Mackay-Whitsunday 2017 Baseline Seagrass Survey:

Marine Inshore South Zone

Carter AB and Rasheed MA

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KEY FINDINGS

- The Mackay-Whitsunday region has extensive seagrass habitat that provides an important food resource for dugong and turtle and a range of other key ecosystem services.

- The Mackay-Whitsunday Healthy Rivers to Reef Partnership (HR2RP) reports on the condition of the region through an annual report card. The HR2RP identified a knowledge gap for the inshore marine south zone, where lack of regular monitoring means no scores could be provided for any of the four indicators: water quality, coral, seagrass and fish.

- Historical seagrass data exists for the inshore marine south zone collected by TropWATER (James Cook University) team during surveys in 1987, 1997, 1999, and in 2003/4 with CSIRO. The 1987 and 1999 surveys revealed substantial intertidal seagrass meadows along the coast, particularly in the Clairview Dugong Protection Area (DPA).

- TropWATER were contracted to address identified knowledge gaps in environmental condition (seagrass, and water quality) for the south inshore marine zone, with a longer-term objective to provide report card scores for these indicators.

- This report presents findings from the 2017 baseline seagrass survey of the marine inshore south zone, which focused on the Clairview DPA.

- Survey methods and the seagrass metrics recorded followed established methods used throughout Queensland. Standardised methods and metrics ensure seagrass data is comparable with data already in use for seagrass report cards, including HR2RP, the Wet Tropics Healthy Waterways Partnership, the Gladstone Healthy Harbour Partnership, and the Queensland Ports Seagrass Monitoring Program (QPSMP).

- 1600 ha of intertidal seagrass and 70 ha of subtidal seagrass was mapped across seven intertidal and two subtidal meadows. Three seagrass species were recorded: *Zostera muelleri* subsp. *capricorni*, *Halodule uninervis*, and *Halophila ovalis.*

- Evidence of dugong feeding was present in four of the seven intertidal meadows.

- Meadows suitable for annual long-term monitoring were identified between Clairview and Flock Pigeon Island. The recommended monitoring program would incorporate a large area (64%) of the total mapped coastal seagrass in the south zone into annual assessments of seagrass condition and therefore provide excellent representation of overall seagrass condition in the zone.

- Long-term monitoring of meadow area, biomass and species composition will provide the data necessary to establish baseline seagrass conditions and develop report card scores for the south zone consistent with the current methods for the HR2RP.

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1 INTRODUCTION

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

Seagrasses are declining globally from natural and anthropogenic effects (Waycott et al. 2009). Natural disturbances include storms, floods, disease, and overgrazing by herbivores (McKenna et al. 2015; Fourqurean et al. 2010; Robblee et al. 1991). Anthropogenic activities identified as the main threats to seagrass ecosystems in the tropical Indo-Pacific region include industrial and urban run-off, port and coastal development, and dredging (York et al. 2015; Grech et al. 2012).

The ecological importance of seagrass, and seagrass' sensitivity to disturbance events and environmental change, make it an ideal indicator for long-term monitoring of marine environmental health (Orth et al. 2006; Abal and Dennison 1996; Dennison et al. 1993). 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 primarily undertaken as part of 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/).

In recent years the seagrass programs have contributed their condition assessments to a variety of report cards, including the Gladstone Healthy Harbour Partnership (GHHP; http://rc.ghhp.org.au/report-cards), and regional report cards for the Wet Tropics Healthy Waterways Partnership (WTHWP; http://wettropicswaterways.org.au/report-card/) and Mackay-Whitsunday Healthy Rivers to Reef Partnership (HR2RP; http://healthyriverstoreef.org.au/). Regional report cards at the Natural Resource management (NRM) scale are divided into zones defined largely by habitat and latitude. The HR2RP report card, for example, reports the condition of five freshwater basins, eight estuaries, four inshore marine zones, and one offshore marine zone (Figure 1a). Attempts to report seagrass condition at the zone scale has revealed a number of gaps where no long-term monitoring data is available to inform the report card scores. This includes the HR2RP inshore marine south zone, where no scores are currently provided for any of the four environmental indicators: water quality, coral, seagrass and fish (http://healthyriverstoreef.org.au/report-card-results/).

TropWATER were contracted in 2017 by HR2RP to address identified knowledge gaps in environmental condition (seagrass and water quality) for the south inshore marine zone, with a longer-term objective to provide report card scores for these indicators. The TropWATER seagrass ecology team have conducted seagrass surveys previously in this zone; in 1987, as part of large-scale seagrass assessments along the Queensland coast (Coles et al. 1987); in 1997, during GBR-wide deep water surveys (Coles et al. 2009); in 1999, during assessments for Dugong Protection Areas (Coles et al. 2002); and 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) that extends from Carmila south to Clairview Bluff (Figure 1b). These meadows were mapped in 1987 (Coles et al. 1987), and the region revisited in 1999 (Roder et al. 2002).

This report presents findings from the 2017 baseline seagrass survey of HR2RP south inshore marine zone. The survey focussed on the Clairview DPA as a known seagrass area. Our objectives were to:

- Map seagrass distribution, density and community composition in the survey area;
- Compare results with previous seagrass survey data from this region;
- Incorporate results into a Geographic Information System (GIS) database for the zone;
- Provide recommendations on the establishment of an annual long-term monitoring program in this region based on these results.
- Provide the recommendations for the development of a seagrass condition indicator score for the HR2RP report card's inshore marine south zone.

