Mackay-Whitsunday-Isaac Seagrass Monitoring 2017-2022

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Authored by: Chris van de Wetering and Michael Rasheed

Mackay-Whitsunday-Isaac Seagrass Monitoring

Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) James Cook University

Townsville Phone: (07) 4781 4262

Email: TropWATER@jcu.edu.au

Web: www.jcu.edu.au/tropwater/

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Contacts
For more information contact: Michael Rasheed, michael.rasheed@jcu.edu.au , (07) 4232 2010

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CONTENTS

1 KEY FINDINGS

Seagrass Condition 2023

GOOD

1. This is the sixth year of annual seagrass monitoring for the southern marine zone in Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership (HR2RP).
2. The overall condition of seagrasses across the three monitoring meadows was rated as good in 2022 with all three indicators (biomass, meadow area and species composition) scoring good or very good against the baseline (Figure 1).
3. This year is the second year that scores can be generated for inclusion in the HR2RP report card, now that the requirement of 5 years of baseline data has been surpassed.
4. There were favourable conditions for seagrass growth leading up to the 2022 survey, with no noteworthy natural or anthropogenic impacts in the region since the previous survey.
5. The low above-ground biomass thin leaf seagrasses meadows in the region continued to have a high level of utilisation by dugongs with dugong feeding trails recorded in the two inshore meadows as well as the presence of a numerous green turtles during the survey.

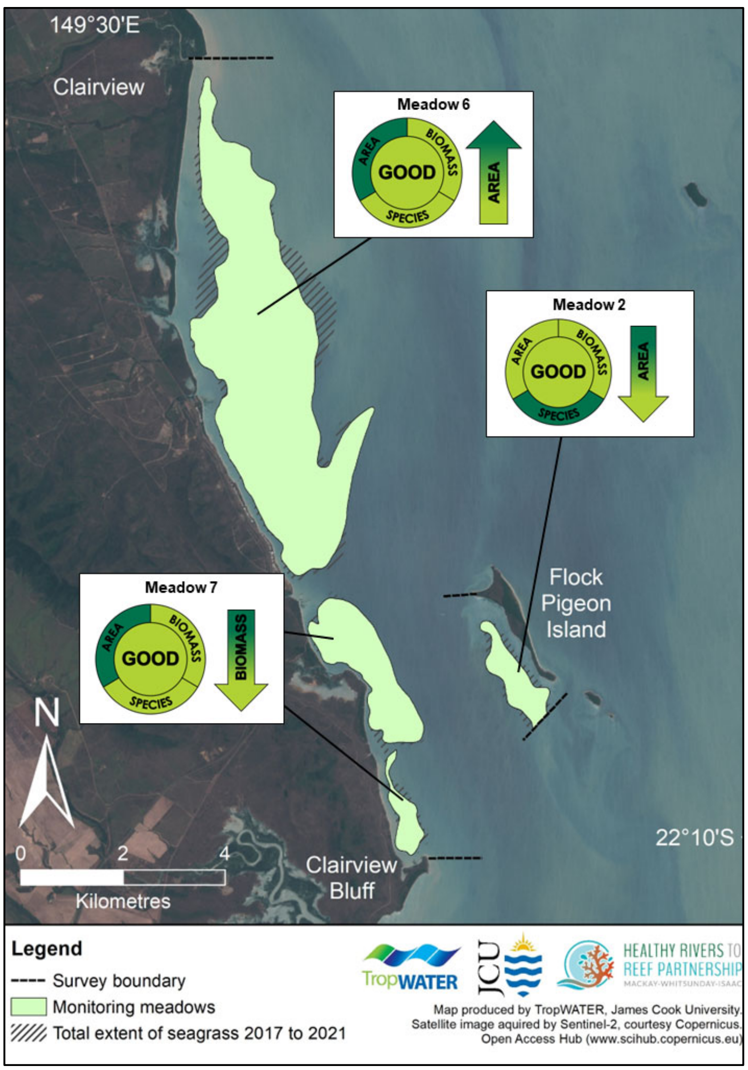

Figure 1. Seagrass condition for HR2R partnership southern zone seagrass monitoring areas 2022

2 INTRODUCTION

Seagrass habitats are immensely productive and provide a range of ecosystem services with substantial economic value (Costanza et al. 2014, Scott et al. 2018). These services include coastal protection, support of fisheries production, nutrient cycling, particle trapping, removal of bacterial pathogens, and acting as a carbon sink (Hemminga and Duarte 2000, Fourqurean et al. 2012, Lamb et al. 2017). Seagrasses provide food for herbivores like dugongs (*Dugong dugon*) and green turtles (*Chelonia mydas*) (Heck et al. 2008, Unsworth and Cullen 2010, Scott et al. 2018, Scott et al. 2020).

Natural and anthropogenic factors have contributed to global declines in seagrass (Waycott et al. 2009). Natural disturbances include tropical cyclones, floods, disease, and overgrazing by herbivores (Robblee et al. 1991, Fourqurean et al. 2010, McKenna et al. 2015). Anthropogenic activities that threaten seagrass habitat in the tropical Indo-Pacific region include industrial and urban run-off, port and coastal development, and dredging (Grech et al. 2012, York et al. 2015).

The sensitivity of seagrass to disturbance and environmental change make it an excellent indicator of marine environmental health (Dennison et al. 1993, Abal and Dennison 1996, Orth et al. 2006). Seagrass condition assessments require adequate baseline information on seagrass presence/absence, biomass, species composition, and meadow area, plus ongoing monitoring to understand and detect change. Long-term monitoring and condition reporting on Queensland's seagrass is largely undertaken by the Queensland Ports Seagrass Monitoring Program (QPSMP) that occurs in the majority of commercial ports (www.jcu.edu.au/portseagrassqld), and the Marine Monitoring Program (MMP) that focusses on the inshore Great Barrier Reef (GBR) (http://www.gbrmpa.gov.au/managing-the-reef/how-the-reefs-managed/reef-2050-marine-monitoring-program) and reports seagrass condition as part of the Reef Water Quality Protection Plan (https://www.reefplan.qld.gov.au/measuring-success/report-cards/).

