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INTERTIDAL HABITATS OF THE SOUTHERN GULF OF CARPENTARIA

Collier C, Settli E, Armstrong D, Tyrell H, Reason C, Langlois L, Navarro Otero A, Carruthers L, Watson M, Yanner M, Cheetham D, George X, Toby M, Bee R Jr, Savo K, Morrissey S, Hodgon J, Hogno M, Saparwan A, Groom R, and Carter A

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Cover images

Front: Intertidal zone in the southern Gulf of Carpentaria. Credit: JCU TropWATER.
Back: Research helicopter flying over seagrass. Credit: JCU TropWATER.

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The Marine and Coastal Hub acknowledges Aboriginal and Torres Strait Islander people as the First Peoples and Traditional Owners and custodians of the land and waterways on which we live and work. This research was conducted in Gangalidda, Garawa, Gkuthaarn, Kukatj, and Kurtijar Sea Country. We honour the Traditional Owners and pay our respects to Elders past, present and future.

Aboriginal and Torres Strait Islander peoples represent the world's oldest living culture. We celebrate and respect this continuing culture and strive to empower Aboriginal and Torres Strait Islander peoples.

Executive summary

The southern Gulf of Carpentaria supports extensive coastal and intertidal habitats that are culturally, ecologically and economically important. These habitats sustain dugongs, marine turtles, shorebirds, fisheries, and other species that are central to Sea Country values and Traditional Owner management priorities. However, until recently, large sections of the mainland coast had not been comprehensively mapped for decades, limiting the ability of Traditional Owners, Rangers and managers to assess habitat condition or detect future change.

This project addressed a major information gap by mapping intertidal benthic habitats from the Northern Territory border to Karumba. Together with recent surveys in the Kurtijar Indigenous Protected Area, this work completes more than 500 km of high-resolution seagrass survey coverage along Queensland's southern Gulf coastline. The surveys were undertaken by helicopter, in collaboration with the Gangalidda Garawa Rangers, the Normanton Rangers, and scientists, combining Traditional Owner knowledge and ranger expertise.

Seagrass was recorded at 413 of 1,764 survey sites. The 2024 and 2025 surveys mapped 18 seagrass meadows across Gangalidda Garawa Sea Country and Gkuthaarn, Kukatj and Kurtijar Sea Country, covering approximately 6,959 ha. The three largest meadows west and south of Point Parker accounted for 53% of the total mapped meadow area. Meadows were generally low density and dominated by *Halodule uninervis*, with *Halophila ovalis* occurring less frequently and typically at low biomass. The updated mapping confirmed some patterns shown in historical data. It also identified new or more clearly defined areas of low-density seagrass, particularly from south of Point Parker to the Albert River and around John's Creek. These differences reflect both underlying ecological patterns and the improved resolution of contemporary mapping methods. Seagrass condition around Karumba was poor, consistent with long-term monitoring for the Port of Karumba that has linked recent declines to several years of above-average river discharge and potentially high tidal exposure. The mapped meadows provide important habitat for culturally significant marine fauna.

The project also established a foundation for ongoing ranger-led monitoring. Five monitoring locations were selected based on seagrass presence, cultural and ecological values, pressures of concern and practical accessibility. Drone orthomosaics and spot checks provide repeatable methods for tracking changes in seagrass extent, density and species composition.

The southern Gulf remains data-poor compared with many other coastal regions. Future monitoring would be strengthened by integrating habitat surveys with environmental data. Baseline subtidal habitat mapping is also needed, particularly along the mainland coast and adjacent islands, and in areas where dugongs were observed but intertidal seagrass was absent.

Overall, this project provides a contemporary baseline for seagrass and intertidal benthic habitats across a previously under-surveyed section of the southern Gulf. It strengthens the knowledge base available to Traditional Owners, Rangers, managers and researchers, and supports long-term Sea Country management. Continued collaboration, monitoring and integration of cultural knowledge with scientific methods will be essential for detecting change, responding to pressures and maintaining the health of Gulf of Carpentaria marine ecosystems.

1. Introduction

1.1. The Gulf of Carpentaria

In the Gulf of Carpentaria (the Gulf), people and the environment are deeply interconnected (Carpentaria Land Council Aboriginal Corporation [CLCAC] 2014). Dreamings run through the water and connect people with neighbouring Sea Country (Gangalidda & Garawa Native Title Aboriginal Corporation [NTAC] 2014). Freshwater is a fundamental resource in this region for people, while also serving as the basis for ecological productivity (CLCAC 2015a).

The rivers in Gulf Country traverse extensive floodplains, ultimately discharging into the Gulf and supporting diverse coastal ecosystems. The Gulf has a seasonal monsoon cycle with a wet season (December–February) characterised by north-westerly winds and occasional cyclones, and a dry season (May–October) with south-easterly winds (Somers and Long 1994). Catchment nutrients are critical to promoting primary productivity (Burford et al. 2021), and variable freshwater flows between wet and dry seasons are critical to the life histories of many important species (O'Mara et al. 2025).

The wetlands and coastal areas are classified as of 'outstanding importance' for migratory waterbirds, with this region exhibiting the highest concentration of migratory shorebirds in Queensland (CLCAC and Kurtijar Traditional Owners 2014, Gangalidda and Garawa NTAC 2014, CLCAC 2015a). The extensive intertidal flats combined with significant food resources reinforce this role.

The Gulf is also a critical habitat for several endangered sawfish species, including the largetooth sawfish (*Pristis pristis*), green sawfish (*Pristis zijsron*), and dwarf sawfish (*Pristis clavate*) (Department of the Environment, 2025). These species are classified as critically endangered by the IUCN Red List and are listed as Vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999, highlighting the need for targeted conservation strategies in this area.

Dugongs and marine turtles are culturally and ecologically significant to Gulf communities (CLCAC and Gkuthaarn and Kukatj Traditional Owners 2014). Traditional Owners of the Wellesley Islands describe dugong and turtle as 'central to our identity and responsibilities' (CLCAC 2015b). Six species of marine turtles are documented in the southern Gulf, with local Rangers actively participating in monitoring and conservation efforts. Notably, green turtles in this region exhibit a localised behaviour, remaining within the Gulf for feeding, mating, and nesting rather than migrating long distances (Kennett et al. 2004a). This characteristic highlights the collective responsibility of Gulf Traditional Owner groups to manage and protect these animals and the crucial habitats that support them.

Additionally, the Gulf is recognised as a vital area for dugong populations, underscoring the importance of understanding coastal ecology and cultural heritage (Marsh et al. 2008b). Traditional Owner's custodianship of these ecological resources is an inherently integrated approach to conservation, combining Indigenous knowledge with contemporary scientific practices.

The Gulf supports highly productive fisheries encompassing both commercial and recreational fishing sectors. There is a strong reliance on productive coastal estuaries for spawning, recruitment, nursery functions and feeding, with many species transitioning between freshwater and offshore environments over their lifetime (Broadley et al. 2020a, Smart et al. 2021, O'Mara et al. 2025). The Northern Prawn Fishery (NPF) operates across northern Australia and is the highest-grossing fishery in the country (Commonwealth of Australia 2020). In particular, the waters of the southeast Gulf of Carpentaria are recognised as the most productive banana prawn fishing grounds in Australia (Smart et al. 2020).

Juvenile banana prawns and barramundi utilise estuaries as vital feeding and refuge areas, which significantly contribute to their growth and survival (Broadley et al. 2020b). In addition to prawns and barramundi, the Gulf's fisheries also target species including Spanish mackerel, salmon, tropical snappers, sharks, mud crab and various bream species, which are important to both commercial and recreational fishers (Fisheries Queensland 2017). Recreational fishing is an important component of the Gulf's regional economy and lifestyle, supporting local tourism and providing opportunities for residents and visitors to target iconic species.

1.2. Seagrass

Seagrass is identified by Traditional Owners of the southern Gulf of Carpentaria as a significant part of Sea Country (Gangalidda and Garawa NTAC 2014, CLCAC 2015b, CLCAC 2015a). Traditional Owners have long described large intertidal and subtidal seagrass meadows in the Wellesley Islands and extensive fringing seagrass meadows in Gangalidda country.

Understanding the condition of seagrass habitats has been identified as a key management priority, with seagrass and fish habitat monitoring recognised as priority actions (CLCAC and Gkuthaarn and Kukatj Traditional Owners 2014). Despite their ecological and cultural importance, there remains a critical lack of baseline data on seagrass habitats across the Gulf. The remoteness of the region means there is limited consistent data collection, with surveys being logistically challenging and costly; as such, comprehensive mapping has not occurred since limited subtidal surveys in 1986 and aerial surveys in 2004. These records show long stretches of the coast with seagrass present, as well as large gaps with no seagrass, and large gaps with no data (Figure 1, Figure 2). Datasets compiled from surveys conducted between 1983 and 2022 show large areas of coastline have not been assessed for decades (Carter et al. 2023c).

Recent surveys have been undertaken to fill these gaps. This includes a 2023 collaboration between Wellesley Island Rangers and scientists to map intertidal habitats of the northern and western coast of Mornington Island and the Bountiful Islands (Carter et al. 2024b), with further work planned in 2026 to complete habitat mapping of Mornington Island. A subtidal section of the Gulf of Carpentaria Marine Park and waters adjacent to Mornington Island were mapped in 2025 (Collier et al. In prep-b). In the Kurtijar Indigenous Protected Area, helicopter and boat-based surveys in 2023 mapped benthic habitats from the Norman River to the Staaten River (Proctor et al. 2025). These efforts form part of a broader initiative to improve seagrass mapping across northern Australia to support decision-making by Traditional Owners, government and environmental managers. The extent and condition of seagrass habitats are widely recognised as indicators of the overall health of coastal and marine environments (CLCAC and Gkuthaarn and Kukatj Traditional Owners 2014). Contemporary, spatially explicit information on seagrass distribution is therefore essential for identifying priority areas for monitoring and management, particularly given their role in supporting

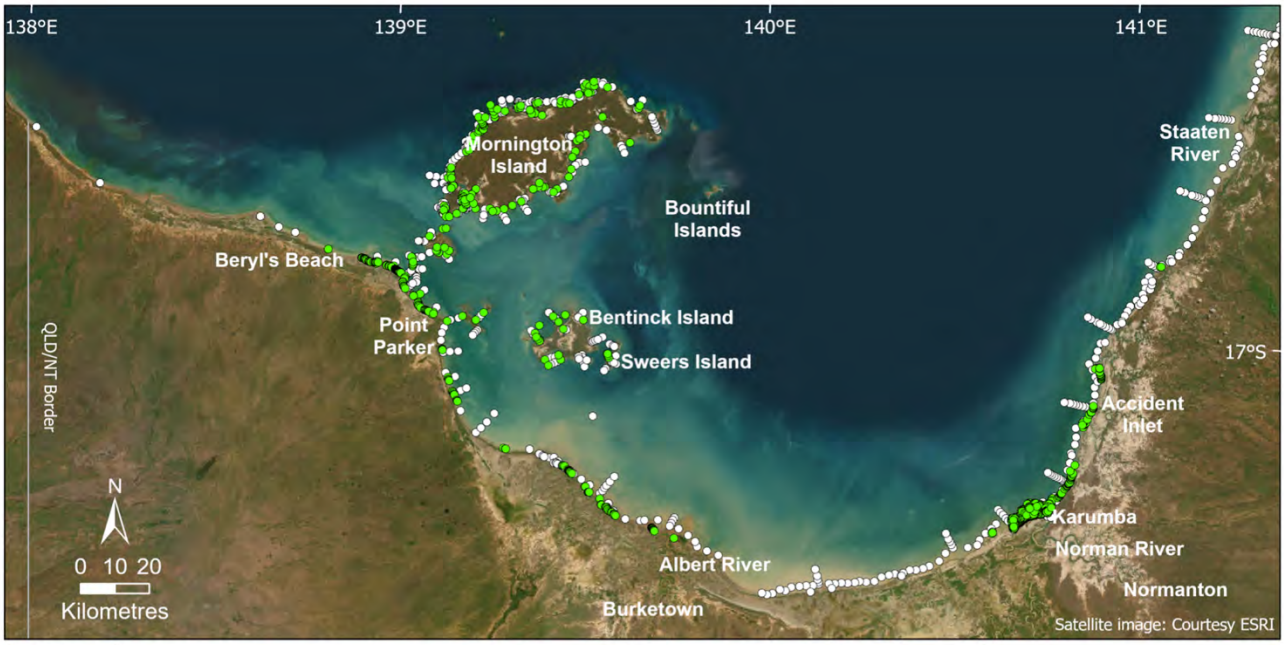


Figure 2: Historical seagrass presence and absence based on surveys conducted between 1987 and 2022. The area from the Northern Territory border to Karumba (the focus of this study), has not been surveyed for decades.

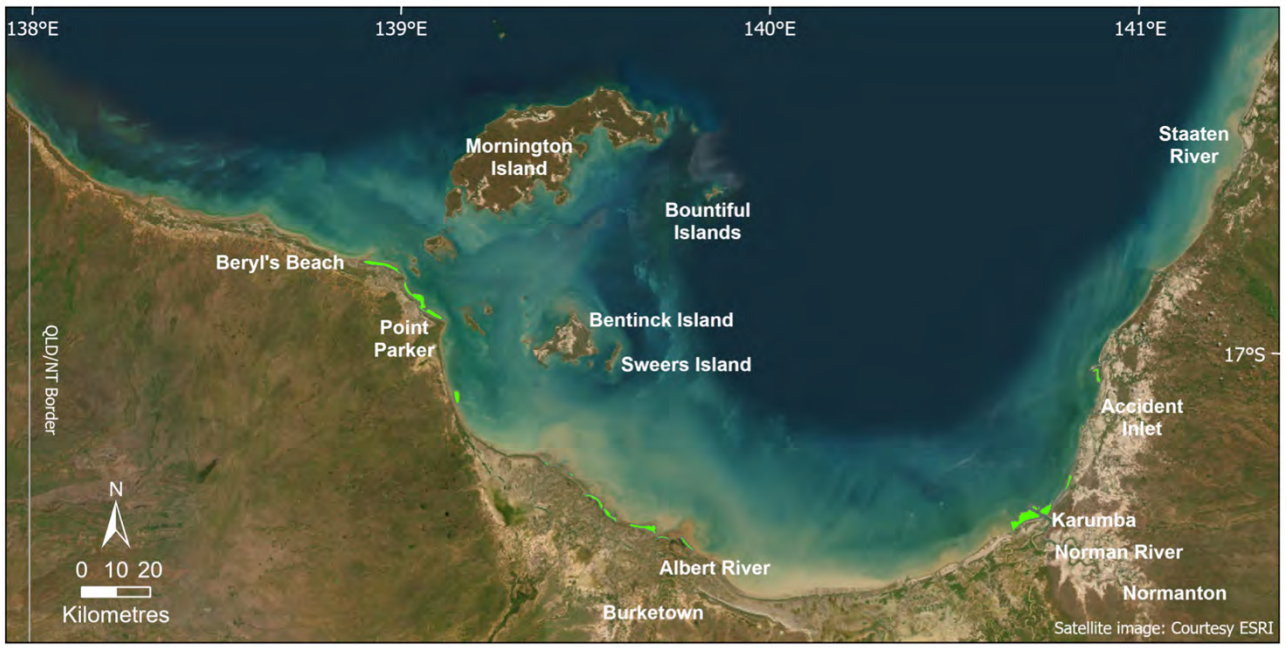


Figure 1: Historical seagrass meadows based on surveys conducted between 1987 and 2022. The area from the Northern Territory border to Karumba (the focus of this study), has not been surveyed for decades.

culturally significant species. Despite recent mapping efforts in Queensland's southern Gulf, information along the mainland coast from Karumba to the Northern Territory border remained outdated. To address this gap, intertidal habitats along this coastline were mapped by Normanton and Gangalidda Garawa Rangers in collaboration with scientists from TropWATER JCU, completing coverage of the CLCAC coastline over more than 500 km.

1.3. People, threats and protection

People of the southern Gulf of Carpentaria maintain strong cultural connections to coastal and marine environments through ongoing care for Sea Country. Multiple language groups across the region continue to manage and protect these environments through Indigenous ranger programs, on-ground management, cultural knowledge transfer and participation in research and monitoring. Ranger groups play an important role in activities such as marine animal monitoring, fisheries management, coastal surveillance, and habitat assessments, while also maintaining cultural responsibilities to Country and supporting the next generation of Traditional Owners to remain connected to Sea Country.

Indigenous Protected Areas (IPAs) are exclusively managed by Traditional Owners to protect biodiversity, cultural heritage and community aspirations. Each IPA is guided by a Plan of Management, which was developed through extensive discussion with Traditional Owners, outlining cultural aspirations, key management priorities and actions required to care for Country (CLCAC 2015b, CLCAC 2015a); they represent collective views from all Traditional Owners.

The IPA Plans of Management emphasise the cultural and ecological significance of seagrass, noting its role in sustaining key species, supporting cultural harvesting practices and maintaining Sea Country health (CLCAC 2015a, CLCAC 2015b).

The Thuwathu IPA Plan of Management identifies seagrass protection as a core Sea Country responsibility. Traditional Owners emphasise the need to safeguard dugong and turtle feeding grounds, manage pressures from commercial fishing, and strengthen monitoring across the Wellesley Islands. The plan highlights the importance of combining Traditional Owner knowledge with scientific monitoring to detect change and protect culturally significant species (CLCAC 2015b).

The Nijinda Durlga IPA Plan of Management identifies declining seagrass condition particularly degradation associated with turbidity, sedimentation and smothering following major rainfall events, as a key concern (CLCAC 2015a). Ranger led monitoring, improved baseline information and strengthened partnerships with scientists and government agencies are needed to address these priority issues. The plan also highlights the importance of maintaining freshwater flows, protecting estuaries and monitoring coastal change, all of which influence seagrass condition.

The Kurtijar Sea Country IPA is in determination and does not yet have a published IPA Plan of Management. The Kurtijar Land and Sea Country Plan, Garawa Land and Sea Country Plan and the Gkuthaarn and Kukatj Land and Saltwater Country Plans reflect similar priorities, acknowledging the role of seagrass in supporting culturally significant species and the importance of continued monitoring, ranger capability and protection of coastal ecosystems (CLCAC and Gkuthaarn and Kukatj Traditional Owners 2014, CLCAC and Kurtijar Traditional Owners 2014, Gangalidda and Garawa NTAC 2014).

