TropWATER
Centre for Tropical Water and Aquatic Ecosystem Research

JAMES COOK UNIVERSITY AUSTRALIA

TORRES STRAIT EASTERN CLUSTER:

INTERTIDAL SEAGRASS BASELINE SURVEY

Report No. 21/12

June 2021

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EXECUTIVE SUMMARY

- This report describes a baseline survey of reef-top and island intertidal benthic habitats, including seagrass, algae and coral, in the Eastern Cluster of the Torres Strait. The Central Cluster's Masig Island was included in the survey due to the island's ecological links with the Eastern Cluster.

- Torres Strait contains extensive seagrass habitat, the largest dugong population in the world, and globally significant populations of green turtles. Dugong feed exclusively on seagrass while green turtles consume seagrass and algae.

- Torres Strait's Eastern Cluster is an ecologically important region in the traditional land and sea country of the Kemer Kemer Meriam Nation. The area is a potential thermal refuge for coral reefs and contains the most important green turtle rookeries in Torres Strait for the northern Great Barrier Reef population.

- 2575 $\pm$ 323 hectares of intertidal seagrass was mapped across 24 intertidal meadows in September 2020. Large seagrass meadows occurred on fringing reefs around the inhabited islands of Erub (Darnley), Masig (Yorke) and Mer (Murray). Smaller high biomass meadows surround Waier and Dauar Islands. Patchy, low biomass meadows occurred on reef-tops close to Erub Island and at Maizub Kaur (Bramble Cay).

- Seagrass species diversity was greatest at meadows surrounding the largest continental islands of Mer and Erub and the heavily vegetated cay of Masig Island. Six seagrass species were recorded, but meadows were dominated by two common reef-associated species *Thalassia hemprichii* and *Cymodocea rotundata*.

- Intertidal reefs and islands also contained extensive algae habitat and coral communities. Hard coral cover was as high as 100% at some survey sites.

- The presence of meadows in similar areas to surveys conducted >10 years prior, and the dominance of the persistent reef-top species *T. hemprichii*, indicates the Masig Island and the Eastern Cluster's intertidal meadows provide a relatively stable foraging ground for marine herbivores.

- Seagrass information presented in this report and available on eAtlas can be used to inform the Erubam Le, Keriba Luzabzab-Lera Dorge and Masigalgal Dugong and Turtle Management Plans.

- Assessing and managing the health of Torres Strait seagrass and other benthic habitats requires the collection of baseline information plus ongoing monitoring to understand long-term variation and detect seagrass decline. We recommend the establishment of long-term, meadow-scale monitoring at Masig, Mer and Erub Islands. We also recommend expanding baseline surveys to include Ugar (Stephens Island) as data there is >10 years old.

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Inverse distance weighted (IDW)
Land and Sea Management Unit (LSMU)
Northern Great Barrier Reef (nGBR)
Reliability estimate (R)
Standard error (SE)
The Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER)
Torres Strait Regional Authority (TSRA)

1 INTRODUCTION

Seagrass meadows provide numerous ecosystem services, including food for megaherbivores (e.g. dugong and green turtle), macroherbivores (e.g. fish and urchins) and mesoherbivores (e.g. amphipods and gastropods) (Scott et al. 2018). In Torres Strait, extensive seagrass meadows flourish in intertidal and shallow subtidal waters (Carter et al. 2014b; Coles et al. 2003; Poiner and Peterkin 1996; Figure 1). These meadows provide food for the largest dugong population in the world (Marsh et al. 2011) and a globally significant green turtle population (Miller and Limpus 1991). Dugong and green turtle have high conservation value as listed species under the *Environment Protection and Biodiversity Conservation Act* (1999), and immense cultural and spiritual significance as cultural keystone species for Torres Strait Islanders (Butler et al. 2012).

Torres Strait's Eastern Cluster is an ecologically important region in the traditional land and sea country of the Kemer Kemer Meriam Nation. The Eastern Cluster includes the inhabited islands of Mer (Murray), Erub (Darnley) and Ugar (Stephen), Dauar and Waier Islands south of Mer, and Maizub Kaur (Bramble Cay) in the north. The region is a potential thermal refuge for coral reefs due to tidally induced upwelling along the continental shelf near Mer Island (Bainbridge et al. 2015). Maizub Kaur and Dauar Island are also the most important rookeries in Torres Strait for the northern Great Barrier Reef (nGBR) green turtle population (4Seas Environmental Consulting 2020). Dauar Island is a potential refuge for the nGBR population (Australian Government 2017), which is in the early stages of decline due to reductions in hatchling production, juveniles recruiting to the population, and feminisation of the population from elevated sand temperatures on nesting beaches (4Seas Environmental Consulting 2020). Despite the importance of the Eastern Cluster for green turtle, critical information on the seagrass resources available in foraging grounds is limited (Figure 1), with a recent review highlighting the region as "data-deficient" (Carter et al. 2014b).

The Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), in collaboration with the Torres Strait Regional Authority (TSRA) Land and Sea Management Unit (LSMU), have been collecting baseline Torres Strait seagrass data since 2002 (Carter et al. 2014b; Figure 1). However, no baseline surveys have occurred for large parts of the Eastern Cluster including at Mer, Dauar and Waier Islands. Long-term monitoring also is limited to two transect sites on Mer Island monitored annually by the Meriam Gesep A Gur Keparem Le Rangers, which contributes data on seagrass condition to the annual seagrass report card (Carter et al. 2020). Survey data for the western part of the region is now relatively old, including at Ugar Island (2008-2009), Erub Island (2009), Maizub Kaur (2009), and some reefs between Erub and Masig Islands (2012-2013) (Carter et al. 2013; Taylor and McKenna 2012; Taylor et al. 2009; Taylor et al. 2008). Deep-water benthic habitat was surveyed in 2005 with no seagrass recorded in the Eastern Cluster (Haywood et al. 2008).

Assessing and managing Torres Strait seagrass requires current baseline information on seagrass presence/absence, seagrass biomass, species composition, and meadow area, plus ongoing monitoring to understand variation over time and detect seagrass change. Our objectives were to:

(1) Conduct baseline mapping of the Eastern Cluster, focusing on benthic habitats found on intertidal reef-tops and around islands; and

(2) Provide recommendations on suitable sites to establish long-term monitoring.

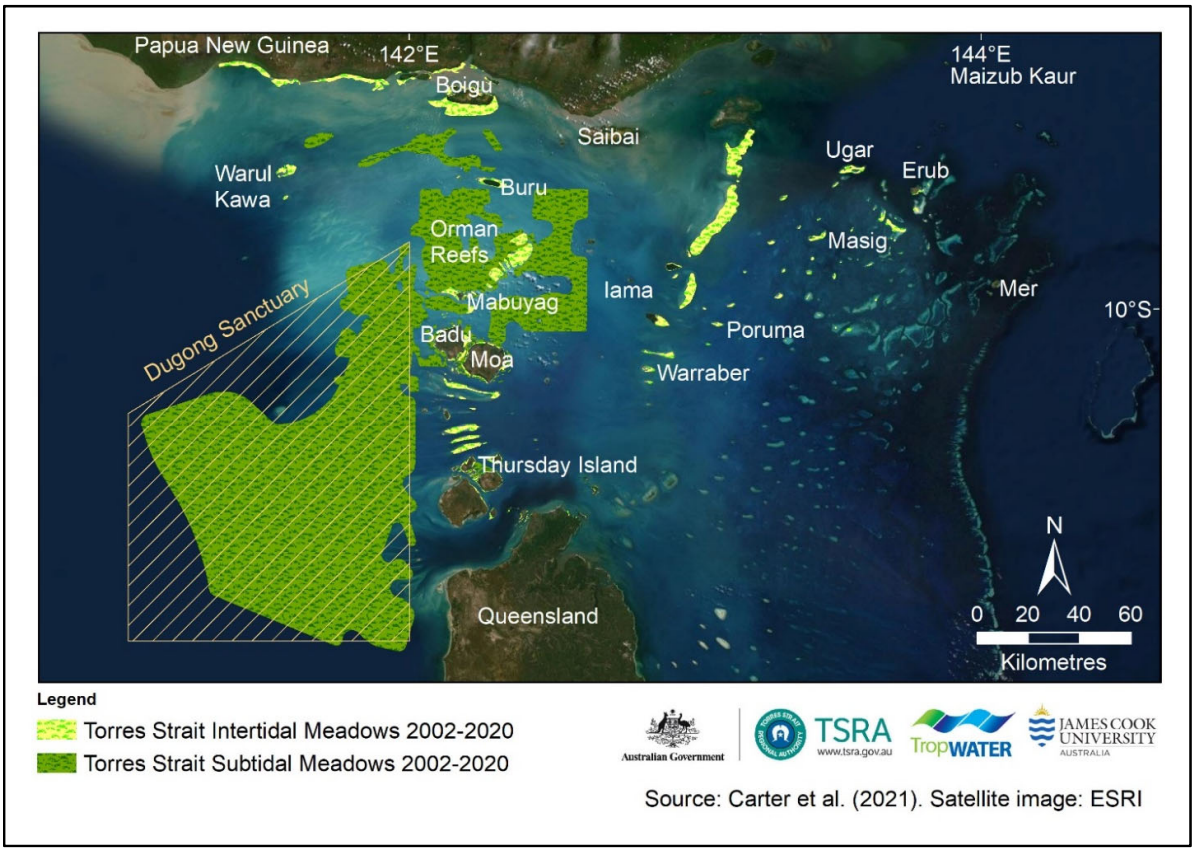

Figure 1. Intertidal and subtidal seagrass meadows mapped across Torres Strait, 2002-2020.

2 METHODS

2.1 Field surveys

TropWATER's approach for intertidal baseline surveys is to sample entire exposed banks, reef-tops, and islands by helicopter, which allows for rapid surveys across large areas (Figure 2). Baseline surveys conducted this way occur in late spring/summer during the peak seagrass growing period to ensure data among years and other locations are comparable. The Eastern Cluster baseline survey was conducted in September 2020.

Figure 2. Intertidal sites were surveyed by helicopter.

2.1.1 Survey sites

The following general details were recorded at all sites:

1. Site number.
2. Survey date.
3. Survey time.
4. Latitude/longitude.
5. Seagrass presence/absence.
6. Sediment type.
7. Sampling method.
8. Relevant comments.

Intertidal sites were sampled while the helicopter maintained a low hover. At each site a visual estimate was made of percent cover of seagrass, benthic macro-invertebrates (BMI), algae, and open substrate within a 10m^2 circular area.

2.1.2 Seagrass biomass and species composition

Seagrass biomass and species composition was estimated in three replicate 0.25 m^2 quadrats placed randomly within the site (Figure 2). Seagrass biomass was determined using the "visual estimates of biomass" technique (Mellors 1991). This involves using trained observers to rank seagrass biomass within each quadrat while referring to a series of quadrat photographs of similar seagrass habitats

where above-ground biomass was previously harvested and measured. Three separate biomass scales were used: low biomass, high biomass, and *Enhalus* biomass. The percent contribution of each seagrass species to total above-ground biomass within each quadrat was recorded.

At the completion of the survey each observer ranked a series of calibration quadrats. A linear regression was calculated of the relationship between the observer ranks and the harvested values. This regression was used to calibrate above-ground biomass estimates for all ranks made by that observer. Biomass ranks were then converted to above-ground biomass in grams dry weight per square metre (g DW m^{-2}). Site biomass (total and for each species) was calculated by averaging the biomass for the three replicate quadrats.

2.1.3 Algae

Percent cover of algae was divided into five functional groups:

- Erect macrophyte – Macrophytic algae with an erect growth form and high level of cellular differentiation, e.g. *Sargassum*, *Caulerpa* and *Galaxaura* species (Figure 3a).
- Filamentous – Thin, thread-like algae with little cellular differentiation (Figure 3b).
- Encrusting – Algae that grows in sheet-like form attached to the substrate or benthos, e.g. coralline algae (Figure 3c).
- Turf mat – Algae that forms a dense mat on the substrate (Figure 3d).
- Erect calcareous – Algae with erect growth form and high level of cellular differentiation containing calcified segments, e.g. *Halimeda* species (Figure 3e).

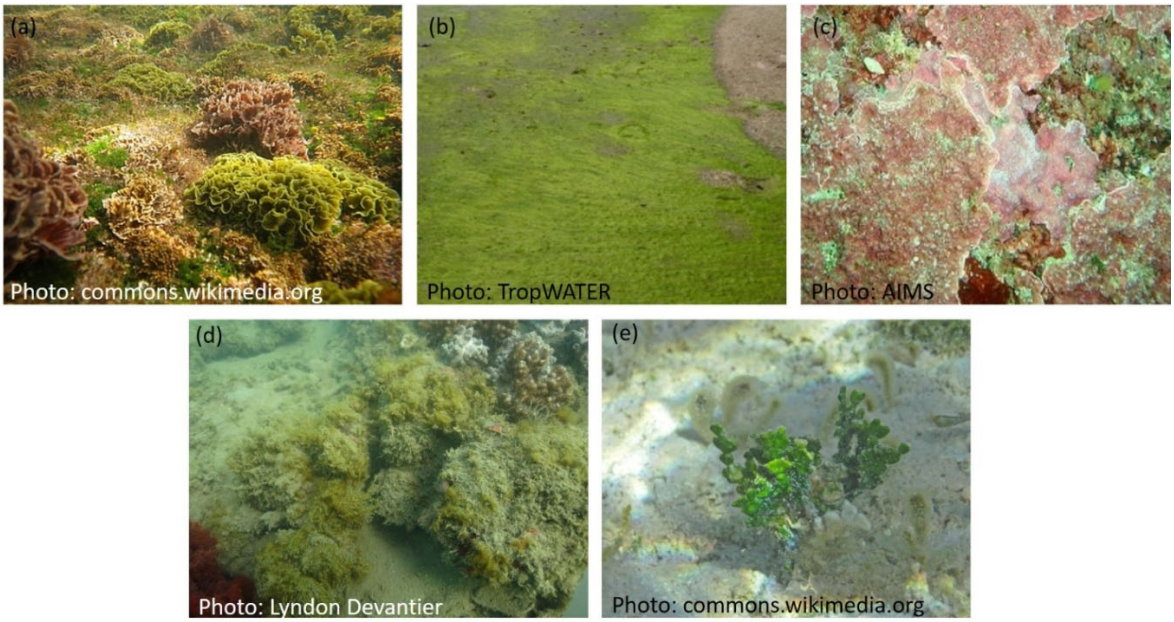

Figure 3. Algae functional groups (a) erect macrophyte, (b) filamentous, (c) encrusting, (d) turf mat and (e) erect calcareous.

2.1.4 Benthic macro-invertebrates

At each site percent cover of benthic macro-invertebrates (BMI) and algae were recorded. Percent cover of benthic macro-invertebrates was divided into four broad taxonomic groups:

- Hard coral – All scleractinian corals including massive, branching, tabular, digitate and mushroom (Figure 4a).
- Soft coral – All alcyonarian corals, i.e. corals lacking a hard limestone skeleton (Figure 4b).
- Sponge (Figure 4c).
- Other BMI – Any other BMI identified, e.g. hydroid, ascidian, barnacle, oyster, and mollusc (Figure 4d). Other BMI are listed in the "comments" column of the GIS site layer.

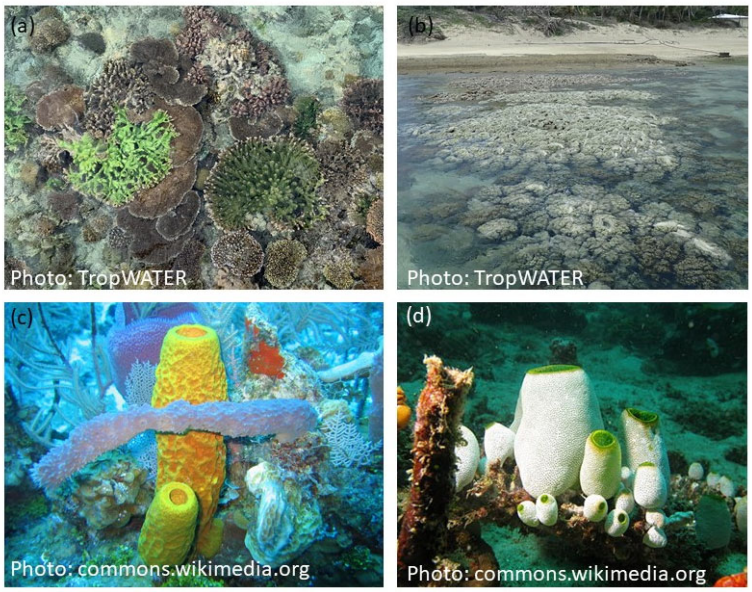

Figure 4. Benthic macro-invertebrates: (a) hard coral, (b) soft coral, (c) sponge and (d) ascidian.

2.2 Geographic Information System (GIS)

Intertidal survey data was entered into a Geographic Information System (GIS) using ArcGIS 10.8. Rectified colour satellite imagery of reefs and islands in the Eastern Cluster (Source: ESRI, Landsat 2020), field notes, and aerial photographs taken during helicopter surveys were used to identify geographical features such as reef tops, channels and deep-water drop-offs, and to assist in determining seagrass meadow boundaries. For each location, three GIS layers were created to describe spatial features of intertidal reef-tops: a site layer (containing all site data outlined in Section 2.1), an intertidal seagrass meadow layer, and a seagrass biomass interpolation layer. All spatial layers are publicly available at eAtlas (eatlas.org.au).

The meadow layer provides seagrass summary information for all sites within the meadow, including species present, meadow community type, meadow density, mean meadow biomass ± standard error (SE), meadow area ± reliability estimate (R), and number of sites. Seagrass meadow (polygon) layers were constructed using seagrass presence/absence site data and meadow boundaries mapped using GPS points recorded while flying along the intertidal meadow edge. Mapping precision estimates (in metres) were based on the mapping method used for that meadow (

Table 1). These estimates were 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
1-20 m	Meadow boundaries mapped in detail by GPS from helicopter Intertidal meadows completely exposed or visible at low tide Relatively high density of mapping and survey sites Recent aerial photography and satellite imagery aided in mapping
20-50 m	Parts of meadow boundary mapped in detail by GPS from helicopter Parts of meadow boundary determined from presence/absence site data and satellite imagery Relatively high density of mapping and survey sites

Intertidal meadow community type was determined according to seagrass species composition within a meadow. Species composition was based on the percent each species' biomass contributed to mean meadow biomass. A standard nomenclature system was used to categorize each meadow (Table 2). This nomenclature also included a measure of meadow density categories (light, moderate, dense) determined by mean biomass of the dominant species within the meadow (Table 3).