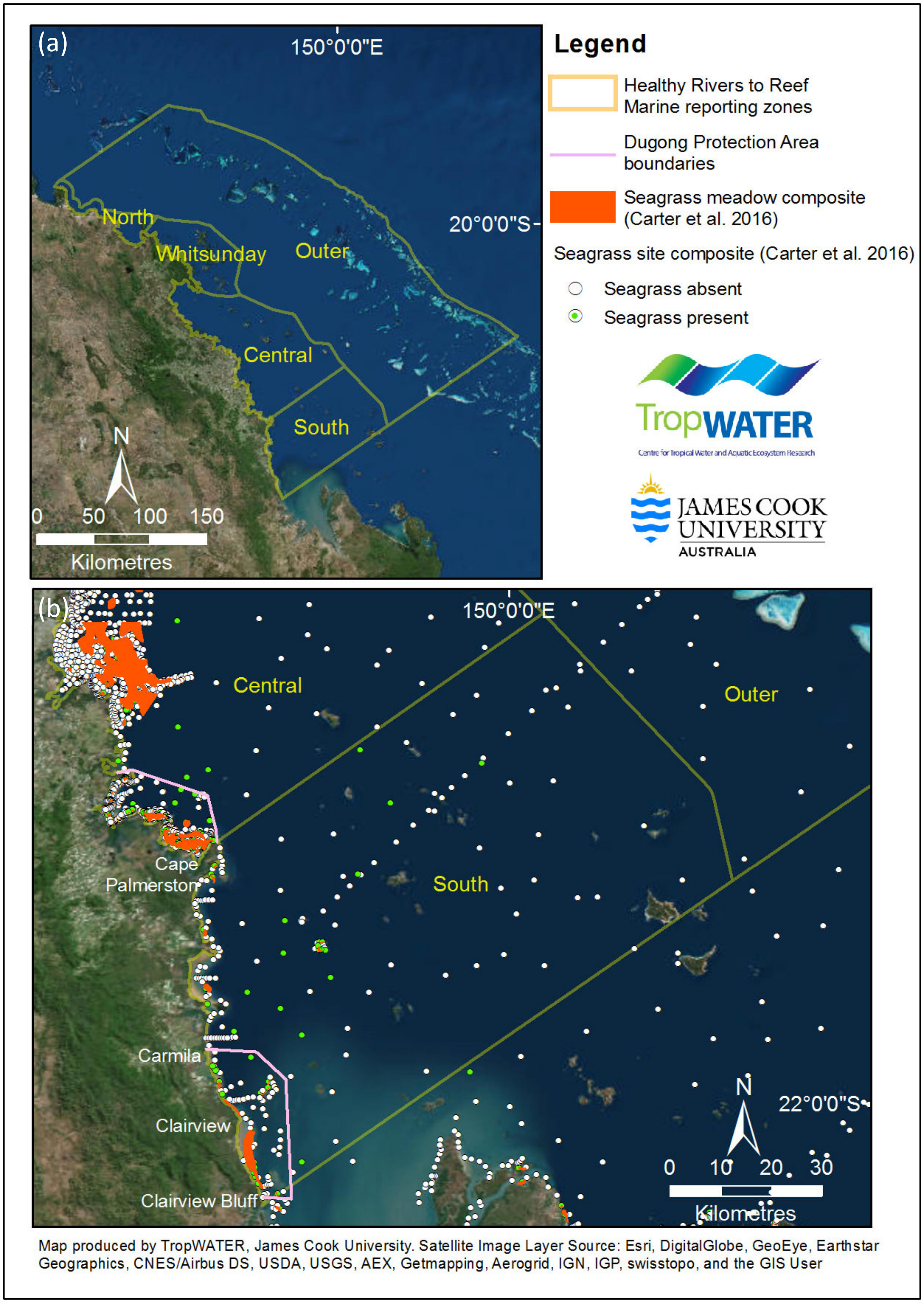


Figure 1. Mackay-Whitsunday Healthy Rivers to Reef Partnership reporting zones for inshore marine (north, Whitsunday, central, south) and offshore marine (outer); and (b) historical seagrass survey data collected 1987 – 2004 in the inshore marine south zone.

2 METHODS

2.1 Survey Approach

A baseline seagrass survey of the Clairview DPA, which extends from Carmila to Clairview Bluff (Figure 1b), was conducted between September and December, 2017. Survey methods and the seagrass metrics recorded followed the established methods for Queensland seagrass baseline assessments and monitoring including similar programs conducted in Townsville (Wells and Rasheed 2017), Gladstone (Rasheed et al. 2017), Cairns (York and Rasheed 2017), Mourilyan (Reason et al. 2017), Mackay-Hay Point (McKenna and Rasheed 2017), Abbot Point (McKenna et al. 2017b), Thursday Island (Sozou et al. 2017), Weipa (McKenna et al. 2017a), and Karumba (Sozou and Rasheed 2017).

The survey was conducted in the peak seagrass growing season (late spring-early summer) when meadows are likely to contain maximum biomass and area (Chartrand et al. 2012), and coincides with other monitoring surveys. Using standardised methods, including survey month and seagrass metrics, ensured that seagrass data is comparable with that used to report on seagrass condition for other marine inshore zones in the HR2RP report card, and in the WTHWP, GHHP, and QPSMP report cards. Standardisation also allowed for comparisons with historical data sets collected previously in the same area.

2.2 Field Surveys

Intertidal meadows were sampled at low tide using a helicopter. At each site the helicopter came to a low hover (within a metre of the ground) and 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 (Figure 2a). Within the larger 10m^2 circular area the percent cover of seagrass, algae, and other benthic macro-invertebrates (BMI) were estimated. GPS was used to record the position of each site, and also intertidal meadow boundaries when visible.

Subtidal meadow sampling follows the same protocol as for intertidal meadows, but the three quadrats are assessed by an underwater CCTV camera system attached to a camera frame that incorporates a 0.25 m^2 quadrat (Figure 2b, c). At each site the camera is lowered from the vessel to the sea floor at 3 random placements (Figure 2b, c). Video footage is observed on a TV monitor from the vessel and seagrass biomass is ranked in real time as above. A van Veen grab (grab area 0.0625 m^2) is used to collect a seagrass sample to help identify species present, and also to assess seagrass presence/absence where visibility is too poor for video biomass assessments (Figure 2d). Species identified from the grab are also used to record species composition for the site (Kuo and McComb 1989). Subtidal sampling extended to the offshore edge of seagrass meadows.

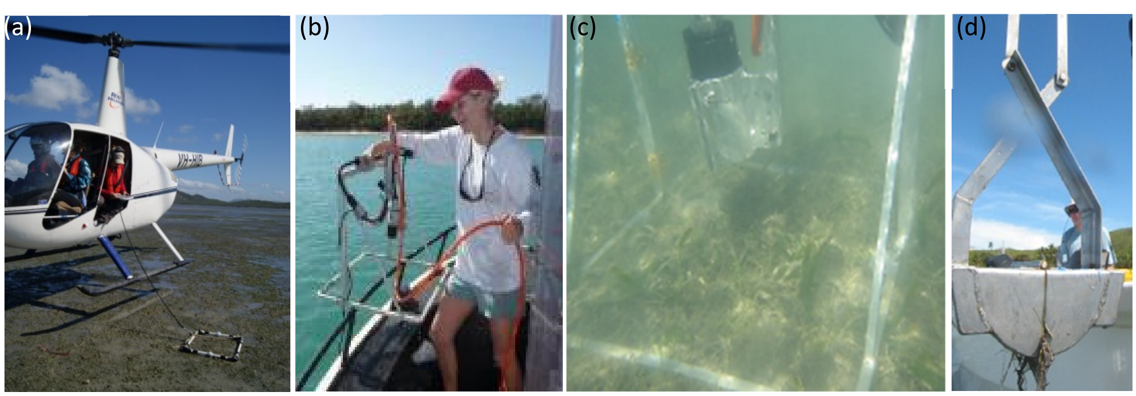


Figure 2. Seagrass monitoring conducted using (a) helicopter with quadrat; (b, c) boat-based underwater camera; and (d) van Veen grab.

