Marine and Coastal

National Environmental Science Program

RESEARCH REPORT
Project 3.5

SUBTIDAL HABITATS OF SOUTH EAST ARNHEM LAND SEA COUNTRY INDIGENOUS PROTECTED AREA: RANJIYIRRIJT TO NYINPINTI POINT

Carter A, Settli E, Nunggarralu C, Hall D, Pomery L, Ponto S, Harvey-Aziz S, Thompson R, Worramara P, Roy J, Daniels C, Hall D, Collier C, McMahon K, Webster C, Groom R

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This project was undertaken as a collaboration between researchers from TropWATER (James Cook University), Northern Institute (Charles Darwin University), Edith Cowan University, Northern Land Council, Numbulwar Numburindi and Yugul Mangi Land and Sea Rangers, and the Numburindi, Wandarrang, and Marra Traditional Owners of South East Arnhem Land. Surveys were conducted using the following permits: Northern Land Council Work Permit ID #141283, and Northern Territory Government Permit to take wildlife for commercial purposes ID #73281. Human research ethics clearance H24099 was provided through Charles Darwin University. Thanks to the following people and organisations for their tremendous support and input into the planning, logistics and people power required to undertake the field campaign: Northern Land Council, Numbulwar Numburindi and Yugul Mangi Land and Sea Rangers; Numburindi, Wandarrang, and Marra Traditional Owners; Eclipse crew Wade Alleyn, Joe Berwick, Enya Dunn-Trethowan and Jamie Cook; and TropWATER's Lloyd Shepherd and Megan Proctor.

Cover images

Front and back: South East Arnhem Land Sea Country. Credit: JCU TropWATER.

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Acknowledgement of Country

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 Sea Country of the Numburindi, Wandarrang, and Marra peoples. We honour the Traditional Owners of South East Arnhem Land 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

Seagrass meadows across northern Australia provide critical habitat for dugongs, turtles, fish, prawns, and other species of cultural and economic importance. However, data on their extent, condition, and long-term trends remain limited. Few large-scale or long-term monitoring programs exist, meaning regional planning and development decisions often proceed with incomplete information about these ecosystems. NESP Marine and Coastal Hub Project 3.5 – Partnerships for Seagrass Research and Protection – aims to address these knowledge gaps by consolidating existing data, identifying priority areas for new surveys, generating new seagrass and benthic habitat datasets, and improving access to information to support evidence-based planning and management.

This project forms part of that broader effort and was delivered through a collaboration between James Cook University, Charles Darwin University and Edith Cowan University, working in partnership with the Northern Land Council, Numbulwar Numburindi and Yugul Mangi Rangers, and the Numburindi, Wandarrang, and Marra Traditional Owners of South East Arnhem Land.

The South East Arnhem Land (SEAL) coastline extends from the Roper River to Blue Mud Bay along the south-west Gulf of Carpentaria in the Northern Territory. The Numburindi, Wandarrang, and Marra peoples are the Traditional Owners and custodians of this coastal region. The South East Arnhem Land Indigenous Protected Area (SEAL IPA) was declared in 2014 for terrestrial areas, and Traditional Owners are now progressing plans to establish a SEAL Sea Country Indigenous Protected Area (SCIPA).

Between 10–13 October 2023, a total of 151 sites were surveyed using underwater video and van Veen grab sampling between Nyinpinti Point and Ranjiyirrijt Point within the proposed SEAL SCIPA. Surveys were conducted with the Numbulwar Numburindi and Yugul Mangi Ranger vessels *Bambeiliwarr* and *Ngarri Larni*. The survey area supports a rich and diverse marine environment, including extensive seagrass meadows, diverse algal and benthic invertebrate communities, and healthy coral reefs. Six seagrass species were recorded, covering an estimated 19,689 ha, with *Cymodocea serrulata* and *Halodule uninervis* the most common. Coral, sponge, and other benthic assemblages were widespread, while algae occurred at nearly half of all sites. These results highlight the ecological diversity and productivity of SEAL SCIPA's marine habitats and provide an important baseline for future monitoring.

The subtidal habitats described in this report complement intertidal surveys conducted in 2022. Together, they demonstrate that SEAL Sea Country supports highly productive ecosystems that play important roles in sediment stabilisation, nutrient recycling, blue carbon storage, and providing feeding grounds for species such as dugongs and green turtles.

This survey directly addresses a major information gap for SEAL Sea Country under NESP Project 3.5, contributing high-quality spatial data to a northern Australian seagrass inventory. The resulting habitat maps and species information provide essential inputs for Traditional Owners and the Northern Territory Government as they plan and manage the SEAL SCIPA. These data will help communities identify and prioritise areas of cultural, ecological, or resource significance for ongoing monitoring, management, and sustainable development.

1. Introduction

The coastal waters of South East Arnhem Land (SEAL) form part of the Sea Country of the Numburindi, Wandarrang and Marra peoples, whose custodianship extends from the Roper River mouth through to southern Blue Mud Bay in the Gulf of Carpentaria (Tamarind Planning, 2021). This coastline is made up of numerous clan estates, each with deep cultural ties to saltwater places, species and practices (Figure 1).

Established in 2014, the South East Arnhem Land Indigenous Protected Area (SEAL IPA) provides a framework for conserving these values while strengthening cultural authority, training, employment and local governance through the Yugul Mangi and Numbulwar Numburindi Rangers (Tamarind Planning, 2021). Traditional Owners are now progressing the formal dedication of the approved Sea Country extension, which will add more than 10,000 km² to the IPA.

Traditional Owners have identified the Sea Country values they want safeguarded. Key habitats include extensive seagrass meadows, coral communities, rocky reefs, mangroves and near-pristine estuaries, which support culturally and ecologically significant species such as dugong, marine turtles, shellfish, fish, crabs, sea cucumbers, crocodiles and seabirds (Carter et al., 2023a; Duke et al., 2017; Tamarind Planning, 2021). Clean water, cultural privacy and opportunities for sustainable livelihoods are also central priorities (Tamarind Planning, 2021). These values reflect both profound cultural relationships with Sea Country and the region's exceptional biodiversity, including nationally significant migratory species such as dugong, sawfish, dolphins, turtles and shorebirds (Griffiths et al., 2020; Kyne et al., 2018; Tamarind Planning, 2021).

Consistent with their long-standing responsibilities for caring for Sea Country, Traditional Owners have emphasised the need for a strong evidence base to guide management. Up-to-date ecological information supports ranger operations, cultural decision-making, blue-carbon assessments and government planning. However, western scientific knowledge of SEAL's marine ecosystems – particularly seagrass – has been limited, with only older seagrass studies (Poiner et al., 1987; Roelofs et al., 2005). However, dugong surveys (Griffiths et al., 2020) and recent habitat and fish assessments from neighbouring Yanyuwa and Marra Sea Country (Collier et al., 2022; Groom et al., 2023; Smith et al., 2025) suggest SEAL Sea Country forms part of a broader, nationally significant seagrass system.

To begin addressing these knowledge gaps, Traditional Owners partnered with the Numbulwar Numburindi Rangers, Northern Land Council (NLC), James Cook University (JCU) and Charles Darwin University (CDU) to deliver the first IPA-wide intertidal benthic habitat survey in 2022 funded by the Australian Government's Sea Country Indigenous Protected Areas Program. Using helicopter-based assessments, the team surveyed 1,638 intertidal sites, mapped more than 7,800 ha of seagrass across 99 meadows, and identified eight seagrass species (Carter et al., 2023a). This work provided a major step forward, revealing clear regional patterns in seagrass species, widespread algal communities and the distribution of reef and rocky-shore habitats. The findings have already informed Traditional Owner discussions on management priorities and monitoring.

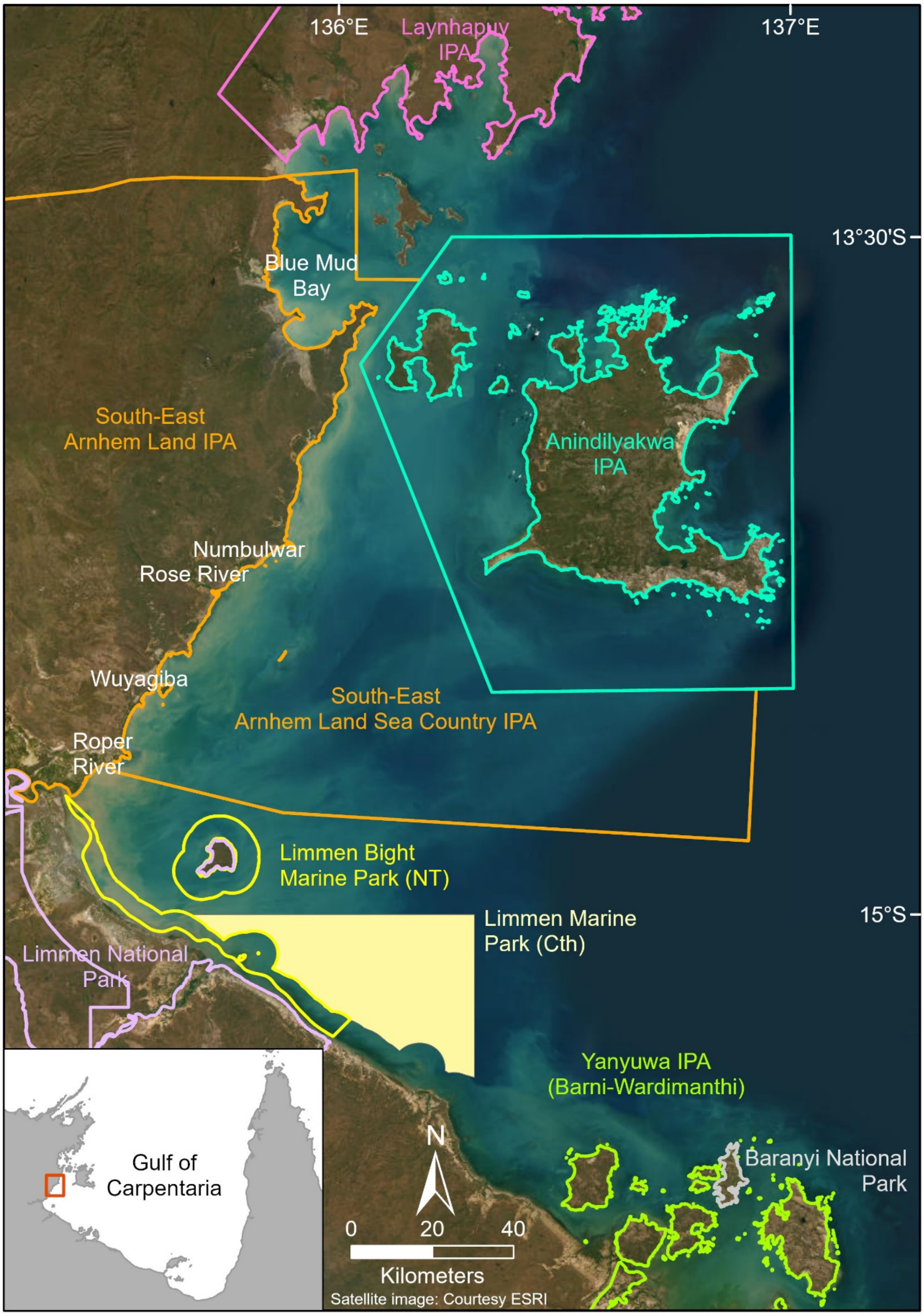


Figure 1: South East Arnhem Land Indigenous Protected Area (IPA) and Sea Country IPA extension, with adjacent protected areas in the Northern Territory Gulf of Carpentaria.

Yet large gaps remained. Adjacent subtidal habitats – where extensive seagrass is expected – had never been comprehensively mapped, limiting the ability of Traditional Owners to evaluate areas of high cultural and ecological importance or to design long-term monitoring programs that integrate cultural knowledge and western science.

To support this need for updated benthic habitat information, the present work was delivered under the National Environmental Science Program (NESP) Marine and Coastal Hub as part of Project 3.5 – Partnerships for Seagrass Research and Protection. NESP 3.5 is a northern Australia–focused program designed to address long-standing data gaps in seagrass distribution, strengthen collaborations with Indigenous ranger groups, and establish the foundations for a ranger-led monitoring network across remote coastal regions (https://www.nespmarinecoastal.edu.au/project/3-5/). The project prioritises mapping seagrass habitats in data-deficient areas, co-designing monitoring approaches with Traditional Owners, trialling new technologies such as drones and drop cameras, and consolidating historical and contemporary datasets into an accessible northern Australia seagrass database.