The QPSMP and MMP contribute their seagrass condition assessments to a variety of regional report cards. These include the Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership (HR2RP; http://healthyriverstoreef.org.au/), the Wet Tropics Healthy Waterways Partnership (WTHWP; http://wettropicswaterways.org.au/report-card/), the Dry Tropics Partnership for Healthy Waters (DTPHW; https://drytropicshealthywaters.org/report-cards-1), and the Gladstone Healthy Harbour Partnership (GHHP; http://ghhp.org.au/report-cards/2020). Regional report cards at the Natural Resource Management (NRM) scale are divided into zones defined largely by habitat and latitude (Figure 1a). Attempts to report zone-scale seagrass condition revealed a number of gaps with no long-term monitoring data available to inform report card scores. For the HR2RP report card, the southern inshore marine zone was identified as a major data and knowledge gap for seagrass condition (http://healthyriverstoreef.org.au/report-card-results/).

James Cook University's TropWATER Centre were contracted in 2017 by the HR2RP to address the knowledge gaps in environmental condition, including seagrass, for the southern inshore marine zone. The longer-term objective is to provide report card scores for seagrass in this zone to be incorporated into the regional report card. TropWATER have conducted seagrass surveys previously in this zone: (1) in 1987, as part of large-scale seagrass assessments along the Queensland coast (Coles et al. 1987); (2) in 1997, during GBR-wide deep water surveys (Coles et al. 2009); (3) in 1999, during assessments for Dugong Protection Areas (Coles et al. 2002); and (4) in 2003-2004, during GBR-wide seabed biodiversity surveys led by CSIRO (Pitcher et al. 2007). These surveys revealed substantial intertidal seagrass meadows along the coast, but sparse and patchy subtidal seagrass. The largest intertidal meadows were located in the Clairview Dugong Protection Area (DPA) between Carmila and Clairview Bluff (Figure 1b). These meadows were mapped in 1987 (Coles et al. 1987), and revisited in 1999 (Roder et al. 2002), and were the focus for TropWATER's seagrass baseline survey in 2017.

The 2017 survey was an important first step in addressing seagrass knowledge gaps in the southern inshore zone of the HR2RP report card (Carter and Rasheed 2018). The 2017 and 1999 surveys revealed similar seagrass distribution, biomass, and species composition to the original 1987 survey, indicating these seagrass areas are likely to be relatively permanent features and ideal for monitoring. Three meadows were selected for long-term monitoring: two large intertidal meadows between Clairview and Clairview Bluff (Meadows 6 and 7), and the intertidal meadow at Flock Pigeon Island (Meadow 2).

This report presents findings from the 2022 seagrass monitoring survey of the HR2RP southern inshore marine zone. Our objectives were to:

- Map seagrass distribution, density and community composition in monitoring meadows;
- Compare results with previous seagrass monitoring results of these meadows;
- Incorporate results into a Geographic Information System (GIS) database for the zone.
- Develop seagrass meadow scores for the southern inshore marine zone for incorporation into the HR2RP report card

3 METHODS

3.1 Survey Approach

The survey was conducted in October 2022 to coincide with the peak seagrass growing season, when meadows are likely to contain maximum biomass and area. Survey methods and the seagrass metrics recorded followed the established methods for Queensland seagrass monitoring which also occur at Townsville (McKenna et al. 2023), Gladstone (Smith et al. 2023), Cairns (Reason et al. 2023a), Mourilyan (Reason et al. 2023b), Mackay-Hay Point (York et al. 2023), Abbot Point (Reason et al. 2023c), Thursday Island (Scott et al. 2022), Weipa (Reason et al. 2022), and Karumba (Scott et al. 2023). Using standardised methods ensures seagrass data is comparable with that used to report seagrass condition for other marine inshore zones in the HR2RP report card, and in the WTHWP, DTPHW, GHHP, and QPSMP report cards. Standardisation also allows for comparisons with historical data sets collected previously in the same area.

3.2 Field Surveys

Intertidal meadows were sampled at low tide using a helicopter. Monitoring meadows are all intertidal because: (1) the large tidal range (up to 8.5m) means that intertidal seagrasses are exposed during spring low tides so helicopter surveys are likely to capture the majority of seagrasses in the region; and (2) subtidal meadows form a relatively minor component of seagrass area and are restricted to very shallow subtidal water, with the same species composition as the much larger adjacent/adjoining intertidal meadows (Carter and Rasheed 2018).

At each site the helicopter came to a low hover (within a metre of the ground). Within a 10m^2 circular area seagrass biomass was ranked, and the percent contribution of each species to that biomass was estimated, from three 0.25 m^2 randomly placed quadrats. Within the larger 10m^2 circular area the percent cover of seagrass, algae, and other benthic macro-invertebrates (BMI) were recorded. GPS was used to record the position of each site, and also intertidal meadow boundaries when visible.

3.3 Biomass and Species Composition

Seagrass above-ground biomass was determined using a “visual estimates of biomass” technique (Kirkman 1978, Mellors 1991). For each 0.25 m^2 quadrat an observer assigned a biomass rank, made in reference to a series of 12 quadrat photographs of similar seagrass habitats for which the above-ground biomass had previously been measured. At the completion of ranking, the observer also ranked a series of at least five photographs of calibration quadrats that represented the range of seagrass observed during the survey. These calibration quadrats had previously been harvested and the actual biomass determined in the laboratory. A separate regression of ranks and biomass from the calibration quadrats were generated for each observer and applied to the biomass ranks given in the field. Field biomass ranks were converted into above-ground biomass estimates in grams dry weight per square metre (g DWm^{-2}; total and for each species).

3.4 Seagrass Meadow Mapping and Geographic Information System (GIS)

All survey data were entered into a Geographic Information System (GIS) developed for the HR2RP southern inshore zone using ArcGIS 10.8.2. Three GIS layers were created to describe seagrass features in the region: a seagrass site layer, seagrass meadow layer, and seagrass biomass interpolation layer.

Site layer

The site layer contains data collected at each site, including:

- Temporal details – survey date.
- Spatial details – latitude and longitude.
- Habitat information – sediment type; seagrass information including presence/absence, above-ground biomass (total and for each species) and biomass standard error (SE); percent cover of seagrass, algae, and open substrate; presence/absence of dugong feeding trails (DFTs).
- Sampling method and any relevant comments.

Interpolation layer

The interpolation layer describes spatial variation in seagrass biomass across each meadow and was created using an inverse distance weighted (IDW) interpolation of seagrass site data within each meadow using ArcGIS®.

