HEALTHY RIVERS TO REEF PARTNERSHIP
MACKAY-WHITSUNDAY-ISAAC

Southern Inshore Monitoring Program

Technical Results Summary 2017 to 2022

ISBN: 978-1-7637543-2-4

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Acknowledgement

The Mackay-Whitsunday-Isaac (MWI) Healthy Rivers to Reef Partnership (HR2RP) are proud to partner with Dalrymple Bay Coal Terminal Pty Ltd (DBCT P/L) and Dalrymple Bay Infrastructure (DBI) to collect water quality, seagrass and coral data for the Southern Inshore Marine Zone.

The Southern Inshore Marine Zone is one of four inshore marine zones in the HR2RP reporting area, and the data collected through the monitoring program is reported in our annual waterway health Report Card.

Monitoring first started in the Southern Inshore Marine Zone in 2017, thanks to funding from DBCT P/L, with DBI coming on board as a funding partner in 2019.

With continued funding support from both DBCT P/L and DBI, the Southern Inshore Monitoring Program is now well established with all indicators assessed across multiple years.

This highly successful industry and community partnership has played a critical role in capturing waterway health data in a previously unreported zone and has contributed to the overall picture of regional waterway health.

The following report summarises the technical findings from the program between July 2017 and June 2022.

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Suggested citation

Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership (2023). *Southern Inshore Monitoring Program: Technical Results Summary 2017 - 2022*. Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership, Mackay, QLD.

This technical report was finalised and released online in July 2023.

Introduction

In 2017, the Healthy Rivers to Reef Partnership commissioned James Cook University (JCU) and Australian Institute of Marine Science to scope monitoring work in the Southern Inshore Zone regarding environmental conditions for water quality, coral, and seagrass health. The main goal of the program was to fill knowledge gaps in this sub-region not covered by reef-wide reporting, and to incorporate the data collected in the surveys in the Report Card for the Mackay-Whitsunday-Isaac region. The monitoring in the Southern Inshore Zone is of significant relevance considering the complexity of this environment due to anthropogenic influence from agriculture and industry, but also in regards to geographical and climatic factors unique to this region. The area is positioned in the proximity of a funnel-shaped bay called Broad Sound where the tidal range is very large and can reach more than 10m and is separated from the outer reef structure by a continental shelf. Furthermore, as it is in a tropical region, major events such as cyclones, heavy rainfall, and high temperatures can occur.

Fig 1: The Healthy Rivers to Reef Partnership reporting region. Prior to 2017, there was no data for the Southern Inshore Marine Zone.

Water Quality

Water quality largely influences the resilience and recovery of marine habitats, and monitoring seasonal and interannual variability is of crucial importance to Reef conservation. A location such as the Southern Inshore Zone with a high tidal range naturally causes sediment resuspension and water turbidity, affecting water quality values. Obtaining data regarding water quality helps with the implementation of management plans to protect waterways.

Methods

JCU TROPWater conducts water quality monitoring in the Southern Inshore Zone. Water quality surveying takes place every 6-8 weeks during the wet season (1st November – 31st March). Three locations (Aquila Island, Morning Cay, and Fanning Shoal) are surveyed by manual (grab) sampling, with additional logger deployment at Aquila Island which records continuous data at 10 minute intervals.