The SEAL subtidal mapping project forms one of these targeted regional surveys. Co-delivered by JCU, CDU, Edith Cowan University (ECU), the NLC, and the Numbulwar Numburindi and Yugul Mangi Rangers (Figure 2) it provides the first dedicated assessment of subtidal habitats within SEAL Sea Country, focussing on the Nyinpinti Point to Ranjiyirrijt Point area. In line with NESP 3.5 objectives, the project provided updated spatial data for a previously unmapped region, applied methods consistent with broader northern Australian habitat mapping, and produced bilingual maps, GIS products and communication materials co-designed with Traditional Owners. These outputs establish a new ecological baseline for SEAL Sea Country and contribute to the wider NESP effort to build a coordinated, accessible, and culturally grounded foundation for long-term seagrass monitoring across northern Australia.

Figure 2: The 2023 subtidal survey team was a collaboration between researchers and rangers. Pictured left to right: Chanelle Webster (ECU), Rachel Groom (CDU), Lloyd Shepherd (JCU), Wade Alleyn (MV Eclipse), Enya Dunn-Trethowan (MV Eclipse), Alex Carter (JCU), and Numbulwar Numburindi Rangers Clive Nunggarrgalu, Siwa Harvey-Aziz, and Lewis Pomery.

2. Methods

2.1. Survey area

We surveyed subtidal waters between Nyinpinti Point and Ranjiyirrijt Point in the SEAL SCIPA 10–13 October 2023. Surveys were conducted during northern Australia's peak seagrass growth period of spring–early summer (Carter et al., 2022), consistent with NESP 3.5 survey protocols across the region. This timing ensures comparability with the 2022 SEAL SCIPA intertidal survey (Carter et al., 2023a) and with adjacent survey locations in Marra and Yanyuwa Sea Country (Collier et al., 2022; Groom et al., 2023), supporting the broader NESP objective of delivering methodologically consistent habitat datasets across northern Australia.

2.2. Benthic habitat

2.2.1. Observations and sampling

Survey operations were co-delivered using the Numbulwar Numburindi and Yugul Mangi Ranger vessels *Bambeiliwarr* and *Ngarri Larni* (Figure 3) in line with NESP 3.5's emphasis on ranger-led participation. At each site, site number, time, latitude and longitude, and sediment type were recorded. Depth in metres below mean sea level (MSL) for each site was extracted from the 250 m Australia bathymetry raster (Beaman, 2023). Where more than one sediment category was recorded, categories were listed from most to least dominant. Observations of dugong, dolphins or turtles made in proximity to a site were also recorded.

Drop video

Benthic habitat video footage was recorded using an underwater camera (SpotX) (field of view: 0.25m^2) attached to a metal frame at approximately 0.5 m off the ground, with the camera facing straight down. A cable attached to the camera relayed footage to a computer screen on board to allow for real-time observation (Figure 3). At each site, the camera and frame were lowered to the seafloor 3 times with a 1–2 metre drift between each replicate drop. Video footage was processed after the field trip using a trained observer.

Van Veen grab

When habitat could not be easily identified by video, a van Veen grab (grab area 0.0625 m^2) was used to collect a small sample to confirm sediment type, seagrass presence, and to identify seagrass species (Figure 3).

Figure 3: (a, b) Subtidal sites were surveyed using Numbulwar Numburindi and Yugul Mangi Ranger vessels *Bambeiliwarr* and *Ngarri Larni*. (c, d) Sites were surveyed by drop camera with live feed to computer, and (e, f) by van Veen grab.

2.2.2. Seagrass biomass and percent cover

Biomass and cover were estimated using methods consistent with previous habitat surveys in northern Australia to ensure comparability across the region. Seagrass biomass was estimated for the 3 replicate quadrats 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. This survey used a high and low biomass scale.

At the completion of the ranking, 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 during the survey. Biomass ranks were then converted to above-ground biomass in grams dry weight per square metre (gDW m^{-2}) and averaged among the 3 quadrats to provide mean total seagrass above-ground biomass, and contribution to total above-ground biomass for each species, for each site.

Seagrass cover and seagrass species percent cover for each quadrat were estimated using a similar reference guide as rank sheets. The reference guide was a series of quadrat photographs with associated seagrass percent covers that were estimated using image analysis software.

2.2.3. Algae communities

The percent cover of algae was estimated for each quadrat according to 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 4a).
- **Filamentous:** Thin, thread-like algae with little cellular differentiation (Figure 4b).
- **Encrusting:** Algae that grow in a sheet-like form attached to the substrate or benthos, e.g. coralline algae (Figure 4c).
- **Turf mat:** Algae that form a dense mat on the substrate (Figure 4d).
- **Erect calcareous:** Algae with erect growth form and high level of cellular differentiation containing calcified segments, e.g. *Halimeda* species (Figure 4e).

2.2.4. Benthic macroinvertebrate communities

The percent cover of habitat-forming benthic macroinvertebrates (BMI) was estimated for each quadrat according to broad taxonomic groups:

- **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, such as whips, sea pens and gorgonians.
- **Sponge**
- **Other BMI**: Any other BMI identified, e.g., hydroids, ascidians, barnacles, oysters, and habitat-forming molluscs such as clams. Other BMI categories are listed in the 'comments' column of the GIS site layer.

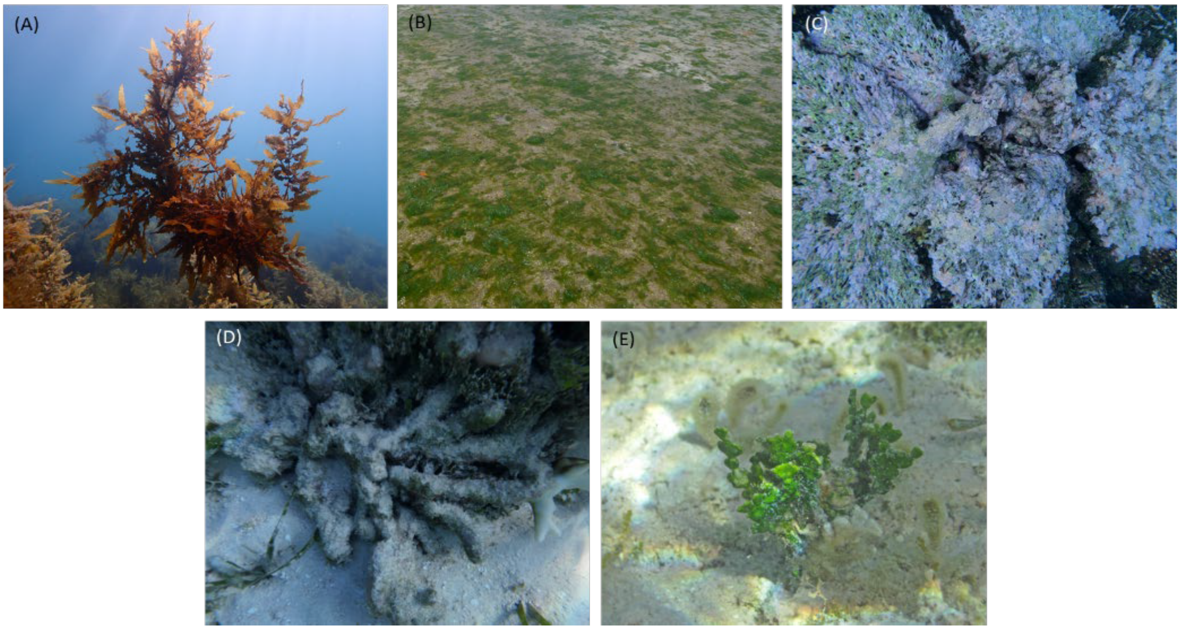


Figure 4: Examples of functional algae groups are (a) erect macrophytes, (b) filamentous, (c) encrusting, (d) turf mat, and (e) erect calcareous.

2.3. Geographic Information System (GIS)

All survey data was entered into a Geographic Information System (GIS) using ArcGIS Pro 3.4 (Environmental Systems Research Institute, ESRI). Data structures and attribute fields were designed to align with NESP 3.5 spatial data standards, enabling integration with existing northern Australian seagrass datasets. Three GIS layers were created to describe spatial habitats in the region: a habitat site layer, seagrass meadow layer and seagrass biomass interpolation layer:

2.3.1. Habitat (site) layer

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

- Temporal details of i.e. survey date and time
- Spatial details of location, tidal zone, latitude/longitude and depth below mean sea level (dbMSL)
- 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
- Sampling method
- The presence of sea cucumbers, turtles, dugongs or dolphins observed at the site
- Survey vessel name
- Data custodians
- 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 of i.e. survey date and time
- Seagrass meadow information, including meadow identification (ID) code, seagrass species present, meadow community type, meadow density, mean meadow above-ground biomass ± standard error (SE), meadow area in hectares, persistence, dominant species, and number of total and biomass sites within the meadow
- Sampling method
- Data custodians
- Comments

Seagrass meadows were defined using seagrass presence/absence site data and intertidal meadow boundaries mapped in 2022 while flying along the intertidal meadow edge. Rectified colour satellite imagery of the survey region sourced from ESRI or Allen Coral Atlas (The Satellite Coral Reef Mosaic is © 2022 Planet Labs and licensed CC BY-SA-NC 4.0) (https://creativecommons.org/licenses/by-nc-sa/4.0/), the intertidal extent model (Bishop-Taylor et al., 2019) and field notes taken during the survey were used to identify geographical features, such as reef tops, channels and deep-water drop-offs, to assist in determining seagrass meadow boundaries.

Meadow community type was determined according to seagrass species composition. Species composition was based on the percent each species' biomass contributed to mean meadow biomass. A standard nomenclature system was used to categorise each meadow (Table 1). 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 2).

Table 1: 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

Meadow community type was determined according to seagrass species composition. Species composition was based on the percent each species' biomass contributed to mean meadow biomass. A standard nomenclature system was used to categorise 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).

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

Density	***H. uninervis***	***H. ovalis*** ***H. decipiens***	***C. serrulate*** ***S. isoetifolium***	***H. spinulosa***
Light	< 1	< 1	< 5	< 15
Moderate	1–4	1–5	5–25	15–35
Dense	> 4	> 5	> 25	> 35

2.3.3. Biomass interpolation raster

An inverse distance weighted (IDW) interpolation was applied to total seagrass above-ground biomass point data (using the habitat site layer) to describe spatial variation in biomass across seagrass meadows. The interpolation was conducted in ArcGIS Pro 3.4.

3. Results

The SEAL SCIPA supports a diverse range of marine habitats, including seagrass meadows, algal communities, benthic invertebrate assemblages, and healthy coral reefs. Surveyed depths ranged from <-1 m to -15 m MSL, and sediments were predominantly sand, shell, and/or mud. Visibility was generally high across the 151 survey sites, enabling confident identification of seagrass species from video footage; only 8% of sites required a van Veen grab sample for species confirmation.

3.1. Seagrass

Six seagrass species were recorded: *Cymodocea serrulata*, *Halodule uninervis*, *Syringodium isoetifolium*, *Halophila spinulosa*, *Halophila ovalis* and *Halophila decipiens* (Figure 5, Figure 6). Seagrass occurred at 57 of the 151 sites (38%), predominantly around the Rose River mouth and Numbulwar and extending south to Nyinpinti Point (Figure 7). Seagrass was recorded to depths of – 10 m MSL. *Halodule uninervis* was the most frequently encountered species (33 sites; 22%), followed by *C. serrulata* (20 sites) and *H. ovalis* (18 sites). Both *C. serrulata* and *H. ovalis* were more common in inshore waters, whereas *H. decipiens* dominated deeper offshore sites (Figure 8).

