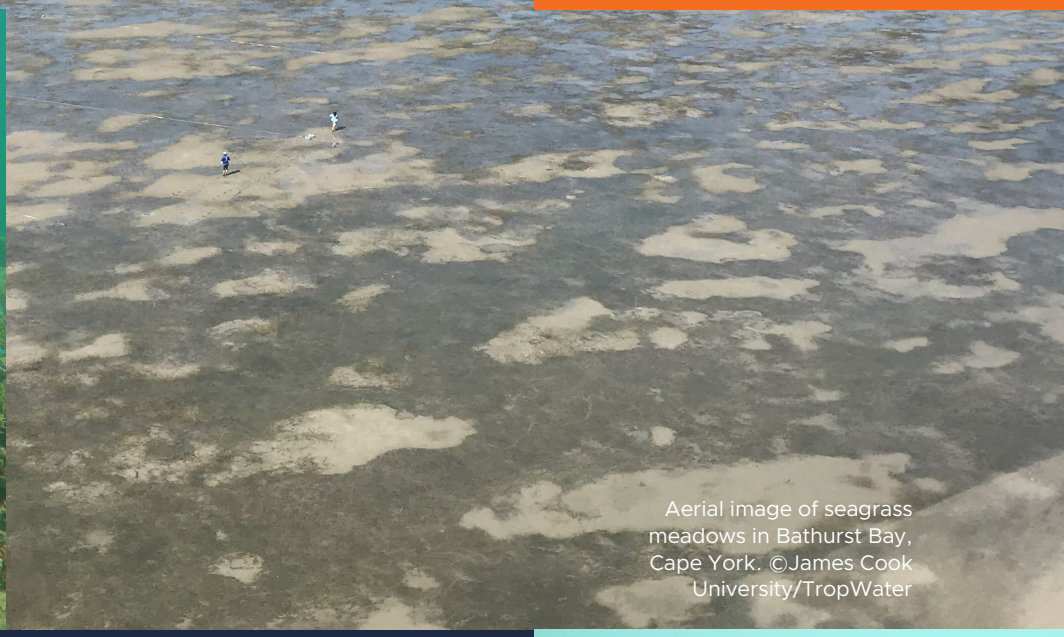
Recovering acroporids in Fitzroy Island, Wet Tropics. ©C. Thompson, Australian Institute of Marine Science

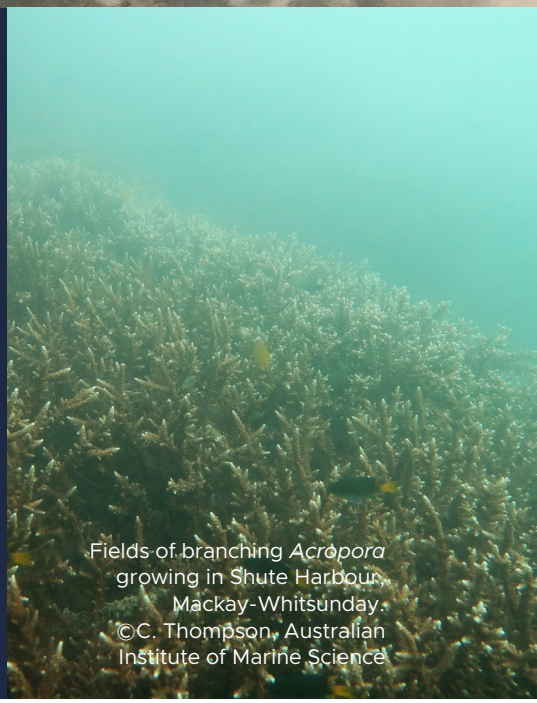


Aerial image of seagrass meadows in Bathurst Bay, Cape York. ©James Cook University/TropWater

GREAT BARRIER REEF
MARINE MONITORING PROGRAM

MONITORING OF THE INSHORE REEF REGIONS 2021–22

Monitoring water quality and the health of inshore coral reef and seagrass habitats is essential to understanding the resilience of the entire Great Barrier Reef.



Fields of branching *Acropora* growing in Shute Harbour, Mackay-Whitsunday. ©C. Thompson, Australian Institute of Marine Science

Australian Government
Great Barrier Reef Marine Park Authority

Australian Government
Australian Institute of Marine Science

Cape York Water Partnership

James Cook University Australia

TropWATER

Diverse yet threatened ecosystems

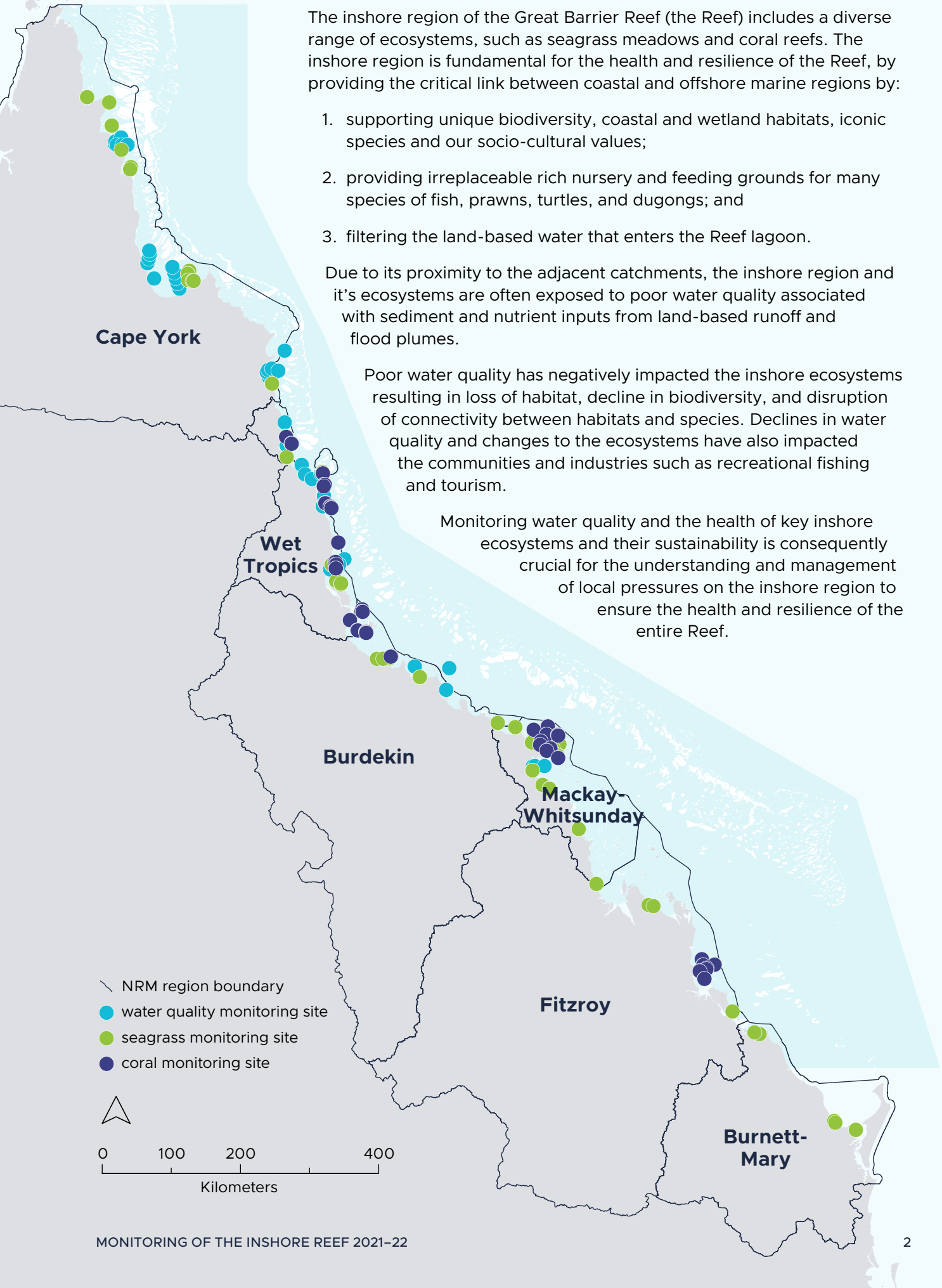
The inshore region of the Great Barrier Reef (the Reef) includes a diverse range of ecosystems, such as seagrass meadows and coral reefs. The inshore region is fundamental for the health and resilience of the Reef, by providing the critical link between coastal and offshore marine regions by:

