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Port of Brisbane Seagrass Monitoring Program

2025 Annual Report

* Chern'ee Sutton
Indigenous artist

Document Control

Document Identification

Title	Port of Brisbane Seagrass Monitoring Program Report 2025
Project No	003884
Deliverable No	002
Version No	01
Version Date	25 November 2025
Customer	Port of Brisbane Pty Ltd
Classification	OFFICIAL

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Amendment Record

The Amendment Record below records the history and issue status of this document.

Version	Version Date	Distribution	Record
00	04 November 2025	Port of Brisbane Pty Ltd	PDF-draft
00	25 November 2025	Port of Brisbane Pty Ltd	PDF-final

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Executive Summary

Seagrass meadows are a cornerstone of Moreton Bay's marine health. They provide habitat for fish and turtles, stabilize sediments, and act as an early warning system for water quality and climate impacts. Healthy seagrass means a healthy bay—and that's critical for the Port's long-term sustainability and reputation.

The 2025 Seagrass Monitoring Program builds on 20+ years of data and shows how meadows near Fisherman Islands and across western Moreton Bay are responding to recent floods and cyclones. Key results of the 2025 monitoring include:

- **Long-term Expansion**: Long-term trends show continued growth in seagrass near Fisherman Islands (Figure 1), aligning with predictions that port expansion would improve habitat conditions.

- **Stable Species Composition:** The same core species remain present year after year, showing ecological stability. This includes *Zostera muelleri* (eelgrass) and several *Halophila* species. A fifth species, *Halodule uninervis*, appeared in small amounts—as is typical for this system.

- **Stable Spatial Patterns:** Intertidal and shallow subtidal zones at Fisherman Islands remain dominated by *Zostera muelleri*, while deeper subtidal areas are primarily utilised by *Halophila* species. These patterns have been consistent since monitoring began in the 1980s.

- **Post Flood Reduction in Seagrass Meadow Extent at Fisherman Islands:** Seagrass coverage at Fisherman Islands is 13.5 km² in 2025, down from 16.7 km² last year due to Ex-Tropical Cyclone Alfred. Despite this dip, coverage is still above the post-flood low of 11.1 km² in 2022. This shows a trend of strong recovery since 2022, with a setback from extreme weather in 2025.

- **Post Flood Responses in Seagrass Meadow Extent Western Moreton Bay:** Control sites mirrored the broader temporal patterns observed at Fisherman Islands but with local differences. The recovery observed at Fisherman Islands was part of a bay-wide pattern of post-2022 flood resurgence, but the magnitude and composition of seagrass changes differed by location. These results reinforce the long-term resilience of seagrass meadows in Moreton Bay, despite short-term impacts from flooding events, trends demonstrate that with adequate recovery time between events, seagrass meadows across the bay are capable of returning to their to previously recorded levels of extent and species composition.

- **Zostera Depth Range:** Some Zostera meadows held their deepest range, while others became shallower due to turbidity from cyclone rains. This indicates that seagrass meadow condition varied in different parts of Fisherman Islands, reflecting local scale differences in habitat condition. Despite impacts of floods, Fisherman Islands seagrass meadows remain in good condition.

- **Algal Growth:** Excessive algal growth on seagrass can occur in response to high nutrient concentrations. The 2025 survey indicates that algae growth declined by 32%, most likely due to flood-related reductions in light and salinity. Floods are a key source of nutrients to the coastal ecosystem, and elevated algal growth are expected to reappear in subsequent surveys.

The 2025 monitoring results confirm that these ecosystems are resilient but sensitive—recovering after floods yet vulnerable to extreme weather and water quality shifts. Long-term expansion in seagrass meadow extent at Fisherman Islands demonstrates that port development has enhanced habitat conditions, and meadows remain close to reference condition. The Port's seagrass monitoring program provides valuable insight into long-term trends, helping ensure port-related activities are managed in ways that minimise impacts and support the health of Moreton Bay.

Figure 1. Long term (1992-2025) seagrass extent trend.

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1 Introduction

1.1 Background

Seagrass meadows are globally recognised as critical ecosystems that underpin coastal productivity and biodiversity. They provide habitat for commercially and ecologically important fish, nursery grounds for invertebrates, foraging areas for iconic megafauna such as dugongs (*Dugong dugon*) and green turtles (*Chelonia mydas*), and serve as vital low tide feeding habitat for both local water birds and internationally important migratory shorebirds. Their root and rhizome systems stabilise sediments, while their photosynthetic activity contributes significantly to carbon sequestration in the form of “blue carbon” (Fourqurean et al., 2012).

In Moreton Bay, seagrass meadows form one of the most extensive coastal ecosystems along the eastern seaboard of Australia. They support over 750 species of fish and more than 120 species of invertebrates, underpinning the productivity of both artisanal and recreational fisheries (Davie, 2011). Research commissioned by the Moreton Bay Foundation has highlighted the critical role of seagrass in sustaining dugong populations in the bay, one of the largest resident populations on Australia’s east coast (Moreton Bay Foundation, 2020). Beyond biodiversity, seagrass provides regulating ecosystem services such as nutrient cycling, water filtration, and shoreline protection, all of which contribute to the ecological resilience of the bay and the wellbeing of communities in the greater Brisbane region.

The ecological significance of Moreton Bay is formally recognised through its designation as both a Ramsar wetland of international importance and as a marine park under Queensland legislation. The Ramsar listing acknowledges the bay’s rich assemblages of migratory birds, marine mammals, and coastal wetland habitats. The Moreton Bay Marine Park extends protection to critical zones of mangroves, saltmarshes, and seagrass meadows, with zoning plans designed to balance conservation with sustainable use. Despite these protections, Moreton Bay is under growing pressure from urbanisation, nutrient inputs, and climate-related disturbances (Dennison & Abal, 1999).

The Port of Brisbane lies at the interface between natural and industrial landscapes, where reclaimed land, shipping channels, and dredging operations exist in close proximity to ecologically sensitive seagrass meadows. This juxtaposition underscores the importance of systematic and long-term monitoring programs to detect potential impacts and to support adaptive management strategies.

1.2 The Port of Brisbane Seagrass Monitoring Program

In response to these ecological and operational considerations, the Port of Brisbane Pty Ltd established the Seagrass Monitoring Program (SMP) in 1992. The SMP has since become one of the most comprehensive long-term seagrass datasets in subtropical Australia, providing insights into spatial extent, species composition, and depth distributions over more than two decades. The monitoring framework includes both a test location adjacent to Fisherman Islands and control locations at Manly, Cleveland, and Deception Bay. This design enables the detection of port-related effects against a backdrop of broader environmental variability.

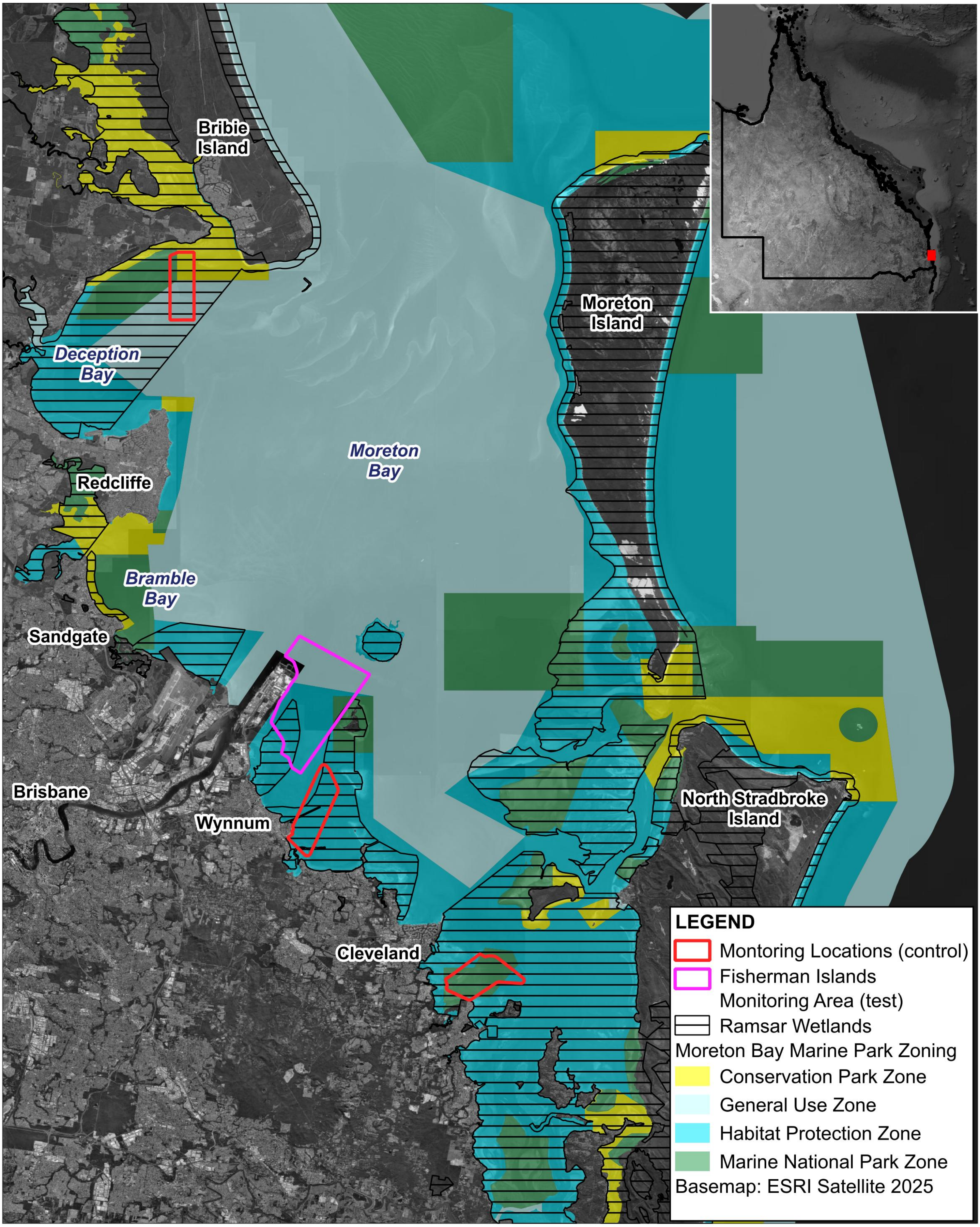
The SMP has consistently shown that seagrass meadows in western Moreton Bay are highly dynamic, influenced by climatic cycles of drought and flood, as well as by localised factors such as sediment resuspension and nutrient enrichment. The 2022 Brisbane River flood provided a striking example of this sensitivity, with extensive losses of seagrass followed by gradual recovery in subsequent years.

1.3 Aims and Objectives

This report synthesises the 2025 SMP findings and situates them within both historical monitoring data and contemporary ecological research, including recent studies published by the Moreton Bay Foundation. The specific aims are:

- To evaluate current patterns of seagrass extent, distribution, and species composition at Fisherman Islands and control locations,
- To interpret inter-annual and decadal trends in seagrass dynamics in relation to environmental drivers such as rainfall, turbidity, and algal competition,
- To integrate monitoring data with broader ecological research in Moreton Bay, highlighting synergies with conservation science and management frameworks, and,
- To provide evidence-based recommendations for ongoing monitoring and adaptive management of seagrass meadows in the context of port operations and regional environmental change

By adopting this integrative perspective, the report seeks to advance understanding of seagrass ecology in Moreton Bay and to contribute to regional efforts aimed at safeguarding the resilience of this internationally significant ecosystem.



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Moreton Bay Ramsar Wetlands and Marine Park Zoning

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2 Methodology

2.1 Study Design

The SMP was designed to generate long-term ecological data on seagrass condition adjacent to port operations while controlling for broader environmental variability across western Moreton Bay. The program has evolved substantially, incorporating advances in remote sensing and spatial analysis while retaining consistency with historical monitoring approaches. This combination ensures both temporal comparability and contemporary relevance.

The SMP study area includes:

- One test location: Fisherman Islands, and,
- Three control locations: Manly, Cleveland, and Deception Bay.

Fisherman Island is located directly adjacent to the FPE seawall and is representative of PBPL activities (see Figure 2.1). Manly and Cleveland are located south of the Brisbane River mouth and are subject to broadly similar hydrological and climatic drivers as Fisherman Islands (Figure 2.2 and Figure 2.3). Deception Bay was included as an additional control in 2020 better define ‘background’ conditions in western Moreton Bay, north of the Brisbane River (Figure 2.4). Deception Bay has slightly different geomorphological and hydrodynamic characteristics which, together, these sites provide a robust comparative framework for evaluating potential port-related effects.