2.3 Biomass and Species Composition

Seagrass above-ground biomass was determined using a "visual estimates of biomass" technique (Mellors 1991; Kirkman 1978). 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. The percent contribution of each seagrass species to above-ground biomass within each quadrat was also recorded. Two separate ranges were used - low biomass and high biomass. At the completion of ranking, the observer also ranked a series of at least four 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 (gDW m^{-2}). Seagrass biomass could not be determined from sites sampled by van Veen grab.

2.4 Seagrass Meadow Mapping and Geographic Information System (GIS)

All survey data were entered into a Geographic Information System (GIS) developed for the MWHR2RP south zone using ArcGIS 10.4. Five seagrass GIS layers were created to describe spatial features of the region: a seagrass site layer, dugong feeding trail (DFT) site layer, seagrass meadow depth category layer, seagrass meadow community type layer, and seagrass biomass interpolation layer.

The seagrass biomass interpolation 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.

The site layers contain data collected at each site, including:

- Temporal details – survey date and time.
- Spatial details – latitude/longitude, depth below mean sea level (DBMSL).
- Habitat information – sediment type; seagrass information including presence/absence and above-ground biomass (total and for each species); percent cover of seagrass, algae, BMI and open substrate; percent contribution of algae functional groups and BMI categories, presence/absence of DFTs.
- Sampling method, vessel name, and any relevant comments.

The meadow layers provide summary information for all sites within each meadow, including:

- Temporal details – survey date.
- Habitat information – meadow identification number, depth category (intertidal/subtidal), mean meadow biomass $\pm$ standard error (s.e.), meadow area (hectares) $\pm$ reliability estimate (R), number of sites within the meadow, seagrass species present, meadow community type, meadow landscape category for intertidal meadows (Figure 3).
- Sampling methods and any relevant comments.

For the meadow (polygon) layer, meadow boundaries were constructed using seagrass presence/absence site data, field notes, GPS marked meadow boundaries, colour satellite imagery of the survey region (Source: Sentinel 2, courtesy Copernicus Open Access Hub www.scihub.copernicus.eu/; and Landsat 2017, courtesy ESRI), and aerial photographs taken during helicopter surveys. Seagrass meadows were assigned a meadow identification number that will be used to compare individual meadows between surveys. Monitoring meadows are referred to by these identification numbers throughout this report.

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.

Figure 3. Seagrass meadow landscape categories: (a) Isolated seagrass patches, (b) aggregated seagrass patches, (c) continuous seagrass cover.

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 (Table 1). The mapping precision for coastal seagrass meadows ranged from ±5 m for intertidal seagrass meadows with boundaries mapped by helicopter, to ±100 m for subtidal boundaries mapped by boat. Subtidal meadow mapping precision estimates were based on the distance between sites with and without seagrass. The mapping precision estimate was used to calculate an error buffer around each meadow; the area of this buffer is expressed as a meadow reliability estimate (R) in hectares.

Table 1. Mapping precision and methods for seagrass meadows.

Mapping precision	Mapping method
≤5 m	Meadow boundary mapped in detail by GPS from helicopter. Intertidal meadows completely exposed or visible at low tide.
10 m	Meadow boundary determined from helicopter and boat surveys. Inshore boundaries interpreted from helicopter sites. Offshore boundaries interpreted from survey sites and aerial photography. Moderately high density of mapping and survey sites.
50 m	Meadow boundaries determined from helicopter and boat surveys. Intertidal boundaries interpreted from helicopter sites. Subtidal boundaries interpreted from boat survey sites. Lower density of survey sites for some sections of boundary.
100 m	Meadow boundaries determined from boat surveys. Low density of survey sites for some sections of boundary.

Meadow community types were defined by the dominant species within a meadow and the density of the dominant species' biomass (Tables 2, 3). A standard nomenclature system was used to categorize seagrass community type depending on the dominant species' percent contribution to mean meadow biomass (for all sites within a meadow). The density of that community type (light, moderate, dense) was based on mean biomass of the dominant species within the meadow (Table 3).

Table 2. 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 3. Seagrass meadow density categories.

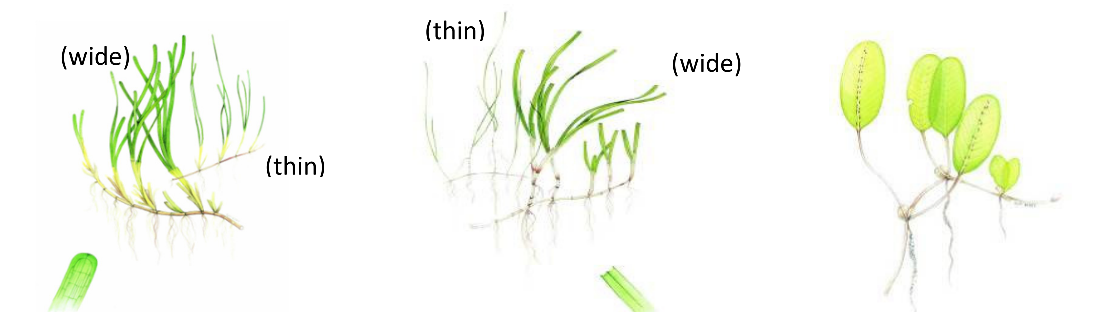
	Mean above-ground biomass (g DW m^{-2})	
Density	*H. uninervis* (thin) *Z. muelleri* subsp. *capricorni* (thin)	*H. ovalis*
Light	< 1	< 1
Moderate	1 - 4	1 - 5
Dense	> 4	> 5

3 RESULTS

The intertidal survey was conducted September 5-6 and the subtidal survey December 6, 2017. Three seagrass species were recorded during the survey: *Zostera muelleri* subsp. *capricorni* (abbreviated to *Z. capricorni* throughout this report), *Halodule uninervis*, and *Halophila ovalis* (Figure 4). Only the thin leaf morphologies of *Z. capricorni* and *H. uninervis* were observed.