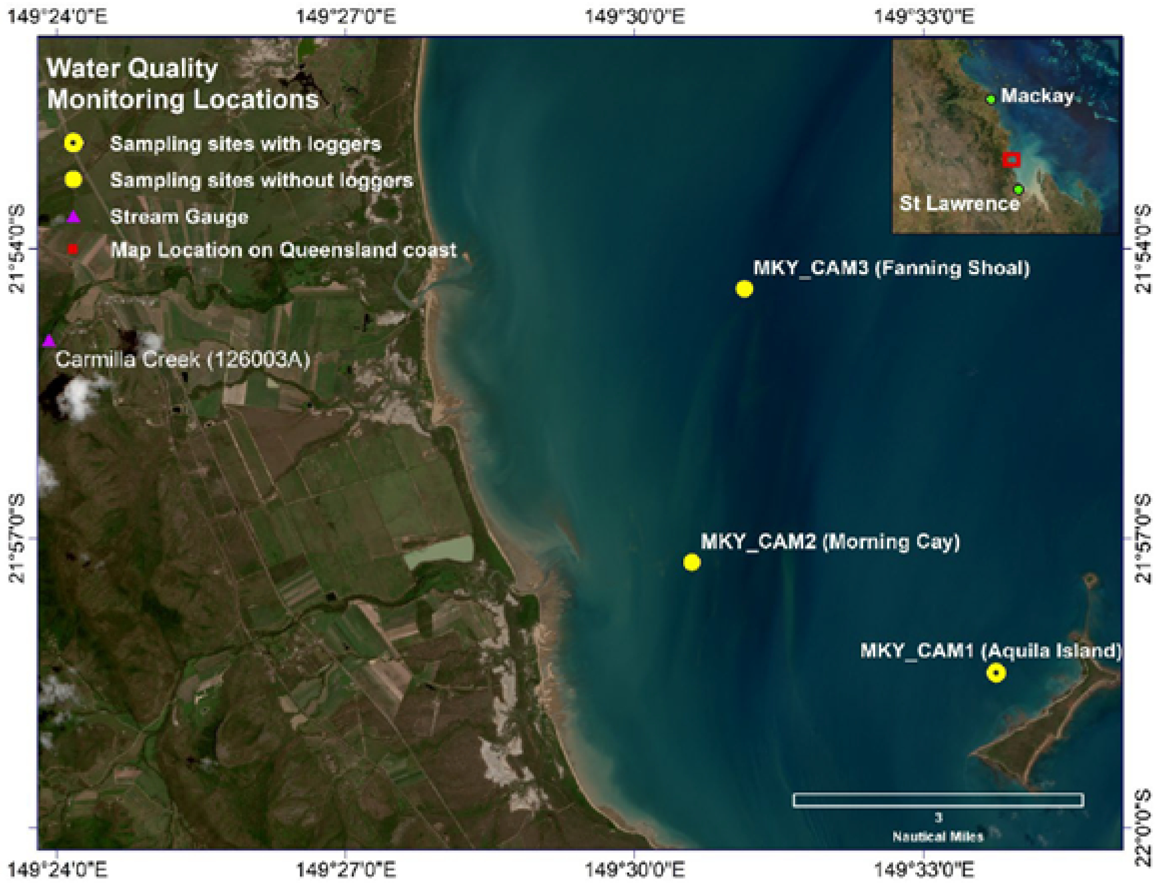

Fig 2: Map of the southern Mackay region with water quality monitoring locations (2022).

Fig 3: James Cook University research vessel, 'Kasmira' enroute to Aquila Island ready to conduct water quality monitoring in the Southern Mackay region (2022).

Metrics

Water samples are taken following a strict and specific methodology for each indicator, with grab samples then analysed in the laboratory. The list below summarises water quality monitoring metrics:

- Temperature. The temperature of the water (°C) is measured at three different depths.
- Nutrients (TN/TP, PN/PP, TDN/TDP). The concentration of nitrogen (N) and phosphorus (P) in the water is recorded. Nutrient concentration is highly impacted by anthropogenic coastal activities. Excessive nutrient concentrations in the water causes excessive algal growth and a reduction of dissolved oxygen in the water.
- Dissolved oxygen (DO). Dissolved oxygen corresponds to the amount of oxygen that is present in water, which is important for the survival of aquatic organisms.
- pH. pH expresses the acidity/alkalinity of the water and is of fundamental importance for the health, behaviour, and survival of plants and animals. It is affected by factors such as CO_2 absorption and anthropogenic activities.
- Salinity. The salinity of the water (PSU) is recorded. This can show the influence of rainfall events and the movement of river plumes into the marine environment.
- Electrical conductivity (EC). Electrical conductivity indicates how easily the water can carry electrical current. Water is usually not a good conductor of electricity, but the more dissolved substances (salt and minerals) there are in the water, the more electricity the water will conduct.
- Turbidity (TSS). Total suspended solids (TSS) refer to the number of solid particles that are suspended in the water and is used as a measure of water clarity.
- Chlorophyll-*a*. Chlorophyll-*a* is the green pigment in plants and is highly influenced by nutrients concentration. It is an indicator for algal growth in the water.
- Secchi disk. A Secchi disk is submerged in the water column, and the depth (cm) of when the disk colours are no longer distinguishable is recorded in order to gauge the clarity of the water from the surface.
- Photosynthetic active radiation (PAR). Photosynthetic active radiation refers to the amount of sunlight that is used by organisms for the process of photosynthesis. It is not a direct indicator

of water quality, but it is important in assessing the health of photosynthetic organisms, including seagrass, algae, and corals.

- Pesticides. The concentration of pesticides in the water can be affected by anthropogenic activities (agricultural & industrial). It is measured by passive samplers, which are devices that absorb pesticides and can determine pesticide concentration in the water.

Fig 4: Water quality loggers ready for deployment to the seabed. The horizontally orientated logger is an NTU-LPT turbidity logger, and the vertically orientated logger is a MS9-LPT multispectral light ligger manufactured by Insitu Marine Optics (2022).

Fig 5: TropWATER staff measuring and recording water quality parameters with a mutiprobe (left) and collecting a water sample for laboratory analysis (right) during water quality sampling trips (2019).

Findings

Tidal Range

At peak tidal ranges, water height above the logger can range more than 10m. During dry periods with minimal rainfall there are still elevated turbidity levels driven by tidal resuspension of sediment where peaks in turbidity have been recorded for over a week.

High Turbidity

Turbidity commonly exceeds 50 NTU (with the current Guideline Value of 1 NTU), and sediment deposition can reach 157.7 mg cm^{-2} in a 10 min period. There are seasonal drivers to sediment processes in the region, with turbidity and suspended sediment loads highest during the wet season due to catchment sediment entering the coastal ocean, biological production, and resuspension of sediments due to wind/wave action in addition to tidal flows.

Turbidity was highest in the bottom horizon measurements, reflecting the impact of resuspension. This is relevant for coral and seagrass populations that are sensitive to water clarity changes. The bottom horizon measurements are more relevant for seagrass and coral communities than are surface measurements or suspended solids concentrations that are less reflective of benthic habitats.

Following 5+ years of surveys, we now have sufficient data to make a case for adjusting Guideline Values (particularly turbidity) to reflect the unique environmental characteristics of the Southern Inshore.

Nutrients

Concentrations of Nitrogen and Phosphorus are likely related to land use in the catchment, and are further detected via remobilisation of coastal sediments and release of nutrients in sediment that is resuspended. Phosphorus in particular can have a high attachment to sediment and be susceptible to resuspension.