An inverse distance weighted (IDW) interpolation was applied to seagrass site data to describe spatial variation in seagrass biomass across each meadow. The interpolation was conducted in ArcMap 10.8.

Table 2. Nomenclature for intertidal 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. Density categories and mean above-ground biomass ranges for each species used in determining intertidal seagrass meadow community density.

	Mean above-ground biomass (g DW m^{-2})			
Density	*H. uninervis* (thin)	*H. ovalis*	*C. serrulata* *C. rotundata* *T. hemprichii*	*E. acoroides*
Light	< 1	< 1	< 5	< 40
Moderate	1-4	1-5	5-25	40-100
Dense	> 4	> 5	> 25	> 100

3 RESULTS

3.1 Seagrass

Seagrass meadows in the Eastern Cluster were mostly associated with fringing reefs around continental islands, particularly within fish traps, and reefs with vegetated cays. Extensive intertidal meadows were mapped around Erub, Mer, Dauar, Waier and Masig Islands. Patchy reef-top meadows occurred at Maizub Kaur and on the reefs closest to Erub Island (Figure 5). Seagrass was present at 27% of the 924 intertidal sites surveyed (Figure 6).

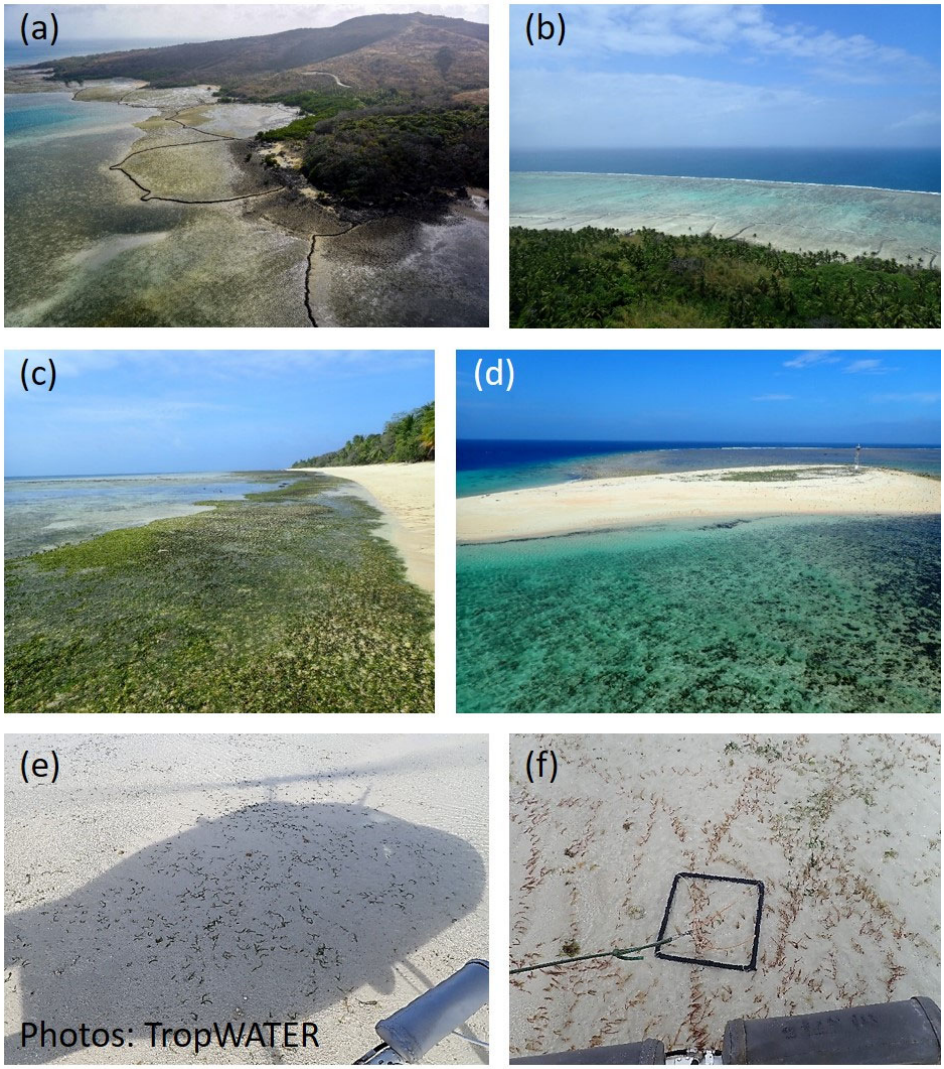

Figure 5. (a) Seagrass in fish traps at Erub Island; (b) Mer Island fringing reef; (c) seagrass meadow at Mer Island; (d) Maizub Kaur had a small meadow on the northern side of the vegetated cay; (e) low biomass reef-top meadow near Erub island; and (f) a typical Masig Island seagrass site.

Figure 6. Seagrass presence and absence at survey sites in the Torres Strait Eastern Cluster, 2020.

Six seagrass species were recorded in the Eastern Cluster (Figure 7) within 2575 ± 323 ha of mapped meadows (Table 4). Meadows were dominated by *T. hemprichii* and/or *C. rotundata* with either light or moderate cover (Figure 8 - Figure 12). Species diversity was greatest at meadows surrounding the largest continental islands of Mer and Erub and the heavily vegetated cay of Masig Island, with up to five species present (Figure 8, Figure 10, Figure 12). *C. serrulata* was only recorded at Masig Island (Figure 12). *E. acoroides* was only recorded along the south-eastern side of Erub Island, and eastern side of Mer Island (Figure 8, Figure 10).

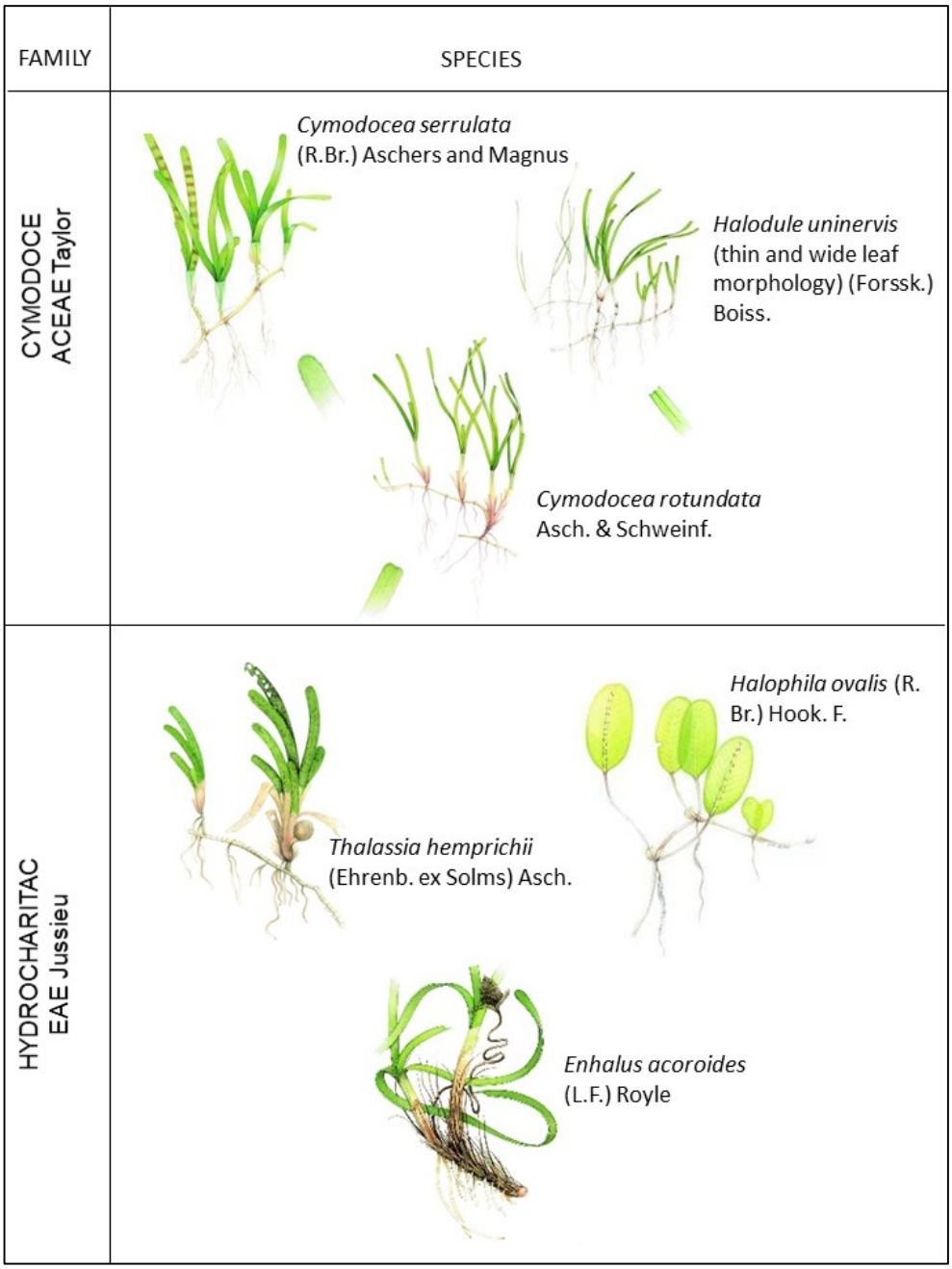

Figure 7. Seagrass species present in Torres Strait's Eastern Cluster.

The largest seagrass meadow mapped was at Masig Island which covered most of the intertidal reef-top (meadow M1; 811 ± 31 ha). Large meadows also occurred at Erub Island (meadow 3; 463 ± 106 ha) and nearby Seo Reef (meadow 6; 689 ± 73 ha) and Gednur Reef (meadow 4; 305 ± 51 ha) (Figure 10, Figure 12; Table 4).

High biomass meadows (>15 g DW m^{-2}) included the *T. hemprichii* dominated meadows at Mer Island (meadow 12) and around Dauar and Waier Islands (meadows 17, 20, 21). These meadows had consistent high biomass throughout the meadow (Figure 13; Table 4). Biomass hotspots were present closest to land on Erub Island, but biomass decreased with distance from shore (Figure 15). Biomass was uniformly low on reef-tops further from land (Figure 14 - Figure 16), while Masig Island was characterised by patchy biomass across the meadow (Figure 17).

Table 4. Eastern Cluster intertidal seagrass meadows including meadow density, community type, area, and mean biomass (g DW m^{-2} ± standard error (SE). Meadow identification (ID) numbers feature on Figure 8 - Figure 12). Biomass SE included where the number of sites in a meadow is >1. M1, Masig Island meadow. See Tables 2 and 3 for meadow density and community type definitions.

Meadow ID	Meadow Density	Meadow Community Type	Area (ha ± R)	Biomass (mean ± SE)
1	Light	*C. rotundata* with *T. hemprichii*	3 ± 2	4.46 ± 0.76
2	Light	*T. hemprichii*	18 ± 4	4.82
3	Moderate	*C. rotundata/ T. hemprichii* w mixed species	463 ± 106	7.98 ± 1.07
4	Light	*C. rotundata* with *T. hemprichii*	305 ± 51	4.09 ± 0.67
5	Moderate	*H. ovalis*	0.4 ± 0.1	1.07
6	Moderate	*C. rotundata/ T. hemprichii*	689 ± 73	4.03 ± 1.02
7	Light	*T. hemprichii*	0.7 ± 0.1	3.93
8	Moderate	*T. hemprichii*	19 ± 7	5.18 ± 1.62
9	Light	*T. hemprichii*	41 ± 14	4.68 ± 2.71
10	Light	*C. rotundata*	0.2 ± 0.1	2.43
11	Moderate	*C. rotundata* with mixed species	9 ± 1	8.86 ± 1.58
12	Moderate	*T. hemprichii* with *C. rotundata/ E. acoroides*	161 ± 25	16.39 ± 1.38
13	Moderate	*H. ovalis*	0.007 ± 0.004	1.98
14	Moderate	*T. hemprichii* with *H. uninervis*	0.3 ± 0.05	14.68
15	Moderate	*T. hemprichii* with *C. rotundata*	7 ± 1	13.04 ± 1.87
16	Moderate	*T. hemprichii* with *C. rotundata*	4 ± 1	11.56 ± 4.02
17	Moderate	*T. hemprichii* with *C. rotundata*	9 ± 3	18.00 ± 1.93
18	Moderate	*T. hemprichii* with *C. rotundata*	4 ± 1	9.07 ± 0.9
19	Moderate	*T. hemprichii* with *C. rotundata*	2 ± 1	11.32
20	Moderate	*T. hemprichii* with *C. rotundata*	0.3 ± 0.05	21.29 ± 6.17
21	Moderate	*T. hemprichii* with *C. rotundata*	9 ± 1	16.64 ± 3.08
22	Light	*C. rotundata/ H. ovalis*	1 ± 0.5	4.42 ± 0.43
23	Light	*C. rotundata*	18 ± 1	1.30
M1	Moderate	*T. hemprichii* with mixed species	811 ± 31	8.89 ± 0.88

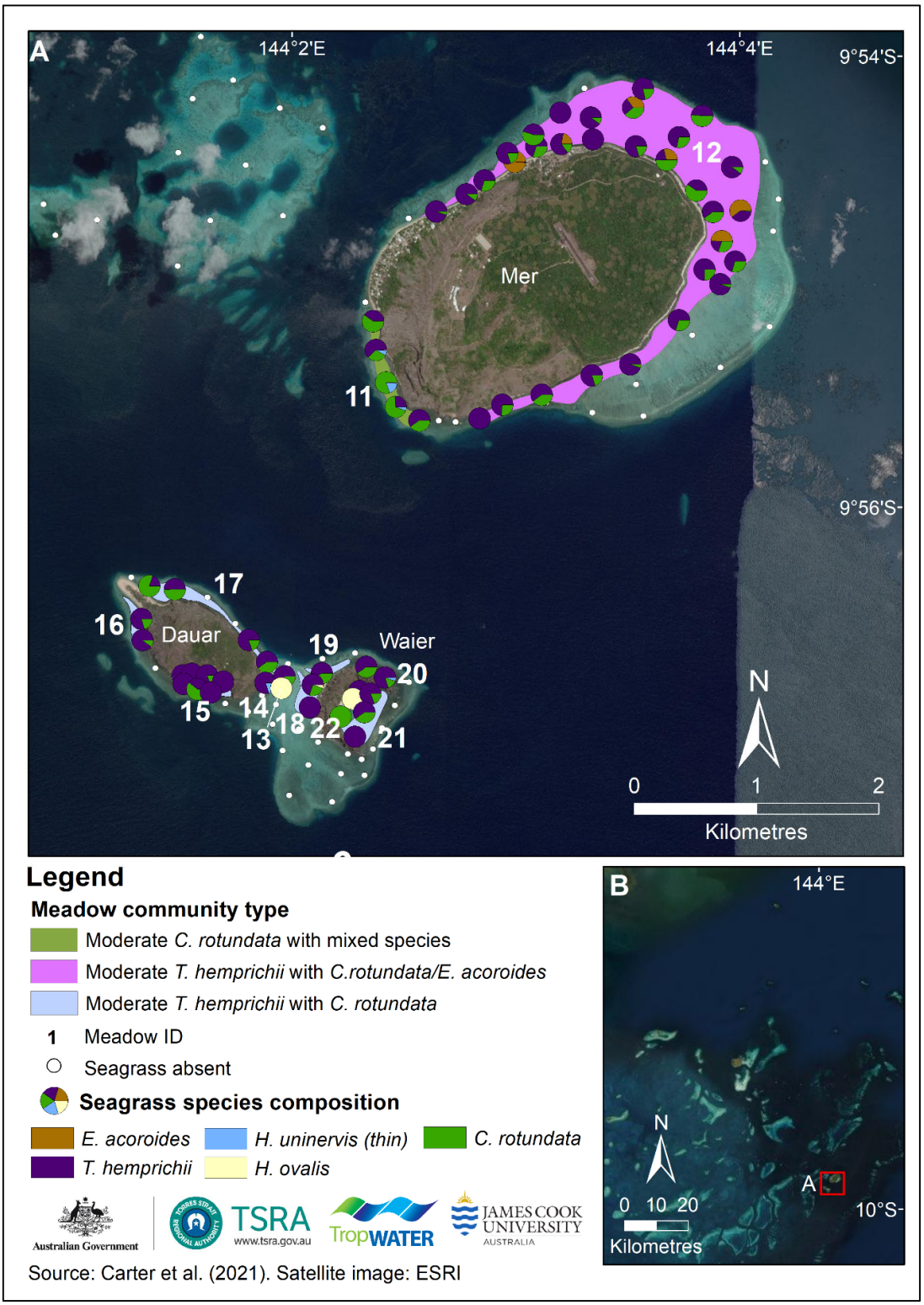

Figure 8. Seagrass meadow community types and variation in seagrass species composition within sites at Mer, Dauar and Waier, Eastern Cluster, 2020.