Meadow layer

The meadow (polygon) layer provides summary information for all sites within each of the three monitoring meadows, including:

- Temporal details – survey date.
- Habitat information – mean meadow biomass ± standard error (SE), meadow area (hectares) ± reliability estimate (R), number of sites within each meadow, seagrass species present, meadow density and community type, meadow landscape category (Figure 2).
- Meadow identification number – A unique number assigned to each monitoring meadow to allow comparisons over time.
- Sampling method and any relevant comments.

Meadow boundaries were constructed using seagrass presence/absence site data, field notes, GPS marked meadow boundaries, colour satellite imagery of the survey region (Source: ESRI, HERE, Garmin © Open Street Map contributors, and the GIS user community), and aerial photographs taken during helicopter surveys.

Meadow area was determined using the calculate geometry function in ArcGIS®. Meadows were also assigned a mapping precision estimate (in metres) based on mapping methods used for that meadow. The mapping precision for coastal seagrass meadows ranged from ±20 m for intertidal seagrass meadows with boundaries mapped by helicopter, to ±50 m for boundaries mapped by distance between sites with and without seagrass. The mapping precision estimate was used to calculate a buffer around each meadow representing error; the area of this buffer is expressed as a meadow reliability estimate (R) in hectares.

Meadows were described using a standard nomenclature system. Seagrass community type is defined using the dominant species' percent contribution to mean meadow biomass (for all sites within a meadow) (Table 1). Meadow density is based on mean biomass and the dominant species within the meadow (Table 2).

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.

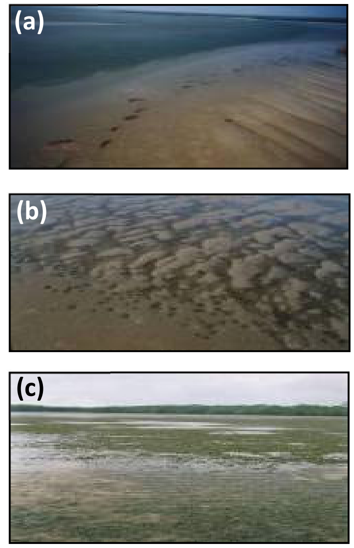

Figure 2. Seagrass meadow landscape categories: (a) Isolated seagrass patches, (b) aggregated seagrass patches, (c) continuous seagrass cover.

Table 1. Seagrass meadow community types.

Community type	Species composition
Species A	Species A is 90-100% of composition
Species A with Species B	Species A is 60-90% of composition
Species A with Species B/Species C	Species A is 50% of composition
Species A/Species B	Species A is 40-60% of composition

Table 2. Seagrass meadow density categories.

	Mean above-ground biomass (g DW m^{-2})	
Density	*H. uninervis* (thin) / *Z. muelleri* subsp. *capricorni* (thin)	*H. ovalis* / *H. decipiens*
Light	< 1	< 1
Moderate	1 - 4	1 - 5
Dense	> 4	> 5

3.5 Seagrass Meadow Condition Index

A condition index was developed for seagrass monitoring meadows based on changes in mean above-ground biomass, total meadow area and species composition relative to a baseline (see Carter et al. 2023 for full details). Seagrass condition for each indicator in the HR2RP southern inshore marine zone was scored from 0 to 1 and assigned one of five grades: A (very good), B (good), C (satisfactory), D (poor) and E (very poor). Overall meadow condition is the lowest indicator score where this is driven by biomass or area. Where species composition is the lowest score, it contributes 50% of the overall meadow score, and the next lowest indicator (area or biomass) contributes the remaining 50% (Carter et al. 2023). This is the second year that we have had the minimum of 5 years of baseline data to generate seagrass grades with confidence to be presented for the HR2RP report card.

4 RESULTS

Four seagrass species were recorded during the 2022 survey of the monitoring meadows: *Zostera muelleri* subsp. *capricorni* (abbreviated to *Z. capricorni* throughout this report), *Halodule uninervis*, *Halophila decipiens* and *Halophila ovalis* (Figure 3). Only thin leaf morphologies of *Z. capricorni* and *H. uninervis* are found in the survey area. These variants of the two species have very similar above ground characteristics and are difficult to differentiate as part of rapid visual surveys.

Seagrass was present at 79% of the 145 intertidal survey sites (Figure 4). The mainland coastal Meadows 6 and 7 were characterised by a largely continuous cover of seagrass, while Meadow 2 at Flock Pigeon Island had aggregated patches of seagrass cover (Figure 5).

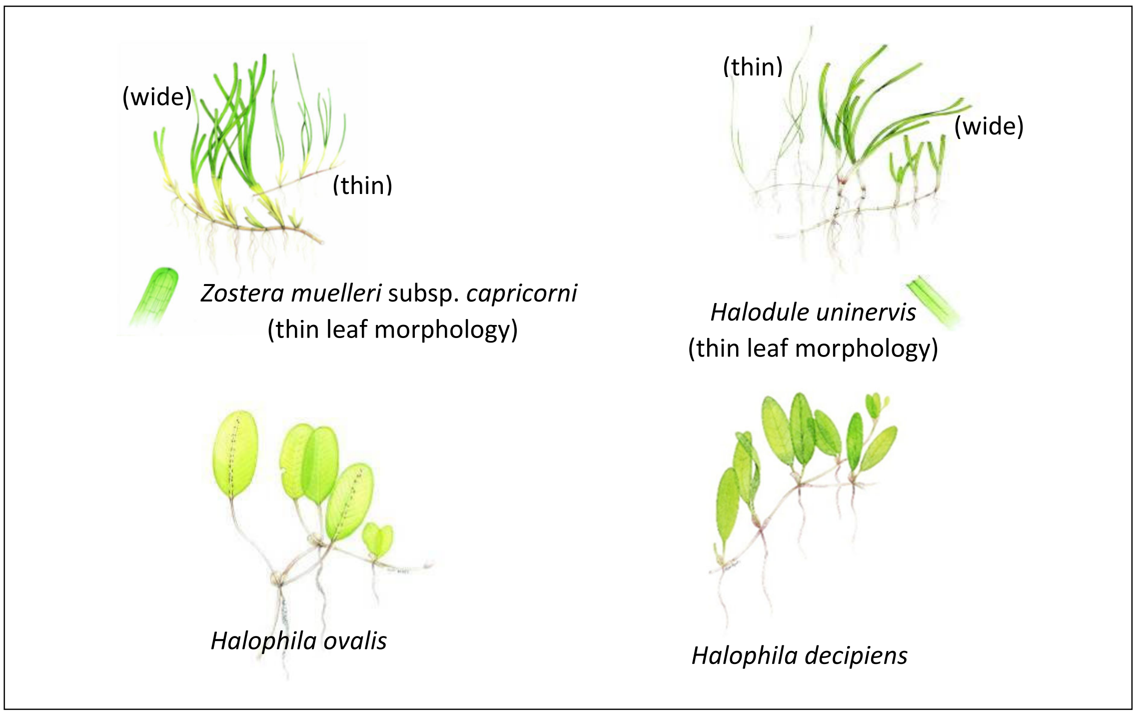

Figure 3. Seagrass species present in the HR2RP southern inshore marine zone during the 2022 survey.

