report Card: [Wet Tropics Technical Report 2021]

7.1.2.5 *Confidence scores*

Overall, there was low confidence in the results due to limited spatial sampling within both bays. The scores for each confidence criterion are shown in Table 39. At each site, there is high confidence in the data, as the sites are frequently monitored. However, across each zone and the entire bay there is low confidence. For example, all enclosed coastal monitoring sites within Cleveland Bay are within only an 11 km section of water, near the coastline and immediately offshore of the Townsville CBD area. The coastline within the Cleveland Bay enclosed coastal zone stretches approximately 58 km and thus there is no sampling within a large part of the enclosed coastal waters. It is noted that there is substantially less development in the area not monitored and thus the current monitoring may capture most of the area affected by human impacts. However more sampling, both along the coast and further offshore, would enable a more accurate understanding of the water quality within the inshore area.

Table 39. Confidence scores for nutrients, phys-chem properties and water quality for the Cleveland and Halifax Bay inshore marine zones.

	Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Cleveland Bay	Nutrients	2	3	1	3	1	7.6	Low (2)
	Phys-chem	2	3	1	3	1	7.6	Low (2)
	Chlorophyll-*a*	2	3	1	3	1	7.6	Low (2)
	Overall water quality						**7.6**	**Low (2)**
Halifax Bay	Nutrients	2	3	1	3	1	7.6	Low (2)
	Phys-chem	2	3	1	3	1	7.6	Low (2)
	Chlorophyll-*a*	2	3	1	3	1	7.6	Low (2)
	Overall water quality						**7.6**	**Low (2)**

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

Confidence criteria were scored 1-3 and weighted by the value identified in parenthesis. Weighted scores were summed to produce a final score (4.5 – 13.5). Final scores were ranked from 1 to 5 (very low to very high).

7.1.2.6 *Comparing scores for water quality between years*

The scores differed to the scores from last year, with the scores for 2020-2021, 2019-2020, and 2018-2019 presented in Table 40. A comparison of the results for each zone for 2020-2021 and 2019-2020 are shown in Appendix J. Scores were not compared to the 2017-18 scores as the water quality objectives (WQOs) used in 2017-18 differed to those used in the subsequent three report cards.

For 2020-2021, the overall water quality and every indicator category in Cleveland Bay declined from the previous year. The decline was driven predominantly by the nutrients indicator category which in turn was influenced significantly by high NOx levels at Magnetic Island and to a lesser extent in the enclosed coastal waters. The overall water quality in Halifax Bay was graded as ‘good’ and was slightly better than the previous year. Although both the nutrient and Chl *a* indicator categories improved year on year, increasing to a higher grade, the phys-chem indicator category declined to a lower grade driven predominantly by ‘moderate’ turbidity and TSS grades at the open coastal and midshelf sites.

There were similar climatic conditions between 2019-2020 and 2020-2021, with no major weather events in either year that would be contributing to the differences in scores.

Table 40. Comparison of scores and grades for overall water quality in the Cleveland and Halifax Bay inshore marine zones between 2020-2021, 2019-2020 and 2018-2019.

Measure	2020-2021		2019-2020		2018-2019	
	Cleveland Bay	Halifax Bay	Cleveland Bay	Halifax Bay	Cleveland Bay	Halifax Bay
Nutrients	58 (C)	59 (C)	71 (B)	39 (D)	2 (E)	6 (E)
Phys-chem	66 (B)	80 (B)	75 (B)	98 (A)	66 (B)	64 (B)
Chl *a*	88 (A)	82 (A)	93 (A)	73 (B)	80 (B)	61 (B)
Water quality	**71 (B)**	**73 (B)**	**80 (B)**	**70 (B)**	**55 (C)**	**43 (C)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

Scores have been rounded to nearest whole number for 2018-2020, and floor rounded for 2020-2021.

7.2 Habitat

Coral and seagrass were the two indicator categories scored within the habitat index.

7.2.1 Coral

7.2.1.1 *Monitoring programs and monitoring sites*

Coral data within the Dry Tropics inshore marine zone was primarily collected by the Great Barrier Reef Marine Monitoring Program (MMP), and the Australian Institute of Marine Science's Long-term Monitoring Program (LTMP). Additional sampling was conducted by the citizen scientist group Reef Check Australia (RCA). Coral was monitored primarily between August 2020 and April 2021. Coral was scored within both Cleveland Bay and Halifax Bay. Within Cleveland Bay, Geoffrey Bay reef was sampled by the MMP. Within Halifax Bay, MMP sampled four reefs, LTMP sampled at two reefs, and RCA sampled coral cover at three reefs. The locations of the reefs monitored are shown in Figure 16 and Figure 17. RCA also surveyed coral cover at five reefs surrounding Magnetic Island.

Figure 16. Sampling locations of inshore reefs within the Cleveland Bay inshore marine zone.

Each reef is denoted by a different colour.

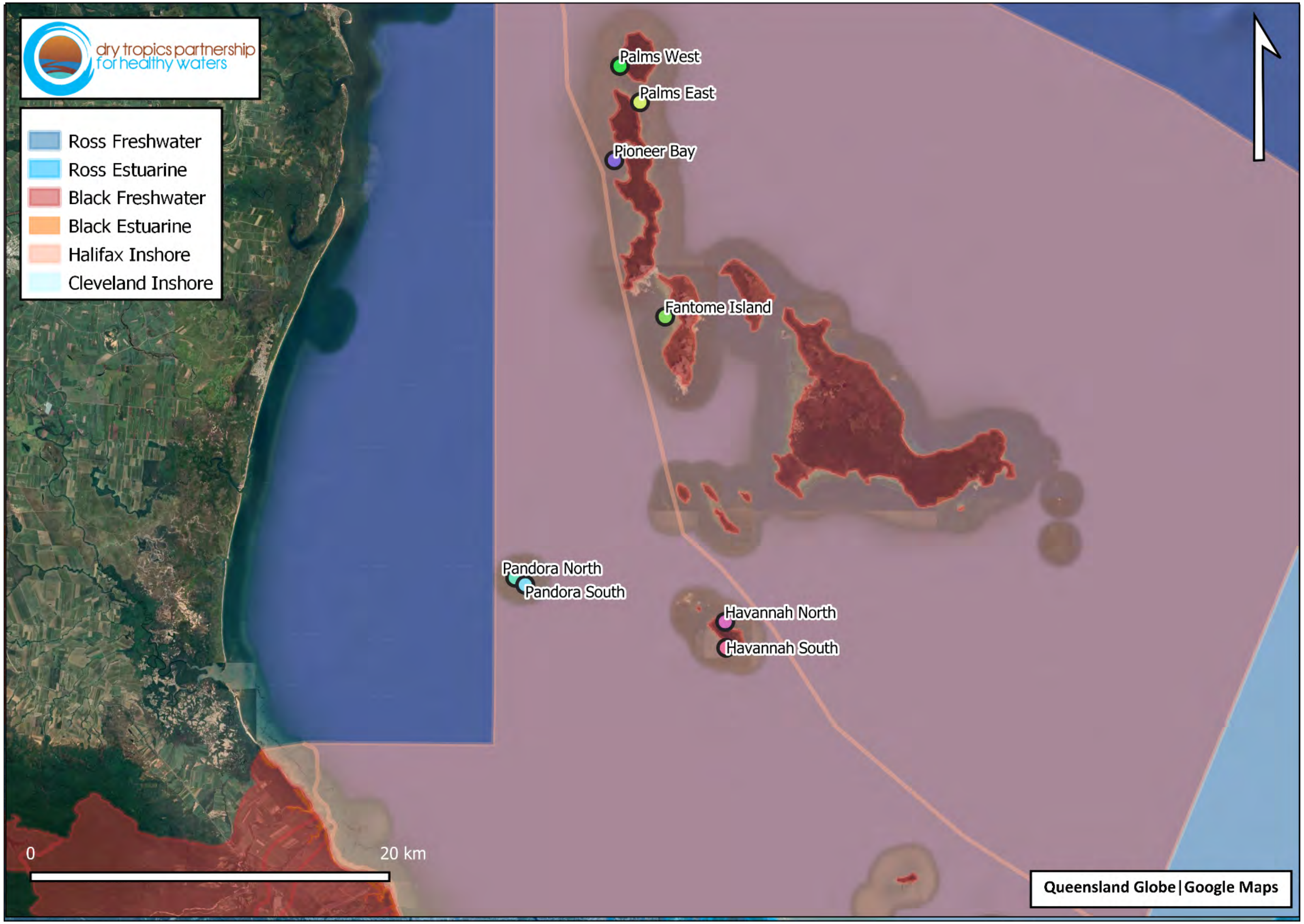


Figure 17. Sampling locations of inshore reefs within the Halifax Bay inshore zone

Each reef is denoted by a different colour

7.2.1.2 *Results*

Overall, coral within Cleveland Bay was in a 'poor' condition, with the scores for each indicator shown in Table 41. Geoffrey Bay was the only reef for which data was available for 2021 under the MMP, and thus the scores for all of Cleveland Bay are based on this single reef. The coral cover indicator improved to 'moderate', as coral cover had recovered from losses caused by high water temperatures in 2020, reflected in a 'moderate' grade for coral cover change indicator. Further, the 'moderate' grade for composition shows that the relative proportion of corals sensitive to poor water quality has remained stable since monitoring began in 2005. Limiting the score for Geoffrey Bay was the continued high cover of macroalgae leading to a 'very poor' grade for this indicator and suggesting high availability of nutrients. The high cover of macroalgae is likely to also contribute to the 'poor' grade for juvenile corals which struggle to settle and survive among beds of macroalgae.

Overall, Halifax Bay was in a 'moderate' condition, with two of the six sampled reefs being in a 'good' condition, two in a 'moderate' condition and two in a 'poor' condition (Table 41). The scores for each indicator substantially varied between reefs, ranging from grades of 'very good' to 'very poor'. For example, macroalgae was highly variable across reefs, grading 'very poor' at the four reefs closest to the coast, but receiving 'very good' grades at Palms East and Palms West. Macroalgae is generally associated with poor water quality and this result reflects the gradient of better water quality with increased distance from the coast. Composition scores also varied substantially between reefs, with Havannah North and Palms East being graded as 'very good', whilst Palms West was graded as 'very poor'. The 'very poor' composition grade at Palms West reflects limited recovery of fast-growing corals of the genus *Acropora* and a shift in community composition to a higher proportion of the genus *Pocillopora*. Juvenile density was the most consistent indicator, scoring 'poor' at most reefs, the exceptions were Palms West and Havannah North, where juvenile density was graded as 'moderate' and 'very good' respectively. Four of the six reefs also graded 'poor' for cover change, indicating slow recovery of coral cover in recent years. The exceptions were Palms East and Havannah North where coral cover has tended to recover rapidly in recent years. However, it should be noted that the cover change indicator only considers change during periods that reefs were not exposed to severe stress associated with an acute event, such as the high water temperature in 2020 that caused coral bleaching.

Table 41. Scores and grades for coral indicators and the coral indicator category for Cleveland and Halifax Bay inshore marine zones.

Reef	Program	Composition of hard corals	% Coral Cover	% Change hard corals	Juvenile density	Macroalgae	Coral Indicator
Alma Bay	RCA	ND	49 (C)	ND	ND	ND	ND
Florence Bay	RCA	ND	30 (D)	ND	ND	ND	ND
Geoffrey Bay	MMP RCA	50 (C)	47 (C)	60 (C)	23 (D)	0 (E)	36 (D)
Middle Reef	RCA	ND	71 (B)	ND	ND	ND	ND
Nelly Bay	RCA	ND	44 (C)	ND	ND	ND	ND
Cleveland Bay	**MMP RCA**	**50 (C)**	**48 (C)**	**60 (C)**	**23 (D)**	**0 (E)**	**36 (D)**
Fantome Island (Juno Bay)	RCA	ND	35 (D)	ND	ND	ND	ND
Havannah	MMP	50 (C)	43 (C)	36 (D)	26 (D)	0 (E)	31 (D)
Havannah North	LTMP	100 (A)	19 (E)	100 (A)	89 (A)	0 (E)	62 (B)
Orpheus Island (Pioneer Bay)	RCA	ND	55 (C)	ND	ND	ND	ND
Palms East	MMP	100 (A)	66 (B)	62 (B)	29 (D)	100 (A)	71 (B)
Palms West	MMP RCA	0 (E)	56 (C)	38 (D)	50 (C)	100 (A)	49 (C)
Pandora	MMP	75 (B)	22 (D)	39 (D)	36 (D)	36 (D)	42 (C)
Pandora North	LTMP	50 (C)	75 (B)	38 (D)	33 (D)	0 (E)	39 (D)
Halifax Bay	**LTMP MMP RCA**	**62 (B)**	**47 (C)**	**52 (C)**	**44 (C)**	**39 (D)**	**49 (C)**

Scoring range: ■ Very Poor = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND)

The scores for the coral indicator category were calculated by averaging the scores for each indicator. The overall scores for Cleveland Bay and Halifax Bay are shown in bold. The overall zone scores for percent (%) coral cover are weighted by monitoring program. Note that these scores are not a direct reflection of the underlying measured value, but rather just a standardised score based on the number of sampling points. Numbers have been rounded to nearest whole number.

RCA = Reef Check Australia, MMP = Marine Monitoring Program, LTMP = Long-Term Monitoring Program.

Key messages: Coral

- Inshore coral communities were graded as 'poor' and 'moderate' within Cleveland Bay and Halifax Bay respectively.
- Composition of hard corals was 'moderate' to 'very good' at most sampled reefs, indicating maintenance of coral community composition since surveys began in ~2005. Palms West is the exception.
- Macroalgae was highly variable across reefs, grading 'poor' or 'very poor' at the reefs closest to the coast and 'very good' at Palms East and Palms West.
- Juvenile density, an indicator of potential reef recovery, graded 'poor' at most reefs with the high cover of macroalgae at many reefs likely to be a contributing factor.

- Cover change scores, an indicator for recent reef recovery, graded 'poor' at four of the six reefs in Halifax Bay, but this contrasted 'good' or 'very good' grades at Palms East and Havannah North.

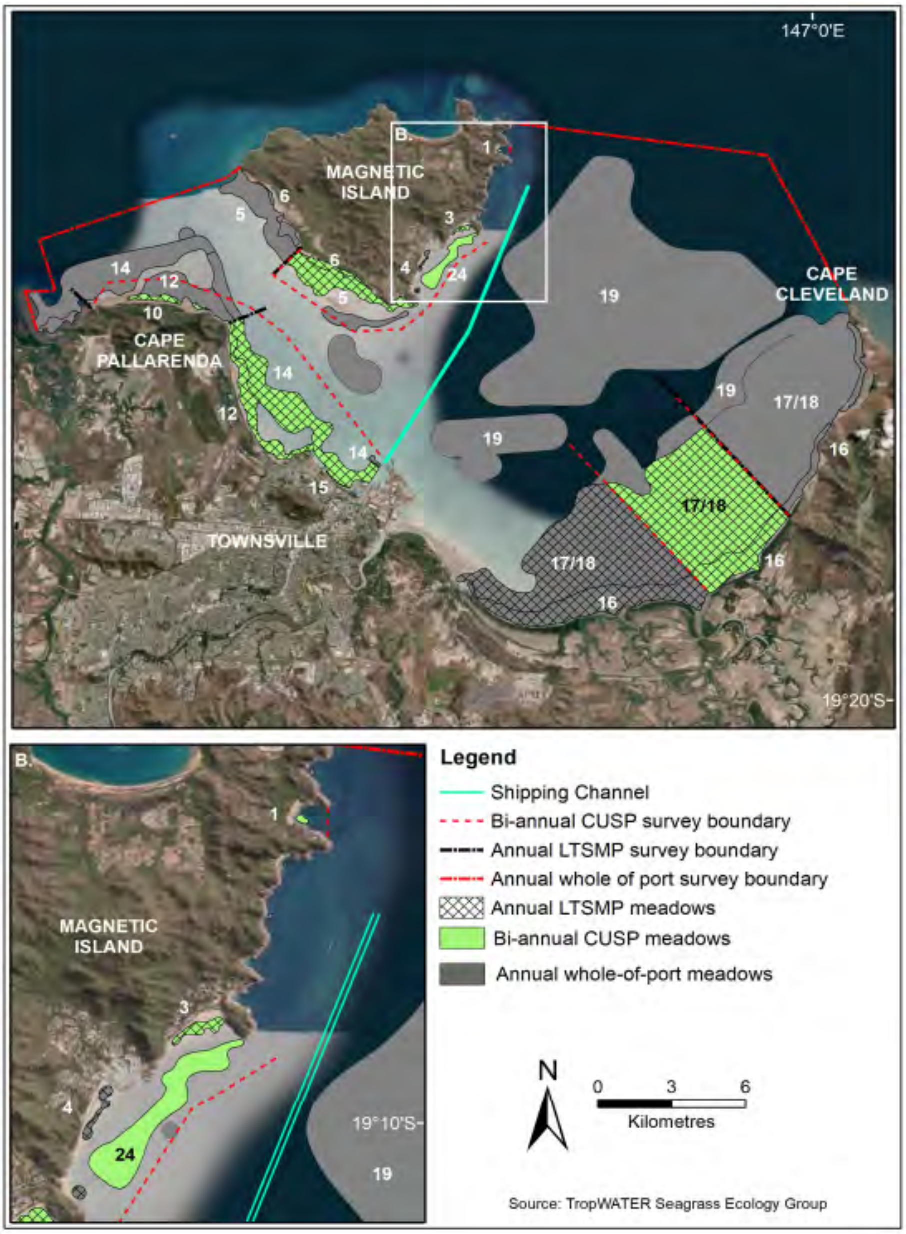
7.2.2 Seagrass

Data on seagrass condition was obtained from the Port of Townsville Long-term Seagrass Monitoring Program (LTSMP), with monitoring conducted by James Cook University (JCU). Ten seagrass meadows were monitored for the LTSMP during the dry season in September-October 2020. The Port of Townsville is also currently upgrading and expanding the port and as part of this work, undertook additional sampling of seagrass meadows in April 2021 (program called the Channel Upgrade Seagrass Program (CUSP)). However, CUSP data will not be included in this years (2020-2021) Technical Report as CUSP survey data reports on a calendar year. Instead, data will be included in the next technical report. The data is subset of the Long-term Seagrass Monitoring Program and does not change the ratings/scoring of the long-term meadows. The locations of the monitored seagrass meadows as part of LTSMP and CUSP are shown in Figure 18 and a broad overview of the two programs, including sites, monitoring, and frequency of surveys, are presented in Table 42. No data were available on seagrass condition within Halifax Bay, and this will be denoted in grey in the Report Card.