PAR

While turbidity is a primary indicator of water quality, the relationship between turbidity and benthic light is not always strong. Photosynthetically active radiation (PAR) is more biologically relevant than turbidity to the health of benthic habitats such as seagrass, algae, and corals; and it is becoming more useful as a management response tool when used in conjunction with known thresholds for healthy growth for these habitats. Light penetration in water is affected in an exponential relationship with depth as photons are absorbed and scattered by particulate matter and shallow inshore sites reach higher levels of benthic PAR so are more variable compared to deeper water coastal sites.

For this reason, it is important to include PAR in the suite of water quality variables when capturing local baseline conditions of ambient water quality. This may be especially relevant in the Southern Inshore due to the naturally variable turbidity to which habitats are adapted.

Pesticides

While concentrations of pesticides remain very low risk, there have been several chemicals detected. Atrazine has been detected in the previous two reporting periods, while Diuron, Metolachlor, and Tebuthiuron were also detected in the most recent reporting period.

Coral

Methods

AIMS conducts coral monitoring in the Southern Inshore Zone. Surveys take place at the end of the wet season, usually between April and June, at five different fringing reefs (Aquila Island, Temple Island, Henderson Island, Pine Peak Island, and Pine Islet). A set of transects were designated at each reef, and sampling methods include both digital photographs assessment post-survey, and coral count *in situ*.

Metrics

The four categories that are assessed for coral monitoring are:

- Coral Cover refers to the percentage (%) coverage of living corals on a reef.
- Macroalgae Cover refers to the percentage (%) coverage of macroalgae on a reef. High macroalgae coverage limits coral's ability to settle on the substrate, and competition in terms of space and light availability.
- Juvenile Density refers to the density of young corals across a reef. This indicator provides insights into the resilience and recovery of the coral as well as their reproductive success.
- Coral Change refers to the assessment of the rate at which hard coral cover increases during periods lacking environmental disturbances.

Findings

Geography

The Southern Inshore Zone has been identified as a challenging environment for corals as a continental shelf isolates it from the well-developed carbonate reef structures of the offshore Great Barrier Reef. Strong tidal currents and proximity to the shallow, silt-laden Broad Sound can challenge the resilience of coral communities.

Coral formations here often form from accumulated detritus rather than consolidated structures in the offshore reefs. These factors impact the development, abundance, and diversity of corals. Current methodology for assessing the condition of corals in the Great Barrier Reef do not account for the variation in environmental factors that influence coral communities. These discoveries have contributed to AIMS undertaking revisions in scoring methodology that more accurately account for variation across environmental gradients, which could provide more realistic thresholds for scoring reef condition in this region in the future.

Coral Cover

Score changes are driven by decline and improvement in hard coral, as soft coral cover remains relatively stable. Branching colonies of *Acropora* are sensitive to environmental pressures yet are also fast-growing and quick to return if conditions are favourable.

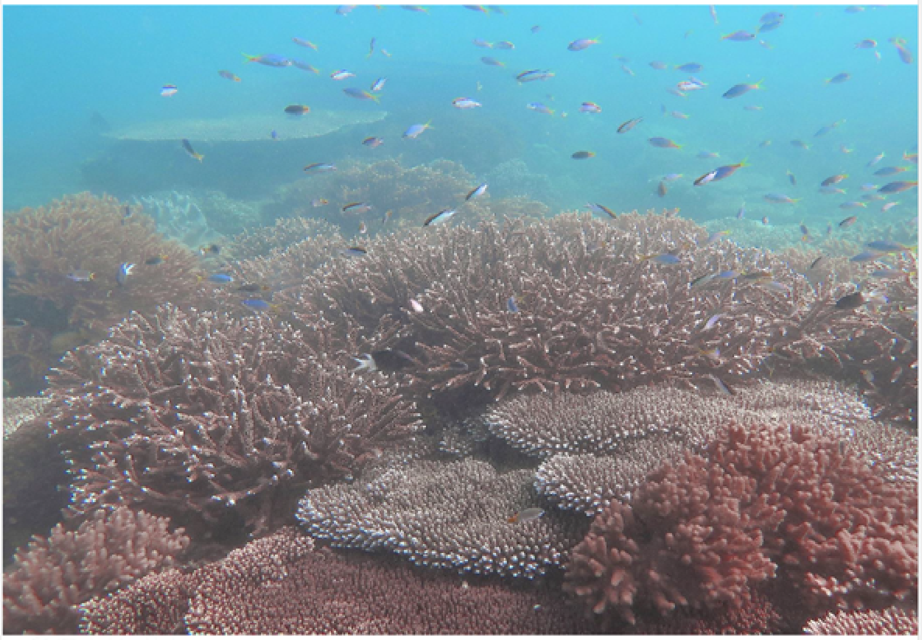

Fig 6: Healthy Acropora colonies at Henderson Island. (2022) Photo credit: Tane Sinclair-Taylor.

Brain corals such as *Lobophyllia* and foliose structures such as *Montipora* have also contributed to improvements in coral cover scores, while robust species such as *Porites* and *Turbinaria* show resilience in a variety of conditions. Soft coral commonly found includes *Klyxum*, *Briareum*, and *Sinularia*.