Both the Nijinda Durlga and Thuwathu IPA Plans of Management are currently undergoing review following their 10-year implementation period. Traditional Owners have reaffirmed the need for contemporary seagrass information, ranger led monitoring programs, improved understanding of coastal change, and strengthened partnerships to support long term Sea Country management.

Despite these protections, the region faces a range of existing and emerging threats. Proposed catchment and coastal developments, including large-scale water resource developments in the Gilbert River catchment, have raised concerns about potential impacts on freshwater flows, estuarine connectivity and coastal ecosystem function (CLCAC and Kurtijar Traditional Owners 2014, Burford and Faggotter 2021, O'Mara et al. 2025). Many areas of the southern Gulf coastline remain poorly studied, limiting the ability of Traditional Owners, ranger groups and environmental managers to detect change and make informed management decisions. Improved baseline information is therefore important to support long-term monitoring, protection and management of these coastal ecosystems.

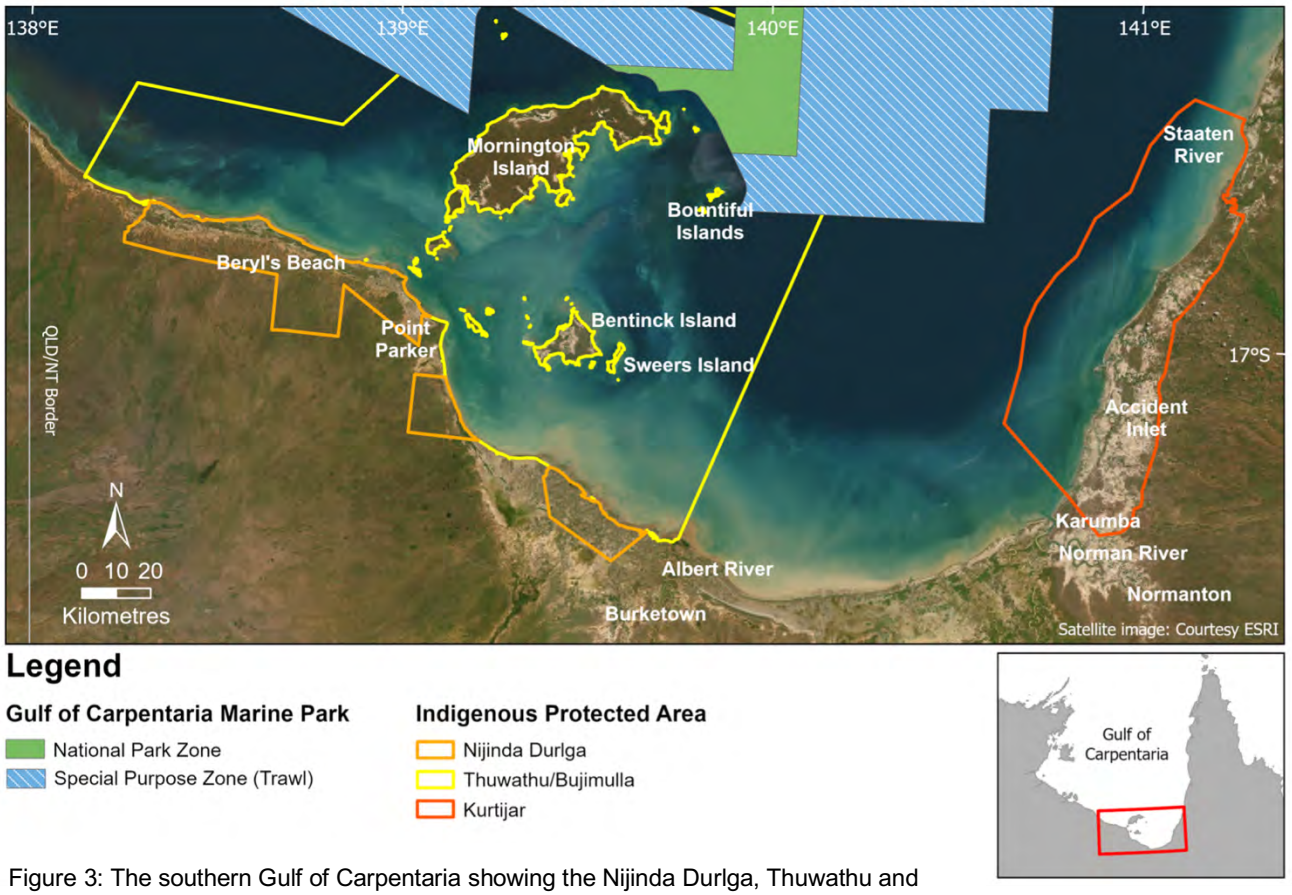


Figure 3: The southern Gulf of Carpentaria showing the Nijinda Durlga, Thuwathu and Kurtijar Indigenous Protected Areas, and parts of the Gulf of Carpentaria Marine Park.

1.4. Aims

Maintaining healthy coastal ecosystems in the Gulf of Carpentaria requires up-to-date information to support sustainable management of natural resources. Coastal zones and adjacent catchments are increasingly influenced by development pressures and environmental change, which can affect the extent and condition of important habitats and the cultural, commercial, and ecological values they support. Improved baseline information is therefore critical for understanding habitat distribution, detecting change, and supporting informed management decisions.

Building capacity for ranger-led habitat monitoring is also important given Traditional Owner's custodianship of coastal and marine environments. Indigenous ranger groups bring extensive local knowledge, practical experience, and ongoing presence in remote northern Australian locations, making them well-placed to undertake long-term monitoring and management activities. The aims of this work were to:

1. Map benthic habitats, with a focus on seagrass, using methods consistent with previous and ongoing surveys in northern Australia.

2. Establish a contemporary benchmark of coastal habitats to support future monitoring and assessment by Traditional Owners, ranger groups, management agencies, and researchers.

3. Co-design habitat mapping and monitoring approaches with Gangalidda Garawa Rangers, Normanton Rangers, and scientists, guided by Traditional Owner knowledge and incorporating technologies such as drones.

4. Interpret and report survey findings, including identifying practical pathways for ongoing ranger-led monitoring and management activities.

2. Methods

2.1. Survey area

The survey was conducted as a collaboration between James Cook University's TropWATER – James Cook University, Northern Institute - Charles Darwin University, Normanton Rangers, Gangalidda Garawa Rangers and CLCAC. The survey focused on the intertidal habitats in the southern Gulf between the Northern Territory border and Karumba (Figure 4). The intertidal surveys were undertaken 28–31 August 2024 based out of Burketown for surveys between the Northern Territory border to Disaster Inlet and based out of Karumba 15–18 September 2025 for surveys between Disaster Inlet and Karumba. Survey dates were selected to coincide with northern Australia's peak seagrass growing period in spring and early summer (Carter et al. 2022). This ensured that data were comparable among years and with adjacent survey locations.

Drone monitoring was established after the baseline mapping was undertaken, enabling selection of drone mapping sites (Figure 4). Surveys with drones were conducted from Burketown 22–24 October 2024 and from Karumba 14–15 October 2025.

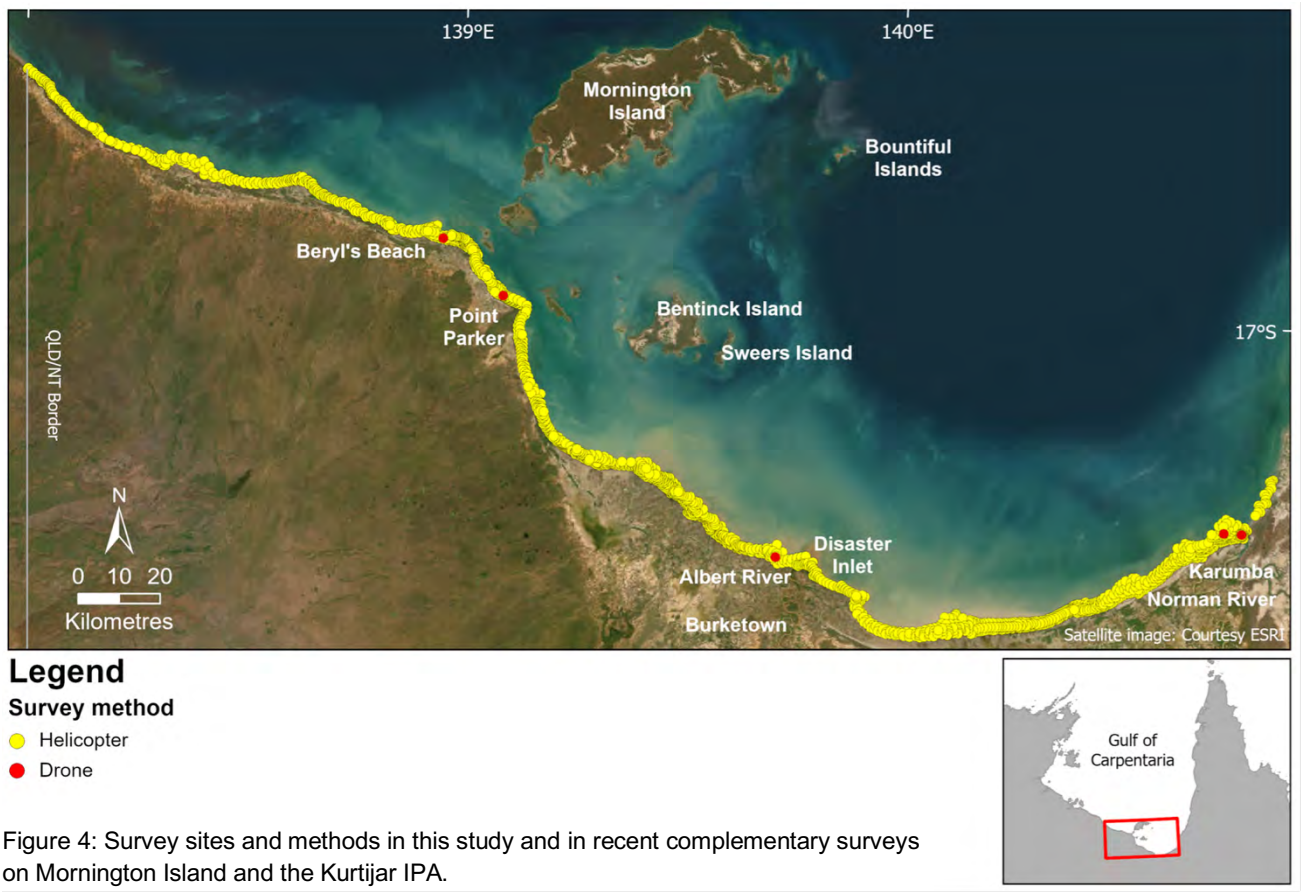


Figure 4: Survey sites and methods in this study and in recent complementary surveys on Mornington Island and the Kurtijar IPA.

2.2. Benthic habitat

2.2.1 Observations and sampling

Exposed intertidal banks were surveyed by helicopter, which allows for rapid surveys across large areas. Intertidal sites were surveyed while the helicopter maintained a low hover (Figure 5). At each site, a visual estimate was made of benthic habitat within three 0.25 m^2 replicate quadrats within an approximate 10 m^2 circular site. Where seagrass formed distinct meadows, they were mapped by recording GPS points while flying along the intertidal meadow edge. There were 1,146 sites in the 2024 surveys with two helicopters operating and 618 sites in the 2025 surveys with one helicopter operating.

2.2.2 Seagrass biomass and percent cover

Seagrass biomass was determined for each quadrat using the 'visual estimates of biomass' technique (Mellors 1991). This involves ranking seagrass biomass while referring to a series of quadrat photographs of similar seagrass habitats for which the above-ground biomass has been previously measured. A low biomass scale was used for this survey. The percentage of each seagrass species contributing to the total above-ground biomass within each quadrat was also estimated. After video analysis, each observer ranked a series of calibration quadrats. A linear regression was then calculated for the relationship between observer ranks and the harvested values and used to calibrate above-ground biomass estimates for all ranks made by that observer. Biomass ranks were converted to above-ground biomass in grams dry weight per square metre (g DW m^{-2}) and averaged among replicates to provide mean total seagrass above-ground biomass and contribution to total above-ground biomass for each species for each site. Similarly, seagrass percent cover was estimated for each quadrat using a series of quadrat reference photographs for which percent cover was previously estimated.

2.2.3 Algae communities

The percent cover of algae was estimated for each quadrat according to five functional groups (Table 1, Figure 7). Benthic microalgae were added as a category because it was a dominant feature. It was recorded only when clearly visible as a layer over the surface of the mud.



Figure 5: Helicopter surveys in the southern Gulf of Carpentaria based out of Burketown including A) survey team, B) view over flood plain, C) team in the helicopter during surveys, D) a helicopter flying over the seagrass habitat and E) scenic view of Gangalidda Garawa Country.

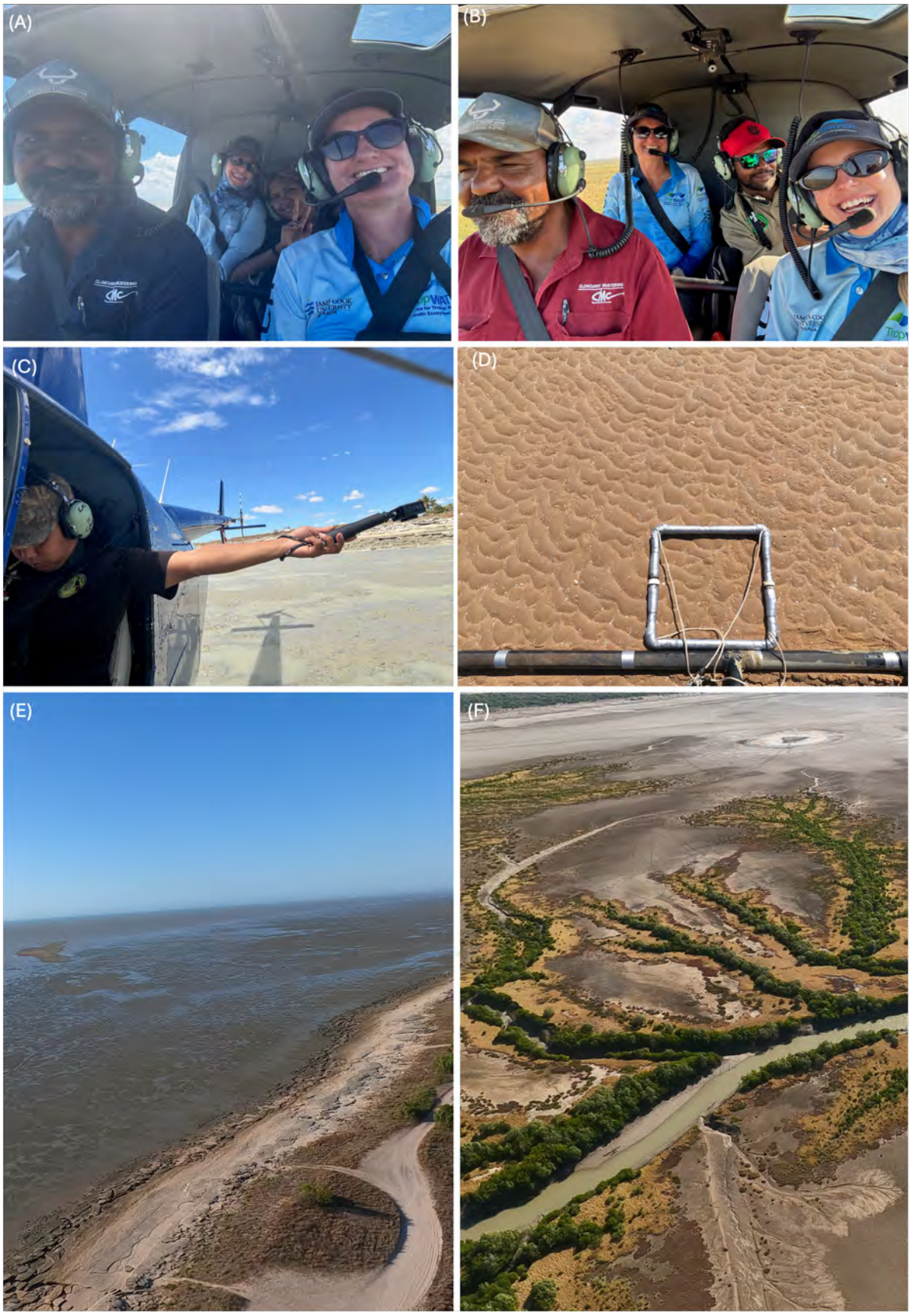


Figure 6: Helicopter surveys in the southern Gulf of Carpentaria based out of Karumba including A) and B) survey team, C) taking a photo of the benthic habitat while at a hover, D) a quadrat lowered out of the helicopter onto the sediment for assessment of composition and biomass, E) intertidal habitat along the coast and F) scenic view.

Table 1: Algae community functional groups and their descriptions.

Functional group label	Description
Erect macrophyte	Macrophytic algae with an erect growth form and high level of cellular differentiation, e.g. *Sargassum, Caulerpa* and *Galaxaura* species.
Filamentous	Thin, thread-like algae with little cellular differentiation.
Encrusting	Algae that grow in a sheet-like form attached to the substrate or benthos, e.g. coralline algae.
Turf mat	Algae that form a dense mat on the substrate.
Erect calcareous	Algae with erect growth form and high level of cellular differentiation containing calcified segments, e.g. *Halimeda* species.
Benthic microalgae	Microscopic photosynthetic organisms that grow on and within the upper surface of marine and estuarine sediments giving a green or green/brown hue to the sediment.