7.2.2.1 *Results*

The results for the LTSMP are shown in Table 43. Only the LTSMP scores are comparable with previous report card scores and these results will be discussed, CUSP data will be included in the subsequent Technical Report. It is noted that the lowest indicator score for each site is used as the overall score for that site. The Dry Tropics report cards have only been reporting on seagrass for four years, with the scores for each meadow presented in Appendix K. Four years of data is insufficient to assess trends, however there is long term data on seagrass data and this information is used below to discuss trends in seagrass condition.

Overall, Cleveland Bay was in a 'good' condition for seagrass condition, with the scores shown in Table 43. The species composition was graded as 'good' or 'very good' for all ten meadows, whilst the area indicator was graded as 'good' or 'very good' for nine of the 10 meadows sampled. Biomass was generally the lowest scoring indicator at most sites; however, the indicator was still in a 'good' or 'very good' condition at all meadows.



Meadows:

1 = Florence Bay^

3 = Geoffrey Bay

4 = Nelly Bay

5 = Cockle/Picnic Bay

6 = Cockle Bay

10 = Shelly Beach

12 = Rowes Bay

14 = Pallarenda inc. Virago Shoal

15 = Strand

16 = Cleveland Bay

17/18 = Cleveland Bay

19 = Deep-water seagrass^

24 = Geoffrey Bay^

Figure 18. Location and survey extent of meadows assessed in annually surveyed LTSMP meadows, at the whole-of-port of port scale and the biannually surveyed CUSP.

Source: Adapted from Bryant & Rasheed (2018) and McKenna et al (2021).

^Meadows were only sampled for CUSP and data will not be presented for the 2020-2021 technical report.

Table 42. Overview of the Long-term Seagrass Monitoring Program (LTSMP) and Channel Upgrade Seagrass Program (CUSP) monitoring meadows.

Monitoring Location (Meadow ID)	LTSMP	Survey frequency for LTSMP	CUSP	Survey frequency for CUSP	Seagrass Meadow Depth	Monitoring History
Florence Bay (1)^	No	-	Yes	Biannually	Intertidal/ shallow subtidal	Limited: (2007, 08, 16, 19)
Geoffrey Bay (3)	Yes	Annually	Yes	Biannually	Intertidal	Detailed Annual >10 years
Nelly Bay (4)	Yes	Annually	No	-	Intertidal/ shallow subtidal	Detailed Annual >10 years
Geoffrey Bay (24)^	No	-	Yes	Biannually	Subtidal	Limited: (2013, 16, 19)
Cockle/Picnic Bay (5)	Yes	Annually	Yes	Biannually	Intertidal/ shallow subtidal	Detailed Annual >10 years
Cockle Bay (6)	Yes	Annually	Yes	Biannually	Intertidal	Detailed Annual >10 years
Shelly Beach (10)	Yes	Annually	Yes	Biannually	Intertidal	Detailed Annual >10 years
Rowes Bay (12)	Yes	Annually	Yes	Biannually	Intertidal/ shallow subtidal	Detailed Annual >10 years
Pallarenda inc. Virago Shoal (14)	Yes	Annually	Yes	Biannually	Shallow subtidal	Detailed Annual >10 years
Strand (15)	Yes	Annually	No	-	Intertidal/ shallow subtidal	Detailed Annual >10 years
Cleveland Bay (16)	Yes	Annually	Yes (meadow section)	Biannually	Intertidal	Detailed Annual >10 years
Cleveland Bay (17/18)	Yes	Annually	Yes (meadow section)	Biannually	Subtidal	Detailed Annual >10 years
Deep-water seagrass: Cleveland Bay to Magnetic Is. (19)^	No	Periodically, before CUSP began	Yes	Annually	Subtidal	Limited: (2007, 08, 13, 16, 19, 20)

Adapted from McKenna et al. (2021).

^Meadows were only sampled for CUSP and data will not be presented for the 2020-2021 technical report.

Table 43. Scores and grades for seagrass indicators and the seagrass indicator category for Cleveland Bay.

Location	Region	Site (meadow)	Standardised Score (Grade)			
			Biomass	Area	Species composition	Seagrass indicator category*
Geoffrey Bay	Magnetic Island	3	67 (B)	87 (A)	100# (A)	67 (B)
Nelly Bay	Magnetic Island	4	82 (B)	95 (A)	100 (A)	82 (B)
Cockle/Picnic Bay	Magnetic Island	5	70 (B)	77 (B)	99 (A)	70 (B)
Cockle Bay	Magnetic Island	6	70 (B)	75 (B)	91 (A)	70 (B)
Shelly Beach	Cape Pallarenda – Strand	10	84 (B)	50 (C)	78 (B)	50 (C)
Rowes Bay	Cape Pallarenda – Strand	12	85 (A)	99 (A)	83 (B)	84 (B)
Rowes Bay	Cape Pallarenda – Strand	14	68 (B)	71 (B)	93 (A)	68 (B)
Strand meadow	Cape Pallarenda – Strand	15	74 (B)	67 (B)	92 (A)	67 (B)
Cleveland Bay	Cleveland Bay	16	78 (B)	80 (B)	93 (A)	78 (B)
Cleveland Bay	Cleveland Bay	17/18	75 (B)	95 (A)	98 (A)	75 (B)
		Cleveland Bay				**71 (B)^**

Scoring range: ■ Very Poor I = 0 to <25 | ■ Poor (D) = 25 to <50 | ■ Moderate © = 50 to <65 | ■ Good (B) = 65 to <85 | ■ Very Good (A) = 85 to 100

*The score for the seagrass indicator category is the lowest score of the three indicators (Biomass, Area, Species Composition). This rule applies except when species composition is the lowest score and then the overall seagrass score is calculated as the average across the two lowest scoring indicators.

^The overall score for Cleveland Bay is averaged from the seagrass indicator category scores for each site.

#Note that the scoring range (0-100) for seagrass is different compared to other indicators. Scores have been rounded to nearest whole number.

Adapted from McKenna et al (2021) (Tables 5 and A3), based on sampling of meadows as part of the Long-term Seagrass Monitoring Program (October 2020).

7.2.2.1.1 Magnetic Island seagrass meadows

"Above-ground biomass in all Magnetic Island meadows increased between 2019 and 2020. The greatest change in condition was in the intertidal *Halodule uninervis* meadow in Geoffrey Bay (meadow 3)" (McKenna, et al., 2021). This meadow was in 'poor' condition in 2019, due to a 'poor' biomass grade which was likely a result from the 2019 floods, with a lag effect seen in the biomass condition in the 2019 survey (pers. comm. Alana O'Brien, 2022). However, "between 2019 and 2020 the meadow substantially increased in biomass, increasing to 'good' condition" (McKenna, et al., 2021). The area of the subtidal Geoffrey Bay *H. spinulosa* meadow increased to its largest recorded area since monitoring began in 2007. "In 2019, this meadow only occupied the Geoffrey Bay area. In 2020, the meadow expanded from Geoffrey Bay down to Nelly Bay. Species composition at all meadows was also above baseline conditions, with a species mix that reflected a 'very good' condition in all meadows" (McKenna, et al., 2021).

7.2.2.1.2 Cape Pallarenda Strand seagrass meadows

"All four meadows in this area were in a 'moderate'[1] or 'good' condition. Seagrass above-ground biomass increased in all meadows between 2019 and 2020, with the biomass condition grade for meadows 12 and 14 (predominantly subtidal meadows) increasing from 'moderate' in 2019 to 'good' or 'very good' in 2020 (Table 43, Figure 18). This was the first time in three consecutive years that

[1] 'Moderate' condition is equivalent to the 'satisfactory' condition noted in the report by McKenna et al (2021)

biomass condition had improved in the subtidal *H. spinulosa* meadow. Species composition for all four meadows was in ‘good’ or ‘very good’ condition in 2020. Of note, this is the first time since 2017 that species composition within the intertidal *Zostera muelleri* meadow (10) at Shelley Beach has improved to a ‘good’ condition. It is worth noting that there was a decrease in the presence of *Z. muelleri*, the dominant species in the meadow, in 2020, and an equivalent increase in less persistent species” (McKenna, et al., 2021).

7.2.2.1.3 Cleveland Bay seagrass meadows

“There are two monitoring meadows in Cleveland Bay: an intertidal *Z. muelleri* meadow (16) and the shallow subtidal *H. uninervis* meadow. These meadows are the largest coastal meadows in Townsville, …with both meadows in ‘good’ or better condition in 2020” (McKenna, et al., 2021).

“At the intertidal *Z. muelleri* meadow (16), above-ground biomass declined in 2019 to below the long-term average to a ‘moderate’ condition. In 2020, biomass increased to above the long-term average to be in ‘good’/’very good’ condition again, similar to previous years. The area of this meadow has remained relatively constant since 2012 with a significant spatial footprint near to or above the long-term average. Species composition has been in ‘very good’ condition since 2014” (McKenna, et al., 2021). The decline in 2019 is thought to be because of the flood.

“At the adjacent subtidal Cleveland Bay meadow (meadow 17/18), above-ground biomass rebounded to be in ‘good’ condition in 2020. The area of this meadow has also been increasing over the last couple of years to recording one of the highest areas in the program in 2020 since 2007. Much of this increase has come from the meadow expanding at the deeper margins. In 2018 the deepest seagrass found in this meadow was 4.26m (below mean sea level); 2019 it was 4.69m, and in 2020 seagrass was found to 4.98m” (McKenna, et al., 2021).

Key messages: Seagrass

- Seagrass Overall in Cleveland Bay was graded ‘good’.
- Species composition was graded ‘good’ or ‘very good’ at all ten meadows.
- Meadow area was ‘good’ or ‘very good’ for nine of the ten meadows.
- Biomass was generally the lowest scoring indicator; however, was still graded as ‘good’ or ‘very good’ condition at all meadows.
- Seagrasses had recovered from the impacts of the February 2019 floods.
- Seagrass in meadow 17/18 has expanded consistently to form one of the largest meadows recorded by the program. Much of the expansion has occurred at the deeper margins, indicating there is sufficient water clarity to allow deeper growth.

7.2.3 Overall habitat score

Overall, the habitat index received a ‘moderate’ grade for both Cleveland Bay and Halifax Bay, with the overall scores presented in Table 44.

Table 44. Scores and grades for coral, seagrass and overall habitat for Cleveland Bay and Halifax Bay inshore marine zones.

Site	Standardised Score (Grade)		
	Coral	Seagrass	Habitat index*
Cleveland Bay	36 (D)	72 (B)	**54 (C)**
Halifax Bay	49 (C)	ND	**49 (C)**

Scoring range for coral: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND)
Scoring range for seagrass: ■ Very Poor I = 0 to <25 | ■ Poor (D) = 25 to <50 | ■ Moderate (C) = 50 to <65 | ■ Good (B) = 65 to <85 | ■ Very Good (A) = 85 to 100 | ■ No data (ND)
*Habitat scores are averages of the scores for coral and seagrass. Scores have been rounded to nearest whole number.

7.2.4 Confidence scores

There was a high confidence in the habitat index results for both Cleveland and Halifax bays, with the confidence result presented in Table 45. The score for each confidence criterion is shown in Table 45. Most seagrass beds within Cleveland Bay were monitored, resulting in a high score (3) for representativeness. The representativeness for coral within Cleveland Bay was rated at two because each site was only surveyed once every two years, rather than each year. Within Halifax Bay, sampling by the MMP and LTMP occurred at a total of six reefs, with these reefs generally sampled every second year, which was considered 'moderate' (2) for representativeness. Only one reef was sampled within Cleveland Bay and therefore the representativeness for Cleveland Bay was low (1.5), which was the same as the other years when Geoffrey Bay was the only site sampled.

Table 45. Confidence score for the habitat index for Cleveland Bay and Halifax Bay inshore marine zones.

Reporting zone	Indicator category	Maturity of method (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured error (x0.71)	Final score	Rank
Cleveland Bay	Coral	1.5	3	1.5	3	2	9.2	Moderate (3)
	Seagrass	3	3	3	3	2	12.8	Very high (5)
	Habitat index						**11**	**High (4)**
Halifax Bay	Coral	1.5	3	2	3	2	10.2	High (4)
	Habitat index						**10.2**	**High (4)**

Rank based on final score: Very low (1): 4.5 – 6.3; Low (2): >6.3 – 8.1; Moderate (3): >8.1 – 9.9; High (4): >9.9 – 11.7; Very high (5): >11.7 – 13.5.
Confidence criteria were scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

7.2.5 Comparing scores for the habitat index between years

Scores between each year were similar, with the Habitat Index in both bays consistently receiving the same grade. Seagrass appears to have recovered from the decline in condition in 2019-2020 caused by the February 2019 flood, and coral has remained relatively consistent in both bays (Table 46).

In the 2020-2021 report card seagrass condition received a score of 72 and a ‘good’ grade, improving significantly from the previous score of 52 and grade of ‘moderate’. This increase is due to improvements in the biomass indicator at all ten sites, the area indicator at three sites, and species composition at five sites. Seagrass condition is slightly lower than report periods before the 2019 floods, and the ‘good’ grade for 2020-2021 should be understood as a return to “normal” seagrass condition, not as an improvement on “normal”. Notably, seagrass in meadow 17/18 has expanded significantly at the deeper margins, indicating there is sufficient water clarity to allow deeper growth.

From 2017-2018 through to 2019-2020, the scores for coral within Cleveland and Halifax Bays had slightly improved, and from 2018-2019 to 2019-2020 the grade for coral in Cleveland Bay increased (from ‘poor’ to ‘moderate’). However, in 2020-2021, the score for coral in both bays declined, with the grade in Cleveland Bay returning to ‘poor’ (Table 46). In Cleveland Bay this decline was attributed to a decrease in juvenile density, and a ‘very poor’ grade for macroalgae. However, despite the downturn, coral cover did increase year on year from a score of 38 to 48 (‘poor’ to ‘moderate’). In Halifax Bay the slight decline was associated with a decrease in juvenile density and macroalgae. Juvenile density declined significantly at the Pandora and Pandora North sites, while bleaching at the Havannah site influenced the macroalgae indicator. Although the overall coral score decreased, coral cover did improve year on year at four sites. It should be noted that due to the biennial sampling design some reefs from the previous year will not be sampled until the 2021-2022 report – potentially skewing results.

Table 46. Comparison of inshore coral, seagrass and overall habitat scores in the Cleveland and Halifax Bay inshore marine zones between 2020-2021, 2019-2020, 2018-2019 and 2017-2018.

Measure	2020-2021		2019-2020		2018-2019		2017-2018	
	Cleveland Bay	Halifax Bay	Cleveland Bay	Halifax Bay	Cleveland Bay	Halifax Bay	Cleveland Bay	Halifax Bay
Coral	36 (D)	49 (C)	44 (C)	52 (C)	38 (D)	52 (C)	33 (D)	47 (C)
Seagrass	72 (B)	ND	52 (C)	ND	74 (B)	ND	78 (B)	ND
Habitat index*	**54 (C)**	**49 (C)**	**48 (C)**	**52 (C)**	**56 (C)**	**52 (C)**	**55 (C)**	**47 (C)**

Scoring range: ■ Very Poor I = 0 to <25 | ■ Poor (D) = 25 to <50 | ■ Moderate (C) = 50 to <65 | ■ Good (B) = 65 to <85 | ■ Very Good (A) = 85 to 100 | ■ No data (ND)
*Habitat scores are averages of the scores for coral and seagrass.

8 Offshore marine

Habitat was the only index scored within the offshore marine zone, due to offshore water quality data being unavailable for this year. Within the habitat index, coral was the only indicator category scored.

8.1 Habitat results

Coral was the only indicator measured within the habitat index and thus provides the overall score for this index.

8.1.1 Coral

Coral was measured at 16 reefs by the Australian Institute of Marine Science (AIMS) Long-term Monitoring Program (LTMP). Reef Check also sampled coral cover at John Brewer Reef (which was also sampled by LTMP) and Lodestone Reef. Coral cover scores were weighted to reflect the differences in the precision and accuracy of sampling programs and then combined into an overall score. The locations of the sampled reefs are shown in Figure 19.

