Port of Brisbane Seagrass Survey 2021 - DRAFT

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Synopsis:	**Findings of the 2021 seagrass monitoring program at Port of Brisbane, Queensland.**	

REVISION/CHECKING HISTORY

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Executive Summary

Background

Seagrass meadows located within and adjacent to the Port of Brisbane support multiple environmental and community values. These meadows vary in condition and extent in time and space in response to changes in environmental conditions, especially water quality.

The Port of Brisbane Pty Ltd (PBPL) has developed the Port of Brisbane Seagrass Monitoring Program (SMP). Every year, the SMP examines trends in seagrass meadow extent and condition in waters at and adjacent to the Port of Brisbane. This long-term dataset provides a basis to explore potential links between seagrass meadow condition and drivers, including the potential influence of port activities.

This report describes the approach and findings of the 2021 sampling event. The SMP monitors meadows at Fisherman Islands and control locations of Cleveland, Manly and Deception Bay. The SMP incorporates field-based (underwater video transects) and remote (aerial imagery) methodologies.

SMP Aims

- Map and describe broad-scale spatial patterns in seagrass extent and species distribution at meadows located near the Port of Brisbane at Fisherman Islands, and at control locations located in western Moreton Bay (Manly, Cleveland and Deception Bay)
- Characterise spatial and temporal trends in seagrass condition indicators
- On the basis of the above, identify possible broad-scale operational impacts of port activities on the distribution and extent of seagrass meadows.

Findings

Species Composition

- A core set of species occur at all locations over time: the eelgrass *Zostera muelleri*, the paddle-weeds *Halophila ovalis*, *Halophila spinulosa* and (typically) *Halophila decipiens*. All four seagrass species were observed during the 2021 field surveys.
- A fifth species, the narrow-leaf seagrass *Halodule uninervis,* is an ephemeral species. This species has been periodically recorded and was observed in 2021.
- A sixth species, *Cymodocea serrulata*, was recorded at Fisherman Island. This species has not previously been recorded in the SMP, but is known to occur in eastern Moreton Bay.


Zostera muelleri


Halodule uninervis


Halophila ovalis


Halophila spinulosa


Halophila decipiens


Cymodocea serrulata

Spatial Patterns in Seagrass Species

- Figure 1 is a map of seagrass meadows at Fisherman Islands in 2021. The map is indicative of patterns in seagrass assemblage structure, but accuracy is constrained by water clarity issues (i.e. >3-5 m depth, especially sparse meadows) and site spacing (500 m grid arrangement).
- Intertidal and shallow subtidal areas were predominately dominated by *Zostera muelleri*, either as a monospecific community or with *Halophila* as sub-dominant.
- Subtidal meadows comprised of mixed communities of *Halophila* and macroalgae species.

Meadow Extent and Condition between 2020 and 2021

- The upper boundary of *Zostera muelleri* dominated meadows retracted at Fisherman Islands between 2020 and 2021, but was within the historical range.
- The seaward boundary of *Zostera muelleri* slightly increased or was stable on both Fisherman Islands transects, as was also observed at control sites (Figure 2).

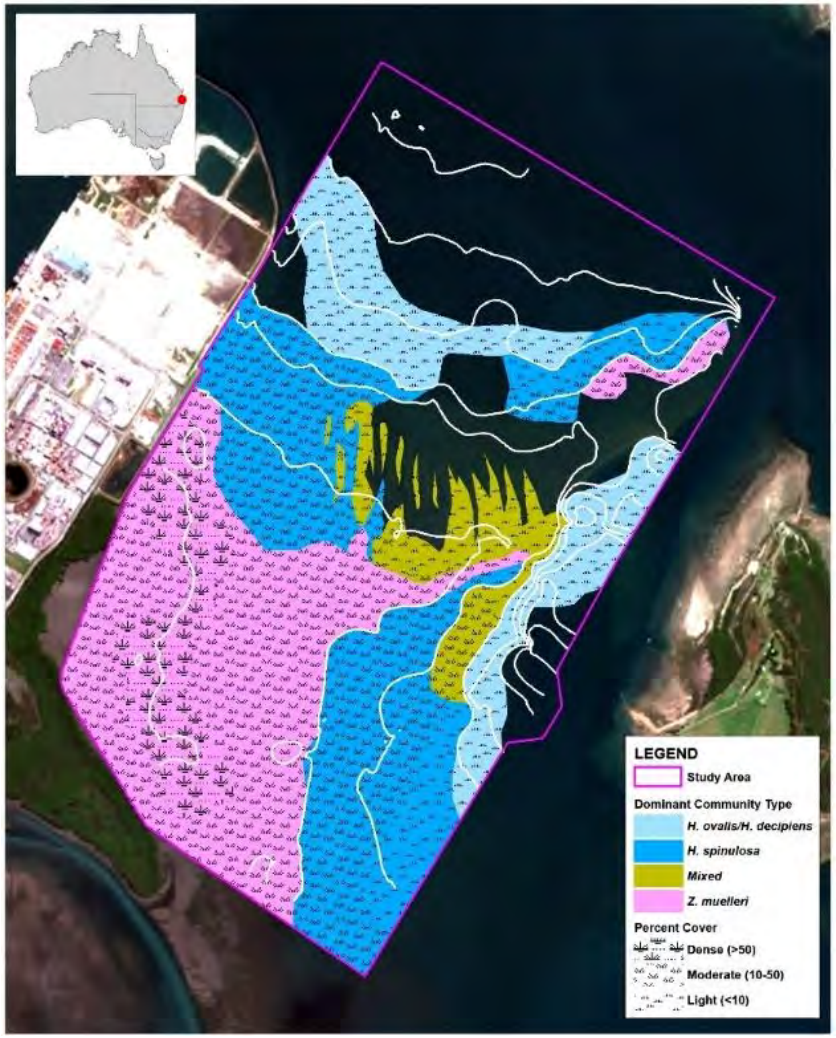

Figure 1 Seagrass Distribution and Composition Adjacent to Fisherman Islands 2021, Showing 1 m LAT Contours