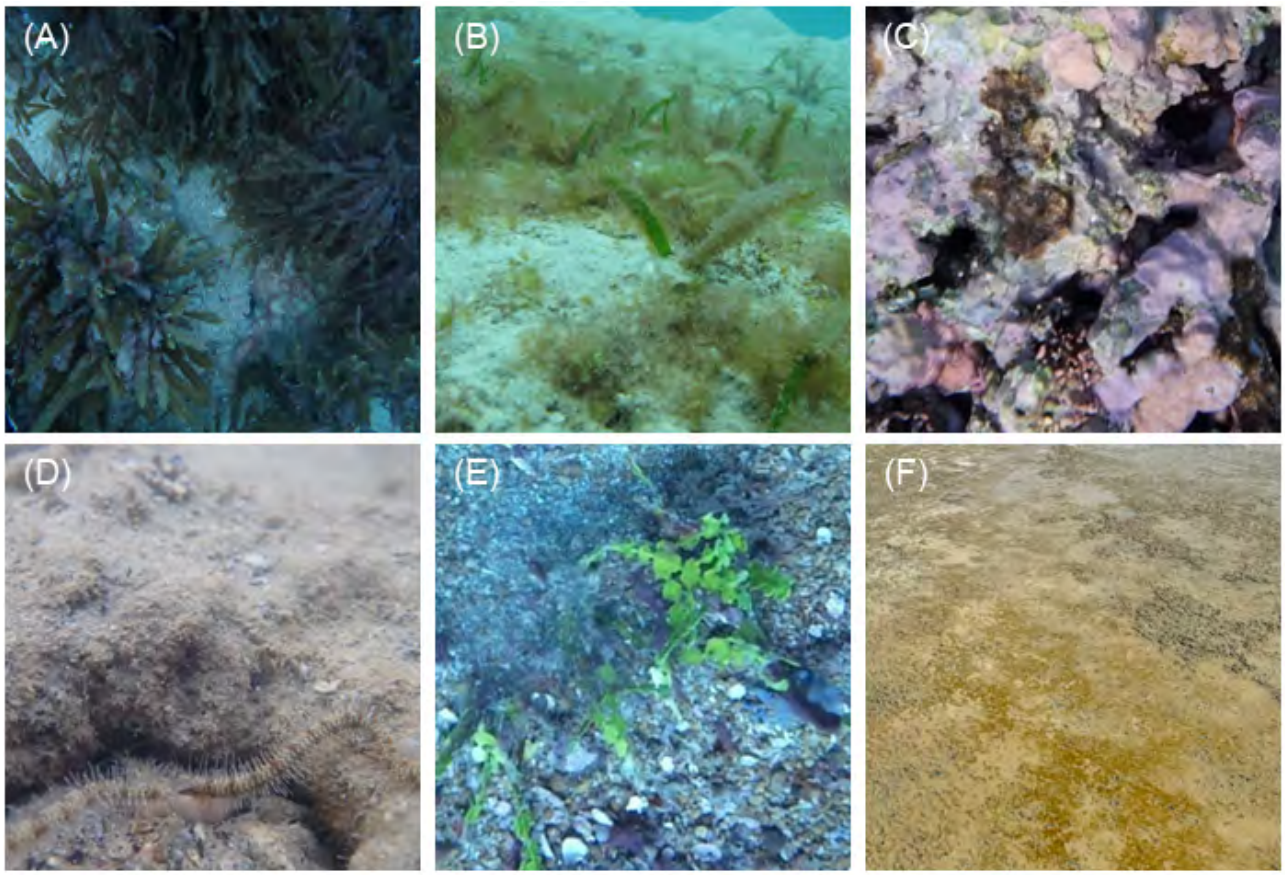


Figure 7: Examples of functional algae groups are A) erect macrophytes, B) filamentous, C) encrusting, D) turf mat, E) erect calcareous, and (F) Benthic microalgae.

2.2.4 Additional information

Sea cucumbers were counted at each site. Dugong feeding trails (presence/absence) were recorded at each site. Other notable observations were recorded, such as dugongs in adjacent water to the intertidal banks, tracks through the mud attributed to baler shells, and mud skipper holes.

2.2.5 Benthic macroinvertebrate communities

Although rare in these surveys, the percent cover of habitat-forming benthic macroinvertebrates (BMI) was estimated for each quadrat according to broad taxonomic groups (Table 2).

Table 2: Benthic macroinvertebrate functional groups and their descriptions.

Functional group label	Description
Hard coral	All scleractinian corals including massive, branching, tabular, digitate and mushroom
Soft coral	All alcyonarian corals, i.e. corals lacking a hard calcareous skeleton
Sponge	All sponges including vase, tube, branching, barrel or encrusting forms
Other BMI	Other BMI identified e.g. oysters

2.3. Geographic Information System (GIS)

All survey data was entered into a Geographic Information System (GIS) using ArcGIS Pro 3.6 (Environmental Systems Research Institute, ESRI). Data structures and attribute fields were designed to align with spatial data standards for other northern Australian seagrass datasets. Three GIS layers were created to describe spatial habitats in the region: a habitat site layer, seagrass meadow layer, seagrass biomass interpolation layer and seagrass percent cover layer.

2.3.1 Habitat site layer

This shapefile contains point data collected at each survey site and includes:

- temporal details of survey date and time
- spatial details of location, tidal zone (i.e. intertidal), latitude/longitude
- sediment type
- seagrass-specific information of seagrass presence/absence, mean total above-ground biomass ± standard error (SE), mean biomass for each species, mean total percent cover seagrass, and mean percent cover for each species
- percent cover of algae and algal types, BMI and BMI types, and bare substrate
- survey method
- the presence of dugong feeding trails, presence of dugongs, turtles or dolphins near the site (in deeper water) and sea cucumber presence/absence observed at the site
- data custodian
- comments

2.3.2 Meadow (polygon) layer

This layer contains polygon features representing discrete seagrass meadows. Each polygon summarises key seagrass attributes for the sites located within that meadow, including:

- temporal details, i.e. survey date
- seagrass meadow information, including meadow identification (ID) code, meadow area in hectares, seagrass species present, meadow community type, meadow density, mean meadow above-ground biomass ± standard error, and number of total sites within the meadow
- survey method
- data custodian
- comments

Intertidal seagrass meadow boundaries were defined using satellite imagery from a low-tide PlanetScope composite, field notes, mapped meadow boundaries using GPS, seagrass presence / absence site data collected during the survey, the intertidal extent model (Bishop-Taylor et al. 2019). The composite was generated by selecting the best available satellite images. Where the imagery was difficult to interpret, such as areas affected by cloud, sun glint or insufficient tidal exposure, or where the habitat was highly fragmented or complex (e.g. comprising a mix of rock, reef and seagrass), the polygons were manually adjusted using the field data to estimate meadow boundaries.

Seagrass meadow community type was determined according to seagrass species composition. Species composition was based on the percent each species' biomass contributed to the mean meadow biomass. A standard nomenclature system was used to categorise each meadow (Table 3). This nomenclature also included a measure of meadow density categories (light, moderate, dense) determined by the mean biomass of the dominant species within the meadow (Table 4).

Table 3: 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 4: Density categories and mean above-ground biomass ranges (gDW m^{-2}) for each species used in determining intertidal seagrass meadow community density.

Density	***H. uninervis***	***H. ovalis***
Light	< 1	< 1
Moderate	1–4	1–5
Dense	> 4	> 5

2.3.3 Biomass interpolation raster

This raster shows an inverse distance weighted (IDW) interpolation applied to seagrass above-ground biomass point data (using the site layer) and percent cover to describe spatial variation across seagrass meadows.

2.4. Drone mapping

Seagrass drone monitoring was established at Beryl's Beach, Point Parker and Albert River on Gangalidda Garawa Country in October 2024. The Beryl's Beach and Point Parker locations were selected because they were within large seagrass meadows mapped during helicopter surveys and located close to the field ranger base. The Albert River mouth location was chosen because of the risk to the meadow of impacts from discharge from the Albert River. It was accessible by boat through the river channel. In 2025, two additional drone locations were established at Karumba Point and the Norman River; sites were again selected based on accessibility from shore or by boat.

A DJI Mavic 3 Enterprise was used to capture imagery. All flight plans were set to achieve image capture with 80% side-lap and front-lap. The altitude used for Beryl's Beach and Point Parker was 37 m (1 cm/pixel resolution), and 30 m at Albert River (0.85 cm/pixel resolution). At Karumba Point and Norman River, altitudes of 50 and 43 m were used, respectively (1.3 and 1 cm/pixel). These settings were selected to ensure mapping could be completed within the tidal window, while still producing images that were both easily processed and of high enough resolution to detect seagrass where coverage exceeded ~5%. Images captured at each site were processed into orthomosaics (stitched maps made from the photographs) using Agisoft Metashape.

Spot-check (field validation) data were collected using DJI Mavic 3 Enterprise and the Litchi app. Ideally, at least 30–40 evenly distributed, water/ glint free, spot-checks are collected within each orthomosaic area to capture variability in seagrass cover and support map development. A total of 38 spot-checks were completed at Albert River, 38 at Beryl's Beach, 40 at Point Parker, 102 at Karumba Point and 46 at Norman River. Spot-checks were captured by positioning the camera directly downward and taking images approximately 1 m above the ground. However, at the Albert River site, spot-checks did not fully align with the orthomosaic extent due to technical issues and therefore only spot-checks are presented in the results.

Each geotagged spot-check image was cropped to eliminate edge pixels. The resulting cropped images (photoquadrats) covered the same area as the quadrats used for helicopter-based seagrass surveys (0.25 m²). There were one to nine photoquadrat replicates collected per spot-check. All individual photoquadrats were assessed for seagrass percent cover and species composition. Data from replicate photoquadrats at each spot-check site were then aggregated by calculating the mean of numerical variables.

Seagrass extent was estimated using several methods. The Point Parker and Norman River meadows were manually drawn in QGIS through visual interpretation of orthomosaics, informed by the in-situ spot-check data. The Beryl's Beach meadow was created via an AI segmentation model (Unet), where we first created meadow segmentation polygons in areas with in-situ data in QGIS and then used them to train the segmentation model and predict seagrass presence on a pixel level over the whole orthomosaic. The prediction results were visually cleaned for artifacts and converted to a smooth polygon layer. Seagrass extent for the Albert River and Karumba Point monitoring locations could not be estimated due to extremely low and sparse seagrass cover.

3. Results

The southern Gulf of Carpentaria supports diverse marine and coastal habitats, including seagrass meadows, algal beds and benthic invertebrate communities (Figure 8).

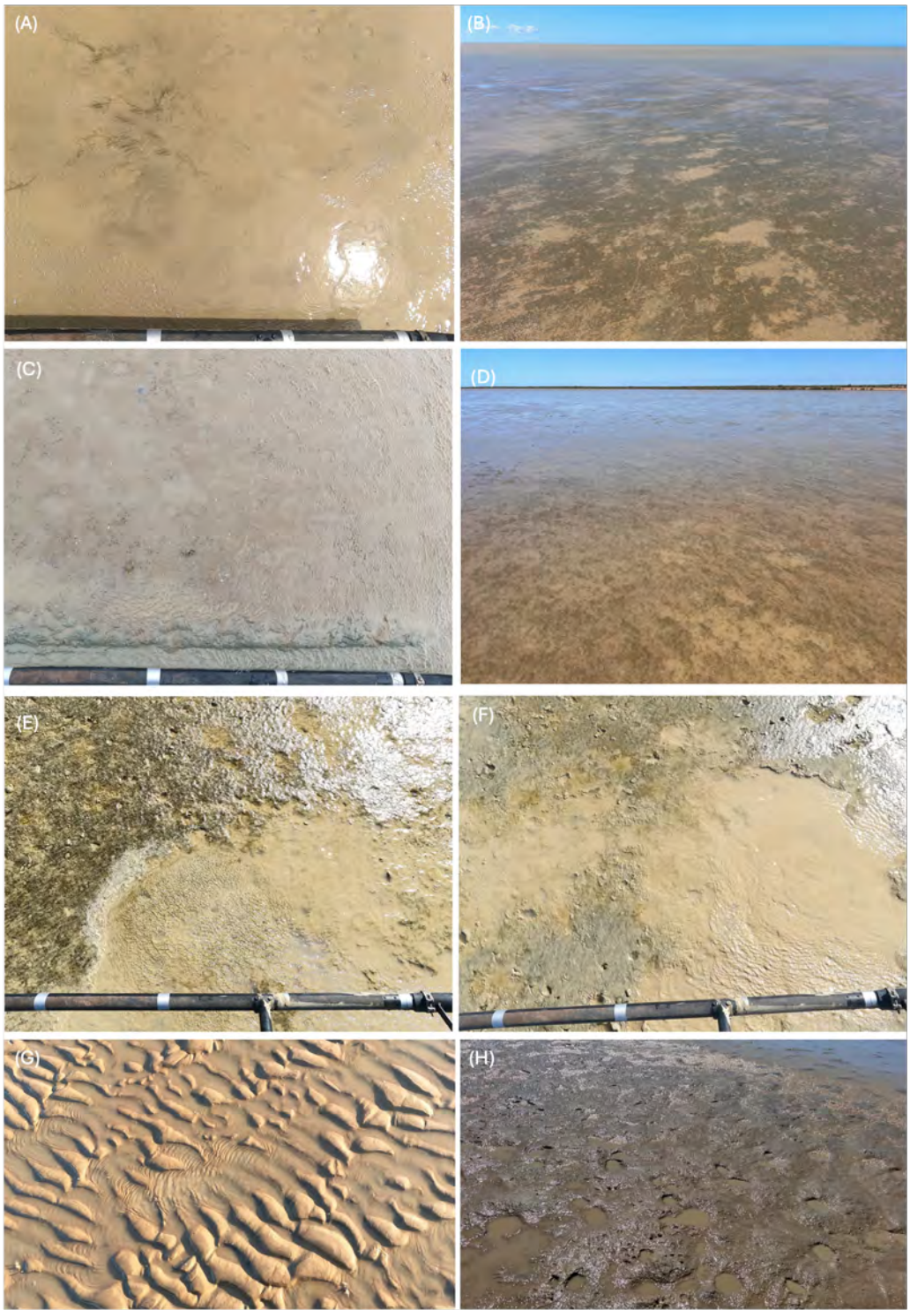


Figure 8:
Habitats observed during surveys included
A) seagrass *H. uninervis* fragmented in Karumba,
B) *H. uninervis* meadow,
C) *H. ovalis* near Karumba,
D) *H. uninervis* meadow between Point Parker and Beryl's Beach,
E) filamentous algae near Karumba,
F) benthic microalgae near Karumba,
G) sand ripples (open substrate) and,
H) mud banks with mud skipper holes.

The majority of sites were a combination of mud and sand substrate. Mud was dominant at 48% of sites particularly between the Albert River and Karumba. Sand was dominant at 17% of sites, mostly between the Northern Territory border and Albert River section where there was no seagrass. Approximately 20% of sites also included either shell, rock, rubble or pebbles.

3.1. Seagrass

Seagrass was present at 413 (23%) of 1,764 intertidal sites and was concentrated between Beryl's Beach and the Albert River, and around Karumba (Figure 9, Appendix Figure 1, Appendix Figure 2). There was a long stretch of coastline from Beryl's Beach to the Northern Territory border with no seagrass present, and from the Albert River to the Bynoe River. There were 40 sites where seagrass was present at the site (i.e. within ~10 m diameter area), but no biomass or percent cover was recorded because it was absent from the quadrats. This is common in patchy meadows.

Two seagrass species from two families were identified in this survey: *Halodule uninervis* and *Halophila ovalis* (Figure 10, Figure 11, Appendix Figure 6, Appendix Figure 7). *H. uninervis* was present at 401 sites and the dominant species from Beryl's Beach to the Albert River, and on the Alligator Bank meadow at the Norman River mouth. *H. ovalis* was present at 30 sites with the majority (21 sites, 70%) around Karumba, particularly on Elbow Bank (Figure 10). *H. ovalis* was present at just five sites west of Point Parker.

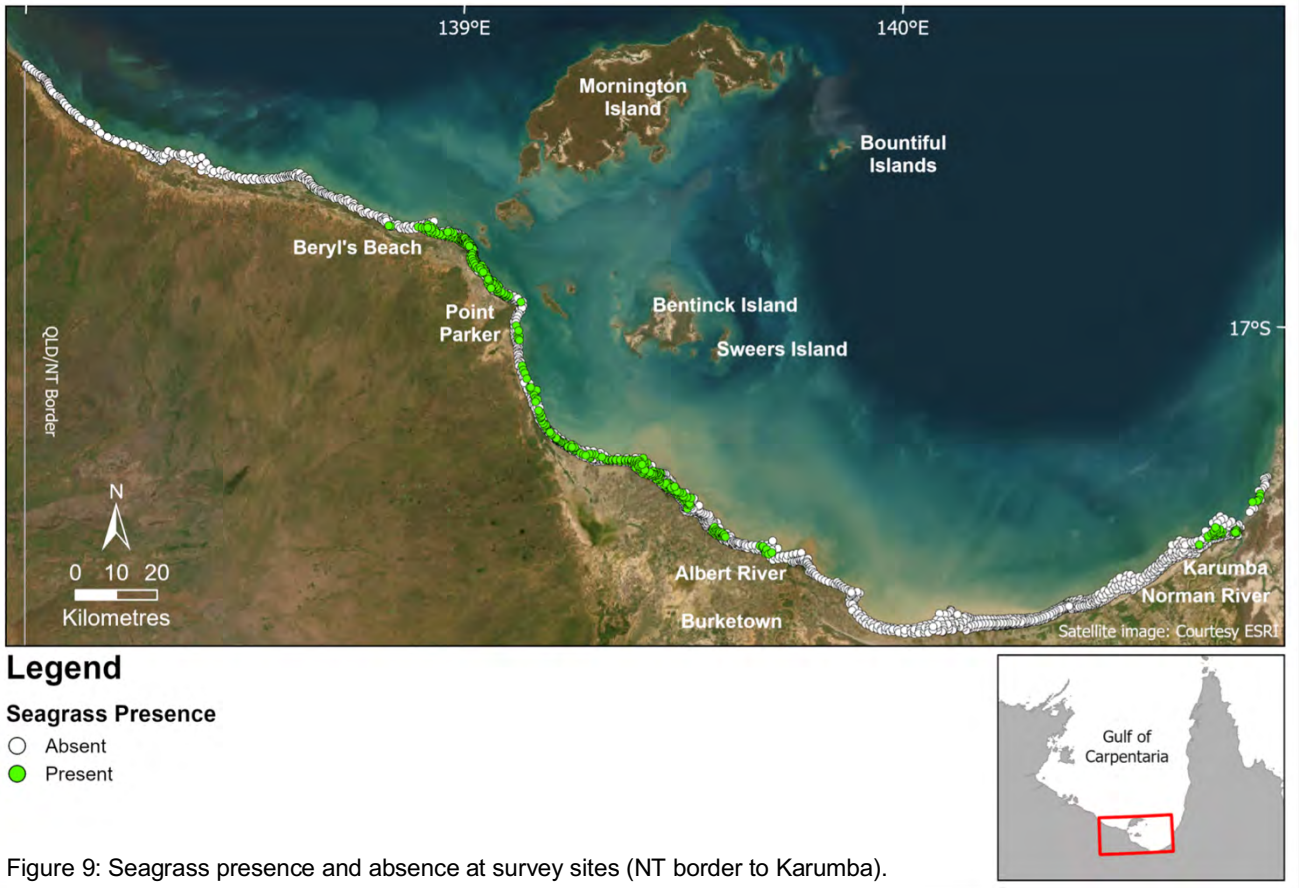


Figure 9: Seagrass presence and absence at survey sites (NT border to Karumba).