8.1.1.1 *Results*

The overall condition of coral within the offshore marine zone was ‘good’, with the scores and grades shown in Table 47. The ‘good’ grade was a slight increase from the 2019-2020 Report Card. Overall, coral cover was ‘poor’, with 58% of reef sites sampled (11 of 19 reef sites) scoring ‘very poor’ or ‘poor’ for this indicator. However, as the LTMP uses a biennial sampling design 10 of the 19 reef sites reported carry forward coral cover and juvenile density estimates that were observed in May-June 2020. Of the six reefs surveyed by LTMP in 2021 coral cover increased at five and declined only very slightly at the other. Juvenile density, which is a sign of recruitment, was ‘very good’ at all reefs, except Roxburgh Reef, where it was ‘good’. While the cover change indicator remains ‘moderate’ across the region scores vary markedly among reefs, it is likely that stress associated with the 2020 bleaching event will have contributed to lower-than-expected rates of coral cover increase at some reefs, with six of the 16 (37.5%) reefs surveyed grading ‘poor’ for this indicator. However, most reefs continue to show ‘moderate’, or better rates of coral cover recovery. Only one reef recorded a ‘good’ grade for change in cover and no reefs were in a ‘very good’ condition for this indicator. The rate of change in coral cover was ‘moderate’, however. There were no active outbreaks of crown-of-thorns starfish observed during the 2020-2021 sampling period and the peak summer temperatures in 2021 were below those that cause severe coral bleaching.

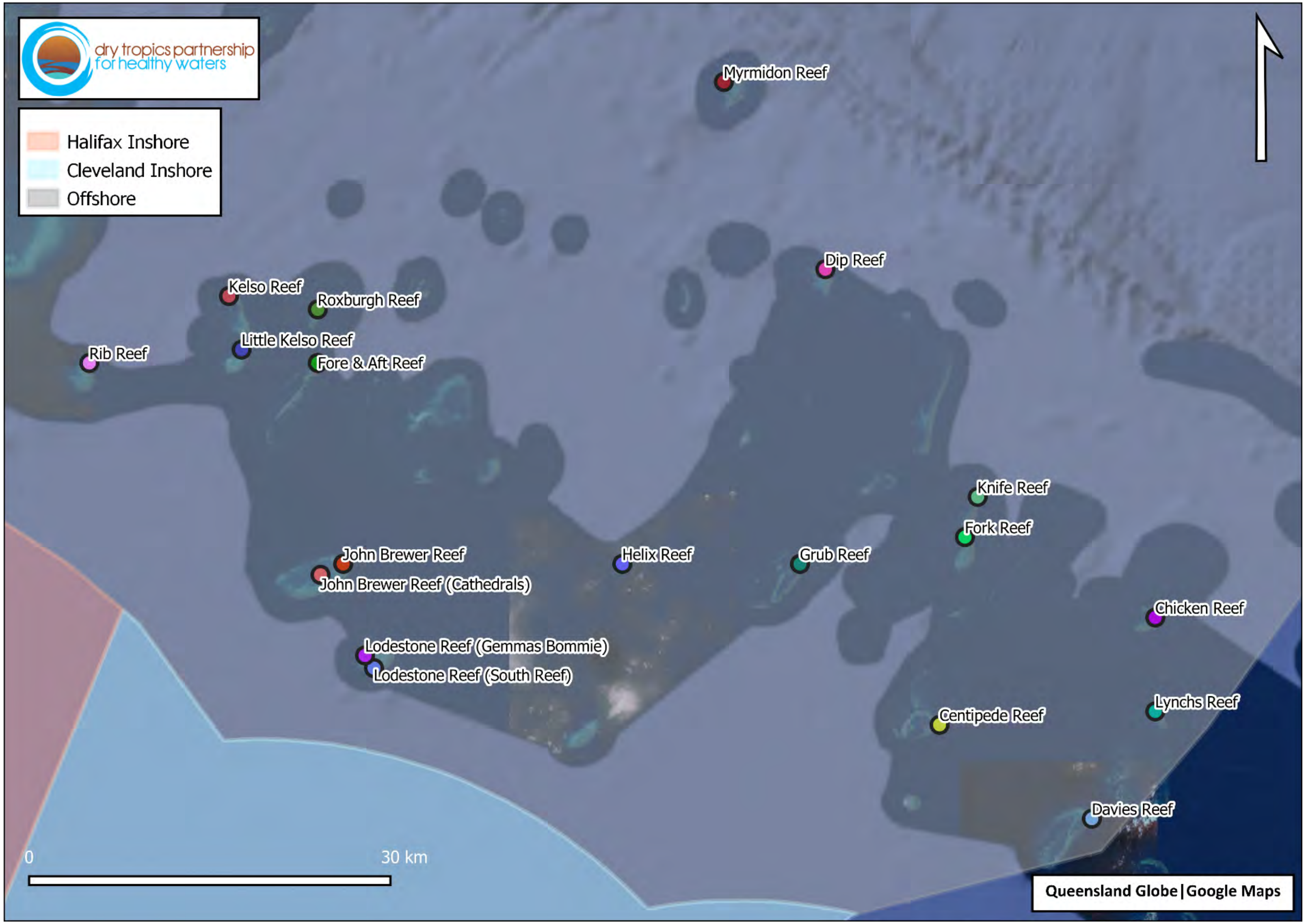


Figure 19. Location of coral reefs that were sampled in the Townsville offshore marine zone.

Each reef is denoted by a different colour.

Table 47. Scores and grades for coral indicators and the coral indicator category for the Townsville offshore marine zone.

Reef	Program	Standardised Scores (Grades)			
		Change in coral cover	% Coral Cover	Juvenile density	Coral Indicator
Centipede Reef	LTMP	49 (C)	29 (D)	97 (A)	**58 (C)**
Chicken Reef	LTMP	63 (B)	67 (B)	100 (A)	**77 (B)**
Davies Reef	LTMP	37 (D)	56 (C)	100 (A)	**64 (B)**
Dip Reef	LTMP	37 (D)	40 (D)	100 (A)	**59 (C)**
Fore and Aft Reef	LTMP	29 (D)	43 (C)	100 (A)	**57 (C)**
Fork Reef	LTMP	48 (C)	38 (D)	100 (A)	**62 (B)**
Grub Reef	LTMP	56 (C)	11 (E)	83 (A)	**50 (C)**
Helix Reef	LTMP	49 (C)	44 (C)	100 (A)	**64 (B)**
John Brewer Reef	LTMP	71 (B)	20 (E)	85 (A)	**59 (C)**
John Brewer Reef (Cathedrals)	RCA	ND	88 (A)	ND	**ND**
Kelso Reef	LTMP	72 (B)	38 (D)	100 (A)	**70 (B)**
Knife Reef	LTMP	31 (D)	59 (C)	100 (A)	**64 (B)**
Little Kelso Reef	LTMP	34 (D)	51 (C)	80 (B)	**55 (C)**
Lodestone Reef (Gemmas Bommie)	RCA	ND	22 (D)	ND	**ND**
Lodestone Reef (South Reef)	RCA	ND	17 (E)	ND	**ND**
Lynchs Reef	LTMP	52 (C)	28 (D)	92 (A)	**57 (C)**
Myrmidon Reef	LTMP	38 (D)	55 (C)	100 (A)	**64 (B)**
Rib Reef	LTMP	66 (B)	15 (E)	100 (A)	**60 (C)**
Roxburgh Reef	LTMP	96 (A)	35 (D)	67 (B)	**66 (B)**
Offshore Zone	**LTMP RCA**	**52 (C)**	**40 (D)**	**94 (A)**	**62 (B)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <80 | ■ Very Good (A) = 80 to 100 | ■ No data (ND), * indicates reefs last surveyed in May-June 2020.

*The LTMP uses a biennial sampling design. These ten reefs carry forward coral cover and juvenile density estimates that were observed in May-June 2020. The remaining six reefs were surveyed in 2021.

^LTMP stands for the Great Barrier Reef Long-Term Monitoring Program.

#The score for the coral indicator category is the average of change in coral cover, % coral cover, and juvenile density. Note that these scores are not a direct reflection of the underlying measured value, but rather just a standardised score.

+Where scores do not appear to add up this is due to rounding.

Key messages: Coral

- Overall, coral condition was 'good' within the offshore zone, however with a score of 62 this grade was borderline. (The transition from 'moderate' to 'good' occurs at a score of 61).
- 11 of 19 reef sites sampled (58%) had 'very poor' or 'poor' coral cover, although cover was increasing at most reefs resurveyed in 2021.
- Juvenile density remained high at all 16 reefs surveyed indicating ongoing resilience despite recent disturbances. The 'very good' grade for juvenile density improved the overall grade of coral condition.
- No active crown-of-thorns starfish outbreaks were recorded,

- Low levels of bleaching were observed in mid-2020, which was a legacy of the 2020 summer heat wave.

8.1.1.2 *Confidence scores*

There was a high confidence in the overall coral indicator category score based on when sampling occurred (Table 48). This score was mostly driven by the representativeness category being ranked as 'moderate' (2), as 33% of offshore reefs within the Townsville region were measured (Table 48).

Table 48. Confidence scoring of offshore coral for the Townsville offshore marine zone.

	Maturity (x 0.36)	Validation (x 0.71)	Represent-ativeness (x 2)	Directness (x 0.71)	Measured error (x 0.71)	Final score	Rank
Coral	3	3	2	3	1	10.1	High (4)

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

Confidence criteria were scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

8.1.1.3 *Comparing scores for offshore coral between years*

The scores were similar between the four years (from 2017-2018 to 2020-2021). Although four years of data is not sufficient to establish definitive trends, AIMS has been conducting reef surveys for over 30 years on the health of 47 mid-shore and offshore reefs across the Great Barrier Reef (AIMS, 2020). For the Townsville Dry Tropics region, hard coral cover on permanent transects, in 2021, was at levels not observed since around 2000, having improved from a low point in 2012 following impacts from crown-of-thorns starfish and cyclones. This recovery has occurred despite impacts of repeated mass coral bleaching events in 2016, 2017 and 2020 and further COTS outbreaks [AIMS Benthic Community Cover]. Reef wide results from manta tow surveys show even greater recovery with regional mean cover in 2021 higher than at any time since surveys began in the late 1980's [AIMS Manta Tows].

Table 49. Comparing offshore coral scores for the Townsville offshore marine zone between 2020-2021, 2019-2020, 2018-2019 and 2017-2018.

Measure	2020-2021	2019-2020	2018-2019	2017-2018
Change in coral cover	52 (C)	38 (D)	49 (C)	51 (C)
% Coral cover	40 (D)	39 (D)	35 (D)	34 (D)
Juvenile density	94 (A)	90 (A)	94 (A)	97 (A)
Coral*	**62 (B)**	**56 (C)**	**59 (C)**	**61 (B)**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100

*Coral is the overall coral condition. The score for coral is calculated by averaging the scores for change in coral cover, % coral cover, and juvenile density.

9 Litter

Data were collected in the field by volunteers as part of Tangaroa Blue clean-up events. The locations of the clean-up events are shown in Figure 20. Site specific results for litter (collected in organised clean up events) are shown in Table 50. Data was available for 12 sites with each site being cleaned between 1 and 9 times (median 2) during the reporting period. The scores are based on the statistical function derived from the available data (2012-2021) contained in the Australian Marine Debris Initiative (AMDI) database to estimate the amount of litter collected per unit effort. For the Report Card (a communication piece), scores were averaged so that the results can be easily communicated to the community. Unlike other indicators in this report, litter data is reported on a site level, and not aggregated to a zone score. This restriction on scoring is applied because of the large variations associated with the methods used in recording litter collected (see section 9.1.3).

9.1 Results

In the Ross Freshwater zone, Aplin's Weir had low pressure and was cleaned on a quarterly basis, whereas the Queensland Country Bank Stadium was cleaned nine times between March and June 2021 and had 'moderate pressure' on average.

Whilst Shelly Cove had slight pressure over quarterly collection events, Shelly Beach and Rowes Bay had high pressure with only one collection event. Shelly Cove cannot be compared with Shelly Beach and Rowes Bay given that the time period prior to the collection event was different. The Strand Park had slight pressure on average from two collection events, however, there are waste collection facilities easily available at this location.

Nelly Bay and Alma Bay posed low pressure and 'moderate pressure' on average, respectively; each had two collection events approximately six months apart. However, the scores for these sites are very similar, with both occurring at the grade boundary scoring 61 and 60 respectively.

At Orpheus Island, Picnic Bay and Yanks Jetty had only one collection event each, whilst Fig Tree Beach and Big Rock Bay had two collection events. Picnic Bay, Fig Tree Beach, and Big Rock Bay are all located on the east coast of Orpheus Island, where litter has been found to have a very high pressure on the environment. Given the remote locations it is likely to have been washed onto the beach rather than being a source location for litter. Further investigation is needed to determine if the litter is coming from vessels or another shore-based location. An analysis of prevailing currents, wind and litter types will provide better insight. In contrast, Yanks Jetty is located on the south-western side of the island. This area contains a public jetty and is a dedicated National Park camping area serviced by a local ranger. Slight pressure was recorded in this location.

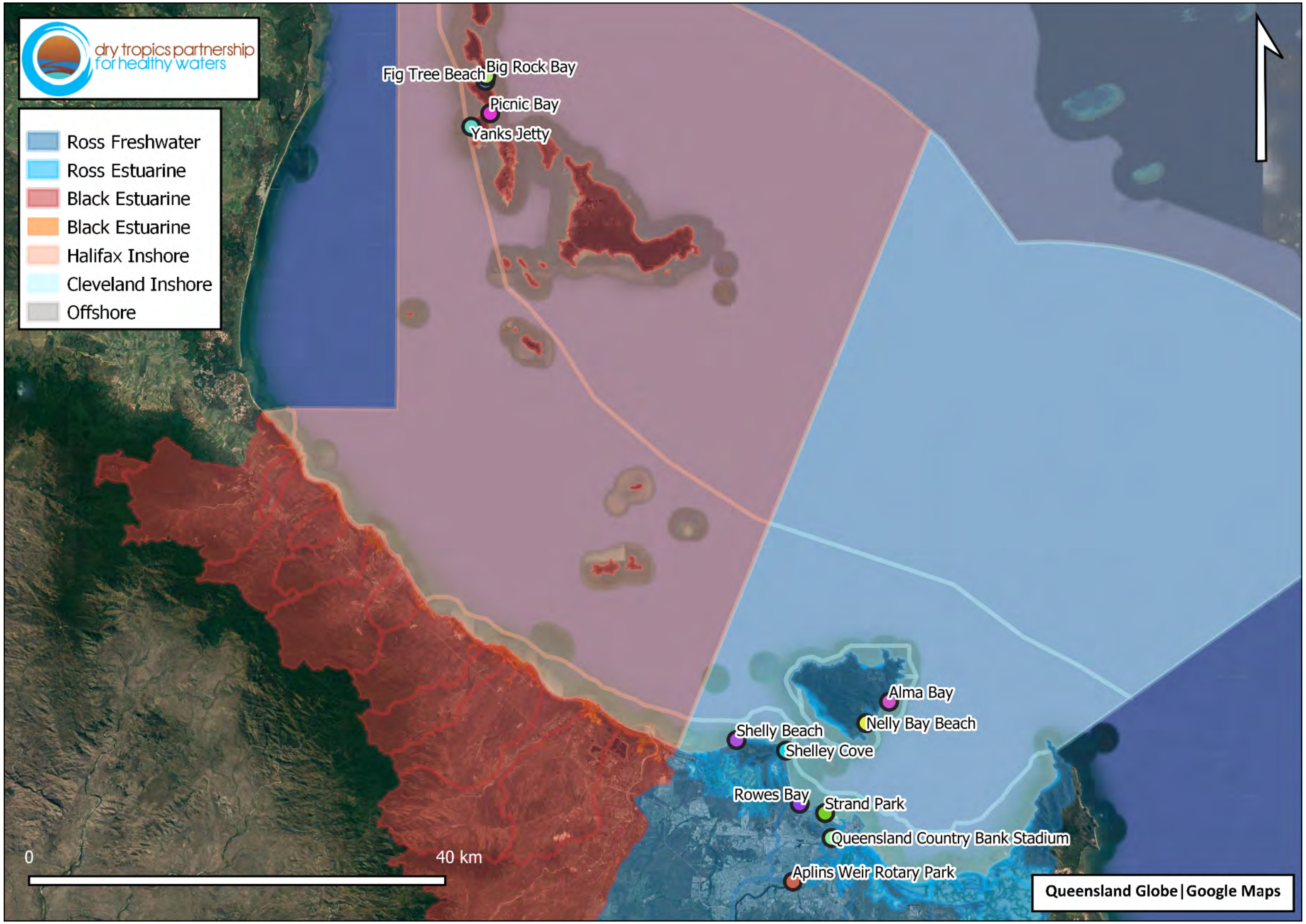


Figure 20. Location of Tangaroa Blue litter clean ups between July 2020 and June 2021.

Each litter collection point is denoted by a different colour.

Table 50. Scores and grades for the litter metric for the Ross freshwater basin, Ross estuarine zone, Cleveland Bay, and Halifax Bay.

Zone	Site	Standardised Scores (Grades)
Ross Freshwater Basin	Aplin's Weir Rotary Park	61 (LP)
	Queensland Country Bank Stadium	44 (MP)
Ross Estuarine Zone	Shelly Cove, Cape Pallarenda Conservation Park	82 (SP)
	Shelly Beach, Pallarenda	27 (HP)
	Rowes Bay	38 (HP)
	Strand Park, Townsville	91 (SP)
Cleveland Bay (Magnetic Island)	Nelly Bay Beach, Magnetic Island	61 (LP)
	Alma Bay, Magnetic Island	60 (MP)
Halifax Bay	Picnic Bay, Orpheus Island	3 (VHP)
	Fig Tree Beach, Orpheus Island	7 (VHP)
	Yanks Jetty, Orpheus Island	84 (SP)
	Big Rock Bay, Orpheus Island	4 (VHP)

Scoring range: ■ Very high pressure (VHP) = 0 to ≤20 | ■ High pressure (HP) > 20 to ≤40 | ■ Moderate pressure (MP) > 40 to ≤60 | ■ Low pressure (LP) > 60 to ≤80 | ■ Slight pressure (SP) > 80 to 100

There were substantially fewer public events throughout 2020 due to social distancing restrictions enforced due to the outbreak of Covid-19. Sources of a high volume of disposable materials can include large-scale public events (Enviromental Protection Agency, 2020) and tourism (Wilson & Verlis, 2017). However, during Covid-19 take-aways increased (as restaurants closed) and this may have increased the amount of rubbish, especially in more remote areas (S. Duce, pers. comm., 2021). The results for the February 2020 - June 2021 period may thus not be representative of the usual amount of litter within the environment.