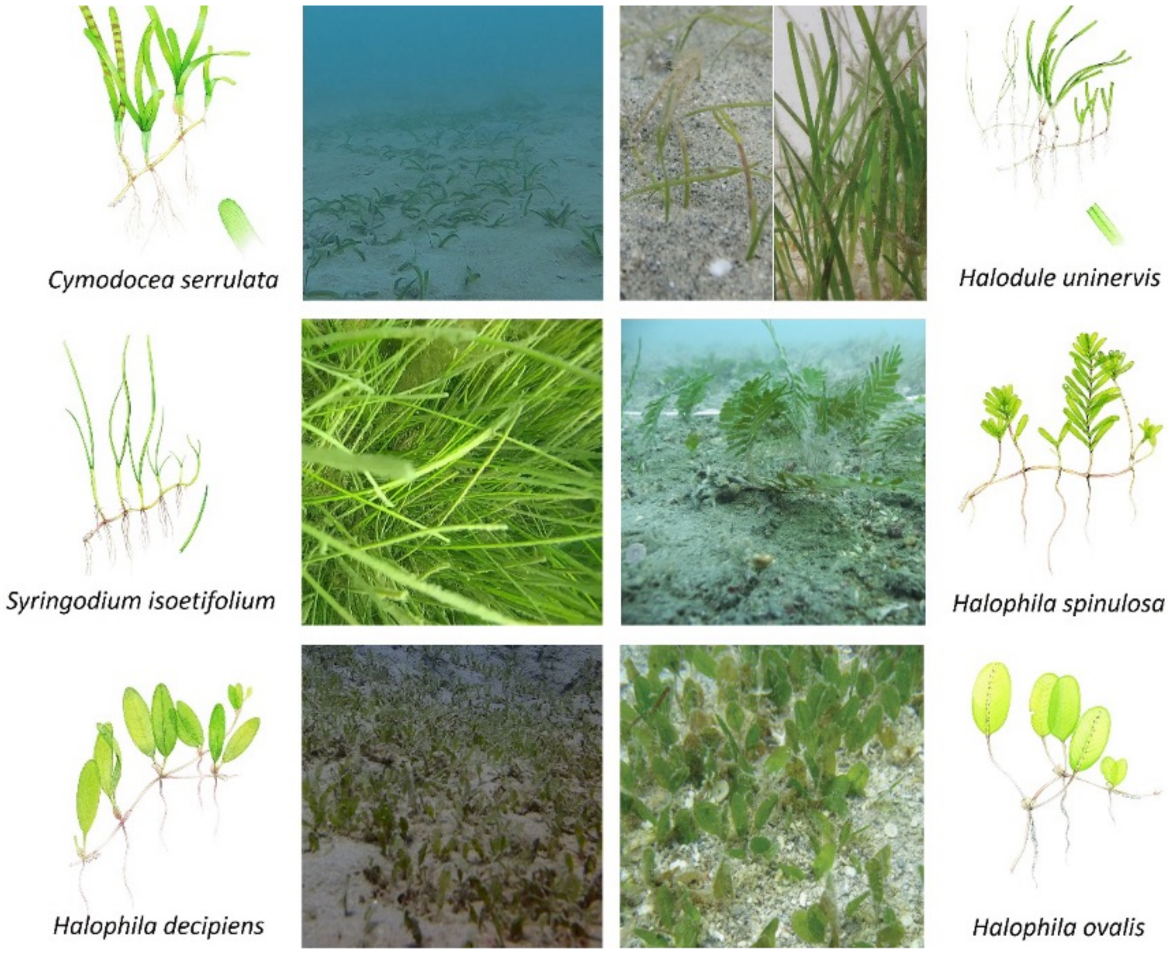


Figure 5: Seagrass species present during 2023 subtidal survey.

A total of 19,689 ha of seagrass was mapped across eight meadows (Figure 9). The largest meadow (NU19), dominated by *C. serrulata*, covered a substantial proportion of the survey area and supported high species diversity, with up to five species recorded. A turtle was observed in this meadow. All *C. serrulata*–dominated meadows exhibited high diversity. In contrast, *H. uninervis* meadows occurred as smaller patches, typically comprising 1–2 sites. Mean meadow biomass ranged <0.002 g DW m⁻² (Meadow NU18) to 4.48 ± 1.15 g DW m⁻² (Meadow NU19).

Site-level percent cover ranged from 0.3–56.7%, and above-ground biomass from <0.001–45 g DW m⁻². Site-level biomass ranged from 0.003–2.5 g DW m⁻² for *H. ovalis*, 0.002–13.3 g DW m⁻² for *H. uninervis*, and 0.002–45.2 g DW m⁻² for *C. serrulata* (Figure 10). Biomass hotspots were common inshore where *C. serrulata* occurred, with biomass declining offshore towards Mawirrangga (Sandy Island) as communities shifted toward the small-leaved *H. decipiens* and *H. ovalis* (Figure 8, Figure 10).

Figure 8: (a) Mixed *Halophila* species subtidal seagrass. (b) Seagrass ID guides were used to identify species. (c, d) Seagrass species was confirmed from van Veen grab samples. (e) *S. isoetifolium* mixed with macroalgae. (f) Wide leaf *H. uninervis*. (g) Mixed seagrass of *C. serrulata* and *H. uninervis*. (h) Seagrass with high epiphytes.

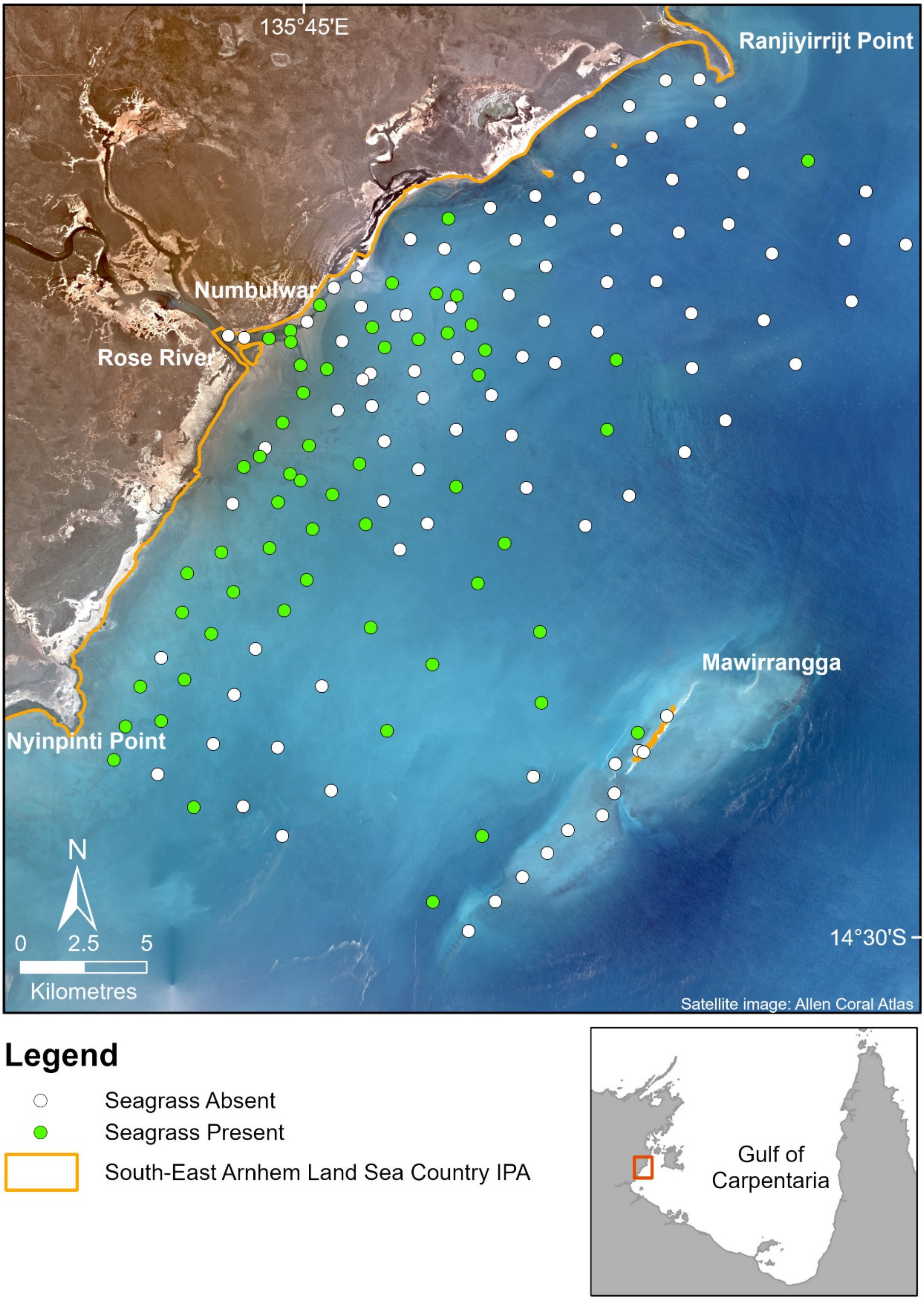


Figure 11: Seagrass presence and absence at survey sites.

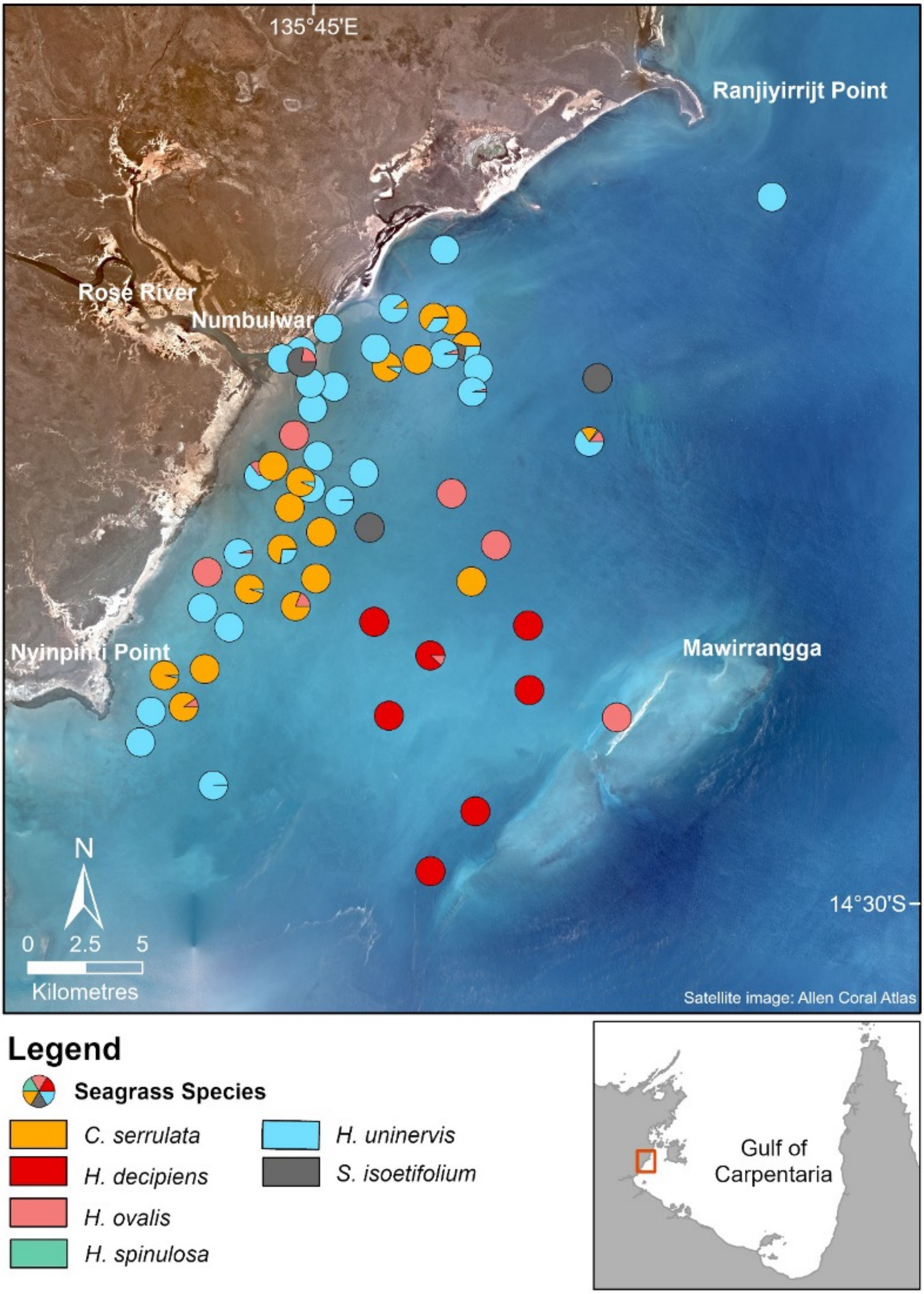


Figure 12: Seagrass species composition at survey sites.