1. supporting unique biodiversity, coastal and wetland habitats, iconic species and our socio-cultural values;
2. providing irreplaceable rich nursery and feeding grounds for many species of fish, prawns, turtles, and dugongs; and
3. filtering the land-based water that enters the Reef lagoon.

Due to its proximity to the adjacent catchments, the inshore region and it's ecosystems are often exposed to poor water quality associated with sediment and nutrient inputs from land-based runoff and flood plumes.

Poor water quality has negatively impacted the inshore ecosystems resulting in loss of habitat, decline in biodiversity, and disruption of connectivity between habitats and species. Declines in water quality and changes to the ecosystems have also impacted the communities and industries such as recreational fishing and tourism.

Monitoring water quality and the health of key inshore ecosystems and their sustainability is consequently crucial for the understanding and management of local pressures on the inshore region to ensure the health and resilience of the entire Reef.



A diver surveys juvenile coral demography along an adult *Acropora* dominated transect. ©J. Davidson, Australian Institute of Marine Science

Routine and event monitoring informs management decisions

The Great Barrier Reef Marine Monitoring Program (MMP) was established to inform managers and the wider community about the condition of inshore corals and seagrass, and the effects on these ecosystems from poor water quality resulting from land-based runoff.

Routine monitoring of water quality, as well as assessment of seagrass and coral condition occur year-round. Monitoring is managed by the Great Barrier Reef Marine Park Authority (the Reef Authority), and conducted in partnership with James Cook University/TropWater, the Cape York Water Partnership, and the Australian Institute of Marine Science. The MMP team is responsible for publishing the annual technical reports and developing communication products that are evidence-based to inform the Reef Authority and the public about condition of the inshore region, ensuring management decisions are based on the best available scientific information.

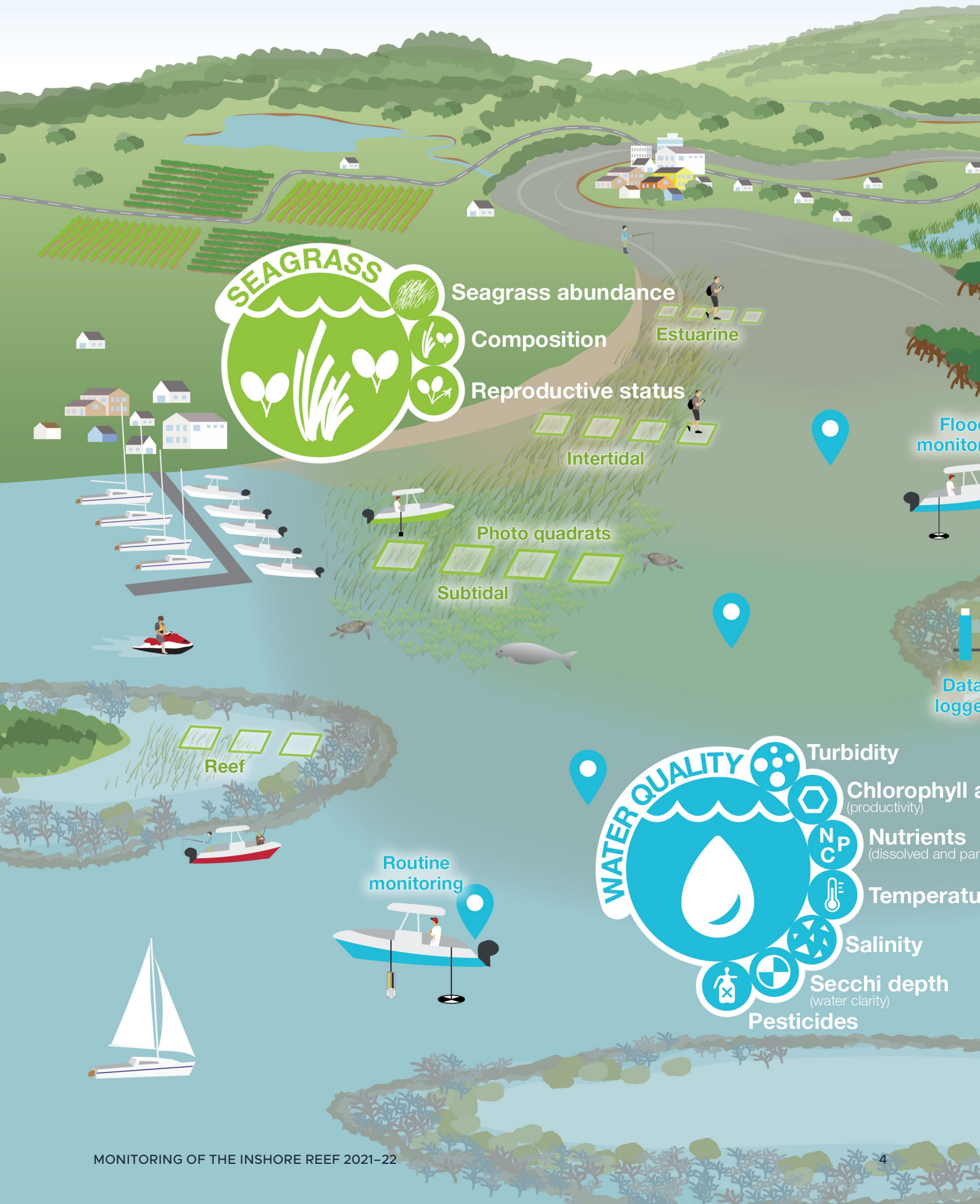
In addition to routine monitoring, the MMP also undertakes reactive flood monitoring. The MMP water quality team assesses the magnitude, extent, and duration of flood plumes, particularly following extreme 'events' such as floods and cyclones. Flood plume monitoring assess the concentration and transport of major land-based pollutants to the Reef.