Key messages: Litter

- 12 sites were scored during 2020-2021, with insufficient data to produce an overall score for a zone.
- Sites that have waste collection facilities that can be regularly serviced exert lower pressure on the environment than remote sites that don't have collection facilities. Further information is required to understand the relationship between location, litter bin availability, litter bin emptying frequency, and litter environmental pressure.
- Further examination of the drivers behind high litter pressure in remote areas such as marine currents and source is required to determine likely points of origin.
- Public events and tourism contribute to litter pressure on the environment.

9.1.1 Confidence scores

As presented in Table 51, there was very low confidence in the scores for the litter reporting category in both 2019 and 2020. This is because there was very limited spatial and temporal sampling and there is no measured error.

Table 51. Confidence scores for the litter reporting category across all zones.

Maturity (0.36)	Validation (0.71)	Represent-ativeness (2)	Directness (0.71)	Measured error (0.71)	Final score	Rank
1	1	1	3	1	5.9	Very Low (1)

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

Confidence criteria were scored 1-3, weighted by the value identified in parenthesis and summed to produce a final (weighted) score (4.5 – 13.5). Final scores rank from 1 to 5 (very low to very high).

9.1.2 Comparing results with last year

The amount of litter within the environment between the two years can only be compared for the five sites where litter was collected in 2019-2020, with the scores shown in Table 52. The Magnetic Island sites were the only sites with a large difference between the years. In 2019-2020 litter was collected at each of these at one event, however, it was collected about six months prior to this event. Litter was collected at two events at each site in the 2020-2021 year. These were approximately six months apart, however, there was a 12-month lead time prior to the first collection event from the previous year.

The amount of litter at a site can vary substantially at sites depending on the length of time between collection events. The Partnership has been working with local community groups to develop regular collection events at specific sites, with the aim of establishing trends in the abundance of litter at them. More frequent collections occurred at some sites during 2020-2021, however there was a delay in commencement due to the Covid-19 pandemic.

In 2020-2021, there was no overall score for a zone because there were too few sites sampled for the data to be extrapolated for an entire zone. Whilst 12 sites within the four reporting zones had collections, this is still insufficient data to extrapolate across each zone. Other factors affecting the quantity of litter need to be considered including the availability of litter bins, their emptying frequency, the volume of tourists frequenting an area, and whether an organised event has occurred just prior to the collection event.

9.1.3 Limitations on data from litter collections

It is acknowledged that there are limitations with the data source. These limitations include:

- At some clean-ups, not all items were counted due to either time constraints or a lack of resources at the clean-up event. This results in false zeros in the data and makes it difficult to differentiate between false zeros and true zeros (where no rubbish was recorded).
- The time-period before a clean-up event occurred differs at each site. Without clean-ups, rubbish accumulates over time and therefore the time-period before the clean-up occurred likely influenced the amount of rubbish at each site.
- The area that data were collected from was not standardised and it is unlikely that all rubbish was collected within the area surveyed. However, the statistical method used to score the data overcomes some of these limitations and it is expected that the method will be refined and improved for future Report Cards. The method was updated for the 2020-2021 year, with the

same methodology also applied to 2019-2020 data. Therefore, the data presented for the 2019-2020 reporting year may appear different to the data reported previously.

Table 52. Scores and grades for the litter metric for the Ross freshwater basin, Ross and Black estuarine zones, and Cleveland and Halifax bays for the 2019-2020 and 2020-2021 years.

Zone	Site	Standardised Scores (Grades)	
		2020-2021	2019-2020
Black Estuarine Zone	Ollera Beach	NA	38 (HP)
	Toomulla Beach	NA	46 (MP)
Ross Freshwater	Aplin's Weir Rotary Park	61 (LP)	NA
	Queensland Country Bank Stadium	44 (MP)	NA
Ross Estuarine Zone	Rowes Bay	38 (HP)	31 (HP)
	Strand Park, Townsville	91 (SP)	83 (SP)
	Shelly Cove, Cape Pallarenda Conservation Park	82 (SP)	NA
	Shelly Beach, Pallarenda	27 (HP)	NA
Cleveland Bay (Magnetic Island)	Nelly Bay Beach, Magnetic Island	61 (LP)	37 (HP)
	Alma Bay, Magnetic Island	60 (MP)	72 (LP)
Halifax Bay	Fig Tree Beach, Orpheus Island	7 (VHP)	NA
	Picnic Bay, Orpheus Island	3 (VHP)	NA
	Yanks Jetty, Orpheus Island	84 (SP)	NA
	Big Rock Bay, Orpheus Island	4 (VHP)	6 (VHP)
	North East Bay, Great palm Island	NA	93 (SP)

Scoring range: ■ Very high pressure (VHP) = 0 to ≤20 | ■ High pressure (HP) > 20 to ≤40 | ■ Moderate pressure (MP) > 40 to ≤60 | ■ Low pressure (LP) > 60 to ≤80 | ■ Slight pressure (SP) > 80 to 100

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Appendix A. Comparisons of values used to calculate water quality scores within the freshwater basins.

Table C-1. Annual median values (med), 80th percentiles (80th) (or 20th percentile for low dissolved oxygen (20th)), water quality objectives (WQOs) and scaling factors (SF) for indicators of nutrients and physical-chemical properties for all sites monitored with

Site	Indicators of nutrients										Indicators of physical-chemical properties														
	DIN (mg/L)					TP (mg/L)					Turbidity (NTU)					High DO (% saturated)					Low DO (% saturated)				
	# Of samples	Med	80th	WQOs	SF	# Of samples	Med	80th	WQOs	SF	# Of samples	Med	80th	WQOs	SF	# Of samples	Med	80th	WQOs	SF	# Of samples	Med	20th	WQOs	SF
Upper Ross River (Ross River Dam)	12	0.015	0.015	0.02	0.38	12	0.01	0.028	0.03	0.46	12	7.3	9.59	10	35	12	103.3	109.8	110	120	12	103.3	100.5	90	70
- Black Weir	11	0.02	0.11	0.02	0.38	10	0.01	0.02	0.03	0.46	11	1.6	3.3	10	35	11	78.7	87.8	110	120	11	78.7	69.6	90	70
- Gleeson Weir	11	0.015	0.095	0.02	0.38	ND	ND	ND	0.03	0.46	11	2.1	3.3	10	35	11	86.7	97.1	110	120	11	86.7	73.8	90	70
- Aplin's Weir	11	0.03	0.07	0.02	0.38	ND	ND	ND	0.03	0.46	11	1.6	3.5	10	35	11	94.2	101.7	110	120	11	94.2	87.8	90	70
- Bohle far-field	11	0.061	0.137	0.08	0.38	11	1.3	2.5	0.05	0.46	11	4.5	16.9	22	35	11	67.7	92.8	110	120	11	67.7	51.2	85	70
- Bohle mid-field	11	0.166	0.320	0.08	0.38	11	4.2	6.0	0.05	0.46	11	10.2	14.6	22	35	11	80.8	94.1	110	120	11	80.8	72.5	85	70
Black River	9	0.019	0.104	0.02	0.05	9	0.021	0.034	0.02	0.03	9	0.8	10.98	5	10	9	106.8	109	105	120	9	106.8	99	90	70
Althaus Creek	5	0.004	0.051	0.02	0.05	5	0.015	0.0166	0.02	0.03	5	9	10.14	5	10	5	102.4	108.3	105	120	5	102.4	97.3	90	70
Bluewater Creek	11	0.015	0.054	0.02	0.05	11	0.015	0.023	0.02	0.03	11	1.2	3.1	5	10	11	94.9	101.8	105	120	11	94.9	89.0	90	70
Sleeper Log Creek	11	0.004	0.027	0.02	0.05	11	0.013	0.016	0.02	0.03	11	3.1	4.7	5	10	11	94.4	99.4	105	120	11	94.4	88.8	90	70
Leichhardt Creek	11	0.009	0.025	0.02	0.05	11	0.012	0.022	0.02	0.03	11	1.7	2.8	5	10	11	90.9	94.8	105	120	11	90.9	60.5	90	70
Saltwater Creek	10	0.0075	0.035	0.02	0.05	10	0.01	0.0134	0.02	0.03	10	1.35	2.22	5	10	10	93.1	95.7	105	120	10	93.1	82.6	90	70
Rollingstone Creek	7	0.172	0.284	0.02	0.05	7	0.009	0.0098	0.02	0.03	7	0.1	0.38	6	10	7	93.3	94.2	105	120	7	93.3	88.4	90	70
Ollera Creek	7	0.009	0.047	0.02	0.05	7	0.009	0.0108	0.02	0.03	7	0.3	1.76	5	10	7	89.4	90.2	105	120	7	89.4	69.6	90	70
Crystal Creek	11	0.009	0.012	0.02	0.05	11	0.008	0.008	0.02	0.03	11	0.5	0.7	2	10	11	96.4	102.6	105	120	11	96.4	85.9	90	70
Paluma Dam	12	0.015	0.056	0.02	0.05	12	0.01	0.01	0.03	0.06	12	1.9	2.18	10	20	12	95.2	99.2	110	120	12	95.2	91.8	90	70

The thick black line delineates between the sites within the Ross estuarine zone (above line) and sites within the Black estuarine zone (below the line). Significant figures differ and indicators are shaded for ease of presentation. ND stands for no data. Shading is added to easily distinguish between indicators.

Appendix B. Distribution (boxplots) of freshwater water quality data.

The following figures are box and whisker plots (boxplots) of water quality indicators at all freshwater water quality monitoring sites. The mid-line is the median and the box depicts the upper and lower quartiles. The whiskers are the lowest and highest datum within 1.5 interquartile range (IQR) and outliers are datum above or below 1.5 IQR. Analysis was conducted on all data points collected during the reporting period (not only on the monthly values used for generating scores).

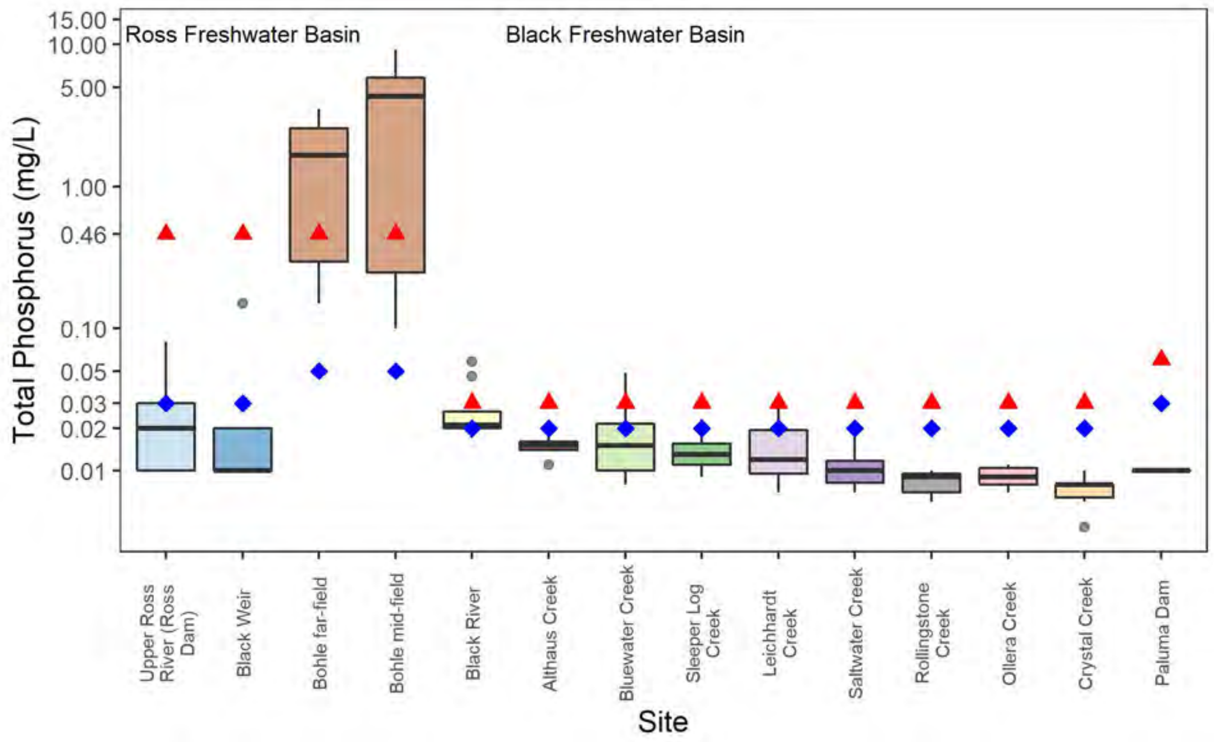

Figure B-1. Boxplot of TP concentrations at each freshwater monitoring site.

The blue diamonds indicate the water quality objectives (WQOs), and the red triangles show the scaling factors. Outliers are shown as grey dots.

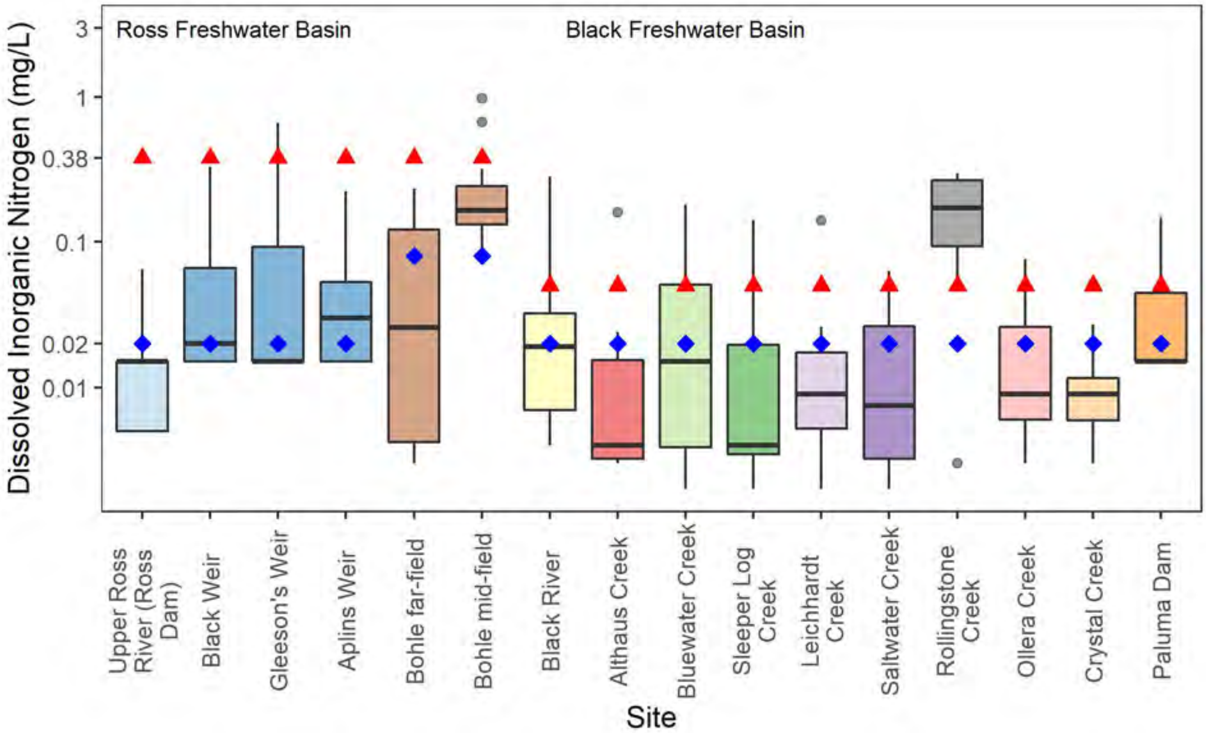

Figure B-2. Boxplot of DIN concentrations at each freshwater monitoring site.

The blue diamonds indicate the water quality objectives (WQOs), and the red triangles show the scaling factors. Outliers are shown as grey dots.

