Long-Term Seagrass Monitoring Program in the Mackay – Hay Point Region 2025

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We acknowledge the Australian Aboriginal and Torres Strait Islander peoples as the Traditional Owners of the lands and waters where we live and work.

CONTENTS

1 KEY FINDINGS

Seagrass Condition 2025

GOOD

Likely causes of seagrass condition:

Recovery from declines in offshore meadow area

Favourable growing conditions for most of the year.

No major climatic events or disturbances

This report compiles findings of the annual Hay Point/Mackay long-term seagrass monitoring conducted in September 2025.

- Seagrass in the Hay Point/Mackay region were in an overall good condition at the end of 2025 compared with expected baseline conditions.

- There was some variability among the different monitoring meadows and condition indicators:
    - The offshore Mackay and Hay Point deepwater meadows improved from satisfactory to very good condition with a substantial increase in meadow area since 2024.
    - The Keswick Island meadow remained in satisfactory condition, with some improvements in area and species composition since 2024.
    - The St Bees Island meadow was in good condition with biomass and meadow area recovering from poor condition in 2024.
    - The only meadow in poor condition was the small inshore monitoring meadow around Dudgeon Point, which was primarily attributed to a decrease in meadow area. This result was likely caused by above-average rainfall and freshwater pulse events during the 2024-2025 wet season, which would have a more prominent impact on inshore areas.

- Improved seagrass condition at Hay Point during 2025 represented a recovery in meadow area from the previous year's survey. Ambient environmental conditions over the 2024/25 period were favourable for meadow growth and expansion, particularly for offshore meadows.

- The good condition of Hay Point/Mackay seagrass meadows means they were likely to have reasonable resilience to potential disturbances over the coming year.

2 IN BRIEF

A long-term seagrass monitoring program and strategy was developed for the Hay Point/Mackay region following a broad-scale extended survey of the region in 2014 and incorporates seagrass monitoring information dating back to 2004 for Hay Point. This annual monitoring strategy assesses two deep offshore monitoring areas at Mackay and Hay Point (Meadows 5 & 8, respectively), a coastal intertidal-shallow subtidal area alongside Dudgeon Point (Meadow 1), two subtidal meadows at the Keswick Island group (Meadows 10 & 14), and some preliminary monitoring around Half Tide Tug Harbour (Figure 1). Seagrass meadows in these areas represent the range of different seagrass community types found in the Hay Point/Mackay region. This report describes seagrass distribution, abundance and condition from the 2025 annual monitoring survey.

Seagrasses across the Hay Point/Mackay region assessed in September 2025 were in a combined overall good condition following three years of satisfactory condition. The offshore Mackay and Hay Point meadows were elevated from satisfactory to very good condition due to expansions in meadow area (Figure 1). Seagrass condition at St Bees Island also increased from satisfactory to good condition in 2025 with increased meadow area and biomass. The Keswick Island monitoring meadow remained unchanged from satisfactory condition in 2024. The Dudgeon Point meadow was the only one to reduce in condition in 2025 and was rated as poor due to a decrease in meadow area, despite improved species composition. As with the previous year, no seagrass was found around Half Tide Tug Harbour.

Environmental conditions throughout the year, particularly in the months preceding the survey, can significantly influence seagrass distribution and abundance. Climate data from the twelve months prior to this survey generally supported favourable conditions for seagrass growth and persistence. The greatest deviations from expected monthly parameters occurred in February 2025, when above-average rainfall coincided with elevated river flow, wave stress (RMS water depth), wave height, and decreased photosynthetically active radiation. Given its closer proximity to the river mouth and greater vulnerability to wave-induced sediment disturbance, the Dudgeon Point meadow may have experienced greater adverse effects than the island and offshore meadows during this period. Benthic water temperatures during peak summer and winter remained within expected seasonal ranges and were unlikely to exceed the thermal optima of predominant *Halophila* species.

Subtidal meadows in the Hay Point/Mackay region are dominated by fast-growing, colonising *Halophila* species, whereas the intertidal-shallow subtidal zone along Dudgeon Point shows fluctuating dominance with *Halodule uninervis* (a more persistent species). This meadow has shown a high variability in species distribution and composition between years which is expected for these often-turbid nearshore coastal environments.

Seagrass monitoring in other locations across the Queensland coast have found similar results in 2025, with seagrasses to the north in the Bowen/Abbot Point region and south in Gladstone all found to be in good condition (Cleguer et al. 2026; Concannon et al. 2026, Reason et al. 2026). For full details of the Queensland ports seagrass monitoring program see: https://www.tropwater.com/themes/seagrass-habitats.

The condition of seagrasses in the Mackay - Hay Point region in 2025 indicates they are likely to have a reasonable level of resilience against potential disturbances over the coming year.

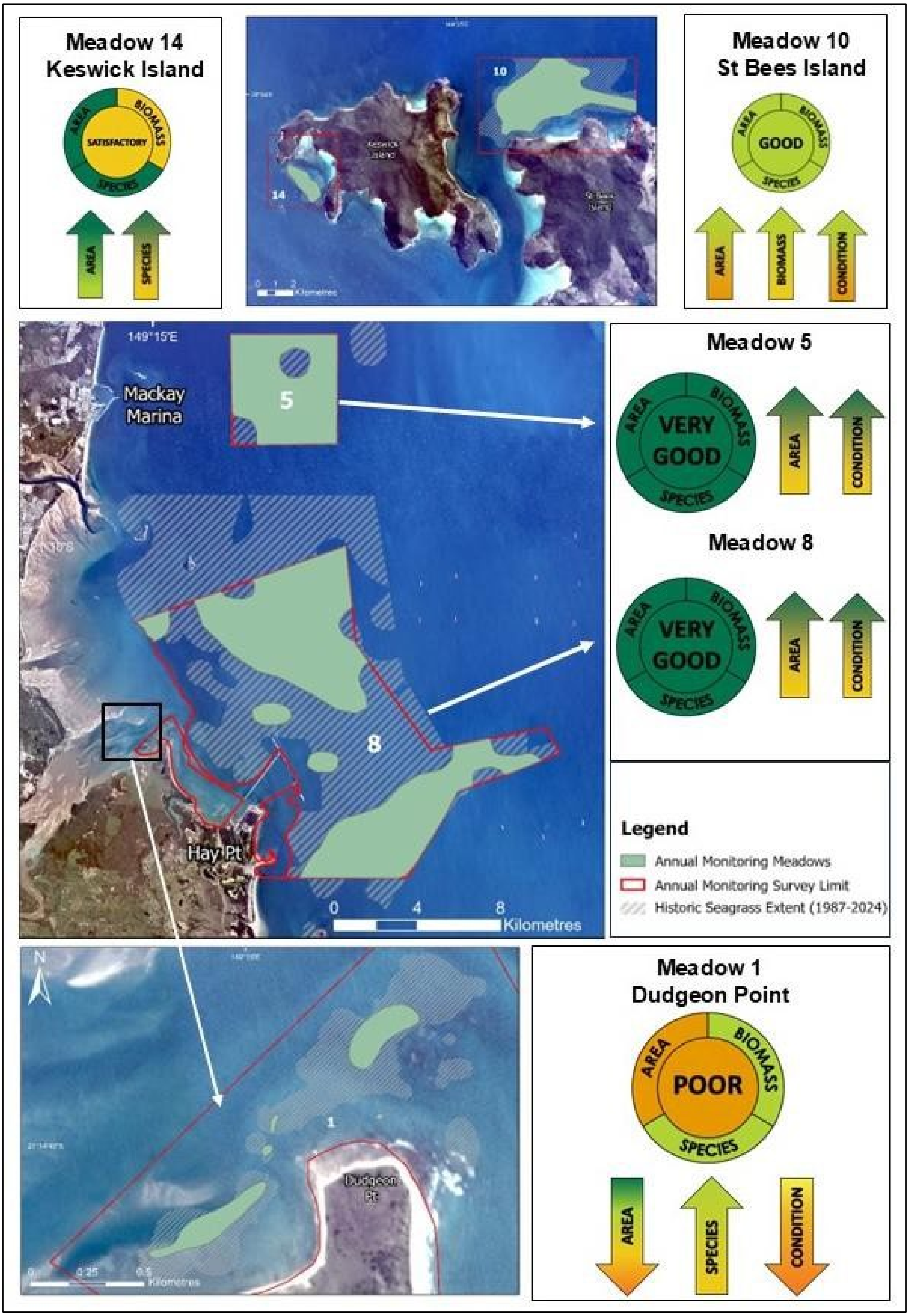

Figure 1. Seagrass meadow condition of the annual monitoring meadows off Mackay, Hay Point, Dudgeon Point, and Keswick and St Bees Islands in 2025.

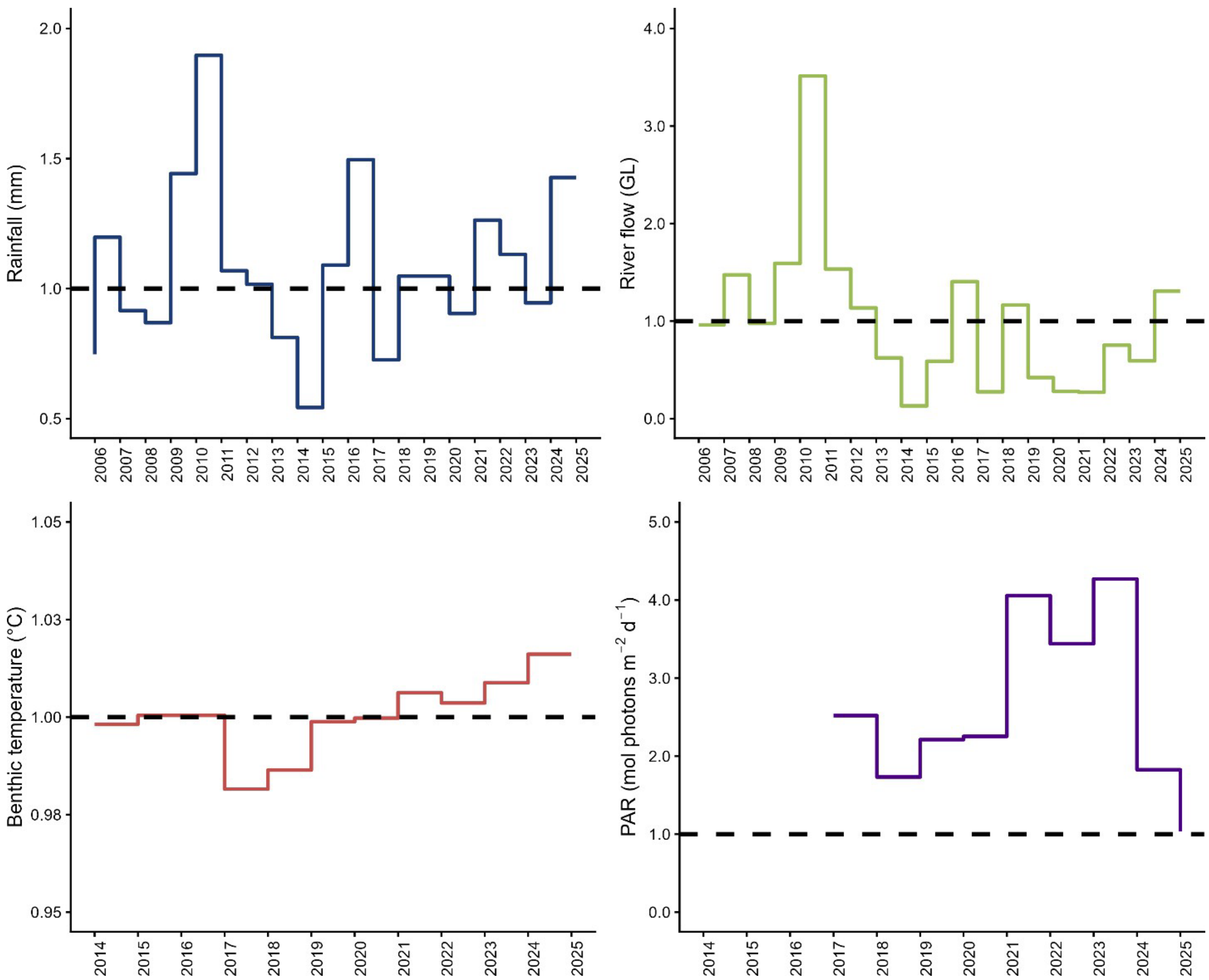

Figure 2. Recent climate trends in the Hay Point and Mackay Area for rainfall, river flow, benthic temperature, and PAR (light): Change in climate variables as a proportion of the long-term average (LTA – black dotted line). See section 5.3 for detailed climate data.

3 INTRODUCTION

Seagrasses are one of the most productive marine habitats on earth and provide a variety of important ecosystem services worth substantial economic value (estimated at US $6.4 trillion annually) (Costanza et al. 2014; Duarte et al. 2025; Foster et al. 2025). These services include the provision of nursery habitat for economically important fish and crustaceans (Coles et al. 1993; Hayes et al. 2020), and food for grazing megaherbivores like dugongs and sea turtles (Scott et al. 2018; Scott et al. 2021; Cleguer et al. 2026). Seagrasses also play a major role in the cycling of nutrients (McMahon and Walker 1998), sequestration of carbon (York et al. 2018, Rasheed et al. 2019; Gomis et al. 2025), stabilisation of sediments (James et al. 2019), and the improvement of water quality (McGlathery et al. 2007). Seagrass meadows further contribute to coastal protection by dissipating wave energy and reducing sediment resuspension, a function of increasing importance under climate-driven sea level rise and intensifying storm events (Duarte et al. 2025).

Globally, seagrasses have been declining due to natural and anthropogenic causes (Waycott et al. 2009; Dunic et al. 2021). Explanations for seagrass decline include natural disturbances such as storms, disease and overgrazing by herbivores, as well as anthropogenic stresses including direct disturbance from coastal development, dredging and trawling, coupled with indirect effects through changes in water quality due to sedimentation, pollution, and eutrophication (Jones et al. 2025). In the Great Barrier Reef (GBR) coastal region, the hot spots with highest threat exposure for seagrasses all occur in the southern two thirds of the GBR, in areas where multiple threats including urban, port, industrial and agricultural runoff accumulate (Grech et al. 2011; Losciale et al. 2023). As seagrasses commonly occur in the same sheltered coastal locations as ports and urban centres, Queensland has established strategic monitoring programs for these high-risk areas to aid in their management (Coles et al. 2015).

3.1 Queensland Ports Seagrass Monitoring Program

A long-term seagrass monitoring and assessment program has been established in most Queensland commercial ports. The program was developed by James Cook University's Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) in partnership with Queensland port authorities. A common methodology and rationale are used to provide a network of seagrass monitoring locations throughout the state (Figure 3).

A strategic long-term assessment and monitoring program for seagrasses provides local information for individual ports and contributes to regional assessments of the status of seagrasses more broadly. This further provides port managers and regulators with the key information necessary for planning and implementing port development and maintenance programs to have minimal environmental impacts.

The program also provides an ongoing assessment of many of the most threatened seagrass communities in the state, contributing to advances in the science and knowledge of tropical seagrass ecology. Efforts have been instrumental in developing tools, indicators, and thresholds for the protection and management of seagrasses, and for understanding the causes of tropical seagrass changes over time.

For more information and reports from the other monitoring locations see: https://www.tropwater.com/themes/seagrass-habitats.

Figure 3. Location of TropWATER and Queensland Ports Seagrass monitoring locations and baseline assessments.

3.2 Mackay and Hay Point long term seagrass monitoring program

The Port of Hay Point (approximately 38 km south of Mackay) is one of the world's largest coal exporting ports and comprises two coal export terminals; Dalrymple Bay Coal Terminal and the Hay Point Coal Terminal. The Port of Mackay is a multi-commodity port mainly exporting sugar and grain; located 5km from the city of Mackay. The Port comprises four wharves and a harbour formed by rock breakwaters. North Queensland Bulk Ports (NQBP) is the port authority for the Port of Hay Point and the Port of Mackay.

NQBP recognise that seagrasses form a key ecological habitat in the Mackay-Hay Point region and commissioned James Cook University (JCU) to re-establish and expand on the long-term seagrass monitoring program that took place from 2004-2012. The current program consists of annual surveys of representative monitoring meadows, with broader whole-of-port mapping occurring every third year. The areas selected for annual monitoring represent the range of seagrass communities within the port and include meadows considered most likely to be influenced by port activity and development, as well as reference areas outside the zone of influence of port activity (Figure 4). A new inshore monitoring area was incorporated into the existing seagrass program in 2023 which extended from the Half Tide Tug Harbour to the Hay Point Terminal (southern jetty).

The long-term monitoring program, together with regular broad-scale surveys and complementary research by TropWATER in the Hay Point region, aims to enhance our understanding of water quality, seagrass, coral and benthic habitat dynamics to support more effective management of marine habitats and port environments. It also contributes to Queensland's network of long-term monitoring sites for important fish habitats in high-risk areas and provides critical input on seagrass condition and trends in the Mackay–Whitsundays NRM region, where spatial coverage of seagrass assessments is otherwise limited.