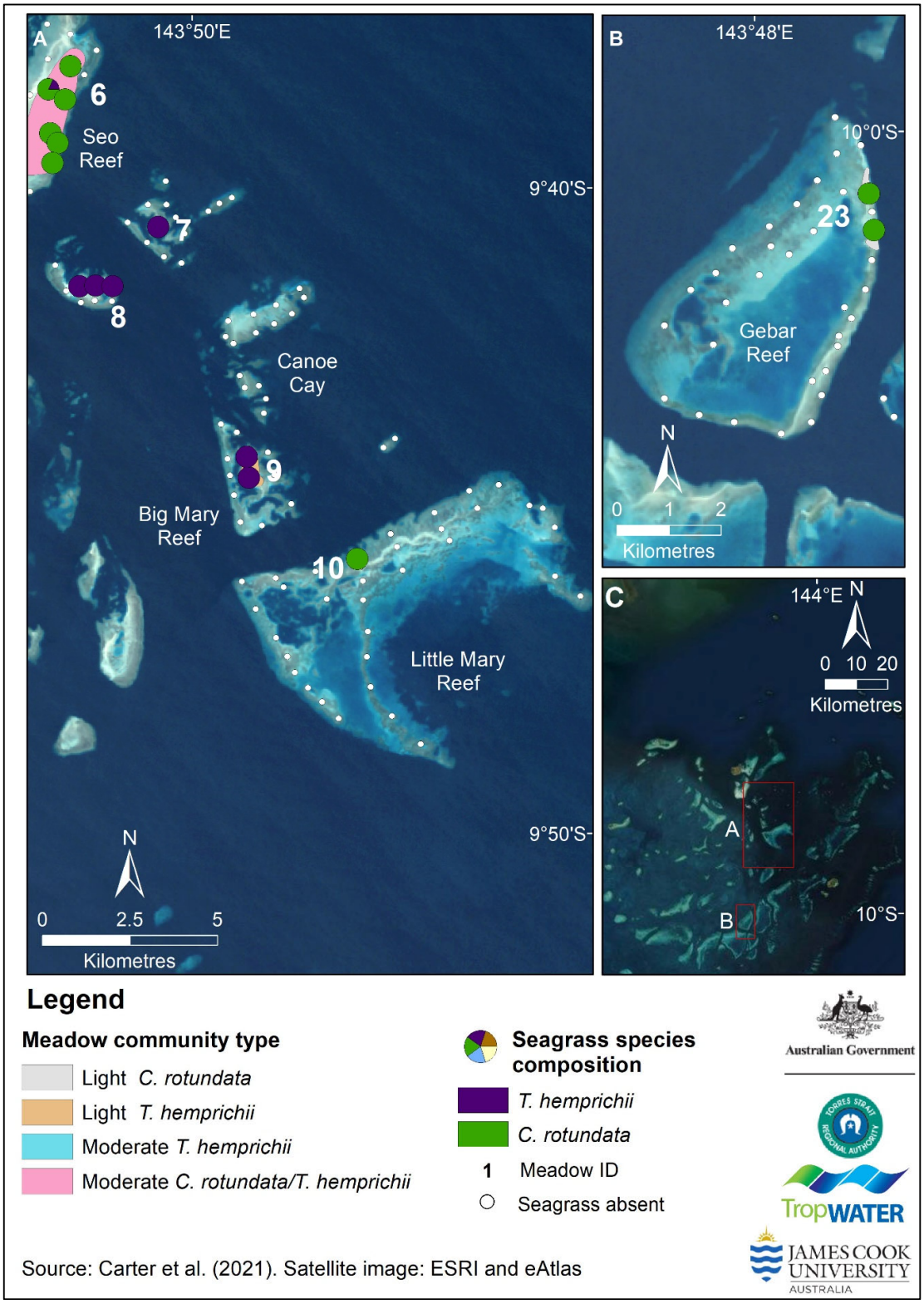

Figure 9. Seagrass meadow community types and variation in seagrass species composition within sites at Eastern Cluster reefs, 2020.

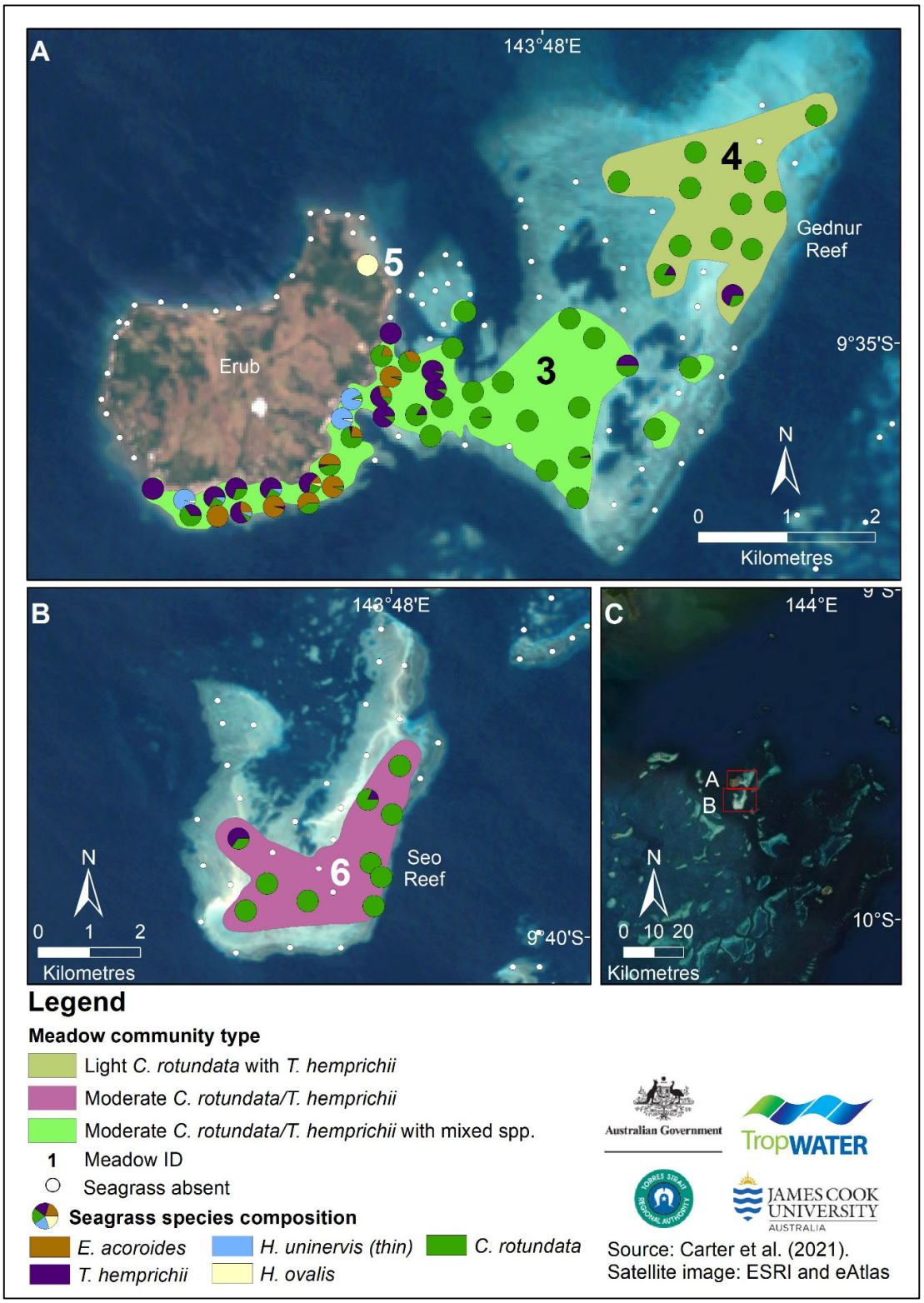

Figure 10. Seagrass meadow community types and variation in seagrass species composition within sites at Erub Island and Gednur and Seo Reefs, Eastern Cluster, 2020.

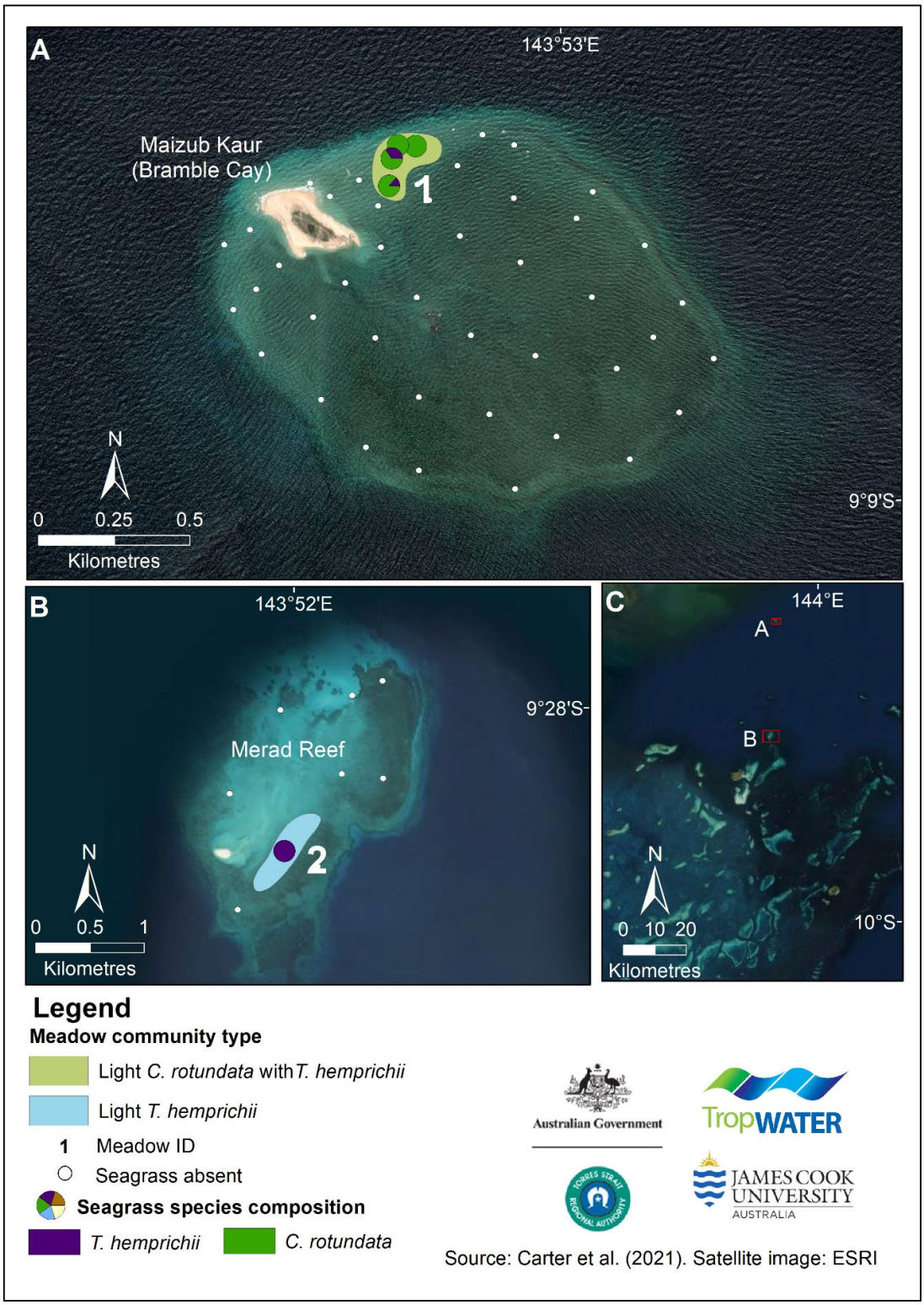

Figure 11. Seagrass meadow community types and variation in seagrass species composition within sites at Maizub Kaur and Merad Reef, Eastern Cluster, 2020.

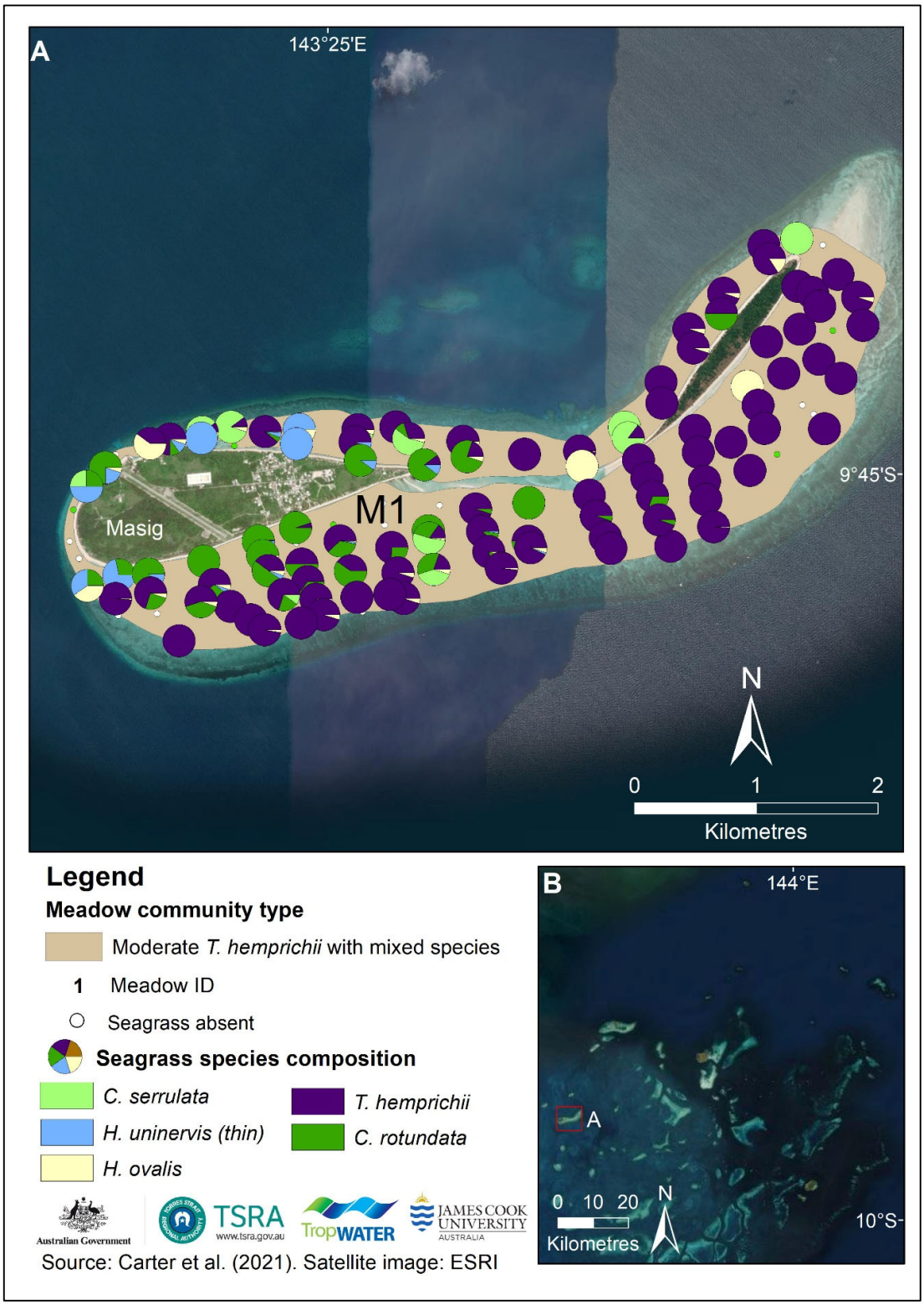

Figure 12. Seagrass meadow community types and variation in seagrass species composition within sites at Masig, Eastern Cluster, 2020.

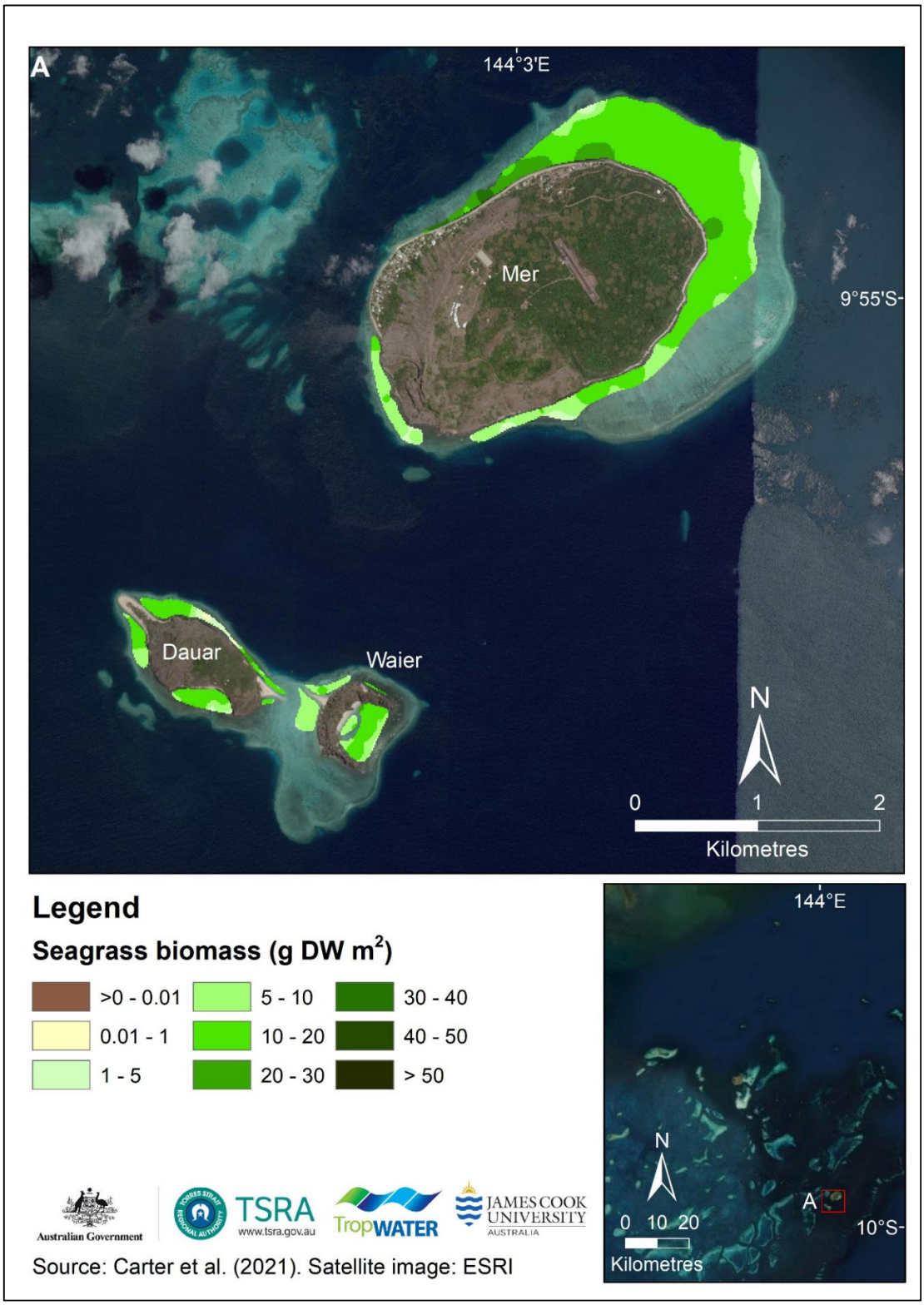

Figure 13. Variation in seagrass biomass at Mer, Dauar and Waier, Eastern Cluster, 2020.