Seagrass was present at 64% of the 111 intertidal sites surveyed and 15% of the 26 subtidal sites (Figure 5). The maximum depth recorded during the survey was 15m DBMSL, but seagrass was not found growing deeper than 4.3m DBMSL (Table 4). A total of 1601 ± 139 ha of intertidal seagrass and 70 ± 57 ha of subtidal seagrass was mapped across seven intertidal and two subtidal meadows (Table 4; Figure 6). The majority of seagrass area was mapped at Meadow 6, a large 1144 ± 103 ha intertidal meadow dominated by *H. uninervis* that extended from Clairview south towards Flock Pigeon Island (Table 4; Figure 7). Six of the nine meadows were dominated by *H. uninervis*, with that species spanning intertidal and subtidal waters, while *Z. capricorni* and *H. ovalis* were exclusively intertidal (Table 4; Figure 7).

Meadows were characterised by continuous seagrass cover (Figure 6). Mean biomass ranged from approximately 1 to 3g DW m^{-2} (Table 4). However, biomass varied greatly within a meadow, ranging from 0 to 7.8g DW m^{-2} (Figure 8). Dugong feeding trails were present in four of the seven intertidal meadows. Feeding trails in the large Meadow 6 coincided with biomass hotspots, but this pattern was not evident in the smaller meadows 1, 3, and 5 where feeding trails were also present (Figure 8).



Zostera muelleri subsp. *capricorni* (thin leaf morphology) | *Halodule uninervis* (thin leaf morphology) | *Halophila ovalis*

Figure 4. Seagrass species present in the HR2RP inshore marine south zone, 2017.

Table 4. Seagrass meadows in the HR2RP inshore marine south zone, 2017.

Meadow ID	Density	Community type	Depth range (DBMSL)	Area (ha ± R)	Biomass (mean ± SE)
1	Moderate	*H. uninervis* (thin) with *Z. capricorni* (thin)	0	36 ± 1	2.88 ± 0.01
2	Moderate	*Z. capricorni* (thin)	0	97 ± 2	1.88 ± 0.53
3	Moderate	*H. uninervis* (thin) with *Z. capricorni* (thin)	0	111 ± 7	1.66 ± 0.64
4	Light	*Z. capricorni*	0	16 ± 2	0.86 ± 0.15
5	Moderate	*Z. capricorni*	0	137 ± 6	1.44 ± 0.65
6	Light	*H. uninervis* (thin)	0	1144 ± 103	0.83 ± 0.19
7	Moderate	*H. uninervis* (thin)	0	60 ± 17	2.69 ± 1.39
8	na*	*H. uninervis* (thin)	4.3	24 ± 21	na*
9	Moderate	*H. uninervis* (thin)	3.4 - 4.0	46 ± 36	1.25 ± 0.65

*na: density and biomass measures not available - seagrass sampled by van Veen grab due to poor visibility.

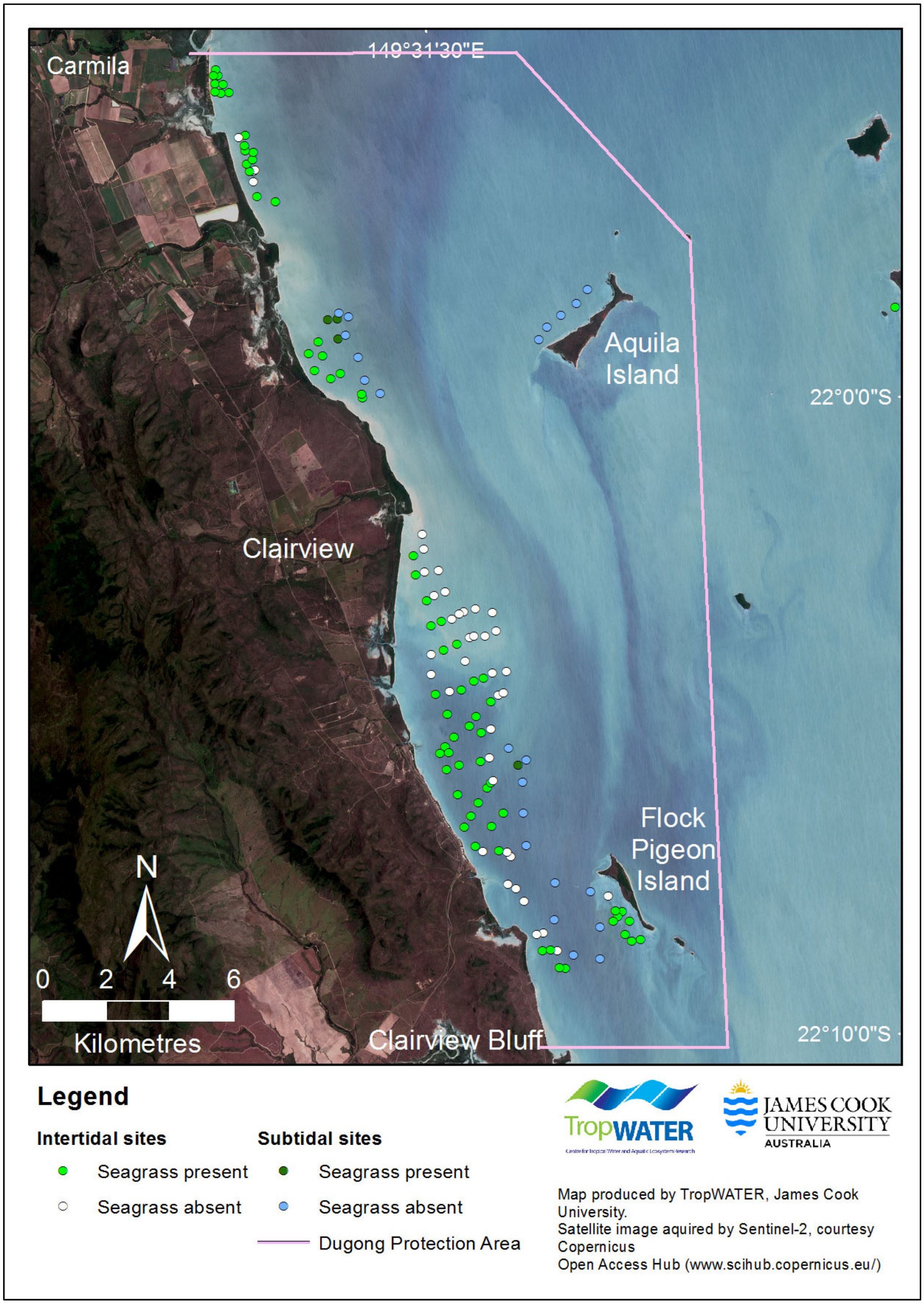


Figure 5. Location of intertidal and subtidal survey sites with seagrass presence/absence, 2017 survey. Survey area bounded by Clairview Dugong Protection Area.