This report presents the findings of the annual seagrass habitat monitoring survey conducted in September 2025 for the Hay Point/Mackay region. Our objectives were to:

- Assess and map seagrass to determine seagrass density (biomass), distribution (area) and community type (species composition) at representative long-term monitoring meadows.
- Compare outcomes with previous monitoring surveys to interpret any changes in seagrass in relation to natural events or human induced port and catchment activities.
- Discuss the implications of monitoring results for the overall health of the Mackay-Hay Point marine environment.

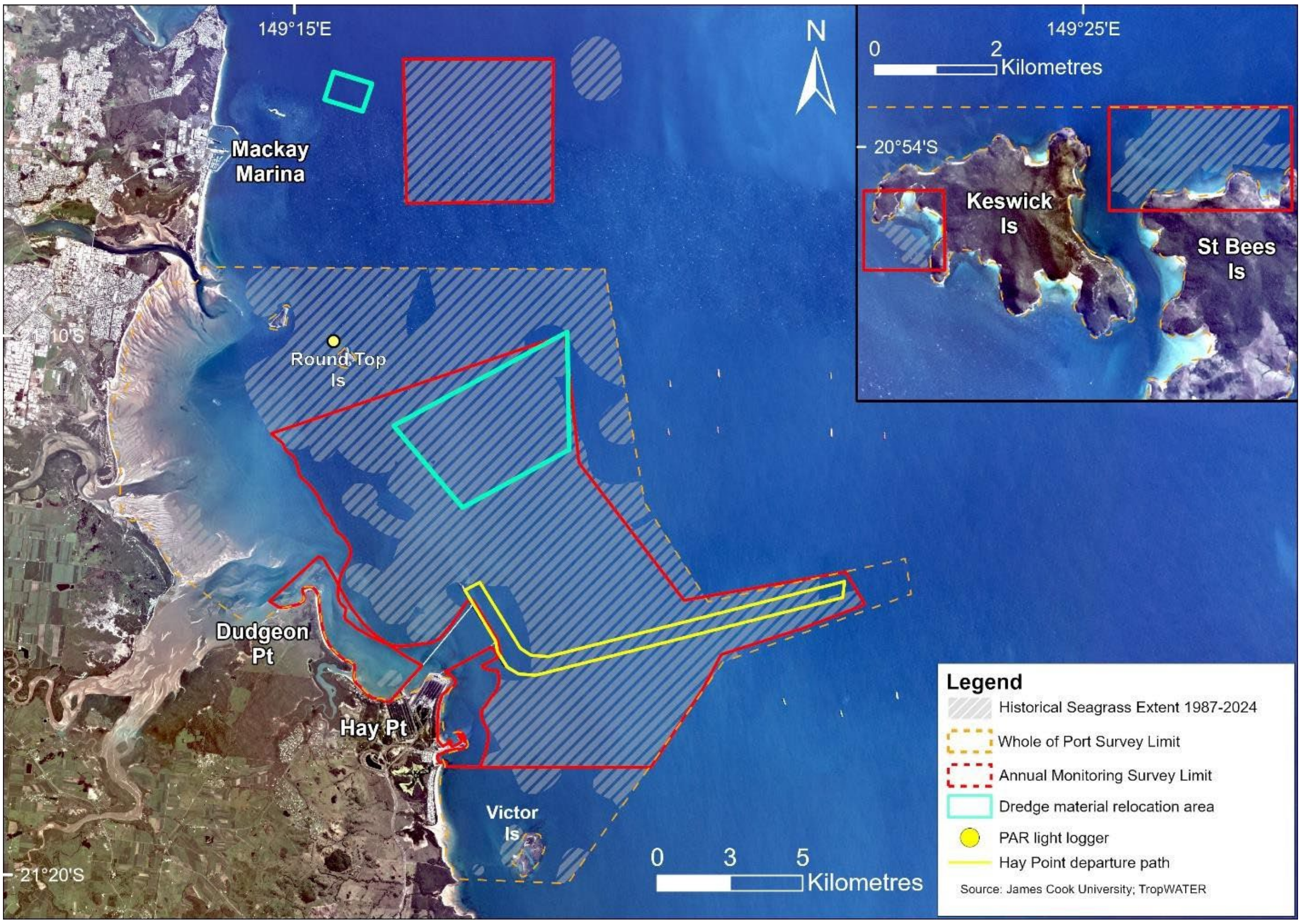

Figure 4. Location of survey limits of annual (red) and extended (orange) seagrass monitoring areas around Mackay, Hay Point and the Keswick Island group in 2025.

4 METHODS

4.1 Sampling approach

Annual monitoring of representative seagrass meadows integrated with a broader-scale survey every three years has been adopted for NQBP's long-term seagrass programs in the Ports of Weipa, Hay Point, Mackay, and Abbot Point, and for multiple other ports in Queensland. Monitoring meadows were selected for detailed assessment because they represented the range of seagrass meadow communities identified in initial surveys and were in areas likely to be vulnerable port operations and developments (or act as reference sites).

Surveys are conducted annually between September and December to assess seagrass at their expected seasonal peak in distribution and abundance, and to facilitate comparisons with the previous surveys conducted in the area. Most recently, the annual monitoring of seagrass communities within the Hay Point/Mackay region (including Keswick and St Bees Islands) occurred in September 2025 (Figure 4; red polygons).

Our approach followed previous surveys, employing standard and extensively reviewed techniques for baseline assessments and monitoring of seagrasses and benthic communities across the regions of Gladstone, Cairns, Mourilyan, Karumba, Abbot Point, Bowen, Clairview, Weipa, Torres Strait, and Townsville. In offshore subtidal areas, techniques ensure that a large area of seafloor is included at each site to account for low seagrass density, spatial variability and patchiness typical of many tropical benthic habitats. Techniques also consider logistical issues associated with naturally high water turbidity and the presence of dangerous marine animals (i.e., crocodiles, marine stingers).

4.2 Sampling methods

Site-appropriate methods were based on existing knowledge of benthic habitats and physical characteristics of the location such as depth, visibility, and logistical and safety constraints. Three sampling techniques were used:

- Small intertidal areas: Walking at low tide.
- Subtidal inshore areas <8m below MSL: Boat based underwater digital camera mounted on a drop frame (Figures 5A, B).
- Offshore subtidal areas >8m below MSL: Boat based digital camera sled tows with sled net attached (Figures 5C, D).

At each survey site, data were recorded on the depth below mean sea level (MSL), time, and position (GPS). Seagrass habitat observations included seagrass presence/absence, species composition, and above-ground biomass. Other benthic habitat characteristics included the percent cover of algae, benthic organisms (i.e., coral, sponges), and sediment type.

At sites where seagrass was present, seagrass above-ground biomass was measured using a "visual estimates of biomass" technique (Kirkman 1978; Mellors 1991). For camera drop sites, an observer ranked seagrass biomass within three randomly placed 0.25m^2 quadrats. For digital camera sled tow sites, an observer ranked seagrass from ten random time frames along a 100m transect. For each frame, the video was paused and advanced to the nearest point where the seabed was clearly visible and the sled was stable. A 0.25 m^2 quadrat, scaled to the camera lens, was then overlaid on the screen to standardise estimates.

Figure 5. (**A-B**) Shallow subtidal assessments of seagrass meadows using live-feed digital camera mounted on a 0.25m^2 drop frame, and (**C-D**) offshore underwater sled tows with digital camera.

4.3 Habitat mapping and Geographic Information System

All survey data were entered into a Geographic Information System (GIS) using ArcGIS PRO 3.5® software. Three GIS layers were created to describe seagrass in the survey area: a site layer, meadow layer and biomass interpolation layer.

- *Seagrass site layer:* The site (point) layer contains all site-level data, including:
  - Site number
  - Temporal details – Survey date and time
  - Spatial details – Latitude, longitude, depth below mean sea level (dbMSL; metres) for subtidal sites.
  - Habitat information – Sediment type, seagrass presence/absence, seagrass above-ground biomass (total and for each species), and biomass standard error (SE), dugong feeding trail (DFT) presence/absence.
  - Sampling method
  - Any relevant comments

- *Seagrass meadow layer:* The meadow (polygon) layer provides summary information for all sites within each meadow, including:
  - Meadow ID number – A unique number assigned to each meadow to allow comparisons among surveys (except for Half Tide Tug Harbour (HTTH), which has not yet been established as a formal monitoring meadow)
  - Temporal details – Survey date
  - Habitat information – Mean meadow biomass ± standard error (SE), number of sites within the meadow, seagrass species present, meadow density, community type (Tables 1 & 2), meadow area (hectares) ± reliability estimate (R) (Table 3), and landscape category (Figure 6)
  - Sampling method and any relevant comments

- *Interpolation layer*: The interpolation (raster) layer describes spatial variation in seagrass biomass across each meadow, created using an inverse distance weighted (IDW) interpolation of seagrass site data within each meadow.

Meadows were described using a standard nomenclature system developed for Queensland's seagrass meadows. Seagrass community type was determined using the dominant and other species' percent contribution to mean meadow biomass (for all sites within a meadow) (Table 1). Community density was based on the mean biomass of the dominant species within the meadow (Table 2).

Table 1. Nomenclature for Queensland seagrass community types.

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

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

Density	Mean above-ground biomass (g dw m^{-2})				
	H. uninervis (narrow)	*H. ovalis* *H. decipiens*	*H. uninervis* (wide)	*H. spinulosa* *H. tricostata*	*Z. muelleri*
Light	< 1	< 1	< 5	< 15	< 20
Moderate	1 - 4	1 - 5	5 - 25	15 - 35	20 - 60
Dense	> 4	> 5	> 25	> 35	> 60

Isolated seagrass patches

Most of the area within the meadow consists of unvegetated sediment interspersed with isolated patches of seagrass.

Aggregated seagrass patches

The meadow consists of numerous seagrass patches but still features substantial gaps of unvegetated sediment within the boundary.

Continuous seagrass cover

Most of the meadow area consists of continuous seagrass cover with a few gaps of unvegetated sediment.

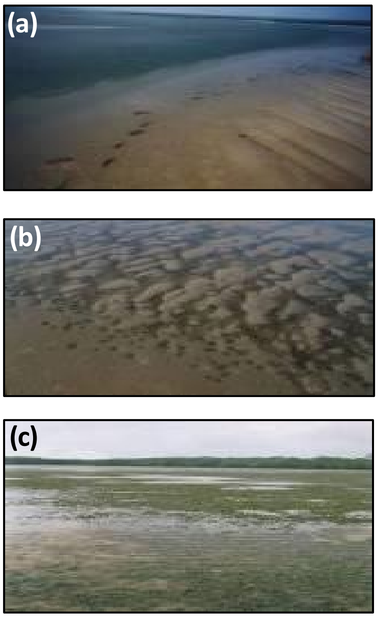

Figure 6. Seagrass meadow landscape categories: (a) Isolated seagrass patches, (b) aggregated seagrass patches, (c) continuous seagrass cover.

Seagrass meadow boundaries were determined from a combination of techniques. Exposed inshore boundaries were guided by recent satellite imagery of the region (Source: ESRI; Google Earth) and researchers walking the inner/exposed boundary. Subtidal boundaries were interpreted from a combination of subtidal survey sites and the distance between sites, field notes, depth contours and recent satellite imagery.

Once meadow polygons were delineated in ArcGIS Pro, area was calculated using the *Calculate Geometry* function. To account for spatial uncertainty, each meadow was assigned a mapping precision estimate (m) based on the survey method (Table 3). Precision ranged from <10 m for intertidal meadows mapped on foot to 90 m for subtidal meadows, where boundaries were inferred from distances between sites with and without seagrass. These estimates were used to generate buffers around each meadow to represent spatial error, with the buffered area expressed as a meadow reliability estimate (R; ha).

Table 3. Mapping precision and methodology for boundary mapping in the Port of Hay Point and Keswick Island group.

Mapping precision	Mapping methodology
10 m	Subtidal meadow boundaries determined from walking in meadows at low tide. Relatively high density of survey sites. Recent aerial photography aided in mapping.
20-50 m	Subtidal meadow boundaries determined from underwater CCTV camera drops. Moderate to high density of survey sites.
80-90 m	Larger subtidal meadows with boundaries determined from underwater CCTV and sled tows. All meadows subtidal. Relatively low density of survey sites.

4.4 Seagrass meadow condition index

A condition index was developed for seagrass monitoring meadows based on changes in mean above-ground biomass, total meadow area and species composition relative to a baseline (see Carter et al. 2023 for full details). Seagrass condition for each indicator in Hay Point-Mackay was scored from 0 to 1 and assigned one of five grades: A (very good), B (good), C (satisfactory), D (poor) and E (very poor). Overall meadow condition is the lowest indicator score of biomass or area. However, where species composition is the lowest score, this contributes only 50% of the overall meadow score, and the next lowest indicator (area or biomass) contributes the remaining 50% (Carter et al. 2023).

Since the onset of monitoring in 2004, ten-year baselines have been established for Dudgeon Point, Keswick Island, St Bees Island, and Hay Point, providing a foundation for characterising long-term interannual patterns in meadow condition. The Mackay offshore meadows were surveyed for the ninth consecutive year in 2025, and condition scores for this site are therefore considered interim until a full ten-year baseline is established. The Half Tide Tug Harbour survey area will be incorporated into Mackay–Hay Point condition reporting once five years of data have been accumulated, at which point interim grades and scores can be assigned to condition indicators, provided sufficient seagrass is recorded to constitute a definable meadow in the following years.

4.5 Environmental data

Environmental data were collated for the 12 months preceding the start of the survey. River flow was provided by the Queensland Government Water Monitoring Information Portal (Station 125016A – Pioneer River at Dumbleton Weir) and total daily rainfall was obtained for the nearest weather station from the Australian Bureau of Meteorology (Mackay Aero station #033045; http://www.bom.gov.au/climate/data/). Wave height data were provided by the Queensland Government Department of the Environment, Tourism, Science and Innovation: Site Hay Point.

Benthic light measured as photosynthetically active radiation (PAR - mol photons m^{-2} day^{-1}), benthic water temperature, and wave stress data were collected by the companion TropWATER Marine Water Quality Monitoring Program at Round Top Island (logger MKY_AMB3B) near the offshore seagrass meadows. Data were collected from a PAR Sensor positioned on the horizontal surface of a multiparameter water quality logging instrument, which takes a PAR measurement at ten-minute intervals for a one second period. Data are presented as a 7-day rolling average of total daily PAR to allow for comparison with modelled thresholds of light requirements for deep-water seagrass in the region, mainly *Halophila spp.* (Collier et al. 2016; Chartrand et al. 2017, 2018).

Wave stress was measured using the root mean square water height (RMS water depth), which represents short-term variability in pressure over the 10-second burst interval and is therefore related to wave energy at the seabed (Cartwright et al. 2025). RMS water depth does not measure wave height at the sea surface but rather provides an index of near-bed orbital motion or wave shear stress relative to depth. Consequently, RMS water depth is a useful relative indicator of potential resuspension that is directly comparable between sites of different depths. For interpretation, higher RMS water height values indicate stronger wave action.

For the full suite of water quality monitoring stations and results, see Cartwright et al. 2025.

5 RESULTS

5.1 Seagrass in the long-term monitoring areas

The 2025 Hay Point/Mackay seagrass monitoring surveys were conducted in October and November 2025. Of the 305 assessment sites, seagrass was present at 39% of these (Figure 8). Six seagrass species were recorded in 2025, all of which are typical for coastal and offshore areas in the Hay Point/Mackay region and common across central Queensland (Figure 7; A1). While absent in 2024, *Zostera muelleri* was recorded at the inshore Dudgeon Point monitoring meadow for the first time since 2021 (Figure A1).

Meadows differed by species composition, with some varying from previous years (Figure 9; A1). The inshore meadow at Dudgeon Point was characterised by moderate densities of *Halodule uninervis* (primarily of the wide leaf variety) with light densities of *Halophila decipiens* and *Z. muelleri* also present. In 2024 this meadow was dominated by *Halophila ovalis*.

In the Keswick Island group, the meadow at St Bees Island was comprised of light *Halophila tricostata* and *H. decipiens*, which was typical of previous years (Figure 9; A1). The Keswick Island monitoring meadow was dominated by *H. tricostata* in 2025, with other species present in lower abundance. In contrast, this meadow was dominated by *H. decipiens* in 2024.

Deepwater seagrass assemblages offshore from Hay Point were dominated by light densities of *H. decipiens* and *H. spinulosa* (Figure 9; A1). *Halophila spinulosa* has not been recorded in the Hay Point offshore meadow since 2023. In the Mackay monitoring block, seagrass above-ground biomass was dominated by a light density *H. spinulosa,* consistent with previous years.