To support future port expansion, additional seagrass monitoring sites have been established at Fisherman Islands (increasing the boundaries of the study area from 19 km^2 to 29 km^2) to provide a comprehensive baseline for future assessments. This has increased the number of sites from 109 to 163 (see Figure 2.1).

2.2 Timing and Sampling Campaign

Field sampling for the 2025 campaign was conducted between 28th August and 3rd September 2025. This mid-winter timing is consistent with previous surveys, allowing comparability across years. Winter has historically been selected for calmer weather and reduced storm activity. This improves field survey reliability, while cooler temperatures are less likely to exacerbate heat-related seagrass stress.

Tidal data from the Tidal Unit, Maritime Safety Queensland was obtained for the Brisbane Bar throughout this study period and was used to correct depth soundings to Australian Height Datum (AHD).

2.3 Field Methods

All field sampling were undertaken aboard the BMT research vessel *Resolution II*. A systematic grid sampling approach was applied across each study area. At Fisherman Islands, a 500 m grid was overlaid across intertidal and shallow subtidal habitats, extending outward to deeper waters where *Halophila* species typically occur. Equivalent grid-based designs were implemented at Manly, Cleveland, and Deception Bay.

At each survey point, researchers recorded water depth, GPS position, and benthic community composition and cover on underwater video transects. Each video transect provided visual confirmation of species presence and percent cover (%), allowing accurate characterisation of mixed meadows where multiple seagrass species occurred. The integration of field observations with video data reduced observer bias and allowed greater certainty in species-level identification.

Seagrass abundance was classified into the following categories:

- Very sparse to absent <5% coverage
- Sparse 5—25% coverage
- Moderate 25—50% coverage
- Dense 50—75% coverage
- Very dense >75% coverage

This classification has been refined since the 2024 monitoring programme to adopt a more refined five-class abundance scheme enabling more sensitive detection of ecological variation and improved classification accuracy.

Macroalgae were also recorded, separated into filamentous epiphytic/turfing forms and other macroalgal taxa.

2.4 Remote Sensing and Data Processing

Sentinel-2 Level 1C imagery acquired on 5 September 2025 was used to classify and map seagrass extent in the study area. The imagery was atmospherically corrected using the Dark Spectrum Fitting (DSF) algorithm, producing bottom-of-atmosphere reflectance (Level 2A) suitable for detecting submerged vegetation.

The GPS-referenced field surveys points, seagrass observations and density measurements were used to train a supervised classification model based on a Convolutional Neural Network (CNN), identifying spectral and spatial patterns associated with seagrass. To account for GPS uncertainty and the 10 m resolution of the imagery, a 20 m radius was applied around each observation during training, improving model robustness.

Once trained and validated, the CNN was applied across the full satellite scene to generate a detailed map of seagrass extent using the seagrass abundance classification categories. Post-processing steps included spatial smoothing to reduce classification noise, edge refinement to improve boundary accuracy, and area estimation to quantify seagrass coverage.

2.5 Depth Range Profiles

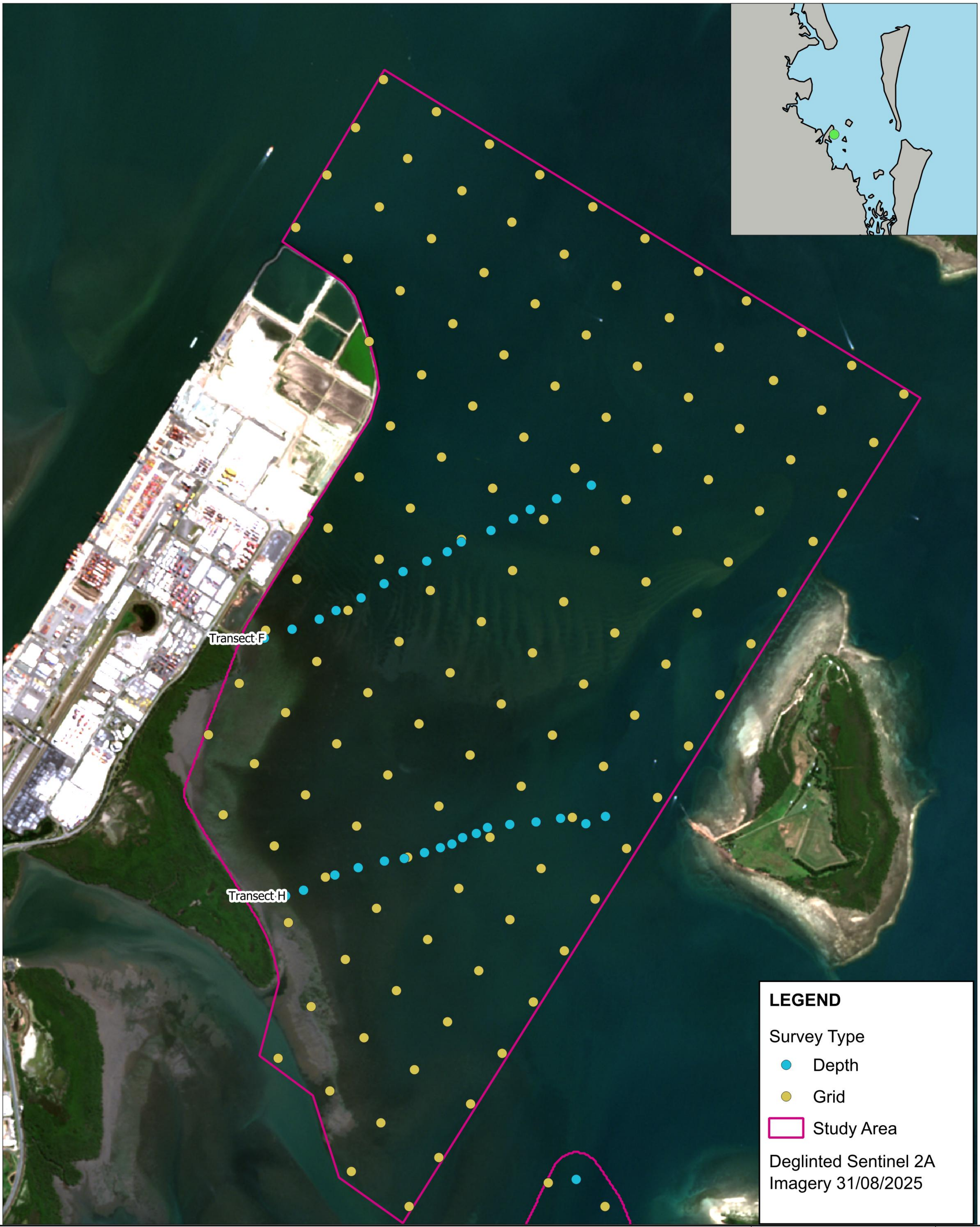
In addition to grid-based mapping, two depth profile transects were established at each monitoring site. These transects, oriented approximately perpendicular to the shoreline, extend from shallow intertidal habitats to the outer edge of the seagrass meadow. Along each transect, seagrass species composition and depth limits were recorded. This provides a quantitative measure of maximum seagrass depth range (SDR), which serves as a long-term indicator of water quality, particularly light availability.

The SDR method is especially valuable because it integrates ecological responses across time. While seagrass cover can fluctuate rapidly after storm or flood events, the maximum depth limit typically reflects cumulative light conditions over multiple years. This makes SDR a powerful tool for detecting long-term trends and for evaluating whether meadows are meeting water quality objectives established for Waterloo Bay.

2.6 Statistical Analyses

To evaluate drivers of SDR variability, Pearson product–moment correlations were applied between annual cumulative rainfall departures (2006—2025, n=14) (relative to long-term means) and mean SDR values across all sites. Rainfall data were sourced from the Bureau of Meteorology’s Brisbane Aero station (40842) and Fort Lytton (40320), providing continuity with previous SMP analyses.

This statistical approach enabled both inter-annual comparisons and broader climatic contextualisation, strengthening the interpretative framework for ecological trends observed in the field.



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Survey points used to map the distribution of seagrass at Fisherman Islands

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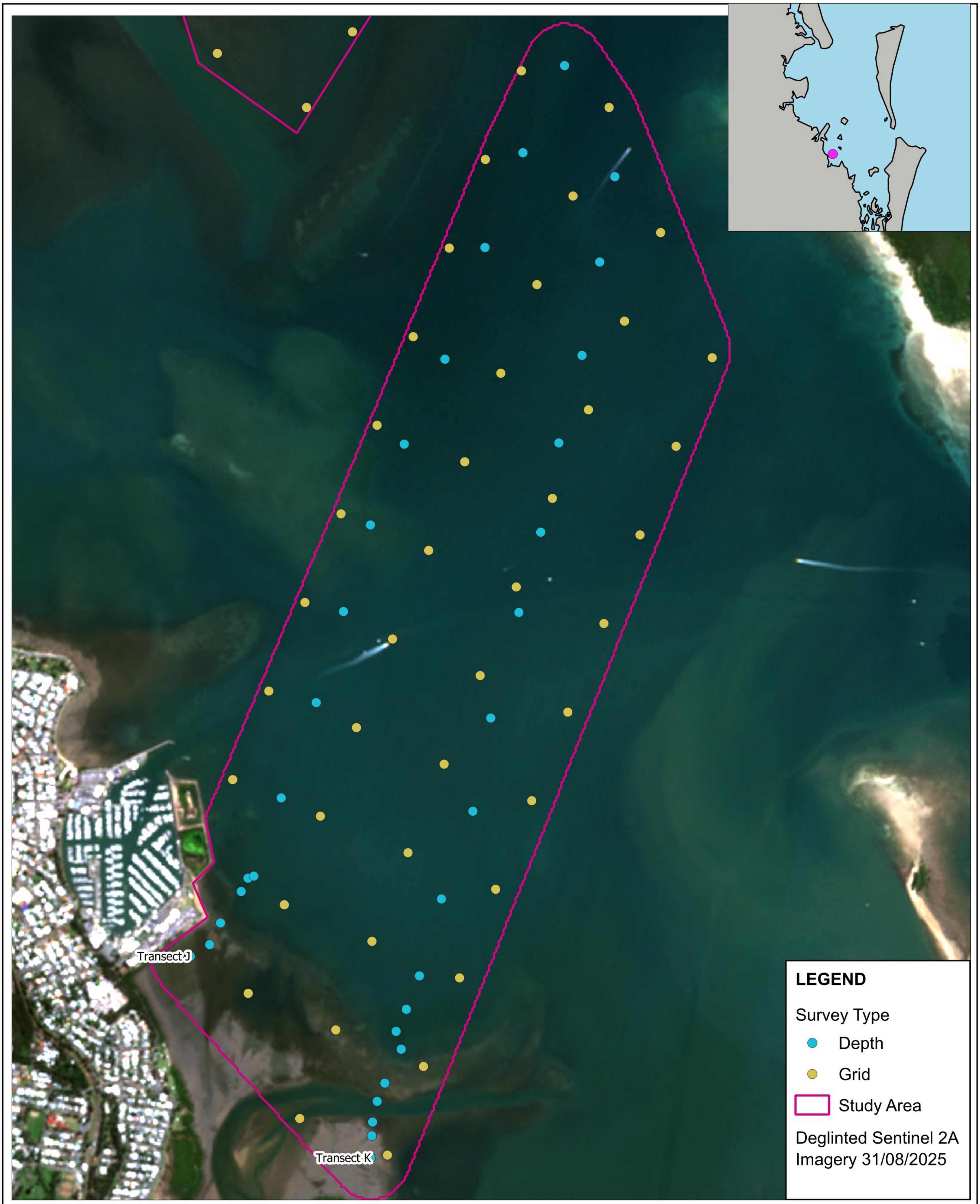

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Survey points used to map the distribution of seagrass adjacent to Manly