Figure 11: Seagrass species present at survey sites (NT border to Karumba).

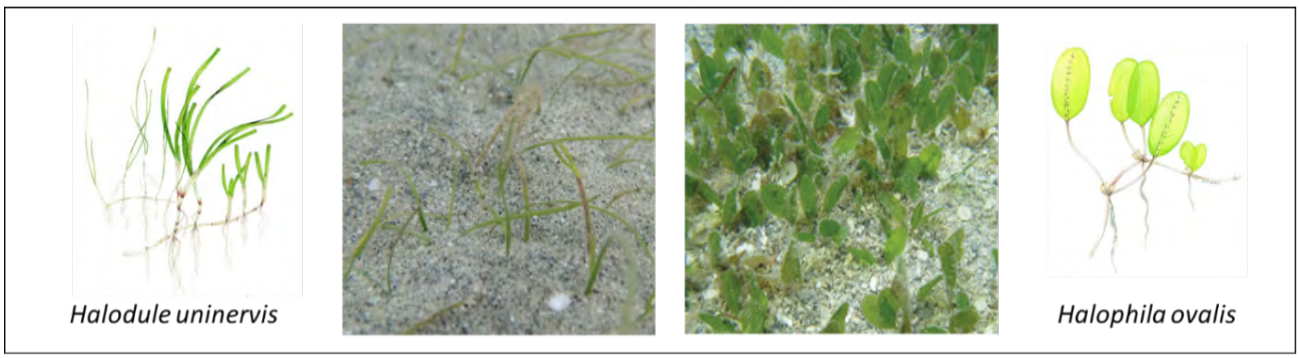


Figure 10: Seagrass species present during surveys.

A total of 6,959 ha of seagrass was mapped across 18 intertidal meadows (Figure 12), with the majority (6,642 ha, 95%) occurring west of the Albert River. The three largest meadows (meadows 6,8,9, Appendix Figure 3) were north-west and south of Point Parker, ranging from 1,021 to 1,372 ha, accounting for more than 50% of the total seagrass area (Figure 13, Figure 14). Other large meadows occurred in the same area, resulting in near continuous seagrass from Beryl's Beach to Point Parker. There was also near-continuous seagrass – only broken by tidal creeks – from south of Point Parker to Gin Arm Creek. Seagrass became more fragmented towards Albert River. On Alligator Bank just west of the Norman River mouth, a small 302 ha meadow was mapped.

Mean meadow biomass ranged from 0.2 to 4.0 g DW m^{-2}. The highest biomass meadow was at Beryl's Beach, one of the most western meadows, followed closely by the adjacent meadow at 3.8 g DW m^{-2}. Biomass of meadows near Karumba were all low (0.2–0.3 g DW m^{-2}). There were two 'meadows' that were detected through remote sensing, but the seagrass was patchy. No seagrass was recorded in quadrats for biomass estimates, although one of them had *H. uninervis* present at the site.

H. uninervis was the dominant species in all meadows except the small meadow on Elbow Bank in Karumba. Site biomass of *H. uninervis* ranged from 0.005–14.5 g DW m^{-2} with a mean of 0.5 g DW m^{-2}, and *H. ovalis* biomass ranged from 0.03–2.0 g DW m^{-2} with a mean of 0.006 g DW m^{-2} (Figure 13). Mean percent cover ranged from 0.3–56.7%, with a mean of 9.3% for both species combined (Appendix Figure 3, Appendix Figure 4, Appendix Figure 5). Percent cover was not assessed for each species individually. The mean percent cover at sites with seagrass cover was 9.6% for meadows around Gangalidda Garawa and 5.6% for meadows near Karumba.

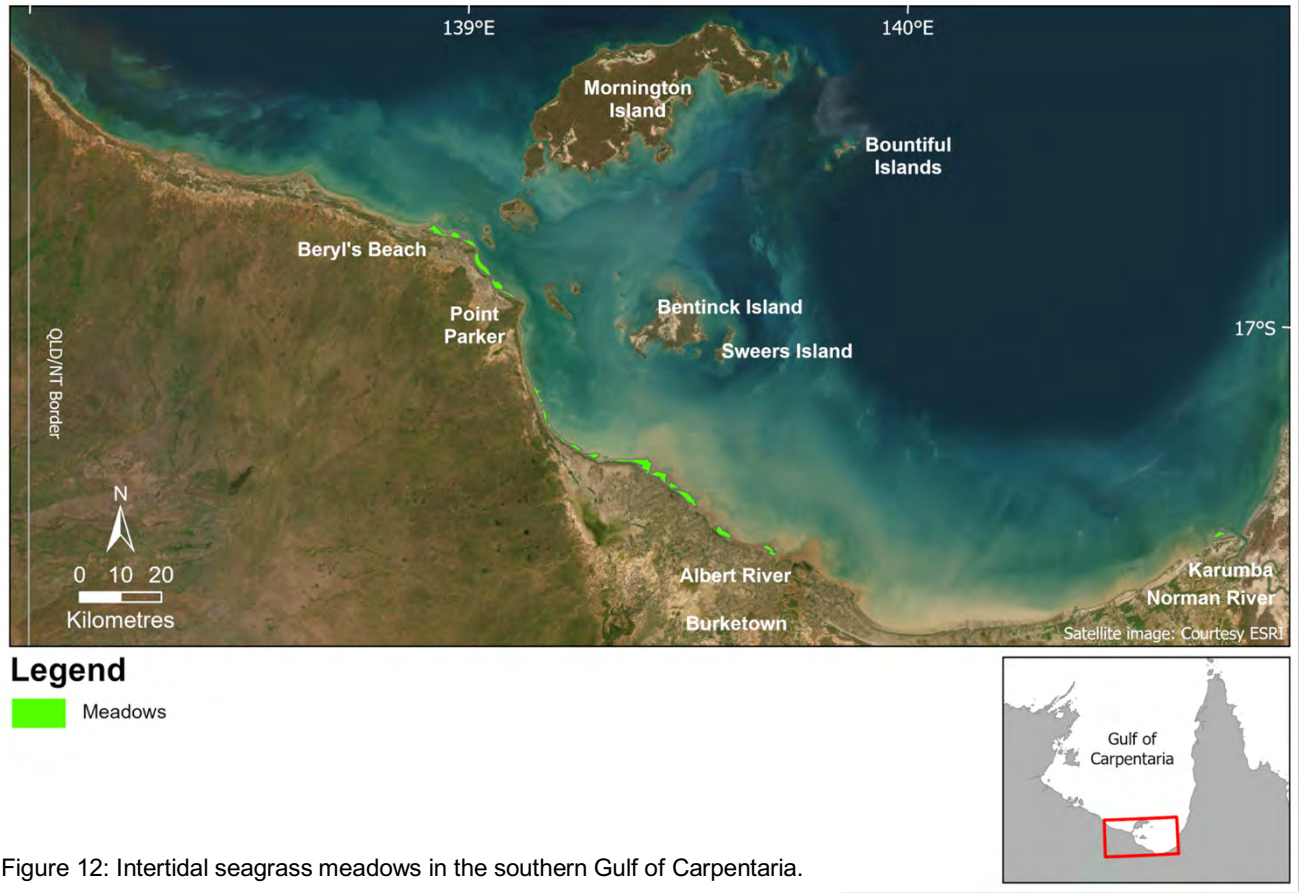
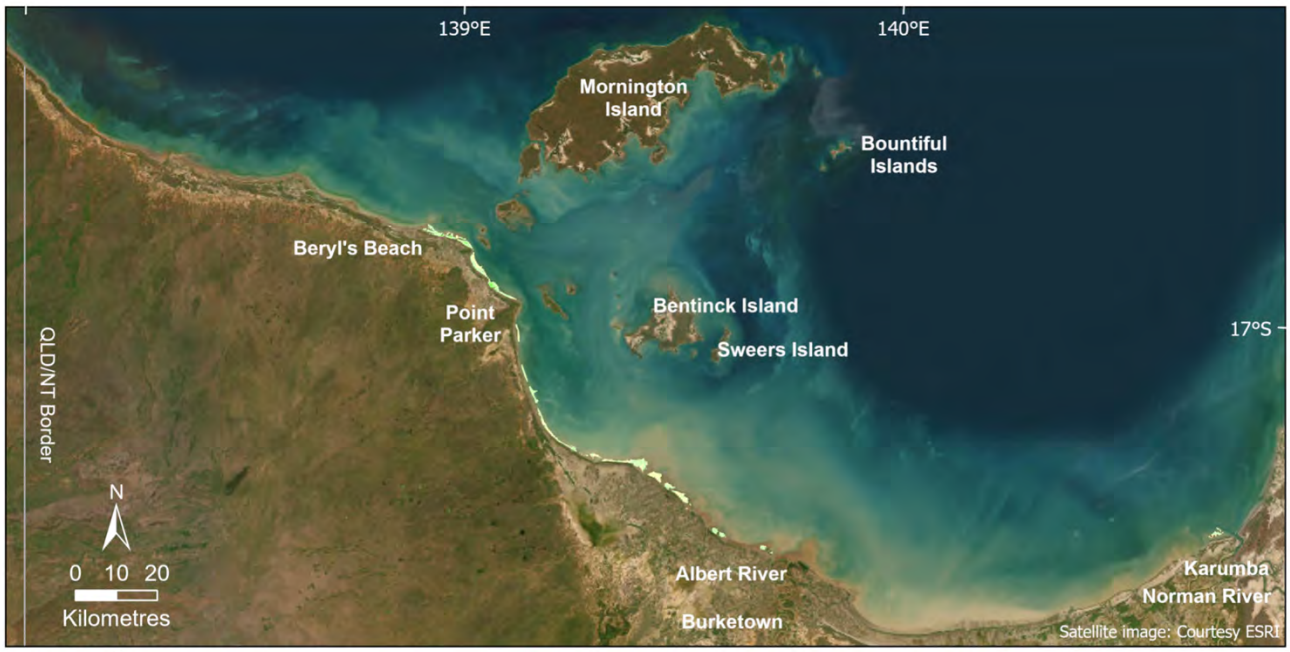


Figure 12: Intertidal seagrass meadows in the southern Gulf of Carpentaria.



Legend

Seagrass biomass g DW m^2

- 0 - 0.01
- 0.01 - 1
- 1 - 5
- 5 - 10
- 10 - 20



Figure 13: Intertidal seagrass biomass variation across meadows.



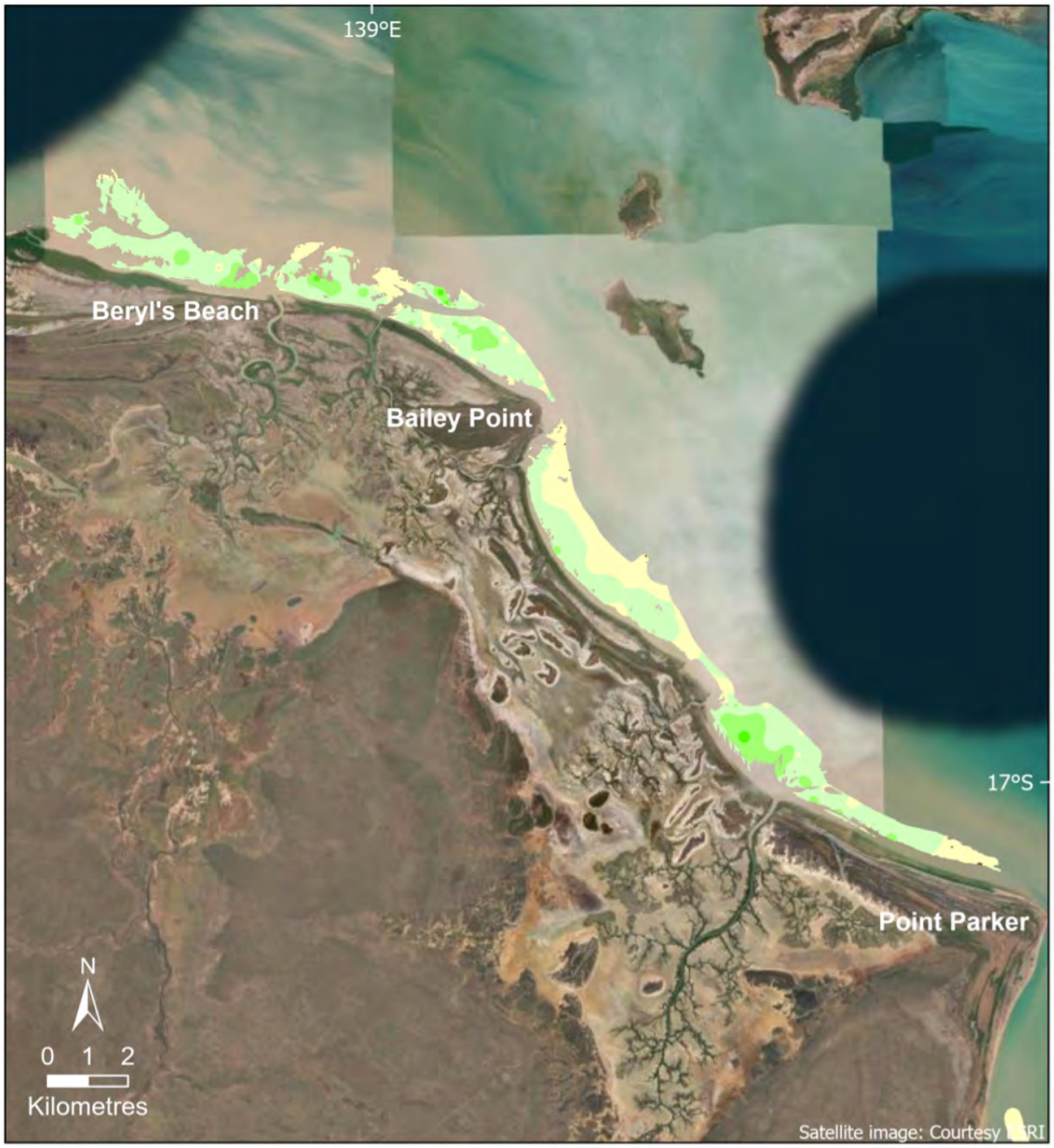
Legend

Seagrass biomass g DW m^2

- 0 - 0.01
- 0.01 - 1
- 1 - 5
- 5 - 10
- 10 - 20



Figure 14: Intertidal seagrass biomass variation from south of Point Parker to the Albert River.



Legend

Seagrass biomass g DW m^2

- 0 - 0.01
- 0.01 - 1
- 1 - 5
- 5 - 10
- 10 - 20

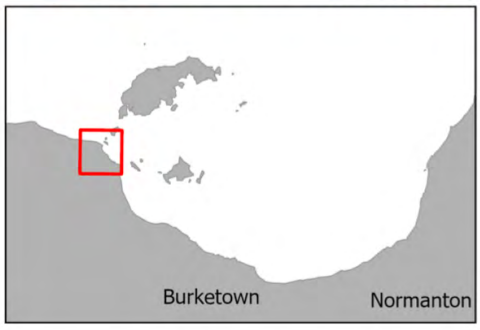


Figure 15: Intertidal seagrass biomass variation from Beryl's Beach to Point Parker.

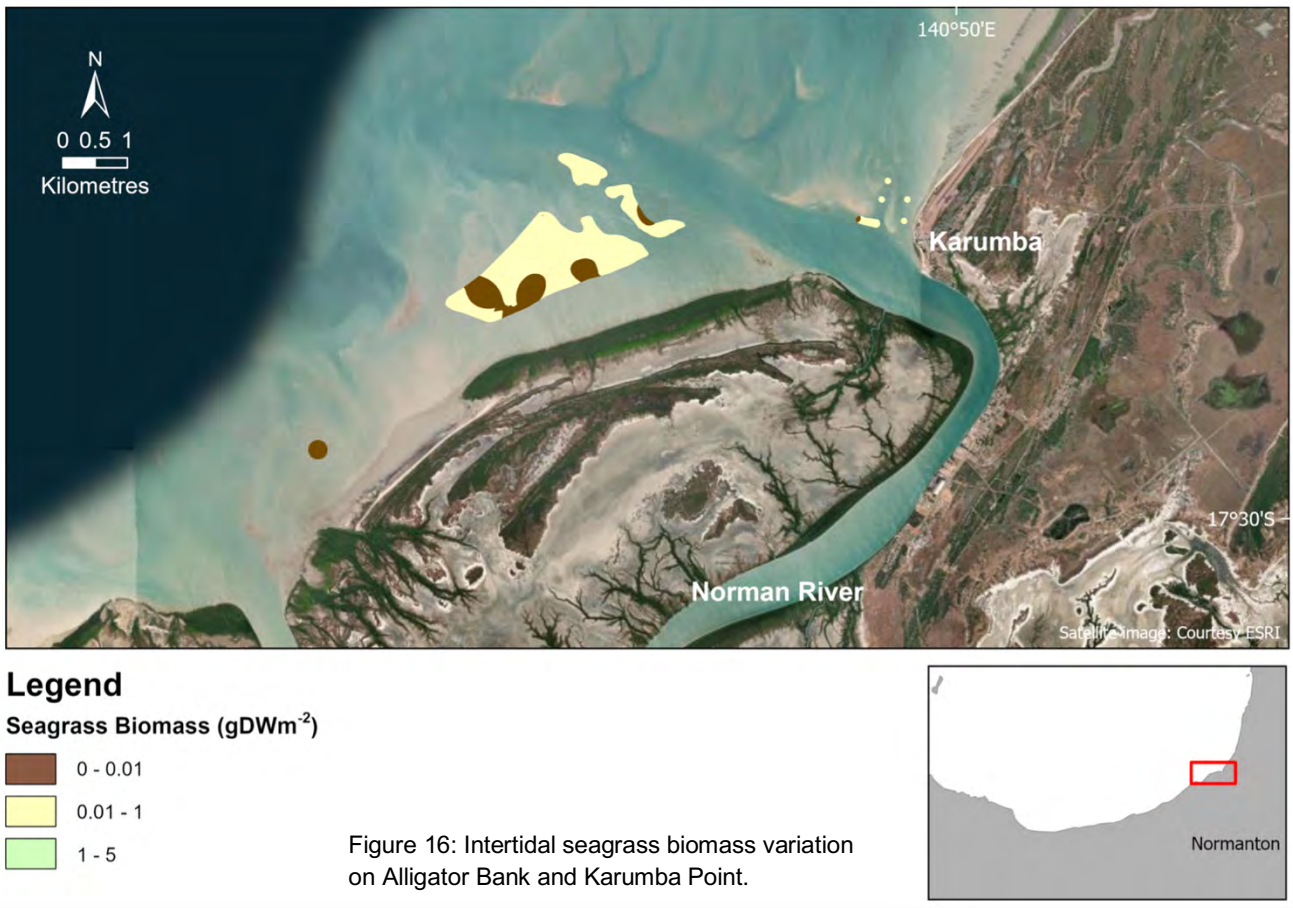


Figure 16: Intertidal seagrass biomass variation on Alligator Bank and Karumba Point.