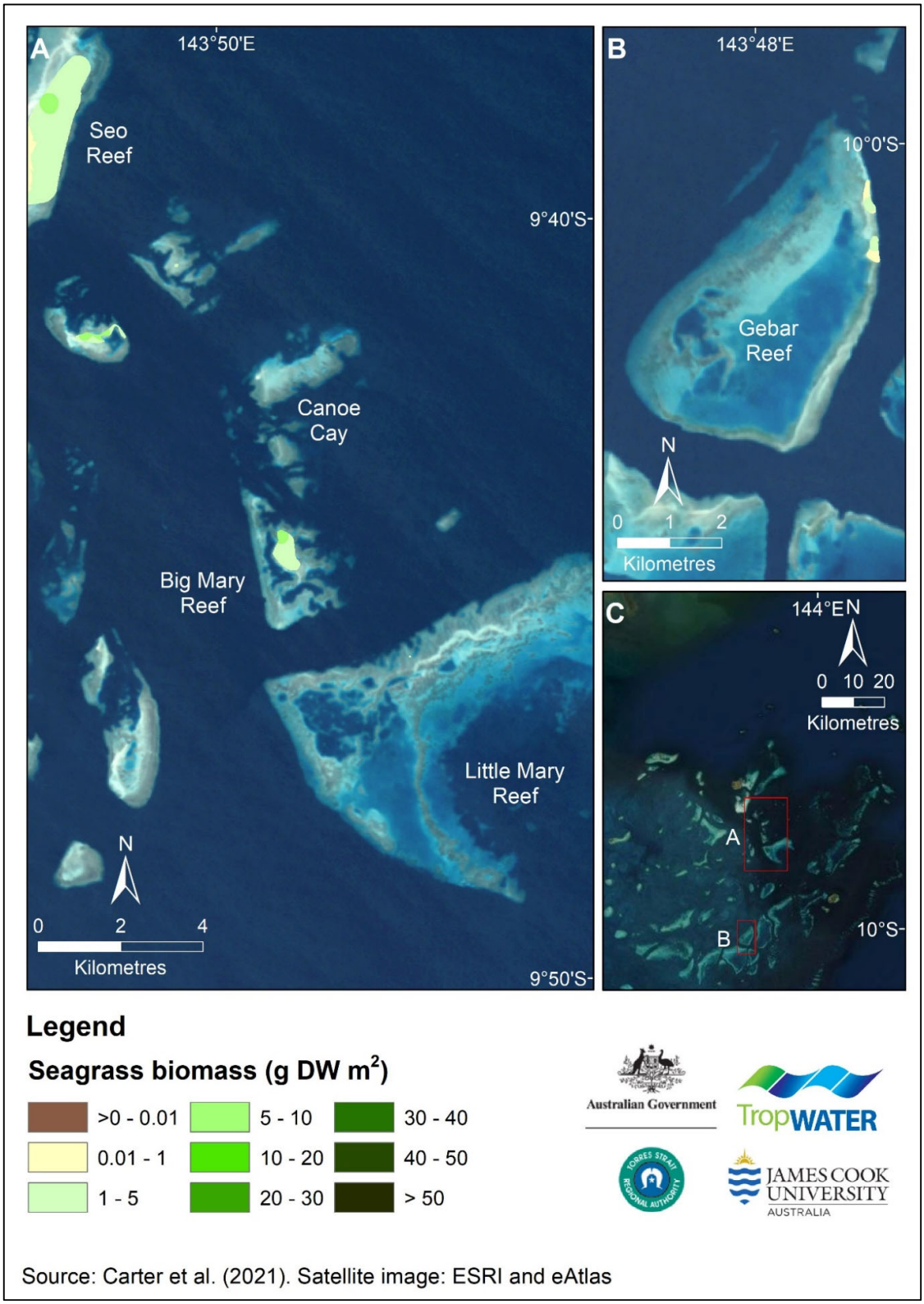

Figure 14. Variation in seagrass biomass at Eastern Cluster reefs, 2020.

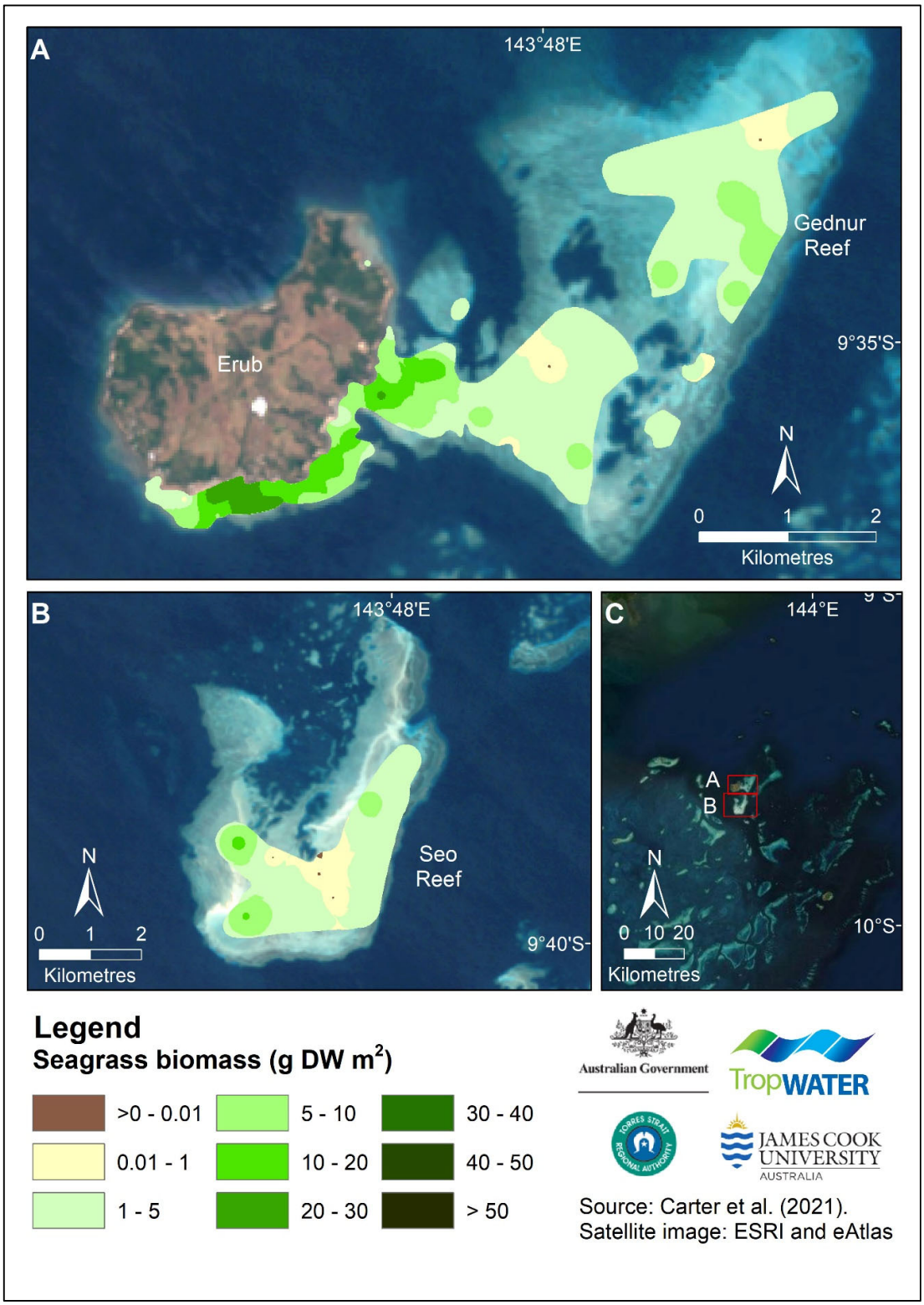

Figure 15. Variation in seagrass biomass at Erub Island and Gednur and Seo Reefs, Eastern Cluster, 2020.

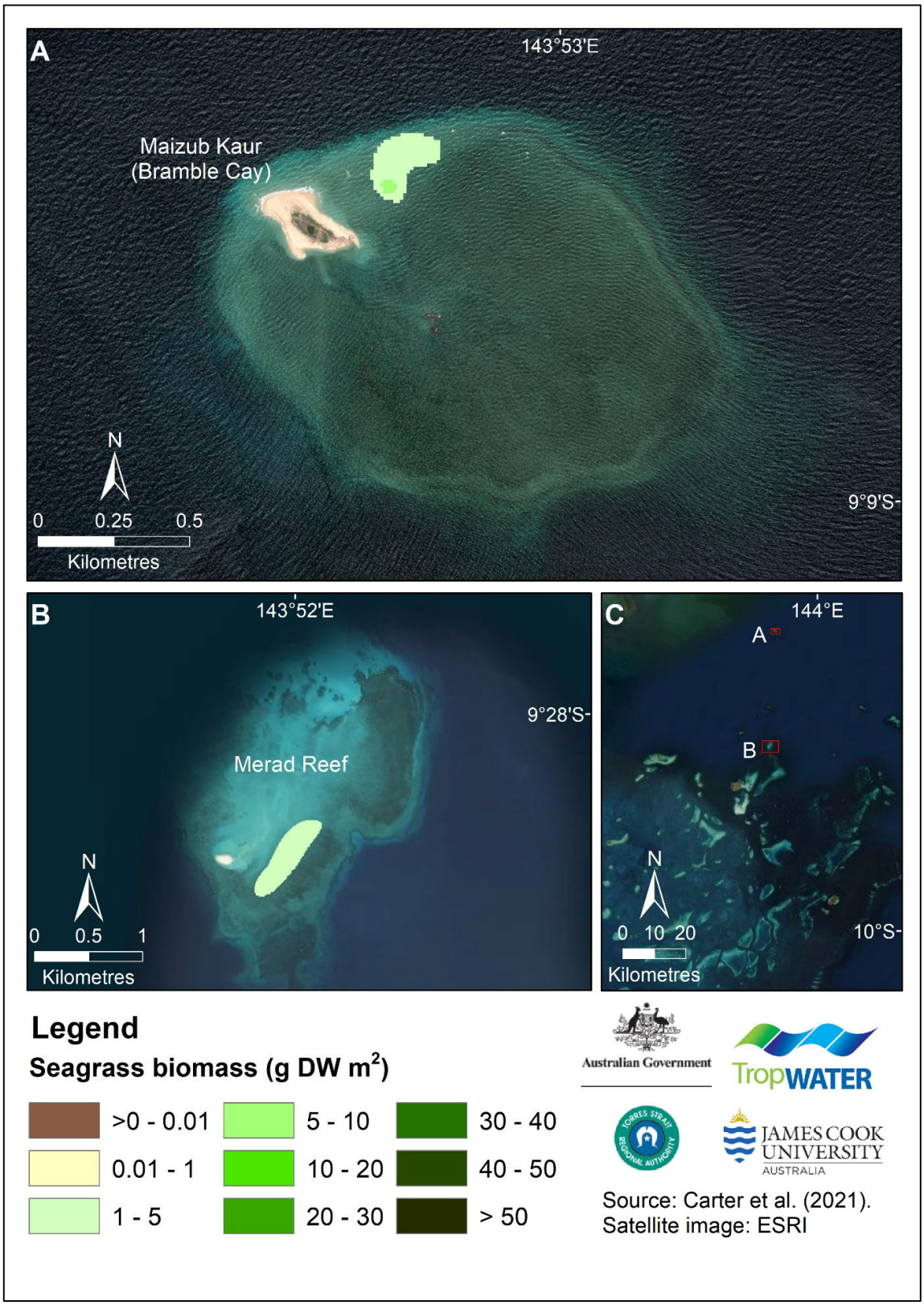

Figure 16. Variation in seagrass biomass at Maizub Kaur and Merad Reef, Eastern Cluster, 2020.

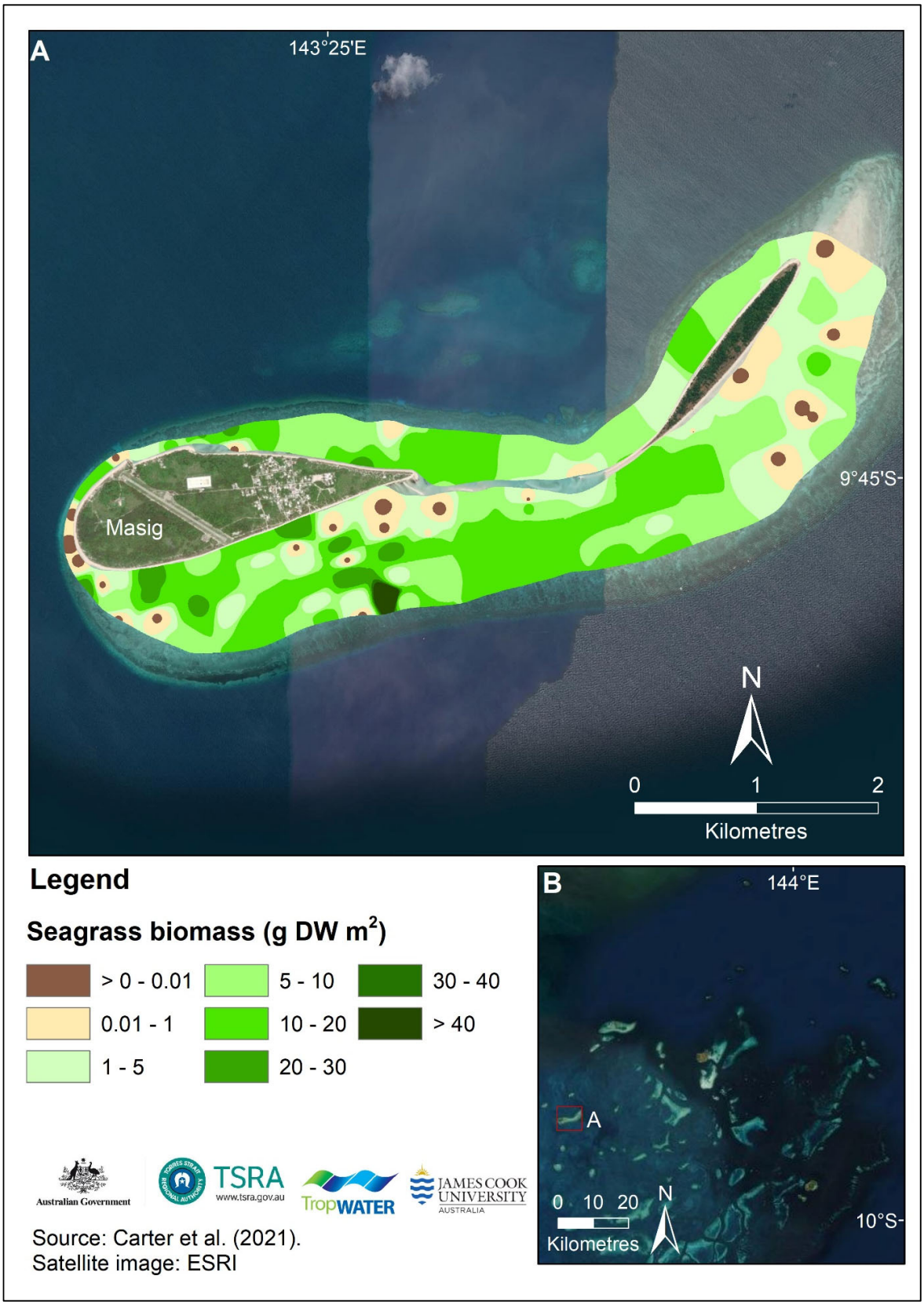

Figure 17. Variation in seagrass biomass at Masig, Eastern Cluster, 2020.

3.2 Algae

Algae cover on intertidal reef-tops was extensive (Figure 18 - Figure 23). Algae was present at 90% of sites and accounted for up to 90% of benthic cover. Most sites featured a mixture of algal groups. Areas of greatest algae cover were mostly on the windward southern and eastern edges of reefs and islands. These sites were dominated by turf mat algae, often with a combination of erect macrophyte and encrusting algae present. Filamentous and encrusting algae were found along the exposed eastern edges of reefs (Figure 18, Figure 21, Figure 22).

Algae cover at Mer Island was high, particularly on the southern side of the island which was dominated by turf mat algae. The northern side of Mer had relatively lower algal coverage with erect calcareous, erect macrophyte and filamentous algae commonly found at sites (Figure 18). Turf mat algae dominated algal communities on Dauar and Waier Islands, and the reef south of these islands. Algal communities on Mabgor Reef were dominated by encrusting and erect macrophyte communities (Figure 18).

At Erub Island the sheltered northern side was dominated by turf mat algae (Figure 20). Algal communities were almost entirely erect macrophyte on the exposed southern side of Erub Island, between Gednur and Little Mary Reefs (Figure 20), and south to Tobag Reef (Figure 19). Algal communities around Masig Island were dominated by turf mat and erect macrophyte communities, with other algal types rarely featuring in the community mix (Figure 23).

Northern reefs were dominated by erect macrophyte communities (Figure 22). Maizub Kaur's algal communities transitioned from turf mat dominated on the eastern side of the reef to erect macrophyte communities on the western side close to the cay (Figure 22). Large numbers of small green turtles were observed on the eastern side of Maizub Kaur's reef-top.

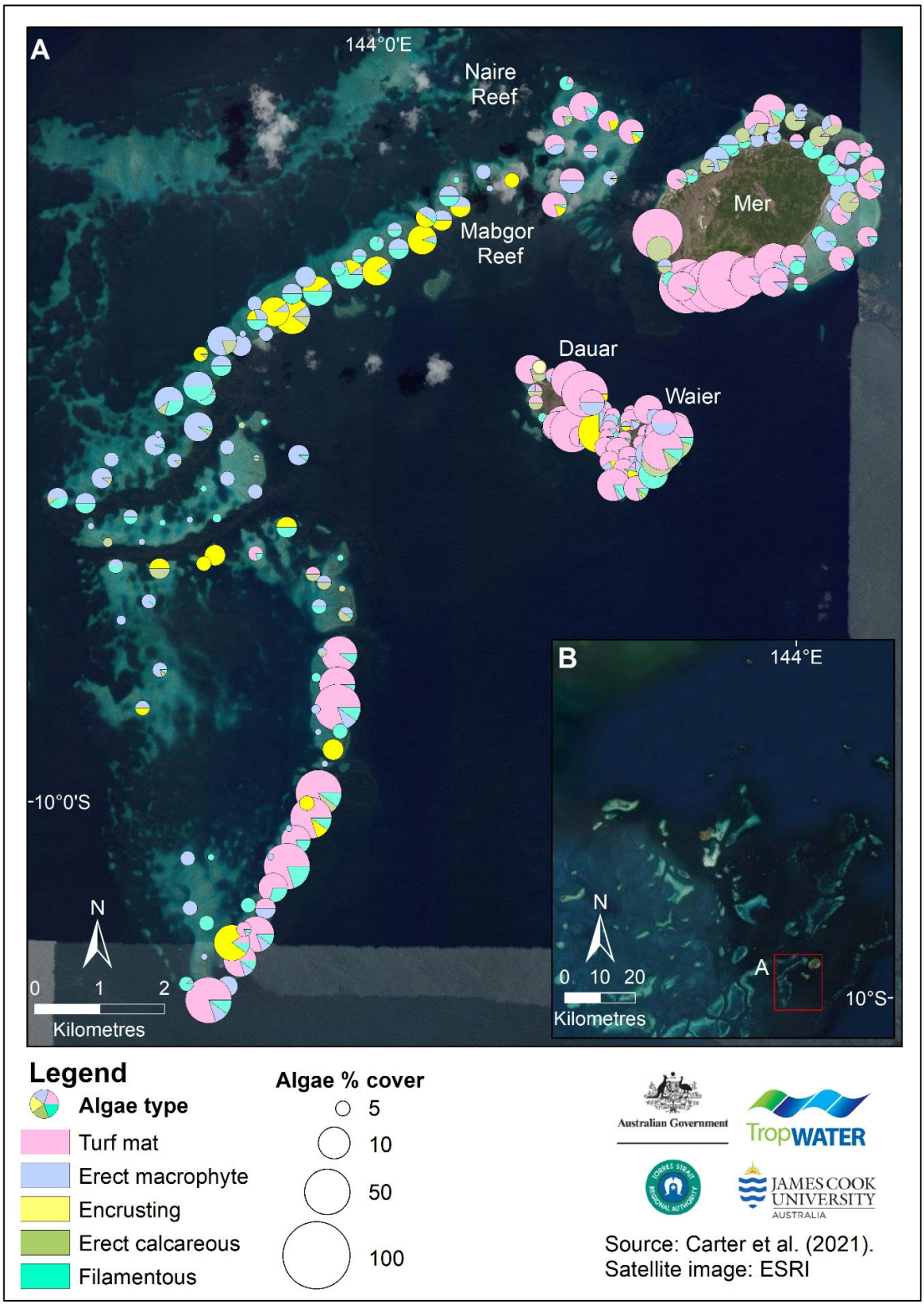

Figure 18. Distribution of algae percent cover and algae type at Mer and surrounding reefs, Eastern Cluster, 2020.