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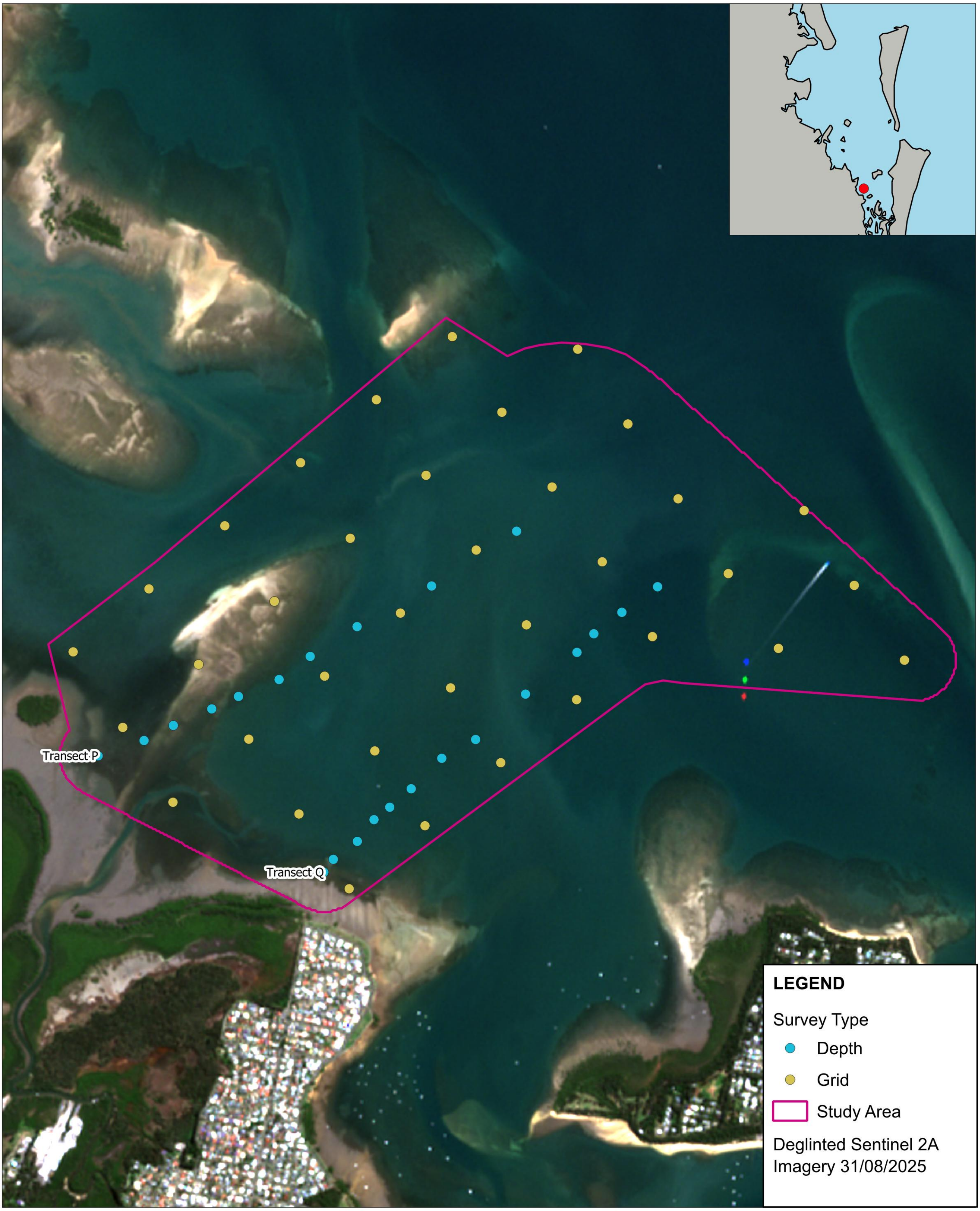

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Survey points used to map the distribution of seagrass at Cleveland

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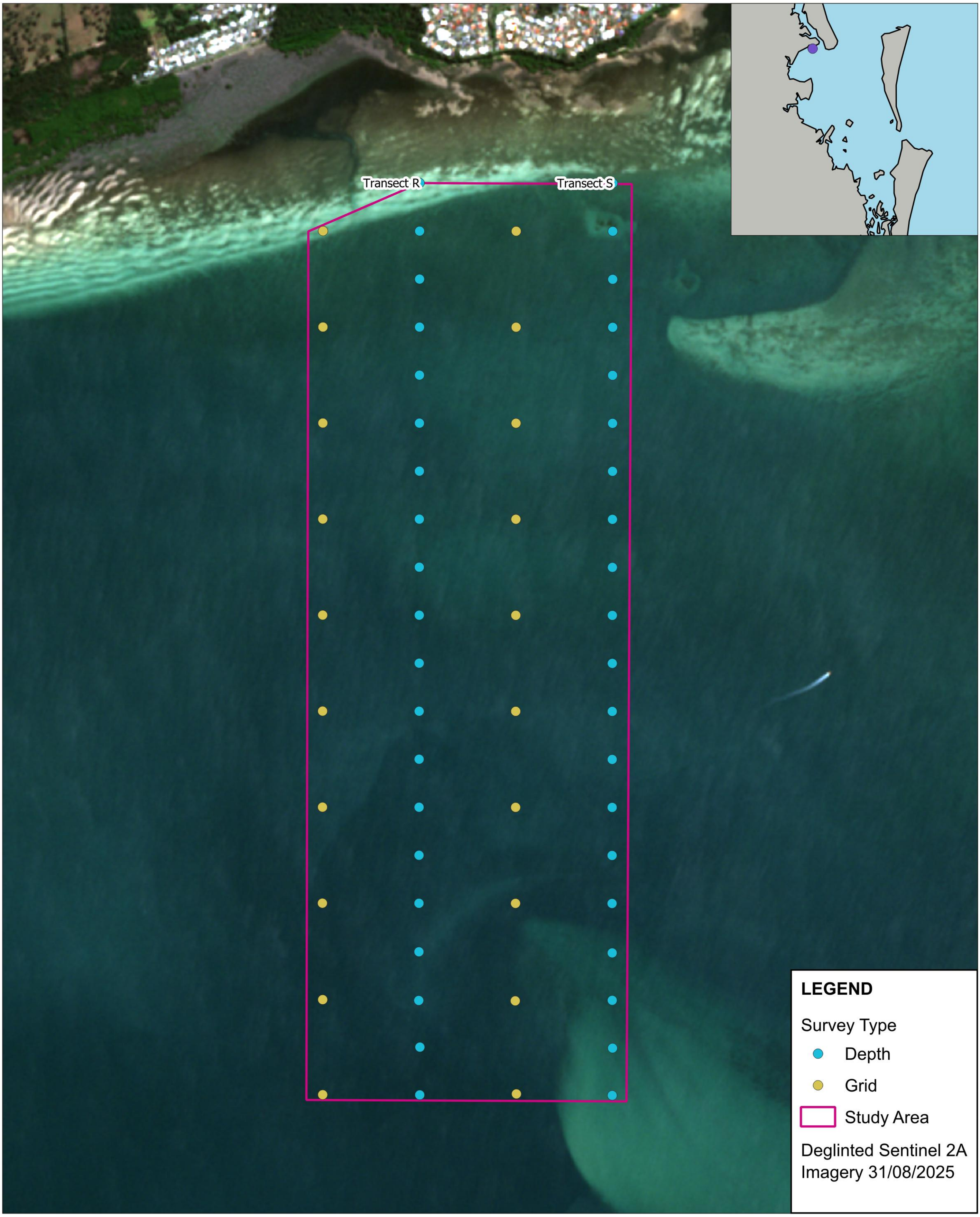

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Survey points used to map the distribution of seagrass at Deception Bay

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3 Results

3.1 Climatic Conditions

Rainfall and temperature patterns leading into the 2025 survey period provide important context for interpreting seagrass responses (Figure 3.1). Annual rainfall in 2025 (1404.2 mm) was higher than the long-term mean of 1065.9 mm, consistent with 2020–2022 where it was wetter-than-average conditions. Twelve-month cumulative rainfall prior to the survey (July 2024—2025) was 1655.6 mm

The mean annual maximum air temperature in 2024 (25.8 C) was slightly above the long-term mean (25.4°C). The highest monthly temperature recorded leading into the 2025 survey period was in February 29.6 C. No monthly average temperature has exceeded the known thermal stress thresholds (>30 °C) for intertidal dominant species Z. muelleri (Collier et al., 2011), but they highlight the potential for seasonal temperature anomalies to exacerbate other stressors such as reduced light availability.

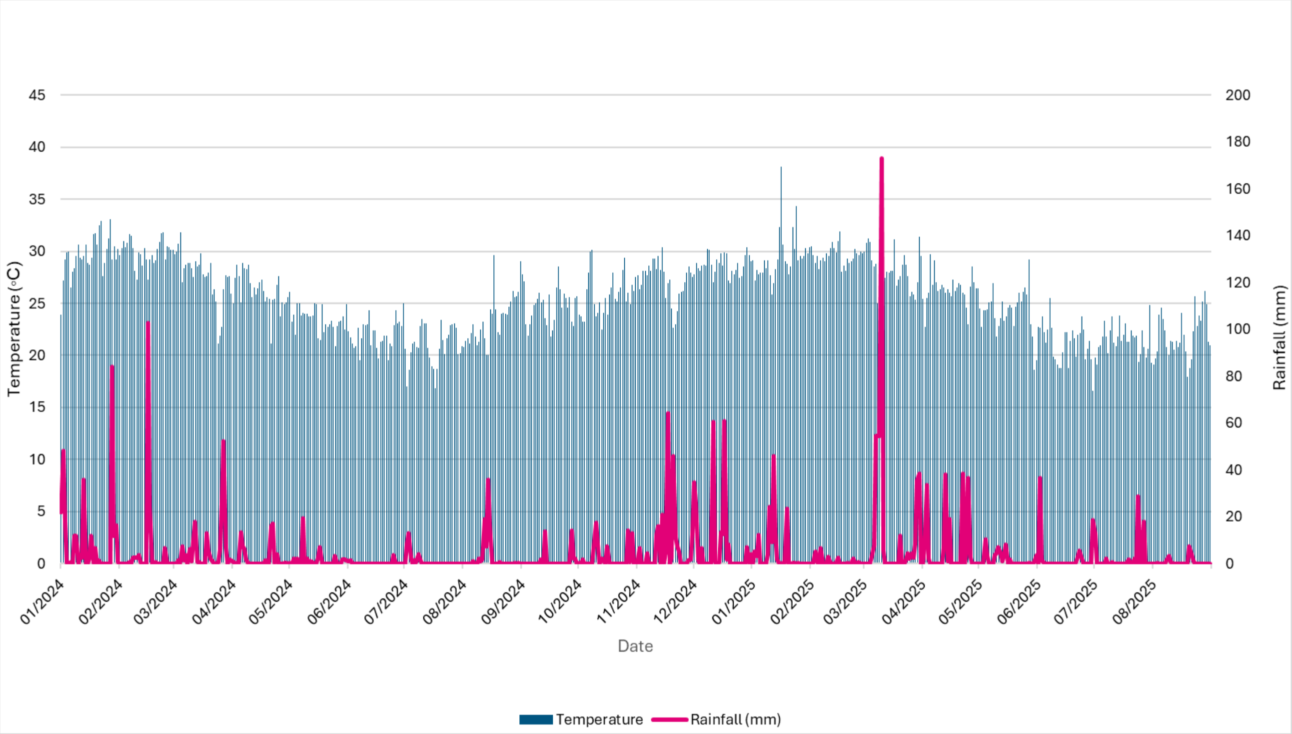

Figure 3.1 Monthly rainfall pattern leading into the 2025 survey period with annual average (2024–2024

3.2 Seagrass Spatial Distribution and Percentage Cover

Regional Overview

A total of 355 survey points were sampled in 2025. Seagrass was detected at 59% of Fisherman Islands sites, (50% based on 2024 study area), 71% of Manly sites, 77% of Cleveland sites, and 35% of Deception Bay sites (Table 3.1). Seagrass species were numerically dominant in intertidal and shallow subtidal zones near the landward perimeter of Moreton Bay, with both abundance and extent decreasing with depth (Figure 3.3— Figure 3.4).

Five of the eight seagrass species known to occur in Moreton Bay were recorded in the 2025 survey: *Zostera muelleri (subsp. capricorni), Halophila ovalis, Halophila spinulosa, Halophila decipiens* and *Halodule uninervis*. Of these, *Halophila spinulosa* and *Z. muelleri* were numerically dominant in intertidal and shallow subtidal zones, while *H. decipiens* and *H. ovalis* colonised deeper habitats. *H. uninervis*, an ephemeral species, was detected at lower frequencies across Manly and Cleveland but at higher frequencies at Fisherman Islands (17% of survey points) and Deception Bay (26% of survey points) compared to 2024 (5% of survey points and 8% of survey points, respectively).

Control Sites

- Overall, seagrass detections decreased across all sites compared to the previous year (Table 3.1).
- **Manly:** Seagrass was detected at 71% of survey points. Seagrass cover decreased, primarily driven by declines in *Z. muelleri* and *H. decipiens*. *H. uninervis* remained consistently dominant, while the relative dominance of *H. ovalis* decreased in the southeastern areas.
- **Cleveland**: Seagrass was detected at 77% of survey points. Seagrass slightly decreased due to a slight decline in *H. decipiens* in the northeastern and eastern areas. All other species remained consistent.
- **Deception Bay**: Seagrass presence was detected at 35% of survey points with the landward margins relatively consistent with spatial detections in 2024. Seagrass cover decreased, primarily driven by declines in *Z. muelleri* and *H. ovalis*. *H. spinulosa* remained consistent, while the relative dominance of *H. decipiens* slightly increased.