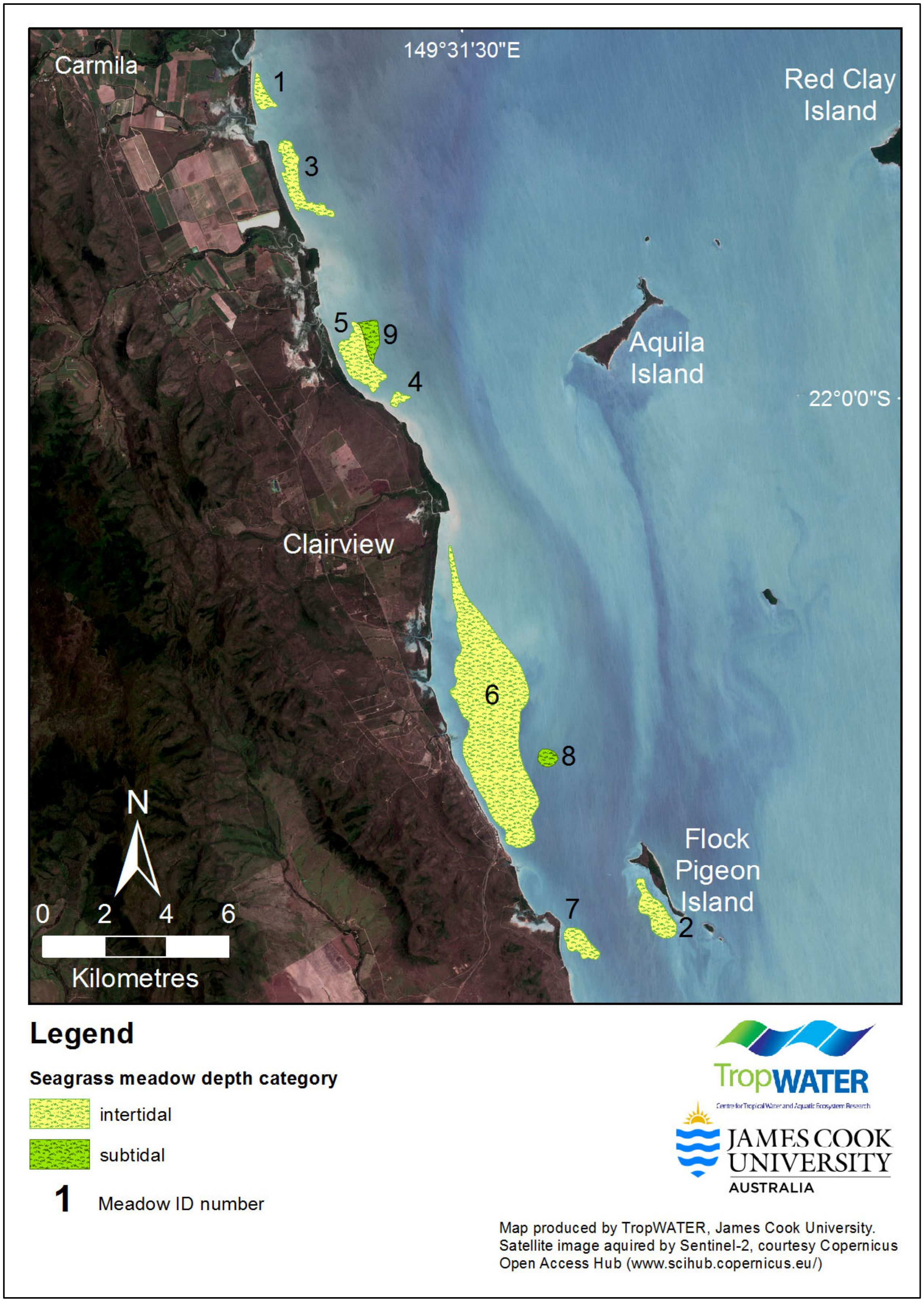


Figure 6. Seagrass intertidal and subtidal meadows with meadow identification (ID) number, 2017 survey.