The MMP currently undertakes monitoring in partnership with Traditional Owners on their Sea Country. In Cape York, water quality monitoring is led by Howley Environmental Consulting and members of the Cape York Water Partnership, including Yintingga Aboriginal Corporation, Rinyirru Aboriginal Corporation, and Yuka Baja Muliku Rangers. Seagrass monitoring is led by James Cook University in collaboration with Traditional Owners from the Wuthathi, Kuku Yau, Yuku Baja Muliku and Girringun groups.

MMP researcher sampling water from the Tully River, Wet Tropics. ©James Cook University/TropWater

Seagrass researcher sampling species of seagrass in the Burdekin region. ©James Cook University/TropWater

Year-round monitoring occurs across the inshore zone




Remote sensing
CORAL
Coral cover
Cover change
Macroalgae cover
Juvenile coral density
Coral community composition
2m
5m
Photo transects

2021–22 scores

Cape York

Wet Tropics

Burdekin

Mackay-Whitsunday

Fitzroy

Burnett-Mary

2021–22 summary

In the monitoring season of 2021–2022, no significant disturbance affected the inshore Reef. There was limited cyclone activity for the Reef with only one cyclone, Tropical cyclone Tiffany that crossed the Cape York coast in early January 2022.

However, the season was characterised by some relatively late rainfall events in April and May 2022 in most Natural Resource Management (NRM) regions. Overall, rainfall and river discharge were just above the long-term median for the Reef. The northern NRM regions (Cape York, Wet Tropics and Burdekin) had discharges around the long-term median while the Mackay–Whitsunday region was around half of the long-term median and the Fitzroy region was 1.5 times above the long-term median. The Burnett–Mary region had very high discharge in the 2021–22 monitoring year at nearly nine times above the long- term median.

Sea-surface temperatures over the 2021–22 summer were above long-term averages in the inshore reef, and marine heatwave was severe in the Burdekin NRM.

Mackay–Whitsunday coral communities are slowly recovering from Tropical cyclone Debbie, in 2017. Sediment resuspension has been an issue in the region, slowing recovery of those reefs. Juvenile coral was detected in the second year in a row (2020-21 and 2021-22 monitoring years) in some sites.

Recovering acroporids and soft coral in the Wet Tropics.
©J. Davidson, Australian Institute of Marine Science

Significant declines in seagrass abundance and resilience in the Fitzroy and Burnett-Mary NRMs, remain vulnerable to further disturbances.

Chlorophyll *a* met guideline values in most regions, except in the Mackay-Whitsunday NRM. Cape York water quality was ‘good’ overall, and ‘very good’ for the Annan-Endeavour.

Overall, water quality improvements have been detected in all NRMs monitored by the MMP.

The issue with high concentration of Chlorophyll *a* concentration in the water column provides an indicator of increased nutrient loads as microalgae (phytoplankton) can grow quickly in response to nutrient availability. Algal blooms can have an impact on light availability and, for example, negatively impacting seagrass growth.

Mooring at the mouth of the Russell Mulgrave Rivers.
©I. Zagorskis, Australian Institute of Marine Science

Cape York region

The annual condition Index for the Cape York region was 'good' for the 2021–22 monitoring year.

Chlorophyll *a* (Chl-*a*), Total Suspended Solids (TSS), phosphate (PO_4) and Particulate Phosphorus met (PP) the water quality Guideline Values at most sites.

During the 2021–22 reporting period, the seagrass condition Index score for the Cape York region improved slightly since the previous reporting period, with the overall grade remaining 'moderate'.

The abundance indicator was on a declining trend from 2015–16 to 2021–22, and declined only slightly between 2020–21 and 2021–22.

Losses occurred at reef subtidal habitats and some reef intertidal habitats where sites lost close to half their percentage cover. There were slight improvements in the resilience indicator. The improvement in the resilience score was partly a consequence of higher reproductive effort and seed banks in coastal habitats.

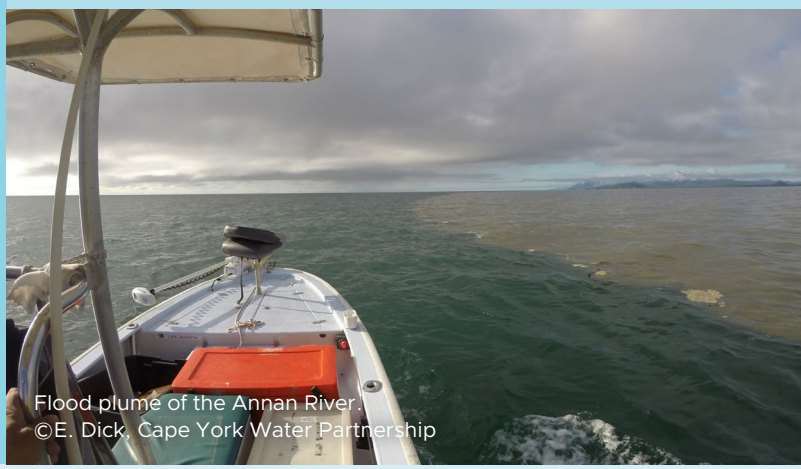
Flood event monitoring

Ex-Tropical cyclone Tiffany, January 2022

The first flooding event was associated with ex-TC Tiffany, which crossed over Prince Charlotte Bay on 10 January 2022. Rainfall associated with TC Tiffany caused flooding in the southern Cape York region, including the Normanby, Stewart, and Annan and Endeavour Rivers. While enclosed coastal areas were affected by land-based runoff, clear water (visibility over 10m) was encountered in the open coastal and mid-shelf zones indicating that there was little flood influence in the vicinity of coral reefs.