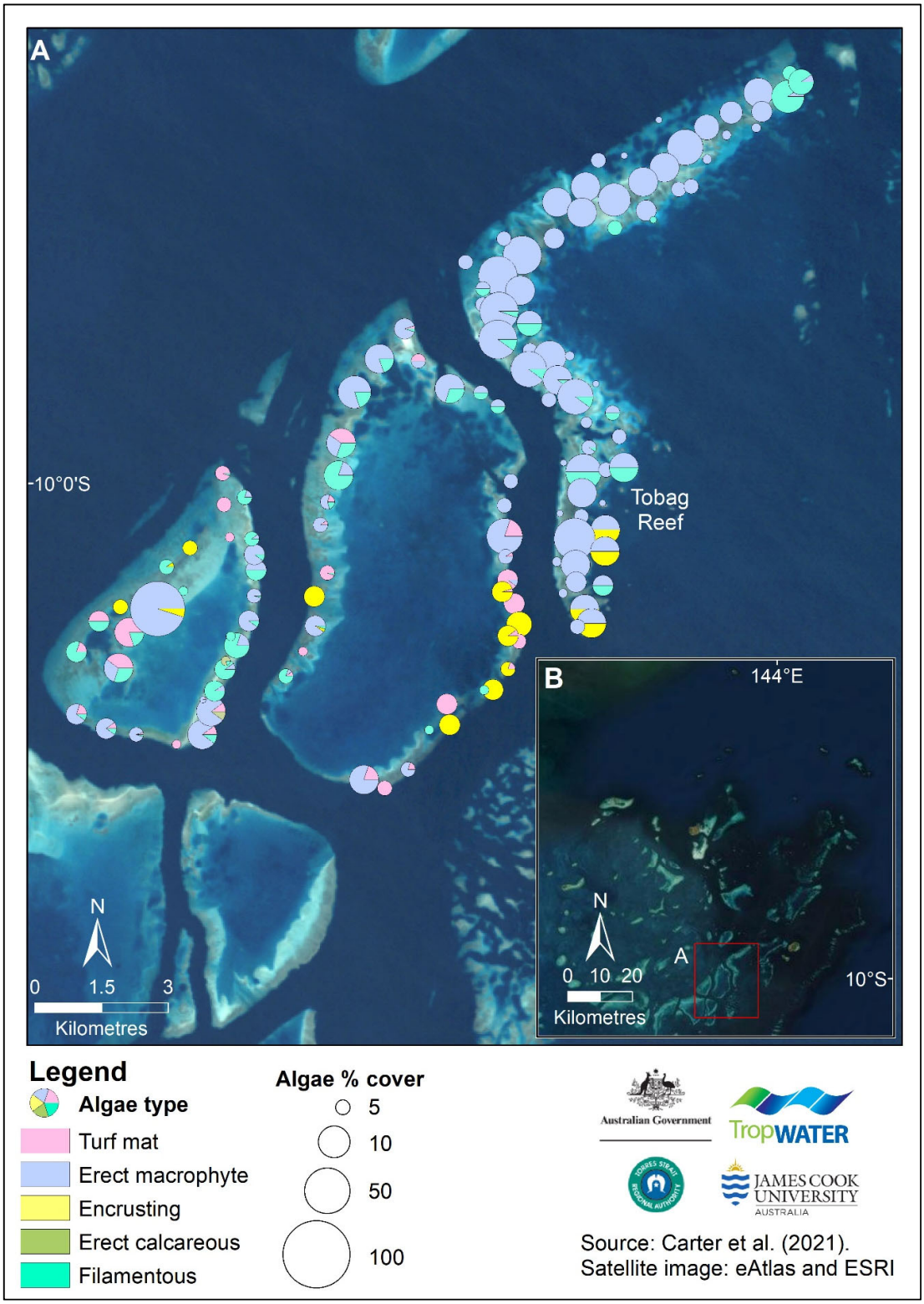

Figure 19. Distribution of algae percent cover and algae type at southern reefs, Eastern Cluster, 2020.

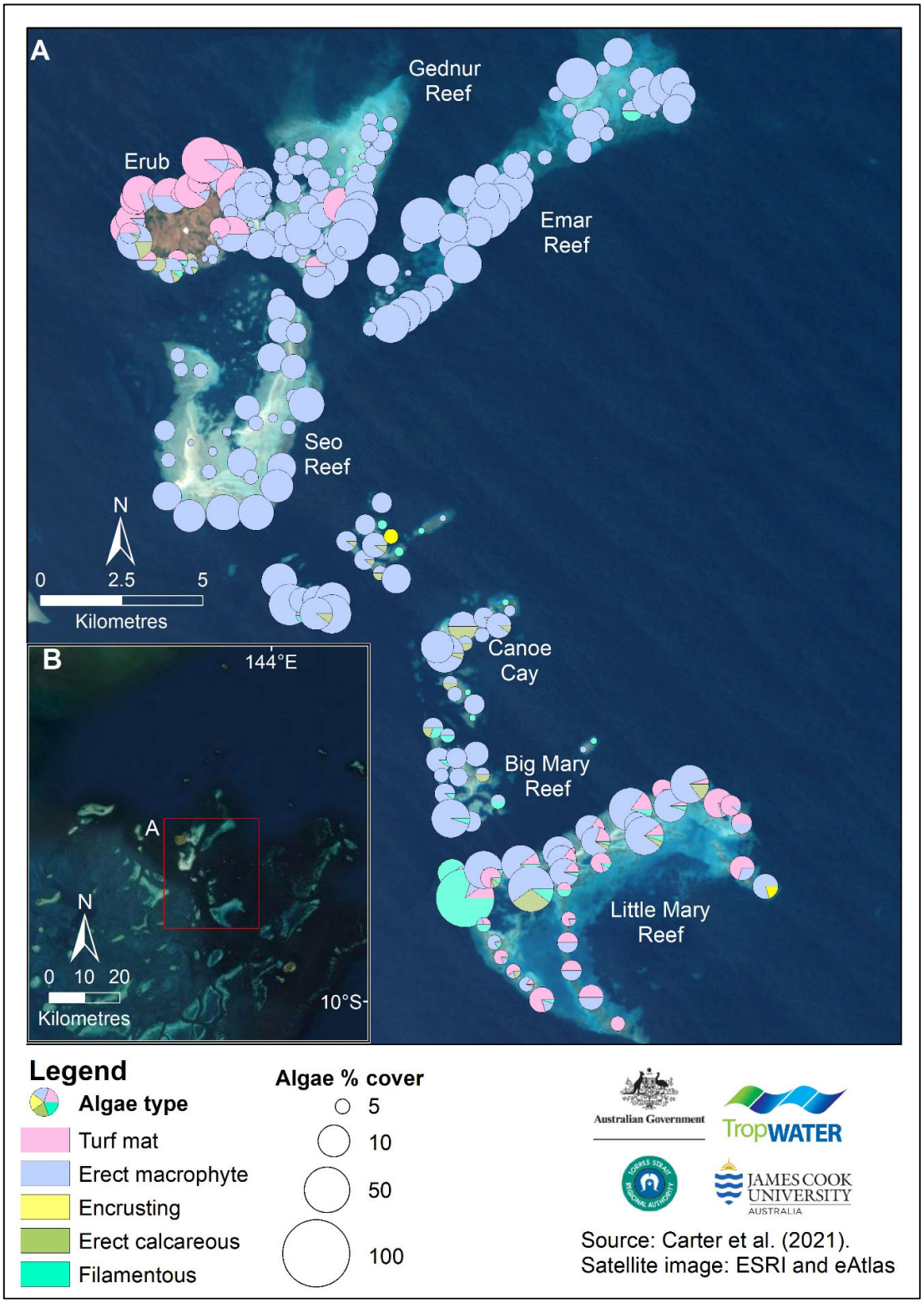

Figure 20. Distribution of algae percent cover and algae type at Erub and surrounding reefs, Eastern Cluster, 2020.

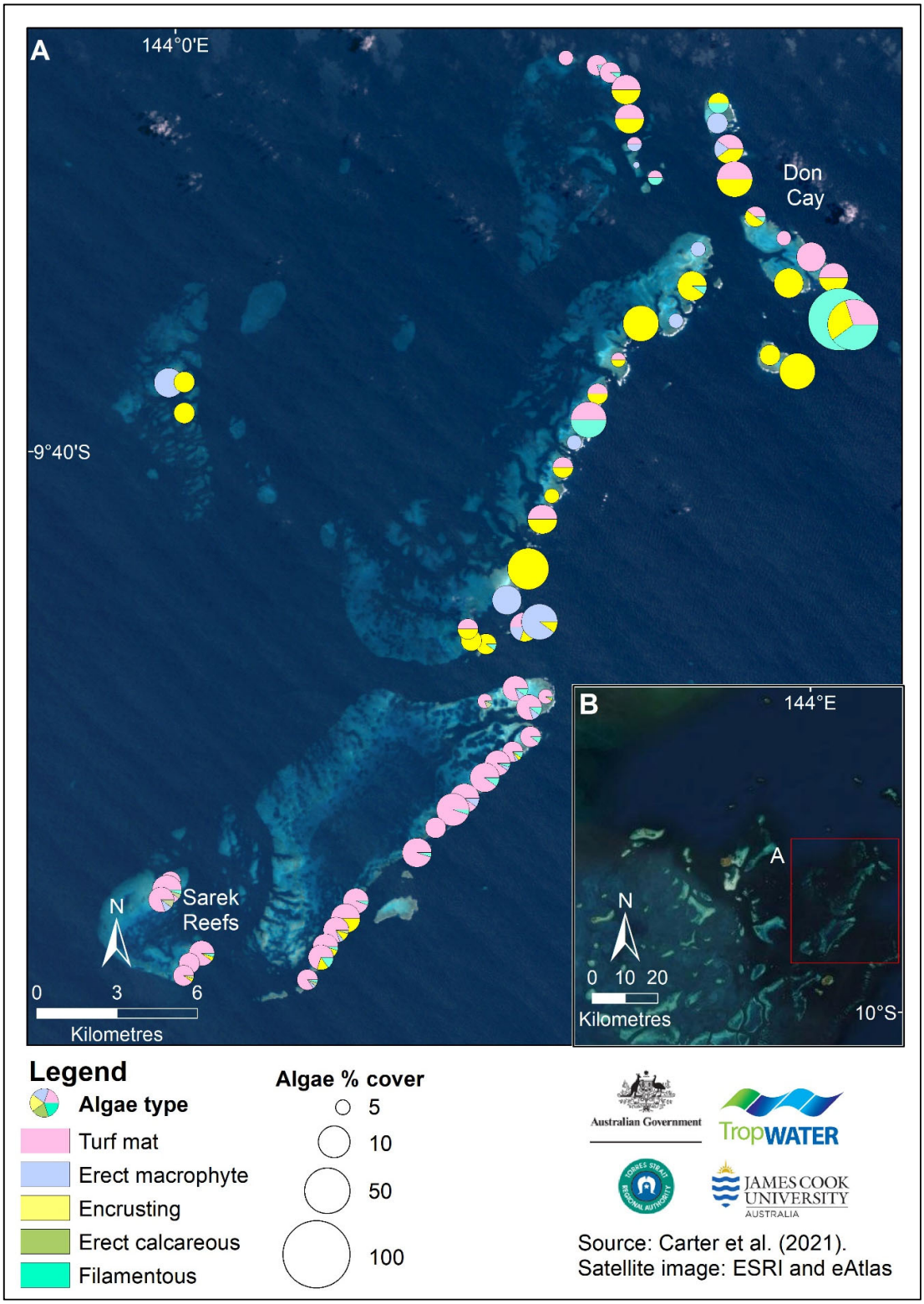

Figure 21. Distribution of algae percent cover and algae type at Don Cay and surrounding reefs, Eastern Cluster, 2020.

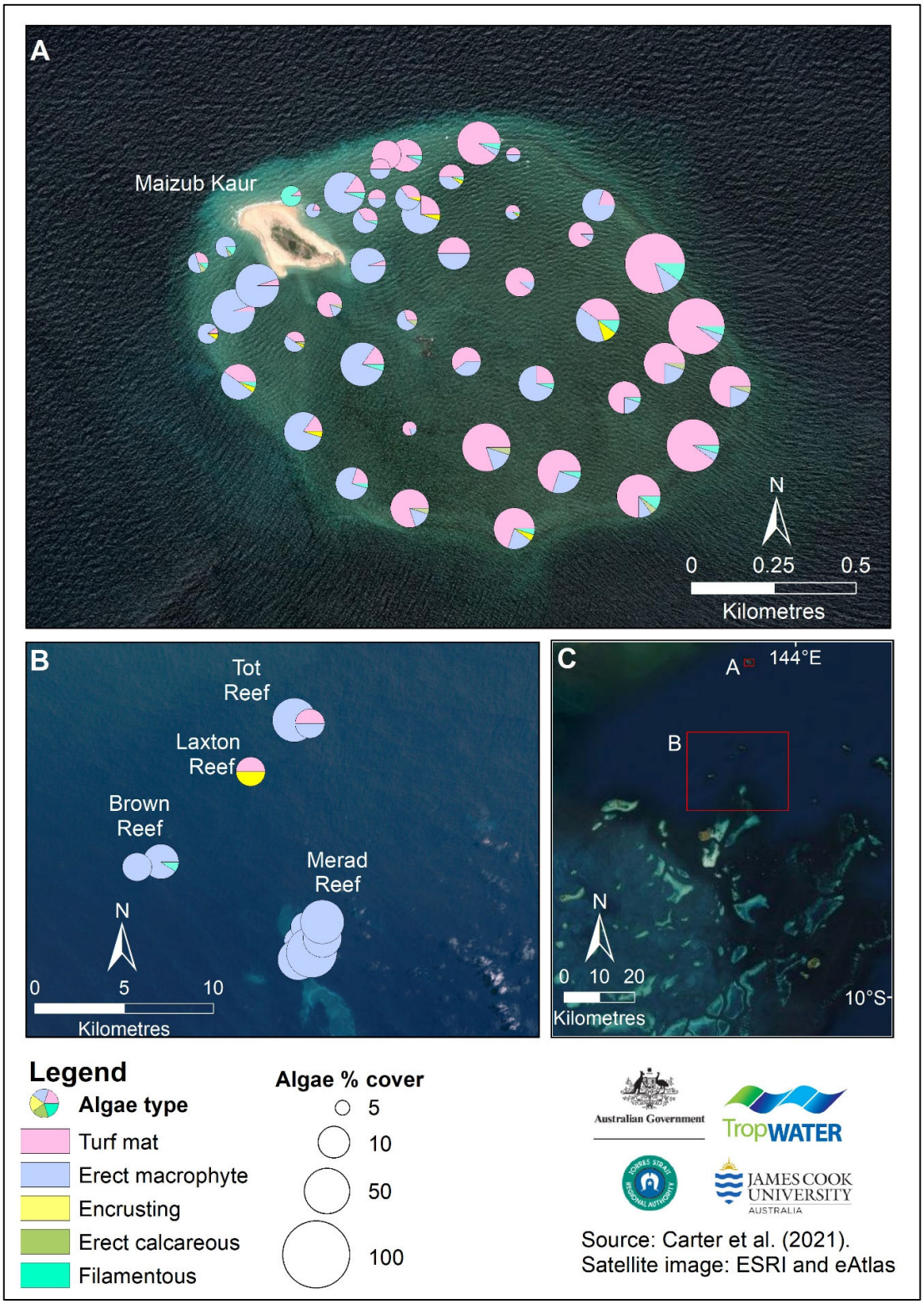

Figure 22. Distribution of algae percent cover and algae type at Maizub Kaur and northern reefs, Eastern Cluster, 2020.