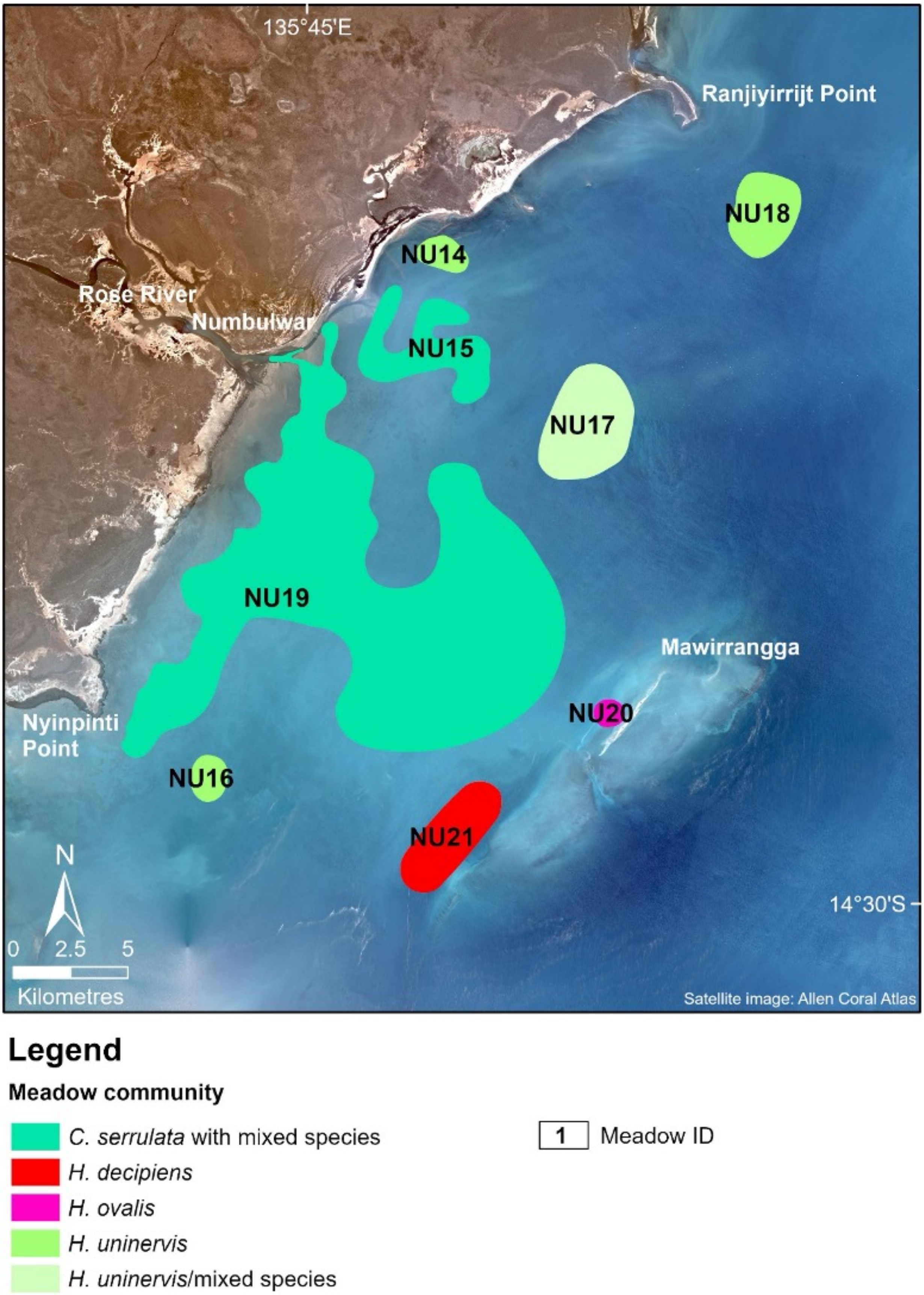


Figure 13: Seagrass meadow community types.

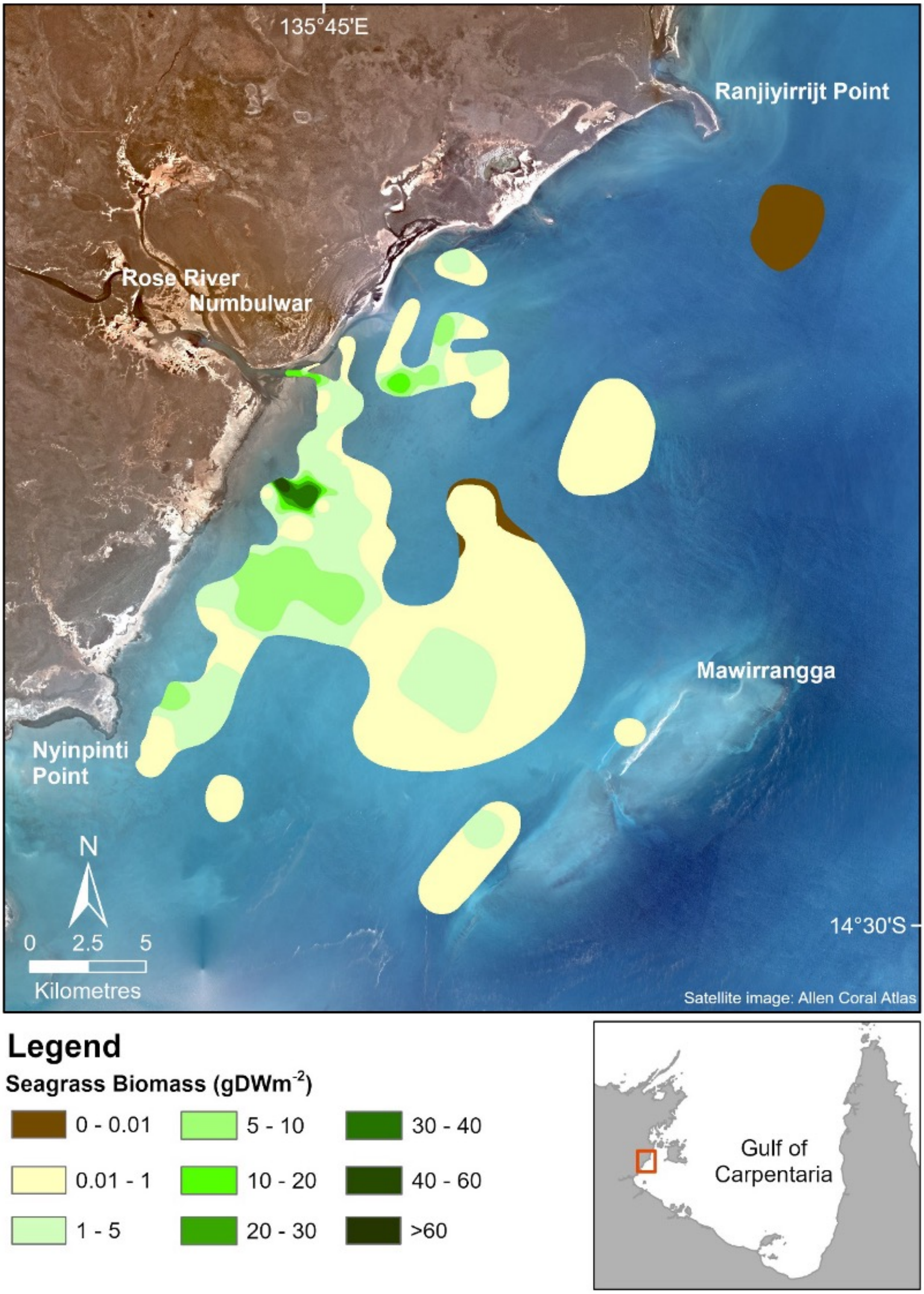


Figure 14: Seagrass above-ground biomass variation within meadows.

3.2. Macroinvertebrate and algal communities

A diverse assemblage of benthic macroinvertebrates was recorded (Figure 11, Figure 12). Hard corals occurred at 21 sites, with cover up to 50%, while soft corals were recorded at 14 sites (12%) with up to 11% cover. Sponges were present at 11 sites (up to 5% cover). Other benthic invertebrates – including hydroids, bryozoans, and ascidians – were observed at 23 sites, reaching up to 16% cover. Reefs with high coral cover were recorded at Mawirrangga (Sandy Island).

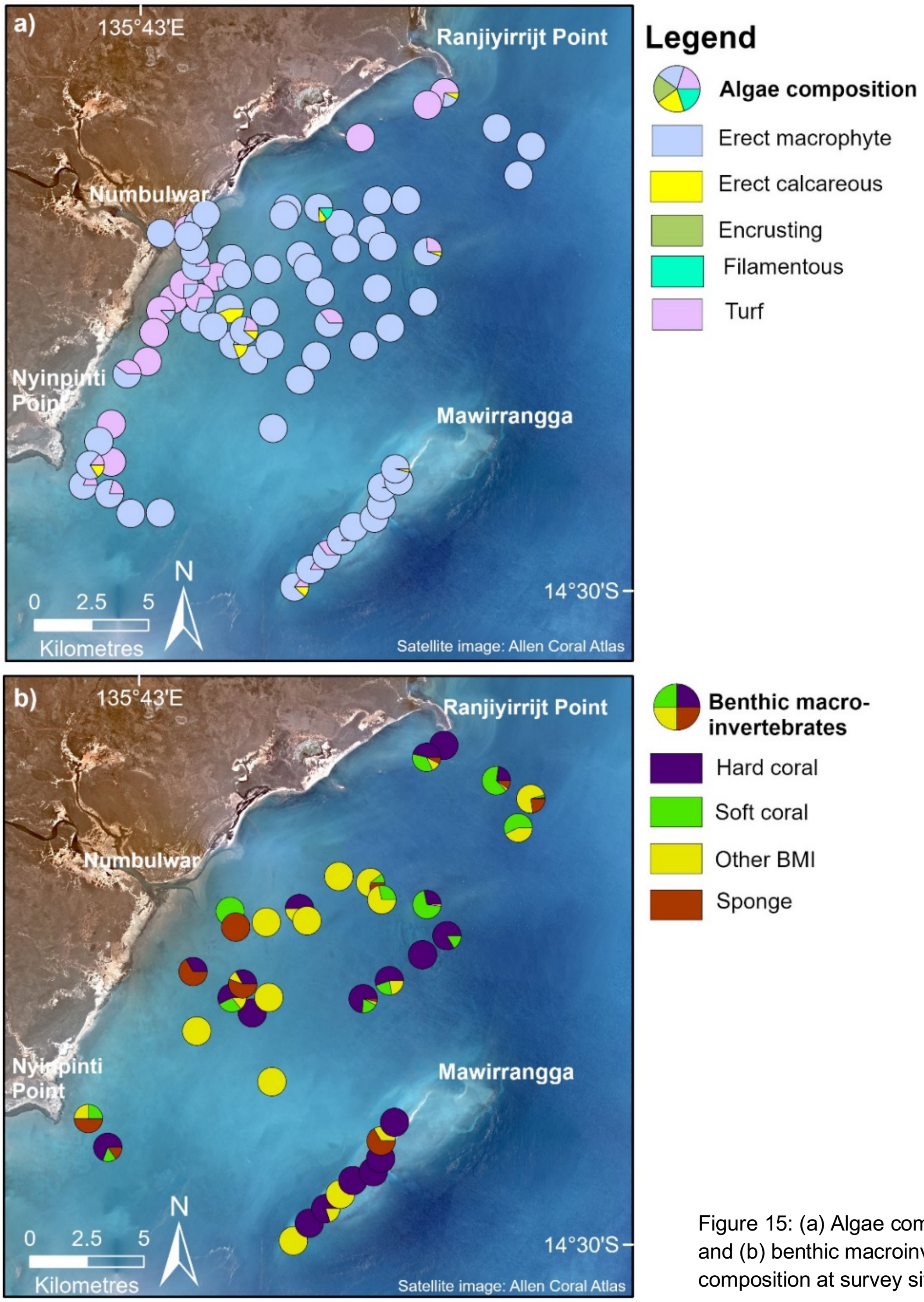


Figure 15: (a) Algae composition and (b) benthic macroinvertebrate composition at survey sites.