Macroalgae

Macroalgae cover has exceeded thresholds across all reefs throughout the monitoring periods and is likely a limiting factor in coral recruitment, resulting in low density of juvenile hard corals. The persistent cover of *Lobophora* macroalgae has been attributed to lack of coral recovery at inshore reefs and can suppress resilience of coral communities.

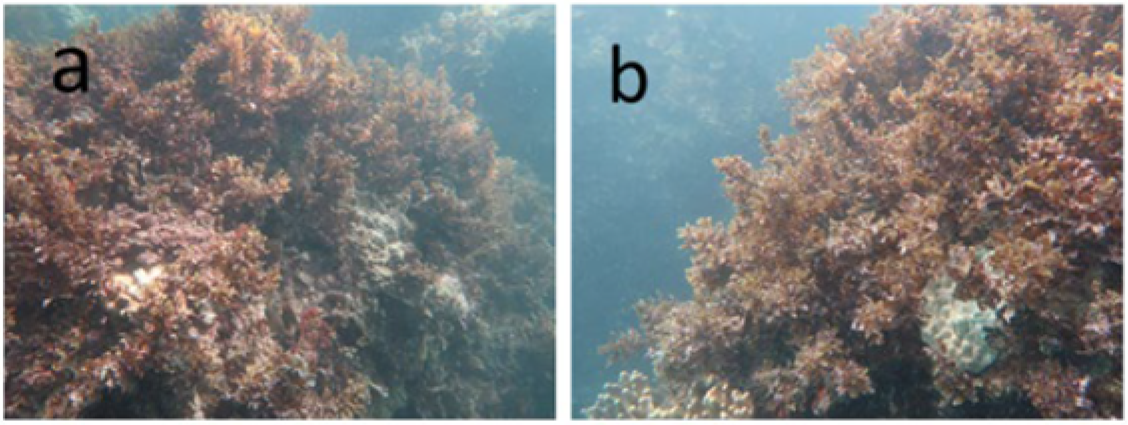

Fig 7: Benthic community photos at outer reefs - Macroalgae dominate at A) Pine Peak Island 2m and B) Pine Peak Island 5m. (2021).

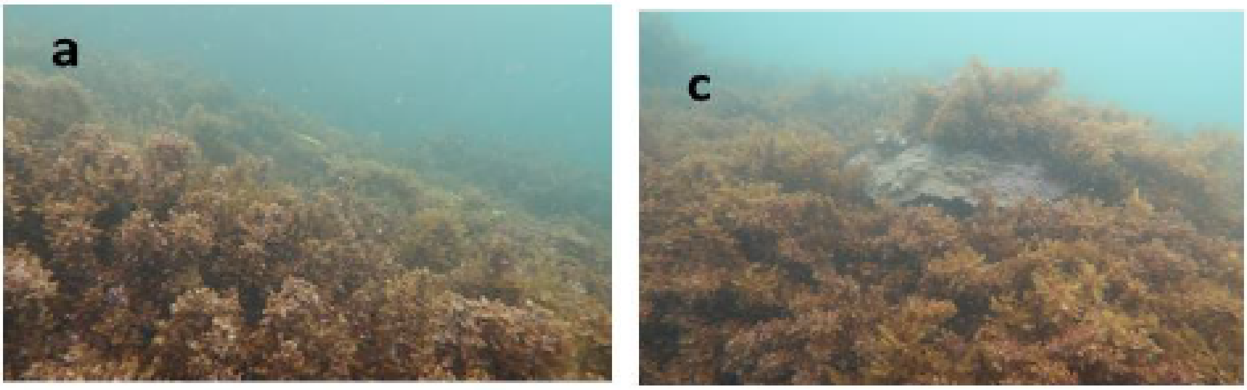

Fig 8: Macroalgae dominate at Pine Peak (A) and Pine Islets (C) (2019)