Table 3.1 Frequency of seagrass detections by site (% of survey points)

Location	2024	2025	Change	Dominant Taxa (2025)
Fisherman Islands	81%	50%* 59%#	-31% based on 2024 sites only (Decrease)	*Z. muelleri*
Manly	89%	71%	-18% (Decrease)	*H. spinulosa*
Cleveland	78%	77%	-1% (Decrease)	*H. spinulosa*
Deception Bay	42%	35%	-7% (Decrease)	*H. uninervis, H. ovalis*

*2024 sites only
All survey points

Fisherman Islands

Seagrass meadow extent has changed over time highlighted in Figure 3.2.

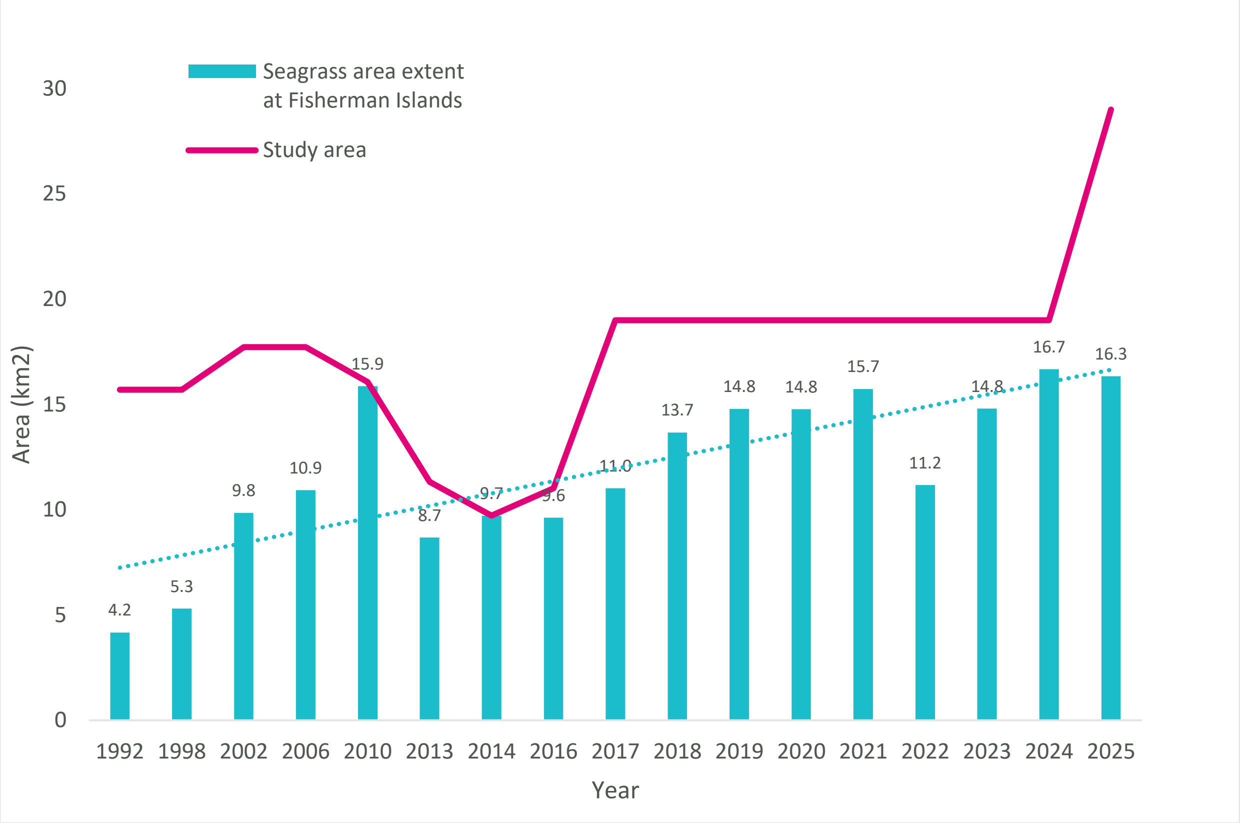

Figure 3.2 Seagrass meadow extent (km^2) at Fisherman Island between 1992—2025[1]

Over the last six years, seagrass meadow extent within the study area has shown notable fluctuations. In both 2019 and 2020, the extent was steady at 14.8 km² out of a 19 km² study area. This increased to 16.7 km² in 2021 before dropping sharply to 11.1 km² in 2022, likely reflecting the impact of major flooding events. Recovery was observed in 2023, with the extent returning to 14.8 km², and further growth was recorded in 2024, reaching 16.7 km² once more. For 2025, the study area was expanded to 29 km², and the total seagrass meadow extent measured 16.1 km², comprising 13.5 km² within the original 2022–2024 19 km² study area and an additional 2.6 km² in the newly expanded study area.

These results show an increase in seagrass meadow extent between 2022 (post major flooding) and 2024 (recovery), and a subsequent reduction following major flooding in February 2025. Interannual changes was largely driven by expansion and contraction of very sparse coverage of *Halophila* species in deepwater areas in the northern and western sectors, while very dense/dense coverage *Z. muelleri* dominated intertidal zones with variable cover along depth transects (Figure 3.5).

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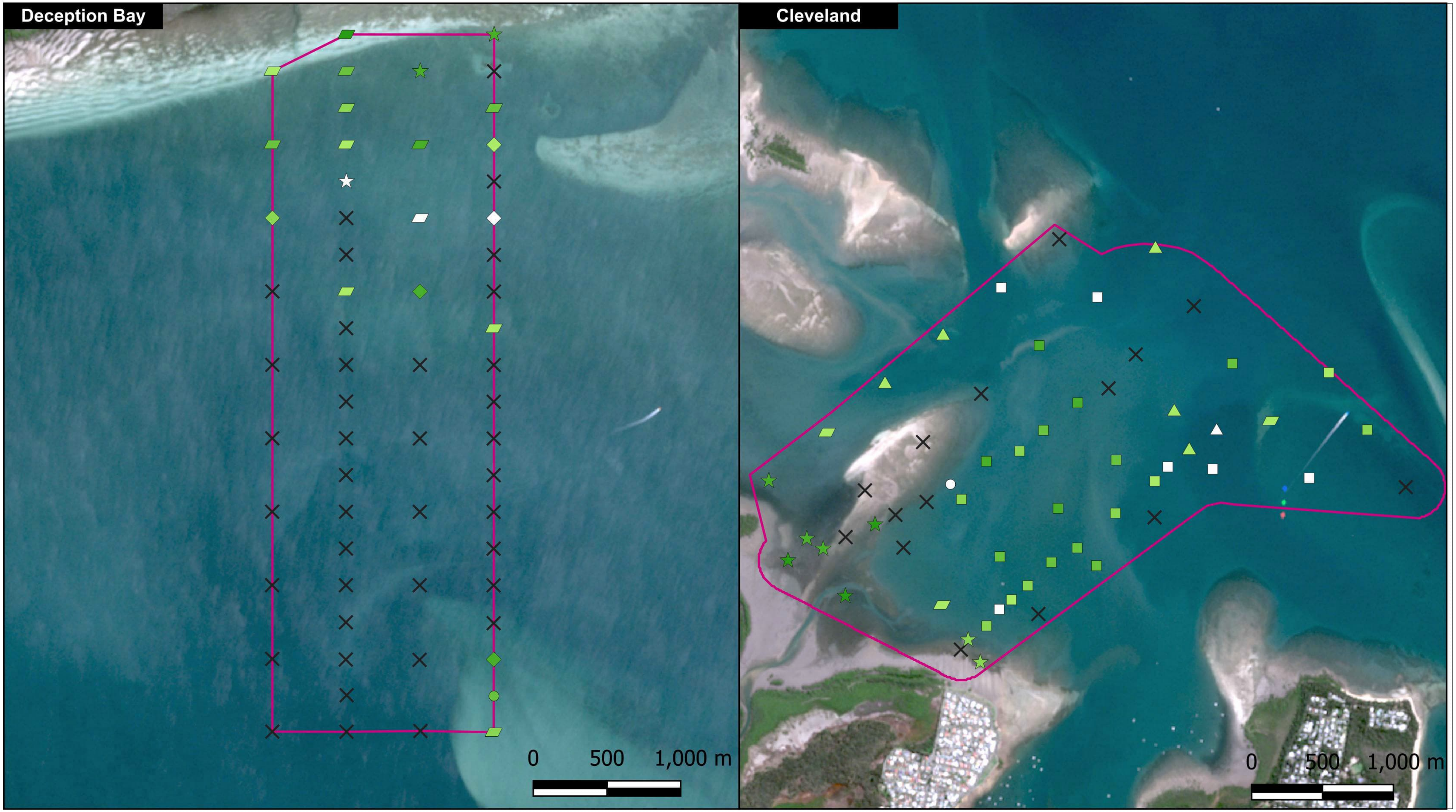
[1] Since 1992, seagrass survey methods within the Port of Brisbane Monitoring Program have been refined as sampling effort, spatial coverage and survey objectives have shifted. Despite these changes in survey area, the findings remain robust and clearly demonstrate an overall long-term increase in seagrass extent.



LEGEND

▭ Study Area

Total Seagrass Cover (%)

○ 0 - 1

● 1 - 5

● 5 - 15

● 15 - 25

● 25 - 50

● 50 - 75

● 75 - 100

Dominant Seagrass Community Type

△ Hd

○ Ho

□ Hs

◇ Hu

▱ Mixed

☆ Zm

✕ No Seagrass Detected

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Species Distribution at Deception Bay and Cleveland

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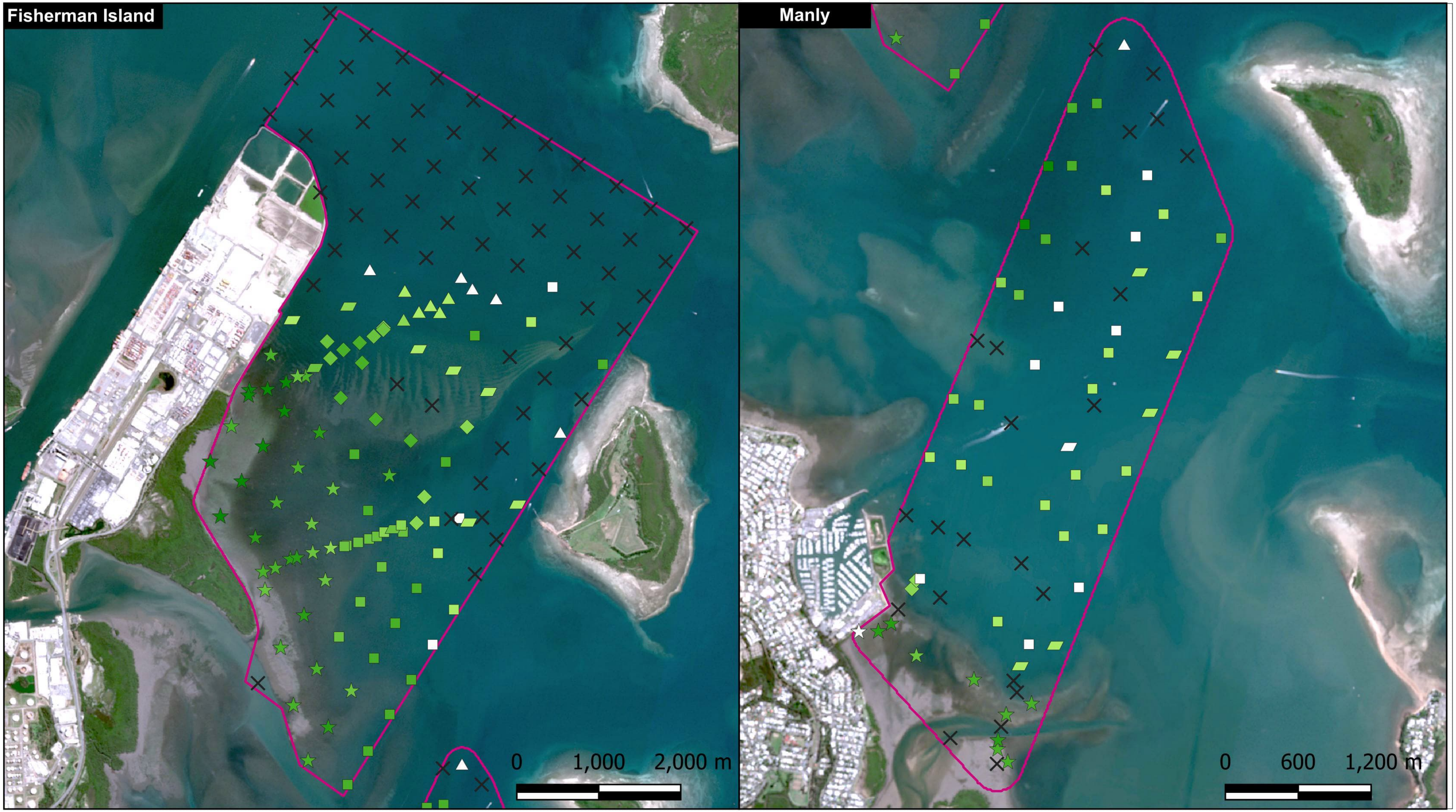