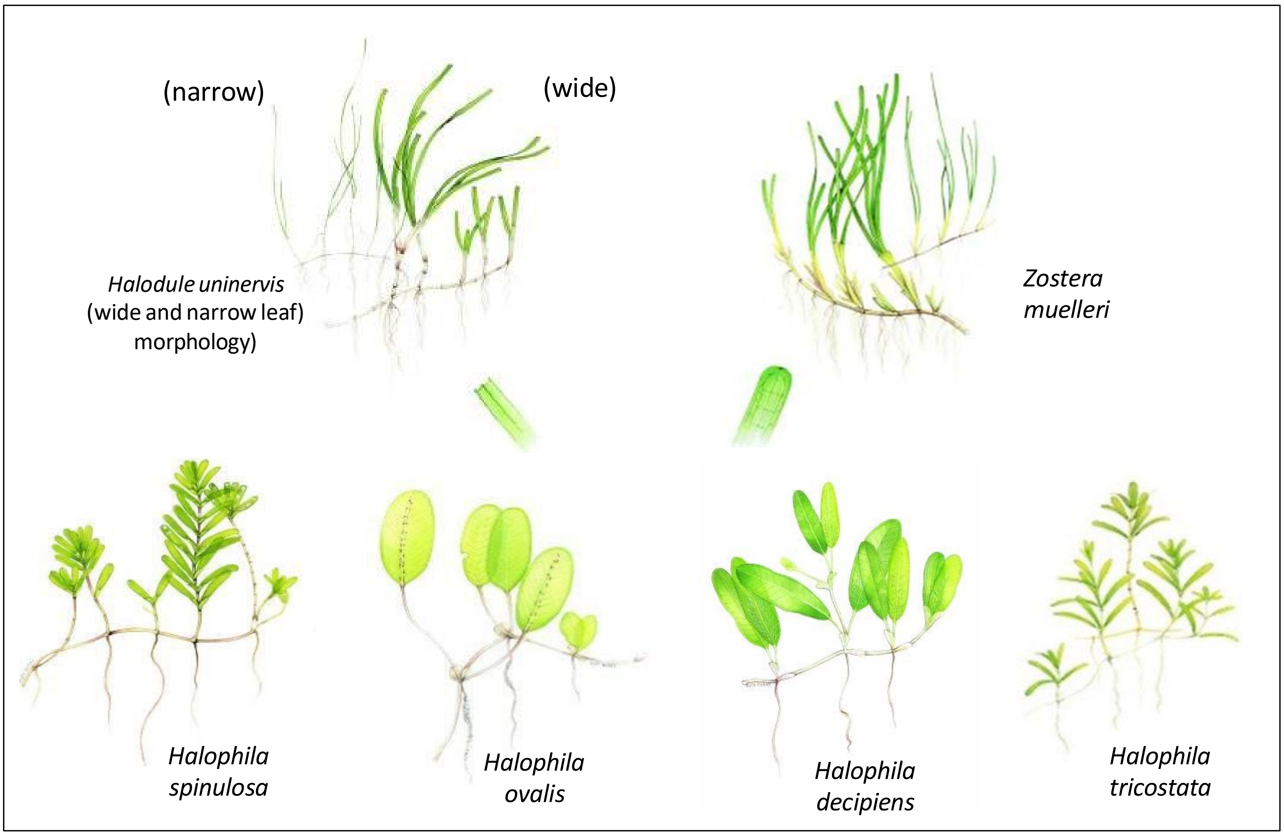

Figure 7. Seagrass species identified in the Hay Point/Mackay annual monitoring meadows in 2025. Leaf size varies widely within species and diagrams are not to scale.

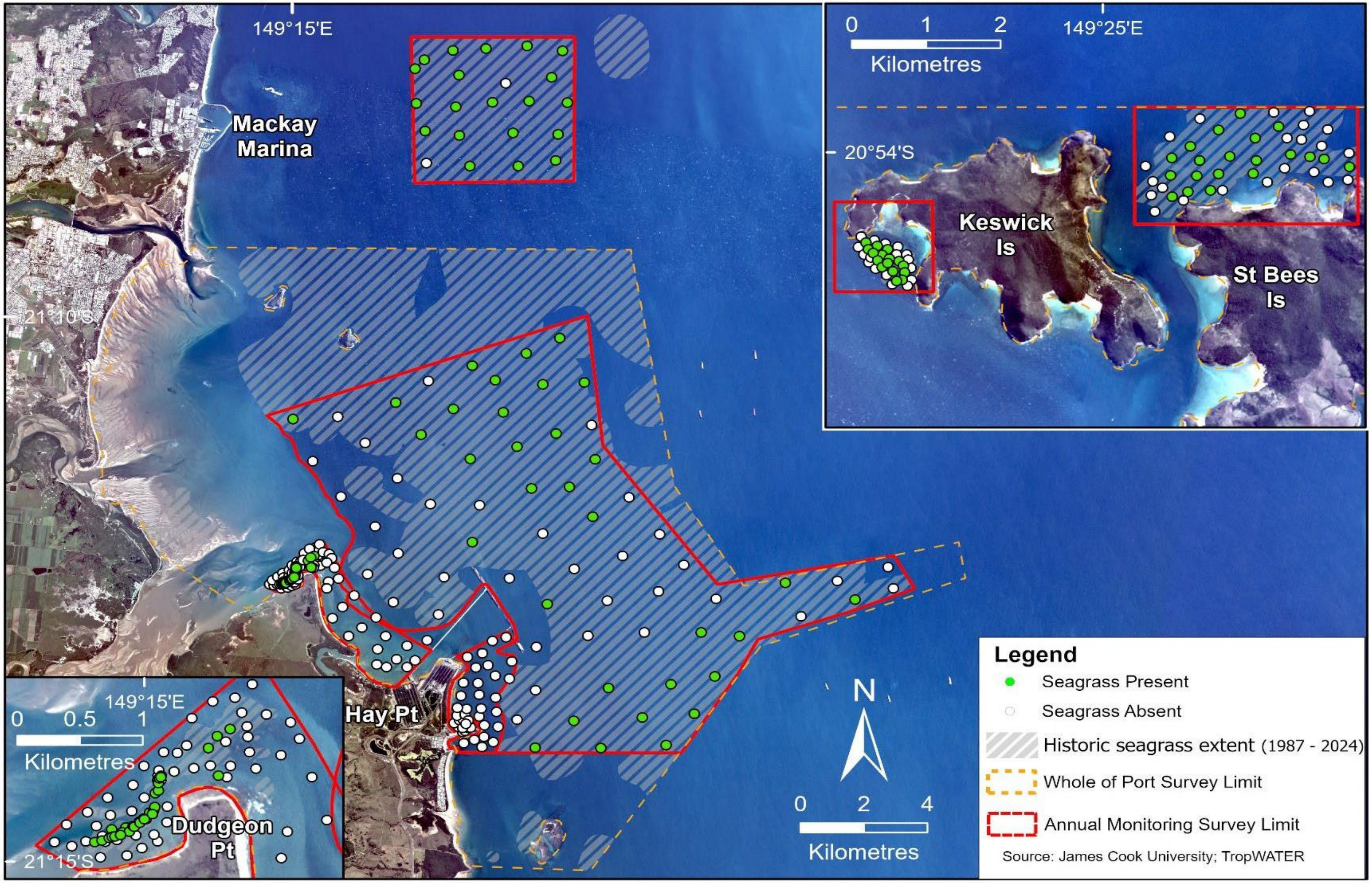

Figure 8 Location of 2025 annual seagrass monitoring assessment sites showing seagrass presence/absence in the Hay Point/Mackay region.

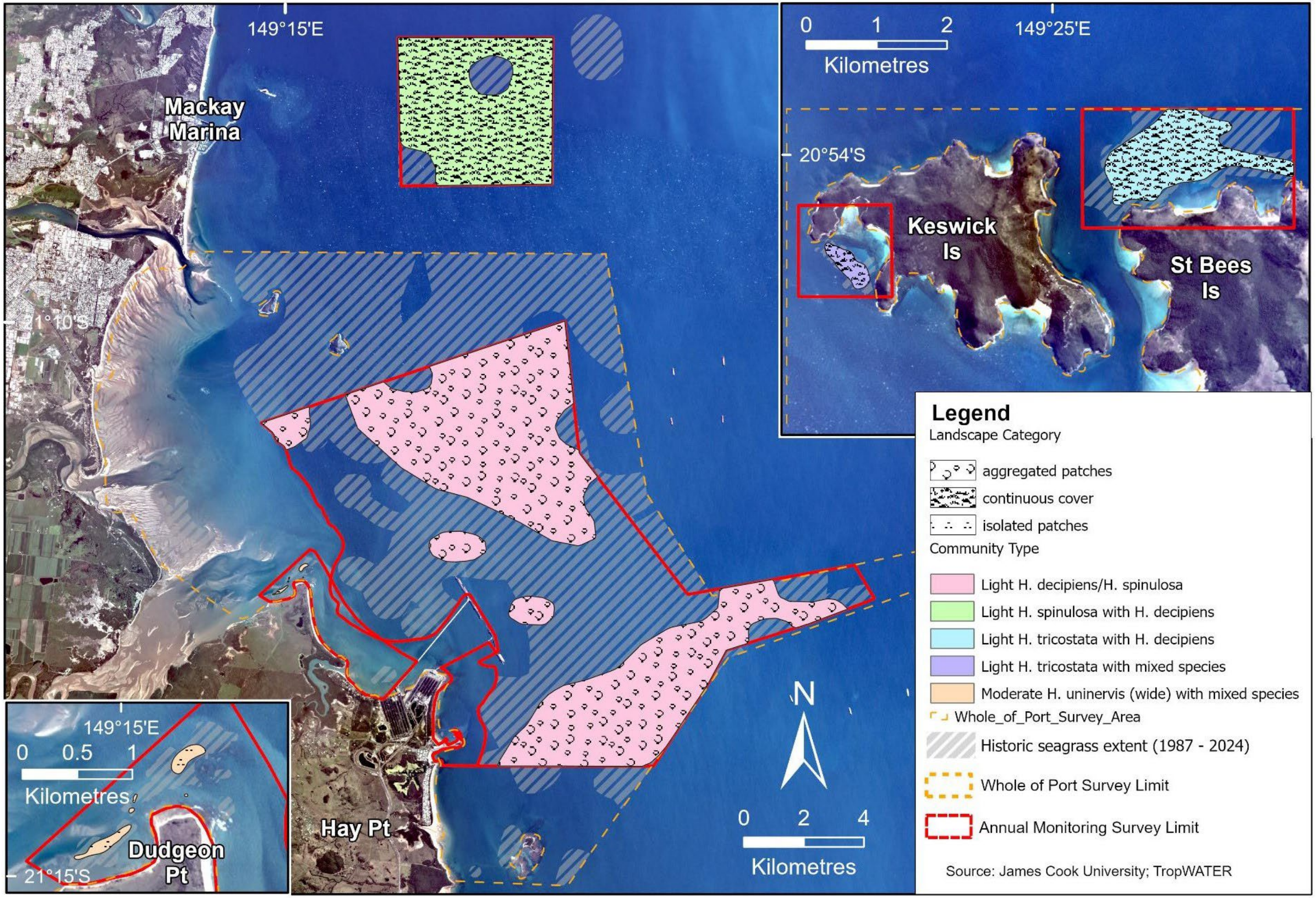

Figure 9. Location of 2025 seagrass meadows in the Hay Point/Mackay region showing seagrass communities and landscape categories.

5.2 Seagrass condition in the Hay Point - Mackay region

The Hay Point/Mackay monitoring meadows were in an overall good condition at the end of 2025 (Table 4) - an improvement from the previous year. Condition varied among monitoring locations, with improvements recorded in most offshore and island meadows, while the Dudgeon Point meadow declined in condition due to reduced meadow area.

5.2.1 Offshore seagrass at Hay Point and Mackay

The offshore meadow at Hay Point (Meadow 8) increased from overall satisfactory condition in 2024 to very good condition in 2025 due to increases in meadow area (Table 4; Figure 10). Since 2024, meadow area increased from 1,968 ± 405 ha to 5,871 ± 685 ha, the largest area mapped since 2021. Species composition remained in very good condition with near-equal contributions of *H. spinulosa* and *H. decipiens* (Figure A1). Seagrass above-ground biomass remained in very good condition.

The offshore Mackay meadow (Meadow 5) showed similar patterns to Meadow 8, increasing from an overall satisfactory to very good condition in 2025 (Table 4; Figure 11). Since 2017, seagrass biomass has generally increased, first reaching very good condition status in 2023 and remaining so in 2024 and 2025. Meadow area more than doubled from 972.6 ± 209.4 ha in 2024 to 2,064 ± 184 ha in 2025 similar to seagrass extent last observed in 2020-2023. As in previous years, species composition of this meadow continued to be dominated by *H. spinulosa* (Figure A1).

Long-term temporal patterns showed seagrass biomass was either greater or comparable to previous years for both meadows (Figures 15-16). For full historic above-ground biomass and area data on offshore meadows, refer to Table A1.

5.2.2 Inshore seagrass at Dudgeon Point and Half Tide Tug Harbour

The Dudgeon Point coastal monitoring meadow (Meadow 1) was the only meadow that received a lower condition score than the previous year (from satisfactory to poor condition). This decrease was primarily driven by a decline in meadow area (Table 4; Figure 12). Since 2024, meadow area dropped from 15.2 ± 4.3 ha (very good condition) to 8.1 ± 2.6 ha (poor condition), which was largely comprised of isolated patches of seagrass. This meadow has historically displayed a high level of variability in area (Figure 17). Biomass at Dudgeon Point has shown modest decreases since 2022 but has remained in good condition over the past seven years. The species composition of this meadow was considered satisfactory in 2024 due to a dominance of *H. ovalis*, but greater contributions of *H. uninervis* (a more stable species) in 2025 resulted in the elevation of this meadow to have a good species composition score in 2025. *Zostera muelleri* was present in this year's survey following a three-year period of absence (Figure A1).

Seagrass was absent from the Half Tide Tug Harbour area, as was the case in 2024.

For full historic details on the above-ground biomass and area of inshore meadows, refer to Table A2.

5.2.3 Keswick and St Bees Islands

Subtidal seagrass at St Bees Island (Meadow 10) improved from poor (2024) to good condition at the end of 2025 due to an increase in seagrass area and biomass (Table 4; Figure 13). The above-ground seagrass biomass was greater than the past two years and increased from 0.86 ± 0.31 g DW m^{-2} in 2024 to 1.27 ± 0.19 g DW m^{-2} in 2025. The area of seagrass increased from 110.9 ± 39.8 ha (2024) to 166.6 ± 13.8 ha in 2025 and was the highest recorded since 2021 (Table 4; Figure 13). Species composition remained similar to previous years, with a dominance of *H. tricostata* and minor contributions of *H. decipiens* (Figure A1).

The Keswick Island monitoring meadow (Meadow 14) remained in a satisfactory condition in 2025 but with some improvements in area and species composition (Table 4; Figure 14). In general, meadow area has increased annually since record low coverage mapped in 2021. Since 2024, the area of the meadow has remained in very good condition with little change in 2025 (16.7 ± 3.8 ha vs 18.1 ± 3.9 ha, respectively). While a shift to a *H. decipiens* dominated meadow in 2024 resulted in a satisfactory condition for species composition, this meadow shifted again to primarily *H. tricostata* (a more stable species), elevating it to very good condition for species composition in alignment with previous years (Figure A1). Biomass remained in satisfactory condition for the third year with an estimated 1.14 ± 0.30 g DW m^{-2} of seagrass.

Long-term trends in seagrass biomass since 2017 are shown for both meadows in Figure 18. For full historic above-ground biomass and area details on meadows in the Keswick Islands group, refer to Table A3.

Table 4. Condition scores for seagrass indicators (biomass, area, and species composition) for the Hay Point-Mackay long-term monitoring meadows in 2025.