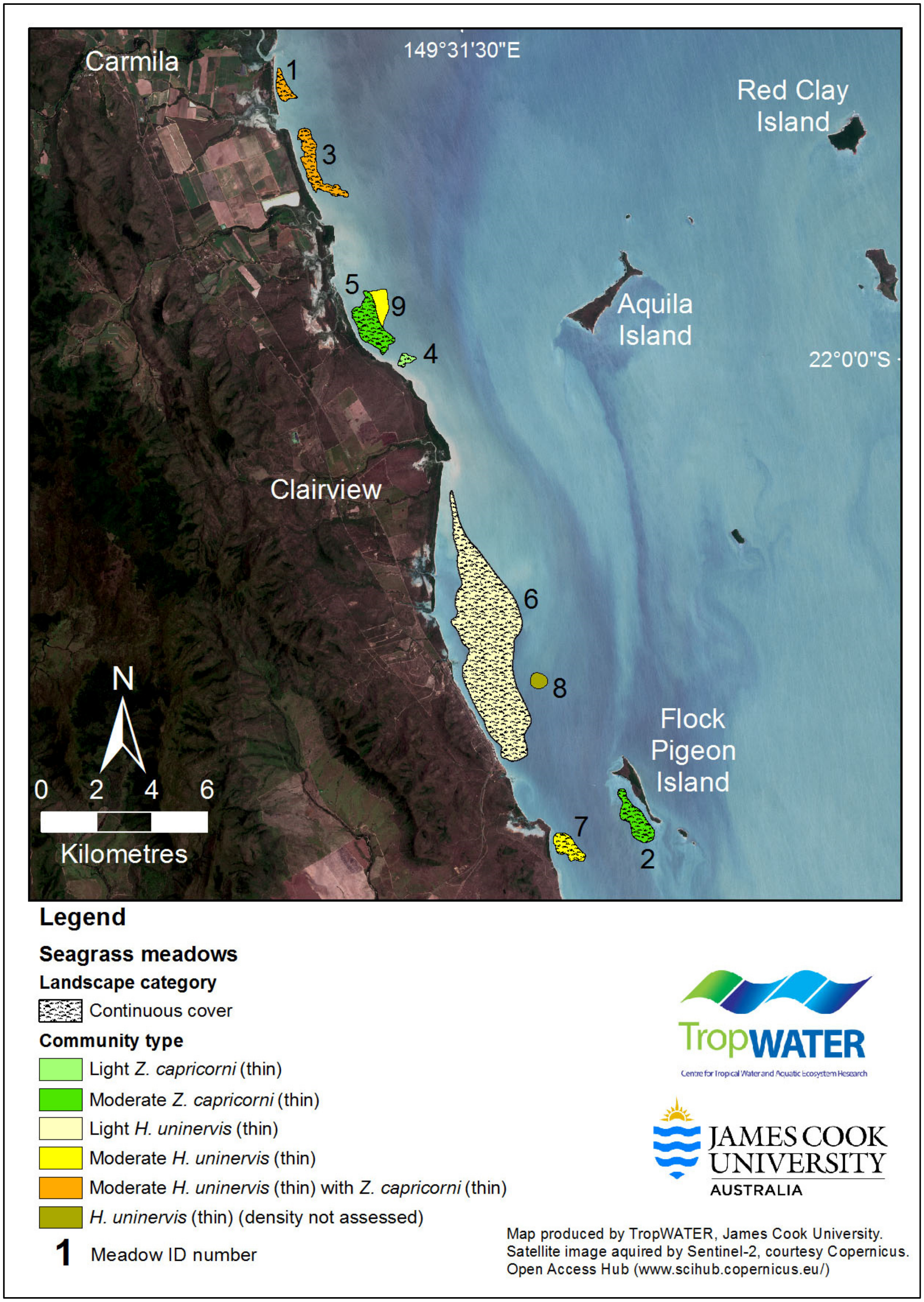


Figure 7. Seagrass meadow landscape category (intertidal meadows only) and community type, 2017 survey.

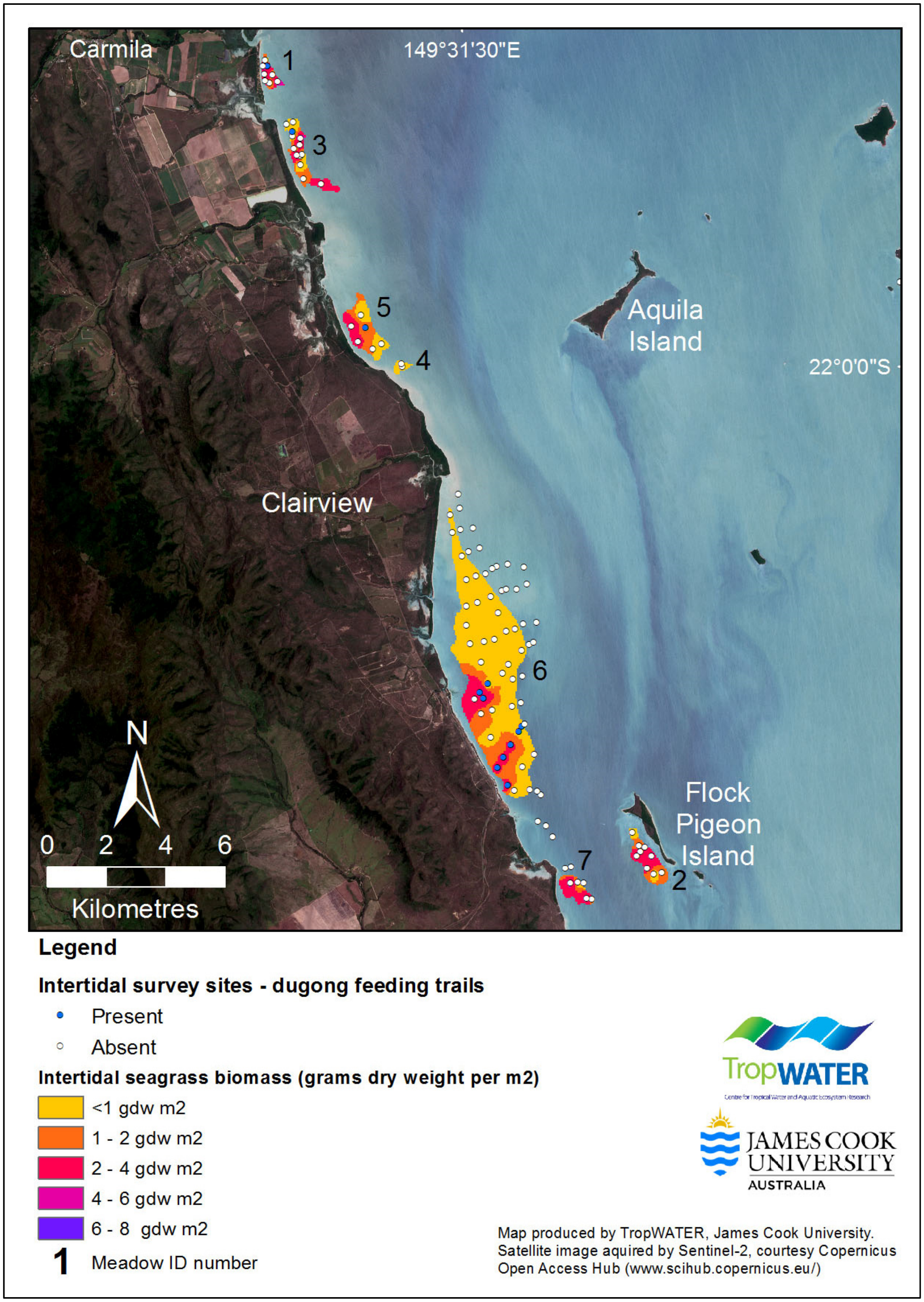


Figure 8. Variation in seagrass biomass within meadows, and presence of dugong feeding trails, 2017 survey. Intertidal sites/ meadows only.