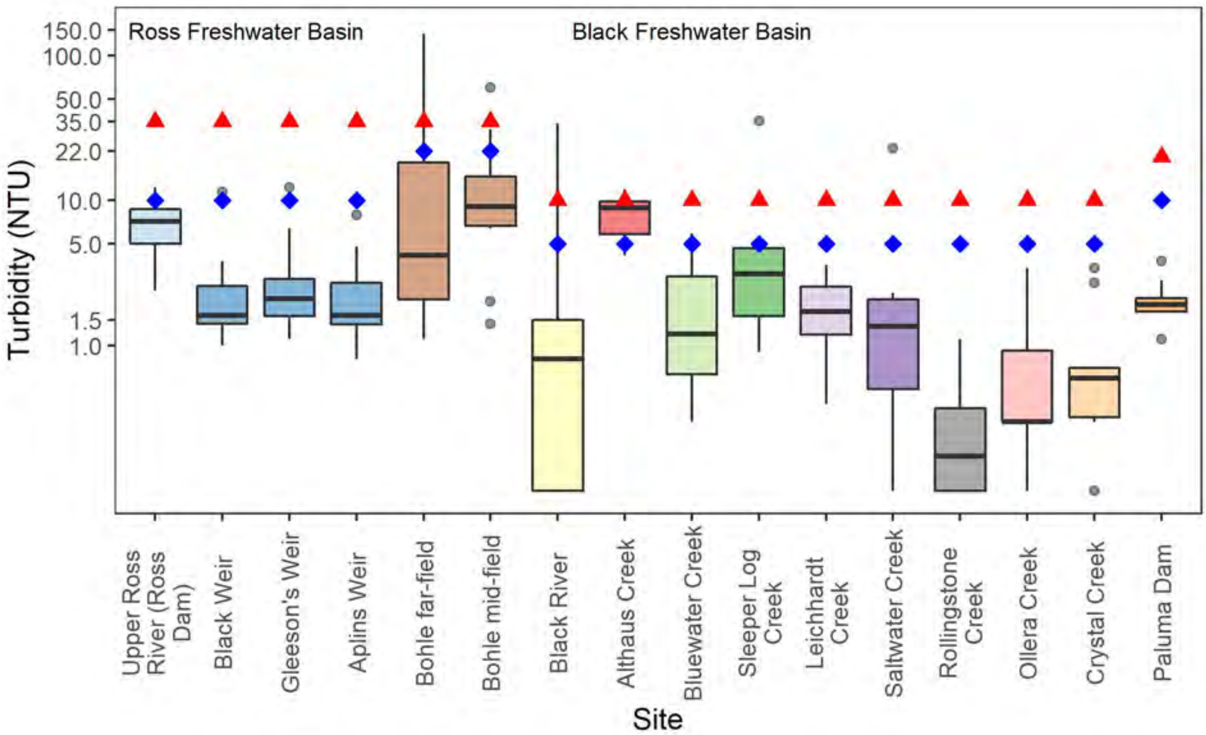

Figure B-3. Boxplot of turbidity levels at each freshwater monitoring site

The blue diamond's indicate the water quality objectives (WQOs), and the red triangles show the scaling factors. Outliers are shown as grey dots.

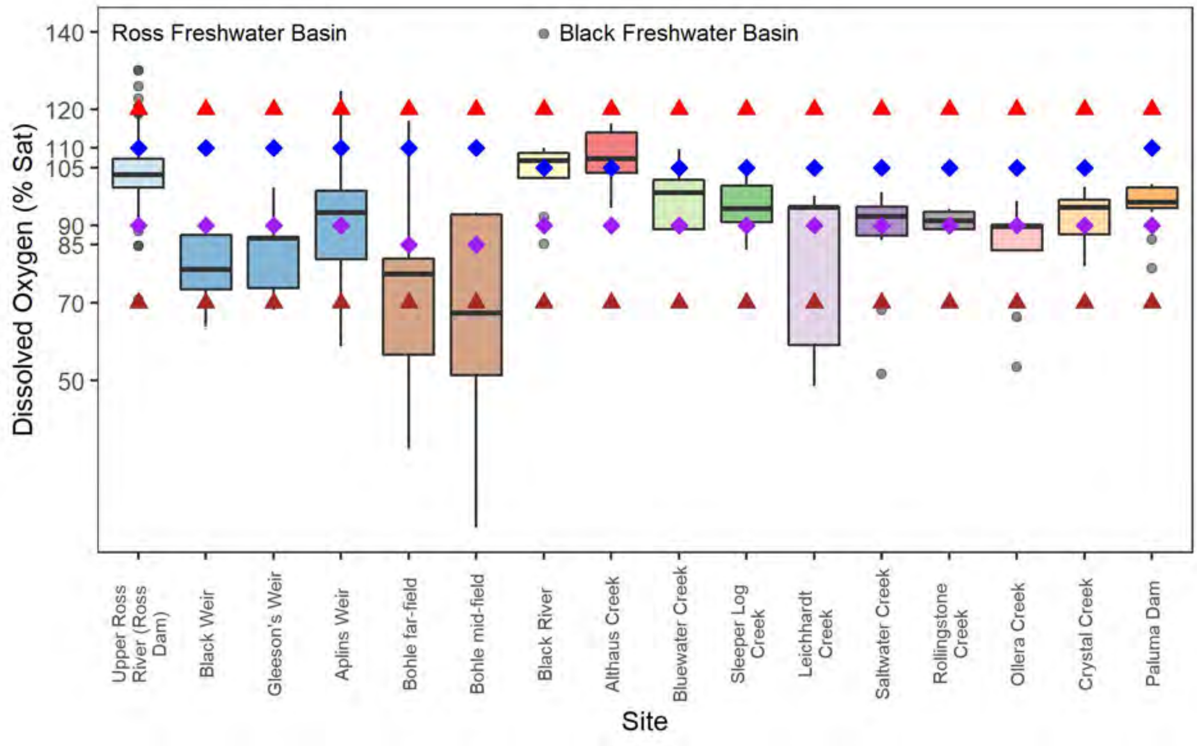

Figure B-4. Boxplot of High and Low DO concentrations at each freshwater monitoring site.

The blue and purple diamonds indicate the water quality objectives (WQOs) for the High and low DO respectively and the red and brown triangles indicate the scaling factors for the High and low DO, respectively. Outliers are shown as grey circles.

Appendix C. Comparison of site-specific results for nutrients and physical-chemical properties for freshwater sites for 2019-2020 and 2020-2021.

Table C-1. Comparison of scores for indicators of nutrients, physical-chemical (phys-chem) properties and overall water quality for freshwater sites sampled in the 2019-2020 and 2020-2021 years.

Site	Non-weighted scores for 2020-2021								Non-weighted scores for 2019-2020							
	DIN	TP	Nutrients	Turbidity	High DO	Low DO	Phys-chem properties	Water quality	DIN	TP	Nutrients	Turbidity	High DO	Low DO	Phys-chem properties	Water quality
Upper Ross River (Ross River Dam)	90	90	90	90	90	90	90	90	68	61	65	90	90	90	90	78
Lower Ross River	60	90	75	90	90	50	70	72	66	70	68	90	90	73	82	75
- Black Weir	61	90	75	90	90	26	58	66	59	70	64	90	90	56	73	69
- Gleeson Weir	62	ND	62	90	90	50	70	66	74	ND	74	90	90	73	82	78
- Aplin's Weir	59	ND	59	90	90	74	82	70	66	ND	66	90	90	90	90	78
Bohle River	54	0	27	90	90	18	54	40	15	0	7	90	90	0	45	26
- Bohle far-field	66	0	33	90	90	37	63	48	29	0	15	90	90	0	45	30
- Bohle mid-field	43	0	21	90	90	0	45	33	0	0	0	90	90	0	45	23
Ross freshwater basin	**68**	**60**	**64**	**90**	**90**	**52**	**71**	**67**	**49**	**33**	**47**	**90**	**90**	**51**	**71**	**59**
Black River	61	54	58	69	53	90	61	59	78	9	44	90	62	90	76	60
Althaus Creek	67	90	78	12	69	90	40	59	74	90	82	90	4	81	47	65
Bluewater Creek	63	73	68	90	90	77	83	76	90	66	78	90	90	11	51	65
Sleeper Log Creek	74	90	82	90	90	76	83	82	62	90	76	70	90	32	51	64
Leichhardt Creek	74	76	75	90	90	61	75	75	90	55	72	90	90	27	59	66
Saltwater Creek	70	90	80	90	90	66	78	79	90	90	90	90	90	90	90	90
Rollingstone Creek	0	90	45	90	90	74	82	63	64	90	77	90	90	51	71	74
Ollera Creek	66	90	78	90	90	59	74	76	63	90	76	90	90	0	45	61
Crystal Creek	90	90	90	90	90	73	81	85	90	90	90	90	90	75	83	87
Paluma Dam	63	90	76	90	90	90	90	83	90	90	90	90	90	69	80	85
Black freshwater basin	**63**	**83**	**73**	**80**	**84**	**75**	**75**	**74**	**79**	**76**	**78**	**88**	**79**	**53**	**71**	**71**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND)

The score for nutrients is the average of the scores for dissolved inorganic nitrogen (DIN) and total phosphorus (TP). The scores for phys-chem properties are the average of turbidity and the lower score of either High or low dissolved oxygen (DO). The overall water quality score is the average of the scores for the nutrients and phys-chem properties. Significant figures differ for ease of presentation.

Appendix D. Distribution (boxplots) of fish data within the Ross and Black freshwater basins.

Figure D-1 and Figure D-2 are box and whisker plots (boxplots) of fish indicator categories for both freshwater basins, based on sampling at 11 and 13 sites. The mid-line is the median and the box depicts the upper and lower quartiles. The whiskers are the lowest and highest datum within 1.5 interquartile range (IQR) and outliers are datum above or below 1.5 IQR.

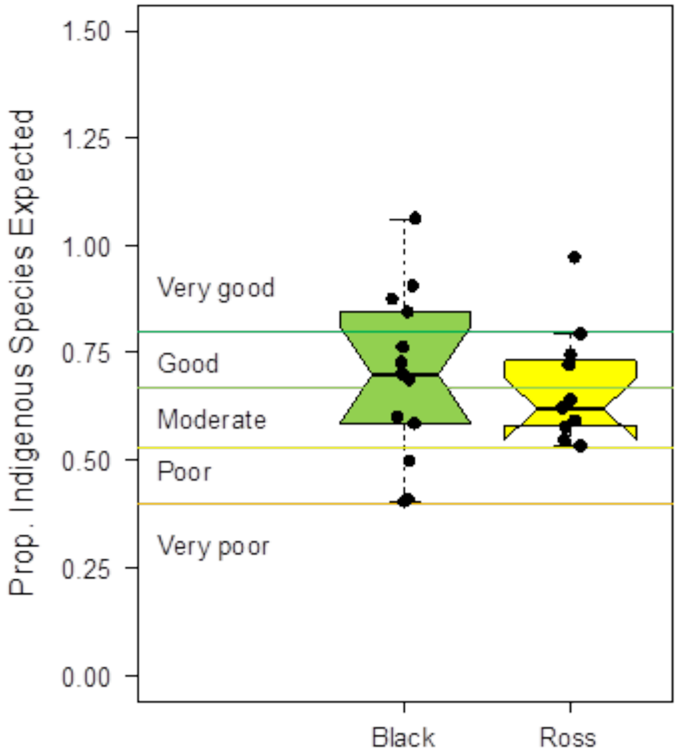

Figure D-1. Boxplot of the proportion of Indigenous (native) species (POISE) expected within waterways within the Ross and Black freshwater basins.

The boxplot is based on sampling from 11 sites within the Ross freshwater basin and 13 sites within the Black freshwater basin. The black dots shown the results for each site. The different coloured lines delineate the cut-offs for the different grades.

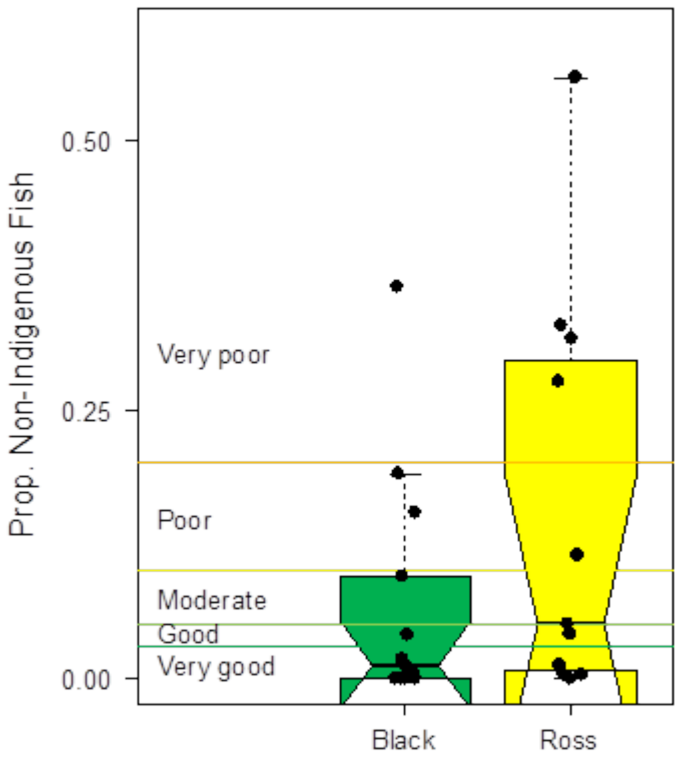

Figure D-2. Boxplot of the proportion of non-Indigenous (native) fish within waterways within the Ross and Black freshwater basins.

The boxplot is based on sampling from 11 sites within the Ross freshwater basin and 13 sites within the Black freshwater basin. The black dots shown the results for each site. The different coloured lines delineate the cut-offs for the different grades.

Appendix E. Distribution (boxplots) of estuarine water quality data.

The following figures are box and whisker plots (boxplots) of water quality indicators at all estuarine water quality monitoring sites. The mid-line is the median and the box depicts the upper and lower quartiles. The whiskers are the lowest and highest datum within 1.5 interquartile range (IQR) and outliers are above or below 1.5 IQR. The blue and purple diamonds indicate the water quality objective (upper and lower respectively), red and brown triangles represent the scaling factor (upper and lower respectively).

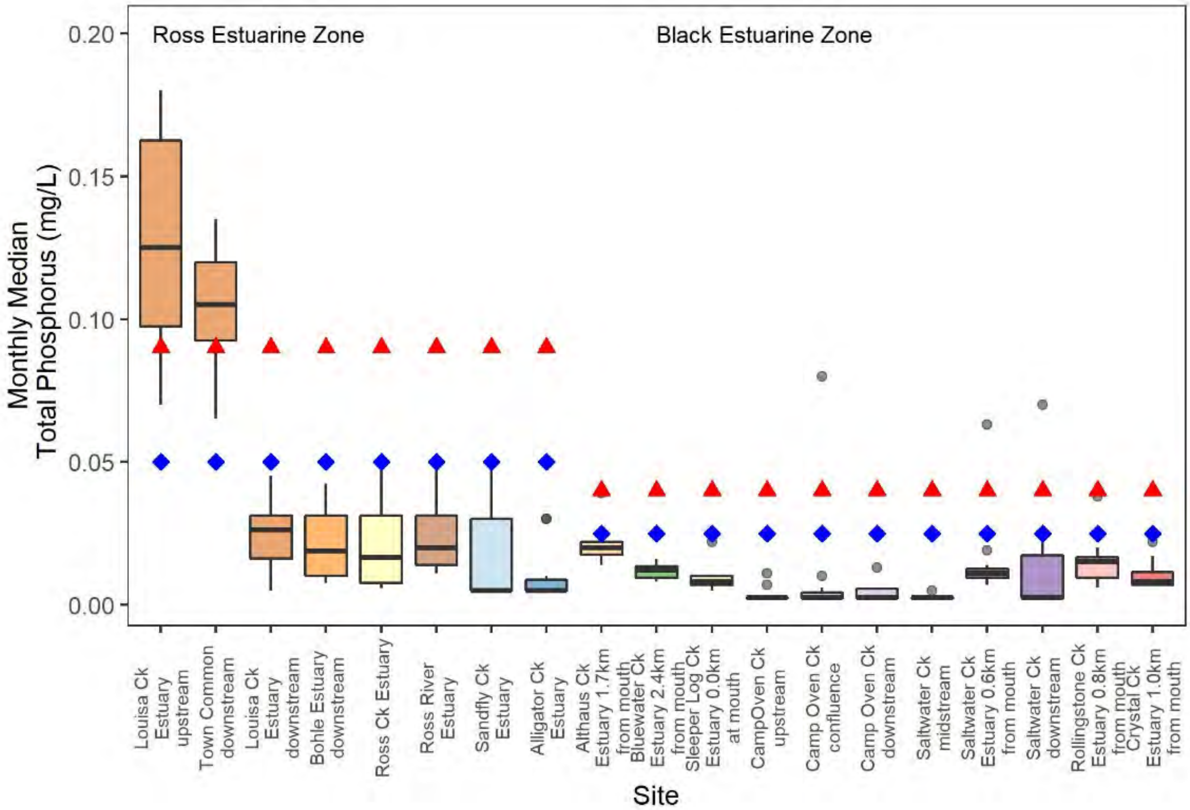

Figure E-1. Boxplot of total phosphorus concentrations at each estuarine monitoring site.