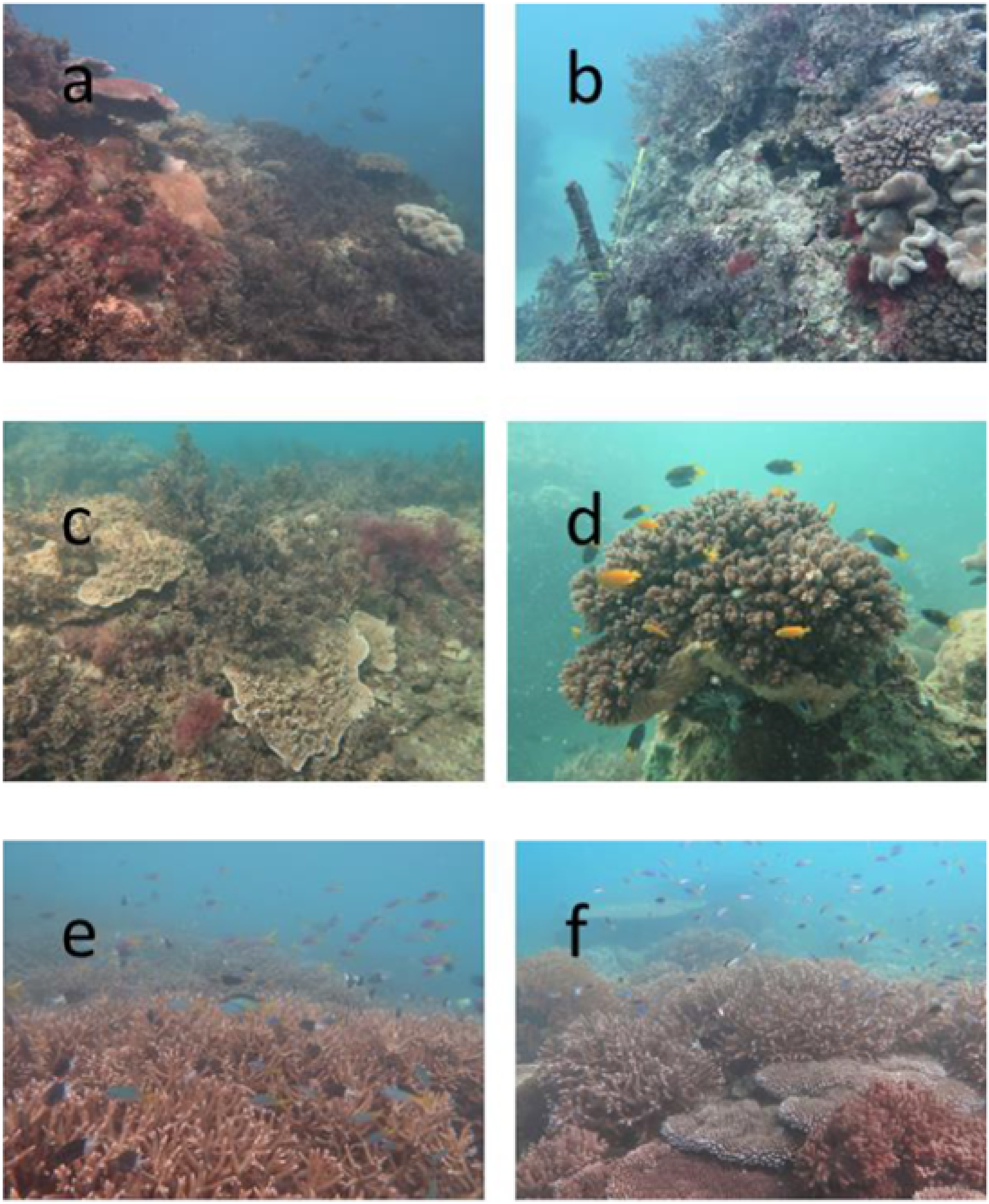

Fig 9: Hard coral cover recovery despite the dominance of macroalgae at Pine Peak Island (a, b) and Pine Islets (c, d). Growth of scattered colonies such as Acropora, Montipora, and Pocillopora indicates continued recovery of coral cover. By contrast, fields of Acropora corals at Henderson Island thrive at both 2m (e) and 5m (f). (2022)

Sargassum macroalgae was also abundant across the region. Although macroalgae scores improved in the most recent survey period (2022) with cover of macroalgae declining to the lowest level recorded during monitored periods, at 60% cover the value was still very high and scores remained 'very poor'.

Heat Waves

The bleaching event of 2020 caused declines in coral cover in both the 2020 and 2021 surveys, with none of the reefs escaping bleaching in 2020. The impact was highly visible at Henderson Island, where 76% of the shallow corals and 58% of the slope corals had bleached. Surveys in 2021 established mortality of over 50% in the shallows and 13% on the slopes at Henderson Island.