Meadow #	Location	Biomass	Area	Species Composition	Overall Meadow Score
1	Dudgeon Point	0.68	0.44	0.74	0.44
5	Mackay - Offshore	0.86	0.88	0.95	0.86
8	Hay Point - Offshore	0.89	0.91	1.00	0.89
10	St Bees Island	0.70	0.81	0.83	0.70
14	Keswick Island	0.63	0.87	0.93	0.63
Overall Score for the Hay Point-Mackay region					0.70

= very good condition = good condition = satisfactory condition

= poor condition = very poor condition

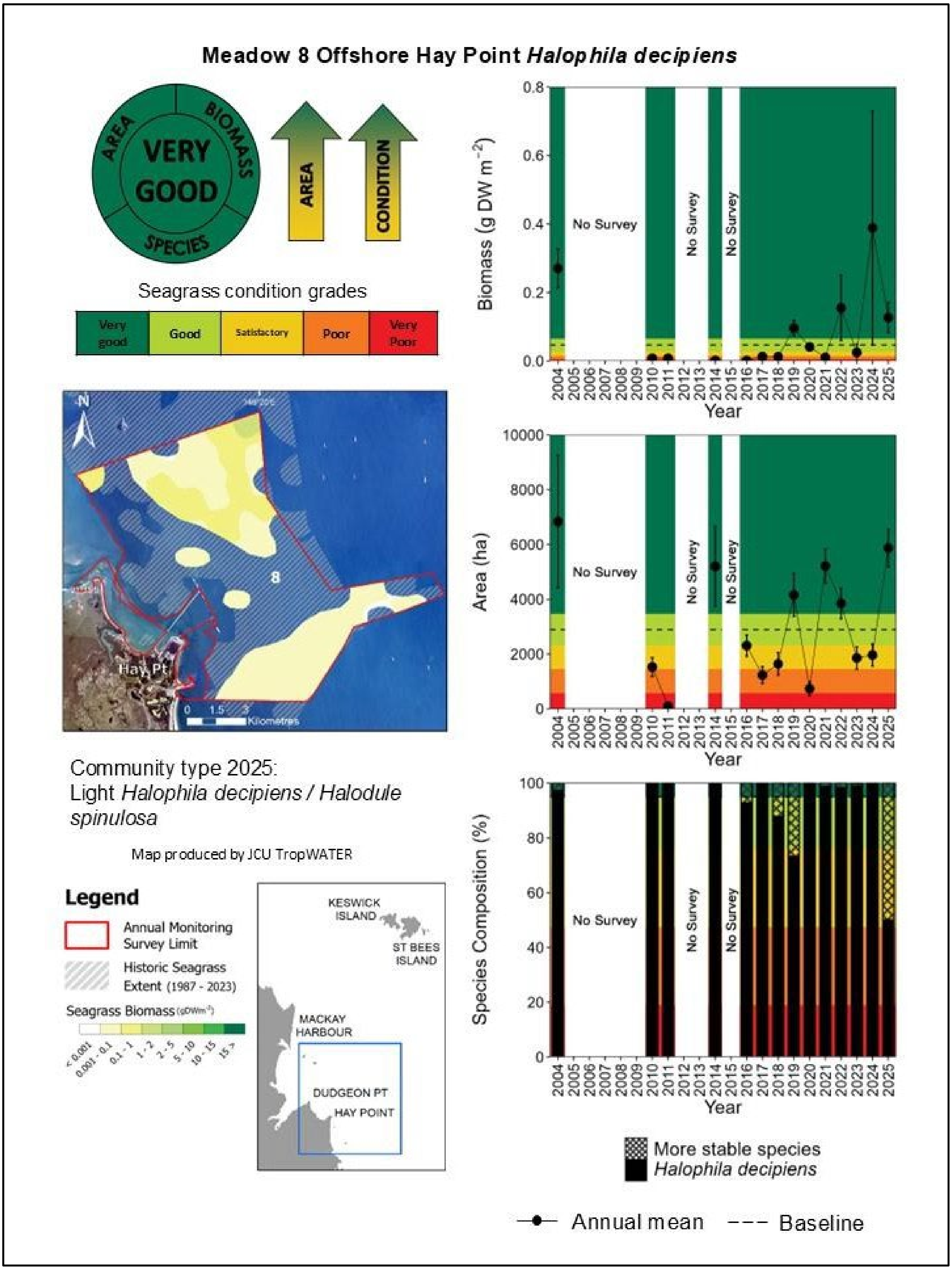

Figure 10. Changes in mean meadow biomass (g DW m^{-2}), total meadow area (ha) and species composition for seagrass in the Hay Point offshore area (Meadow 8), 2004 – 2025 (biomass error bars = SE; area error bars = reliability estimate). Lack of condition indicator arrow means no change in condition index from the previous year.

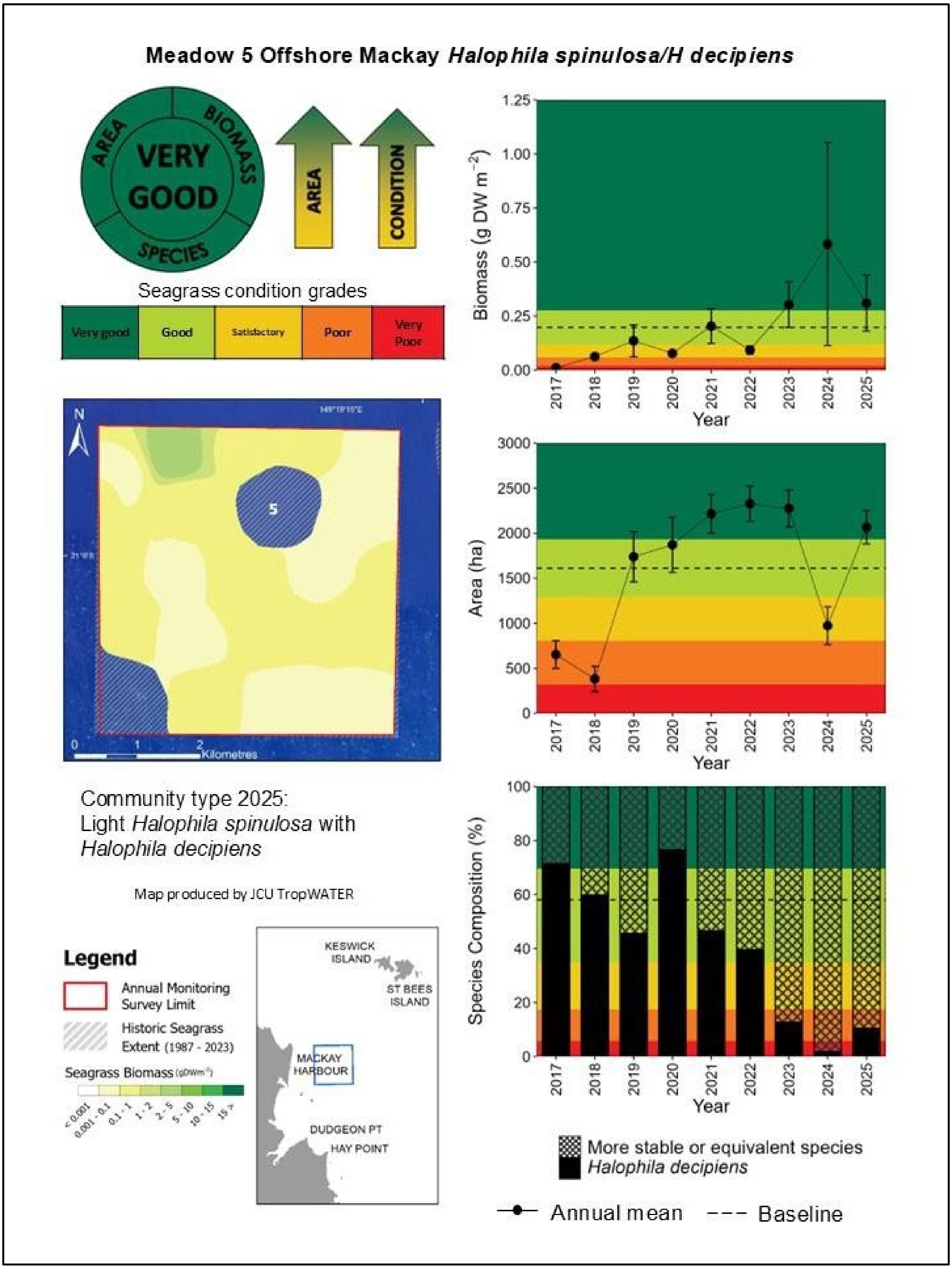

Figure 11. Changes in mean meadow biomass (g DW m^{-2}), total meadow area (ha) and species composition for seagrass in the Mackay offshore area (Meadow 5), 2017 – 2025 (biomass error bars = SE; area error bars = reliability estimate). Lack of condition indicator arrow means no change in condition index from the previous year.

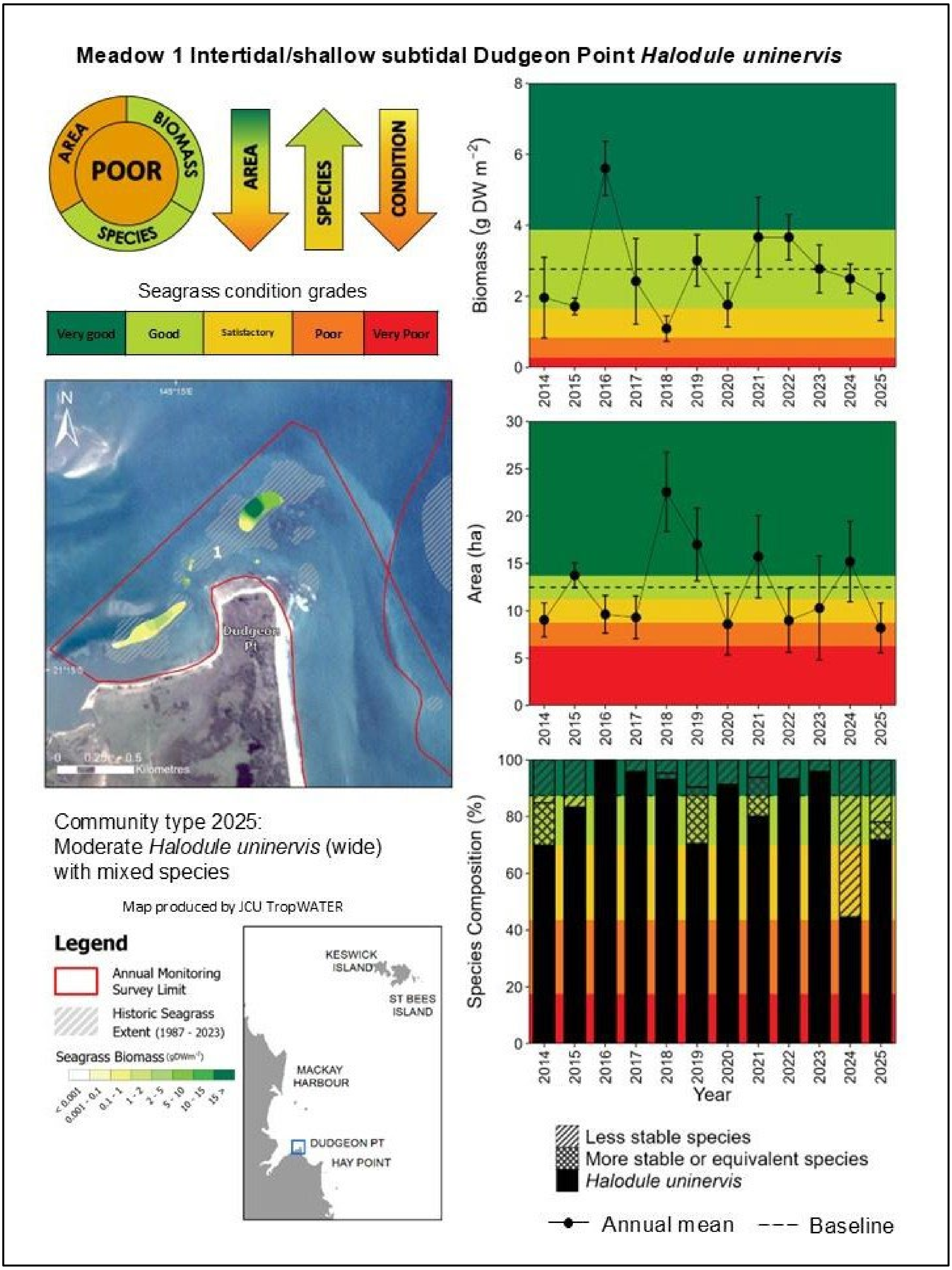

Figure 12. Changes in mean meadow biomass (g DW m^{-2}), total meadow area (ha) and species composition for seagrass in the Dudgeon Point coastal area (Meadow 1), 2014 – 2025 (biomass error bars = SE; area error bars = reliability estimate). Lack of condition indicator arrow means no change in condition index from the previous year.

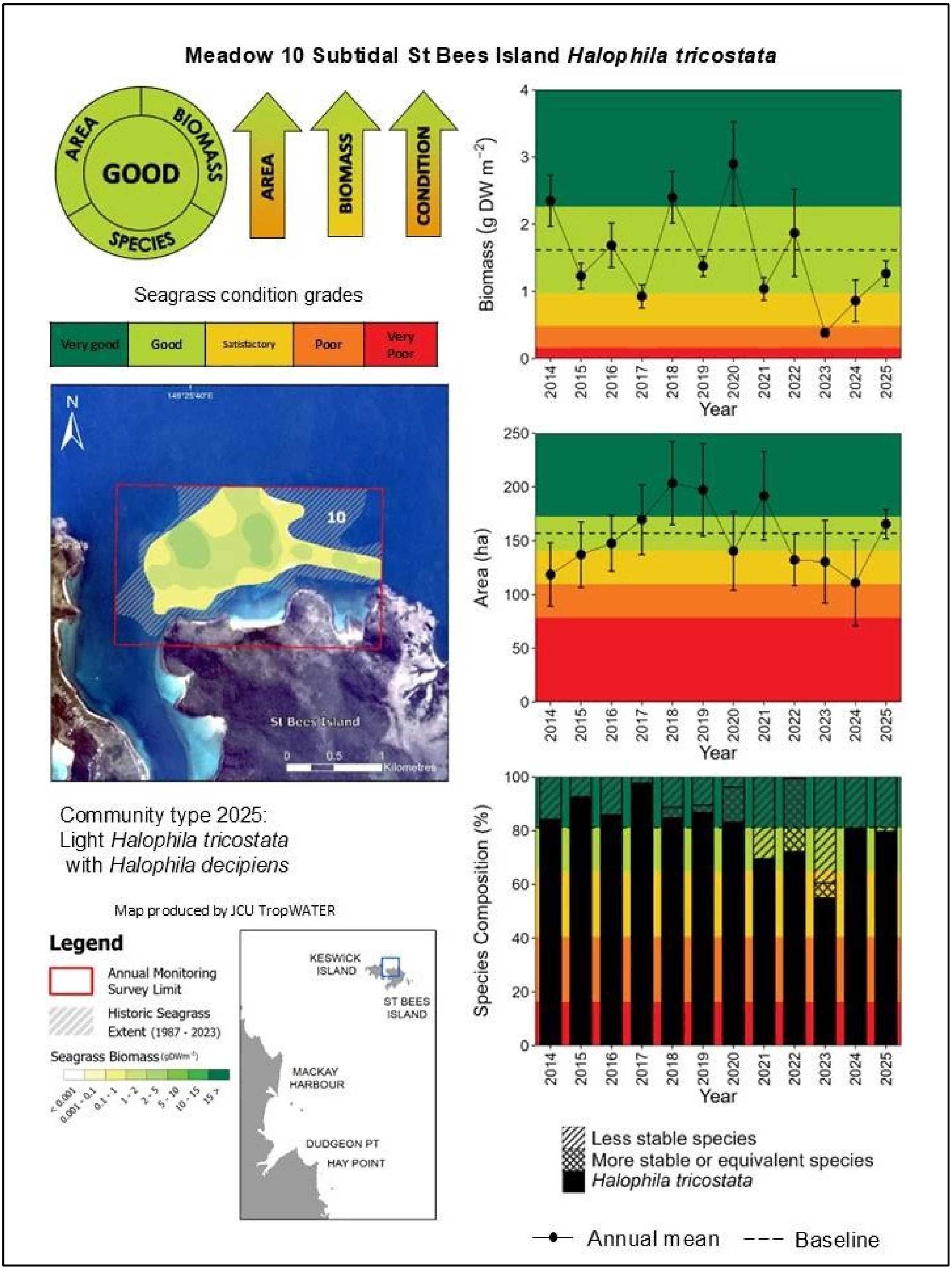

Figure 13. Changes in mean meadow biomass (g DW m^{-2}), total meadow area (ha) and species composition for seagrass in the St Bees Island coastal area (Meadow 10), 2014 – 2025 (biomass error bars = SE; area error bars = reliability estimate). Lack of condition indicator arrow means no change in condition index from the previous year.