4 DISCUSSION

Extensive and healthy intertidal seagrass meadows grow throughout the HR2RP marine inshore zones. The 2017 baseline survey confirmed findings from previous assessments along the Queensland coast (Coles et al. 2002; Coles et al. 1987) that within the south zone, seagrass is particularly extensive within the Clairview DPA. Meadows were spatially extensive but relatively low density; mean meadow biomass ranged from just 1 to 3g DW m^{-2}. This is typical of meadows in the marine inshore zones, with mean meadow biomass typically <3g DW m^{-2} for inshore coastal meadows between Dudgeon Point and Hay Point (central zone; McKenna and Rasheed 2017; McKenzie et al. 2017), and Abbot Point (north zone; McKenna et al. 2017b).

Seagrass species can be classed as colonising, opportunistic, or persistent, and vary in their sensitivity and resilience to impacts (Kilminster et al. 2015). The dominance of the opportunistic species *Z. capricorni* and *H. uninervis* in the survey area is characteristic of coastal intertidal and shallow subtidal seagrass meadows in the inshore zones. This includes seagrass monitoring meadows and sites between Dudgeon Point and Hay Point, Midge Point and Sarina Inlet (central zone; McKenna and Rasheed 2017; McKenzie et al. 2017), Hamilton Island and Pioneer Bay (Whitsunday zone; McKenzie et al. 2017), and Abbot Point (north zone; McKenna et al. 2017b). Opportunistic and persistent species have the greatest capacity to resist disturbance-related stress; colonising species tend to be transitory, being quick to succumb to disturbances but often the first to recolonise (Kilminster et al. 2015). The only colonising species recorded in the 2017 survey was *H. ovalis*, which was present only in Meadow 6 and a minor contributor (4%) to mean meadow biomass. The current dominance of opportunistic species in this region indicates meadows may be relatively resilient.

The largest mapped intertidal meadow (meadow 6) in the south zone extends from Clairview to Flock Pigeon Island (Figure 9). This meadow was first mapped in 1987 (Figure 1; Coles et al. 1987), was present (but not mapped) when the region was revisited in 1999 (Roder et al. 2002), and remained the largest meadow in the 2017 survey area at 1144 $\pm$ 103 ha. The large size and temporal consistency of this meadow means it likely provides a consistent source of primary production that supports the region's marine ecosystems, including important fisheries species, dugong, and green turtle. Extensive dugong feeding was recorded in the southern half of meadow 6, plus 3 other intertidal meadows in 2017 (Figure 7). Roder et al. (2002) also recorded evidence of extensive dugong feeding between Carmila and Flock Pigeon Island, and east to Aquila Island. Seagrasses are a critical food for dugong and green turtle (Unsworth and Cullen 2010; Heck et al. 2008). Large-scale seagrass loss associated with flooding in late 2010 and early 2011 along Queensland's east coast saw dugong and turtle deaths increase 215% and 176% respectively (compared to 2010), mainly as a result of starvation (DERM 2011). Future declines in meadow area or biomass in this region are likely to impact dugong and green turtle health and survival.

Large tidal ranges (up to 8.5m) and tidal currents generate high coastal turbidity in the south zone meaning most seagrass is confined to intertidal and very shallow subtidal depths. The quality and quantity of light, the primary driver of photosynthesis, affects the growth, survival and depth penetration of seagrass (Dennison 1987; Dennison and Alberte 1985). Seagrass species have different minimum light requirements to maintain a stable state or to achieve positive growth (Collier et al. 2016; Chartrand et al. 2012; Collier et al. 2012). Environmental conditions (e.g. rainfall, river flow, daytime tidal exposure, wind-driven resuspension, water temperature), impacts (e.g. tropical cyclones, floods, dredging), and habitat (e.g. depth, sediment) all influence available light and seagrass growth/persistence in Queensland (McKenna et al. 2015; York et al. 2015; Carter et al. 2014; Rasheed et al. 2014; Unsworth et al. 2012; Rasheed and Unsworth 2011). The species most commonly found in subtidal waters are characterised by their low light requirements. For example, *Halophila* require only 10 - 30% surface light intensity (Freeman et al. 2008), and are the dominant genera in deep subtidal waters (>10m DBMSL) on the Great Barrier Reef (Carter et al. 2016). Subtidal seagrasses are extremely limited in the south zone. No seagrass was recorded deeper than <4.3m DBMSL (Table 4) in the 2017 survey, and only sparse and patchy subtidal seagrass was recorded during deep water surveys in 1997 (Coles et al. 2009) and seabed biodiversity surveys in 2003-2004 (Pitcher et al. 2007). Ongoing monitoring in this zone will provide important insight into environmental drivers of seagrass growth and persistence.

Monitoring recommendation

This survey was an important first step in addressing identified knowledge gaps in environmental condition (seagrass, coral, and water quality) for the HR2RP south zone report card. We recommend establishing long-term monitoring meadows between Clairview and Flock Pigeon Island (Figure 9). 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. This area would incorporate the large intertidal *H. uninervis* meadow, mapped as meadows 6 and 7 in 2017 but as a single meadow in 1987, and the intertidal *Z. capricorni* meadow 2 at Flock Pigeon Island (not surveyed before 2017). Monitoring the proposed meadows would incorporate a large area (64%) of the total mapped coastal seagrass in the south zone into annual assessments of seagrass condition. Monitoring these meadows also captures the diversity of meadow sizes, the two dominant seagrass species in the zone, and seagrasses growing along the mainland coast and an island. Monitoring in this location also complements water quality monitoring established at nearby Aquila Island in 2017.

We recommend monitoring at the meadow-scale because meadow area is a fundamental indicator of seagrass condition, i.e. how much of the seagrass resource is present. Meadow area is already incorporated as a condition indicator in a range of seagrass report cards (e.g. QPSMP, GHHP, WTHWP, MWHR2RP). Meadow-scale monitoring is also important because seagrass biomass (see Figure 8) and species composition are rarely uniform across a meadow. Spatial variation caused by aggregated distribution patterns can significantly influence the precision and interpretation of time series analyses, and the scale of sampling relative to the distributional pattern of the organisms to be sampled must be considered (Greig-Smith 1983). Meadow-scale monitoring is required to capture this variation for the meadow types found in south zone survey area.