Fig 10: 2020 Cover showing aerial view of bleaching at Henderson Island

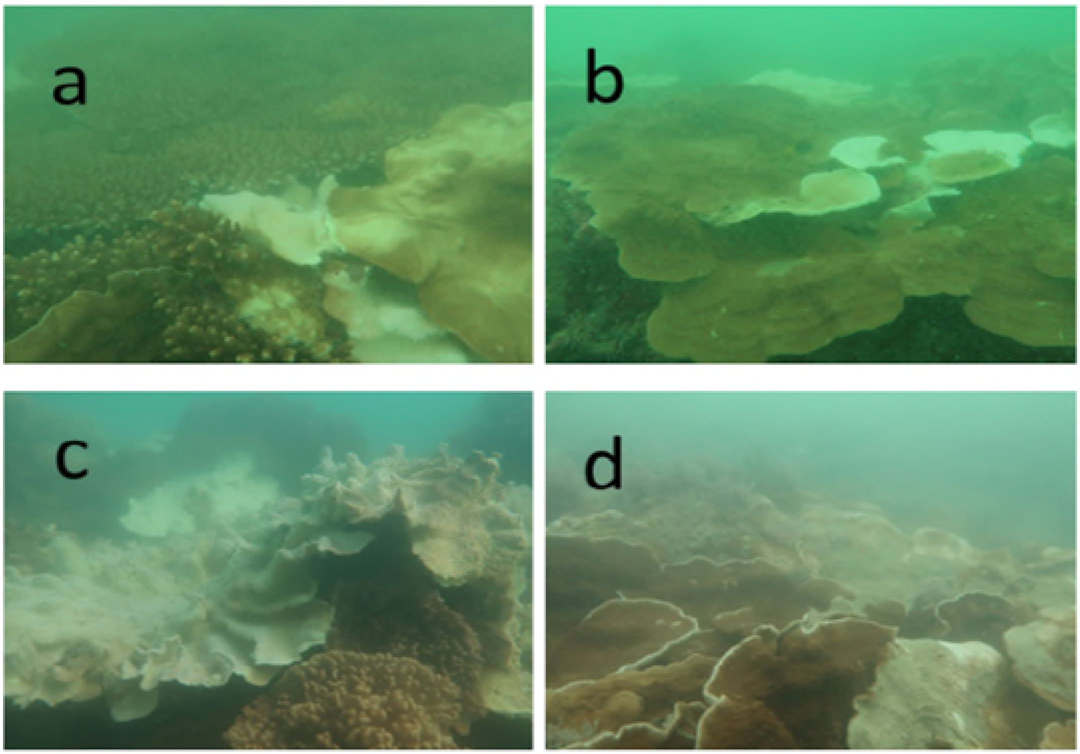

Fig 11: Benthic community photos at inner reefs a) Connor Island 2m. b) Connor Island 5m. c) Temple Island 1m. d) Aquila Island 1m. Mixed hard corals at Connor Island 2m and 5m show a mixed bleaching response. At Temple Island 1m, different bleaching patterns exhibited by large foliose colonies of Turbinaria *and the soft coral* Sacrophyton. *At Aquila Island 1m, overlapping colonies of foliose* Montipora *have varying bleaching response (2020).*

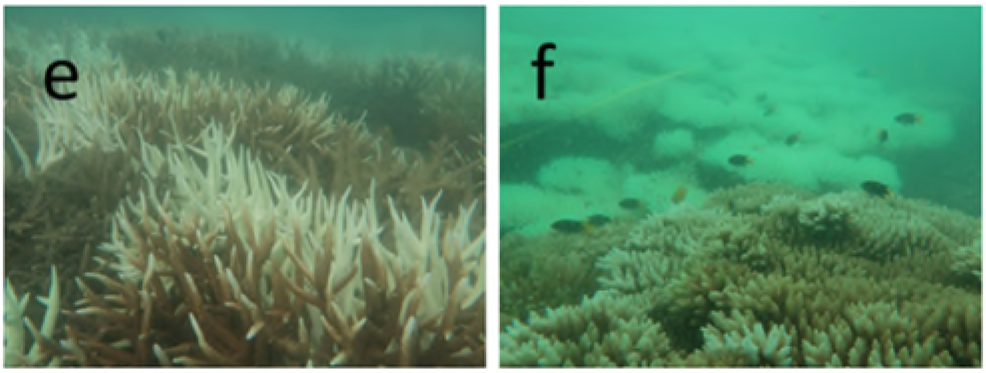

Fig 12. Bleaching of Acropora at Henderson Island (E,F) (2020).

Water temperatures peaked again in 2022 and severe bleaching was predicted. However, the temperature anomaly was lower than in the 2020 event and although partial bleaching was observed, it is unlikely that this will result in mortality. In the most recent surveys (2022) there was a notable increase in genus richness alongside an increase in coral cover, which suggests resilience to recent bleaching events.

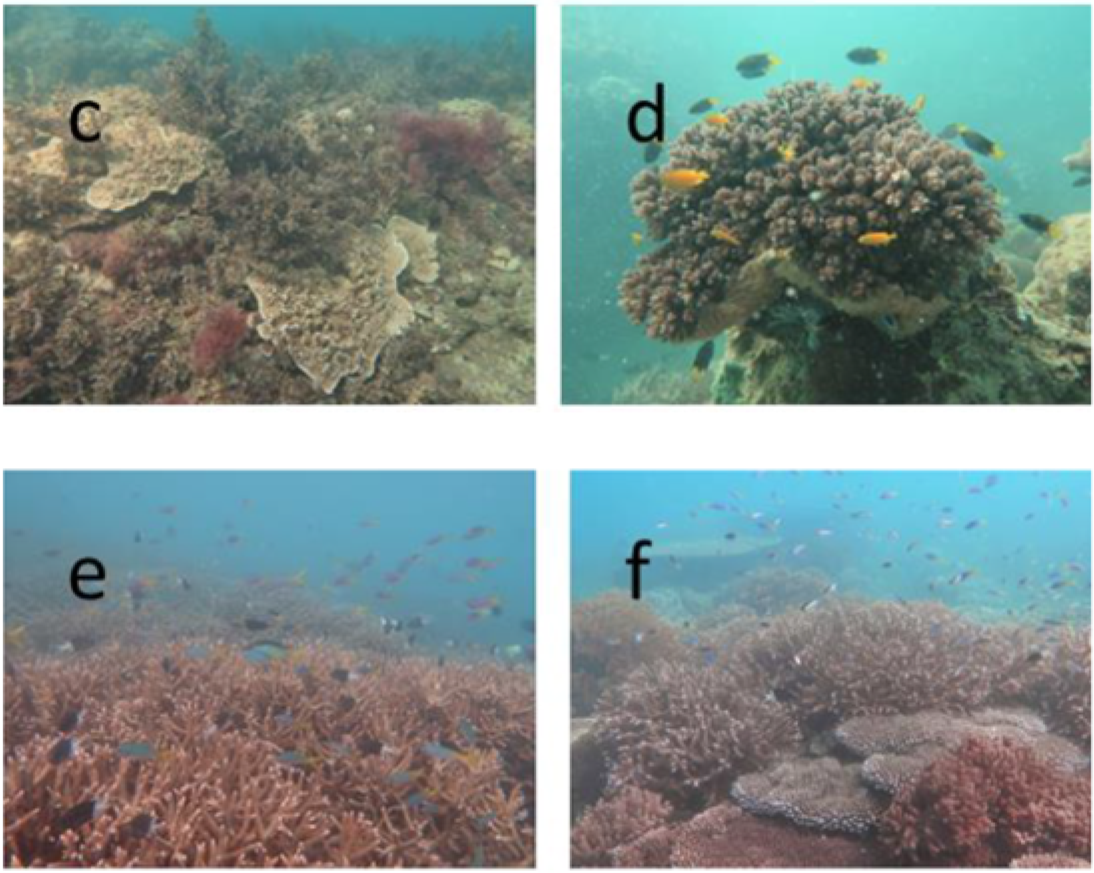

Fig 13: Pocillopora colonies at Pine Islets (D), and Acropora colonies at Henderson (E-F) (2022)