Heavy rainfall, February 2022

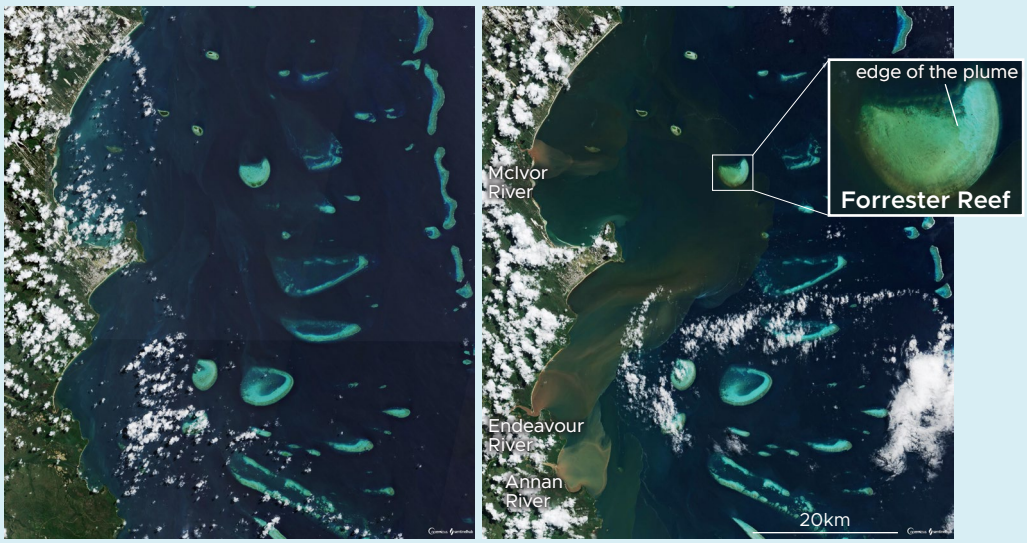
In early February 2022, significant rainfall in south-eastern Cape York caused flooding of the Normanby Basin and Princess Charlotte Bay over the week on 7 February. At the Normanby, Kalpowar Crossing gauge, approximately 75km upstream from the Normanby River mouth. Floodwaters peaked at 7m on 9 February causing major flooding in that catchment.



Flood plume of the Annan River.
©E. Dick, Cape York Water Partnership

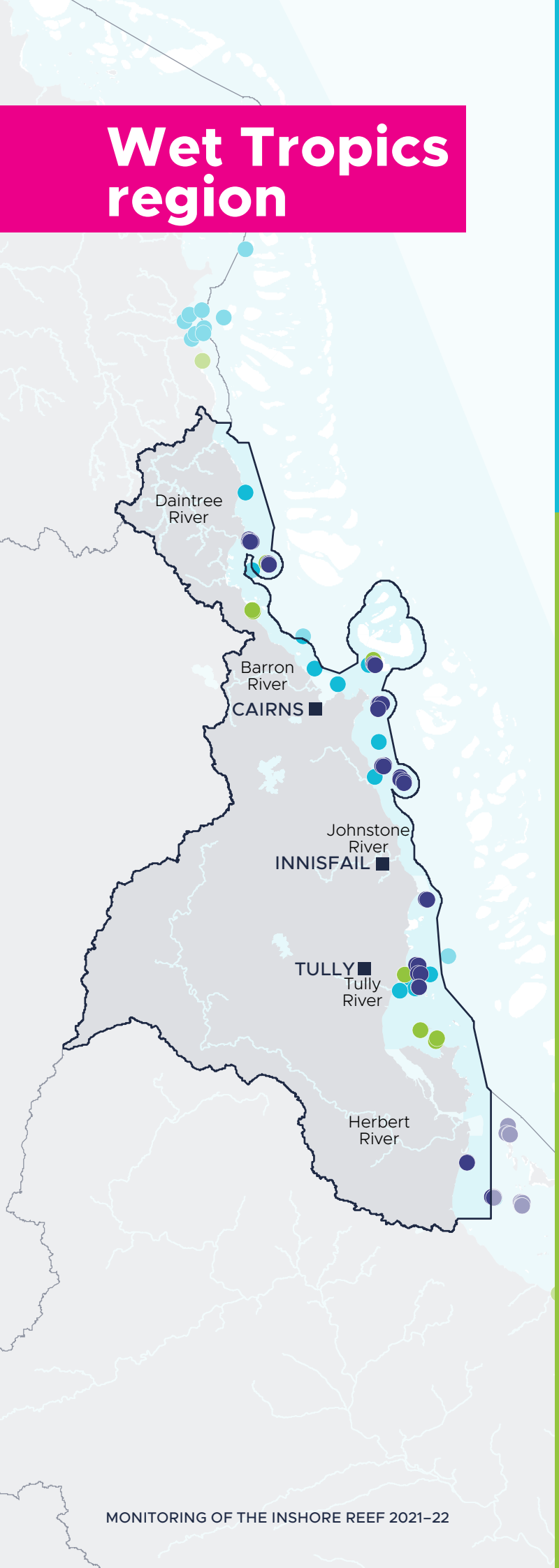
Heavy rainfall, April 2022

Heavy rainfall caused significant flooding of the Annan-Endeavour Rivers. Satellite images showed that the flood plume flowed north, inundating reefs in the mid-shelf waterbody, including Forrester Reef, approximately 30km to the northeast of the Endeavour River mouth. This event highlights the impact of flood plumes on offshore reefs, particularly the negative effects of low salinity but also of fine sediments, which can travel hundreds of kilometres away from the river mouth. Fine sediments can aggregate and deposit on the seafloor potentially causing long-term impacts by reducing light availability to corals and seagrass, and also contributing to increased turbidity during wind-induced resuspension events.



Satellite images showing flooding from the Annan and Endeavour Rivers on the 26 April 2022 (right) compared to ambient conditions before the flood (left, 6 April 2022). Source: Sentinel EO Hub, downloaded by Caroline Petus, TropWater/James Cook University.

Wet Tropics region



The annual condition Index for the Wet Tropics region was 'moderate' for the 2021–22 monitoring year.

Annual water quality guideline values were exceeded for many water quality variables within the Wet Tropics, except for Chl-*a*, PO_4 and TSS which met guidelines for most sites in all regions (Barron-Daintree, Russell-Mulgrave, and Tully-Herbert). Over the period from 2017 to 2022, many water quality variables are showing signs of an improving trend.

In the 2021–22 monitoring period, the seagrass condition Index for the overall Wet Tropics region improved and was 'moderate'.

Both indicators increased when averaged across the Wet Tropics and the abundance score was the highest level recorded for the Wet Tropics. There were differences in the trends of the indicators between regions, though both showed overall improvement in the condition Index.