The meadows we recommend for monitoring are all intertidal. We do not recommend monitoring subtidal meadows in this zone because: (1) the large tidal range (up to 8.5m) means that all intertidal seagrasses are exposed during spring low tides so intertidal (helicopter) surveys are likely to capture the majority of seagrasses in the region; (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 adjacent/adjoining intertidal meadows; (3) extremely poor visibility means achieving consistently adequate sampling with an underwater video is unlikely and will result in data gaps, particularly for biomass and species composition estimates; and (4) monitoring only intertidal meadows will reduce the ongoing monitoring costs as a helicopter survey of the recommended area could be completed in one tidal window and there is no requirement for an additional boat-based survey.

Report card development

Seagrass meadow area, biomass and species composition data collected in 2017 provides the first year of data toward estimating baseline seagrass conditions and developing report card scores for the south zone consistent with the current methods for the HR2RP. We recommend ongoing annual monitoring to build our understanding of seagrass condition in this zone for adequate reporting. Our previous analyses determined 10 years as the ideal length of time to develop an accurate baseline of seagrass condition against which condition thresholds can be determined, as this time period generally incorporates the range of environmental conditions known to influence seagrass condition such as the El Niño Southern Oscillation cycles (Bryant et al. 2014). We recommend a minimum 5 years of data collection before scores are incorporated into a report card, and with the caveat that our confidence in these scores are reduced while baseline values and thresholds are updated annually until the 10-year baseline target is reached.

Unfortunately, the historical seagrass data for the proposed monitoring meadows cannot be incorporated into baseline condition calculations. No previous surveys were conducted at Meadow 2 at Flock Pigeon Island. The meadow mapped in 1987 that incorporates Meadows 6 and 7 from the 2017 survey included only 7 survey sites, has no biomass estimates but instead binned percent cover estimates ranging from <1% to 10%, and no breakdown of the contribution of each species to percent cover. For meadow area, it is unclear how the northern section of the meadow was mapped as there are few sites and the meadow extends into subtidal waters, although this may reflect changes in the extent of intertidal banks between 1987 and 2017. A community Seagrass Watch site was surveyed within this meadow in May 2017 and October 2017 (Figure 9). If a community seagrass program remains consistent and seagrass condition assessments can be incorporated into the MMP this will provide a seasonal context to the larger-scale monitoring proposed here, and complementary information (e.g. reproductive effort and tissue nutrients) that can be incorporated into future report cards.

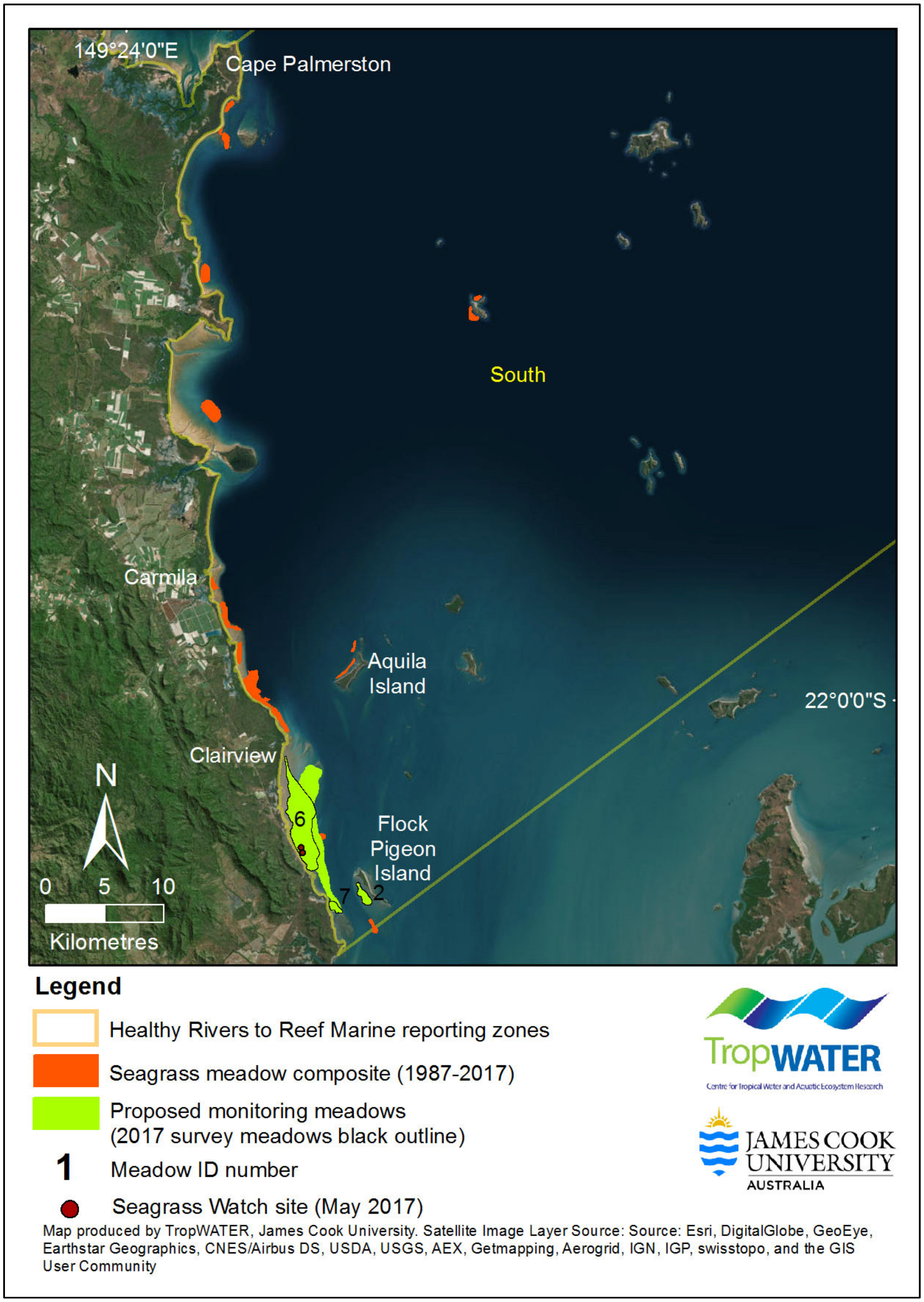


Figure 9. Mackay-Whitsunday Healthy Rivers to Reef Partnership south zone - proposed seagrass monitoring area in relation to all seagrass meadow data (1987 – 2017).

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