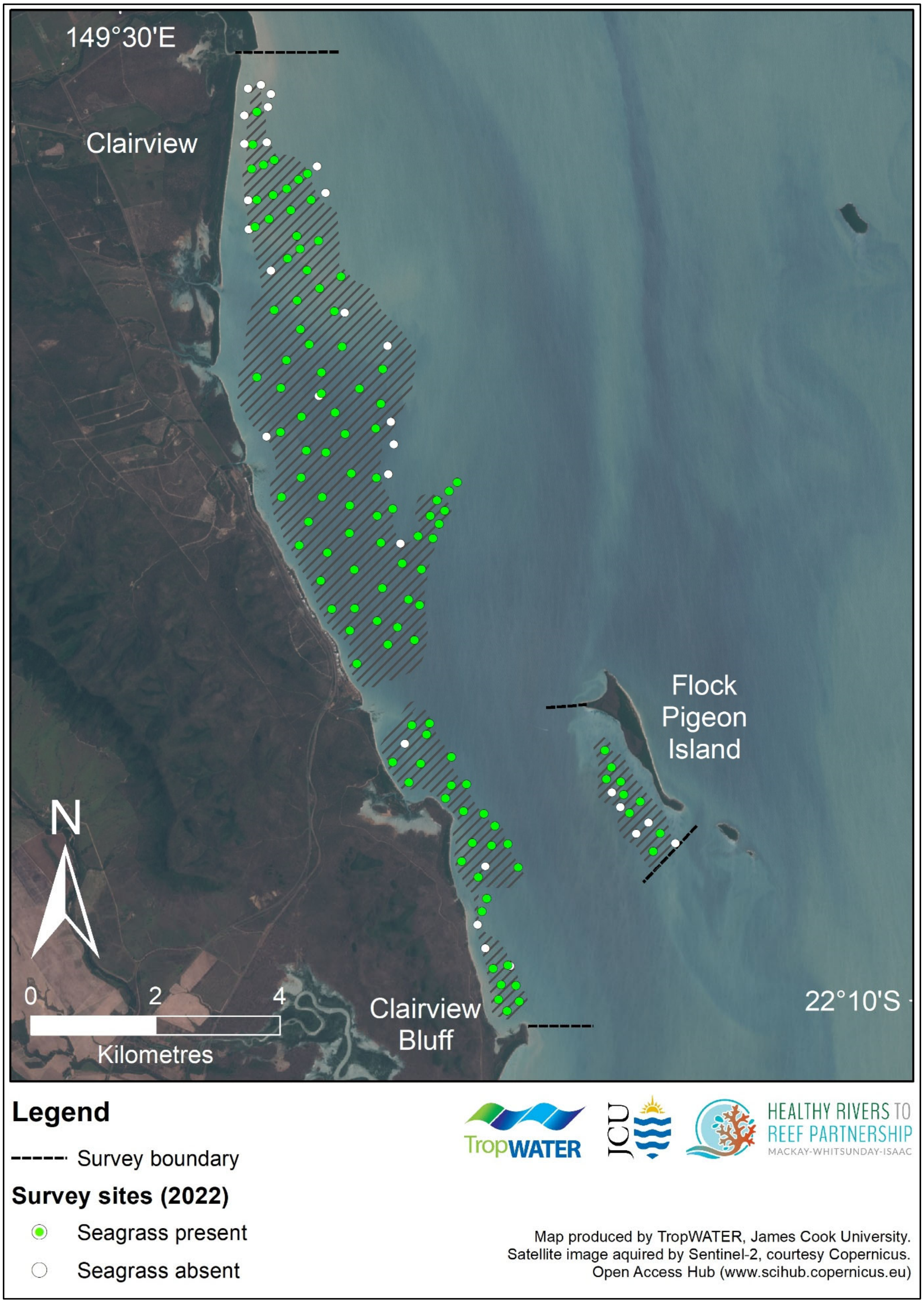

Figure 4. Location of intertidal survey sites in the southern inshore marine zone with seagrass presence/absence in 2022.