Dugong feeding trails were observed at 103 sites in the Gangalidda Garawa area (Figure 17, Figure 18). Around Karumba it was difficult to distinguish feeding trails in the highly fragmented meadows, and none were recorded. Dugongs were recorded at 18 sites, though not associated with a meadow. The majority of these were towards the Northern Territory border where no intertidal seagrass was observed.

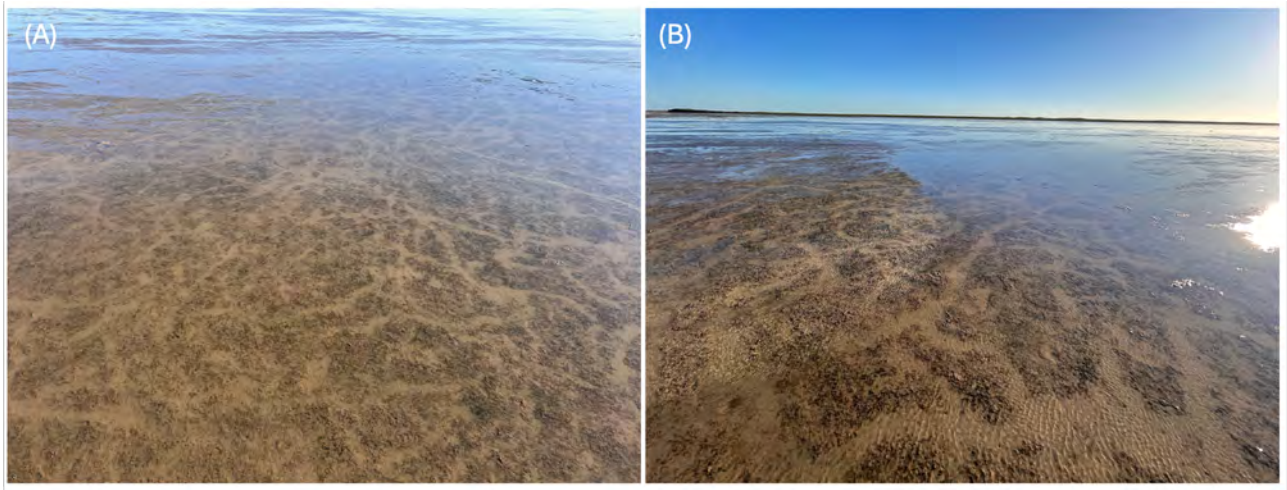


Figure 17: Dugong feeding trails were visible from the helicopter during intertidal surveys at Tarrant Point north-west of the Albert River.

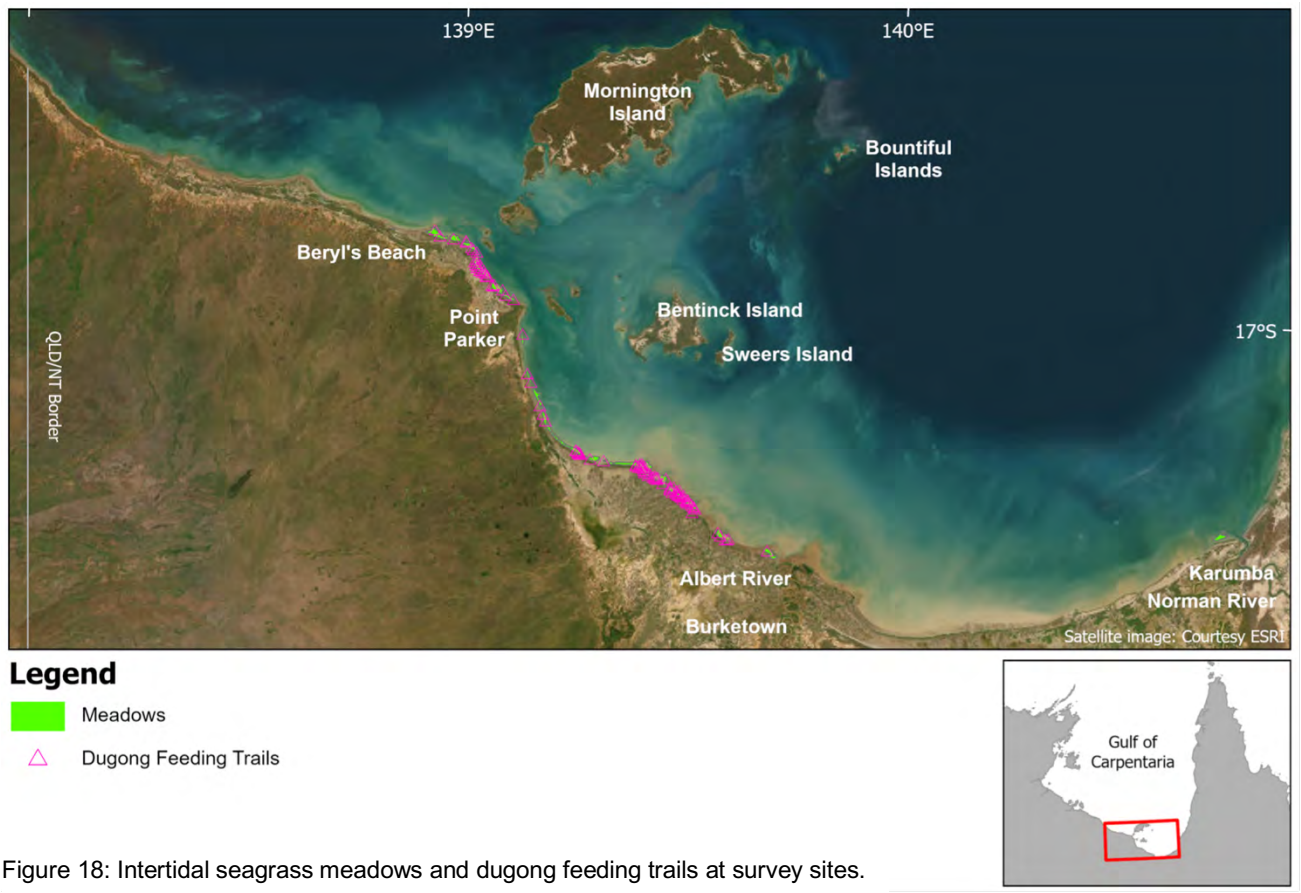


Figure 18: Intertidal seagrass meadows and dugong feeding trails at survey sites.

3.2. Macroinvertebrate and algal communities

There were a range of alga types observed across the survey area. Microalgae were the most common and were recorded at 401 sites between Disaster Inlet and Karumba, with a mean cover of 56% when it was observed (Figure 19).

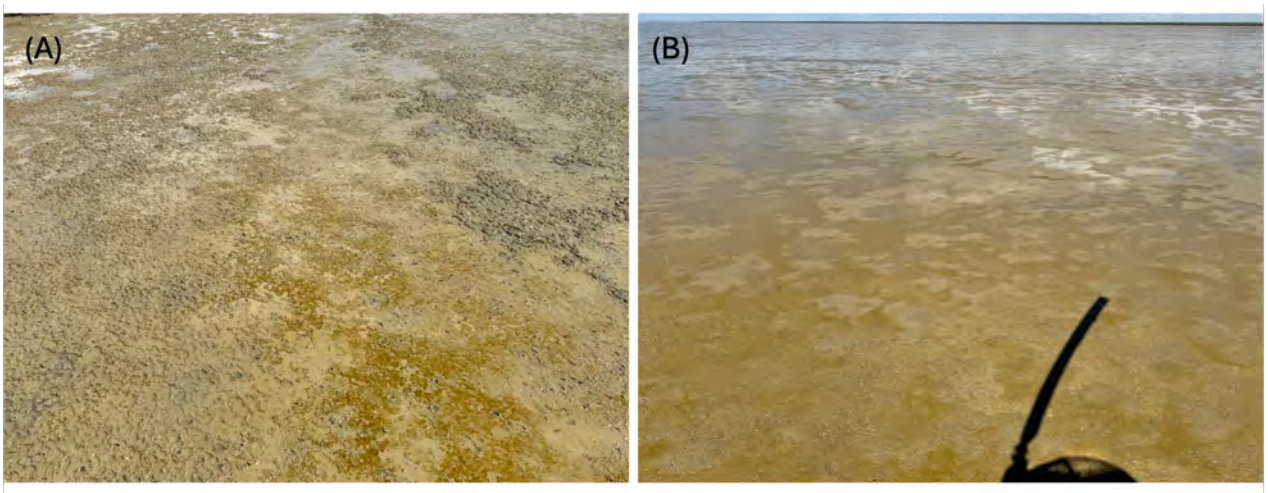


Figure 19: Benthic microalgae form the slime-like layer over the mud that gives it a green-brown hue.
A) Close-up view and B) a zoomed-out view showing that it is very extensive.

Filamentous algae were recorded at 120 sites, with the highest cover of 90% in the meadow adjacent to the Albert River mouth. Benthic microalgae associated with mud habitat were the most common algal group, recorded at 507 sites (29%) with a mean cover of 47% when present (Figure 20) Turf (61 sites), erect macroalgae (12 sites) and encrusting algae (2 sites) were less common, and no erect calcareous algae were recorded (Figure 20).

Benthic macroinvertebrates were recorded at 21 sites with up to 38% cover, and included oysters (Figure 21).



Figure 20: Algae cover and composition at survey sites.

Other observations included sea snails (gastropod molluscs) and sea stars. There was a high density of tracks through the mud on the banks from the Albert River to Karumba that appeared to be caused by baler shells (Figure 22). There were also sections with a high density of mudskippers (Figure 23). Although these tracks and holes were common, they were not quantified.

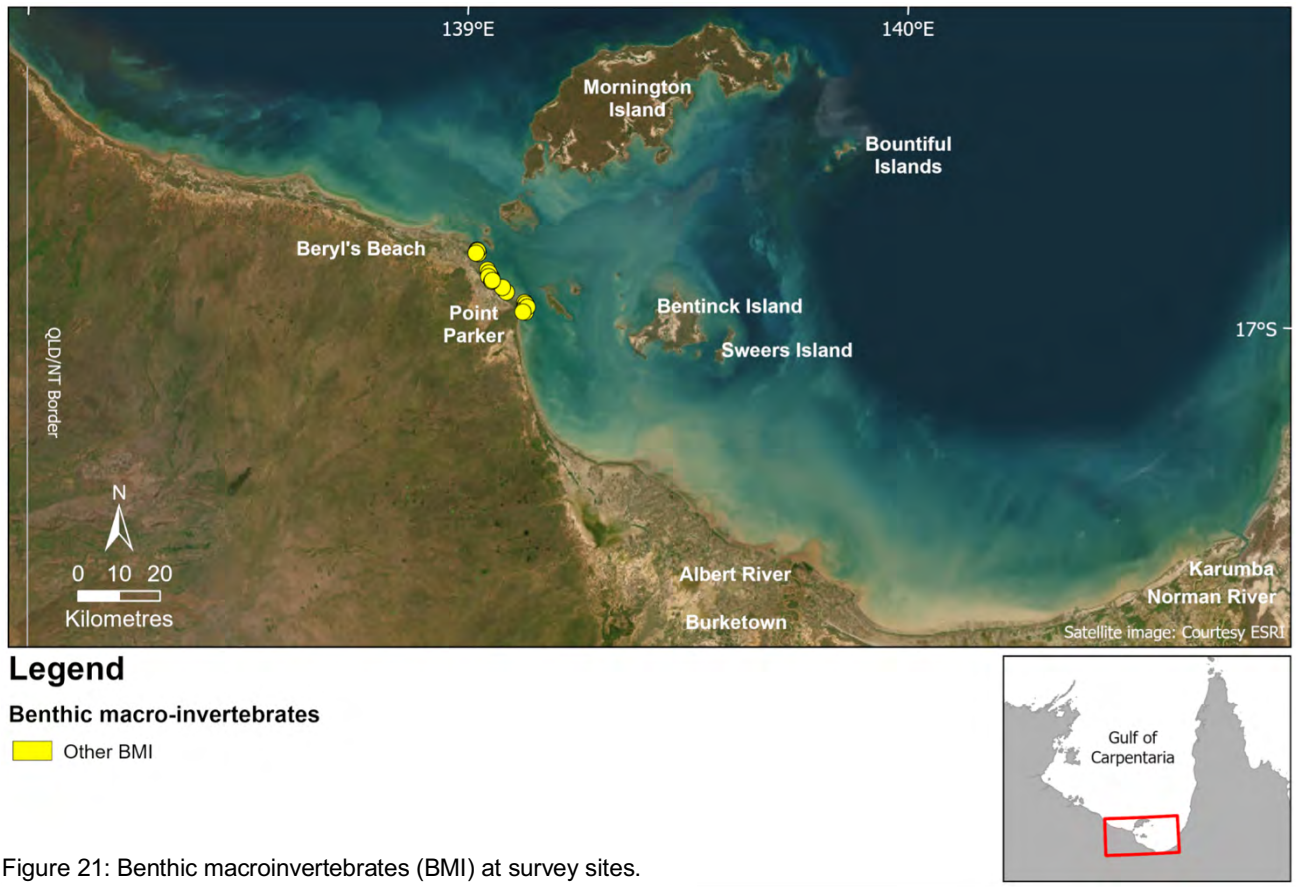


Figure 21: Benthic macroinvertebrates (BMI) at survey sites.

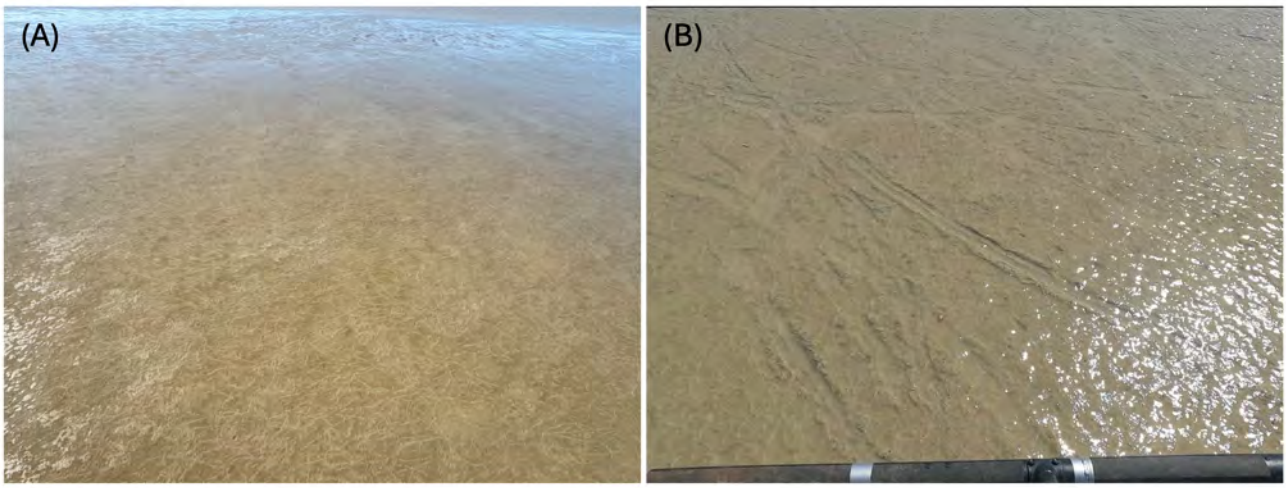


Figure 22: Baler shell tracks in the mud banks between the Albert River and Karumba.

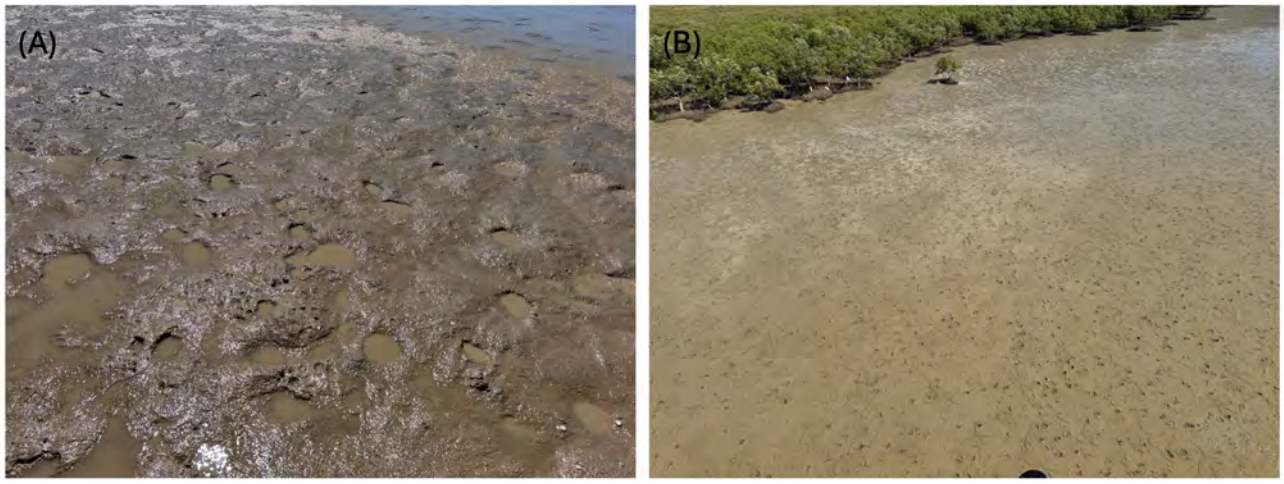


Figure 23: Signs of mudskippers (A) west of Beryl's Beach and (B) midway between Albert River and Karumba.