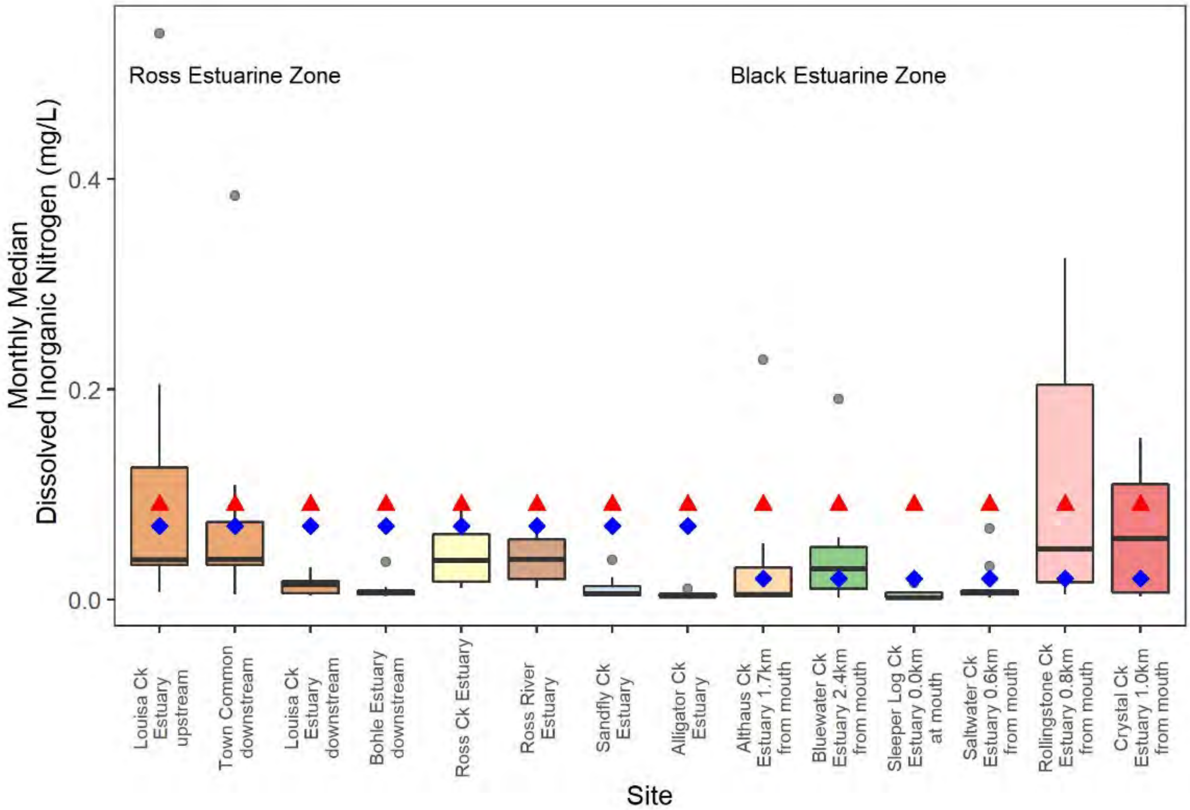

Figure E-2. Boxplot of dissolved inorganic nitrogen (DIN) concentrations at each estuarine monitoring site.

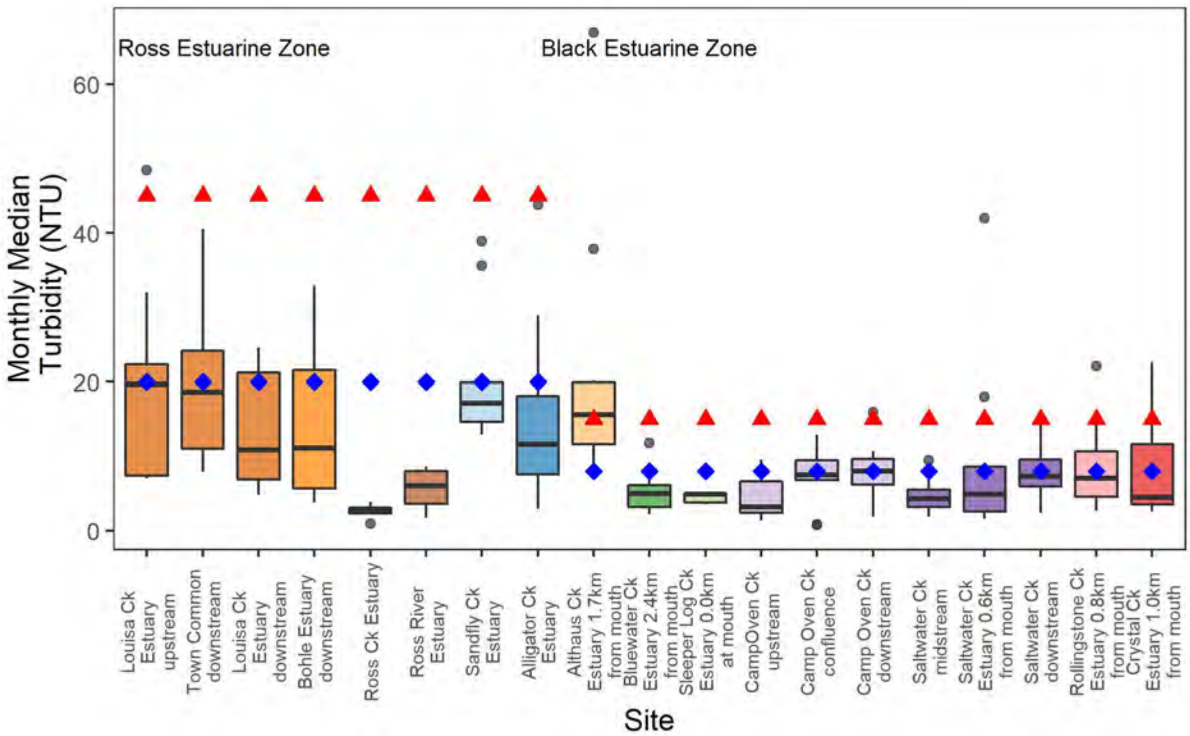

Figure E-3. Boxplot of turbidity levels at each estuarine monitoring site.

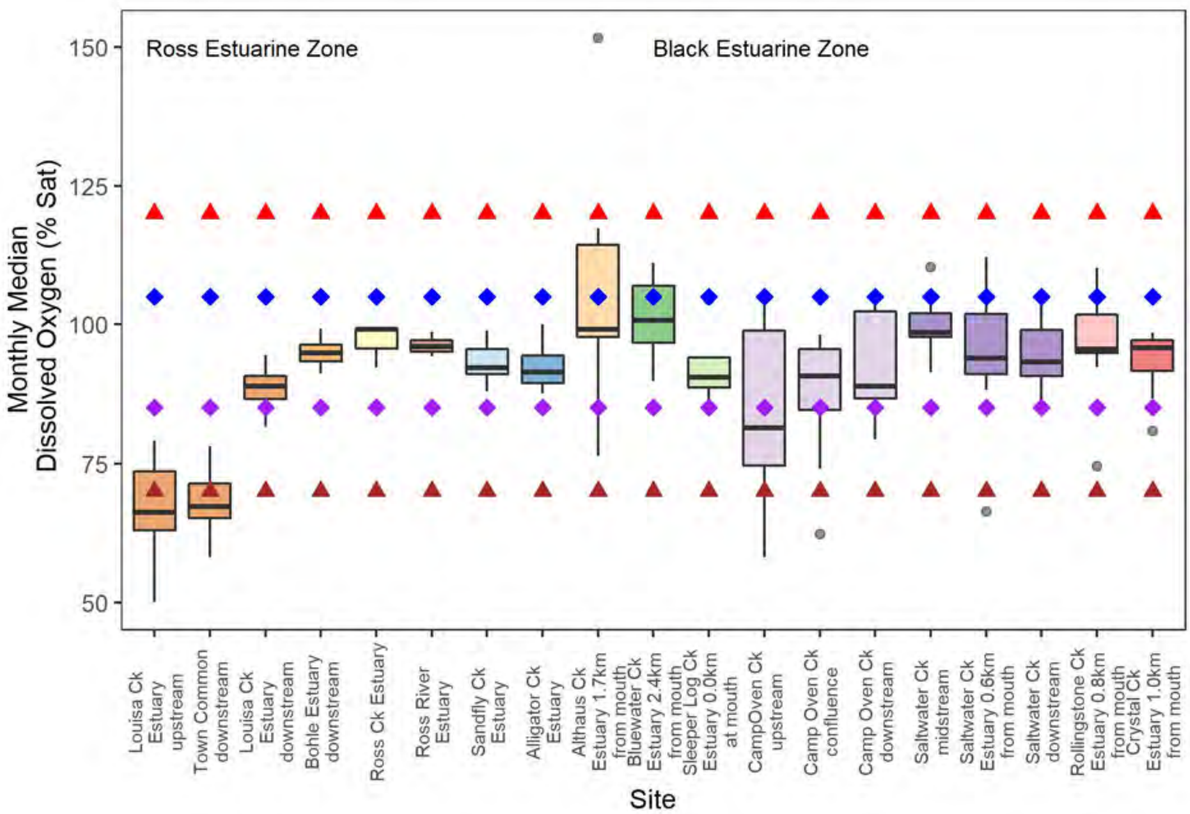

Figure E-4. Boxplot of dissolved oxygen (DO) concentrations at each estuarine monitoring site.

Appendix F. Comparisons of values used to calculate water quality scores within the Ross and Black estuarine zones.

Table F-1. Annual median values (med), 80th percentiles (perc) (or 20th percentile for low dissolved oxygen), water quality objectives (WQO) and scaling factors (SF) for indicators of nutrients and physical-chemical properties for all sites monitored within the R

Site	# Of sampling months	Indicators of Nutrients												Indicators of physical-chemical properties							
		DIN (mg/L)				TP (mg/L)				Turbidity (NTU)				High DO (% saturation)				Low DO (% saturation)			
		Median	80th Percentile	WQO	SF	Median	80th Percentile	WQO	SF	Median	80th Percentile	WQO	SF	Median	80th Percentile	WQO	SF	Median	20th[1] Percentile	WQO	SF
- Louisa Creek upstream	12	0.038	0.16	0.07	0.09	0.125	0.168	0.05	0.09	19.6	23.5	20	45	66.2	73.7	105	120	66.2	61	85	70
- Town Common downstream	12	0.039	0.093	0.07	0.09	0.105	0.12	0.05	0.09	18.6	24.9	20	45	67.2	72.6	105	120	67.2	64.8	85	70
- Louisa Creek downstream	12	0.014	0.018	0.07	0.09	0.026	0.034	0.05	0.09	10.9	23	20	45	88.9	91	105	120	88.9	85.3	85	70
Bohle River Estuary	12	0.006	0.011	0.07	0.09	0.019	0.034	0.05	0.09	11.1	22.8	20	45	94.8	96.9	105	120	94.8	93.2	85	70
Ross Creek Estuary	4	0.037	0.067	0.07	0.09	0.017	0.035	0.05	0.09	2.8	3.2	20	45	99.2	99.2	105	120	99.2	95	85	70
Ross River Estuary	4	0.039	0.059	0.07	0.09	0.02	0.035	0.05	0.09	6	8.1	20	45	96	97.5	105	120	96	94.9	85	70
Sandfly Creek Estuary	12	0.005	0.018	0.07	0.09	0.005	0.03	0.05	0.09	17.1	20.6	20	45	92.1	95.5	105	120	92.1	90.3	85	70
Alligator Creek Estuary	10	0.003	0.006	0.07	0.09	0.005	0.014	0.05	0.09	11.6	21.6	20	45	91.4	95.3	105	120	91.4	88.9	85	70
Althaus Creek Estuary	10	0.005	0.039	0.02	0.09	0.02	0.023	0.025	0.04	15.6	23.7	8	15	99.1	115.4	105	120	99.1	96.2	85	70
Bluewater Creek Estuary	11	0.029	0.055	0.02	0.09	0.012	0.014	0.025	0.04	5	6.5	8	15	100.7	107.8	105	120	100.7	95.8	85	70
Sleeper Log Creek Estuary	5	0.002	0.009	0.02	0.09	0.008	0.012	0.025	0.04	4.9	5.6	8	15	90.5	96.1	105	120	90.5	87.8	85	70
- Camp Oven Creek upstream	11	ND	ND	0.02	0.09	0.002	0.002	0.025	0.04	3.2	8	8	15	81.5	98.9	105	120	81.5	68	85	70
- Camp Oven Creek confluence	11	ND	ND	0.02	0.09	0.002	0.006	0.025	0.04	7.5	9.7	8	15	90.7	96.2	105	120	90.7	80.4	85	70
- Camp Oven Creek downstream	11	ND	ND	0.02	0.09	0.002	0.006	0.025	0.04	8	10.5	8	15	88.8	102.8	105	120	88.8	84.1	85	70
- Saltwater Creek midstream	12	ND	ND	0.02	0.09	0.002	0.002	0.025	0.04	4.3	5.8	8	15	98.5	103.5	105	120	98.5	97.4	85	70
- Saltwater Creek Estuary	11	0.007	0.01	0.02	0.09	0.011	0.014	0.025	0.04	4.9	8.8	8	15	93.9	104.3	105	120	93.9	91	85	70
- Saltwater Creek downstream	12	ND	ND	0.02	0.09	0.002	0.024	0.025	0.04	7.3	10.6	8	15	93.2	101	105	120	93.2	90.6	85	70
Rollingstone Creek Estuary	11	0.048	0.274	0.02	0.09	0.015	0.017	0.025	0.04	7.1	11.3	8	15	95.6	101.8	105	120	95.6	94.8	85	70
Crystal Creek Estuary	11	0.058	0.123	0.02	0.09	0.008	0.012	0.025	0.04	4.5	14.5	8	15	95.8	97.5	105	120	95.8	91.2	85	70

The double black line delineates between the sites within the Ross estuarine zone (above line) and sites within the Black estuarine zone (below the line). Significant figures are one greater for the data to allow comparison with the water quality objective and scaling factor with median values higher than the water quality objective highlighted in yellow and 80th/20th percentile values higher/lower than the scaling factor highlighted in red. Indicators are shaded for ease of presentation. ND stands for no data. 20th percentile is used in the calculations for low dissolved oxygen, with the 80th percentile used for all other indicators.

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[1] 20th percentile is used in the calculations for low dissolved oxygen, with the 80th percentile used for all other indicators.

Appendix G. Comparison of site-specific results for nutrients and physical-chemical properties of estuarine sites for 2020-2021, 2019-2020 and 2018-2019.

Table G-1. Comparison of scores for indicators of nutrients for estuarine sites sampled in the 2020-2021, 2019-2020 and 2018-2019 years.

Site	Non-weighted scores for 2020-2021			Non-weighted scores for 2019-2020			Non-weighted scores for 2018-2019		
	DIN	Total P	Nutrients	DIN	Total P	Nutrients	DIN	Total P	Nutrients
- Louisa Creek upstream	66	0	33	66	0	33	0	0	0
- Town Common downstream	72	0	36	68	0	34	0	0	0
- Louisa Creek downstream	90	90	90	90	90	90	75	61	68
Louisa Creek Estuary	76	30	53	75	30	52	25	20	23
Bohle River Estuary	90	90	90	90	90	90	90	75	83
Ross Creek Estuary	90	90	90	90	90	90	0	90	45
Ross River Estuary	90	90	90	90	90	90	0	90	45
Sandfly Creek Estuary	90	90	90	90	90	90	83	75	79
Alligator Creek Estuary	90	90	90	90	90	90	90	65	77
Ross estuarine zone	**87**	**80**	**83**	**84**	**68**	**76**	**48**	**69**	**59**
Althaus Creek Estuary	69	90	79	90	72	80	61	90	76
Bluewater Creek Estuary	53	90	71	71	90	81	46	90	68
Sleeper Log Creek Estuary	90	90	90	ND	ND	ND	ND	ND	ND
- Camp Oven Creek upstream	ND	90	90	ND	ND	ND	ND	ND	ND
- Camp Oven Creek confluence		90	90						
- Camp Oven Creek downstream		90	90						
Camp Oven Creek Estuary		90	90						
- Saltwater Creek midstream	ND	90	90	ND	ND	ND	ND	ND	ND
- Saltwater Creek Estuary	90	90	90	67	90	79	57	90	74
- Saltwater Creek downstream	ND	90	90	ND	ND	ND	ND	ND	ND
Saltwater Creek Estuary	90	90	90	67	90	79	57	90	74
Rollingstone Creek Estuary	36	90	63	49	90	70	9	90	49
Crystal Creek Estuary	27	90	58	58	90	74	28	90	59
Black estuarine zone	**61**	**90**	**77**	**67**	**86**	**77**	**40**	**90**	**65**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data available (ND)
The score for nutrients is the average of the scores for dissolved inorganic nitrogen and total phosphorus.

Table G-2. Comparison of scores for indicators of physical-chemical (phys-chem) properties for estuarine sites sampled in the 2020-2021, 2019-2020 and 2018-2019 years.

Site	Non-weighted scores for 2020-2021				Non-weighted scores for 2019-2020				Non-weighted scores for 2018-2019			
	Turbidity	High DO	Low DO	Phys-chem properties	Turbidity	High DO	Low DO	Phys-chem properties	Turbidity	High DO	Low DO	Phys-chem properties
- Louisa Creek upstream	63	90	0	31	90	90	0	45	78	90	0	39
- Town Common downstream	65	90	0	32	90	90	0	45	71	90	0	36
- Louisa Creek downstream	76	90	90	83	90	90	64	77	80	90	60	70
Louisa Creek Estuary	68	90	30	49	90	90	21	56	77	90	20	48
Bohle River Estuary	76	90	90	83	90	90	90	90	90	90	77	84
Ross Creek Estuary	90	90	90	90	90	90	90	90	90	90	90	90
Ross River Estuary	90	90	90	90	90	90	90	90	90	90	90	90
Sandfly Creek Estuary	77	90	90	83	52	90	90	71	61	90	90	76
Alligator Creek Estuary	77	90	90	83	90	90	90	90	42	90	90	66
Ross estuarine zone	**79**	**90**	**80**	**79**	**85**	**90**	**64**	**75**	**75**	**90**	**76**	**76**
Althaus Creek Estuary	0	68	90	34	4	28	90	16	61	90	90	76
Bluewater Creek Estuary	90	73	90	81	0	0	90	0	90	90	90	90
Sleeper Log Creek Estuary	90	90	90	90	ND	ND	ND	ND	ND	ND	ND	ND
- Camp Oven Creek upstream	90	90	46	68	ND	ND	ND	ND	ND	ND	ND	ND
- Camp Oven Creek confluence	65	90	72	68								
- Camp Oven Creek downstream	61	90	77	69								
Camp Oven Creek Estuary	72	90	65	68								
- Saltwater Creek midstream	90	90	90	90	ND	ND	ND	ND	ND	ND	ND	ND
- Saltwater Creek Estuary	76	90	90	83	90	76	90	83	44	90	90	67
- Saltwater Creek downstream	65	90	90	77	ND	ND	ND	ND	ND	ND	ND	ND
Saltwater Creek Estuary	77	90	90	83	90	76	90	83	44	90	90	67
Rollingstone Creek Estuary	65	90	90	77	73	65	90	69	10	90	90	50
Crystal Creek Estuary	68	90	90	79	90	69	90	80	41	35	90	66
Black estuarine zone	**66**	**84**	**86**	**73**	**51**	**48**	**90**	**50**	**49**	**79**	**90**	**70**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data available (ND)
The scores for phys-chem properties are the average of turbidity and the lower score of either high or low dissolved oxygen.