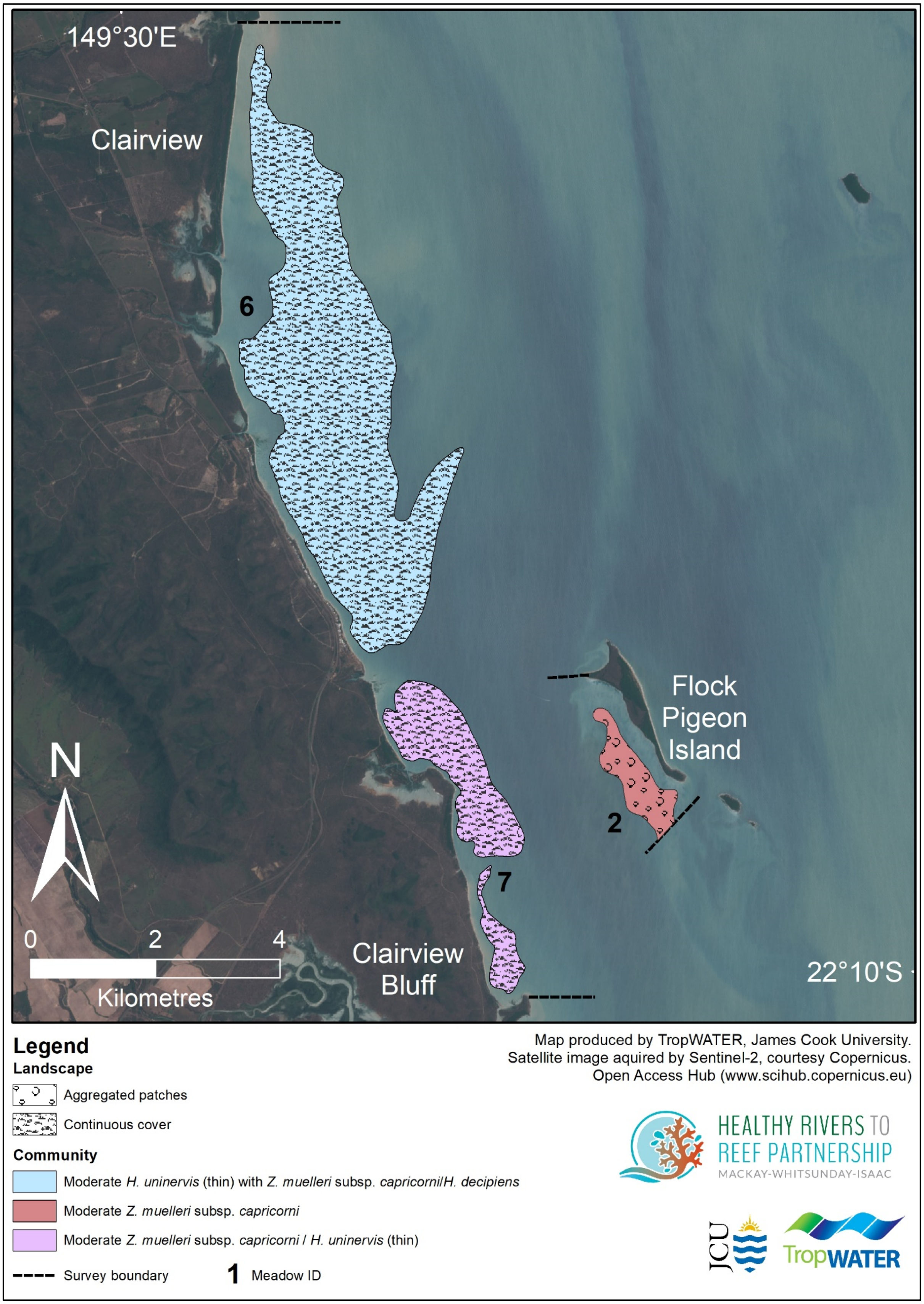

Figure 5. Seagrass monitoring meadow landscape categories and community types in 2022.

4.1 Seagrass condition for annual monitoring meadows

All three of the seagrass monitoring meadows scored an overall good condition assessed against their baseline (currently 6 year baseline). All the individual indicators (seagrass above-ground biomass, meadow area and species composition) were scored as either good or very good condition across the three meadows in 2022 (Table 3).

Within each monitoring meadow seagrass biomass (density) was not distributed evenly throughout the meadow footprints but rather varied as a mosaic of biomass hot spots and low spots ranging from 0 to 6.2 g DWm^{-2} (Figures 6-8). Biomass was greatest throughout Meadow 7 and in the southern end of Meadow 6. These areas of high biomass coincide with where the majority of dugong feeding trails were recorded (Figure 9). No dugong feeding trails were recorded in Meadow 2 after being present in the previous year (Figure 9).

Table 3. Grades and scores for condition indicators (biomass, area, and species composition) for Clairview monitoring meadows, 2022.

Meadow	Biomass	Area	Species Composition	Overall Meadow Score
2 – Flock Pidgeon	0.72	0.83	1.00	0.72
6 – Clairview North	0.73	0.92	0.79	0.73
7 – Clairview South	0.66	1	0.74	0.66
Clairview Overall Score				0.70

The Flock Pidgeon Island Meadow 2 had a mean biomass of 1.51 ± 0.56 g DWm^{-2} demonstrating further recovery from the lowest value recorded so far in the monitoring in 2020 (Figure 7). There was a slight reduction in area of this small meadow, from 116 ± 11 ha in 2021 to 99.6 ± 2.8 ha in 2022, (Figure 7). Meadow 2 is dominated by the narrow leaf forms of *Z. capricorni* and *H. uninervis* and maintained a very good species score in 2022 (Figure 7).

The Clairview North Meadow 6 is the largest monitoring meadow in the southern inshore zone and covered a total area of 1445 ± 13 ha in 2022 achieving a very good grade for this indicator. Meadow area has been fairly stable over the last five years with slightly positive trend (Figure 8). Since the program began in 2017 the meadow biomass has been relatively low, with a good grade recorded in 2022 (1.8 ± 0.16 g DWm^{-2}). This meadow remains dominated by *H. uninervis*, and *Z. capricorni* but had the highest presence of the colonising species *Halophila ovalis* in 2022 since surveying begun, although species composition was still rated as good (Figure 9).

The Clairview South Meadow 7 had a reduction in biomass to good condition in 2022 from the highest biomass on record in 2021 (2.4 ± 0.4 g DWm^{-2} compared to 3.6 ± 0.6 g DWm^{-2}). The area of Meadow 7 has been consistently growing since 2017, with 2022 producing the highest area (322.9 ± 6.7 ha) recorded for the program to date achieving very good grades (Figure 9). There was a slightly higher presence of colonising *Halophila* species in the meadow in 2022 although *H. uninervis* and *Z. capricorni* still comprised 86% of the meadow biomass resulting in a good grade for this indicator.