Northern Wet Tropics

In the northern Wet Tropics, seagrass abundance increased from 'moderate' to 'good' and was the highest ever recorded. Resilience in the northern Wet Tropics declined in 2021–22 and is the fourth lowest score since records began.

Southern Wet Tropics

In the southern Wet Tropics, the seagrass condition Index improved and reached the highest level since monitoring began in 2005. This was driven by improvements in resilience, which was also at the highest level observed and was 'moderate'. Abundance declined in 2021–22 and remained poor in the southern Wet Tropics.

Overall, the main pressures affecting seagrass habitats in the southern Wet Tropics in 2021–22 were similar to those in the northern with above average temperatures and temperature extremes.

At the regional level, the Coral Index scores have remained relatively stable at 'moderate' since 2016. In 2022, the Cover change indicator remained 'good', the Coral cover indicator increased to 'good', and all other indicators (macroalgae, juvenile coral, and coral composition) remained 'moderate'. While there were no severe disturbances over the 2021–22 monitoring year, scores within sub-regions have varied as communities have been impacted by, and recovered from, localised pressures. For example, coral communities in the Barron Daintree sub-region experienced reductions in scores due to coral bleaching in 2017 and then the combined influence of a flood of the Daintree River and cyclone Owen prior to 2019 surveys.

The Wet Tropics is the only region which crown-of-thorns starfish have been common on inshore reefs. Crown-of-thorns starfish populations have been at, or near, outbreak levels since 2012 in the Johnston Russell-Mulgrave sub-region, and have been the primary cause of coral cover loss in the region.

Colonies of branching *Acropora* in the Frankland Islands, Wet Tropics. ©C. Thompson, Australian Institute of Marine Science

Positive signs of recovery for seagrass

There were also positive signs of recovery. In the Wet Tropics the overall score was the fourth highest on average since the start of the program in 2005. In the northern Wet Tropics, the abundance score increased to the highest on record and was a 'good' rating. In the southern Wet Tropics, the Index has been on an increasing trend since 2012–13, but in 2021–22, abundance declined a little and was poor, though resilience increased to 'moderate' and the highest score on record. There was elevated discharge in 2018–19, particularly in the Far North Region from the Daintree River, but otherwise environmental conditions were relatively benign in the Wet Tropics from 2010–11 to 2021–22. The exception is water temperature, which was elevated in 2021–22 and which continues a trend for warm within-canopy temperature anomalies to be more frequent than cool within-canopy temperature anomalies in the region. Otherwise, the relatively low-pressure conditions have supported recovery across the Wet Tropics. Healthy seagrass meadows provide habitats and foraging grounds to hundreds of fish species, turtle, and dugongs, can quickly assimilate nutrients from the water column, and trap sediments within the leaves, keeping the water column clear.

Burdekin region

The annual condition Index for the Burdekin was 'moderate' for the 2021–22 monitoring year.

Annual water quality guideline values were met for Chl-*a*, PO_4, and PP at all sites, and are showing a continuous improving trend. Secchi depth did not meet the guidelines but is stable in the region.

Phosphate (PO_4)

Elevated concentration of PO_4 indicates nutrient contamination. The inshore region of the Reef is regularly exposed to phosphorus pollution through land-runoff largely due to agriculture but also deforestation and soil erosion. Phosphate contamination negatively affects reef-building corals by compromising reproduction, skeletal calcification, which can hinder the resilience of coral communities.

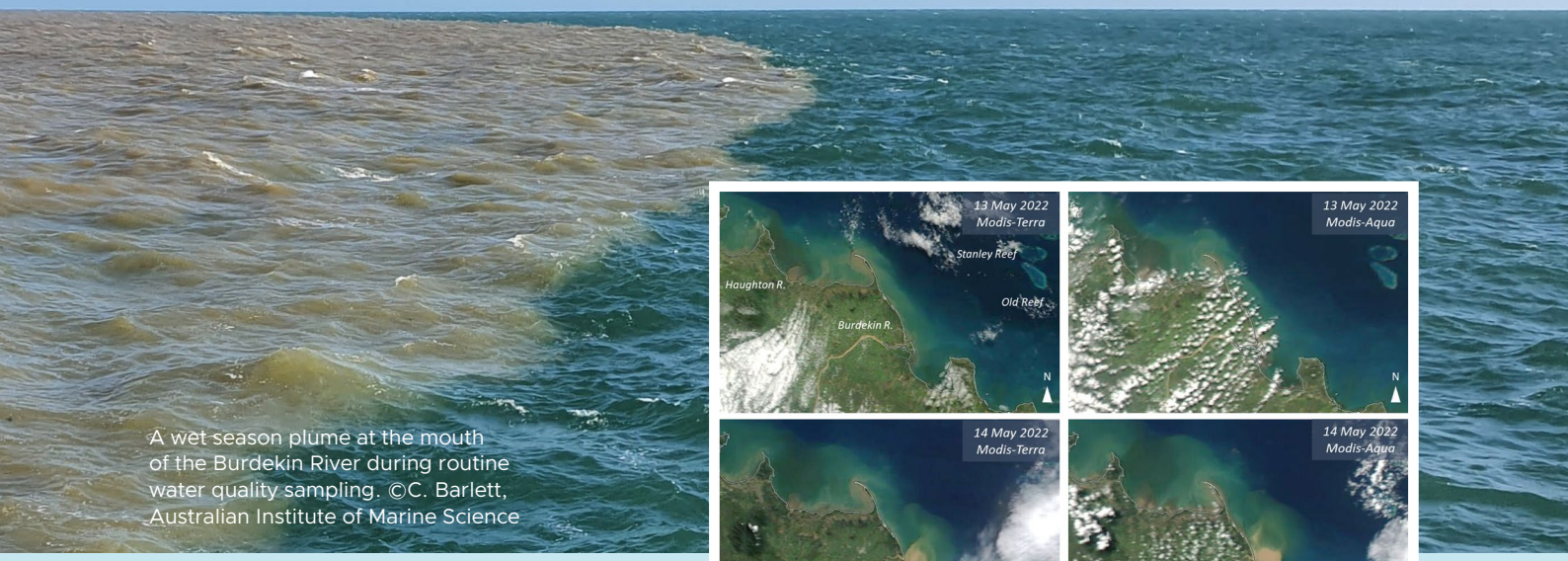
In the 2021–22 monitoring period, the seagrass condition Index for the Burdekin region was unchanged and remained 'moderate'.

Seagrass abundance marginally increased relative to the previous period but remains lower than historical records.

Seagrass resilience reduced marginally in the 2021–22 monitoring year compared to the previous reporting period and remained 'moderate'.