LEGEND

▭ Study Area

Total Seagrass Cover (%)
- ○ 0 - 1
- ● 1 - 5
- ● 5 - 15
- ● 15 - 25
- ● 25 - 50
- ● 50 - 75
- ● 75 - 100

Dominant Seagrass Community Type
- △ Hd
- ○ Ho
- □ Hs
- ◇ Hu
- ▱ Mixed
- ☆ Zm
- ✕ No Seagrass Detected

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Species Distribution at Fisherman Island and Manly

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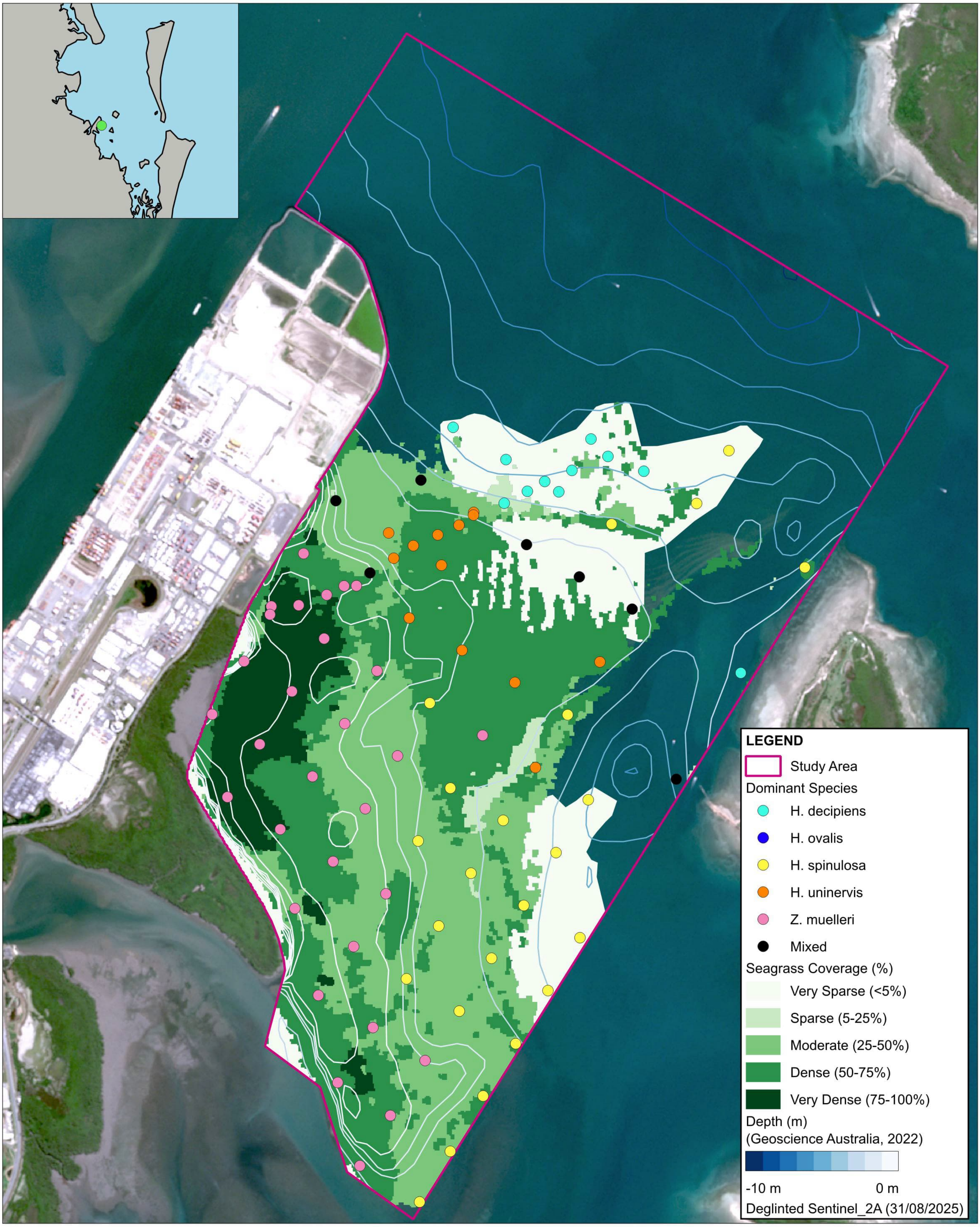

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Seagrass meadow extent, percent coverage (%) and dominant species at Fisherman Island

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3.3 Species-Specific Trends

Halophila decipiens

The number of detections decreased sharply by 62% (Figure 3.6) between 2024 to 2025 surveys, making this species a major contributor to the overall meadow decline. Losses were most pronounced at Cleveland (65%) and Manly (81%).

Halophila ovalis

The number of detections decreased by 49% between 2024 and 2025 surveys (Figure 3.6), with the steepest declines at Manly (87%) and Fisherman Islands (40%).

Halophila spinulosa

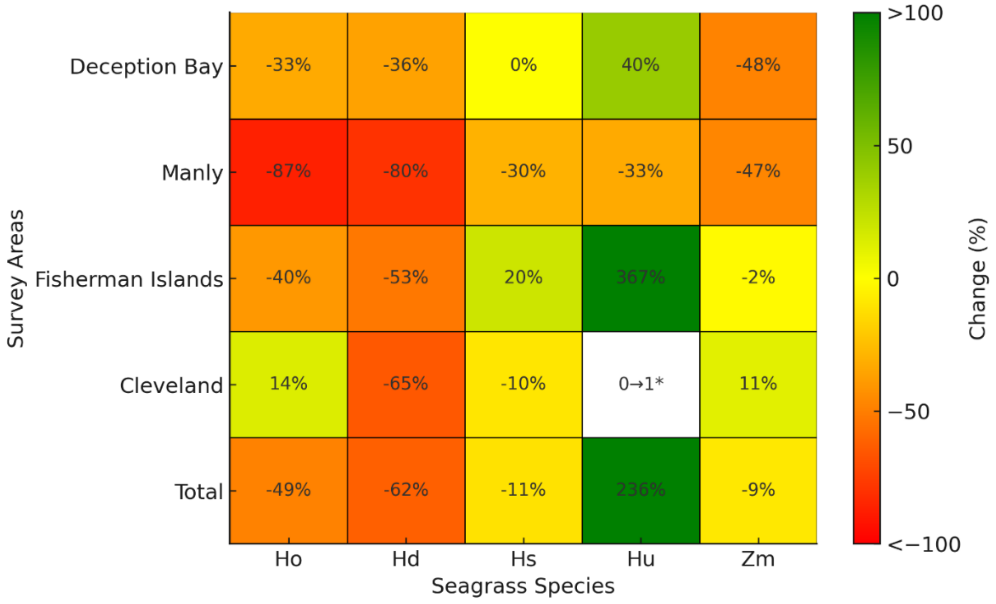
While still widespread, *H. spinulosa* showed an overall decrease 11% decline between the 2024 and 2025 surveys (Figure 3.6). Patterns varied by site: decreases occurred at Manly (30%) and Cleveland (10%), but increased at Deception Bay (40%) and Fisherman Islands (20%).

Zostera muelleri

This species had the smallest negative change, with number of detections down 9% overall. Site-specific trends included decreases at Deception Bay (48%), Manly (47%), and a minor drop at Fisherman Islands (2%), while Cleveland recorded a modest 11% increase.

Halodule uninervis

H. uninervis dramatically increased by 236%, rising from 14 to 47 detections. Growth was driven by Fisherman Islands (367% increase, 6 to 28 detections) and Deception Bay (40% increase, 5 to 16 detections). Manly saw a 33% decrease, and Cleveland had its first detection in 2025.



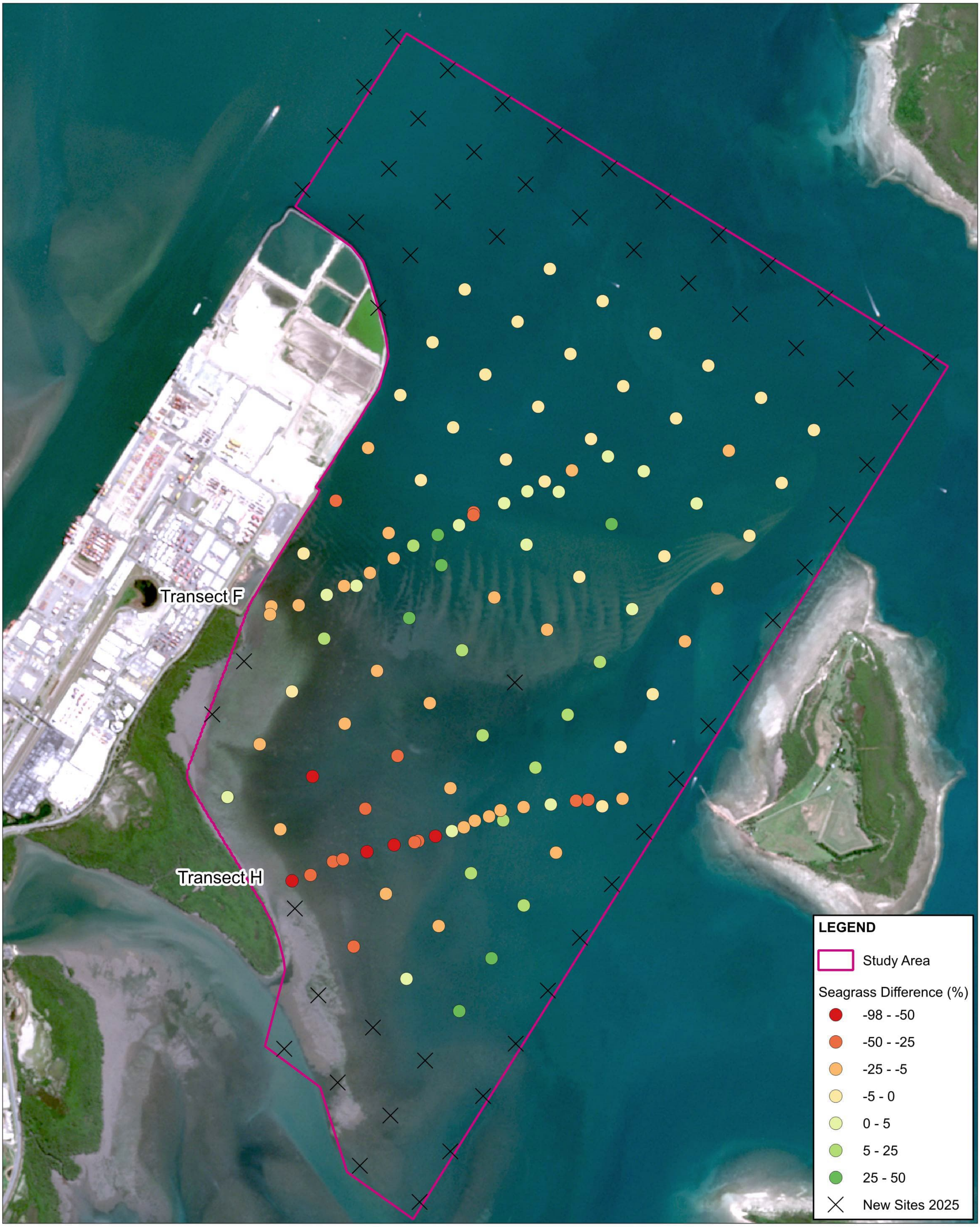
	Ho	Hd	Hs	Hu	Zm
Deception Bay	-33%	-36%	0%	40%	-48%
Manly	-87%	-80%	-30%	-33%	-47%
Fisherman Islands	-40%	-53%	20%	367%	-2%
Cleveland	14%	-65%	-10%	0→1*	11%
Total	-49%	-62%	-11%	236%	-9%

*Hu detection at Cleveland was 0 in 2024 and 1 in 2025 (displayed as 0→1)

Figure 3.6 Change in seagrass species detection from 2024 to 2025

3.4 Seagrass Cover at Fisherman Islands

Intertidal *Z. muelleri* meadows on Transect F was near the historical maximum cover values, whereas Transect H was well below the historical maxima (Figure 3.8). Species within the subtidal areas remained below long-term maxima, consistent with trends observed in 2024. *H. decipiens* coverage were particularly notable in the northeastern and offshore areas as observed on Transect F in the subtidal (Figure 3.8) and distribution in Figure 3.4, with slight coverage change (<5%) recorded from 2025. In contrast, large declines in coverage change since 2024 (–98% to –25%) were observed in southern and central areas, especially in *Z. muelleri*-and *H. spinulosa* dominated zones (Figure 3.7).