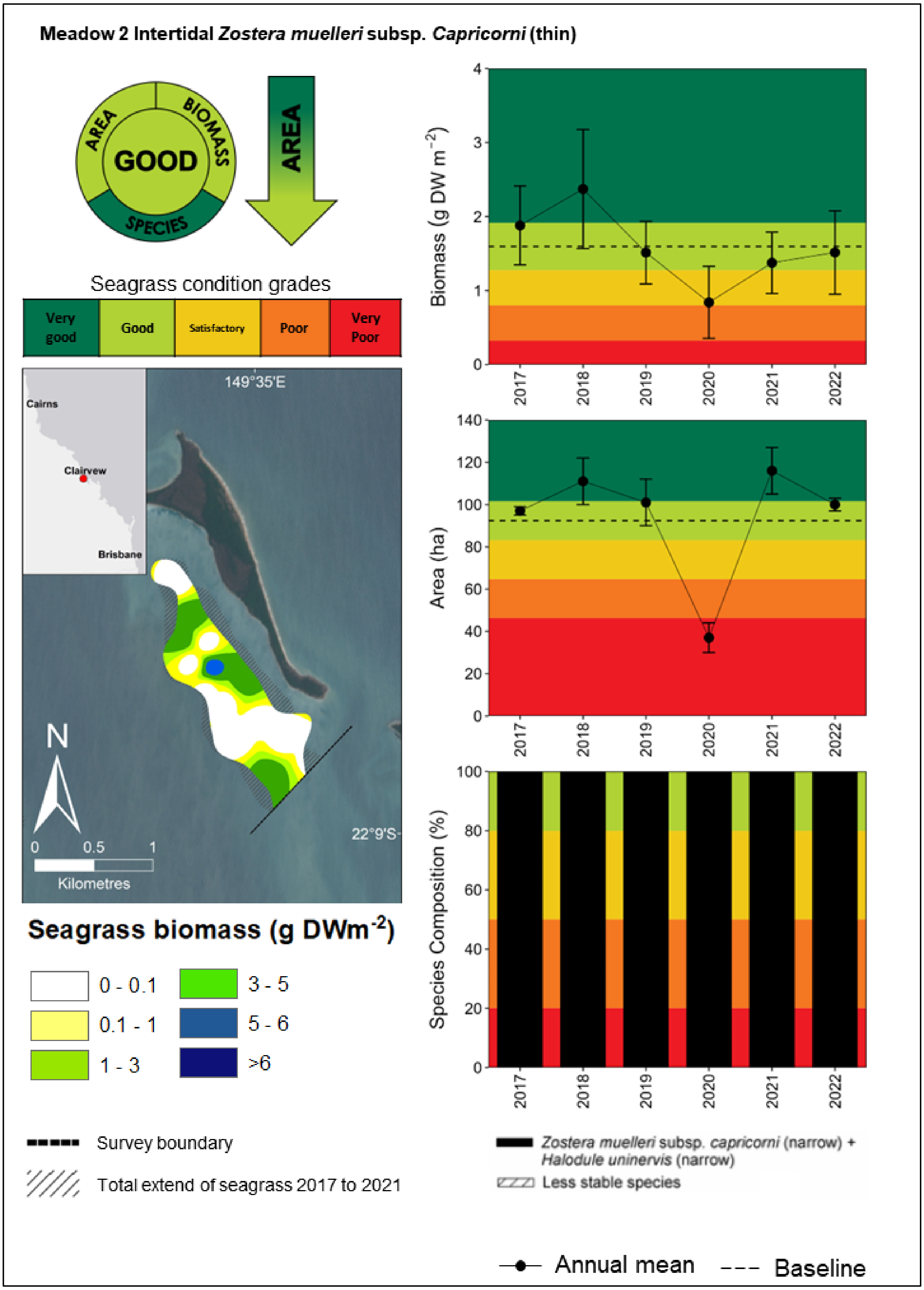

Figure 6. Changes in biomass, area and species composition for Meadow 2, 2017 - 2022 (biomass error bars = SE; area error bars = "R" reliability estimate).

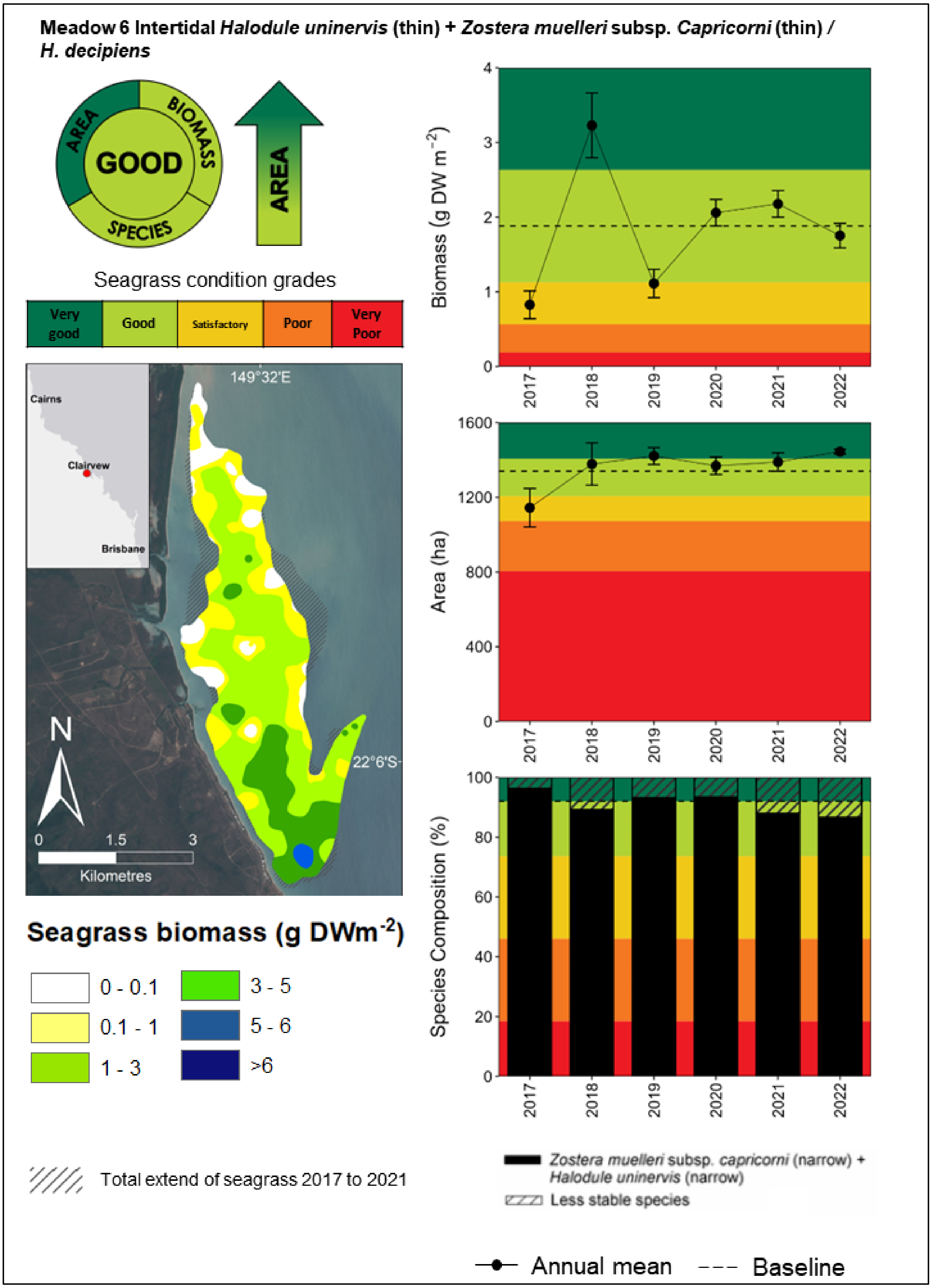

Figure 7. Changes in biomass, area and species composition for Meadow 6, 2017 - 2022 (biomass error bars = SE; area error bars = "R" reliability estimate).