The Coral Index score for the Burdekin NRM declined from a peak reached in 2020 and remains 'moderate' in 2021–22 monitoring year. The primary pressure to have influenced coral communities between 2021 and 2022 surveys was a marine heatwave during early 2022. The decline from 2020 is due primarily to declines in Juvenile coral and Macroalgae scores.

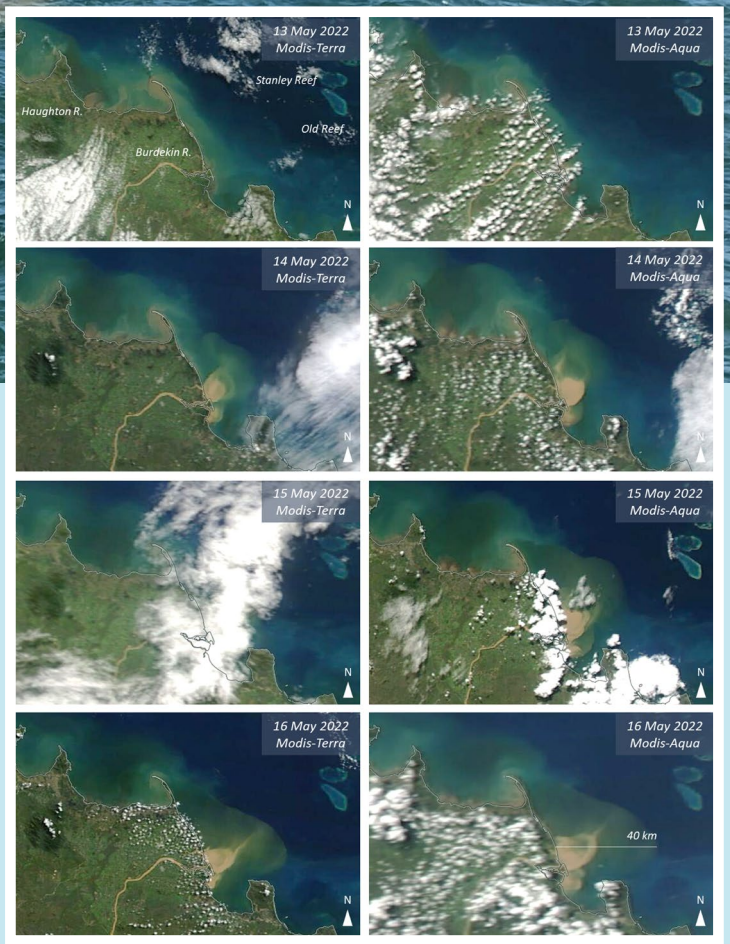
Declines in juvenile corals can negatively affect the recovery of these coral communities hindering the replenishment of coral populations. Additionally, low macroalgal indicator scores indicate that high prevalence of macroalgae on many reefs are also likely to be suppressing the recovery potential of coral communities.



A wet season plume at the mouth of the Burdekin River during routine water quality sampling. ©C. Barlett, Australian Institute of Marine Science

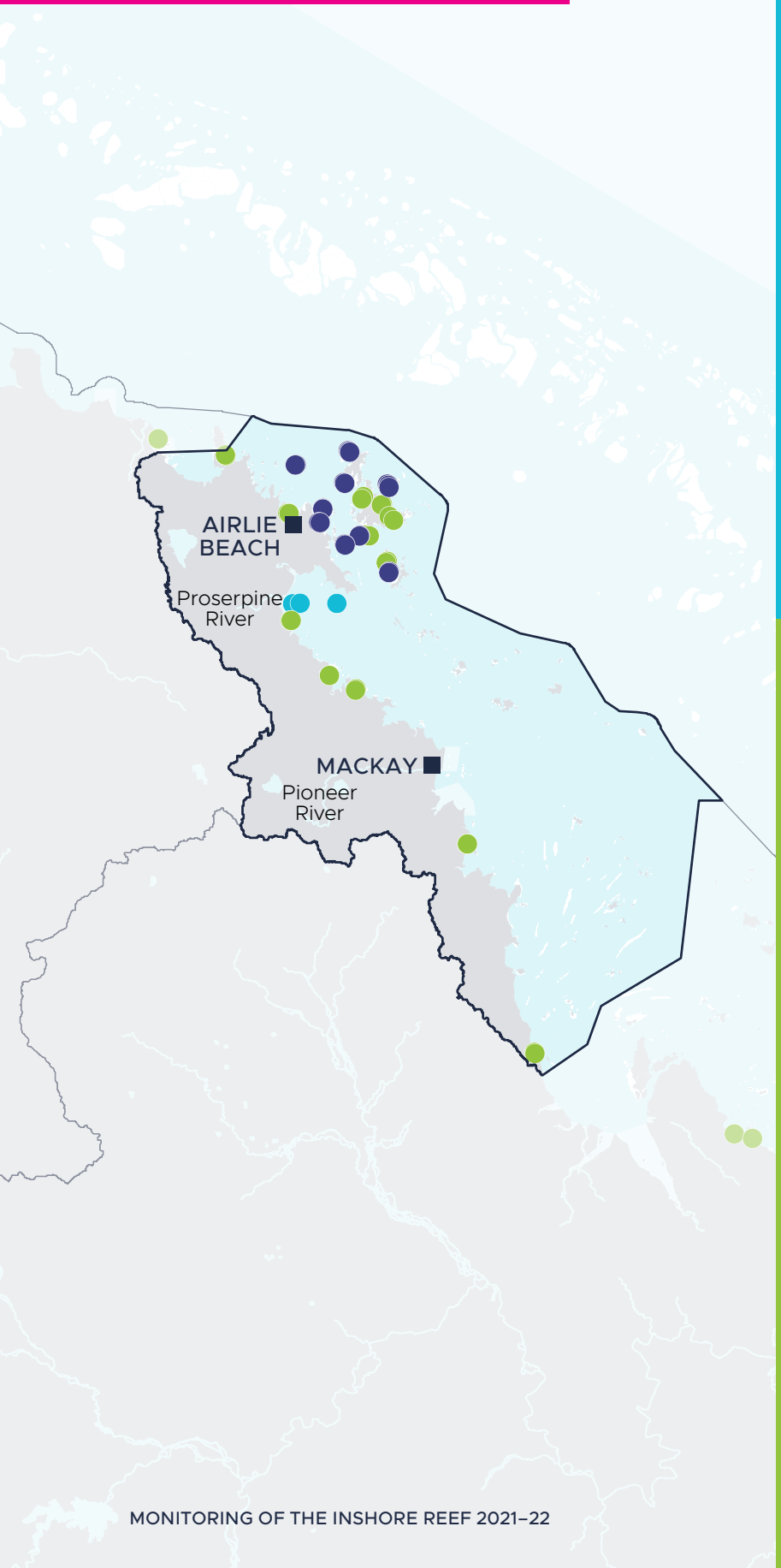
Flood of the Haughton and Burdekin Rivers, May 2022

After heavy rainfall in early May in the Burdekin NRM, water flowing from the Haughton and Burdekin Rivers resulted in significant discharge into the Reef lagoon. Flood plume reached the coast a week later affecting mainly the inshore region. Flood plume monitoring is relevant as it allows the quantification of exposure of reef habitats to land-based contaminants that would not otherwise reach large areas of the Reef.