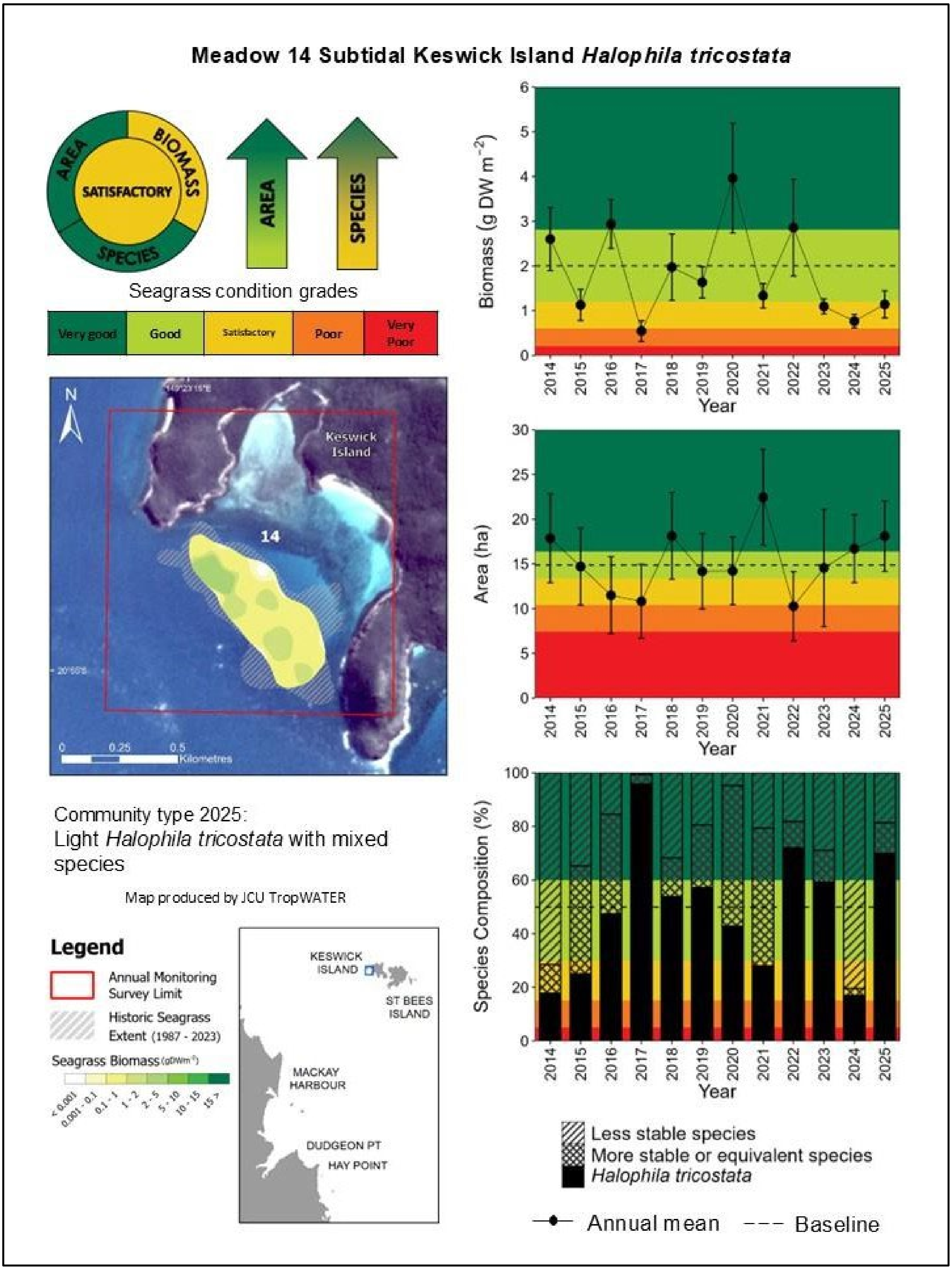

Figure 14. Changes in mean meadow biomass (g DW m^{-2}), total meadow area (ha) and species composition for seagrass in the Keswick Island coastal area (Meadow 14), 2014 – 2025 (biomass error bars = SE; area error bars = reliability estimate). Lack of condition indicator arrow means no change in condition index from the previous year.

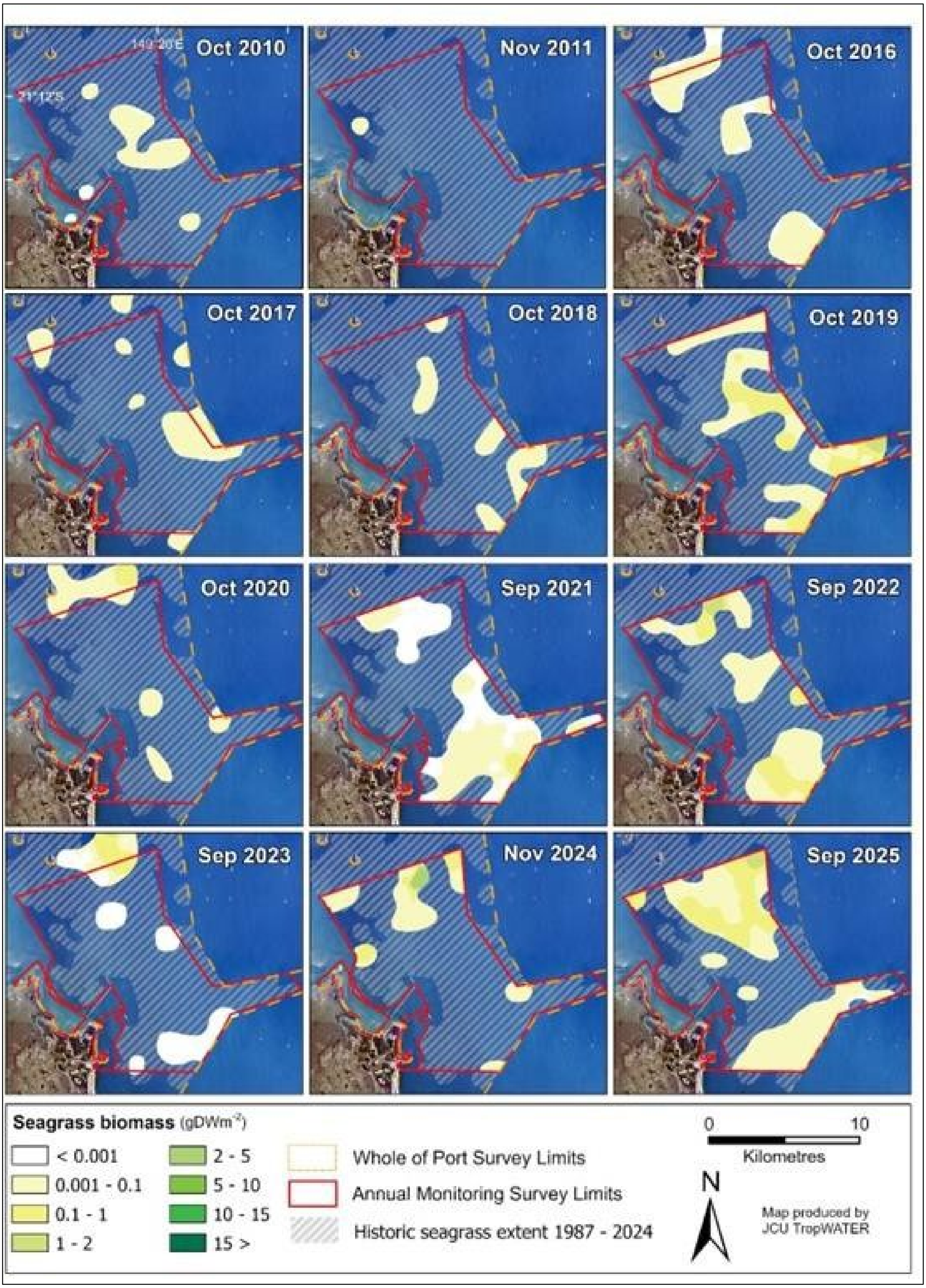

Figure 15. Temporal comparisons of seagrass above-ground biomass (g DW m^{-2}) distribution and seagrass meadow extent in the Hay Point offshore monitoring area (Meadow 8) from 2010-2025.

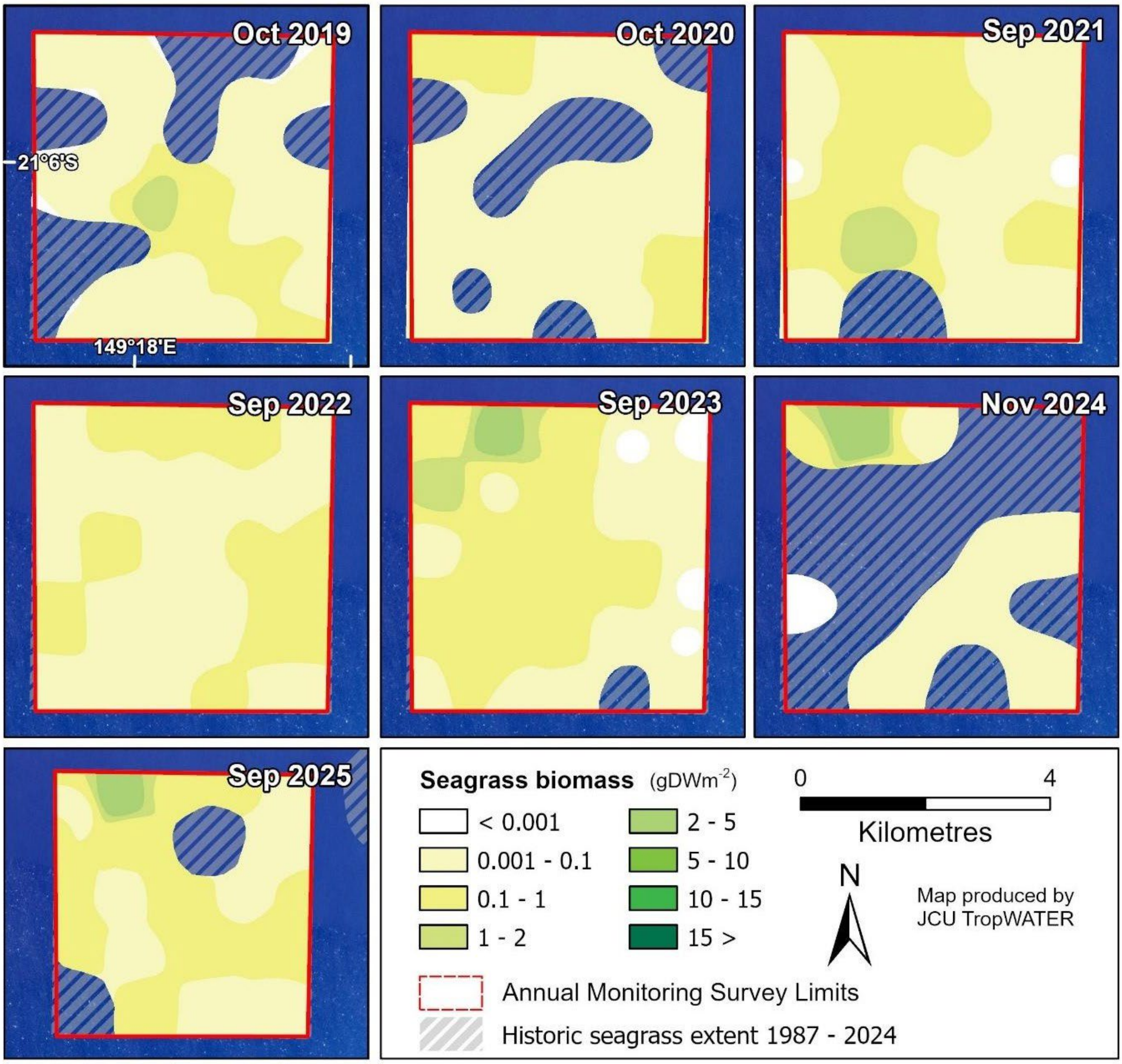

Figure 16. Temporal comparisons of seagrass above-ground biomass (g DW m^{-2}) distribution and seagrass meadow extent in the Mackay offshore monitoring area (Meadow 5) from 2019-2025.

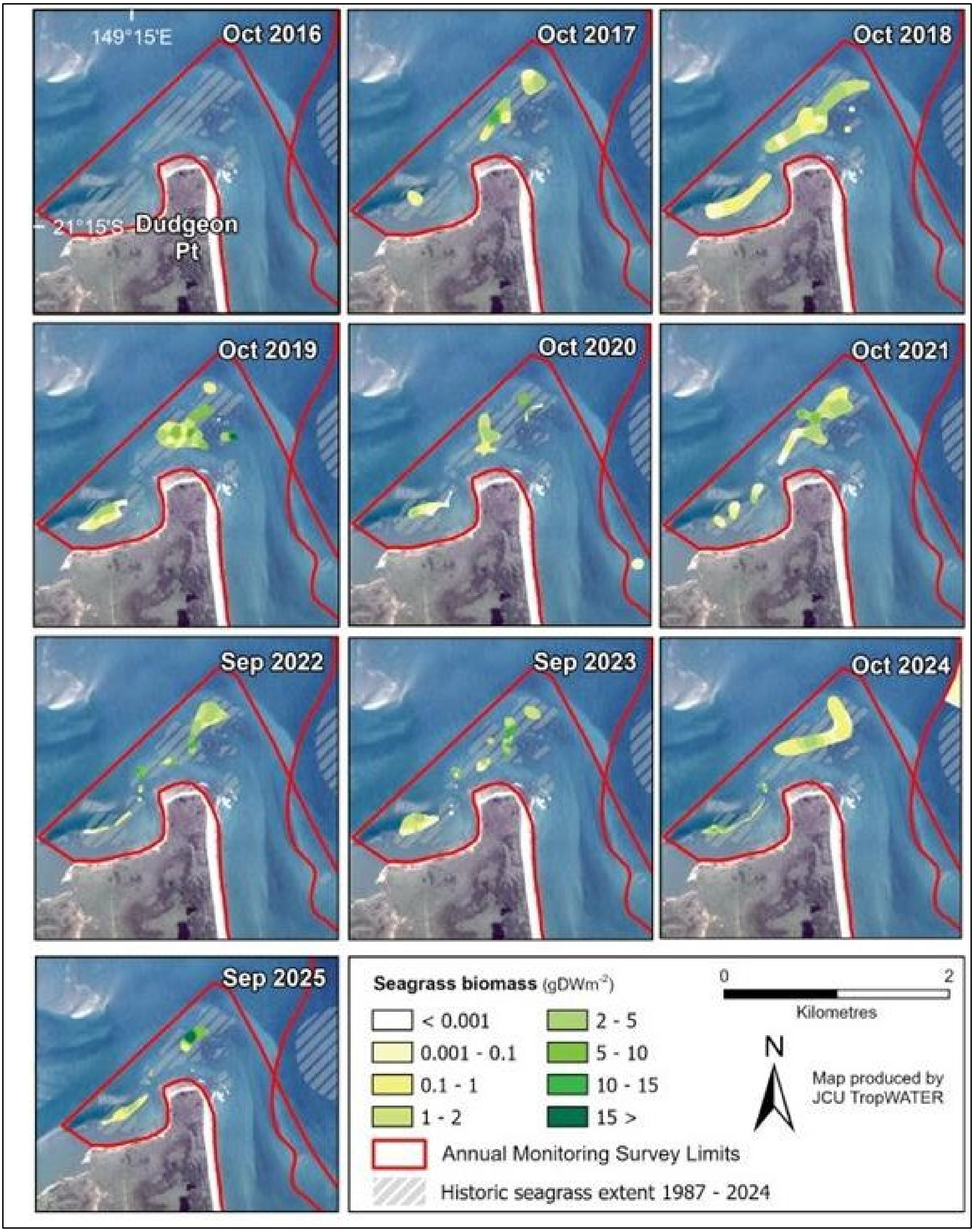

Figure 17. Temporal comparisons of seagrass above-ground biomass (g DW m^{-2}) distribution and seagrass meadow extent in the Dudgeon Point monitoring area (Meadow 1) from 2016-2025.