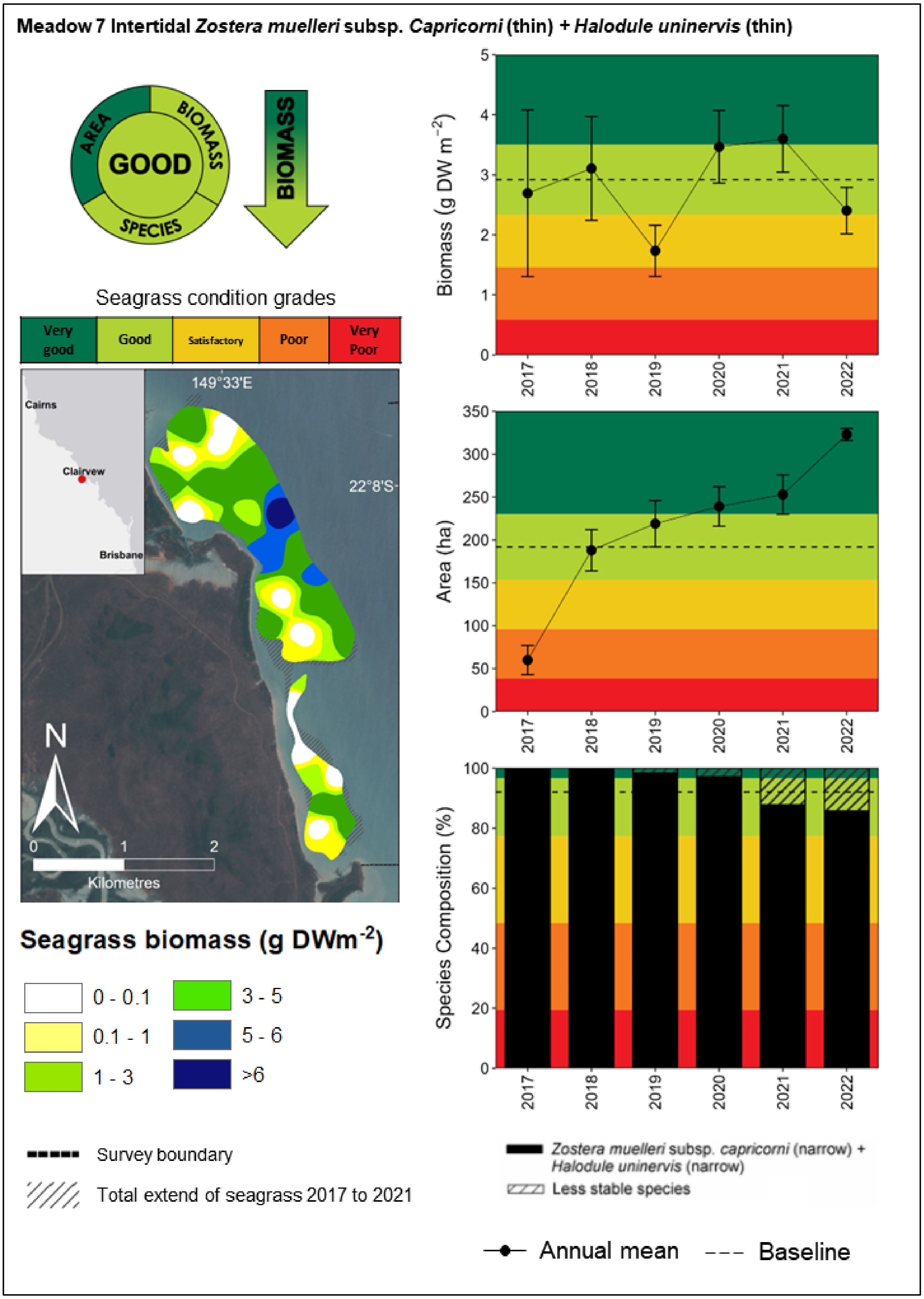

Figure 8. Changes in biomass, area and species composition for Meadow 7, 2017 - 2022 (biomass error bars = SE; area error bars = "R" reliability estimate).