3.3. Drone monitoring

3.3.1 Gangalidda Garawa

Two seagrass species were identified during the Gangalidda Garawa drone surveys*: H. uninervis* and *H. ovalis*. *H. uninervis* was dominant across all sites, with *H. ovalis* recorded at only one spot-check at Beryl's Beach (Table 5, Figure 24).

The highest average seagrass cover – calculated from spot-checks where seagrass was present – was at Point Parker (17.8%), followed by Beryl's Beach (6.9%) and Albert River (1.1%).

The seagrass at Albert River could not be mapped by drone because it was patchy and had low percent cover. The mapped seagrass meadow area was 2.3 ha at Beryl's Beach and 11.9 ha at Point Parker, within drone survey areas of approximately 19.8 ha and 19.1 ha, respectively.

Table 5: Seagrass characteristics at Gangalidda Garawa drone survey sites.

Site	Seagrass species present	All spot-checks % cover mean (± SE)	Spot-check with seagrass only % cover mean (± SE)	Seagrass area (ha)	Drone survey area (ha)
Albert River	*H. uninervis* (100%)	0.8 ± 0.3	1.1 ± 0.4	n/a	19.0
Beryl's Beach	*H. uninervis* (99.9%), *H. ovalis* (0.1%)	4.2 ± 1.3	6.9 ± 2.0	2.3	19.8
Point Parker	*H. uninervis* (100%)	14.7 ± 1.8	17.8 ± 1.7	11.9	19.1

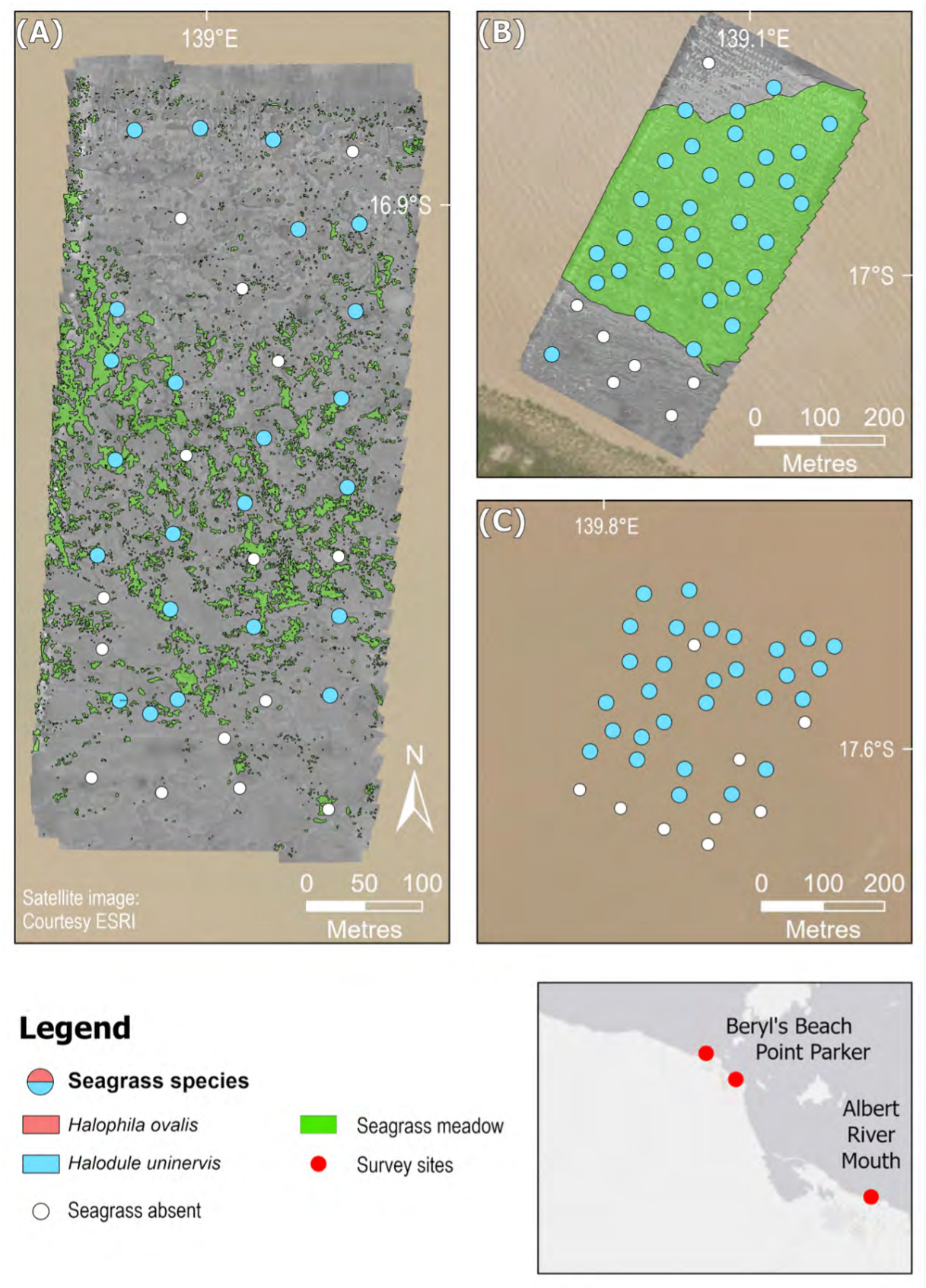


Figure 24: Seagrass species composition from spot-checks and meadow extent for three Gangalidda Garawa drone survey sites (A) Beryl's Beach, (B) Albert River mouth, and (C) Point Parker. Note that orthomosaic was not usable at Albert River mouth and therefore meadow extent could not be determined.

3.3.2 Piiju Karumba Point and Alligator Bank

Two seagrass species were identified during the Karumba drone surveys: *H. uninervis* and *H. ovalis*. At Karumba Point, both species were recorded in equal proportions across the seagrass-present spot-checks. At Alligator Bank, *H. ovalis* was dominant, contributing 92% of the average species composition, with *H. uninervis* contributing 8% (Table 6, Figure 25).

Seagrass was present at 2 of 96 usable spot-checks at Karumba Point and 41 of 45 usable spot-checks at Alligator Bank.

Alligator Bank had the highest average seagrass cover in the spot checks (5.7%), followed by Karumba Point (4.0%) (Table 6). The seagrass could not be mapped at Karumba Point because the seagrass was very patchy and had low percent cover. The mapped seagrass meadow area at Alligator Bank was 32.4 ha, within a drone survey area of approximately 43.9 ha.

Table 6: Seagrass characteristics at Karumba Point and Alligator Bank drone survey sites.

Site	Seagrass species present	All spot-checks % cover mean (± SE)	Spot-check with seagrass only % cover mean (± SE)	Seagrass area (ha)	Drone survey area (ha)
Karumba Point	*H. uninervis* (50%) *H. ovalis* (50%)	0.1 ± 0.1	4.0 ± 3.0	n/a	42.6
Alligator Bank	*H. ovalis* (92%) *H. uninervis* (8%)	5.2 ± 0.6	5.7 ± 0.6	32.4	43.9

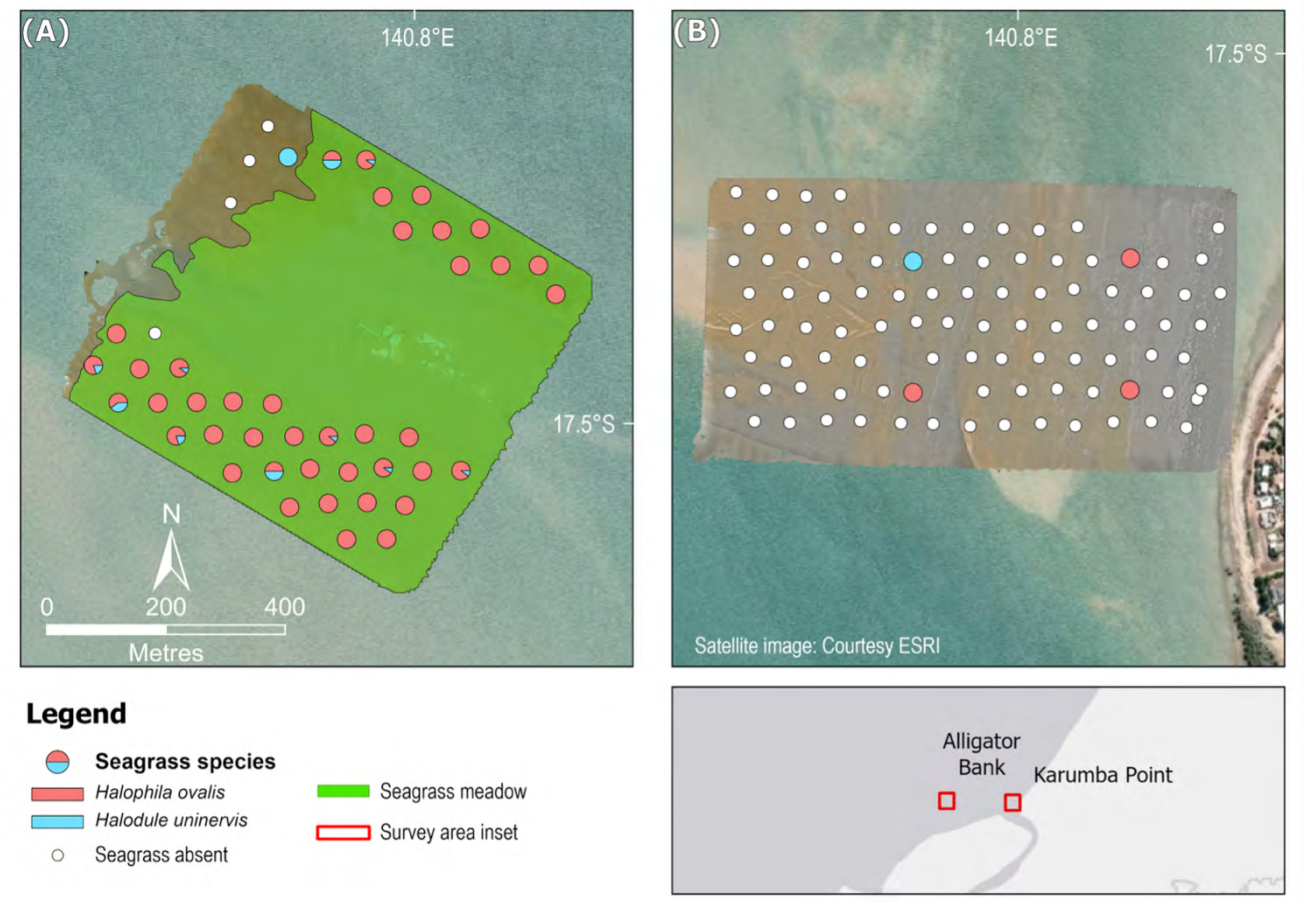


Figure 25: Seagrass species composition from spot-checks and meadow extent for two Karumba drone survey sites at (A) Alligator Bank and (B) Karumba Point. Note that meadow extent at Karumba Point could not be determined due to the very low seagrass cover.

4. Discussion

4.1. Seagrass meadows of the southern Gulf

This project has filled a critical information gap in the southern Gulf of Carpentaria by mapping intertidal benthic habitats from the Northern Territory border to Karumba. This, combined with previous surveys (Proctor et al. 2025) completes over 500 km of high-resolution seagrass surveys for the Queensland southern Gulf extending from the border to the Staaten River (Figure 26, Appendix Figure 8).

The historical composite meadows are similar in distribution to the recently mapped meadows around Point Parker and Beryl's Beach (Figure 27) which had some of the highest biomass of the meadows mapped in recent surveys. Advances in survey methods, GPS accuracy and the use of remote sensing paired with high-density in-situ observations have resulted in higher-resolution contemporary maps compared to the historical composite for this region. This provides a substantial baseline for establishing ongoing monitoring in these meadows. A further consistency between the historical and recent data is the absence of seagrass from the Albert River to the Bynoe River.

There are also some notable differences in the recent maps compared to historical data. The recent surveys identified near continuous, albeit low density, seagrass from south of Point Parker to the Albert River, punctuated by breaks where tidal creeks discharge into the coast. Seagrass was identified in the historical data along that coastline, but the density of survey points was low, and

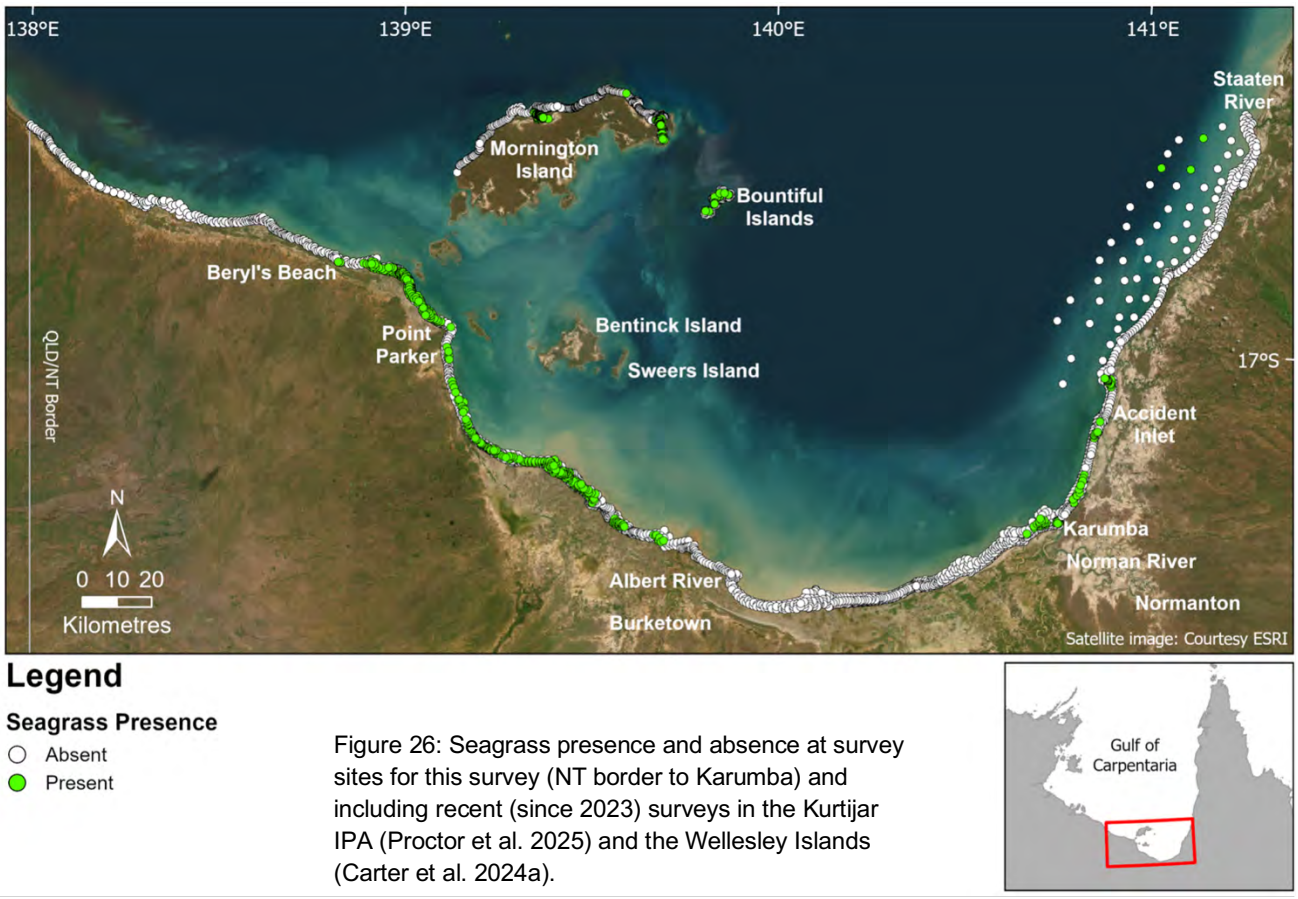


Figure 26: Seagrass presence and absence at survey sites for this survey (NT border to Karumba) and including recent (since 2023) surveys in the Kurtijar IPA (Proctor et al. 2025) and the Wellesley Islands (Carter et al. 2024a).

meadows couldn't be drawn from that data with confidence. The additions to the mapped meadows were mostly around John's Creek and to the north.