Figure 18: Benthic macroinvertebrate communities in the SEAL SCIPA. (a-d) Hard corals near Mawirrangga (Sandy Island). (e-g) Mixed hard and soft coral communities with sea whips and gorgonians. (h) Invertebrate and macroalgae habitat with ascidians. (i) Bryozoan attached to sea whip. (j) High cover of hard corals.

Algae were widespread, occurring at nearly half of all sites (68 sites; 45%) (Figure 11, Figure 13). Macroalgae was the most common type, present at 64 sites (42%) and reaching dense cover of up to 100%. Turf algae were also frequent, particularly inshore, recorded at 22 sites (15%) with cover up to 37%. Calcareous algae occurred at 11 sites (7%) with up to 13% cover, while filamentous algae were recorded only once (3% cover). No encrusting algae were recorded.

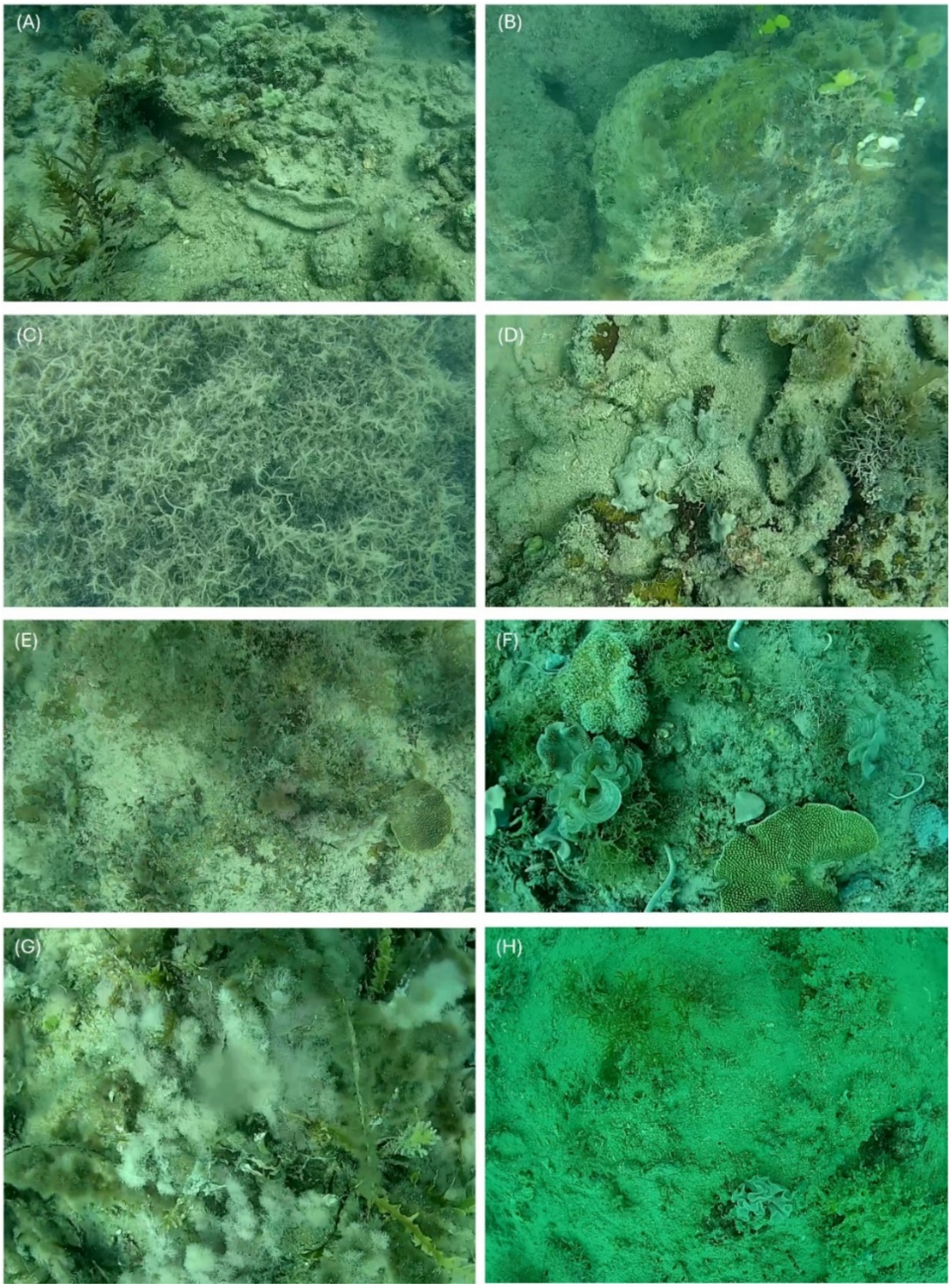


Figure 21: Algae communities in the SEAL SCIPA. (a) turf algae on rubble with macroalgae. (b) Calcareous algae. (c) Macroalgae. (d-h) Mixed algae communities with sponge, hard coral, soft coral and bryozoan.

4. Discussion

This project was built on strong partnerships and a co-designed approach, integrating both-ways knowledge throughout planning, fieldwork and interpretation. Traditional Owners and Rangers shaped survey priorities and contributed local knowledge essential for understanding local conditions, access, and habitat patterns. The collaboration produced bilingual habitat maps, communication materials co-designed with Rangers and Traditional Owners including posters for schools and ranger offices in Creole and English, GIS datasets, and this technical report to support community, management and research needs. By working closely with partners and investing in ranger-led monitoring capacity, the project contributes to broader efforts across northern Australia to improve the availability and accessibility of benthic habitat information, while establishing a strong benchmark for future co-designed seagrass and habitat monitoring across SEAL Sea Country.

This survey provides the first detailed baseline of subtidal seagrass in SEAL Sea Country and fills a major gap in northern Australian habitat data. Information on benthic habitats across the Gulf of Carpentaria has historically been piecemeal, with many areas – particularly remote subtidal zones – remaining unmapped or surveyed only via aerial observation. Recent mapping initiatives across the NT and Queensland side of the Gulf (Carter et al., 2023b; Carter et al., 2024b; Carter et al., 2025; Collier et al., 2022; Groom et al., 2023; Smith et al., 2025) are beginning to address this gap, reflecting growing recognition of the ecological importance of Gulf seagrass ecosystems and the leadership of Traditional Owners in guiding Sea Country research. The new subtidal dataset from this project substantially improves regional coverage and provides a reliable benchmark for future ranger-led monitoring, management and planning.

Six seagrass species were recorded in the Nyinpinti Point to Ranjiyirrijt Point subtidal survey area, representing moderate diversity for northern Australia (Carter et al., 2024a). Species composition aligned closely with adjacent intertidal meadows, with *C. serrulata*, *S. isoetifolium*, *H. uninervis*, *H. ovalis*, *H. decipiens* and *T. hemprichii* recorded in both (Carter et al., 2023a). The subtidal species *H. spinulosa* was recorded only in this survey, while *Enhalus acoroides* and *Cymodocea rotundata* – present in the 2022 intertidal survey – were absent, consistent with their preference for sheltered intertidal habitats. Subtidal species were distributed along clear environmental gradients, with *C. serrulata*, *H. uninervis* and *H. ovalis* dominant in shallow inshore waters and *H. decipiens* found in deeper offshore areas, a pattern also found in neighbouring Marra Sea Country (Carter et al., 2025; Collier et al., 2022; Smith et al., 2025). *Halophila decipiens* has low biomass but high turnover (Kilminster et al., 2015), enabling it to occupy deeper and more variable light environments (Chartrand et al., 2018). This shift from persistent, high-biomass species inshore to small-bodied colonisers offshore mirrors trends described throughout the Gulf of Carpentaria and northern Australia (Carter et al., 2024a; Carter et al., 2021b).

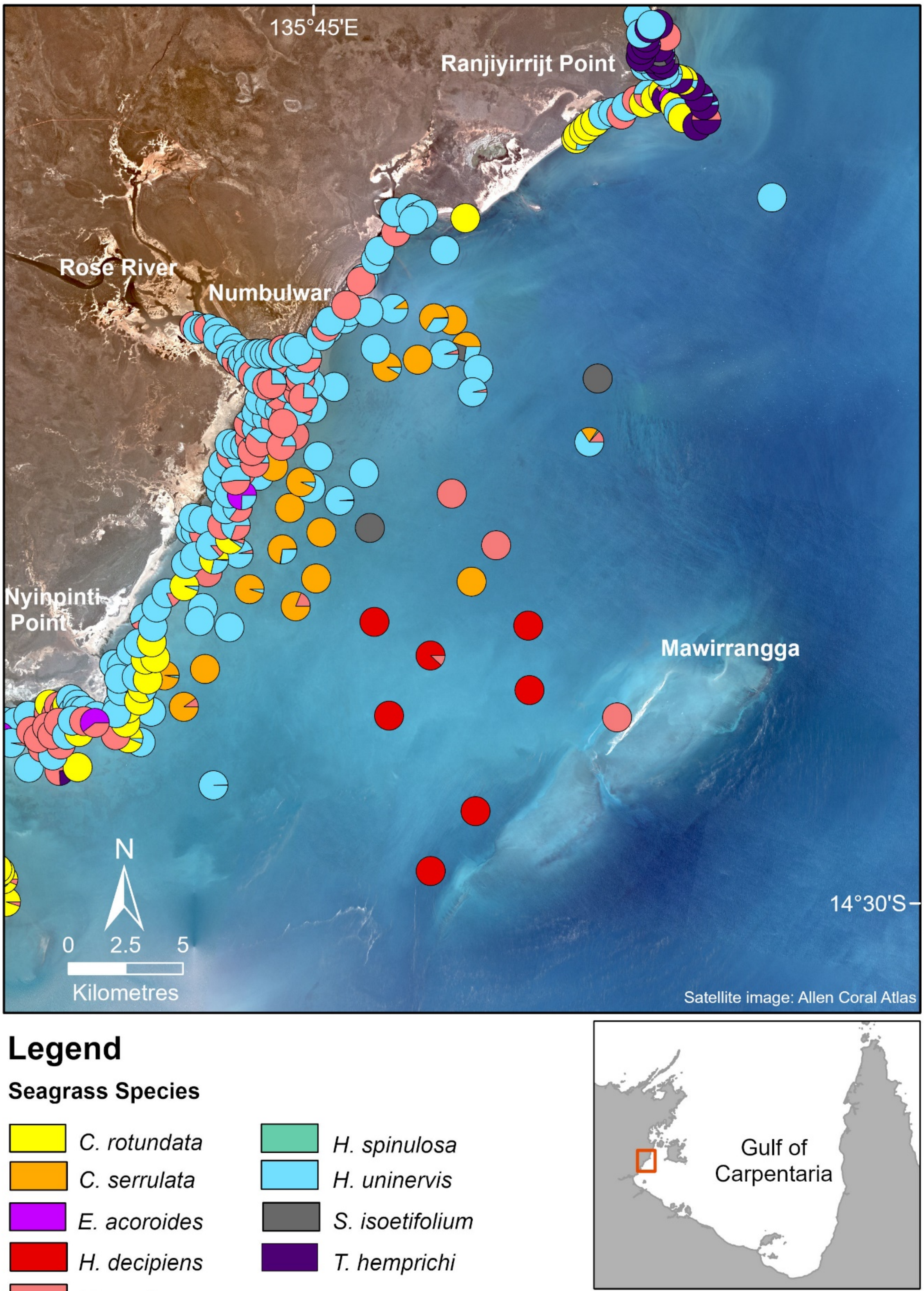


Figure 24: Distribution of intertidal and subtidal seagrass species in the survey area.

The mapped extent – 19,689 ha across eight meadows – underscores the significance of SEAL Sea Country for subtidal seagrass. The largest meadow supported high biomass seagrass and high species richness (up to five species), indicating favourable growing conditions despite being so close to the Rose River. These high-diversity meadows are consistent with regional patterns in which *T. hemprichii*, *S. isoetifolium* and *C. serrulata* species thrive in relatively clear coastal waters, such as between Beatrice Island and Rosie Creek in Marra Sea Country and around islands in Yanyuwa Sea Country. In contrast, more turbid sections of the Gulf – particularly near the Roper River and McArthur Rivers (Carter et al., 2025; Collier et al., 2022; Groom et al., 2023; Smith et al., 2025) – are typically dominated by *H. uninervis*, a species tolerant of elevated turbidity and intertidal exposure (Collier et al., 2016; Collier et al., 2012).