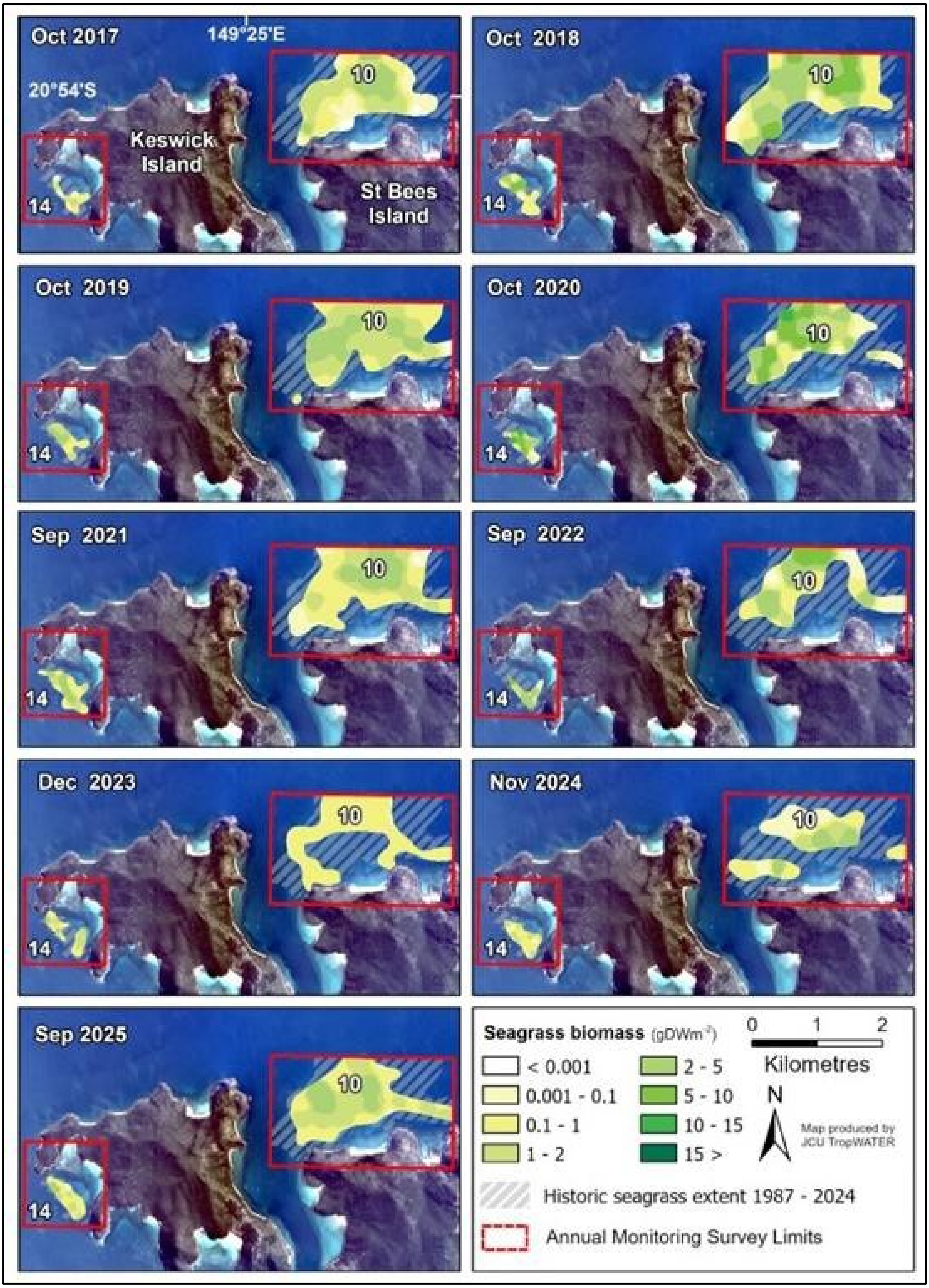

Figure 18. Temporal comparisons of seagrass above-ground biomass (g DW m^{-2}) distribution and seagrass meadow extent at the Keswick and St Bees Islands (Meadows 10, 14) from 2017–2025.

5.3 Environmental data

5.3.1 Benthic water temperature

Daily benthic water temperatures at Round Top Island ranged from 19.1 - 30.0 ◦C (average = 25.6 ◦C) over the past three years. In the past twelve months leading up to the survey, benthic temperatures did not fall outside of this range (19.9 – 30.5 ◦C), and seasonal fluctuations were comparable to previous years (Figure 19).

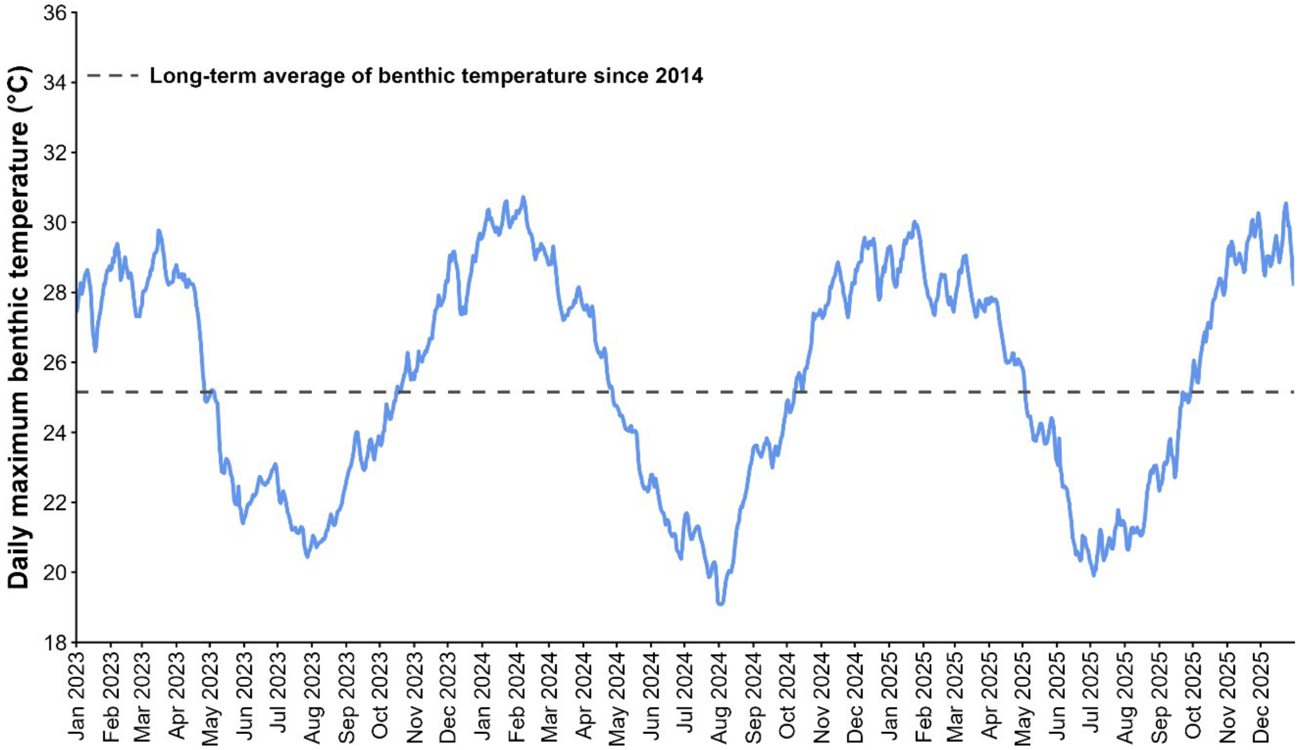

Figure 19. Daily photosynthetically active radiation (PAR; mol photons m^{-2} day^{-1} over a 7-day rolling average) at Round Top Island. Data presented from January 2023 to December 2025. Data provided by the TropWATER Marine Water Quality Monitoring Program).

5.3.2 Benthic daily light (Photosynthetically Active Radiation - PAR)

Daily PAR measurements at the deep water Round Top Island site in the twelve months prior to the 2025 survey ranged from 0 – 9.05 mol photos m^{-1} day^{-1} (average = 1.9 mol photos m^{-2} day^{-1}) (Figure 20). Light levels (PAR) decreased gradually since peaking in September 2024 and remained relatively low after February 2025. The longest durations for which light was below the expected light requirements of *Halophila spp.* occurred during January/February 2025 (18 days), May 2025 (19 days), and September 2025 (21 days).

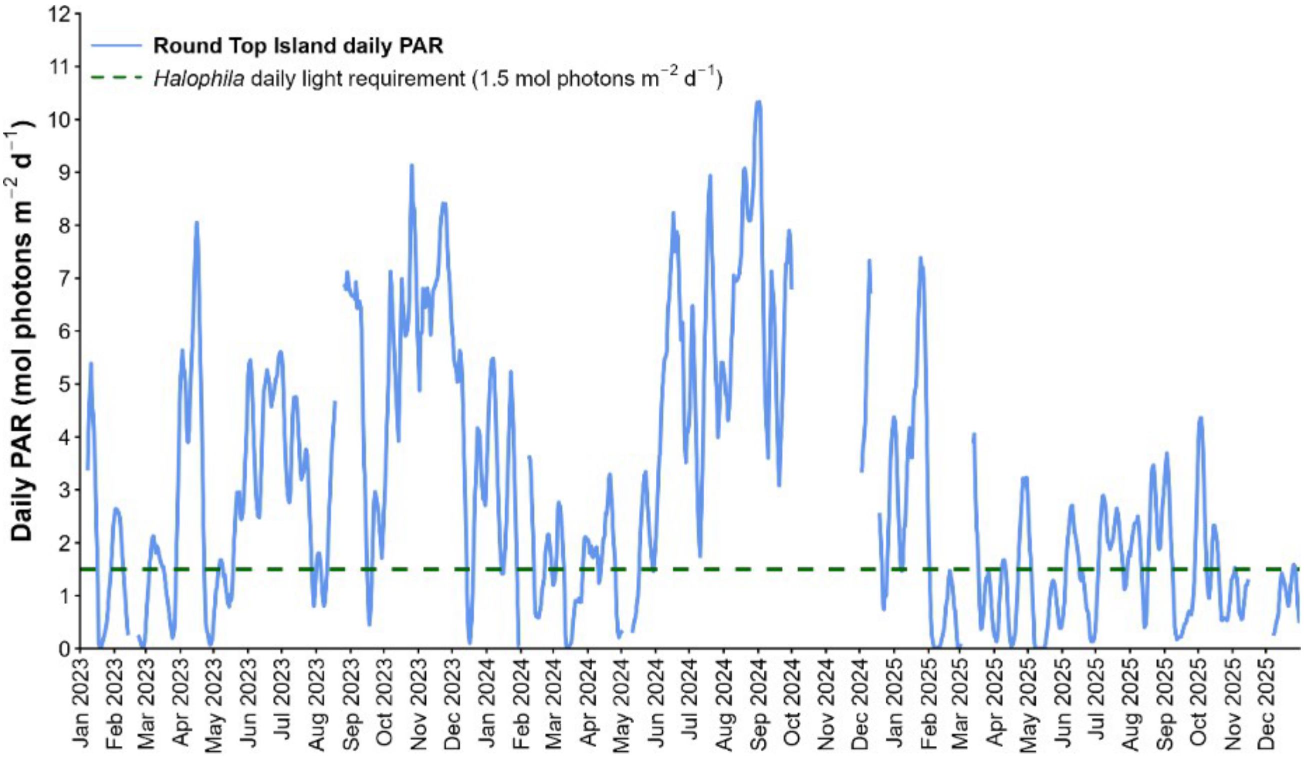

Figure 20. Daily benthic water temperature (°C) measured at Round Top Island from January 2023 – December 2025 relative to the long-term average (data provided by the TropWATER Marine Water Quality Monitoring Program).

5.3.3 Rainfall

The 2024/25 survey year yielded an annual rainfall of 1992 mm, which exceeded the long-term average of 1396 mm (Figure 21a) but was comparable to rainfall accumulation during previous years. Monthly/seasonal patterns showed that rainfall primarily occurred from December to March with a very high peak in February 2025 (Figure 21b). Rainfall exceeded the monthly average in December to March but was generally consistent with expected levels during late wet season and dry season months.

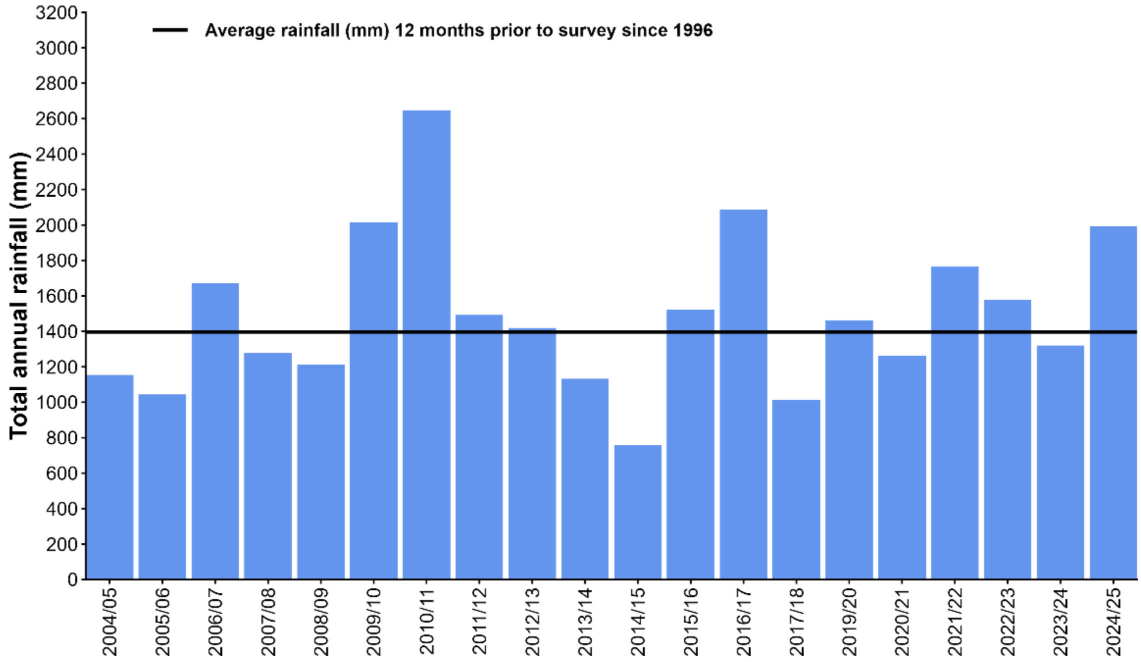

Figure 21a. Long-term trends in total annual rainfall (mm) from 2004/25 – 2024/25. Source: Bureau of Meteorology (BOM), Station number 033045.

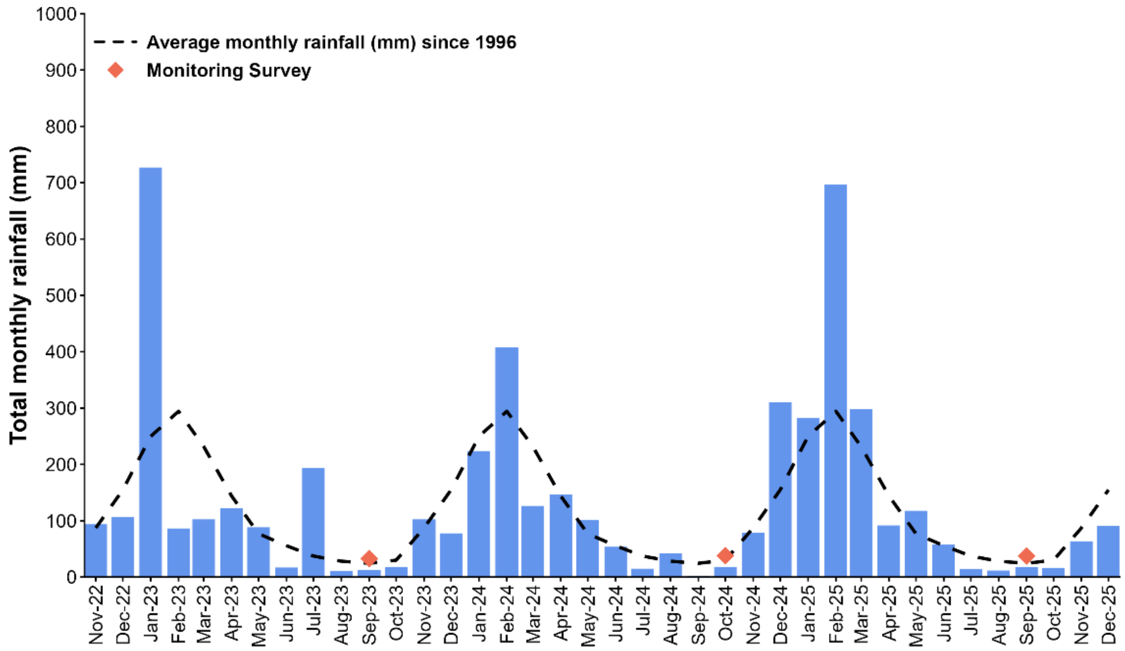

Figure 21b. Total monthly rainfall (mm) over the past three years (November 2022 – December 2025). Source: Bureau of Meteorology (BOM), Station number 033045.

5.3.4 River flow – Pioneer River

River flow volume was 1213 gigalitres for the 2024/25 survey year, exceeding the long-term average of 928 gigalitres (Figure 22a). This increase followed a five-year period of below-average river flow and was comparable to levels recorded in 2016/17 and 2018/19 (Figure 22a). In the past twelve months prior to the survey, river flow exceeded the monthly mean discharge volume during February to April 2025 and tracked average levels during subsequent months (Figure 22b).