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Seagrass Coverage Difference (2024 to 2025) at Fisherman Island

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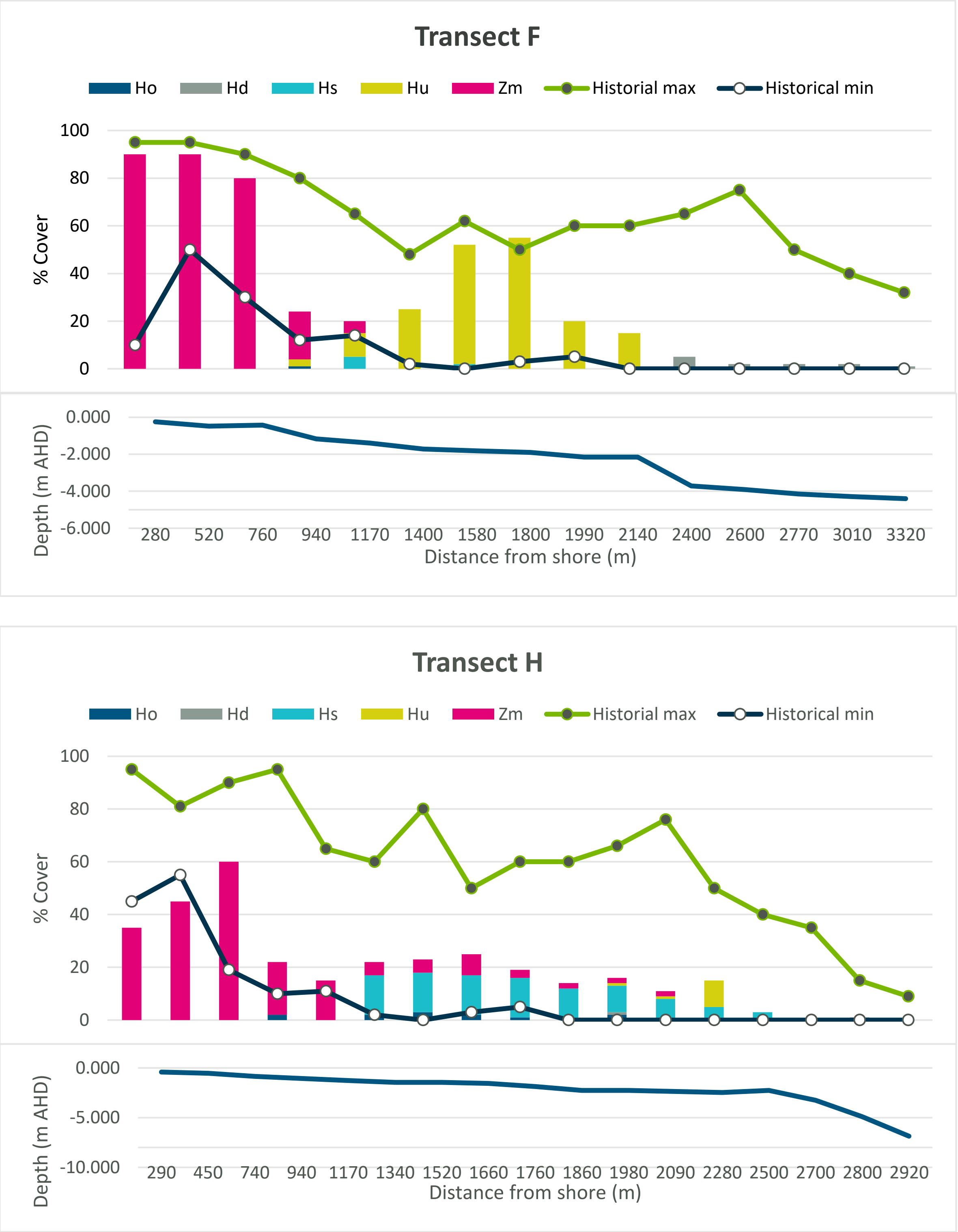

Figure 3.8 Percent cover of seagrass distribution across depth transects at Fisherman Islands (transects H & F). Ho = *Halophila ovalis*, Hd = *Halophila decipiens*, Hs = *Halophila spinulosa*, Zm = *Zostera muelleri*, Hu = *Halodule uninervis*

3.5 Seagrass Depth Range (SDR)

Zostera muelleri

Depth range results revealed divergent trends between transects (Figure 3.9). At Transect H (central Fisherman Islands), SDR was –2.4 m in 2025, consistent with long-term maxima and met the Waterloo Bay water quality objective (–1.9 m). At Transect F (northern Fisherman Islands), SDR contracted to –1.4 m, shallower compared to 2024 values (–2.0 m), the long-term mean (–1.8 m), and the control site average (–1.9 m).

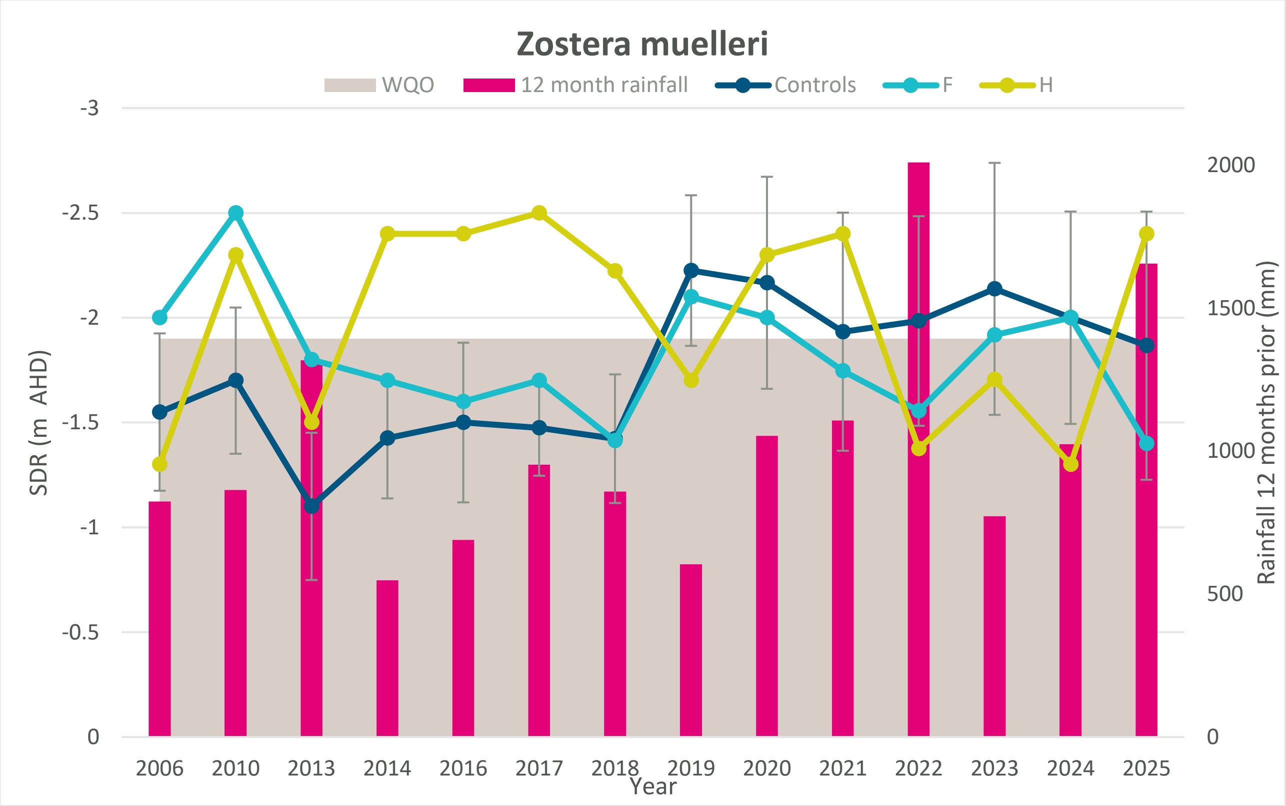

Figure 3.9 *Zostera muelleri* seagrass depth range (SDR) for Transect F and H at Fisherman Islands and the average (±SE) for control sites. Rainfall in the 12 months leading to the survey is also shown (BoM station number 040842 – Brisbane Aero)

Figure 3.10 shows the relationship between cumulative rainfall departure value rainfall (from long term annual average rainfall from Fort Lytton) and mean SDR for each year. There was a highly significant negative relationship between mean *Zostera* SDR and rainfall departure (d.f. = 12, $r^2 = 0.32$, $p < 0.01$), indicating that SDR was lower in and immediately following wet years.

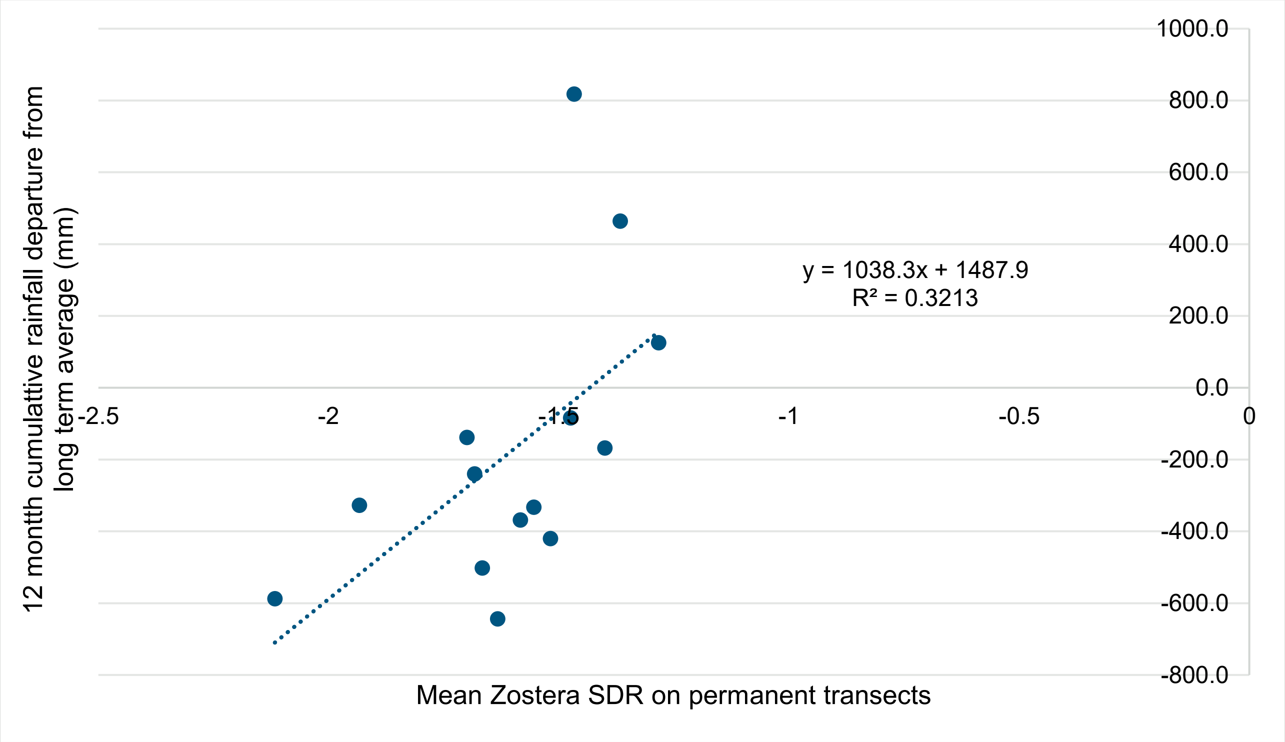

Figure 3.10 Relationship between average Zostera SDR value and rainfall departure from the long-term average value