Appendix H. Distribution (boxplots) of inshore marine water quality data.

The following figures are box and whisker plots (boxplots) of water quality indicators at all inshore marine water quality monitoring sites. The whiskers are the lowest and highest datum within 1.5 interquartile range (IQR) and outliers are above or below 1.5 IQR. Analysis was conducted on all data points collected during the reporting period (not only on the monthly values used for generating scores).

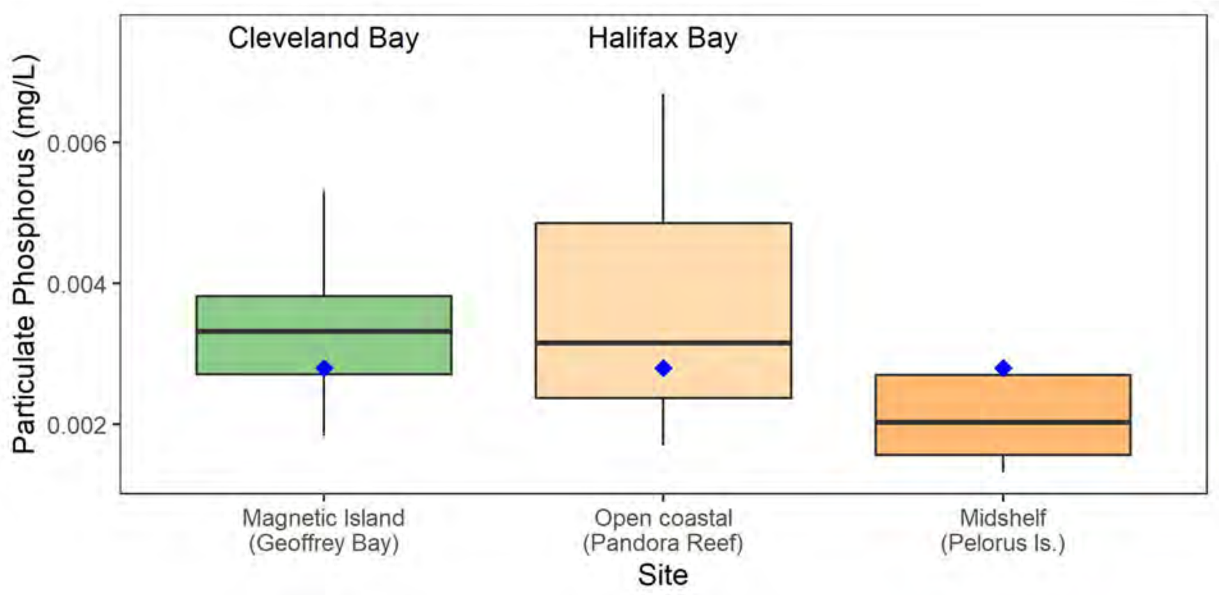

Figure H-1. Boxplot of particulate phosphorus concentrations at each inshore marine monitoring sites where the data was collected.

Data were collected using grab samples. The blue diamonds indicate the water quality objectives.

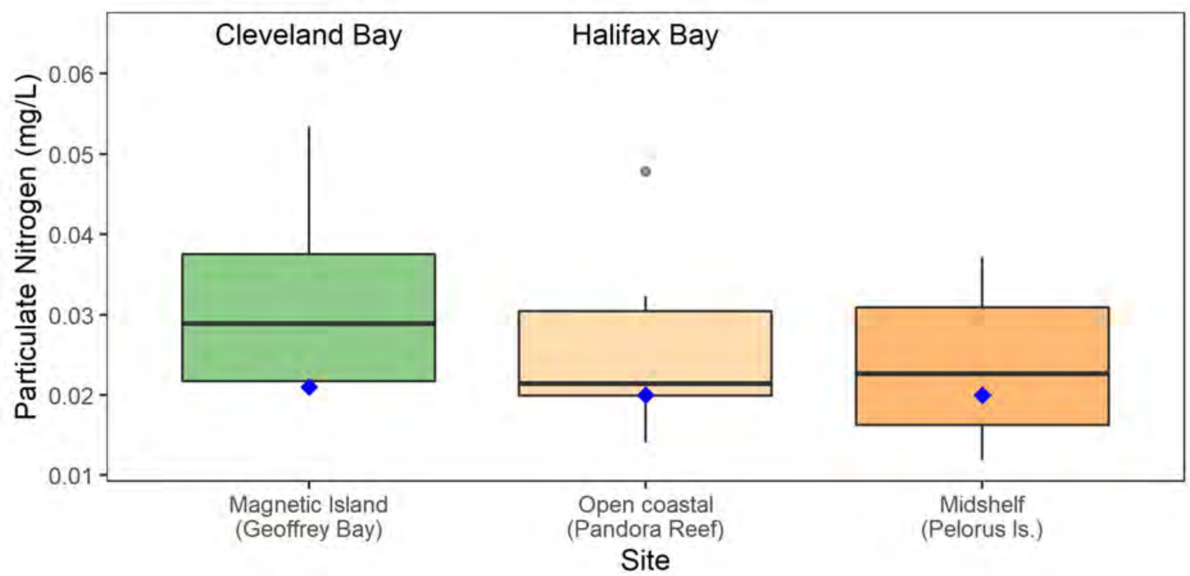

Figure H-2. Boxplot of particulate nitrogen concentrations at each inshore marine monitoring site.

Data were collected using grab samples. The blue diamonds indicate the water quality objectives.

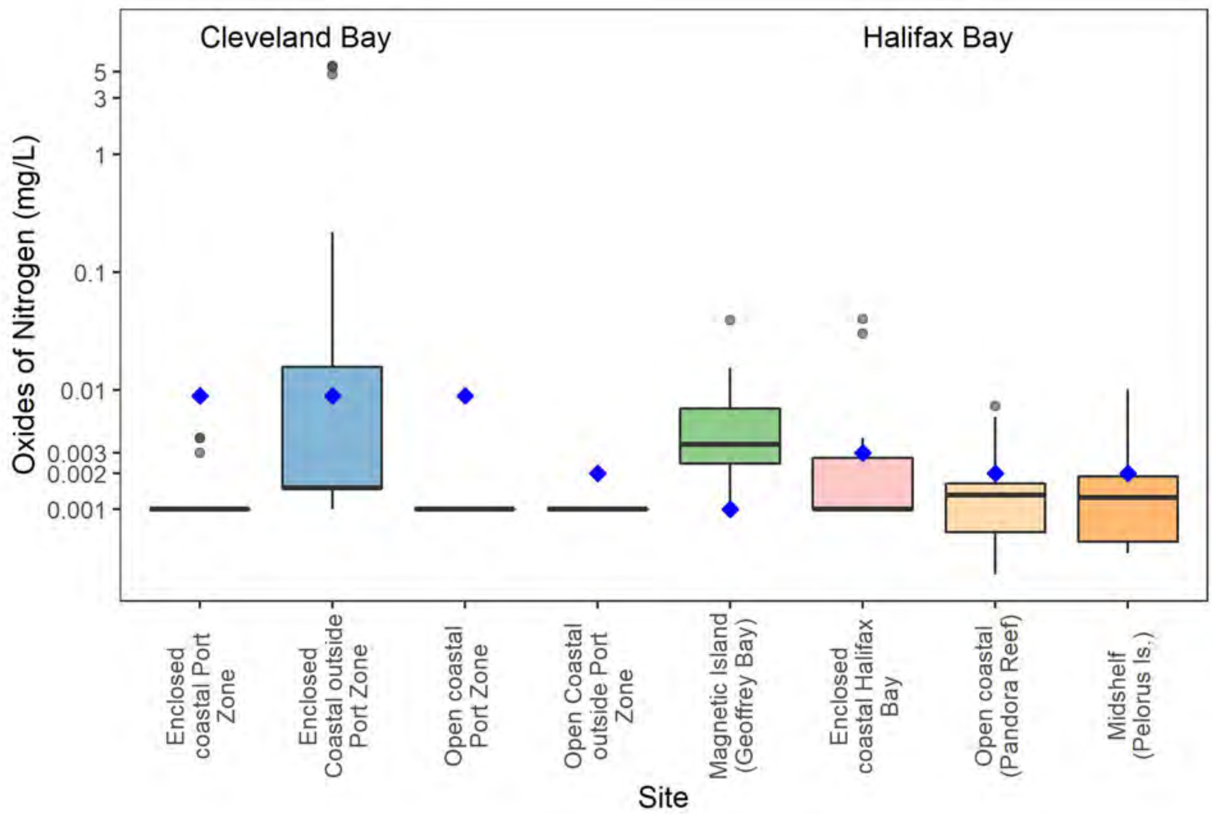

Figure H-3. Boxplot of oxidised nitrogen concentrations at each inshore marine monitoring site, with outliers included.

Data were collected using grab samples. The blue diamonds indicate the water quality objectives.

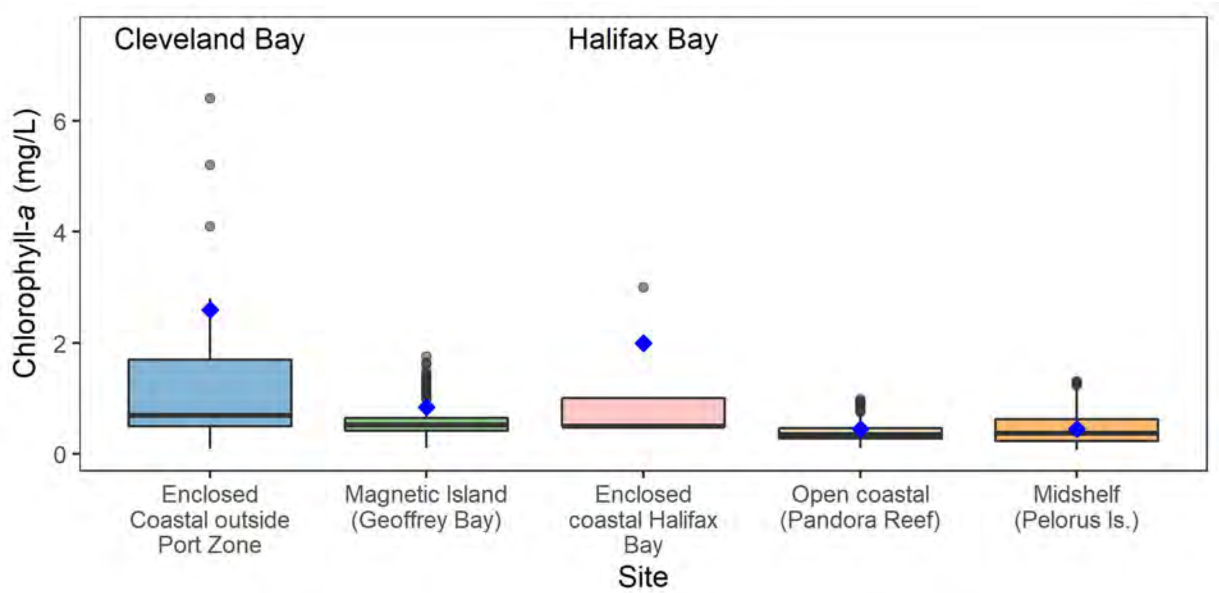

Figure H-4. Boxplot of chlorophyll a concentration at each inshore marine monitoring site.

Data were collected using grab samples and at some sites, logger samples. The blue diamonds indicate the water quality objectives.

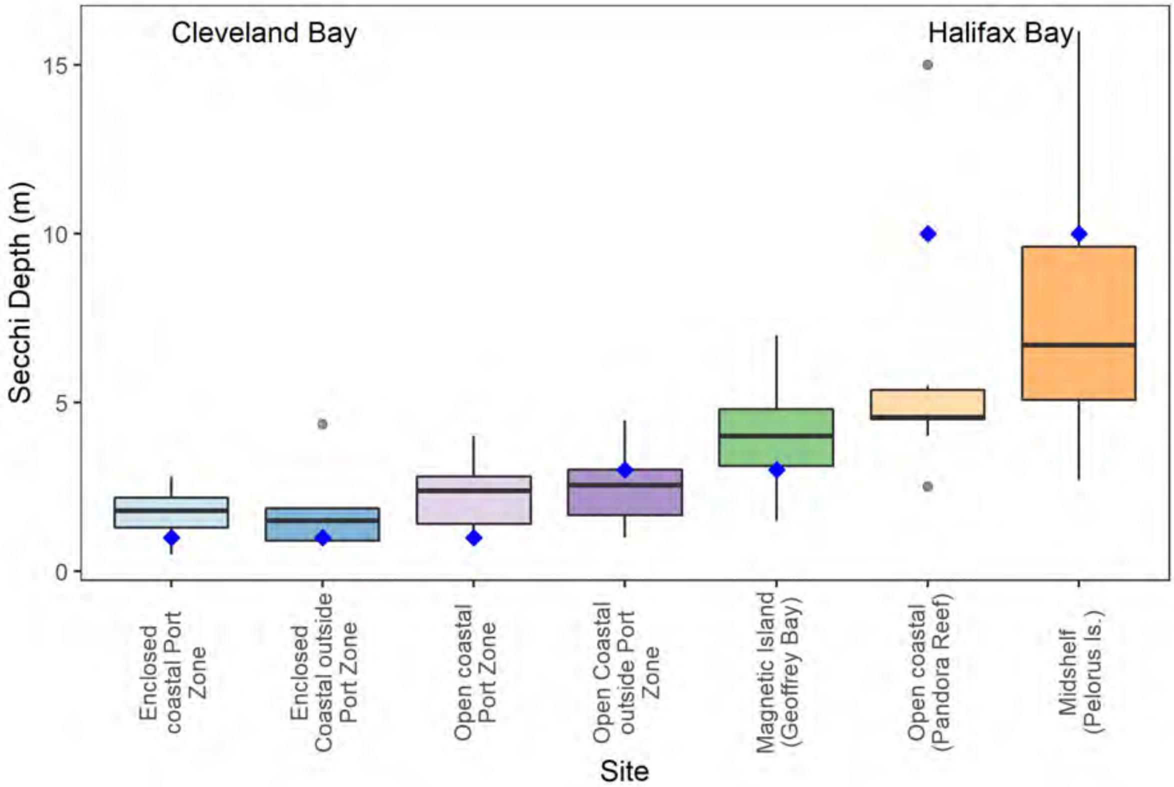

Figure H-5. Boxplot of secchi depth at each inshore marine monitoring site.

Data were collected using grab samples. The blue diamonds indicate the water quality objectives.

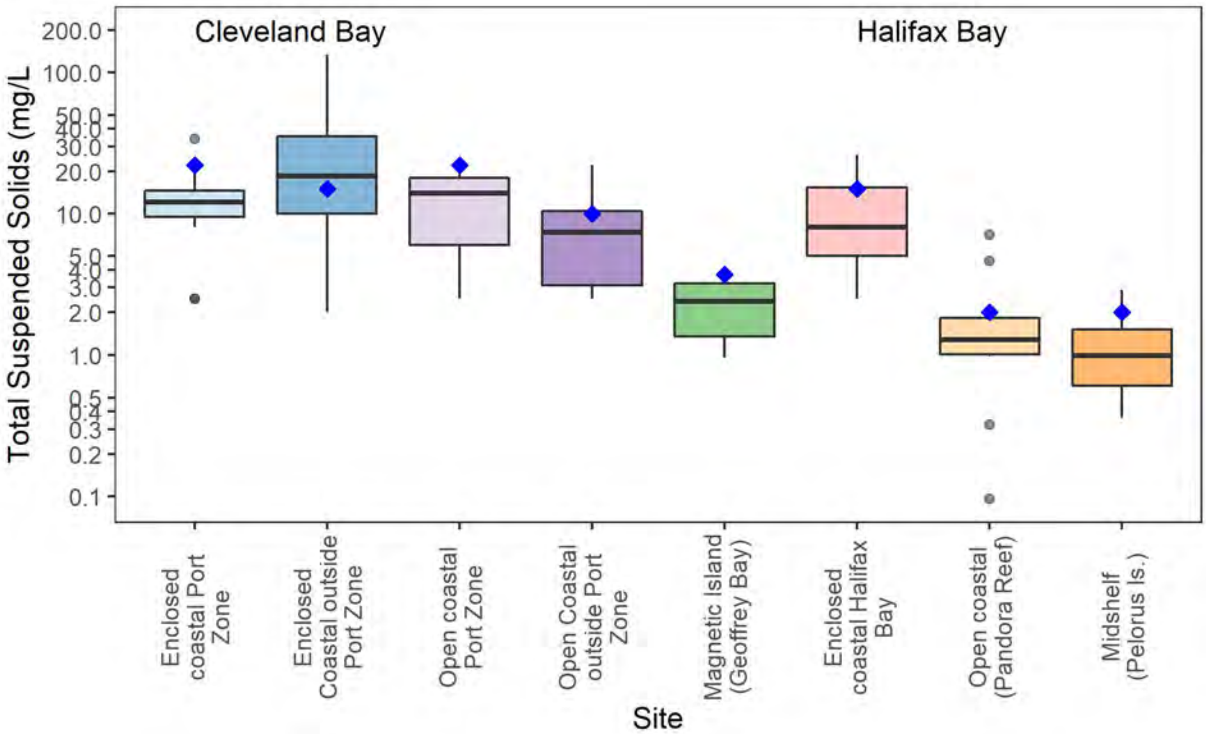

Figure H-6. Boxplot of total suspended solids at each inshore marine monitoring site.