Satellite image showing the flood plume of the Haughton and Burdekin Rivers. Source: NASA MODIS Aqua & Terra, downloaded by Caroline Petus, TropWater/James Cook University.

Mackay–Whitsunday region



The annual condition Index for the Mackay-Whitsunday NRM was 'moderate' for the 2021–22 monitoring year.

Concentrations of five water quality variables (nitrogen oxide (NOx), PO_4, PP, Secchi depth, and Chl-*a*) did not meet annual water quality guideline values. These results were despite the combined discharge and loads calculated for the 2021–22 monitoring year from the Proserpine, O'Connell, Pioneer, and Plane Basins were around half of the long-term median values and were once again amongst the lowest recorded over the past decade.

Water Quality Index scores have shown a long-term trend of decline since 2008 but have been stable over the past few years.

In the 2021–22 monitoring period, the seagrass condition Index for the Mackay-Whitsunday region improved on overall condition and increased to 'moderate'.

The 2021–22 monitoring period in the Mackay–Whitsunday was relatively benign with environmental pressures around or below the long-term averages. It was characterised by wet season rainfall, annual discharge and turbid water exposure that was below the long-term average and daily light levels were higher than average.

The seagrass abundance score decreased slightly again in 2021–22 monitoring year, but substantial improvement in the resilience scores were detected.

The Coral Index in the Mackay-Whitsunday NRM declined dramatically from 2016 through to 2019, due to the impacts of Tropical cyclone Debbie in March 2017. In 2021–22 monitoring year, the Coral Index has increased only marginally from 2021. However, coral communities are showing some signs of recovery on the back of increasing densities of juvenile corals and slight declines in macroalgae density at some reefs.

Acropora coral growing amonsgt macroalgae *Padina* and *Sargassum*. ©C. Thompson, Australian Institute of Marine Science

Slow coral recovery following Cyclone Debbie

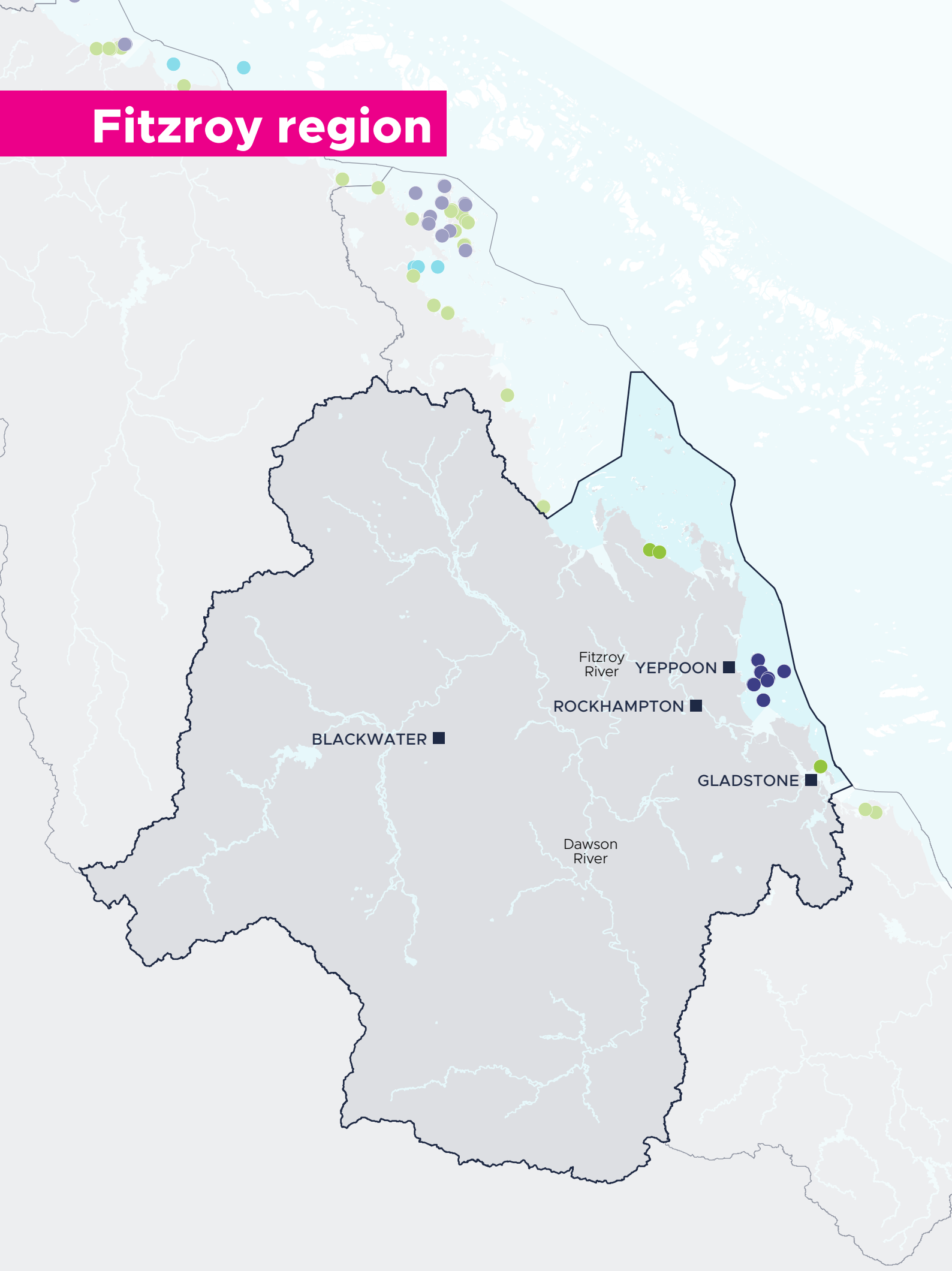
Prior to cyclone Debbie, Coral Index scores had remained relatively stable in the 'moderate' range. During this period, Macroalgae scores remained 'good' as macroalgae cover was very low on most monitored reefs. Equally, Coral cover scores were generally 'good', except for a short decline to 'moderate' levels due to damage imposed by cyclone Ului in 2010.