Pressures

Other key pressures for coral in this region include low salinity due to flooding, and biological pressures such as the predatory gastropod *Drupella* and habitat encroaching sponge *Cliona.*

Seagrass

Methods

JCU TROPWater conducts seagrass monitoring in the Southern Inshore Zone. The surveys are conducted at the end of the dry season (typically October), which coincides with the peak of seagrass area and biomass. A helicopter is flown at low tide over the seagrass meadows and measurements of 3 indicators (listed in the section "Metrics" below) are taken within quadrats. Helicopter surveys allow for large spatial coverage, which is important as the biomass can be highly variable and shift locations within seagrass meadows.

Fig 14: View from helicopter undertaking aerial survey (2021).

Fig 15: Transect of seagrass (2021).

Metrics

The three measurements that are assessed during seagrass monitoring are:

- Biomass is recorded by observation and visual estimates and a rank of each quadrat, with calibration from a series of reference photographs that had previously been harvested and assessed for biomass in a lab.
- Composition records an estimation of the percent contribution of each seagrass species within the quadrats assessed for the biomass indicator.
- Area records the percent (%) coverage of seagrass, algae, and other benthic macro-invertebrates (BMI) within the survey quadrats.

Findings

Natural variability in meadow composition

There are four main species of seagrass recorded in the Southern Inshore Zone *(Zostera capricorni, Halodule uninervis, Halophila decipiens, Halophila ovalis)*, and seagrass was present at 77% of the 156 intertidal survey sites in the most recent surveys (2022).

Seagrass meadows in the region range from continuous cover of vegetation to meadows where unvegetated sediment is interspersed with isolated patches of seagrass. The nearshore meadows at Clairview are more consistently continuous cover, whereas the meadow at Flock Pigeon Island is much patchier and biomass can change quite a bit from year to year.

Isolated seagrass patches
The majority of area within the meadow consists of unvegetated sediment interspersed with isolated patches of seagrass.

Aggregated seagrass patches
The meadow consists of numerous seagrass patches but still features substantial gaps of unvegetated sediment within the boundary.

Continuous seagrass cover
The majority of meadow area consists of continuous seagrass cover with a few gaps of unvegetated sediment.

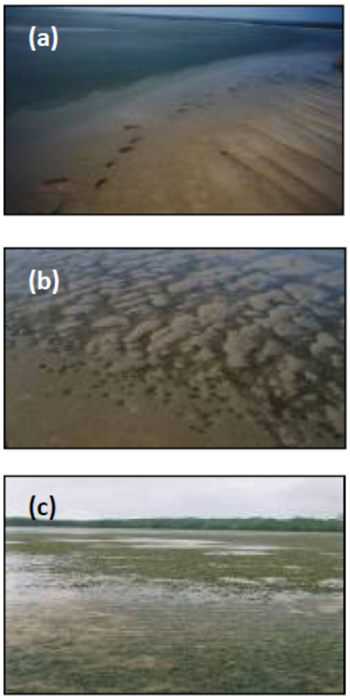

Fig 16: Meadow composition types in the Southern Inshore (2018).

Furthermore, there is a high degree of variability as to where seagrass biomass hotspots occur within the meadow boundaries, so although there can be dramatic changes in biomass hotspots in meadow sub-sections, the changes are less dramatic when viewed at a meadow scale.

Correlation between biomass and herbivory

While above ground biomass is low compared to some other meadows of the same species in Queensland, the continued use of these meadows by dugongs indicate that they are performing an important biological function.

Fig 17: Dugong feeding trails in Clairview seagrass meadow (2022).

The patterns of herbivory may be a major influence in the changing locations of biomass hotspots, as turtle and dugong feeding can have large effects on seagrass biomass and structure across meadows. This can change between years and seasons alongside the feeding patterns of dugong and turtles.