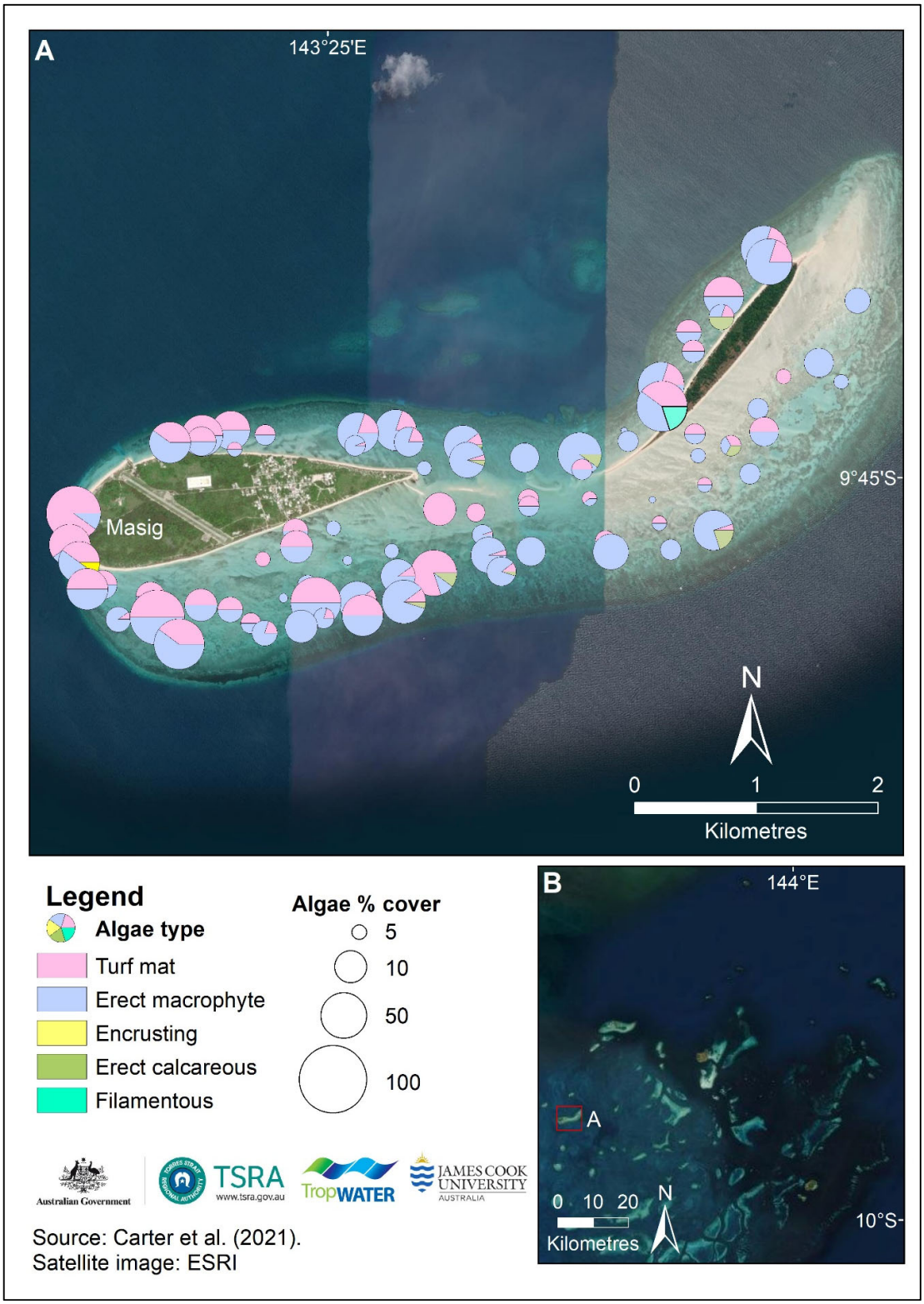

Figure 23. Distribution of algae percent cover and algae type at Masig, Eastern Cluster, 2020.

3.3 Benthic macro-invertebrates

Benthic macro-invertebrate cover was primarily hard coral (up to 100% cover at a site), soft coral (up to 100% cover), sponges (up to 5% cover), and clams and ascidians (up to 5% cover, classed as "other BMI") (Figure 25 - Figure 30). Healthy coral communities were observed on reefs throughout the survey area, often growing along the intertidal edge of the reef, dominating the reef crest and extending into the subtidal region (Figure 24). Live coral cover was high, with 50 - 100% hard coral cover recorded at 66 sites. Sites with the highest coral cover occurred on reefs that did not fringe islands and cays (Figure 25 - Figure 29). Coral cover was low on the intertidal reef-top around Masig Island. Hard and soft coral occurred along Masig Island's southern reef edge but did not exceed 15% and 5% cover, respectively (Figure 30). Sponges and clams mostly occurred along the northern reef edge of Masig Island (Figure 30), the northern side of Mer and Dauar Islands (Figure 25), the southern side of Erub Island (Figure 27), and on Maizub Kaur (Figure 29).

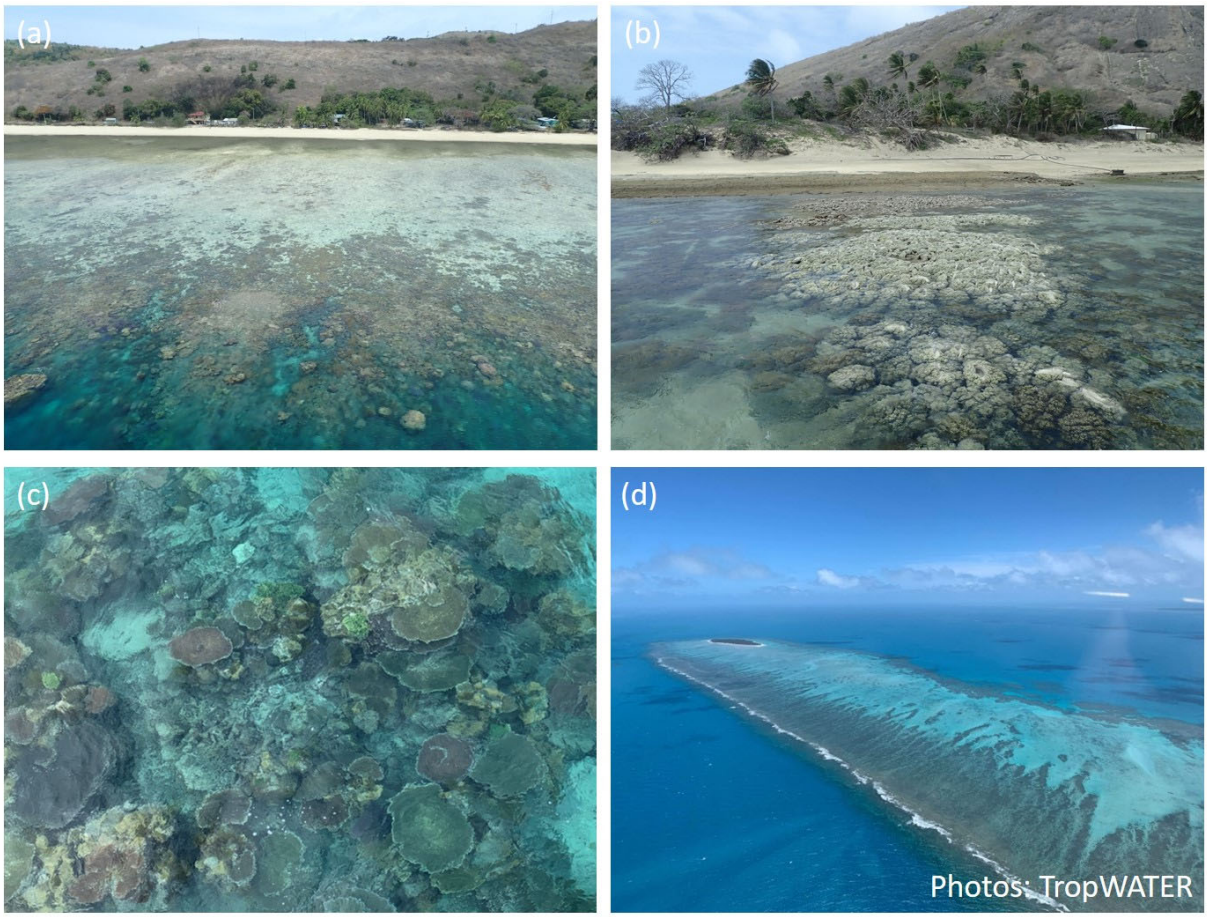

Figure 24. (a) Hard coral at Mer Island, (b) soft coral at Mer Island, (c) live coral cover was high on reef tops, (d) Eastern Cluster reef.

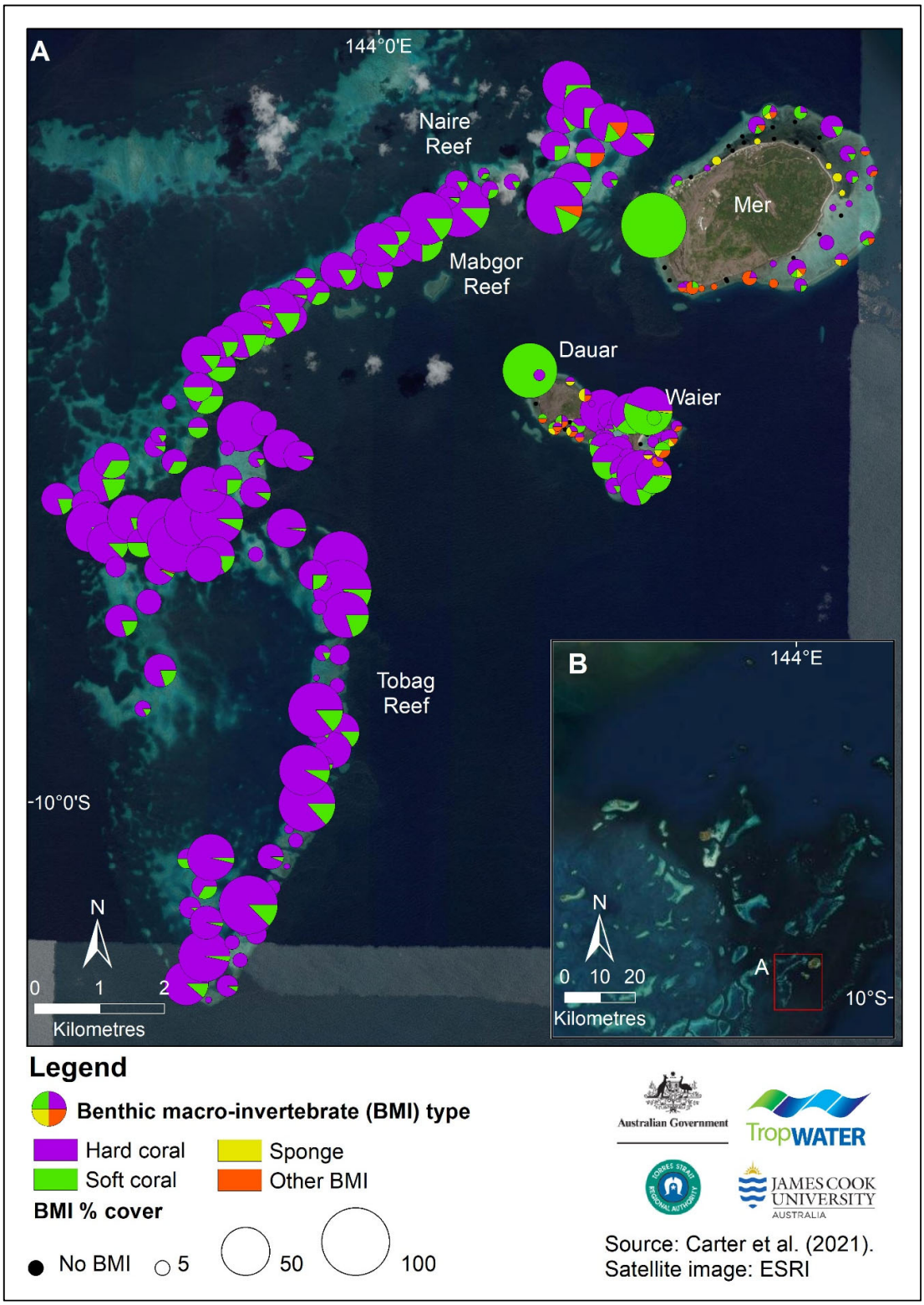

Figure 25. Benthic macro-invertebrate distribution and cover at Mer and surrounding reefs, Eastern Cluster, 2020.

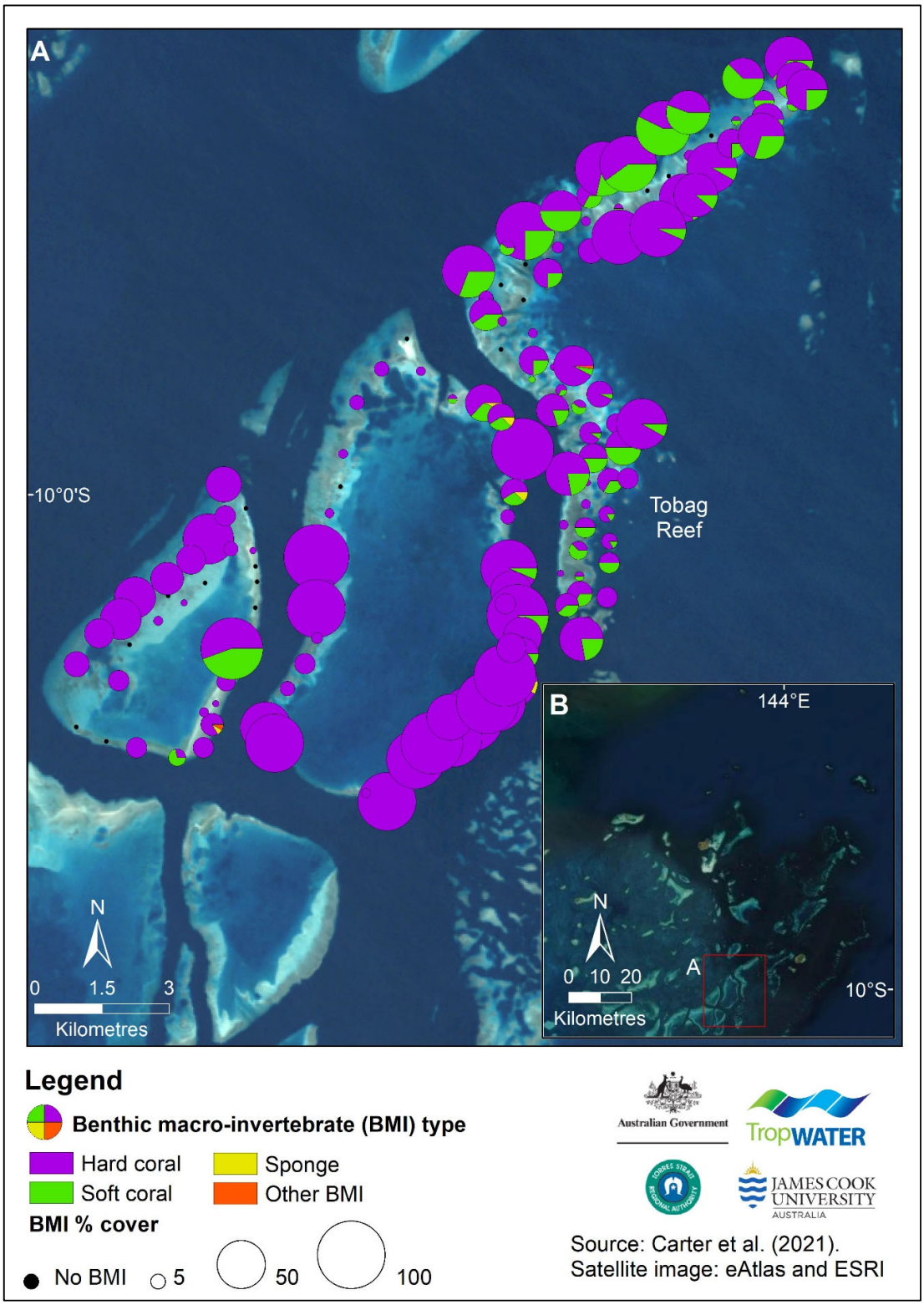

Figure 26. Benthic macro-invertebrate distribution and cover at southern reefs, Eastern Cluster, 2020.

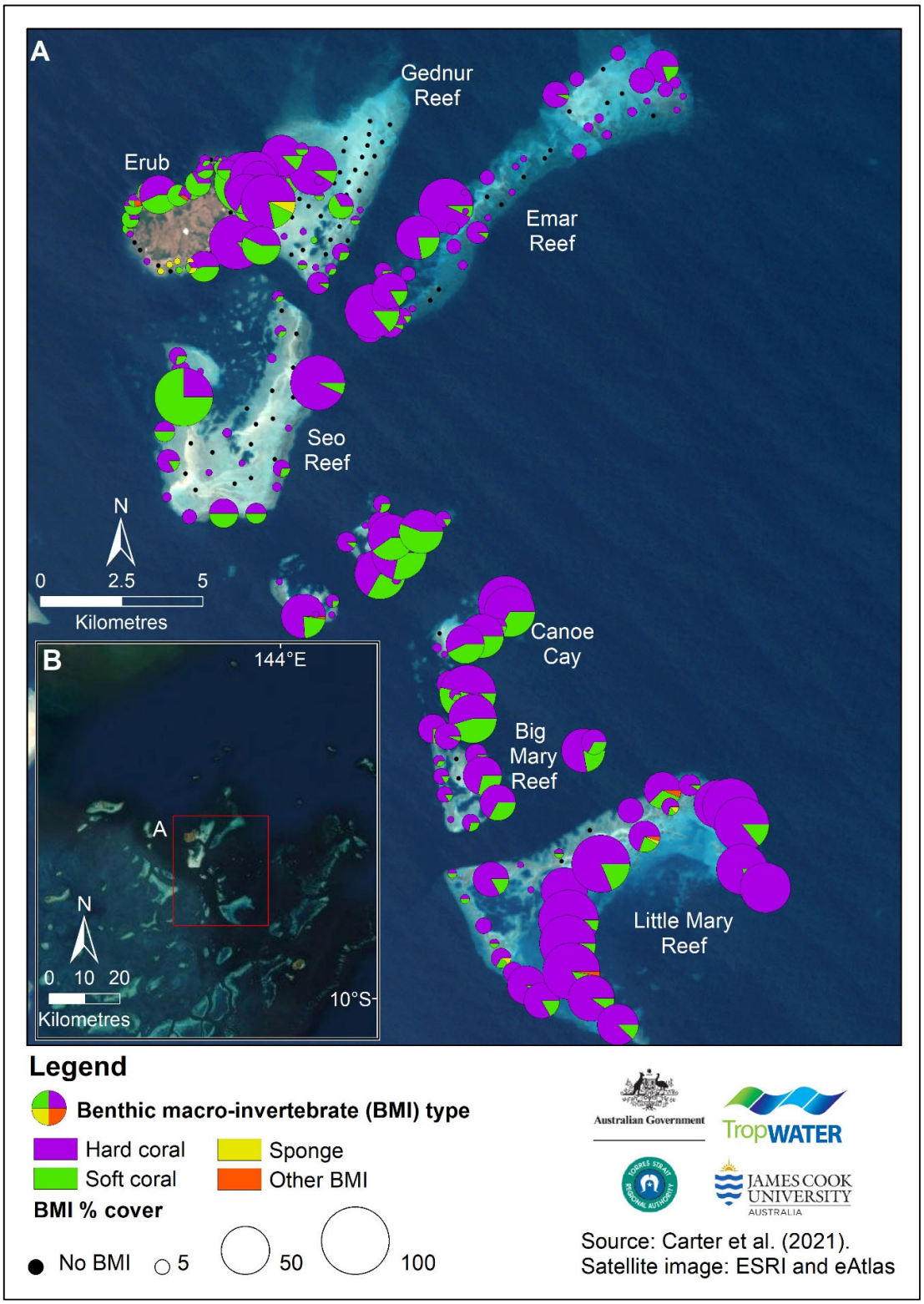

Figure 27. Benthic macro-invertebrate distribution and cover at Erub and surrounding reefs, Eastern Cluster, 2020.