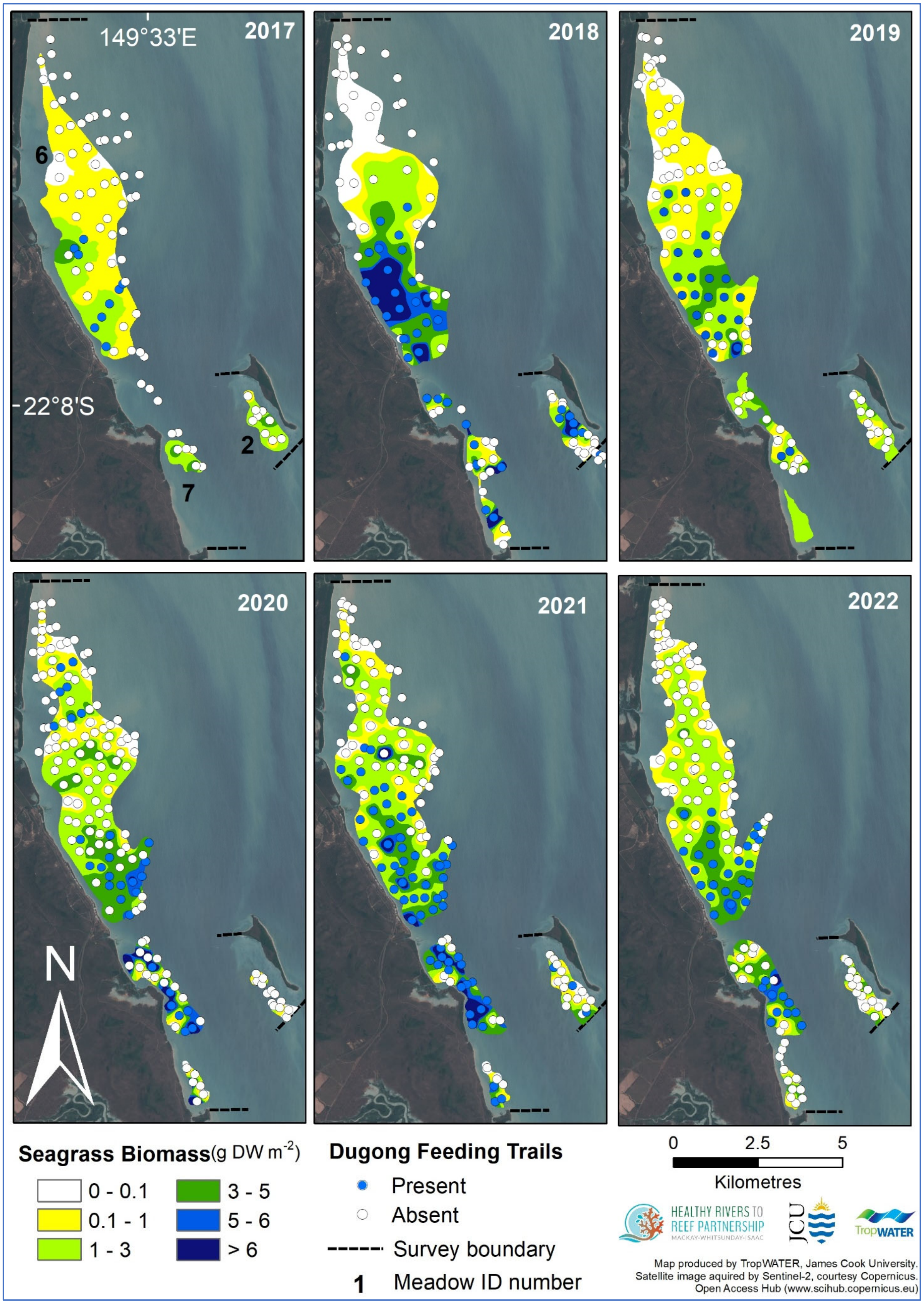

Figure 9. Variation in intertidal seagrass biomass within monitoring meadows, and presence of dugong feeding trails, 2017-2022.

5 DISCUSSION

In 2022, the sixth annual seagrass monitoring effort in the southern inshore marine zone of the Mackay-Whitsunday-Isaac HR2RP provided valuable insights into the condition and dynamics of the seagrass meadows. Overall, the three monitoring meadows were in a good condition when compared to their six-year baseline average. Each of the individual indicators, including seagrass above-ground biomass, meadow area, and species composition, received good or very good condition scores across the board in 2022 (Figure 7, 8, 9). However, seagrass biomass was not distributed evenly throughout the meadows. Biomass was higher in the central region of Meadow 7 and the southern end of Meadow 6, which coincided with the locations where most dugong feeding trails were recorded (Figure 9). While the monitoring program is still in its early days, there appears to be an overall positive trend for seagrass health metrics over the six years, indicating that the conditions in the region have been generally favourable for seagrass.

The Flock Pigeon Island seagrass meadow underwent substantial declines in biomass and area in 2020 but over the past two years has recovered with biomass returning to around the long-term average, and area and species composition in above average condition in 2022. While this meadow was in good condition in 2022 there was no evidence of recent dugong feeding, unlike the two large seagrass meadows adjacent to the mainland coast where extensive areas of dugong feeding trails were recorded. The two mainland seagrass meadows (6 & 7) had an increased presence of the colonising species *Halophila ovalis* in 2022 but remained dominated by *H. uninervis* and *Z. capricorni*. Both of these meadows had biomass values considered to be good when compared with their 6-year average condition, however these values were relatively low compared with some meadows of these species elsewhere in Queensland. This low biomass in Clairview is quite typical for similar meadows in the greater region (Reason et al. 2023b, York et al. 2023), and is likely to be locally driven by a combination of large tidal movements, high grazing pressure and low light conditions preventing seagrasses from reaching higher abundances. The southernmost monitoring meadow (7) has shown a consistent year on year expansion in area since 2017, reaching its highest recorded area in 2022.

The distribution of seagrass biomass within the meadows has shown a constantly changing mosaic of hot spots and low spots between years. It underscores the importance of adopting a comprehensive monitoring approach that captures the entire meadow (Figure 9) to allow for a more representative assessment of changes in the regional seagrass resource, as particular sub-sections of the meadows may exhibit dramatic shifts in biomass from year to year but don't reflect the health of the greater meadow on their own. The correlation between biomass hot spots and dugong feeding efforts suggests a potential role of herbivory in shaping the location of seagrass biomass concentrations within the meadows or vice versa.

The dominance of thin leaf morphologies in *Z. capricorni* and *H. uninervis* within the monitoring meadows raises interesting questions about the factors influencing local seagrass growth. The shift to thin leaf growth morphologies has been attributed to a range of factors including light levels (York et al. 2013), exposure to air and sediment type (McMillan 1983), and herbivory (Fourqurean et al. 2010). Further investigation is needed to understand the specific drivers behind the observed thin leaf forms in these species in the Clairview region.

The findings of the 2022 survey contribute to our understanding of the seagrass communities within the southern inshore zone and their ecological importance, particularly for dugongs and green sea turtles. These monitoring efforts provide valuable data for the Mackay-Whitsunday-Isaac HR2RP report card, enabling the assessment of seagrass health in the region. The continued monitoring and analysis of the meadows will further refine the understanding of their dynamics and assist in defining their baseline condition for future monitoring efforts. It is worth noting that seagrass meadows can exhibit spatial and temporal variability, even in the absence of major natural or anthropogenic impacts, and continued monitoring can help capture these localised fluctuations and will help establish a more robust baseline as we approach the required 10-year mark for fixing the baseline as per the methods outlined in Carter et al. (2023). In 2023 after six years of the annual monitoring program, seagrasses were in a good condition indicating a healthy marine environment, with water quality and environmental conditions favourable for seagrass growth and a positive outlook for seagrasses and their dependant species if similar conditions remain.

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