This survey contributes to a broader effort to improve knowledge of benthic habitats – particularly seagrass – across northern Australia. Previous seagrass mapping in SEAL Sea Country was conducted primarily by aerial observation in 1986, 2004 and 2022 (Carter et al., 2023a; Poiner et al., 1987; Roelofs et al., 2005), but with some ground truthing (Poiner et al. 1987). This focus on intertidal and shallow subtidal areas provided only a partial understanding of the region's seagrass meadows (Figure 15). This new dataset links with recent syntheses of four decades of seagrass mapping from Torres Strait, the Gulf of Carpentaria and the Great Barrier Reef to build a comprehensive spatial database for northern Australia (Figure 16) (Carter et al., 2021a; Carter et al., 2024a). By combining high-resolution drop-camera surveys with local knowledge from Ranger partners, this work provides the most comprehensive subtidal dataset yet available for SEAL Sea Country and reveals almost 20,000 ha of previously undocumented seagrass. These findings substantially update regional understanding of seagrass distribution and establish an essential benchmark for future monitoring and Sea Country planning.

The extent and composition of these subtidal meadows have important implications for culturally and ecologically important species. Dugongs rely heavily on small, fast-growing *H. uninervis* and *Halophila* species found across both intertidal and subtidal meadows, which are more nutritious than larger, fibrous seagrasses due to their higher nitrogen content and digestibility (de Iongh et al., 1995; Lanyon, 1991; Preen, 1998; Sheppard et al., 2006; Yamamuro & Chirapart, 2005). Evidence of herbivory, including feeding trails around Numbulwar, was recorded during the 2004 and 2022 intertidal surveys (Carter et al., 2023a; Roelofs et al., 2005). Together, these shallow and deeper meadows form a connected foraging landscape that likely influences dugong distribution, movement and reproductive condition. Regional dugong surveys estimated approximately 3,390 ± 1,092 (s.e.) individuals in the Gulf of Carpentaria, with SEAL Sea Country supporting about 8% of sightings (Griffiths et al., 2020). Although numbers appear to have declined in this region over successive survey years – despite stable populations in adjacent Marra and Yanyuwa waters – the reason for this trend remain unclear. Insufficient seagrass forage does not appear to be a likely cause given the extensive meadows here. Green turtle density in SEAL Sea Country is relatively high for the NT (Groom et al., 2017). Given the vulnerability of seagrass habitats to climate change (McMahon et al., 2022), maintaining detailed knowledge of both intertidal and subtidal meadows is essential for understanding and managing future risks to dugong, turtle and seagrass-associated fish populations.

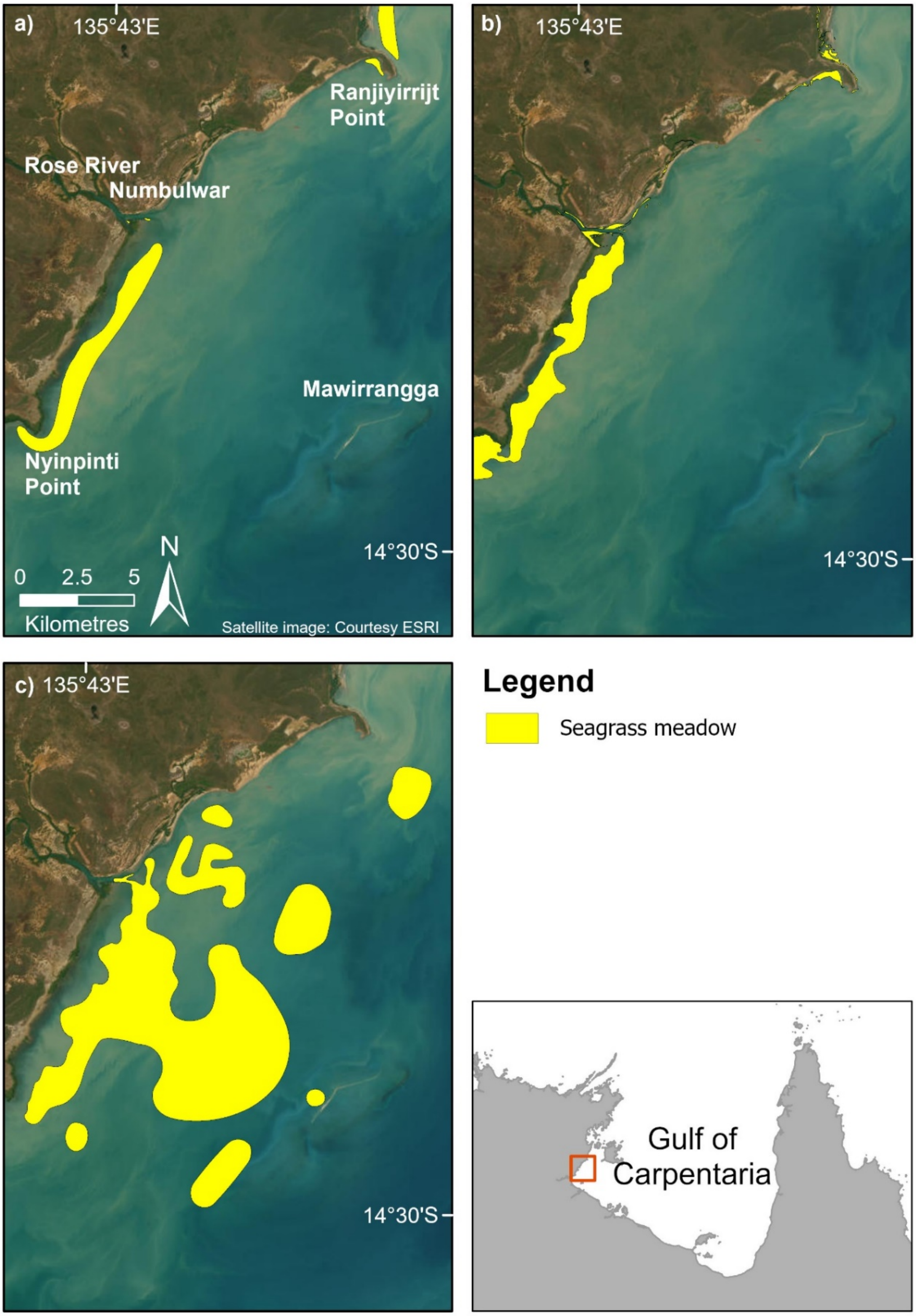


Figure 27: Comparison of 2023 meadows with historical data. (a) Meadows mapped in 1986 and 2004 (Roelofs et al., 2005), (b) 2022 (Carter et al., 2023a) and (c) 2023 survey.

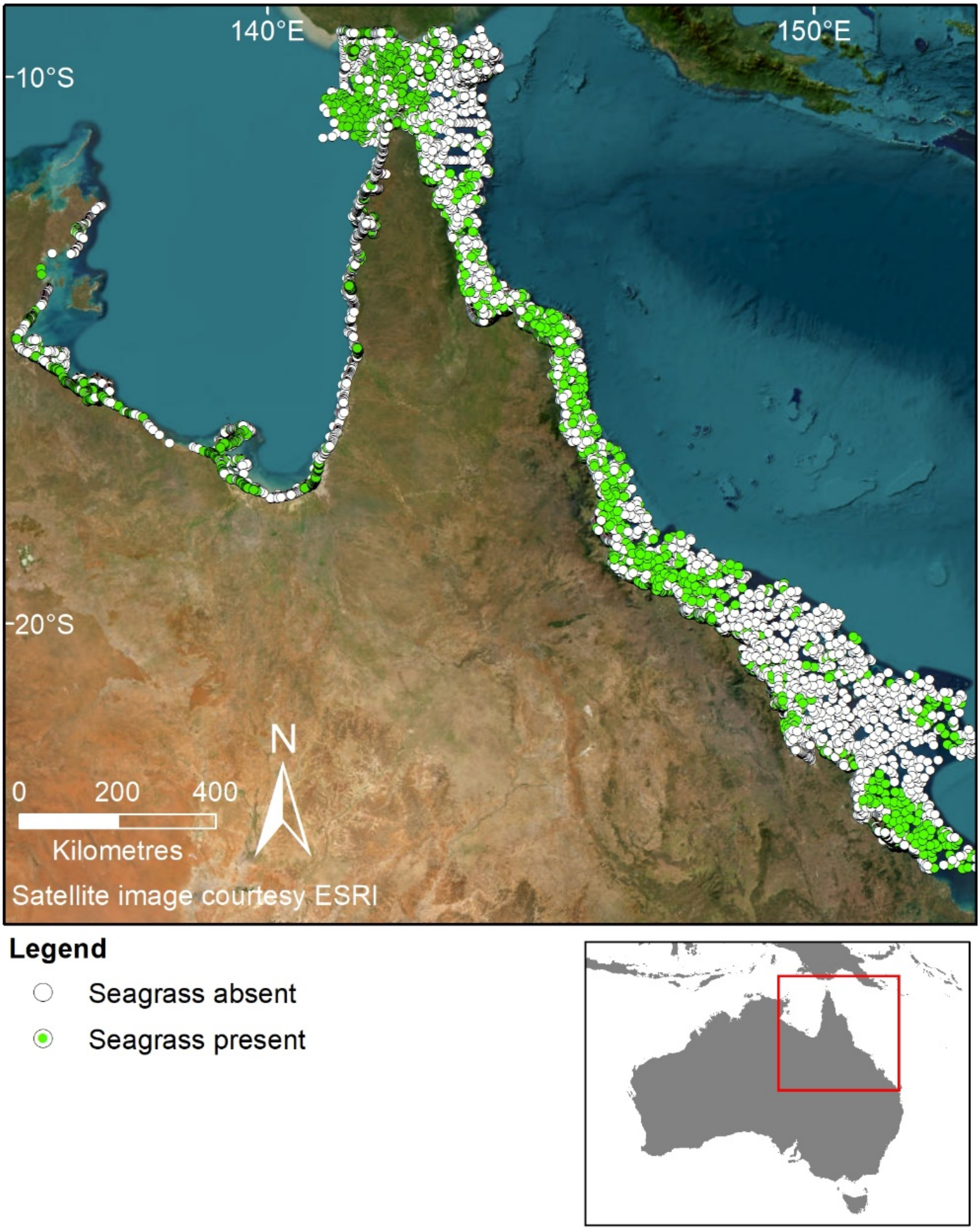


Figure 30: Seagrass presence and absence at individual sampling sites across the Gulf of Carpentaria and Torres Strait (1983–2022, excluding this study) and Great Barrier Reef World Heritage Area (1984-2018).

Algae and invertebrate communities are key components of the subtidal habitat mosaic across SEAL Sea Country, reflecting the dynamic Gulf of Carpentaria environment. Macro, filamentous, turf, and calcareous algae occurred at nearly half of surveyed sites, often intermixed with seagrass and invertebrates, and support key fauna such as green turtles – whose foraging preferences for seagrass or algae shape site fidelity (Bjorndal, 1980; Di Beneditto et al., 2017) – and provide occasional supplementary food for dugongs (Marsh et al., 1982; Preen & Marsh, 1995). Benthic invertebrates – including hard and soft corals, sponges, hydroids, ascidians, and bryozoans – were recorded across a range of habitats, with coral cover reaching up to 50% at some sites, highlighting structurally complex and productive reef communities. Extensive coral reef communities were recorded around Mawirrangga (Sandy Island). With seagrass and mangroves, algal and invertebrate communities provide habitat and refuge for fish and mobile invertebrates and are integral to the structure, functioning and resilience of the wider seascape (Lim et al., 2016; McNeil et al., 2021; Mosman et al., 2026; Smith et al., 2025). These patterns mirror observations from Marra and Yanyuwa Sea Country, where diverse subtidal algae and invertebrate assemblages are concentrated in clearer offshore waters and around island margins (Collier et al., 2022; Groom et al., 2023; Smith et al., 2025). Reefs in the Gulf of Carpentaria are among Australia's oldest Holocene reef systems yet remain poorly understood (Harris et al., 2008). Establishing these algal and invertebrate baselines alongside seagrass mapping is critical for detecting future ecological change and improving regional habitat characterisation for northern Australia.