Data were collected using grab samples and at some sites, logger samples. The blue diamonds indicate the water quality objectives.

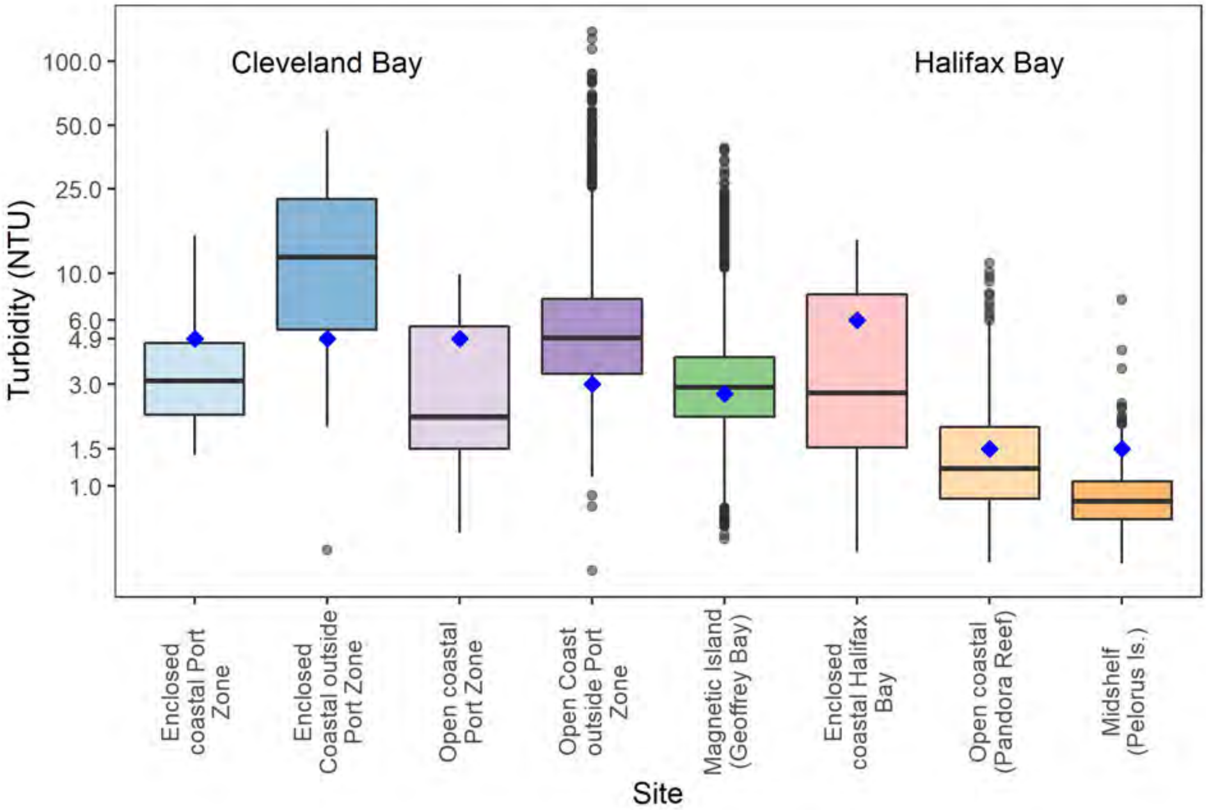

Figure H-7. Boxplot of turbidity levels at each inshore marine monitoring site.

Data was collected using grab samples at most sties, with logger samples used to collect turbidity data at Geoffrey Bay South and Arthur Bay. The blue diamonds indicate the water quality objectives.

Appendix I. Comparison of site-specific results for nutrients and physical-chemical properties for inshore marine sites for 2019-2020 and 2020-2021.

Table I-1. Comparison of scores for indicators of nutrients, physical-chemical (phys-chem) properties, chlorophyll a, and overall water quality for inshore marine sites sampled in the 2019-2020 and 2020-2021 years.

Site	Non-weighted scores for 2020-2021											Non-weighted scores for 2019-2020										
	Nutrients					Phys-chem				Chl *a*	Water quality*	Nutrients					Phys-chem				Chl *a*	Water quality
	TP	PP	PN	NOx	Nutrients	TSS	Secchi depth	Turbidity	Phys-chem			TP	PP	PN	NOx	Nutrients	TSS	Secchi depth	Turbidity	Phys-chem		
Enclosed coastal	100	ND	ND	50	75	52	94	43	63	95	**78**	84	ND	ND	94	89	69	81	40	64	100	**84**
- Inside port subzone^	100	ND	ND	100	100	89	91	86	89	ND	**94**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
- Outside port subzone	100	ND	ND	0	50	15	96	0	37	95	**61**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Open Coastal	100	ND	ND	100	100	81	72	58	70	ND	**85**	100	ND	ND	100	100	100	100	100	100	ND	**100**
- Inside port subzone	100	ND	ND	100	100	95	100	100	98	ND	**99**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
- Outside port subzone	100	ND	ND	100	100	66	45	16	42	ND	**71**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Magnetic Island	ND	46	27	0	24	86	77	55	66	82	**57**	ND	67	9	0	25	100	ND	71	71	85	**60**
Geoffrey Bay North	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	ND	67	9	0	25	100	ND	100	100	85	**54**
Geoffrey Bay South	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	ND	ND	ND	54	54	ND	**58**
Arthur Bay	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	ND	ND	ND	58	58	ND	**70**
Cleveland Bay+	**100**	**46<**	**27**	**60**	**58**	**70**	**82**	**51**	**68**	**89**	**72**	**92**	**67**	**9**	**65**	**71**	**90**	**91**	**71**	**75**	**93**	**80**
Enclosed Coastal	100	ND	ND	22	61	81	ND	100	91	100	**84**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Open coastal (Pandora Reef)	ND	61	44	44	50	76	ND	67	71	64	**62**	ND	75	8	48	44	100	ND	90	95	70	**70**
Midshelf (pelorus Island)#	ND						ND					ND	70	2	28	33	100	ND	100	100	75	**69**
Halifax Bay	**100**	**61**	**44**	**33**	**55**	**78**	**ND**	**83**	**81**	**82**	**73**	**ND**	**73**	**5**	**38**	**39**	**100**	**ND**	**95**	**98**	**73**	**70**

Scoring range: ■ Very Poor I = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND)

*Nutrients is comprised of the average for TP, PP, PN, and NOx. Phys-chem properties is comprised of the average for TSS, Secchi, and Turbidity. Water quality is comprised of the average of Nutrients, Phys-chem properties, and Chl *a*.

^ Independent site names are written in black, non-independent site names are written in brown. Non-independent site scores are averaged to create independent site scores.

+ Zone/basin names are written in bold. Independent site scores for each indicator are averaged to create zone indicator scores. Zone indicator scores are averaged to produce zone indicator category scores.

< All scores are floor rounded.

Data for the Open Coastal (Pandora) and Midshelf (Pelorus) sites were sourced from the Wet Tropics Technical Report [Wet Tropics Technical Report 2021]

Appendix J. Comparison of site-specific results for seagrass meadows within Cleveland Bay for 2020-2021, 2019-2020, 2018-2019, and 2017-2018.

Table J-1. Comparison of scores for indicators of seagrass for meadows within Cleveland Bay sampled during the 2020-2021, 2019-2020, 2018-2019, and 2017-2018 years.

Location	Site	Scores for 2020-2021				Scores for 2019-2020				Scores for 2018-2019				Scores for 2017-2018			
		Biomass	Area	Species composition	Seagrass indicator category	Biomass	Area	Species composition	Seagrass indicator category	Biomass	Area	Species composition	Seagrass indicator category	Biomass	Area	Species composition	Seagrass indicator category
Geoffrey Bay	3	67	87	100	**67**	28	73	97	**28**	85	88	84	**85**	82	95	79	**80**
Nelly Bay	4	82	95	100	**82**	41	85	98	**41**	67	88	100	**67**	84	87	85	**84**
Cockle/ Picnic Bay	5	70	77	99	**70**	60	89	98	**60**	78	85	98	**78**	86	84	100	**84**
Cockle Bay	6	70	75	91	**70**	66	50	97	**50**	70	59	89	**59**	86	53	96	**53**
Shelly Beach	10	84	50	78	**50**	68	51	96	**51**	91	54	99	**54**	93	57	92	**57**
Rowes Bay	12	85	99	83	**83**	60	100	69	**60**	92	100	84	**88**	90	100	80	**85**
Rowes Bay	14	68	71	93	**68**	55	74	87	**55**	68	92	98	**68**	82	89	98	**82**
Strand meadow	15	74	67	92	**67**	73	74	58	**65**	93	86	70	**78**	89	92	89	**89**
Cleveland Bay	16	78	80	93	**78**	59	100	94	**59**	90	100	99	**90**	95	79	97	**79**
Cleveland Bay	17/18	75	95	98	**75**	55	88	98	**55**	71	86	95	**71**	86	86	96	**86**
Cleveland Bay					**71**				**52**				**74**				**78**

Scoring range: ■ Very Poor (E) = 0 to <25 | ■ Poor (D) = 25 to <50 | ■ Moderate (C) = 50 to <65 | ■ Good (B) = 65 to <85 | ■ Very Good (A) = 85 to 100

Appendix K. Comparison of site-specific results for inshore reefs within Cleveland and Halifax bays for 2020-2021, 2019-2020 and 2018-2019.

Table K-1. Comparison of scores for indicators of inshore coral sampled in the 2020-2021, 2019-2020, and 2018-2019 years.

Site (Reef)	Monitoring Program	Standardised scores for 2020-2021						Standardised scores for 2019-2020						Standardised scores for 2018-2019					
		Composition of hard corals	% Coral cover^	% Change hard corals	Juvenile density	Macroalgae	Coral indicator category*	Composition of hard corals	% Coral cover	% Change hard corals	Juvenile density	Macroalgae	Coral indicator category	Composition of hard corals	% Coral cover	% Change hard corals	Juvenile density	Macroalgae	Coral indicator category
Alma Bay	RCA	ND	49 (C)	ND	ND	ND	ND	ND	42 (C)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Florence Bay	RCA	ND	30 (D)	ND	ND	ND	ND	ND	29 (D)	ND	ND	ND	ND	ND	42 (C)	ND	ND	ND	ND
Geoffrey Bay	MMP RCA	50 (C)	47 (C)	60 (C)	23 (D)	0 (E)	36 (D)	75 (B)	48 (C)	47 (C)	59 (C)	0 (E)	46 (C)	50 (C)	40 (C)	49 (C)	44 (C)	0 (E)	37 (D)
Middle Reef	RCA	ND	71 (B)	ND	ND	ND	ND	ND	46 (C)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nelly Bay	RCA	ND	44 (C)	ND	ND	ND	ND	ND	25 (D)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cleveland Bay+	**MMP RCA**	**50** (C)	**48** (C)	**60** (C)	**23** (D)	**0** (E)	**36** (D)	**63** (B)	**38** (D)	**47** (C)	**57** (C)	**0** (E)	**44** (C)	**50** (C)	**41** (C)	**49** (C)	**44** (C)	**0** (E)	**37** (D)
Fantome Island (Juno Bay)	RCA	ND	35 (D)	ND	ND	ND	ND	ND	45 (C)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Havannah	MMP	50 (C)	43 (C)	36 (D)	26 (D)	0 (E)	31 (D)	100 (A)	42 (C)	50 (C)	40 (D)	50 (C)	56 (C)	100 (A)	47 (C)	50 (C)	24 (D)	77 (B)	60 (C)
Havannah North	LTMP	100 (A)	19 (E)	100 (A)	89 (A)	0 (E)	62 (B)	100 (A)	28 (D)	77 (B)	52 (C)	0 (E)	52 (C)	100 (A)	28 (D)	77 (B)	52 (C)	0 (E)	52 (C)
- Site 1#	RCA	ND	ND	ND	ND	ND	ND	ND	73 (B)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
- Site 2#	RCA	ND	ND	ND	ND	ND	ND	ND	58 (C)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Orpheus Island (Pioneer Bay)	RCA	ND	55 (C)	ND	ND	ND	ND	ND	55 (C)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Palms East (OI)	MMP	100 (A)	66 (B)	62 (B)	29 (D)	100 (A)	71 (B)	100 (A)	62 (B)	70 (B)	34 (D)	100 (A)	73 (B)	100 (A)	58 (C)	91 (A)	38 (D)	88 (A)	75 (B)
Palms West (PI)	MMP RCA	0 (E)	56 (C)	38 (D)	50 (C)	100 (A)	49 (C)	0 (E)	45 (C)	35 (D)	41 (C)	100 (A)	44 (C)	25 (D)	46 (C)	55 (C)	39 (D)	100 (A)	53 (C)
Pandora	MMP	75 (B)	22 (D)	39 (D)	36 (D)	36 (D)	42 (C)	75 (B)	17 (E)	50 (C)	71 (B)	20 (E)	47 (C)	75 (B)	14 (E)	47 (C)	52 (C)	7 (E)	39 (D)
Pandora North	LTMP	50 (C)	75 (B)	38 (D)	33 (D)	0 (E)	39 (D)	0 (E)	77 (B)	31 (D)	52 (C)	0 (E)	32 (D)	0 (E)	77 (B)	31 (D)	52 (C)	0 (E)	32 (D)
Halifax Bay	**LTMP MMP RCA**	**62** (B)	**47** (C)	**52** (C)	**44** (C)	**39** (D)	**49** (C)	**63** (B)	**50** (C)	**52** (C)	**48** (C)	**45** (C)	**52** (C)	**67** (B)	**45** (C)	**59** (C)	**43** (C)	**45** (C)	**52** (C)

Scoring range: ■ Very Poor (E) = 0 to <21 | ■ Poor (D) = 21 to <41 | ■ Moderate (C) = 41 to <61 | ■ Good (B) = 61 to <81 | ■ Very Good (A) = 81 to 100 | ■ No data (ND)

*The score for the coral indicator category is the average of the scores for the five indicators (listed previously).

^Data on percent coral cover is collected by both the MMP program and Reef Check.

+The overall score for Cleveland Bay and Halifax Bay is the average of the scores for the sites listed above.

#These sites were previously listed as individual locations despite representing the same site. Beginning 2020-2021 all data will reported under the Orpheus Island (Pioneer Bay) site name.

RCA = Reef Check Australia, MMP = Marine Monitoring Program, LTMP = Long-term Monitoring Program, OI = Orpheus Island, PI = Pelorus Island.

Appendix L. Australian Land Use and Management Classifications used to establish the Dry Tropics land use map.

Table L-1.Australian land use and management classifications used to establish the Dry Tropics land use map

Australian Land Use and Management Classification		Area (ha)	Area (%)
1	Conservation and Natural Environments	19,249,971	11.12
1.1	Nature conservation	9,973,908	5.76
1.2	Managed resource protection	7,150,319	4.13
1.3	Other minimal use	2,125,745	1.23
2	Production from Relatively Natural Environments	140,846,920	81.39
2.1	Grazing native vegetation	137,844,503	79.66
2.2	Production native forests	3,002,418	1.74
3	Production from Dryland Agriculture and Plantations	3,494,547	2.02
3.1	Plantation forests	253,631	0.15
3.2	Grazing modified pastures	150,151	0.09
3.3	Cropping	3,057,362	1.77
3.4	Perennial horticulture	11,782	0.01
3.5	Seasonal horticulture	183	<0.01
3.6	Land in transition	21,438	0.01
4	Production from Irrigated Agriculture and Plantations	1,058,475	0.61
4.1	Irrigated plantation forests	4,440	<0.01
4.2	Grazing irrigated modified pastures	27,044	0.02
4.3	Irrigated cropping	885,632	0.51
4.4	Irrigated perennial horticulture	77,000	0.04
4.5	Irrigated seasonal horticulture	61,907	0.04
4.6	Irrigated land in transition	2,452	<0.01
5	Intensive Uses	1,168,687	0.68
5.1	Intensive horticulture	2,160	<0.01
5.2	Intensive animal production	20,219	0.01
5.3	Manufacturing and industrial	28,457	0.02
5.4	Residential and farm infrastructure	682,538	0.39
5.5	Services	126,258	0.07
5.6	Utilities	7,904	<0.01
5.7	Transport and communication	96,578	0.06
5.8	Mining	198,491	0.11
5.9	Waste treatment and disposal	6,082	<0.01
6	Water	7,227,560	4.18
6.1	Lake	1,022,831	0.59
6.2	Reservoir/dam	312,113	0.18
6.3	River	356,881	0.21
6.4	Channel/aqueduct	6,357	<0.01
6.5	Marsh/wetland	5,468,523	3.16
6.6	Estuary/coastal waters	60,853	0.04
		173,046,161	100.00