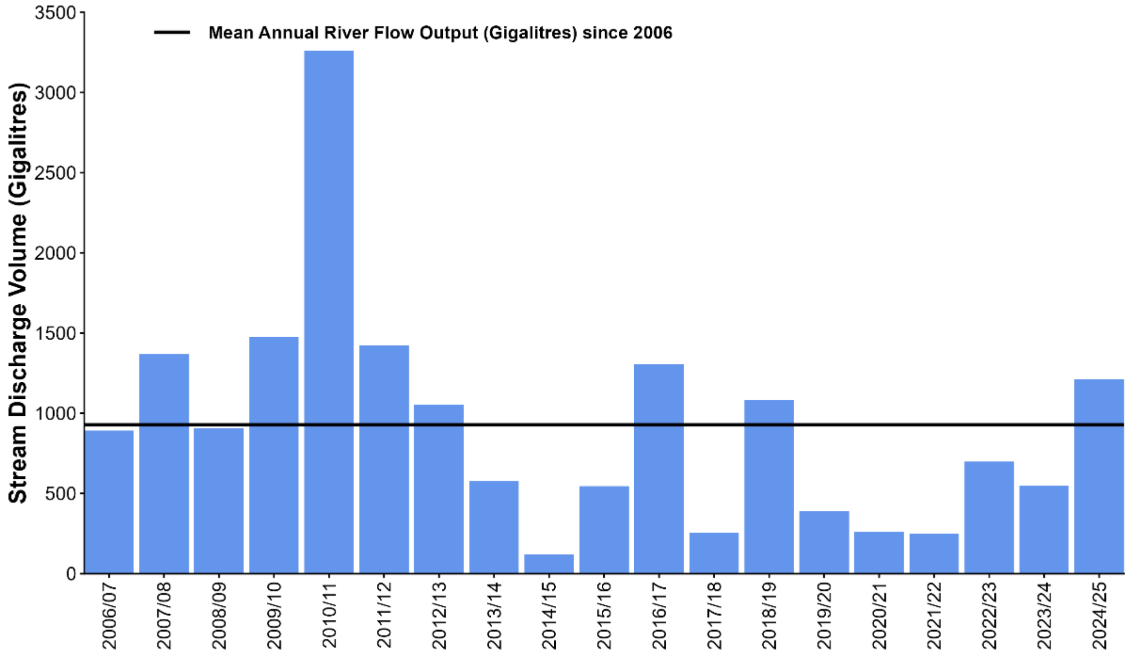

Figure 22a. Total annual river flow (gigalitres) for the Pioneer River from 2006/07 - 2024/25. Source: Queensland Government Water Monitoring Information Portal, Station number 125016A.

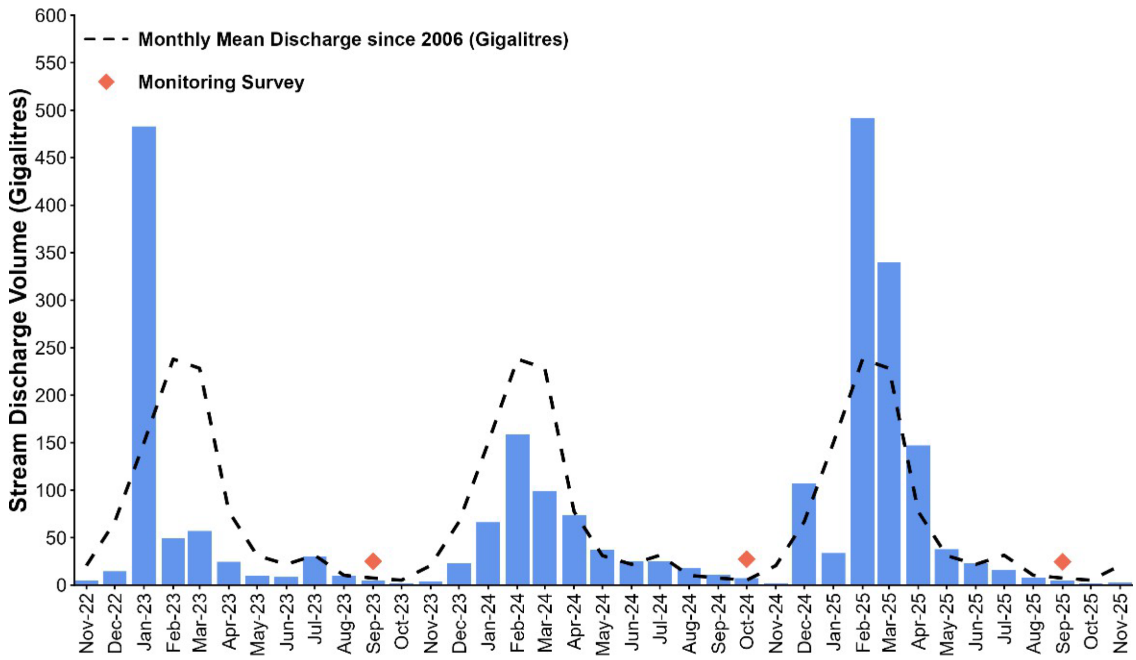

Figure 22b. Monthly river flow (Mega litres) for the Pioneer River over the past three years (January 2021 - October 2024). Source: Queensland Government Water Monitoring Information Portal, Station number 125016A.

5.3.5 RMS water depth

Wave stress at depth was measured as the root mean square water height (RMS). Daily RMS in the twelve months prior to the survey ranged from 0.01 – 0.12 m (average = 0.03 m), remaining within the low energy range (Figure 23a). Higher energy peaks in RMS above 0.1 m (representing greater wave disturbance) occurred in February and May 2025. These events were short-lived (lasting 1-2 days) and generally coincide with periods of low PAR and/or high rainfall. While peaks in RMS longer than one week can cause sediment resuspension, each of these peaks only lasted a few days. Monthly RMS measurements exceeded the long-term average during these months but was otherwise consistent with historic levels (Figure 23b).

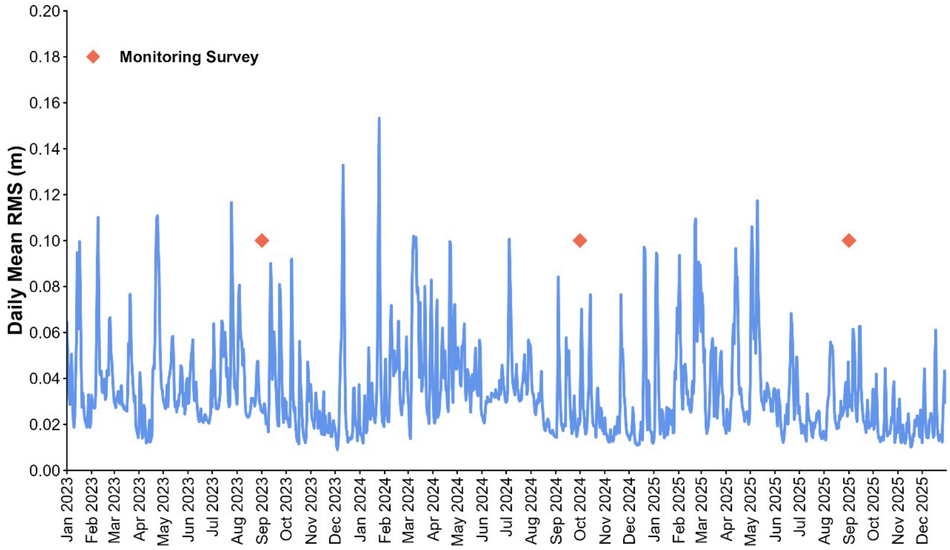

Figure 23a. Daily RMS water depth measured at Round Top Island from January 2023 – December 2025 (data provided by the TropWATER Marine Water Quality Monitoring Program site AMB3B).

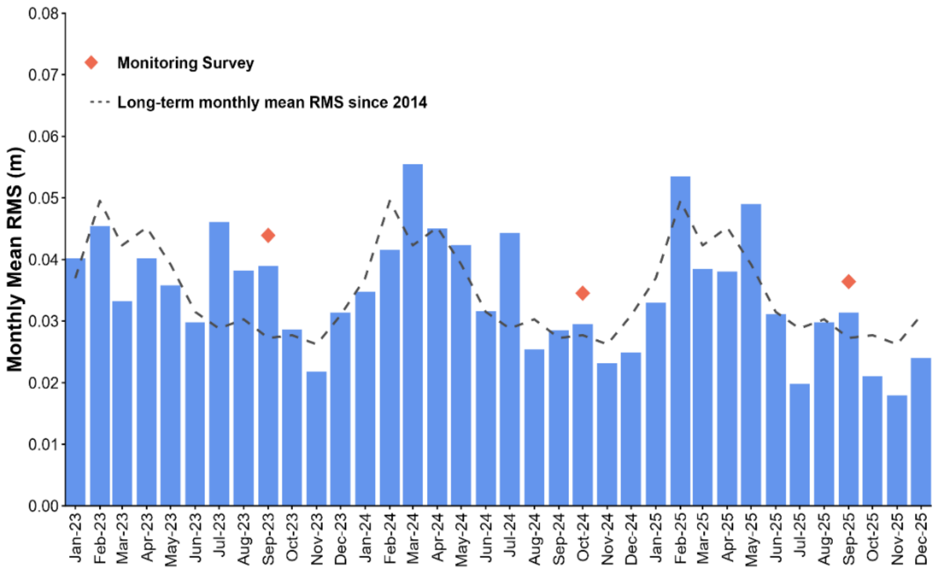

Figure 23b. Monthly RMS water depth measured at Round Top Island from January 2023 – December 2025 relative to long-term baseline (data provided by the TropWATER Marine Water Quality Monitoring Program site AMB3B).

5.3.6 Maximum wave height (Hmax)

Daily maximum wave height in the twelve months prior to the survey ranged broadly from 0.16 – 2.89 m but generally remained at low height levels (average = 1.08 m) (Figure 24a). Moderate-height peaks exceeding 2.0 m were common. Monthly mean wave height was greatest in February, coinciding with peaks in rainfall and river flow, and were relatively consistent with the long-term baseline for other months (Figure 24b).

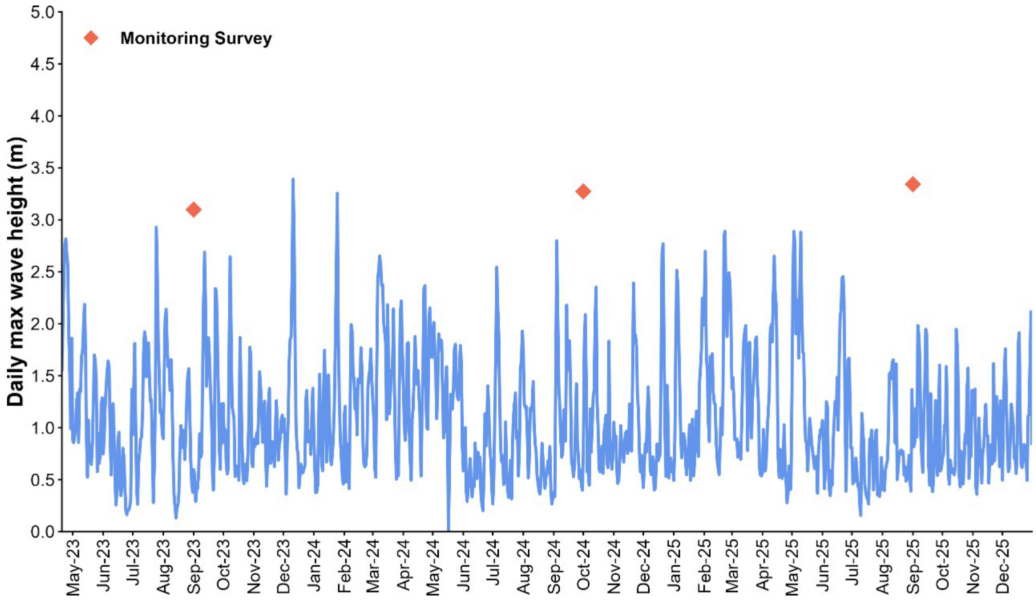

Figure 24a. Daily maximum wave height (m) recorded at Hay Point from May 2023 – December 2025. Data source: Queensland Government Department of the Environment, Tourism, Science and Innovation: Site Hay Point.

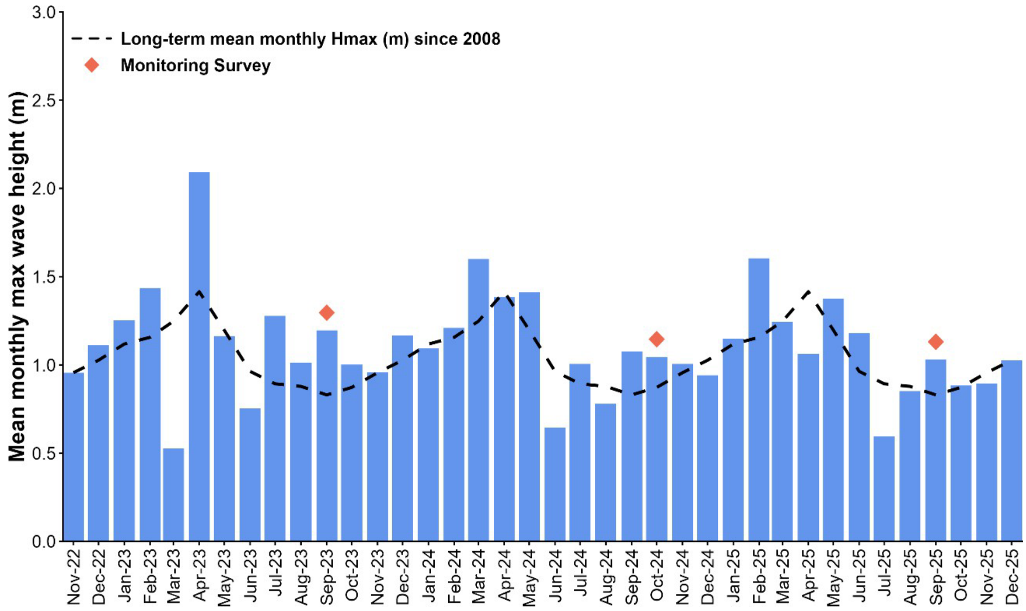

Figure 24b. Monthly maximum wave height (m) recorded at Hay Point from November 2022 – December 2025 relative to long-term baseline. Data source: Queensland Government Department of the Environment, Tourism, Science and Innovation: Site Hay Point.

6 DISCUSSION

Seagrass meadows in the Hay Point/Mackay region were in an overall good condition at the end of 2025, an improvement following three years of satisfactory condition. Improved condition scores were primarily driven by increases in meadow area for the offshore monitoring meadows, while island meadows showed moderate improvements. The Dudgeon Point shallow coastal meadow was the only one to decline due to reduced spatial extent in 2025. These patterns reflected local environmental and water quality conditions and the inherently dynamic nature of tropical seagrass meadows in the region.

Environmental conditions, particularly in the three months preceding the survey, can significantly influence seagrass distribution and abundance. High rainfall and river discharge in February and March 2025 combined with higher wave energy induced sediment resuspension and resulting reduced photosynthetically active radiation (PAR) were likely to have led to unfavourable conditions for seagrass growth during that period. However, apart from the coastal Dudgeon Point meadow, any negative impacts were not sustained and environmental conditions for the rest of the year were generally favourable for seagrass growth.

Deepwater meadows in Hay Point follow an annual cycle of occurrence, typically present seasonally between July and December (York et al. 2015). These meadows recruit each season from a seed bank, so poor growing conditions with low light in February and March were unlikely to affect their annual growth and establishment. The island meadows located further offshore were also distanced from the impacts of turbid river flows, and both island and Hay Point offshore meadows were dominated by rapidly growing *Halophila* species capable of quick recovery when light conditions improved during the year.

Relatively low PAR levels were recorded at the deep water Round Top logging station in February and March 2025, with light falling below the minimum predicted requirements for *Halophila spp.* (1.5 mol photons $m^{-2} d^{-1}$) for three separate periods of 18-21 days. In laboratory studies *H. decipiens* (predominant across the study area) requires greater than 1.1 mol photons $m^{-2} d^{-1}$ to maintain growth, and field monitoring suggests that between 1.5–2.0 mol photons $m^{-2} d^{-1}$ is likely necessary to support germination and sustained meadow health (Chartrand et al. 2017). Prolonged light deficiency below this threshold for more than seven days during the key growing season (approximately July–December) may impair seed bank replenishment and compromise the capacity for meadow regeneration in subsequent years (Chartrand et al. 2017). In Hay Point the extended low light periods occurred early in the year outside the critical growing season window in 2025.

The only meadow that declined from satisfactory to poor condition between 2024 and 2025 was the coastal Dudgeon Point monitoring meadow (Meadow 1). The impacts of wet season flooding were likely to be more pronounced here relative to the offshore and Keswick Island group meadows, given its proximity to creek and river mouths. Its elevated position along the tidal gradient also exposes seagrass to flow and wave-induced sediment disturbance, turbidity and freshwater, making it more vulnerable to adverse effects of heavy rainfall, river flow, and wave stress, such as those observed during the 2024/25 wet season. These inshore meadows have been highly variable since monitoring began, with area and biomass undergoing large year-to- year changes, while species composition has shifted between more persistent species (*Halodule uninervis* and *Zostera muelleri*) and colonising opportunists (*Halophila ovalis* and *H. decipiens*). In 2025, despite declines in meadow area, biomass remained in good condition and species composition shifted to include more *Halodule uninervis* - a positive indicator of meadow condition.

Despite small patches of colonising seagrass species documented in the Half Tide Tug Harbour monitoring area in 2023 (McKenna & Wetering 2024), seagrass was absent here in both 2024 and 2025. It is likely this is a highly ephemeral seagrass area, and a longer period of monitoring, beyond this initial 3 years is required to understand the expected state of seagrasses here.