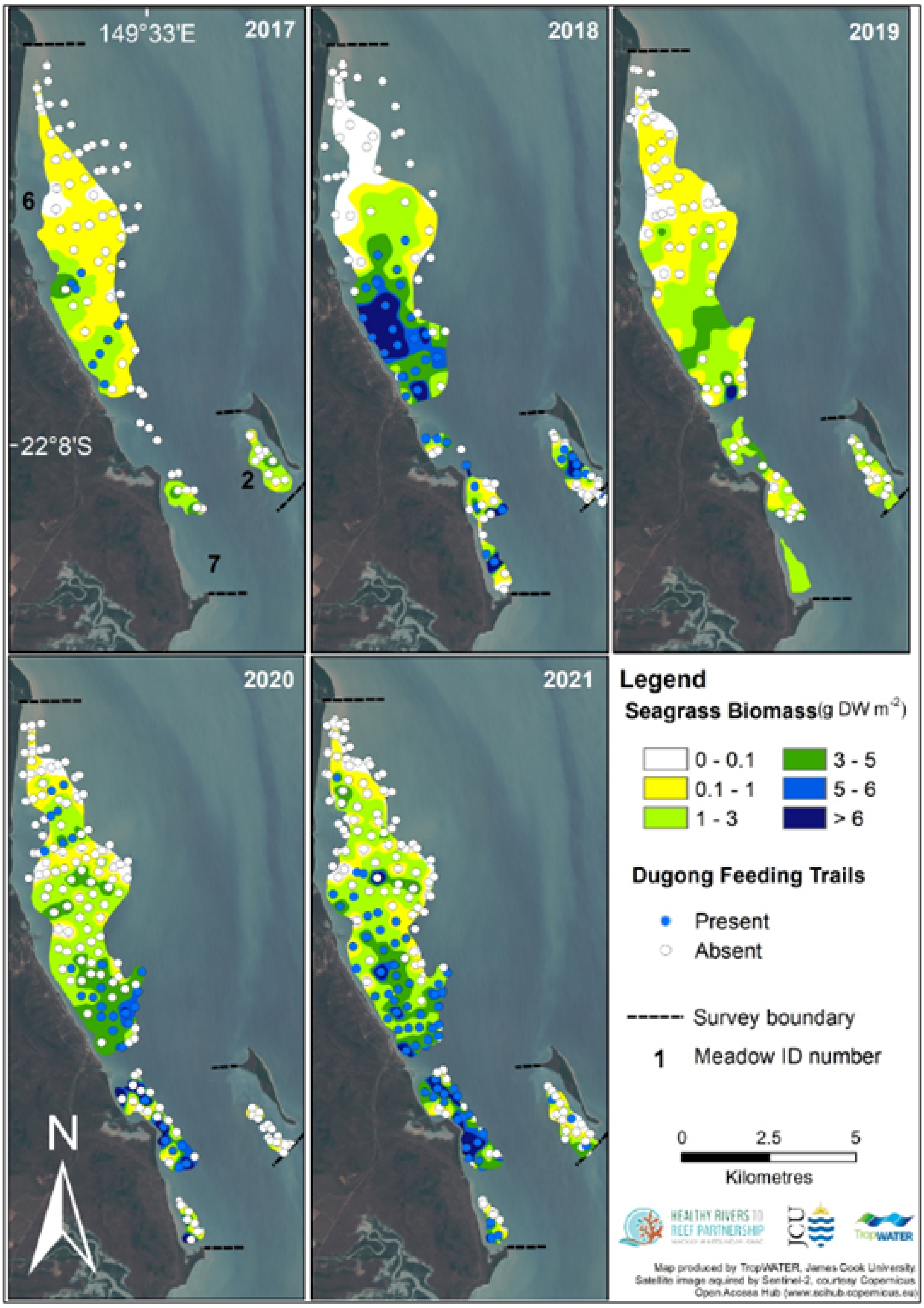

Fig 18: Changing patterns of seagrass biomass and locations of dugong feeding trails (2022).

Prevalence of thin-leaf morphologies

The prevalence of thin-leaf morphologies for *Zostra* and *Halodule* has been associated with low light levels, air exposure, sandy sediments, and high herbivory rates. The southern inshore has many of these conditions with sandy sediments and a large tidal range leading to extended periods of air exposure, and high levels of herbivory.

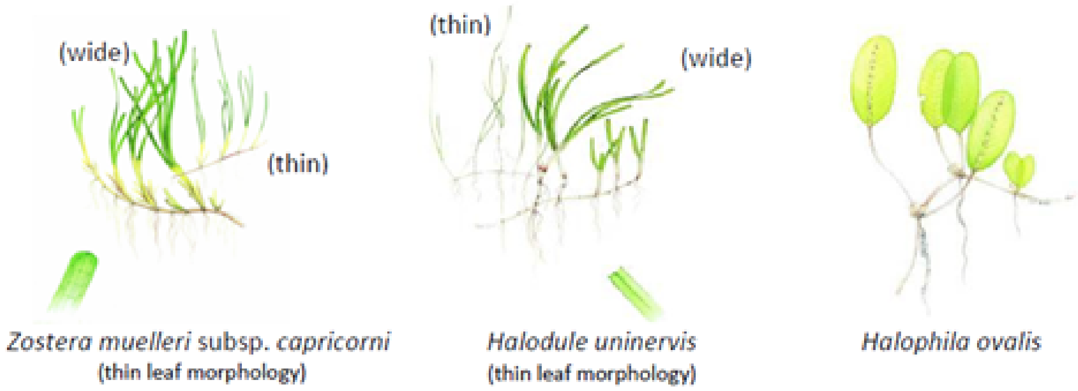

Fig 19: Common seagrass species and thin-leaf morphology (2017).

Thank you to our funding partners

The Southern Inshore Monitoring Program, developed for the Healthy Rivers to Reef Partnership, is made possible thanks to funding from Dalrymple Bay Coal Terminal Pty Ltd and Dalrymple Bay Infrastructure.

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ABOUT US

The Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership is a collaboration between community, Traditional Owners, farmers and fishers, industry, science, tourism, and government who recognise that more can be achieved by working together.

Contact us to learn more about how we help build and shape our community's understanding of waterway health and inform management actions.

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ISBN: 978-1-7637543-2-4