Other Species

- *Halophila spinulosa*: SDR values at Fisherman Islands ranged from -3.7 up to a new SDR maximum of –4.9 m, below the historical lower quartile range.
- *Halophila ovalis*: Transects: Transect F recorded an SDR of −1.8 (above the historical upper quartile), while Transect H recorded −2.4 (between Q1 and Q2),
- *Halophila decipiens*: Both transects had SDR values of -4.9 m within the typical historical range
- *Halodule uninervis*: SDR values ranged between –2.1 and –2.5 m at Fisherman Islands, within historical ranges but at relatively low abundance

Table 3.2 Selected SDR values for 2025 compared to benchmarks and historical quartile ranges

Species	Transect F (m AHD)	Transect H (m AHD)	Control Average in 2025 (m AHD) ± (SE)	Benchmark (WQO[2])	Q1 (25%)	Q2 (50%)	Q3 (75%)
Z. muelleri	–1.4	–2.4	–1.9 m ± 0.6 (SE)	-1.9 m	-2.28	-1.86	-1.63
H. spinulosa	–3.7	–4.9	–3.8 m ± 0.3 (SE)	None set	-3.45	-2.49	-2.13
H. ovalis	–1.8	–2.4	–2.2 m ± 05 (SE)	None set	-3.80	-2.34	-1.83
H. decipiens	–4.9	–4.9	–4.9 m ± 0.8 (SE)	None set	-5.03	-4.10	-3.95
H. uninervis	–2.1	-2.5	–3.0± 0.6 (SE)	None set	-2.50	-2.05	-1.80

3.6 Algal Detections

Macroalgae were recorded at 49% of surveyed sites in 2025, showing an overall decline compared to 2024. Patterns varied among locations:

- Fisherman Islands— Detections dropped by 32% since 2024. Where algae were present, they were mainly filamentous forms, often growing moderately to densely on Zostera muelleri leaves.
- Manly— Macroalgae prevalence remained relatively stable at around 15%, making Manly the site with the highest overall prevalence in recent years (BMT 2023, BMT 2024). Communities were dominated by filamentous and epiphytic algae, colonizing available substrates.
- Cleveland—Detections decreased from 78% in 2024 to 67% in 2025, but community composition stayed consistent (~15%). Most records were filamentous algae associated with Zostera and Halophila beds.
- Deception Bay—Unlike other sites, Deception Bay showed an increase in macroalgae detections—from 43% in 2024 to 52% in 2025. This site has historically exhibited different trends, suggesting that northern Moreton Bay may be influenced by distinct environmental factors.

Table 3.3 Frequency of macroalgae detections by site (% of survey points)

Location	2024	2025	Change	Dominant Forms
Fisherman Islands	80%	54%	–32% based on 2024 sites only	Filamentous
Manly	85%	51%	–34%	Filamentous, Epiphytic
Cleveland	78%	67%	–14%	Filamentous
Deception Bay	43%	52%	+9%	Filamentous

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[2] WQO in Moreton Bay (WQ1441) for Zostera muelleri in Waterloo Bay (-1.9 m AHD) (Department of Environment and Science, 2022)

4 Discussion

4.1 Species Composition and Regional Context

The 2025 SMP cycle coincided with significant weather events, notably Ex-Tropical Cyclone Alfred in March, which brought extreme rainfall, flooding, and strong easterly to southeasterly winds to Moreton Bay. Annual rainfall exceeded the long-term average, creating conditions generally unfavourable for seagrass growth and persistence (Rasheed et al., 2014).

Despite these disturbances, seagrass meadows across Moreton Bay demonstrated resilience, with dominant species persisting throughout the survey area, although overall abundance declined compared to 2024.

- Stable species: *Zostera muelleri* and *Halophila spinulosa* remained largely consistent, indicating minimal damage.

- Declining species: *Halophila ovalis* and *H. decipiens* showed marked reductions, likely driven by prolonged water quality changes (simultaneous shifts in water temperature, dissolved oxygen and turbidity) (Correia & Lee Smee, 2022) similarly seen after major flood events in 2010, 2013 and 2022.

Zostera muelleri is highly resilient due to its dense root system, which stabilizes sediments and supports survival during environmental fluctuations (Macreadie et al., 2014). *Halophila spinulosa* is moderately resilient—less robust but capable of rapid recolonization (McLennan & Sumpton, 2005).

Halodule uninervis, an ephemeral pioneer species, increased significantly in 2025. Conditions following Cyclone Alfred—high sediment suspension, seabed disturbance, and nutrient enrichment—likely favored its rapid establishment (Carruthers et al., 2002; Udy & Dennison, 1997).

The absence of *Cymodocea serrulata* since its detection in 2021 suggests stochastic colonization rather than persistent populations. Overall, species composition remains consistent with historical records (Hyland et al., 1989; Davie, 2011), underscoring ecological stability despite fluctuations in meadow extent.

4.2 Inter-Annual Patterns (2020–2025)

Western Moreton Bay seagrass meadows exhibit cyclic fluctuations linked to flood-drought dynamics (Roelfsema et al., 2009).

- Flood impacts: Major floods in 2010, 2013, and 2022 caused significant reductions in meadow extent due to turbidity and physical disturbance (Campbell & McKenzie, 2004; Maxwell et al., 2013).

- 2022 flood: Coverage dropped from 12.8 km² (2021) to 11.15 km² (2022), similar to 2013 declines.

- Recovery phase: Between 2023–2024, extent rebounded to 16.7 km², surpassing pre-flood levels under drier conditions.

In 2025, Cyclone Alfred reversed this trend, reducing Fisherman Islands coverage from 16.7 km² to 13.5 km² (88% to 71% of study area). Sediment loading and reduced light availability were likely primary drivers of loss.

Halophila Species

Declines were driven by contraction of deepwater Halophila meadows, especially H. ovalis and H. decipiens. H. spinulosa remained widespread but decreased overall by 11%, with site-specific variability (e.g., +40% at Deception Bay, –30% at Manly).

Halophila species are opportunistic colonizers—rapid recovery post-disturbance but low tolerance to light limitation (Kilminster et al., 2015). SMP results confirm dynamic occupancy of deep waters during clear conditions and retreat after floods (Longstaff et al., 1999). Small-scale heterogeneity in *Halophila* distributions was evident across transects, influenced by interspecific competition, grazing, and variable light availability linked to sediment dynamics and proximity to channels (Hearne et al., 2018).

Halodule uninervis

H. uninervis displayed site-specific temporal patterns. At Fisherman Islands and Deception Bay, total detections increased substantially, whereas Manly control sites experienced reductions. A detection of *H.uninervis* was detected at one site at Cleveland, where the species was previously absent in 2024. *H. uninervis*, like *H. ovalis*, is a pioneer species adapted to dynamic or depositional environments (Carruthers et al., 2002; Waycott et al., 2004).

Zostera muelleri

Zostera muelleri was primarily confined to intertidal and shallow waters (<2.5 m AHD) due to high light requirements (Abal & Dennison, 1996; Collier & Waycott, 2009). Temporal patterns were spatially heterogeneous:

- Fisherman Islands: Frequency of detection decreased at some transects (e.g., Transect F), with SDR values near historical minima, while other transects (e.g., Transect H) remained stable near maxima. Generally detections across the area substantially decreased and with large declines in cover (–98% to –25%) were observed in southern and central areas

- Control sites: Temporal variability was observed; mean SDR remained relatively stable.

These results indicate marked spatial variability in meadow condition. Drivers of local *Z. muelleri* losses are summarized in Table 4.1.

Table 4.1 Assessment of potential drivers of *Zostera muelleri* loss

Potential driver	Assessment
Reduced light due to turbidity	Likely – The contraction of *Zostera muelleri* depth range at Transect F (–1.4 m AHD in 2025, down from –2.0 m in 2024) suggests reduced light availability, likely due to increased turbidity from sediment and stormwater runoff following Ex-Tropical Cyclone Alfred. This is supported by the significant negative correlation between rainfall and SDR, indicating that flood events can limit light penetration and constrain seagrass depth distribution. In contrast, Transect H (central Fisherman Islands) maintained a deeper SDR (–2.4 m), consistent with long-term maxima and

Potential driver	Assessment
	exceeding the water quality objective (–1.9 m), suggesting that local hydrodynamic conditions may have mitigated turbidity impacts to that transect.
Reduced light due to epiphytic algae	Unlikely – Long-term trends from the SMP indicate that algal abundance can fluctuate over time. In Moreton Bay, algal growth is primarily driven by nutrient enrichment, particularly nitrogen, phosphorus, and iron inputs from the catchment (Saeck *et al.,* 2019). Algal communities were dominated by filamentous epiphytic and turfing forms, which colonise seagrass leaves and can smother photosynthetic tissue. Non-filamentous macroalgae were less frequently encountered but were present at some sites. Although filamentous algae were still present overall detection frequency at Fisherman Islands declined from 80% in 2024 to 54% in 2025. This suggests that while epiphytic algae may contribute to light limitation in some years, they were less likely to be a primary driver in 2025.
Reduced salinity	Likely – Residual effects from earlier high rainfall and runoff following Ex-Tropical Cyclone Alfred may have temporarily reduced salinity levels in nearshore areas.
Physical disturbance	Likely – Ex-Tropical Cyclone Alfred likely contributed to physical disturbance of seagrass meadows through elevated wave energy and sediment resuspension.
Bait worming	Unlikely – Disturbance of seagrass by bait worm digging typically occurs at smaller spatial scales than the broad scale changes observed at Fisherman Islands
Disease	Unknown
Macroalgae/competition	Unlikely – *Caulerpa* and other macroalgae species were not abundant in *Zostera* meadows. Areas previously occupied by *Zostera* in 2024 were colonised by *Halophila* species, which due to their smaller size, are unlikely to outcompete *Zostera*.
Over-grazing	Unlikely – Disturbance by dugongs and sea turtles typically occurs at fine spatial scales (10s of metres). *Zostera* is not a preferred food resource for dugongs. No major infestations of sea urchins or other grazing invertebrate species were observed.

4.3 Decadal-scale Changes

Despite inter-annual variability, the SMP indicates a long-term trajectory of meadow expansion at Fisherman Islands since the 1990s (over 4 km^2) and early 2000s to present day (over 16 km^2). This expansion is consistent with predictions from the Future Port Expansion Impact Assessment Study (WBM, 2000), which suggested that hydrodynamic alterations associated with seawall construction would enhance seagrass development (Figure 4.1).

After significant flood events in 2011, 2013, and 2022, seagrass cover declined but subsequently rebounded, often reaching or exceeding pre-disturbance levels within two to three years.

Three processes likely underpin the observed resilience:

1. **Hydrodynamic buffering—**The FPE seawall has reduced the exposure of seagrass meadows to northerly wave action, minimizing physical disturbance during storm events.

2. **Deposition of fine sediments—**Finer sediment deposition within sheltered embayments, stabilising substrates suitable for colonisation.

3. **Reduced influence of freshwater flood—**The repositioning of the Brisbane River mouth, relative to the meadows, has lessened the frequency and severity of salinity and turbidity stress.

These processes illustrate how anthropogenic modifications can inadvertently create conditions favourable for seagrass, although the ecological consequences are complex (Ludlow and Bloun, 2020). A decreased rate of accretion of sediment in Fisherman islands has stabilised the environment for seagrass colonisation (BMT, 2022b). The decadal-scale record from Fisherman Islands indicates that, while seagrass meadows are sensitive to episodic stressors, they possess intrinsic resilience.

LEGEND

- ☐ Study Area
- 🟩 Seagrass Extent
- ▨ Fisherman Island Land Area

Title:

Seagrass Extent Change 1992 - 2025

Figure: **4.1**

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4.4 Comparative Analysis of Control Sites

Patterns observed at the control sites provided essential context for interpreting changes at Fisherman Islands. In 2025, all control sites experienced a decline in overall seagrass detections compared to 2024, though the magnitude and species-specific trends varied. *Zostera muelleri* declined at Manly (–47%) and Deception Bay (–48%), while Cleveland showed a modest increase (+11%), suggesting that local environmental conditions played a significant role in shaping species responses.

Cleveland, the most sheltered of the control sites, exhibited the greatest stability in species composition and seagrass cover, with minimal inter-annual variation. In contrast, Manly, being the most exposed site, experienced declines across all major seagrass species, likely reflecting the impact of increased wave energy and sediment resuspension following Ex Tropical Cyclone Alfred. Similar declines would likely have occurred across the western Fisherman Islands meadows if not for the protection provided by the FPE seawall which buffered the area (as seen with coverage change near Transect F) from southeast cyclone-driven wave energy, whereas Transect H, positioned in the more exposed southern sector, experienced greater seagrass cover loss since 2024. Deception Bay, which represents broader background conditions in northern Moreton Bay, showed a mixed response: while *Z. muelleri* and *H. ovalis* declined, *H. spinulosa* and *H. uninervis* increased in relative dominance, indicating a shift toward more opportunistic species.