With the severe loss of coral cover at many sites post-Debbie, successful recovery relied heavily on the recruitment and survival of juvenile corals. There has been a gradual movement of fine sediment deposited by cyclone Debbie away from the inshore reef region, allowing space for new corals to settle. Even though the density of juvenile corals continues to increase in 2021–22 monitoring year, juvenile density remains low at most reefs and suggests a bottleneck for the recovery of these communities. Included amongst the increasing numbers of juveniles are the fast-growing genus *Acropora*, the survival and growth of these colonies will be central to the recovery trajectory of the coral communities in coming years.

Coral monitoring in Daydream Island, Mackay-Whitsunday, in 2016 before Tropical cyclone Debbie impacted the region. ©P. Costello, Australian Institute of Marine Science

The same site at Daydream Island in 2022. ©C. Thompson, Australian Institute of Marine Science

Fitzroy region



The seagrass condition score for the Fitzroy NRM reduced but remained 'poor' in 2021–22. Both indicators, abundance and resilience, declined.

Environmental conditions were challenging in the 2021–22 monitoring year. River discharge from the Fitzroy River was more than 1.5 times the annual median and exposure of seagrass meadows to turbid water was above the long-term average.

Inshore seagrass meadows across the region continue to decline for the second year in a row, after what had been gradual recovery over 2012–13 to 2019–20 from multiple years of climate related impacts. There are local-scale impacts and process that are driving declines in indicators at some sites, while the other within the same habitat improves.

The Coral Index increased in 2021–22 monitoring season but remains 'poor'. Severely limiting improvements of Coral Index scores is the ongoing very high cover of macroalgae at most reefs. Most concerning is macroalgal cover in Middle Island, but also Keppels South, where, when first visited in 2005, there was almost no macroalgae. Cover of macroalgae at Middle Island is now 50% and includes a high proportion of the persistent brown algae *Lobophora* and *Sargassum*.

The current condition of reefs in the region is still influenced by the cumulative impacts of thermal stress in 2006, a series of cyclones and storms, and flooding of the Fitzroy River that drove Coral Index scores to a 'very poor' level in 2014. The recovery from these pressures has been suppressed by high water temperatures in 2016 and 2017, and again in 2020.

In 2022, the density of juvenile corals continued to decline and slipped into the 'very poor' category for the first time since 2015.

Tabulate and branching acroporids populate the shallow areas of Barren Island, Fitzroy. ©J. Davidson, Australian Institute of Marine Science

Water quality and coral recovery

Variation among reefs in the recovery of coral communities further illustrates the role of water quality in suppressing coral community resilience.

The most offshore site, Barren Island (5m) is the only location in the region that reached a rating of 'good' in 2022.

Burnett–Mary region

Inshore seagrass meadows across the Burnett–Mary NRM declined in overall condition in the 2021–22 monitoring year, with the Index score declining but remaining as a 'poor' grade. Both indicators, abundance and resilience, declined.

Extreme weather events affected the Burnett-Mary NRM region in 2021–22. Annual river discharge was nine times greater than the long-term median and was affected by late periods of elevated rainfall after the wet season (i.e. in May).

The seagrass abundance score declined to poor for the first time since 2013–14. The decline is a continuing trend that has been occurring for the NRM region since 2015–16.

Resilience declined to poor overall in the Burnett-Mary region, and is only one of three years since 2005–06 that the score has declined below 'moderate'.

The decrease in the seagrass condition Index in 2021–22 to the second lowest on record, was based on surveys prior to elevated discharge in May when further declines were likely to have occurred in vulnerable meadows. The region has a history of variable seagrass condition but has shown a reasonable capacity for recovery following extreme events.

Seagrass meadow in Burrum Heads in 2019, Hervey Bay. ©Seagrass-Watch

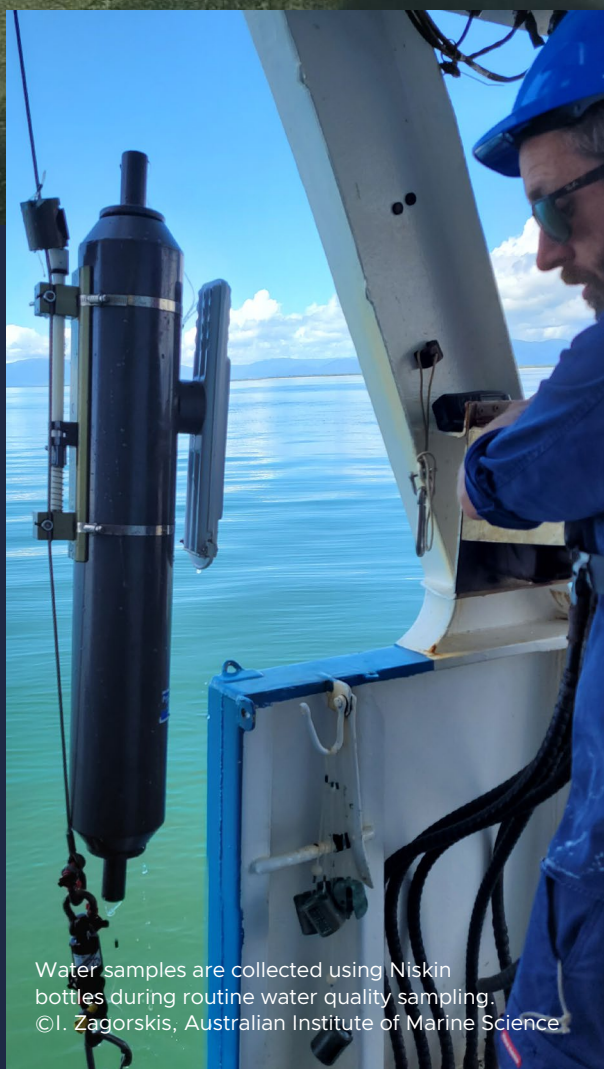
Seagrass meadow in Burrum Heads in 2022, Hervey Bay. ©Seagrass-Watch

Algal bloom in Cape York
©E. Dick, Cape York Water Partnership

What's this?

Trichodesmium slicks are seen all through the Reef. It's a naturally occurring blue-green planktonic bacteria that can form extensive algal blooms in warmer water conditions. It propagates at depths and the blooms rise to the surface where it dies, and smells!

This photo shows a live bloom recently risen and bright green, gradually turning to a brown saw-dust appearance as it expires. The MMP is interested in the role of algal blooms in nitrogen and phosphorus nutrient cycling in the inshore waters of the Reef, which is considered to be very significant. However, there is still a lack of scientific understanding of algal blooms in nutrient cycling. That's why the MMP is supporting a 3-year research program to better understand yet more of the unknown in our Reef to better manage it into the future.



Water samples are collected using Niskin bottles during routine water quality sampling.
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