Although environmental conditions contribute to changes in meadow condition, effects are highly influenced by meadow-specific characteristics. Consequently, the resultant changes to seagrasses are likely influenced by a combination of factors. This is primarily because individual seagrass meadows vary in seagrass species composition, depth ranges, benthic substrate composition, hydrodynamic exposure, and the structural and functional characteristics of the seagrass communities themselves, which collectively moderate their resilience to environmental variability and specific environmental drivers (Connolly et al. 2018; Cowley et al. 2025). For example, reductions in seagrass condition at the Keswick Island meadows have been associated with finer sediment composition, which increases the risk of sediment burial and smothering of *Halophila* shoots and seeds during years with elevated wave stress (Benham et al. 2019; Rasheed et al. 2024) and potentially driving interannual fluctuations in meadow area and biomass. At other sites with coarser sand, such as the Mackay monitoring meadow, the impacts from increased wave energy and sediment resuspension are likely reduced. With RMS and maximum wave height (both indicators of sediment resuspension potential) at or below monthly averages preceding the 2025 survey, this likely assisted in their improved condition in 2025.

Since the commencement of long-term monitoring at Hay Point in 2004, seagrass meadows in the region have had substantial cycles of loss and recovery from year to year, but over longer timeframes have demonstrated a strong ability to recover from both climate events and capital dredging disturbance (York et al., 2015). At the end of 2025, seagrasses at Hay Point followed similar trends recorded at other ports within JCU's long-term seagrass monitoring program, with meadows at Bowen and Abbot Point to the north and Gladstone to the south similarly rated in good condition in 2025 (Cleguer et al. 2026; Concannon et al. 2026, Reason et al. 2026). Overall, the improvement in seagrass condition in 2025 suggests that seagrass meadows in the Hay Point/Mackay region were in a good position to resist and recover from potential disturbances in the coming year. For information on all seagrass monitoring projects and previous reports, see https://www.tropwater.com/themes/seagrass-habitats.

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8 APPENDIX

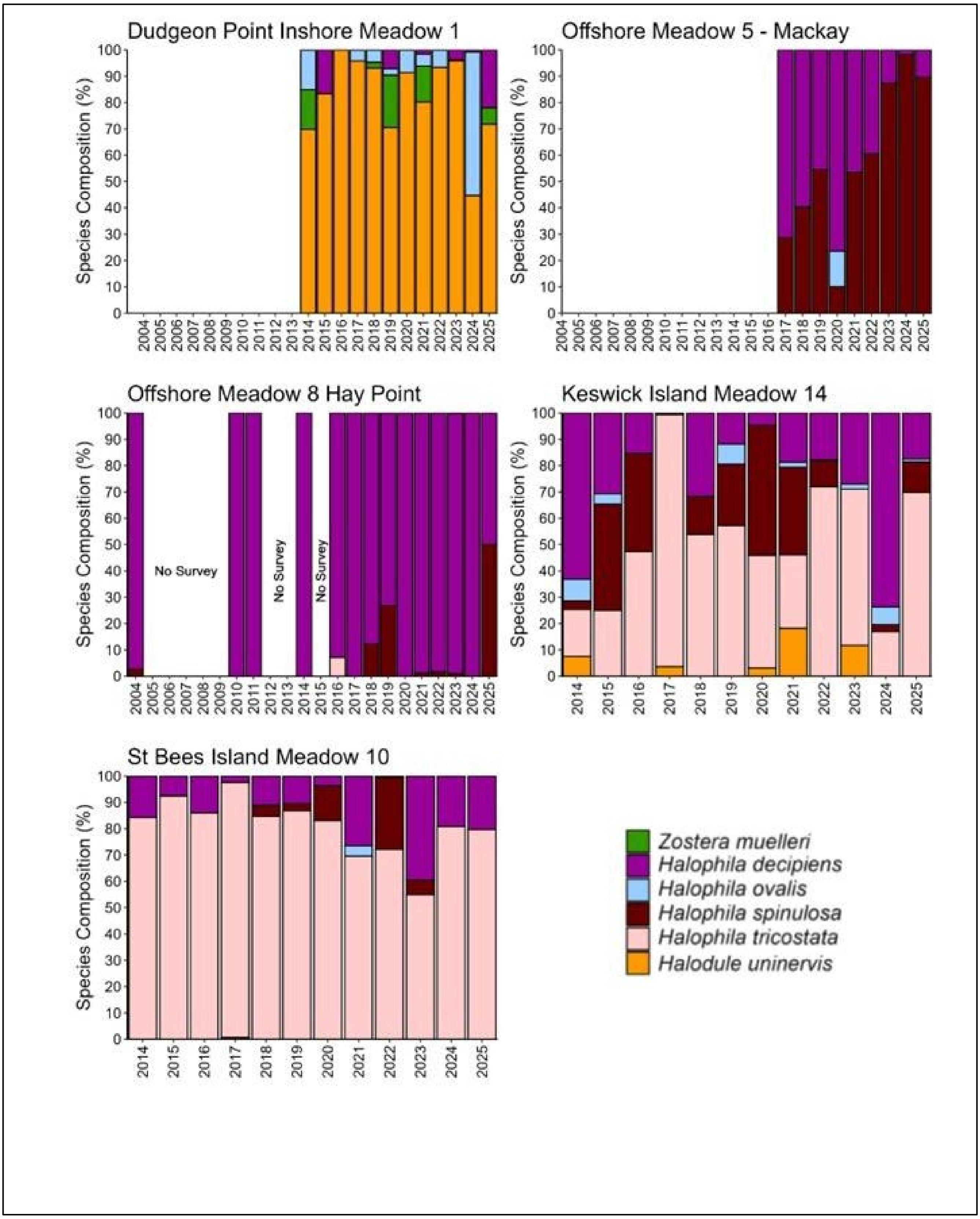

Figure A1. Long-term species composition (as percentages of overall biomass) of monitoring meadows in the Hay Point/Mackay region, and the Keswick Island group.

Table A1. Seagrass meadow characteristics in the Hay Point (Meadow 8) and Mackay (Meadow 5) offshore areas.

Meadow ID	Meadow location	Community type	Mean meadow biomass ($gDWm^{-2} \pm SE$)	Area ± R (ha)
Hay Point and Mackay Offshore survey area				
July 2004				
5	Offshore	Not surveyed	na	na
8	Offshore	Light *H. decipiens*	0.270 ± 0.057	6837.6 ± 2415.3
		Total		**6837.6 ± 2415.3**
December 2005				
5	Offshore	Not surveyed	na	na
8	Offshore	Light *H. spinulosa*	2.186 ± 0.764	332.9 ± 152.9
		Total		**332.9 ± 152.9**
October 2010				
5	Offshore	Not surveyed	na	na
8	Offshore	Light *H. decipiens*	0.008 ± 0.003	1528.6 ± 346.6
		Total		**1528.6 ± 346.6**
November 2011				
5	Offshore	Not surveyed	na	na
8	Offshore	Light *H. decipiens*	0.008	105.1 ± 39.8
		Total		**105.1 ± 39.8**
October/November 2014				
5	Offshore	Light *H. spinulosa* with *H. decipiens*	0.244 ± 0.108	Not mapped
8	Offshore	Light *H. decipiens*	0.002 ± 0.001	5204.7 ± 1448.1
		Total		**5204.7 ± 1448.1**
October/November 2016				
5	Offshore	Light *H. spinulosa*	0.108 ± 0.078	Not mapped
8	Offshore	Light *H. decipiens*	0.002 ± 0.0001	2311.0 ± 387.0
		Total		**2311.0 ± 387.0**
October 2017				
5	Offshore	Light *H. decipiens* with *H. spinulosa*	0.011 ± 0.003	652.8 ± 151.9
8	Offshore	Light *H. decipiens*	0.046 ± 0.032	1234.1 ± 309.9
		Total		**1886.9 ± 461.8**
October 2018				
5	Offshore	Light *H. decipiens* with *H. spinulosa*	0.062 ± 0.015	381.6 ± 141.2
8	Offshore	Light *H. decipiens*	0.013 ± 0.004	1642.7 ± 406.2
		Total		**2024.3 ± 547.4**
October 2019				
5	Offshore	Light *H. spinulosa* with *H. decipiens*	0.135 ± 0.073	1737.3 ± 277.4
8	Offshore	Light *H. decipiens* with *H. spinulosa*	0.096 ± 0.023	4160.8 ± 777.8
		Total		**5898.1 ± 1055.2**
October 2020				
5	Offshore	Light *H. decipiens* with *H. spinulosa*	0.077 ± 0.0137	1871.6 ± 306.6
8	Offshore	Light *H. decipiens*	0.041 ± 0.004	736.9 ± 258.2
		Total		**2608.5 ± 564.8**
September 2021				
5	Offshore	Light *H. spinulosa* with *H. decipiens*	0.203 ± 0.080	2215.7 ± 213.0
8	Offshore	Light *H. decipiens*	0.011 ± 0.006	5216.6 ± 618.2
		Total		**7432.3 ± 831.2**
September 2022				
5	Offshore	Light *H. spinulosa* with *H. decipiens*	0.09 ± 0.02	2326.3 ± 196.0
8	Offshore	Light *H. decipiens*	0.15 ± 0.1	3853.2 ± 559.65
		Total		**6163.2 ± 729.6**
September 2023				
5	Offshore	Light *H. spinulosa*	0.30 ± 0.11	2274.78 ± 205.77
8	Offshore	Light *H. decipiens*	0.02 ± 0.02	1858.97 ± 404.92
		Total		**4133.77 ± 610.79**
November 2024				
5	Offshore	Light *H. spinulosa*	0.59 ± 0.47	972.64 ± 209.4
8	Offshore	Light *H. decipiens*	0.39 ± 0.34	1967.97 ± 405.3
		Total		**2940.6 ± 614.7**
September 2025				
5	Offshore	Light *H. spinulosa* with *H. decipiens*	0.31 ± 0.13	2,064 ± 184
8	Offshore	Light H. *decipiens/H. spinulosa*	0.13 ± 0.04 g	5,871 ± 685
		Total		**7,935 ± 869**

Table A2. Seagrass meadow characteristics in the St Bees Island (Meadow 10) and Keswick Island (Meadow 14) areas.

Keswick/St Bees Islands inshore survey areas				
Meadow ID	**Meadow location**	**Seagrass meadow community type**	**Meadow biomass (mean g dw m^{-2} ± SE)**	**Area ± R (ha)**
October/November 2014				
10	Inshore	Light *H. tricostata* with *H. decipiens*	2.34 ± 0.38	118.6 ± 29.5
14	Inshore	Moderate *H. decipiens* with mixed species	2.6 ± 0.71	17.9 ± 5.0
		Total		**136.5 ± 34.5**
October 2015				
10	Inshore	Light *H. tricostata*	1.23 ± 0.19	137.2 ± 30.5
14	Inshore	Light *H. spinulosa* with mixed species	1.13 ± 0.35	14.7 ± 4.3
		Total		**151.9 ± 34.8**
October/November 2016				
10	Inshore	Light *H. tricostata*	1.69 ± 0.33	147.6 ± 25.9
14	Inshore	Light *H. spinulosa* with mixed species	2.94 ± 0.54	11.5 ± 4.3
		Total		**159.1 ± 30.2**
October 2017				
10	Inshore	Light *H. tricostata*	1.09 ± 0.23	169.6 ± 32.5
14	Inshore	Light *H. tricostata*	0.54 ± 0.23	10.8 ± 4.1
		Total		**180.4 ± 36.6**
October 2018				
10	Inshore	Light *H. tricostata* with H. *decipiens*	2.40 ± 0.38	203.6 ± 38.7
14	Inshore	Light *H. tricostata*	1.97 ± 0.74	18.1 ± 4.8
		Total		**221.7 ± 43.5**
October 2019				
10	Inshore	Light H. *tricostata* with *H. decipiens*	1.37 ± 0.15	197.3 ± 42.9
14	Inshore	Light *H. tricostata* with *H. spinulosa / H. decipiens*	1.63 ± 0.35	14.2 ± 4.2
		Total		**211.5 ± 47.1**
October 2020				
10	Inshore	Light *H. tricostata* with *H. spinulosa*	2.90 ± 0.63	140.4 ± 36.5
14	Inshore	Light *H. spinulosa / H. tricostata*	3.96 ± 1.23	14.2 ± 3.8
		Total		**154.6 ± 40.3**
September 2021				
10	Inshore	Light *H. tricostata* with *H. decipiens*	1.04 ± 0.17	191.8 ± 41.1
14	Inshore	Light *H. spinulosa / H. tricostata*	1.33 ± 0.27	22.5 ± 5.4
		Total		**206.0 ± 46.5**
September 2022				
10	Inshore	Light *H. tricostata* with *H. spinulosa*	1.87 ± 0.65	132.2 ± 23.8
14	Inshore	Light *H. tricostata* with *H. decipiens*	2.86 ± 1.10	10.3 ± 3.9
		Total		**142.5 ± 27.7**
September 2023				
10	Inshore	Light *H. tricostata* with *H. decipiens / H. uninervis*	0.39 ± 0.06	130.5 ± 38.6
14	Inshore	Light *H. tricostata* with *H. decipiens*	1.09 ± 0.17	14.6 ± 6.6
		Total		**145.1 ± 45.2**
November 2024				
10	Inshore	Light *H. tricostata* with *H. decipiens*	0.86 ± 0.31	110.9 ± 39.8
14	Inshore	Light *H. decipiens* with *H. tricostata*	0.77 ± 0.15	16.7 ± 3.8
		Total		**127.6 ± 43.6**
September 2025				
10	Inshore	Light *H. tricostata* with *H. decipiens*	1.27 ± 0.19 g	166.6 ± 13.8
14	Inshore	Light *H. tricostata* with mixed species	1.14 ± 0.30 g DW	18.1 ± 3.9
		Total		**184.7 ± 17.7**

Table A3. Seagrass community types, mean above-ground biomass and meadow area in the Dudgeon Point area (Meadows 1, 20). For details on the historic extent of Meadow 20, refer to York and Rasheed, 2020.

Hay Point – Dudgeon Point inshore survey area				
Meadow ID	**Meadow location**	**Seagrass meadow community type**	**Meadow biomass (mean g dw m^{-2} ± SE)**	**Area ± R (ha)**
October/November 2014				
1	Inshore	Light *H. uninervis* with *Z. muelleri* & *H. ovalis*	1.96 ± 1.14	9.0 ± 1.8
20	Inshore	Not present	Not assessed	-
Total				**9.0 ± 1.8**
October 2015				
1	Inshore	Light *H. uninervis* (wide) with *H. decipiens*	1.72 ± 0.23	13.7 ± 1.3
20	Inshore	Not present	-	-
Total				**13.7 ± 1.3**
October/November 2016				
1	Inshore	Moderate *H. uninervis* (wide)	5.60 ± 0.76	9.6 ± 2.0
20	Inshore	Not present	-	-
Total				**9.6 ± 2.0**
October 2017				
1	Inshore	Moderate *H. uninervis* (wide)	2.42 ± 1.20	9.3 ± 2.3
20	Inshore	Not present	-	-
Total				**9.3 ± 2.3**
October 2018				
1	Inshore	Light *H. uninervis* (wide) with *H. ovalis*	1.09 ± 0.35	22.6 ± 4.2
20	Inshore	Not present	-	-
Total				**22.6 ± 4.2**
October 2019				
1	Inshore	Light *H. uninervis* with *Z. muelleri* /*H. decipiens*	3.01 ± 0.72	17.0 ± 3.8
20	Inshore	Light *H. uninervis*	0.72 ± 0.72	1.7 ± 1.1
Total				**18.7 ± 4.9**
October 2020				
1	Inshore	Light *H. uninervis* with *H. ovalis*	1.76 ± 0.62	8.6 ± 3.3
20	Inshore	Not present	-	-
Total				**8.6 ± 3.3**
September 2021				
1	Inshore	Light *H. uninervis*	3.66 ± 1.12	17.0 ± 3.8
20	Inshore	Not present	-	1.7 ± 1.1
Total				**15.7 ± 4.3**
September 2022				
1	Inshore	Light *H. uninervis*	3.66 ± 0.64	8.97 ± 3.4
20	Inshore	Not present	-	-
Total				**8.97 ± 3.4**
September 2023				
1	Inshore	Light *H. uninervis* (wide)	2.77 ± 0.68	10.28 ± 5.5
20	Inshore	Not present	-	-
Total				**10.28 ± 5.5**
October 2024				
1	Inshore	Moderate *H. ovalis* /*H. uninervis* (wide)	2.49 ± 0.42	15.19 ± 4.3
20	Inshore	Not present	-	-
Total				**15.19 ± 4.3**
September 2025				
1	Inshore	Moderate H. uninervis (wide) with mixed species	1.98 ± 0.66 g	8.1 ± 2.6
20	Inshore	Not present	-	-
		Total		**8.1 ± 2.6**