These observations suggest that the placement of meadows within the bay plays a significant role in protecting seagrass, and that the observed changes are the result of local responses to the extreme weather event.

4.5 Implications for Ecosystem Function and Resilience

The findings have broader implications for ecosystem functioning in Moreton Bay. Seagrass meadows support one of the largest populations of dugongs on the east coast of Australia, with estimates ranging from 600 - 800 individuals (Moreton Bay Foundation, 2020). Dugongs preferentially forage on *Halophila ovalis* which retracted in 2025. However, the presence of *H. uninervis*, which increased in the 2025 SMP, was predicted to increase dugong abundance by up to 6.8 times (Said *et al.,* 2025).

At an ecosystem level, the observed resilience of pioneer taxa suggests that seagrass meadows can recover rapidly following disturbances, provided environmental conditions are favourable. Seagrass meadows have demonstrated the ability to recover from large losses of cover during major events but their long-term recovery is usually unpinned by a regeneration from seed bank (Maxwell et al., 2013; Carruthers et al., 2002; Waycott, Longstaff, & Mellors, 2005). The interaction between localised dynamics and regional climatic variability will be critical in shaping future trajectories (Udy & Dennison, 1997).

5 Conclusion

- **Seagrass diversity:** Eight species documented, including *Zostera muelleri*, *Halophila* spp., *Halodule uninervis*, *Cymodocea serrulata*, and *Syringodium isoetifolium*; *S. isoetifolium* and *H. minor* have been recorded within the Port of Brisbane SMP. Moreton Bay represents the southern distribution limit for several species.

- **Inter-annual dynamics:** Seagrass extent and cover declined in 2025 compared to 2024, reversing the recovery trend observed after the 2022 Brisbane River flood. Extreme rainfall and southeast winds associated with Ex-Tropical Cyclone Alfred likely drove sediment resuspension and turbidity, reducing light availability and causing meadow contraction. However, long-term monitoring demonstrates that, with adequate recovery time between flooding events, seagrass meadows at Fisherman Islands consistently rebound to maximum extents and diversity levels. This pattern of decline followed by recovery highlights the resilience of these meadows under average rainfall conditions, provided further extreme events do not occur

- **Species-specific responses:**

    - *Halophila* species declined across most sites, while *Halodule* species surged, especially at Fisherman Islands and Deception Bay, indicating a shift toward opportunistic colonizers after disturbance.

    - *Zostera muelleri* showed spatially variable declines, likely linked to flooding and physical disturbance compared to epiphytic algae and nutrient enrichment.

- **Long-term trends:** Decadal monitoring indicates increased meadow extent and connectivity, particularly adjacent to the FPE seawall, growing from 4 km² in 1992 to more than 16 km² in present day. Port expansion has modified local hydrodynamics, providing enhanced wave protection, sediment deposition, and improved water clarity.

- **Management implications:** Maintaining water quality, regulating nutrient inputs, and monitoring hydrodynamic conditions are critical to support seagrass resilience and ecosystem services in Moreton Bay.

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Annex A Seagrass photo plate

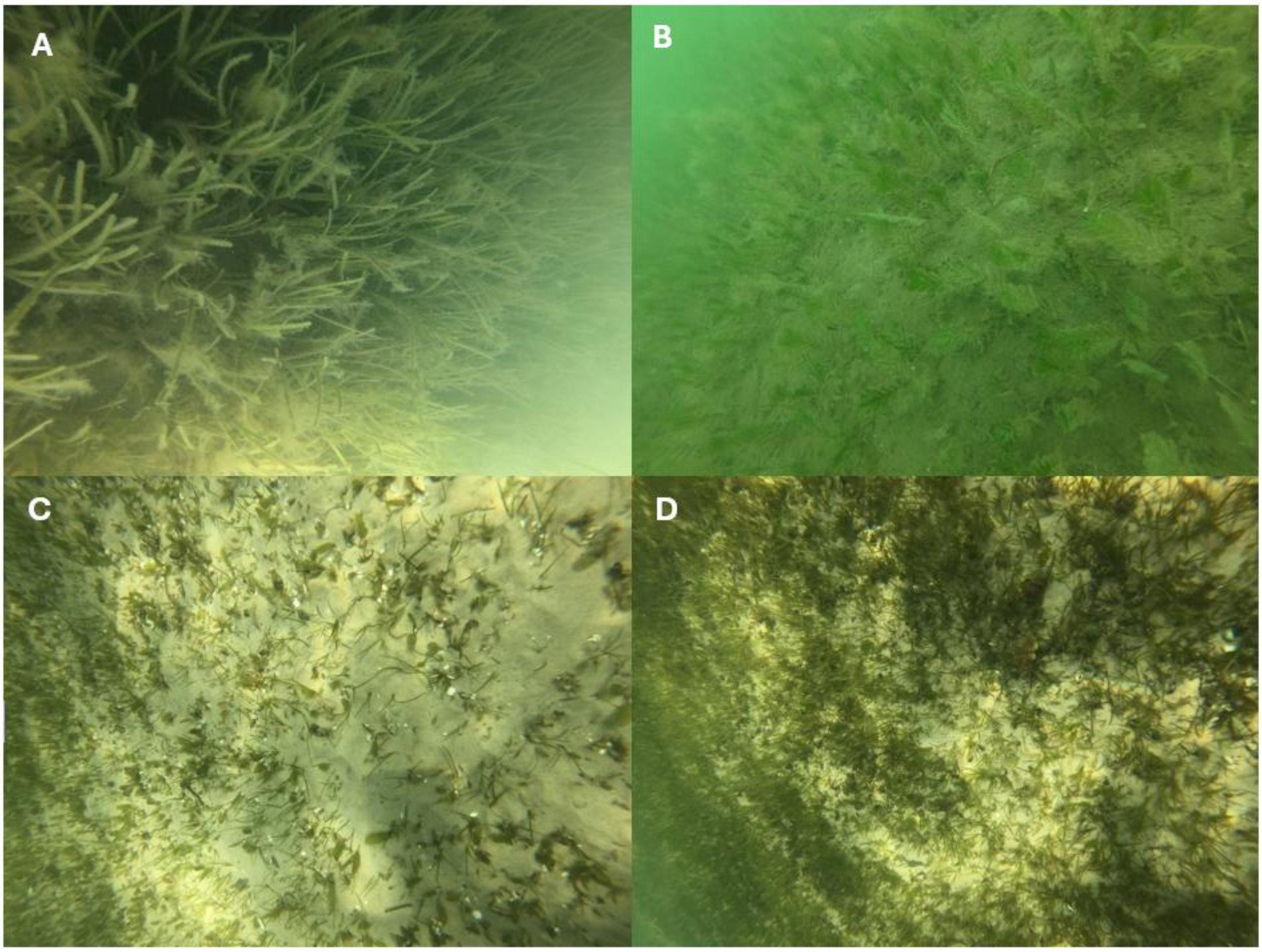


Figure A.1 Dense *Zostera muelleri* at Fisherman Islands (A), Moderate *Halophila spinulosa* at Fisherman Islands (B), Moderate *Halophila ovalis and Halodule uninervis* at Deception Bay (C), Dense mixed species meadow at Deception Bay (D).

Annex B Algae photo plate

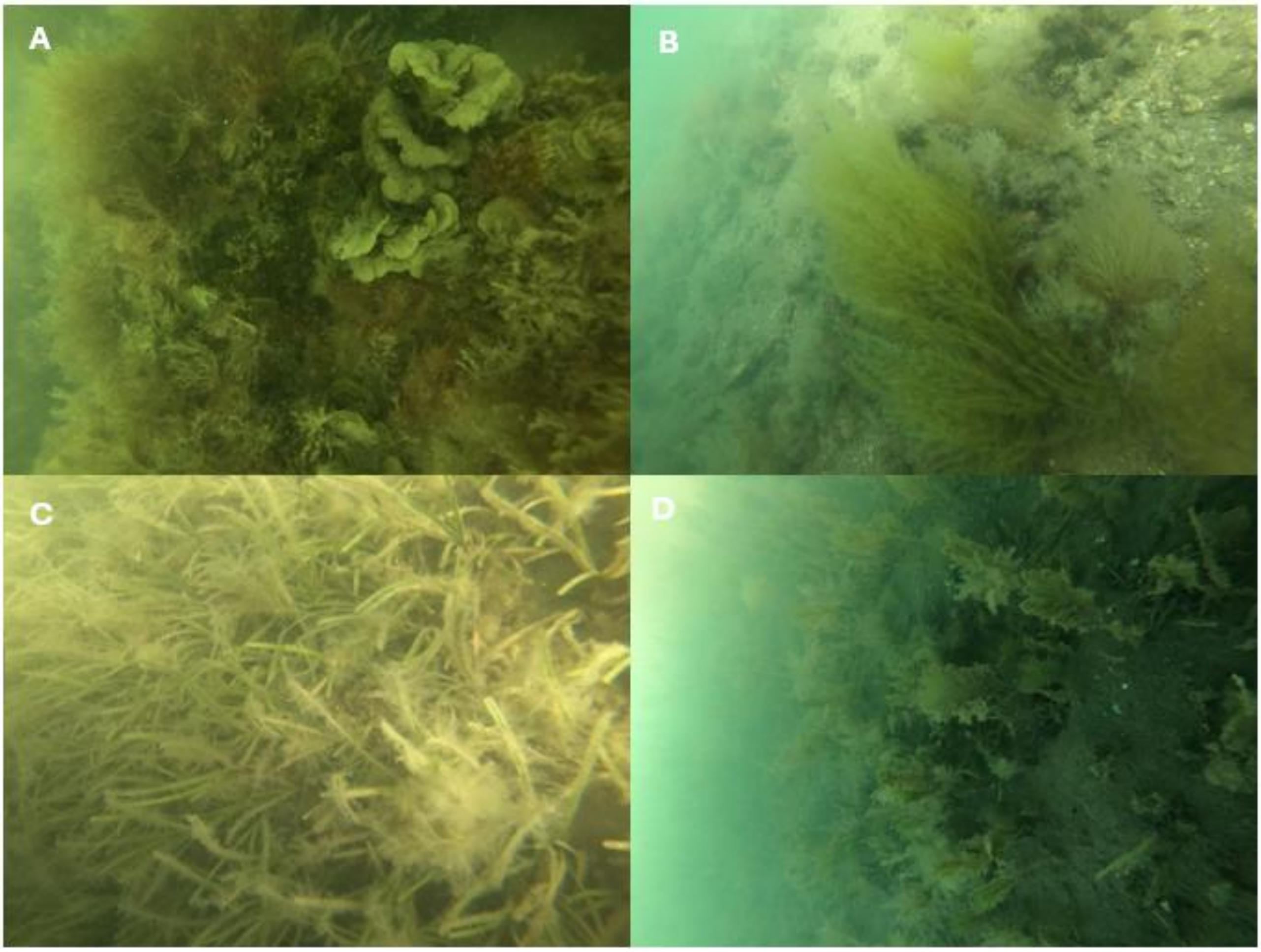
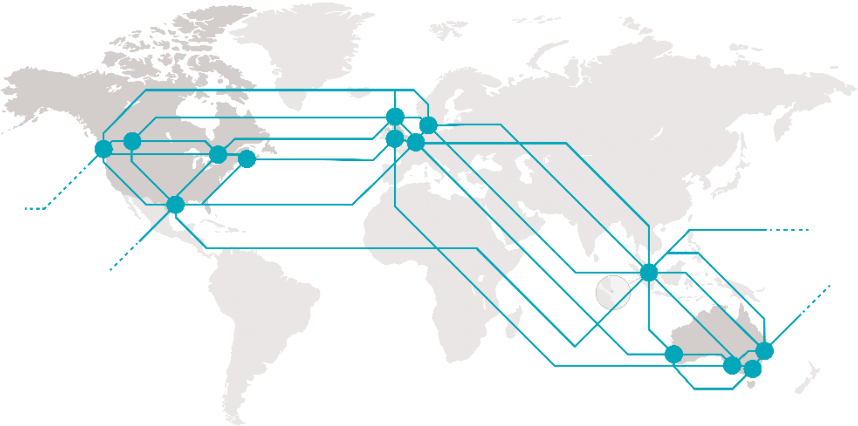


Figure B.1 Multispecies algae assemblage at Fisherman Islands (A-D).



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