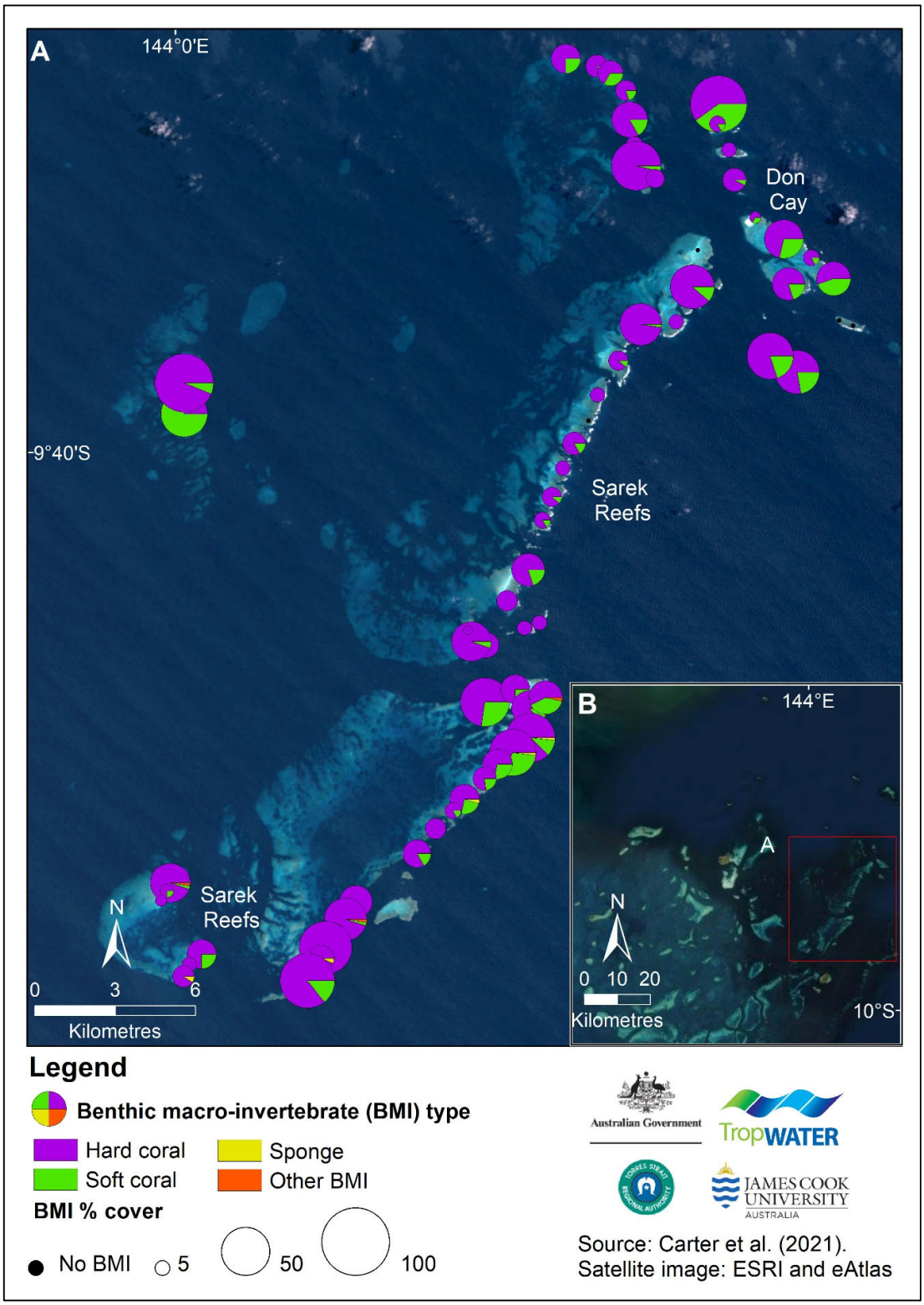

Figure 28. Benthic macro-invertebrate distribution and cover at Don Cay and surrounding reefs, Eastern Cluster, 2020.

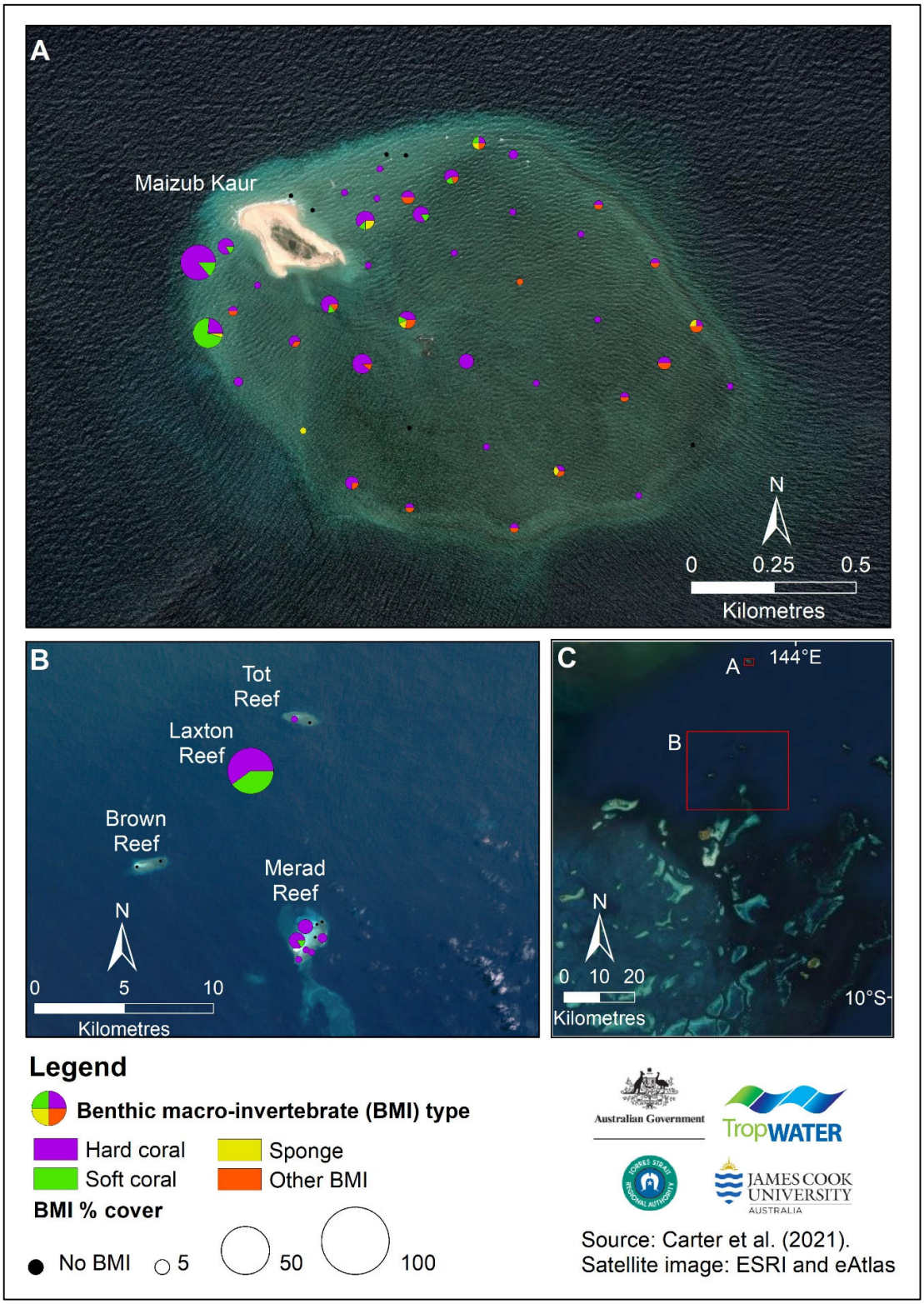

Figure 29. Benthic macro-invertebrate distribution and cover at Maizub Kaur and northern reefs, Eastern Cluster, 2020.

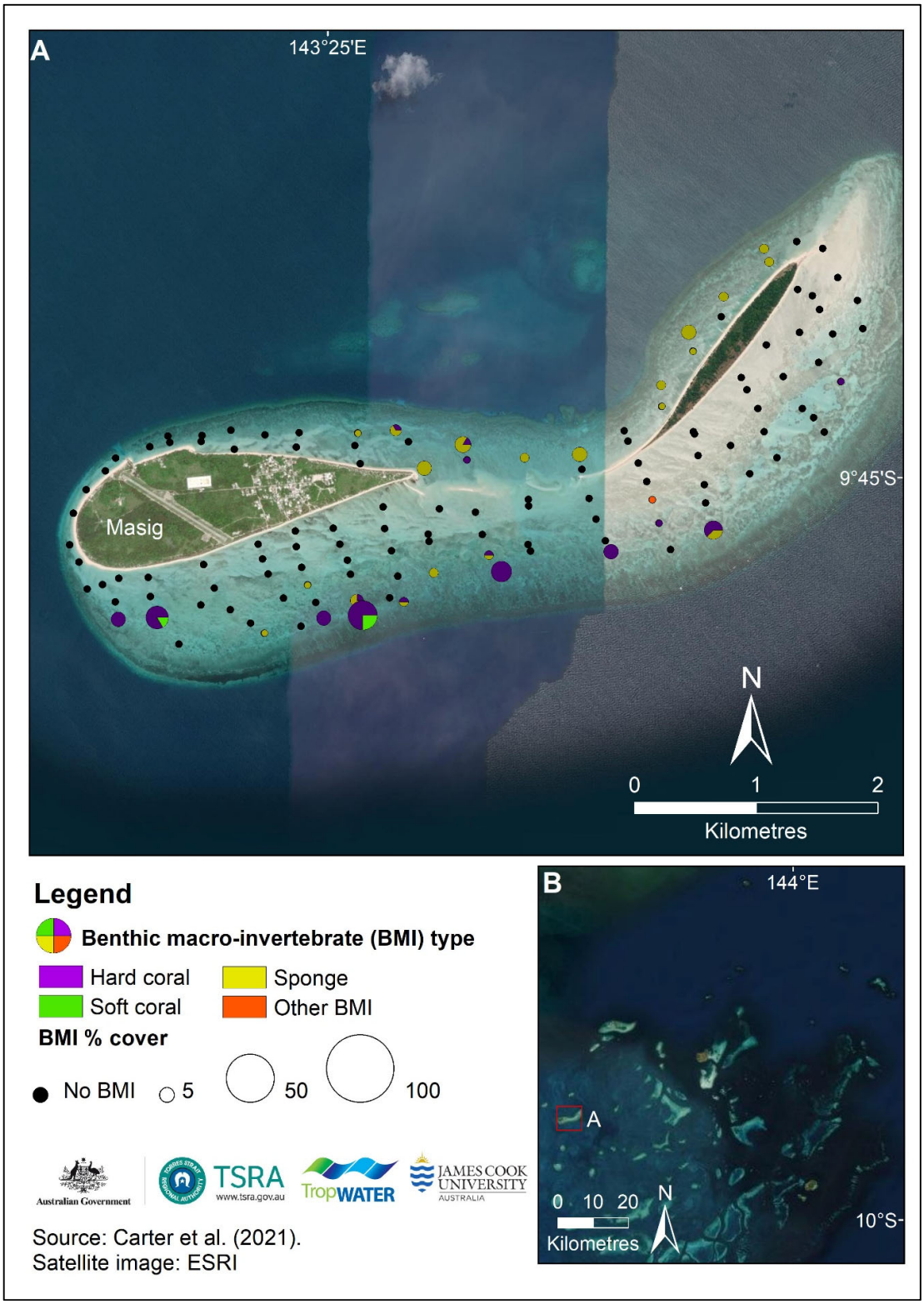

Figure 30. Benthic macro-invertebrate distribution and cover at Masig, Eastern Cluster, 2020.

4 DISCUSSION

4.1 Seagrass meadows of the Eastern Cluster

Large and diverse seagrass meadows grow around the continental islands of Erub, Mer, Dauar and Waier Islands in Torres Strait's Eastern Cluster, and around Masig Island's large vegetated cay in the Central Cluster. Seagrass also was found on the intertidal reef-top adjacent to the vegetated cay at Maizub Kaur and reef-tops adjacent to continental islands, although with much lower species diversity and biomass.

The Eastern Cluster's intertidal seagrass meadows have high ecological importance because they account for the majority of seagrass habitat, with previous benthic surveys finding no subtidal seagrass in this region (Haywood et al. 2008). Seagrass species are mostly constrained to shallow waters due to high light requirements of most species (Carter et al. 2021). Light availability is an important positive driver of seagrass growth and distribution in Torres Strait (Carter et al. 2014a; Taylor et al. 2013) and the Great Barrier Reef (Chartrand et al. 2018; Collier et al. 2018; Collier et al. 2016). Inter-reef waters in the Eastern Cluster are relatively deep, declining to >20 m depth within a short distance from reef and island edges and often reaching >40 m depth (Figure 31). In contrast, extensive subtidal seagrass habitat extends throughout the shallow waters (<20 m) west of the Warrior Reefs (Figure 31) and into the Dugong Sanctuary (Figure 1; Carter et al. 2014b). Subtidal seagrass does not grow beyond the western edge of the Dugong Sanctuary in waters deeper than 30 m (Carter et al. 2014b), and is also sparse in north-west Torres Strait where low light conditions from turbid water along the Papua New Guinea coast limit the light available for seagrass growth even in very shallow water (Figure 31; Carter and Rasheed 2016).

The presence of seagrass close to islands, vegetation and birds suggests nutrient availability is a key factor in the distribution of intertidal seagrass in the Eastern Cluster. Seagrass productivity can be significantly reduced where nutrients are limited (Dennison et al. 1987; Short 1987). Sediment-nutrient interactions in tropical seagrass beds can vary significantly between terrigenous and carbonate sediments, including total carbon, organic carbon, total nitrogen, total phosphorus, exchangeable phosphorus and exchangeable ammonium (Erftemeijer and Middelburg 1993). The presence of seabirds also can significantly enhance seagrass growth and recovery following disturbance due to the nutrients delivered from seabird excrement (Kenworthy et al. 2018; Powell et al. 1989). Maizub Kaur had a large sea bird population on the cay (Figure 5d), which may explain the persistent small meadow immediately north of the cay (Figure 32b). The addition of nutrients, whether through increased terrestrial input of organic matter from islands and cays and/or sea birds, appears to provide suitable growing conditions for seagrass in the Eastern Cluster.

4.2 Comparison with previous seagrass surveys

The 2020 survey marked the first time intertidal seagrass was surveyed for the majority of reefs and islands in the Eastern Cluster. For the handful of reefs and islands that have been previously surveyed, seagrass was in as good or better condition in 2020 (Figure 32). The Masig Island meadow in 2020 (811 $\pm$ 31 ha) had changed little from the 2008 survey (769 $\pm$ 28 ha) and continued to cover the majority of the intertidal reef-top (Table 4; Figure 32). *T. hemprichii* was the dominant species in

both surveys, with smaller contributions of *C. rotundata*, *H. uninervis* and *H. ovalis*. *C. serrulata* was not present in the meadow in 2008 but recorded at several sites in 2020. Meadow biomass was the only significant condition indicator to change over time, with mean meadow biomass double the value in 2020 (8.9 ± 0.9 g DW m^{-2}) than in 2008 (4.3 ± 1.0 g DW m^{-2}).

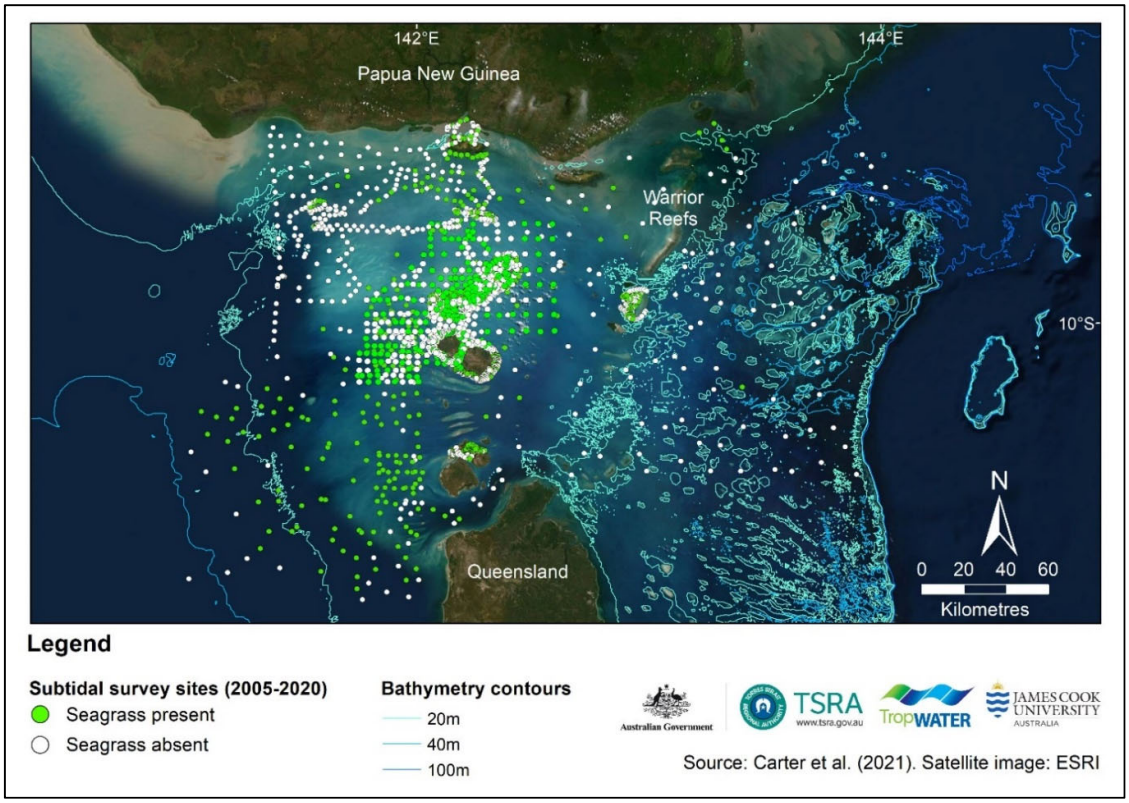

Figure 31. Distribution of subtidal seagrass presence/absence in relation to depth contours across Torres Strait.