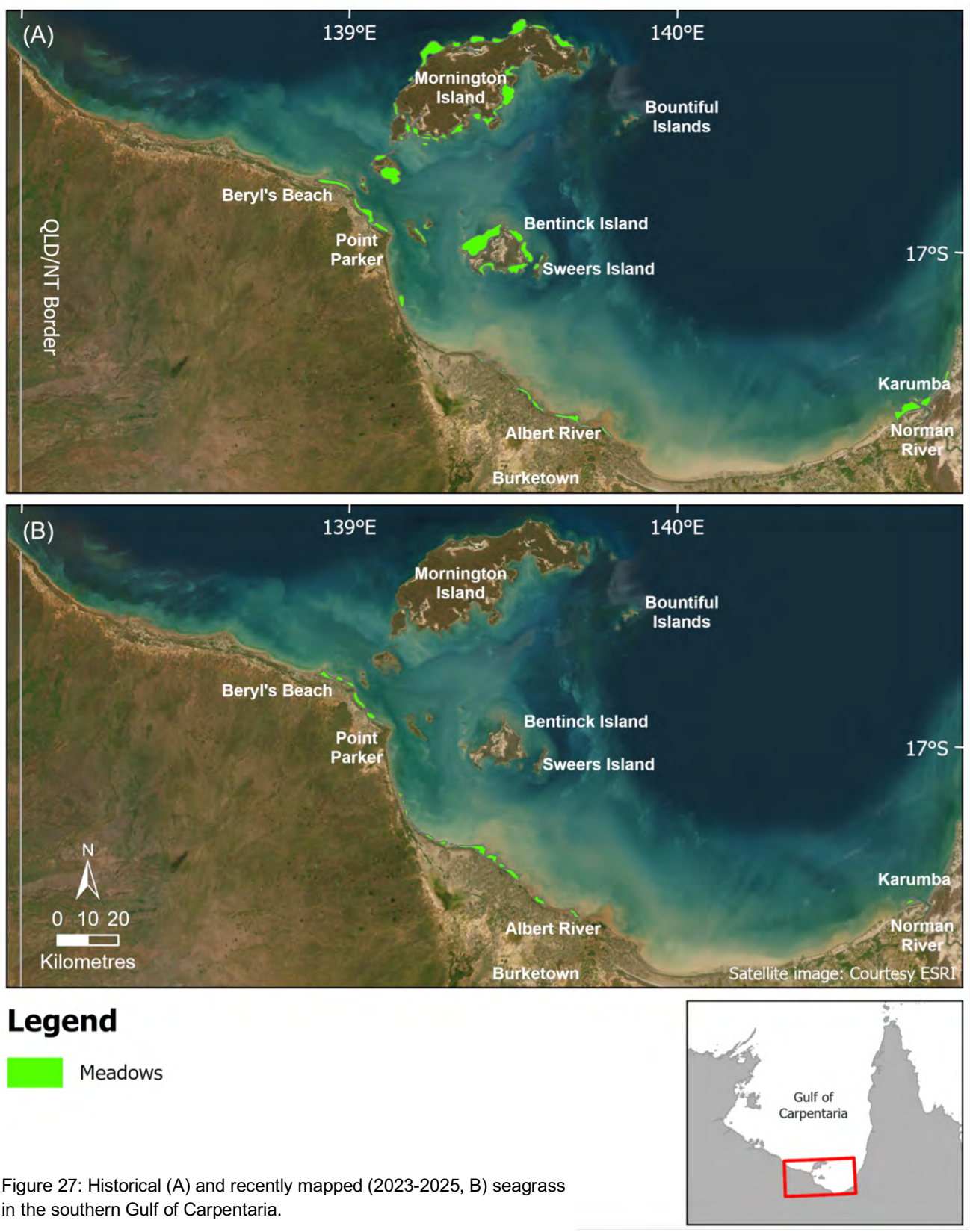


Figure 27: Historical (A) and recently mapped (2023-2025, B) seagrass in the southern Gulf of Carpentaria.

The meadow on Alligator Bank was in poor condition for biomass and extent in 2025 based on long-term monitoring for the Port of Karumba (Scott and Rasheed 2026). The Elbow Bank meadow, which does not form part of the annual monitoring program and was last mapped in 2024, had also contracted to 1 ha in 2024 from 567 ha in 2021 when it was last mapped (Scott and Rasheed 2025). This decline was caused by several years of above-average river discharge, and potentially high levels of tidal exposure (Scott and Rasheed 2026). These meadows are highly variable through time and have demonstrated the capacity to recover in the past. This decline in seagrass around Karumba may be indicative that seagrass habitats in the southern Gulf are also in a poor state. Therefore, it is important to consider this data as a 'baseline' from which either recovery or further decline can occur.

The low-density seagrass meadows we mapped were dominated by *H. uninervis*, with *H. ovalis* occurring less frequently and generally at low biomass. This species composition is consistent with the tolerance of these species, particularly *H. uninervis*, to turbid inshore conditions where light availability is often limited (Longstaff and Dennison 1999, Collier et al. 2016). Similar seagrass assemblages have been documented in other muddy, turbid intertidal coastal environments of the Gulf of Carpentaria, including the (in determination) IPA (Proctor et al. 2025), around the Roper River mouth (Collier et al. 2022, Carter et al. 2023a), and in comparable estuarine habitats on Queensland's east coast (Carter et al. 2021).

This survey builds on recent efforts that have greatly expanded our understanding of benthic habitats elsewhere in the Gulf, including new mapping projects in collaboration with Traditional Owners and rangers in the Kurtijar IPA (Proctor et al. 2025), Wellesley Islands (Carter et al. 2024b), the Gulf of Carpentaria Marine Park (Collier et al. In prep-a), Kaurareg and Angkamuthi Sea Country in West Cape York (Carter et al. 2023b, Carter et al. 2026a), Marra Sea Country (Collier et al. 2022, Smith et al. 2025), Yanyuwa Sea Country (Groom et al. 2023), and South East Arnhem Land (Carter et al. 2023a, Carter et al. 2025) in the Northern Territory. A recent data synthesis has also been compiled, making historical data available for the region (Carter et al. 2024a).

4.2. Habitat use

Although seagrass habitats were relatively low in density, they provide important foraging habitat for dugong and turtles, species of high cultural significance. Seagrass habitats across northern Australia occur as a patchwork of meadows rather than a continuous expanse of suitable habitat, meaning that even relatively small meadow systems can have high ecological and conservation value. The mapped intertidal meadows are evidently important feeding habitat for dugongs, as shown by the widespread dugong feeding trails recorded during the 2024 helicopter surveys (Figure 17, Figure 18). Feeding trails were observed at 103 sites across 12 meadows, including several of the largest mapped meadows. Dugongs were also directly observed at 18 sites: four observations occurred near meadow 8, while 14 were recorded outside mapped intertidal seagrass. Marine turtles were observed at six sites, including two within mapped meadows and four outside mapped intertidal seagrass.

Megafauna aerial surveys in 2007 found that dugong density in the Gulf of Carpentaria was highest in the south-east Gulf, particularly in offshore waters around the Wellesley Islands (Marsh et al. 2008a) where extensive seagrass habitats also occur (Carter et al. 2023c). Aerial surveys of the Gulf of Carpentaria were conducted in late 2025 to enable comparison with the 2007 baseline;

preliminary results indicate a reduction in the Queensland Gulf population, although the formal analysis and reporting was not available at the time of writing (Groom, pers. comm).

During both the 2024 seagrass surveys and the 2007 megafauna surveys (Marsh et al. 2008a) dugongs were observed near the Northern Territory border, where no intertidal seagrass was recorded. These observations suggest that subtidal seagrass may occur in those waters or are a movement corridor between seagrass meadows; subtidal benthic habitat assessments have not yet been conducted to identify whether it may be an area of habitat use.

In Queensland, dugongs are listed as vulnerable to extinction and are listed by the Commonwealth as marine and migratory species under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. Australian waters support a large proportion of the world's dugongs, and the Gulf of Carpentaria remains one of the most important regions for the species in Australia, with an estimated population of ~12,500 individuals (Marsh et al. 2008a).

Green turtles (*Chelonia mydas*) are listed as vulnerable and migratory species in Australian waters under the *EPBC Act*. Green turtles forage in the Gulf's seagrass habitats in high density, and genetic studies indicate that Gulf populations are distinct because individuals tend to remain within the Gulf rather than migrating long distances (Kennett et al. 2004b).

Indigenous peoples of the Gulf have cultural responsibility to care for dugongs and marine turtles in their Sea Country and to ensure the seagrass habitats that sustain them remain healthy (Marsh et al. 2008b, CLCAC and Gkuthaarn and Kukatj Traditional Owners 2014, Gangalidda and Garawa NTAC 2014, CLCAC 2015a). Seagrass diebacks are known to reduce dugong fecundity (Marsh and Kwan 2008), reinforcing the need for integrated regional monitoring of seagrass habitats, dugongs and marine turtles (Marsh et al. 2008a).

The southern Gulf contributes important habitat within this broader Gulf network, supporting the movement and persistence of marine megafauna across northern Australian waters. This underscores the importance of understanding and monitoring the condition of these habitats, as well as the pressures and risks that may affect them, to support informed management and protection of Sea Country.

There were vast mud banks along the coastline, which appeared to support a high level of productivity despite the absence of structural habitat. This was apparent through high density of benthic microalgae and filamentous algae, baler shell tracks and mud skippers.

4.3. Monitoring, pressures and risks

The seagrass distribution maps developed through this project, combined with Traditional Owner knowledge of Sea Country and access logistics, provided the foundation for establishing seagrass monitoring at five locations along the mainland coast. Priority areas were selected based on the presence of intertidal seagrass meadows, known or potential pressures, cultural and ecological importance, and practical accessibility.

Drone surveys were used to map the monitoring focus areas and produce high-resolution orthomosaics of seagrass extent. These products provide a repeatable baseline for detecting future changes in meadow area, fragmentation and condition. They also create opportunities to derive additional indicators from the imagery, including dugong feeding trail intensity (Cleguer et al. 2025)

and meadow fragmentation, which can provide insight into habitat resilience (Unsworth et al. 2015, James et al. 2024).

Drone-based spot checks provide complementary information on seagrass abundance and species composition (Langlois et al. In prep). These spot checks are relatively quick to conduct, can be flown at lower altitude, and may be more practical than full orthomosaic mapping under some weather conditions. Spot checks can also be used independently or to ground-truth orthomosaics, which is particularly important for sparse or low-density seagrass that may be difficult to detect from orthomosaic imagery alone.

Continuation of annual monitoring at these sites will help identify local changes in seagrass extent, density, and species composition over time. Larger regional surveys by helicopter or boat require greater investment but could be repeated every three to five years to assess whether changes detected at monitoring sites are representative of broader regional trends.

Although late wet season monitoring may be of interest for understanding seasonal stress and post-flood seagrass condition, suitable tides are generally limited until later in the year. As a result, monitoring is likely to remain focused on the late dry season, which is also consistent with established seagrass monitoring programs across northern Australia (Scott and Rasheed 2025, Carter et al. 2026b, McKenzie et al. 2026).

The southern Gulf remains data-poor compared with many other coastal regions, limiting the ability to explain changes in benthic habitats and associated fauna. Integrating seagrass monitoring with environmental data collection, including flood plume mapping, water quality, turbidity, temperature and light availability, would improve understanding of the drivers of change. This information would help Traditional Owners, Rangers and managers detect early warning signs and respond to pressures affecting coastal ecosystems.

Establishing monitoring between Karumba and the Smithburne River has been identified as a next step for the Kurtijar IPA and would involve the Normanton Rangers (Proctor et al. 2025). Initial access-scoping indicated that routine coast-based drone monitoring would be difficult because of shoreline access constraints and the distance of meadows from the beach for drone pilots. These areas may be better suited to vessel-based monitoring using drop cameras during high tides, supported by targeted drone surveys where conditions and access allow.

Although the Gulf remains relatively remote, its Sea Country ecosystems are influenced by local and regional pressures. Climate change is expected to affect marine habitats through rising sea temperatures, sea-level rise, altered rainfall patterns, and changes in the frequency and intensity of extreme weather events and effects on water quality (Fabricius et al. 2025). These pressures may affect the distribution, condition and resilience of seagrass meadows and the species that depend on them (Collier and Waycott 2014, Collier et al. 2017, Collier et al. 2018, Olsen et al. 2018, Said et al. 2026). For example, intertidal seagrass meadows may also be exposed to thermal stress during low tides, when plants can experience elevated air and sediment temperatures (Collier and Waycott 2014). These effects may be intensified during marine heatwaves and can contribute to declines in seagrass condition where exposure is prolonged. Potential future changes in seagrass extent and composition need to be developed to provide flexibility in planning and policy, and to support evidence-based decisions on resource management (Unsworth et al. 2019).

Seagrass habitats are particularly sensitive to changes in water quality and light availability (Bainbridge et al. 2018, Collier et al. 2024). Increased sediment loads, turbidity, and nutrient inputs can reduce light reaching the seabed, limiting seagrass growth and recovery. Across northern Australia, large rainfall and flood events have been associated with seagrass declines due to reduced water clarity and prolonged light limitation (Collier et al. 2012, McKenzie et al. 2026).

Continued monitoring will be important for identifying these changes and understanding how seagrass habitats recover after disturbance.

4.4. Recommended next steps

Improving knowledge of coastal ecosystems is increasingly important as environmental pressures intensify. The habitat data collected during this project provides an important baseline for Gulf communities to support Sea Country planning, management and monitoring. Baseline habitat information helps identify areas of ecological and cultural importance and supports decisions about monitoring priorities, protection, and sustainable use of marine resources.

A monitoring program has now been established that balances safety, accessibility, ranger capacity and the need to track key habitats over time. Continuing to monitor seagrass condition including extent, density, species composition will provide an important indicator of coastal ecosystem health.

Future monitoring should continue to integrate Traditional Owner knowledge with scientific approaches, ensuring that monitoring reflects both cultural priorities and ecological processes.

Key recommendations include:

1. Continue Ranger-led annual seagrass monitoring at established sites
2. Repeat broader regional seagrass surveys every three to five years, where resources allow
3. Complete baseline subtidal habitat mapping of the mainland coast and adjacent islands
4. Establish vessel-based monitoring options for less accessible areas, including between Karumba and the Smithburne River
5. Integrate habitat monitoring with environmental monitoring, including water quality, turbidity, light and temperature measurements
6. Link habitat monitoring with species-focused programs, particularly for culturally important species such as dugongs and green turtles.

Through continued collaboration between Traditional Owners, Rangers, and research partners, these actions will support a long-term, integrated monitoring program that strengthens knowledge, informs Sea Country management, and helps maintain the health of Gulf of Carpentaria marine ecosystems.