SEAL Sea Country's diverse habitats are shaped by natural and anthropogenic pressures. Seasonal wind, river flow, and sediment transport influence habitat distribution. Water clarity is a key driver of habitat condition, with turbidity from rivers, cyclones, and sediment resuspension posing stress for seagrass communities, particularly in deeper or light-sensitive habitats (Lambert et al., 2021; McKenna et al., 2015). Climate change further increases vulnerability, with rising sea surface temperatures, marine heatwaves, and extreme weather events threatening inshore meadows and reef-associated communities (McMahon et al., 2022). While fast-growing offshore *Halophila* species may provide resilience to short-term disturbances, shifts toward these species in areas historically dominated by *Cymodocea* or *Halodule* could indicate declining environmental quality. Regular monitoring – especially of high-biomass *C. serrulata* meadows – would help detect early signs of decline. With climate change driving rising water temperatures, more frequent heatwaves and sea-level rise, and widespread habitat deterioration (Halpern et al., 2019; Halpern et al., 2015), regular coral monitoring will allow for detecting early signs of stress and decline, and understanding how vulnerable marine communities respond to acute thermal events.

Local human activities also intersect with ecological and cultural values. Dugongs and green turtles rely on seagrass meadows, which are vulnerable to fishing pressures – including netting, crabbing, and propeller damage – as well as impacts from coastal development (Grech et al., 2011) and altered river flows (Plagányi et al., 2022). Maintaining the connectivity and condition of intertidal and subtidal habitats is critical for resilience, enabling recovery through dispersal, foraging movements, and sustaining Traditional Owner values. Mitigation of local stressors, alongside ongoing ranger-led monitoring of seagrass and coral communities, is essential to detect ecological change, guide management, and support long-term planning and stewardship of SEAL Sea Country.

4.1. Recommendations

Seagrass habitats are key indicators of marine ecosystem health (Roca et al., 2016) and underpin the productivity, biodiversity, and cultural values of SEAL, yet their extent, density, and species composition shift in response to seasons, extreme weather, river flow, and increasing human pressures (Carter et al., 2023c; Lambert et al., 2021; Unsworth et al., 2012). This survey, together with recent intertidal mapping, provides a critical baseline for subtidal and intertidal seagrass and broader benthic habitats across the SEAL SCIPA, offering Traditional Owners and managers essential spatial information for detecting change, assessing threats, and guiding culturally informed decision-making. Given the ecological and cultural importance of seagrass – particularly as forage for species such as dugong and green turtles – continued ranger-led monitoring will be vital for tracking habitat condition, strengthening local capacity, and building the evidence base required for long-term Sea Country stewardship. Building on these foundations, the following recommendations outline priorities for future habitat mapping and long-term monitoring across the SEAL SCIPA:

- Complete benthic habitat mapping across the full SEAL SCIPA to fill major knowledge gaps and build a comprehensive understanding of habitat diversity, distribution, and condition.
- Co-design and establish a long-term seagrass and benthic monitoring program, with boat-based subtidal monitoring based out of Numbulwar to build a consistent time series.
- Implement drone-based monitoring of accessible intertidal meadows identified in the 2022 baseline to enable efficient, ranger-led assessments of meadow extent, cover, species composition, and change.
- Monitor key environmental drivers – including water clarity, temperature, and sedimentation – to support interpretation of habitat change in coastal areas.
- Link habitat condition to dugong, turtle, and fisheries resources to strengthen culturally informed Sea Country management and align with Traditional Owner priorities.

5. References

Beaman, R. (2023). AusBathyTopo 250m (Australia) 2023 Grid - A High-resolution Depth Model for Australia (20230004C). Retrieved from: https://doi.org/10.26186/148758

Bishop-Taylor, R., Sagar, S., Lymburner, L., & Beaman, R. (2019). Between the tides: Modelling the elevation of Australia's exposed intertidal zone at continental scale. *Estuarine, Coastal & Shelf Science*, 223, 115-128. doi: https://doi.org/10.1016/j.ecss.2019.03.006

Bjorndal, K. A. (1980). Nutrition and grazing behavior of the green turtle Chelonia mydas. *Marine Biology*, 56, 147-154. doi: https://doi.org/10.1007/BF00397131

Carter, A., Collier, C., Firby, L., Reason, C., & Groom, R. (2023a). Mapping Intertidal Habitat in South East Arnhem Land. James Cook University, Cairns: Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Report Number 23/27.

Carter, A., Groom, R., Smith, T., Shepherd, L., van de Wetering, C., & Willan, R. (2023b). Benthic habitats, fish and invertebrate communities of West Cape York Marine Park and surrounding waters. James Cook University, Cairns: Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Report Number 23/31.

Carter, A., McKenna, S., Rasheed, M., Collier, C., McKenzie, L., Pitcher, R., & Coles, R. (2021a). Synthesizing 35 years of seagrass spatial data from the Great Barrier Reef World Heritage Area, Queensland, Australia. *Limnology & Oceanography Letters*, 1-11. doi: https://doi.org/10.1002/lol2.10193

Carter, A., McKenna, S., Rasheed, M., Taylor, H., van de Wetering, C., Chartrand, K., Reason, C., Collier, C., Shepherd, L., Mellors, J., McKenzie, L., Duke, N., Roelofs, A., Smit, N., Groom, R., Barrett, D., Evans, S., Pitcher, R., Murphy, N., Carlisle, M., David, M., Lui, S., Torres Strait Indigenous Rangers, & Coles, R. (2024a). Seagrass spatial data synthesis from north-east Australia, Torres Strait and Gulf of Carpentaria, 1983 to 2022. *Limnology and Oceanography Letters*, 9(1), 7-22. doi: https://doi.org/10.1002/lol2.10352

Carter, A., Proctor, M., Wilson, T., Koleck, J., & Collier, C. (2024b). Intertidal Habitat of the Northern Wellesley Islands. . James Cook University, Cairns: Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Report Number 24/14.

Carter, A., Whitman, K., Collier, C., Smith, T., Barrett, D., Barrett, E., Evans, S., Kerr, R., Wilkins, S., Kellett, D., & Groom, R. (2025). Subtidal Habitat of North-West Marra Sea Country: James Cook University, Cairns.

Carter, A. B., Coles, R., Jarvis, J. C., Bryant, C. V., Smith, T. M., & Rasheed, M. A. (2023c). A report card approach to describe temporal and spatial trends in parameters for coastal seagrass habitats. *Scientific Reports*, 13(1), 2295. doi: https://doi.org/10.1038/s41598-023-29147-1

Carter, A. B., Collier, C., Coles, R., Lawrence, E., & Rasheed, M. A. (2022). Community-specific “desired” states for seagrasses through cycles of loss and recovery. *J Environ Manage*, 314, 115059. doi: https://doi.org/10.1016/j.jenvman.2022.115059

Carter, A. B., Collier, C., Lawrence, E., Rasheed, M. A., Robson, B., & Coles, R. (2021b). A spatial analysis of seagrass habitat and community diversity in the Great Barrier Reef World Heritage Area. *Scientific Reports*, 11. doi: https://doi.org/10.1038/s41598-021-01471-4

Chartrand, K. M., Szabó, M., Sinutok, S., Rasheed, M. A., & Ralph, P. J. (2018). Living at the margins: The response of deep-water seagrasses to light and temperature renders them susceptible to acute impacts. *Mar Environ Res*, 136, 126-138. doi: https://doi.org/10.1016/j.marenvres.2018.02.006

Collier, C. J., Adams, M. P., Langlois, L., Waycott, M., O'Brien, K. R., Maxwell, P. S., & McKenzie, L. (2016). Thresholds for morphological response to light reduction for four tropical seagrass species. *Ecological Indicators*, 67, 358-366. doi: https://doi.org/10.1016/j.ecolind.2016.02.050

Collier, C. J., Carter, A., Shepherd, L., van de Wetering, C., Coles, R., Evans, S., Barrett, D., Willan, R. C., & Groom, R. (2022). Benthic habitats of Marra Sea Country - Gulf of Carpentaria: Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Report Number 23/13, James Cook University, Cairns.

Collier, C. J., Waycott, M., & Ospina, A. G. (2012). Responses of four Indo-West Pacific seagrass species to shading. *Marine Pollution Bulletin*, 65(4), 342–354. doi: https://doi.org/10.1016/j.marpolbul.2011.06.017

de Iongh, H. H., Wenno, B. J., & Meelis, E. (1995). Seagrass distribution and seasonal biomass changes in relation to dugong grazing in the Moluccas, East Indonesia. *Aquatic Botany*, 50(1), 1-20. doi: https://doi.org/10.1016/0304-3770(94)00438-R

Di Beneditto, A. P. M., Siciliano, S., & Monteiro, L. R. (2017). Herbivory level and niche breadth of juvenile green turtles (Chelonia mydas) in a tropical coastal area: insights from stable isotopes. *Marine Biology*, 164, 1-12. doi: https://doi.org/10.1007/s00227-016-3044-2

Duke, N. C., Kovacs, J. M., Griffiths, A. D., Preece, L., Hill, D. J., Van Oosterzee, P., Mackenzie, J., Morning, H. S., & Burrows, D. (2017). Large-scale dieback of mangroves in Australia's Gulf of Carpentaria: a severe ecosystem response, coincidental with an unusually extreme weather event. *Marine and Freshwater Research*, 68, 1816-1829. doi: https://doi.org/10.1071/MF16322

Grech, A., Coles, R., & Marsh, H. (2011). A broad-scale assessment of the risk to coastal seagrasses from cumulative threats. *Marine Policy*, 35(5), 560-567. doi: https://doi.org/10.1016/j.marpol.2011.03.003

Griffiths, A. D., Groom, R. A., & Dunshea, G. (2020). Dugong distribution and abundance in the Gulf of Carpentaria, Northern Territory: October 2019. Department of Environment, Parks and Water Security, Northern Territory Government: Darwin.

Groom, R., Carter, A., Collier, C., Firby, L., Evans, S., Barrett, S., Hoffmann, L., van de Wetering, C., Shepherd, L., Evans, S., & Anderson, S. (2023). Mapping Critical Habitat in Yanyuwa Sea Country. Charles Darwin University: Darwin.

Groom, R. A., Dunshea, G. J., Griffiths, A. D., & Mackarous, K. (2017). The distribution and abundance of dugong and other marine megafauna in the Northern Territory, November 2015: Northern Territory Government, Darwin. Retrieved from https://hdl.handle.net/10070/265115

Halpern, B. S., Frazier, M., Afflerbach, J., Lowndes, J. S., Micheli, F., O'Hara, C., Scarborough, C., & Selkoe, K. A. (2019). Recent pace of change in human impact on the world's ocean. *Scientific Reports*, 9(1), 1-8. doi: https://doi.org/10.1038/s41598-019-47201-9

Halpern, B. S., Frazier, M., Potapenko, J., Casey, K. S., Koenig, K., Longo, C., Lowndes, J. S., Rockwood, R. C., Selig, E. R., & Selkoe, K. A. (2015). Spatial and temporal changes in cumulative human impacts on the world's ocean. *Nature Communications*, 6(1), 1-7. doi: https://doi.org/10.1038/ncomms8615

Harris, P. T., Heap, A. D., Marshall, J. F., & McCulloch, M. (2008). A new coral reef province in the Gulf of Carpentaria, Australia: colonisation, growth and submergence during the early Holocene. *Marine Geology*, 251(1-2), 85-97. doi: https://doi.org/10.1016/j.margeo.2008.02.010

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., & Udy, J. (2015). Unravelling complexity in seagrass systems for management: Australia as a microcosm. *Science of The Total Environment*, 534, 97-109. doi: http://dx.doi.org/10.1016/j.scitotenv.2015.04.061

Kyne, P. M., Brooke, B., Davies, C.-L., Ferreira, L. C., Finucci, B., Lymburner, L., Phillips, C., Thums, M., & Tulloch, V. (2018). Final Report. Scoping a Seascape Approach to Managing and Recovering Northern Australian Threatened and Migratory Marine Species. Report to the National Environmental Science Programme, Marine Biodiversity Hub. Charles Darwin University: Darwin. Retrieved from https://www.nespmarine.edu.au/system/files/Kyne%20Scoping%20a%20seascape%20approach_Milestone%2017%20Final%20report_RPv3%202017_14Nov18.pdf

Lambert, V. M., Bainbridge, Z. T., Collier, C., Lewis, S. E., Adams, M. P., Carter, A., Saunders, M. I., Brodie, J., Turner, R. D. R., Rasheed, M. A., & O'Brien, K. R. (2021). Connecting targets for catchment sediment loads to ecological outcomes for seagrass using multiple lines of evidence. *Marine Pollution Bulletin*, 169. doi: https://doi.org/10.1016/j.marpolbul.2021.112494

Lanyon, J. (1991). The Nutritional Ecology of the Dugong (Dugong dugon) in tropical North Queensland. (Thesis). Department of Ecology and Evolutionary Biology, Monash Univesity, Clayton, Victoria.