The spatial footprint of the small meadow at Maizub Kaur in 2020 also was very similar to the 2009 survey (Meadow 1; Figure 32; Table 4). The Maizub Kaur meadow was in the same location for both surveys (north-east of the cay) and area was similar between surveys - 4.8 ha in 2009 and 3.3 ha in 2020. The most significant difference in the meadow was the transition from a low biomass (<1 g DW m^{-2}) *H. uninervis* meadow in 2009 to a moderate biomass (4.4 ± 0.8 g DW m^{-2}) *C. rotundata* with *T. hemprichii* meadow in 2020.

The condition of seagrass meadows at Erub Island and nearby reefs was generally better in 2020 than during 2009 when smaller, lower biomass and less diverse meadows were mapped (Figure 32). Seagrass coverage at Erub Island's Meadow 3 extended much further across the reef in 2020 than in 2009, accounting for a >200 ha size increase. Mean meadow biomass was very similar between the two surveys - ~8 g DW m^{-2} in 2020 and ~7 g DW m^{-2} in 2009, and the species in the meadow also remained the same among surveys. Meadow 4 at Gednur Reef in 2020 was much larger (305 ha) compared to 2009 (45 ha), and mean biomass also was much greater in 2020 (~4 g DW m^{-2}) compared with <1 g DW m^{-2} in 2009. Meadow 6 at Seo Reef was three times larger in 2020 than in 2013, and biomass was more than double (Figure 32; Table 4). The Gednur and Seo Reef meadows also were more diverse with the addition of *C. rotundata* to the species mix; in earlier surveys only *T. hemprichii* was present.

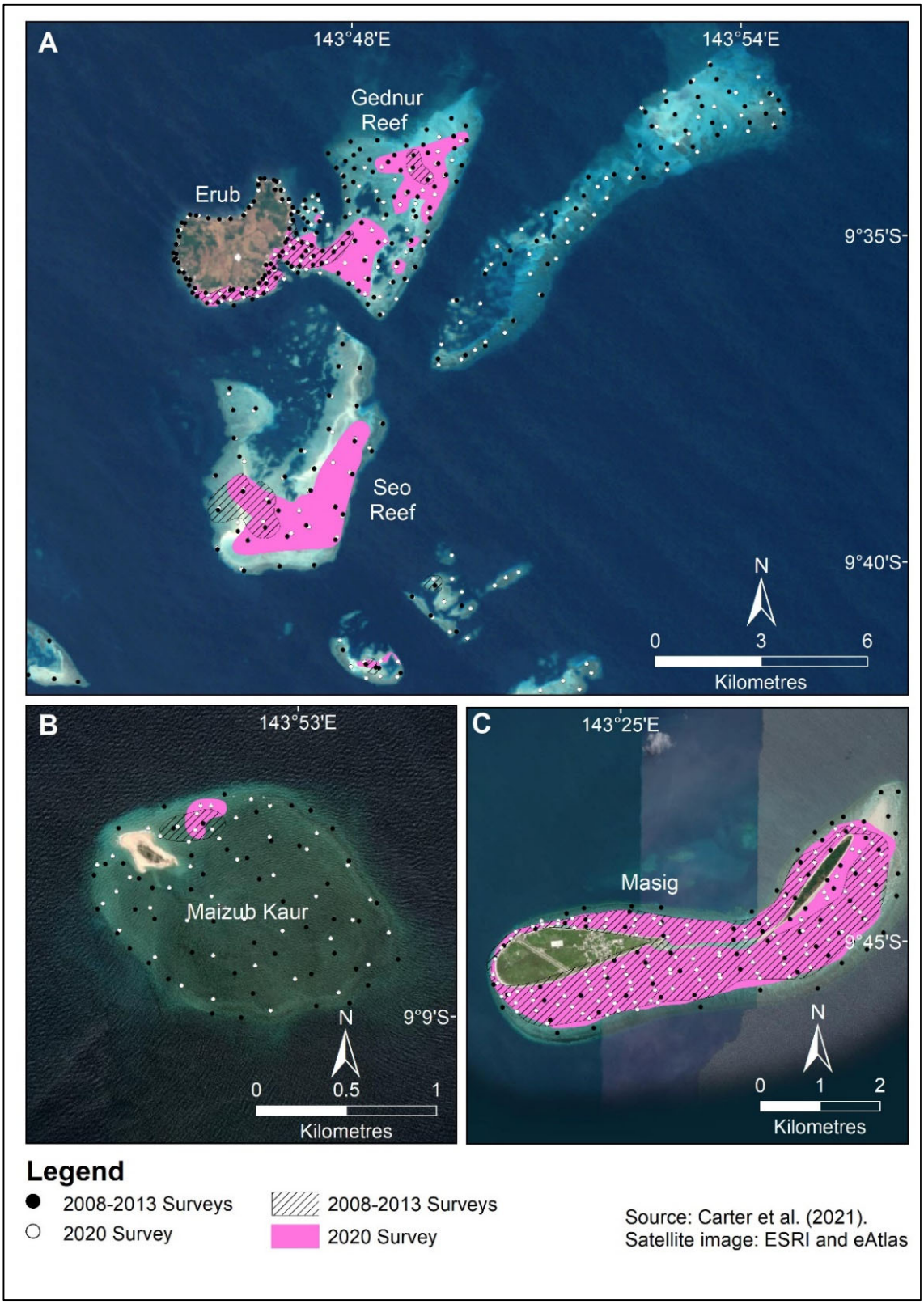

Figure 32. Comparison of intertidal seagrass meadows and site coverage for surveys conducted in 2008-2009 and 2020 at (a) Erub Island and surrounding reefs, (b) Maizub Kaur, and (c) Masig Island.

4.3 Eastern Cluster and Masig Island turtle foraging grounds

The spatial distribution and quality of foraging grounds influences the movement, foraging behaviour and reproduction of green turtle (Limpus and Nicholls 2000). Seagrass species vary in their sensitivity and resilience to impacts and can be classed as colonising, opportunistic, or persistent (Kilminster et al. 2015). Persistent species common in Torres Strait include *T. hemprichii* and *E. acoroides* which form enduring meadows in stable habitats; colonising genera such as *Halophila* tend to be transitory – they are quick to succumb to disturbances but are often the first species to recolonise (Kilminster et al. 2015). The overlap in seagrass distribution and the persistence of *T. hemprichii* as the dominant species in meadows from surveys conducted more than a decade apart indicates Masig Island and the Eastern Cluster's intertidal meadows provide a relatively stable foraging ground for marine herbivores. However, this assumption is based on very limited data. Recent declines in intertidal seagrass at Orman Reefs and Mabuyag Island in the Western Cluster demonstrate meadow condition declines can be rapid and dramatic (Carter et al. 2020). Ongoing monitoring of a selection of these meadows would provide important information on natural variation in seagrass condition indicators (meadow area, biomass, species composition) and a more robust baseline for comparison should a seagrass dieback occur in the Eastern or Central Clusters.

This report provides important habitat information for community-based Dugong and Turtle Management Plans. The 2020 survey area included reefs and islands that incorporate three Dugong and Turtle Management Areas: Erubam Le, which includes Erub Island and Maizub Kaur; Keriba Luzabzab-Lera Dorge, which includes Mer, Dauar and Waier Islands; and Masigalgal, which includes Masig Island. Seagrass also occurs in the Ugaram Dugong and Turtle Management Area which includes Ugar Island (Carter et al. 2014b), but was outside the scope of our survey area. The importance of the Eastern Cluster as the location of important rookeries for the northern Great Barrier Reef (nGBR) green turtle population, e.g. Maizub Kaur and Dauar Island, is well established (4Seas Environmental Consulting 2020). However; little is known about how green turtles use the Eastern Cluster for foraging. Stomach content analysis indicates green turtles consume seagrass and macroalgae in Torres Strait (André et al. 2005), and green turtles are often reef-associated and use the shallow 0-5m zone (Cleguer et al. 2016; Gredzens et al. 2014; Marsh et al. 2011). We mapped ideal foraging grounds in the intertidal seagrass meadows around inhabited islands and macroalgal communities throughout each of the Erubam Le, Keriba Luzabzab-Lera Dorge and Masigalgal Dugong and Turtle Management Areas. How green turtles use these seagrass and macroalgae habitats for foraging should be a priority for future research.

4.4 Recommendations

Effective management and planning requires recent, spatially relevant seagrass information. The 2020 survey of intertidal habitats in the Eastern Cluster and Masig Island provides a baseline against which future seagrass change and green turtle movement can be assessed. The addition of long-term meadow-scale monitoring would provide important information on annual variation in reef-associated meadows in this important region of Torres Strait. Seagrass meadows that grow around the inhabited islands of Erub, Mer and Masig are ideal for long-term monitoring as there are Rangers on each island, ease of access (airstrip, fuel, accommodation), and because these meadows have the greatest species diversity in the region (Figure 8, Figure 10, Figure 12). The presence of colonising (*H. ovalis*), opportunistic (*H. uninervis*, *C. rotundata*, *C. serrulata*), and persistent species (*T. hemprichii*, *E. acoroides*) means the Erub, Mer and Masig Island meadows are comprised of species with a range of tolerances and capacity to recover from impacts. These island's meadows collectively

represent a large seagrass area (1444 ± 163 ha) (Table 4) and span the geographic extent of the region which allows for spatial comparisons (Figure 6). Incorporating these meadows into a long-term monitoring program would also ensure one major seagrass meadow is monitored in each of the Erubam Le, Keriba Luzabzab-Lera Dorge, and Masigalgal Dugong and Turtle Management Areas. We also recommend resurveying Ugar Island as seagrass mapping for this island is now >10 years old.

5 REFERENCES

4Seas Environmental Consulting. 2020. Extinction risk assessment for the green turtle (*Chelonia mydas*) – The role of the Torres Strait Region in the National Recovery Plan. Report prepared for the Torres Strait Regional Authority, pp.

André, J., Gyuris, E. and Lawler, I. R. 2005. Comparison of the diets of sympatric dugongs and green turtles on the Orman Reefs, Torres Strait, Australia. Wildlife Research, **32**: 53-62

Australian Government. 2017. Recovery plan for marine turtles in Australia 2017-2027. 146 pp.

Bainbridge, S. J., Berkelmans, R., Sweatman, H. and Weeks, S. 2015. Monitoring the health of Torres Strait Reefs - Final Report. Report to the National Environmental Science Program. Reef and Rainforest Research Limited, Cairns, 74 pp.

Butler, J. R., Tawake, A., Skewes, T., Tawake, L. and McGrath, V. 2012. Integrating traditional ecological knowledge and fisheries management in the Torres Strait, Australia: the catalytic role of turtles and dugong as cultural keystone species. Ecology And Society, **17**: 1-19

Carter, A., McKenna, S., Rasheed, M., Collier, C., McKenzie, L., Pitcher, R. and Coles, R. 2021. Synthesizing 35 years of seagrass spatial data from the Great Barrier Reef World Heritage Area, Queensland, Australia. Limnology & Oceanography Letters, 1-11

Carter, A., Mellors, J., Whap, T., Hoffmann, L. and Rasheed, M. 2020. Torres Strait Seagrass 2020 Report Card. Centre for Tropical Water & Aquatic Ecosystem Research Publication 20/24. James Cook University, Cairns, 62 pp.

Carter, A., Taylor, H., McKenna, S. and Rasheed, M. 2013. Critical Marine Habitats in High Risk Areas, Torres Strait – Seo Reef to Kai-Wareg Reef. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication. James Cook University, Cairns, 67 pp.

Carter, A., Taylor, H., McKenna, S., York, P. and Rasheed, M. 2014a. The effects of climate on seagrasses in the Torres Strait, 2011-2014. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns, 36 pp.

Carter, A., Taylor, H. and Rasheed, M. 2014b. Torres Strait Mapping: Seagrass Consolidation, 2002 – 2014. Report no. 14/55. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), James Cook University, Cairns, 47 pp.

Carter, A. B. and Rasheed, M. A. 2016. Assessment of Key Dugong and Turtle Seagrass Resources in North-west Torres Strait. Report to the National Environmental Science Programme and Torres Strait Regional Authority. Reef and Rainforest Research Centre Limited, Cairns 40 pp.

Chartrand, K. M., Szabó, M., Sinutok, S., Rasheed, M. A. and Ralph, P. J. 2018. Living at the margins: The response of deep-water seagrasses to light and temperature renders them susceptible to acute impacts. Marine Environmental Research, **136**: 126-138

Cleguer, C., Preston, S., Hagihara, R., Shimada, T., Hamann, M., Simpson, S., Loban, F., Bowie, G., Fujii, R. and Marsh, H. 2016. Working with the Torres Strait community to understand use of space

by dugongs and green turtles in Torres Strait. Final Report to the Mura Badulgal Representative Native Title Body Corporate and the National Environment Science Program Tropical Water Quality Hub on Project No. 3.2. James Cook University, Townsville, 60 pp.

Coles, R. G., McKenzie, L. J. and Campbell, S. J. 2003. Chapter 11: The seagrasses of eastern Australia. Page 119-128. In E. P. Green and F. T. Short (eds), World Atlas of Seagrasses. University of California Press, Berkley, USA

Collier, C. J., Chartrand, K., Honchin, C., Fletcher, A. and Rasheed, M. 2016. Light thresholds for seagrasses of the GBR: a synthesis and guiding document. Including knowledge gaps and future priorities. Report to the National Environmental Science Programme, Cairns, 41 pp.

Collier, C. J., Langlois, L., Ow, Y., Johansson, C., Giammusso, M., Adams, M. P., O'Brien, K. R. and Uthicke, S. 2018. Losing a winner: thermal stress and local pressures outweigh the positive effects of ocean acidification for tropical seagrasses. New Phytologist, **219**: 1005-1017

Dennison, W., Aller, R. and Alberte, R. 1987. Sediment ammonium availability and eelgrass (*Zostera marina*) growth. Marine Biology, **94**: 469-477

Erftemeijer, P. L. A. and Middelburg, J. J. 1993. Sediment-nutrient interactions in tropical seagrass beds - a comparison between a terrigenous and a carbonate sedimentary environment in South Sulawesi (Indonesia). MARINE ECOLOGY PROGRESS SERIES, **102**: 187-198

Gredzens, C., Marsh, H., Fuentes, M. M., Limpus, C. J., Shimada, T. and Hamann, M. 2014. Satellite tracking of sympatric marine megafauna can inform the biological basis for species co-management. PLOS ONE, **9**: e98944

Haywood, M. D. E., Pitcher, C. R., Ellis, N., Wassenberg, T. J., Smith, G., Forcey, K., McLeod, I., Carter, A., Strickland, C. and Coles, R. 2008. Mapping and characterisation of the inter-reefal benthic assemblages of the Torres Strait. Continental Shelf Research, **28**: 2304-2316

Kenworthy, W. J., Hall, M. O., Hammerstrom, K. K., Merello, M. and Schwartzschild, A. 2018. Restoration of tropical seagrass beds using wild bird fertilization and sediment regrading. Ecological Engineering, **112**: 72-81

Kilminster, K., McMahon, K., Waycott, M., Kendrick, G. A., Scanes, P., McKenzie, L., O'Brien, K. R., Lyons, M., Ferguson, A., Maxwell, P., Glasby, T. and Udy, J. 2015. Unravelling complexity in seagrass systems for management: Australia as a microcosm. Science of The Total Environment, **534**: 97-109

Limpus, C. and Nicholls, N. 2000. Enso Regulation of the Indo-Pacific Green Turtle Populations. Page 7. In G. Hammer, N. Nicholls and C. A. Mitchell (eds), Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems - The Australian Experience. Kluwer Academic Publishers, Dordrecht

Marsh, H., O'Shea, T. J. and Reynolds III, J. E. 2011. Ecology and Conservation of the Sirenia: Dugongs and Manatees. Cambridge University Press, Cambridge, United Kingdom

Mellors, J. E. 1991. An evaluation of a rapid visual technique for estimating seagrass biomass. Aquatic Botany, **42**: 67-73

Miller, J. D. and Limpus, C. J. 1991. Torres Strait marine turtle resources. Sustainable Development for Traditional Inhabitants of the Torres Strait Region. Workshop Series. Great Barrier Reef Marine Park Authority, Townsville, 213-226 pp.

Poiner, I. R. and Peterkin, C. 1996. Seagrasses. Pages 40–45 in L. Zann and P. Kailola, editors. The state of the marine environment report for Australia. Great Barrier Reef Marine Park Authority, Townsville, Australia.

Powell, G. V. N., Kenworthy, W. J. and Fourqurean, J. W. 1989. Experimental evidence for nutrient limitation of seagrass in a tropical estuary with restricted circulation. Bulletin Of Marine Science, **44**: 324-340

Scott, A. L., York, P. H., Duncan, C., Macreadie, P. I., Connolly, R. M., Ellis, M. T., Jarvis, J. C., Jinks, K. I., Marsh, H. and Rasheed, M. A. 2018. The role of herbivory in structuring tropical seagrass ecosystem service delivery. Frontiers in Plant Science, **9**: 1-10

Short, F. T. 1987. Effects of Sediment Nutrients on Seagrasses - Literature-Review and Mesocosm Experiment. AQUATIC BOTANY, **27**: 41-57

Taylor, H., Carter, A., Davies, J., McKenna, S., Reason, C. and Rasheed, M. 2013. Seagrass productivity, resilience to climate change and capacity for recovery in the Torres Strait – 2011-2013. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 13/40, James Cook University, Cairns, 80 pp.

Taylor, H. and McKenna, S. 2012. Critical Marine Habitats in High Risk Areas, Torres Strait – Woiz Reef to Kaliko Reef – 2012 Atlas. DAFF Publication. Northern Fisheries Centre, Cairns, 55 pp.

Taylor, H. A., McKenna, S. A. and Rasheed, M. A. 2009. Critical marine habitats in the Great North East Shipping Channel, Torres Strait - Kirkcaldie Reef to Bramble Cay - 2009 Atlas. DEEDI Publication PR09-4458. Northern Fisheries Centre, Cairns, 64 pp.

Taylor, H. A., Rasheed, M. A., Chartrand, K., McKenna, S. A. and Sankey, T. L. 2008. Critical marine habitats and marine debris in the Great North East Channel, Torres Strait - Poruma to Ugar Islands - 2008 Atlas. Department of Primary Information & Fisheries (DPI&F) Information Series, Northern Fisheries Centre, Cairns, Australia, 55 pp.