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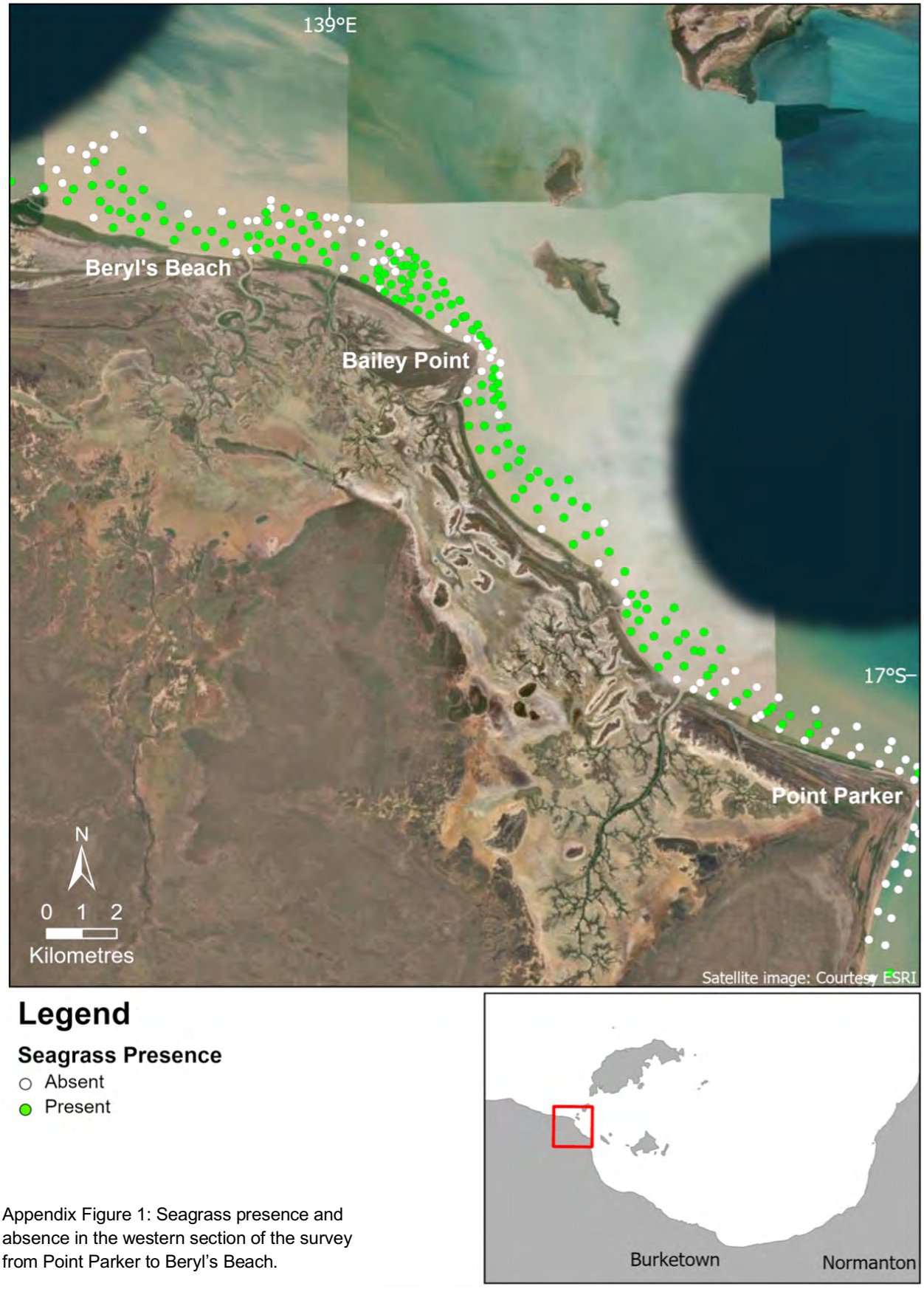
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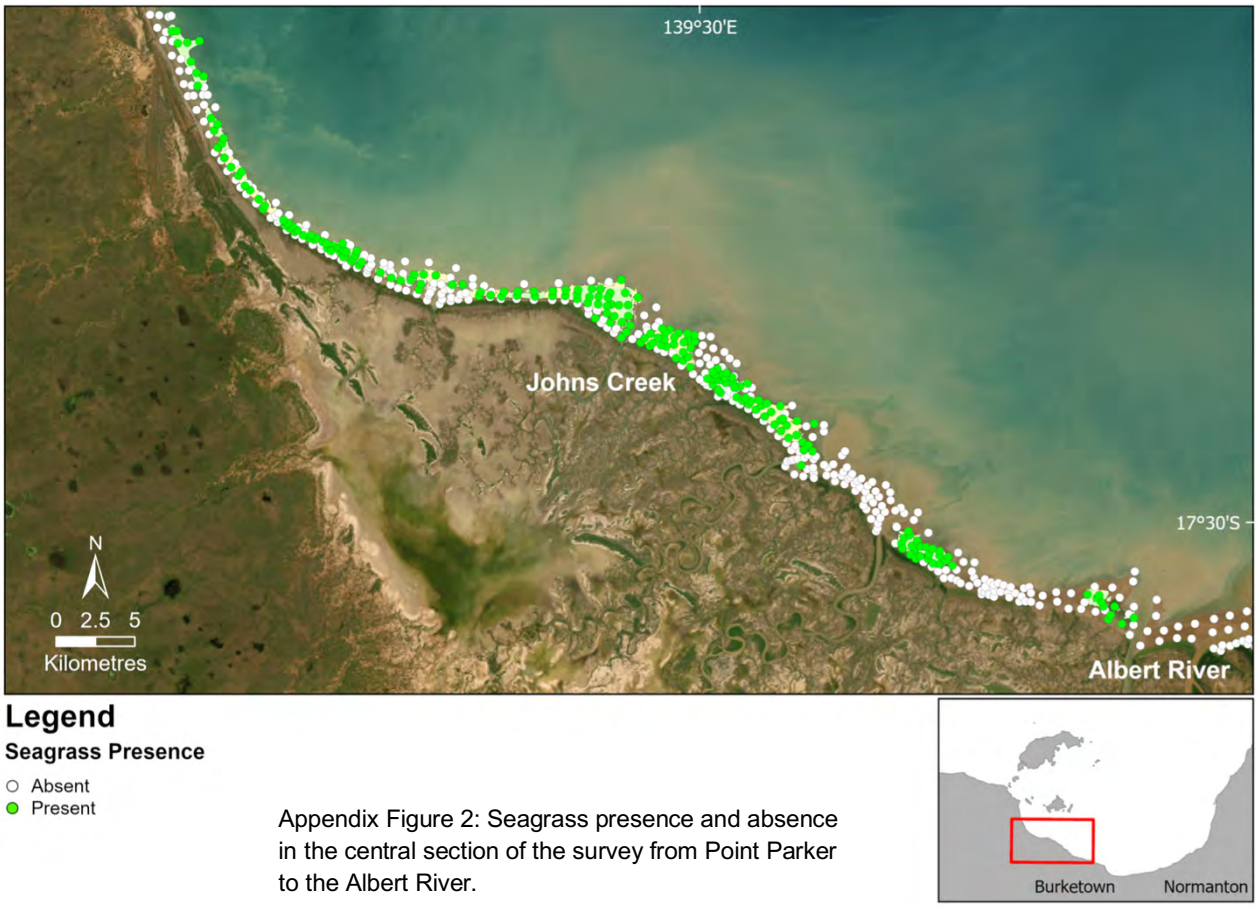
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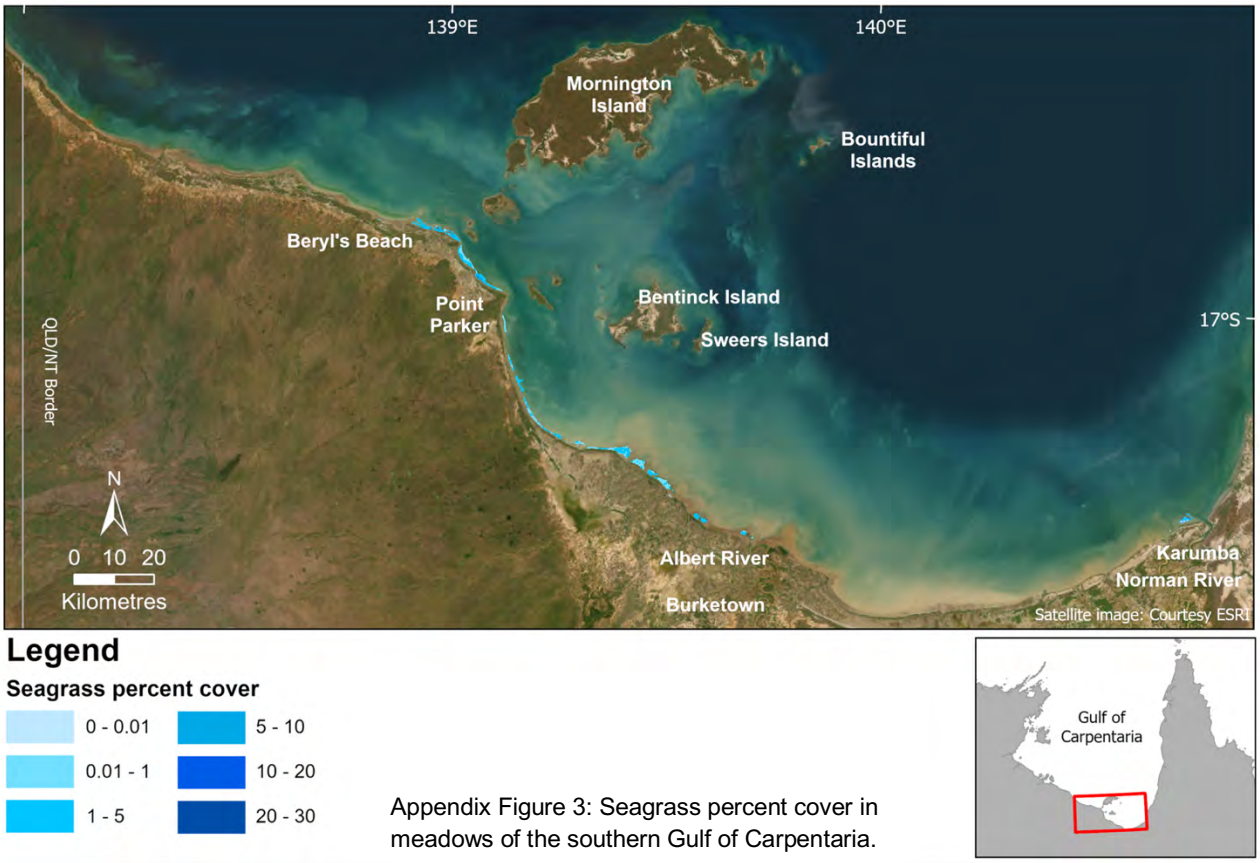
Appendix A: Additional maps



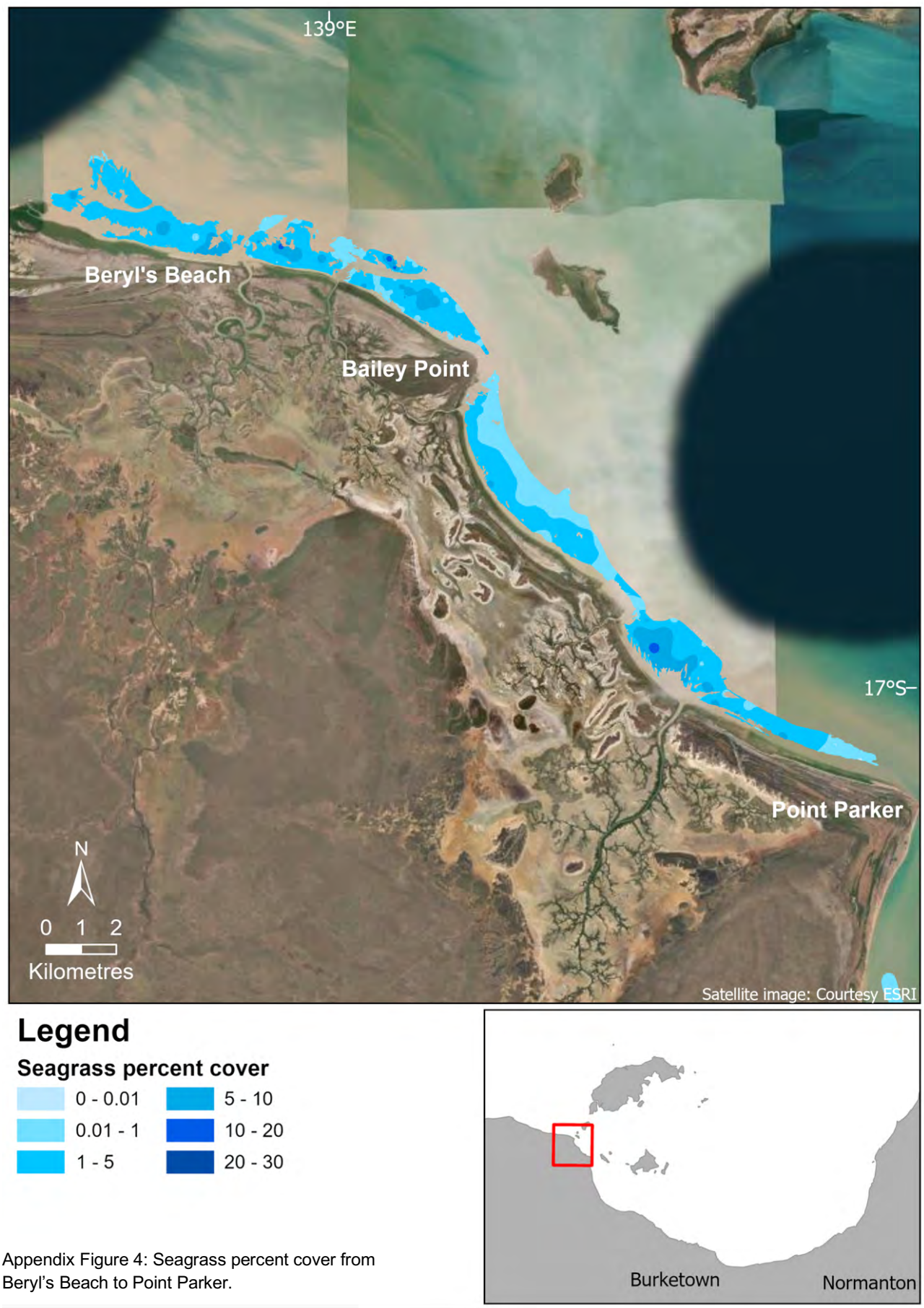
Appendix Figure 1: Seagrass presence and absence in the western section of the survey from Point Parker to Beryl's Beach.



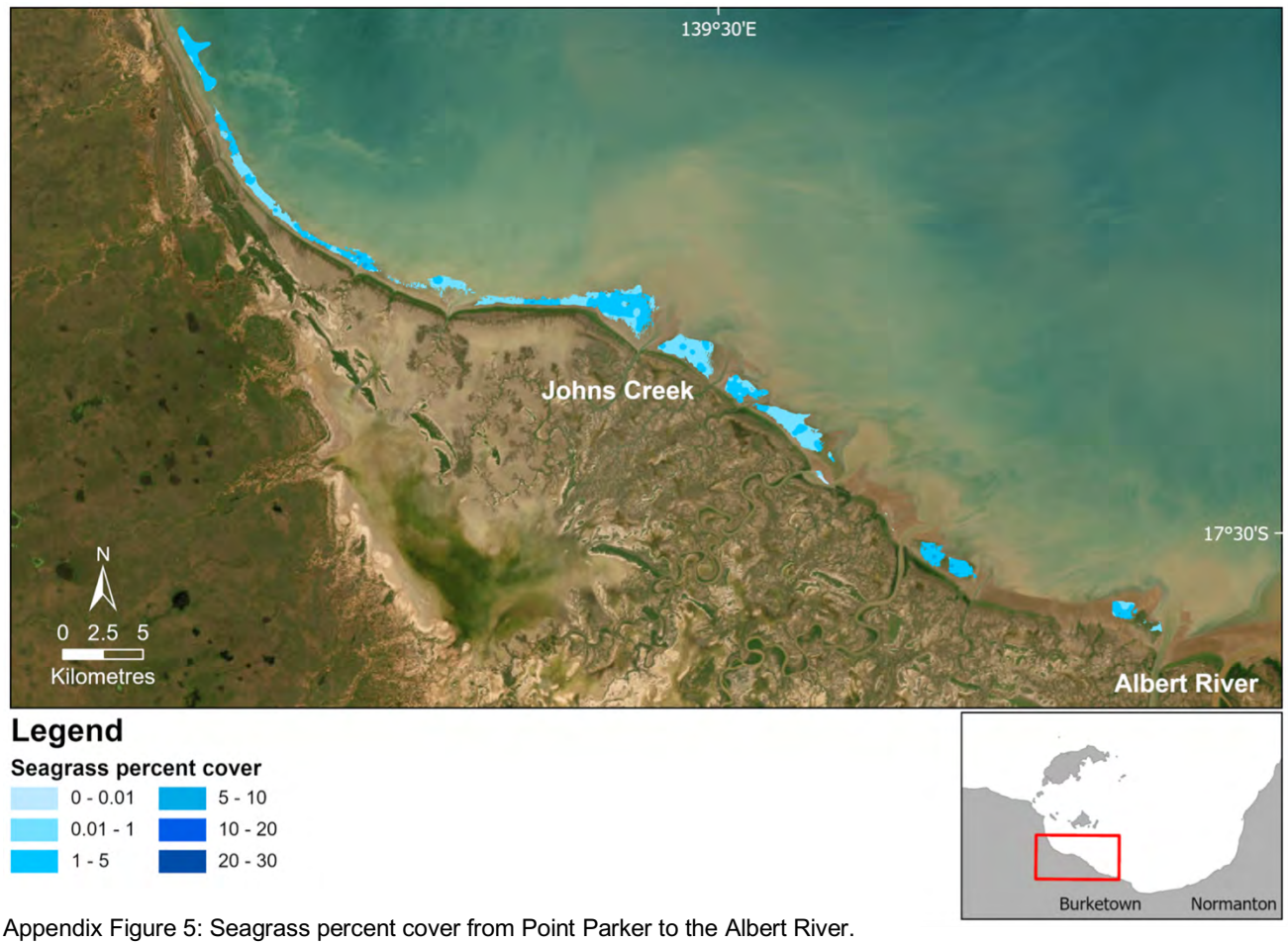
Appendix Figure 2: Seagrass presence and absence in the central section of the survey from Point Parker to the Albert River.



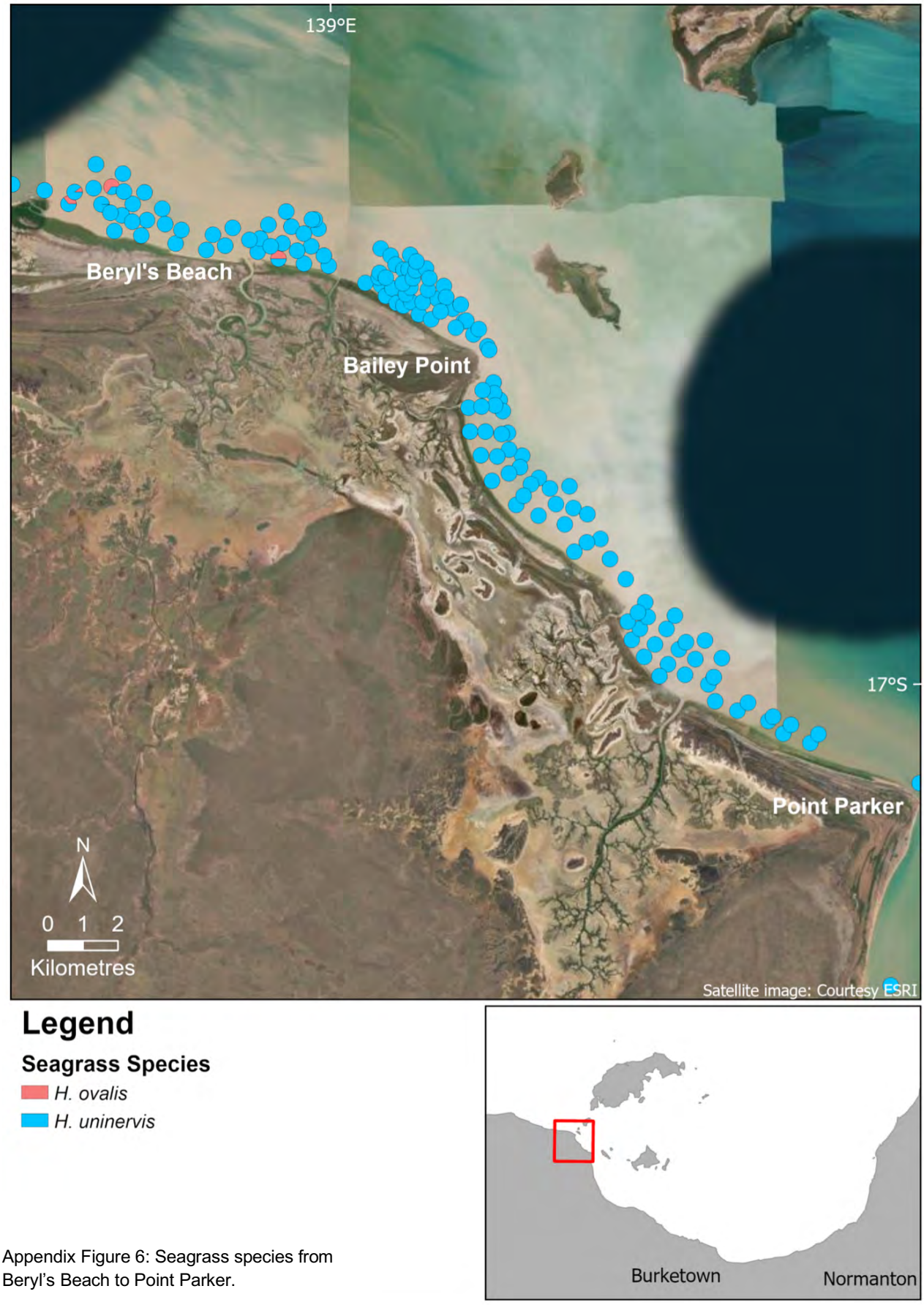
Appendix Figure 3: Seagrass percent cover in meadows of the southern Gulf of Carpentaria.



Appendix Figure 4: Seagrass percent cover from Beryl's Beach to Point Parker.



Appendix Figure 5: Seagrass percent cover from Point Parker to the Albert River.



Appendix Figure 6: Seagrass species from Beryl's Beach to Point Parker.



Appendix Figure 8: Seagrass species from south of Point Parker to the Albert River.



Appendix Figure 7: Seagrass species present at survey sites for this survey (NT border to Karumba) and including recent (since 2023) similar surveys in the Kurtijar IPA (Proctor et al. 2025) and the Wellesley Islands (Carter et al. 2024a).



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Northern Institute People. Policy. Place. | Charles Darwin University Australia | CLCAC Carpentaria Land Council Aboriginal Corporation

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