Lim, I. E., Wilson, S. K., Holmes, T. H., Noble, M. M., & Fulton, C. J. (2016). Specialization within a shifting habitat mosaic underpins the seasonal abundance of a tropical fish. *Ecosphere*, 7(2), e01212. doi: https://doi.org/10.1002/ecs2.1212

Marsh, H., Channells, P. W., Heinsohn, G. E., & Morrissey, J. (1982). Analysis of Stomach Contents of Dugongs From Queensland. *Wildlife Research*, 9(1), 55-67. doi: https://doi.org/10.1071/WR9820055

McKenna, S. A., Jarvis, J. C., Sankey, T., Reason, C., Coles, R., & Rasheed, M. A. (2015). Declines of seagrasses in a tropical harbour, North Queensland, Australia, are not the result of a single event. *Journal of Biosciences*, 40, 389-398. doi: https://doi.org/10.1007/s12038-015-9516-6

McMahon, K., Kilminster, K., Canto, R., Roelfsema, C., Lyons, M., Kendrick, G. A., Waycott, M., & Udy, J. (2022). The risk of multiple anthropogenic and climate change threats must be considered for continental scale conservation and management of seagrass habitat. *Frontiers in Marine Science*, 9, 837259. doi: https://doi.org/10.3389/fmars.2022.837259

McNeil, M., Firn, J., Nothdurft, L. D., Pearse, A. R., Webster, J. M., & Roland Pitcher, C. (2021). Inter-reef Halimeda algal habitats within the Great Barrier Reef support a distinct biotic community and high biodiversity. *Nature Ecology & Evolution*, 5(5), 647-655. doi: https://doi.org/10.1038/s41559-021-01400-8

Mellors, J. E. (1991). An evaluation of a rapid visual technique for estimating seagrass biomass. *Aquatic Botany*, 42(1), 67–73. doi: https://doi.org/10.1016/0304-3770(91)90106-F

Mosman, J.D., Borland, H.P., Rummell, A.J., Henderson, C.J., Allan, S., Bannam, A., Bierwagen, S.L., Bradley, M.J., Carter, A.B., Ceccarelli, D.M. Coles, R., Emslie, M.J., Gilby, B.L., Goodridge Gaines, L.A., Hay, E.J., Kaposi, K., Konovalov, D.A., Murphy, T., Murray, J.C., Sheaves, M., Smith, T.M., Stowar, M., Olds, A.D. (2026). Seascape diversity and configuration shape habitat selection across multiple coastal ecosystems. *Biological Conservation*, 313, p.111558. doi: https://doi.org/10.1016/j.biocon.2025.111558.

Plagányi, É., Kenyon, R., Blamey, L., Burford, M., Robins, J. B., Jarrett, A., Laird, A., Hughes, J., Kim, S., & Hutton, T. (2022). Ecological modelling of the impacts of water development in the Gulf of Carpentaria with particular reference to impacts on the Northern Prawn Fishery.

Poiner, I. R., Staples, D. J., & Kenyon, R. (1987). Seagrass communities of the Gulf of Carpentaria, Australia. *Australian Journal of Marine and Freshwater Research*, 38, 121–131. doi: https://doi.org/10.1071/MF9870121

Preen, A. R. (1998). Marine protected areas and dugong conservation along Australia's Indian Ocean coast. *Environmental Management*, 22(2), 173–181. doi: https://doi.org/10.1007/s002679900094

Preen, A. R., & Marsh, H. (1995). Response of dugongs to large-scale loss of seagrass from Hervey Bay, Queensland Australia. *Wildlife Research*, 22(4), 507-519.

Roca, G., Alcoverro, T., Krause-Jensen, D., Balsby, T. J., Van Katwijk, M., Marbà, N., Santos, R., Arthur, R., Mascaró, O., & Fernández-Torquemada, Y. (2016). Response of seagrass indicators to shifts in environmental stressors: a global review and management synthesis. *Ecological Indicators*, 63, 310-323. doi: https://doi.org/10.1016/j.ecolind.2015.12.007

Roelofs, A. J., Coles, R., & Smit, N. (2005). A survey of intertidal seagrass from Van Diemen Gulf to Castlereagh Bay, Northern Territory, and Gove to Horn Island, Queensland. Report to the National Oceans Office. Queensland Department of Primary Industries & Fisheries: Cairns. Retrieved from https://www.dcceew.gov.au/sites/default/files/documents/seagrass-survey-report-2005.pdf

Sheppard, J. K., Preen, A. R., Marsh, H., Lawler, I. R., Whiting, S. D., & Jones, R. E. (2006). Movement heterogeneity of dugongs, *Dugong dugon* (Müller), over large spatial scales. *Journal of Experimental Marine Biology and Ecology*, 334. doi: https://doi.org/10.1016/j.jembe.2006.01.011

Smith, T. M., Collier, C. J., Evans, S., Barrett, D., Barrett, E., Forsman, S., Settli, E., Whitman, K., Langlois, L., Groom, R., & Carter, A. (2025). Fish communities and benthic monitoring of Marra Sea Country in the Gulf of Carpentaria. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Report Number 25/13: James Cook University, Cairns.

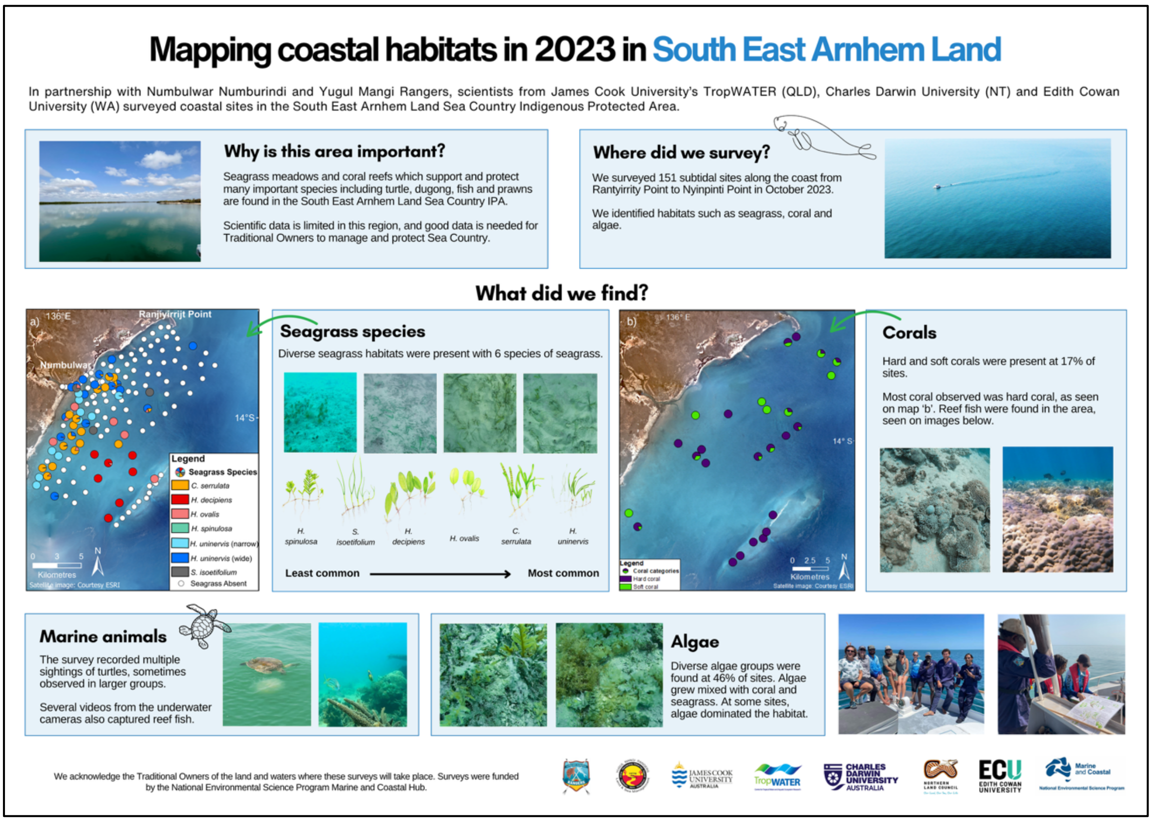
Tamarind Planning. (2021). South East Arnhem Land Sea Country IPA: A Proposed Marine Indigenous Protected Area.

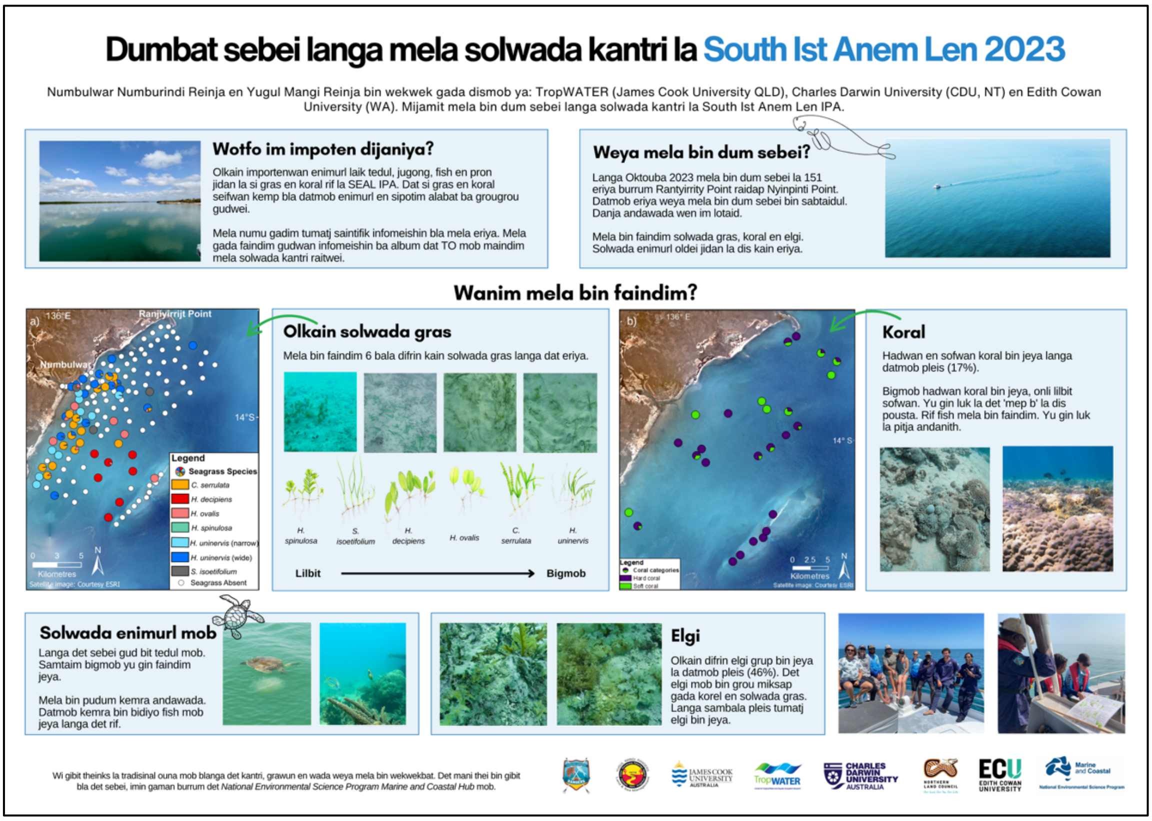
Unsworth, R. K. F., Rasheed, M. A., Chartrand, K. M., & Roelofs, A. J. (2012). Solar radiation and tidal exposure as environmental drivers of *Enhalus acoroides* dominated seagrass meadows. *PLOS ONE,* 7(3), e34133. doi: https://doi.org/10.1371/journal.pone.0034133

Yamamuro, M., & Chirapart, A. (2005). Quality of the seagrass *Halophila ovalis* on a Thai intertidal flat as food for the dugong. *Journal of Oceanography*, 61, 183-186. doi: https://doi.org/10.1007/s10872-005-0030-6

6. Appendices

Community poster for 2023 surveys:





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