- *Environmental Protection Policy (Water and Wetland Biodiversity)* sets out water quality objectives (WQO) for the protection of environmental values. The policy adopts *Zostera muelleri* seagrass depth range (i.e. maximum depth of *Zostera*) as a WQO. Fisherman Island transects H and F, Manly transect J and both Deception Bay transects met the WQO, all other transects at control sites did not (Figure 2).

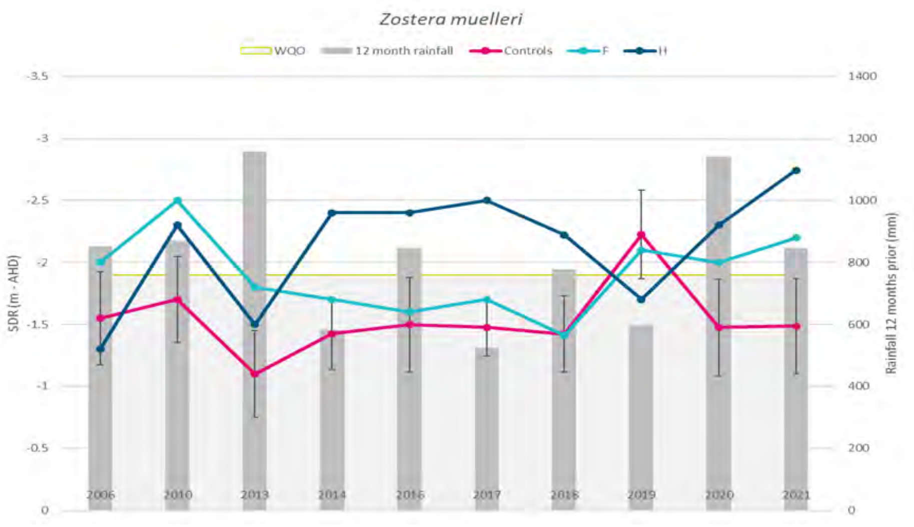

Figure 2 *Zostera* seagrass depth range at Fisherman Islands transect F and H, and the average (±SE) for control sites. Rainfall in the 12 months leading to the survey is also shown

- There was a reduction in seagrass meadow extent in the northern sector of Fisherman Islands. In 2020 this area had sparse *Halophila* species.
- A variety of macroalgae species were recorded, with *Hydroclathrus, Hypnea* and *Sargassum* typically the most abundant. *Caulerpa taxifolia* was dominant in the study area during the 2000s, but was sparse to absent in 2021.

Long Term Changes in Seagrass Meadow Extent

- There has been a long-term trend of seagrass meadow expansion followed by stability at Fisherman Islands. This trend is consistent with predictions of the Future Port Expansion Impact Assessment Study, which suggested that land reclamation would enhance growing conditions for nearby seagrass meadows.
- A larger sample size is required to assess quantitative linkages between rainfall and seagrass condition/extent.

Key Conclusions

- Fisherman Islands seagrass meadow condition was relatively stable between 2020 and 2021.
- Similar trends were observed at control sites, and changes recorded at Fisherman Island were within the range of natural variability.
- This suggests that the driver/s leading to changes between 2020 and 2021 were operating over broad scales throughout western Moreton Bay, and were therefore unrelated to Port activities.

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1 Introduction

1.1 Background

Moreton Bay contains a mosaic marine habitats supporting outstanding ecological, social and economic values. In recognition of these values, parts of Moreton Bay are listed as an internationally significant wetland (Moreton Bay Ramsar Site) and Moreton Bay Marine Park (Figure 1-1).

The Port of Brisbane is located adjacent to Waterloo Bay, which contains some of the largest seagrass meadows in western Moreton Bay (Dennison and Abal 1999). The Port of Brisbane Pty Ltd (PBPL) has developed a Seagrass Monitoring Program (SMP) to provide information on the status and condition of seagrass meadows through time to identify if there are any signs of impact from port activity.

The extent and health of seagrass meadows is a useful indicator of water quality change, especially aquatic light climate (ANZECC/ARMCANZ 2000, p A3-79). The maximum depth at which seagrass grows is thought to mainly be a function of the availability of certain wavelengths of light[1] (Abal and Dennison 1996). A reduction in light availability below the requirements of a particular seagrass species can reduce seagrass energy production (through the process of photosynthesis), typically resulting in the death of that seagrass. A reduction in light availability and associated loss of seagrass can therefore be manifested as a reduction in the vertical, and associated horizontal, distribution of seagrass.

Different species of seagrass vary in terms of their long-term light requirements and tolerances to transient periods of light deprivation. Therefore, the distribution, abundance and composition of seagrasses at any time in a region may be a function of both the long-term trends in light availability and by their ability to survive or regenerate after pulsed or seasonal (i.e. regular) turbidity events (Moore *et al.* 1997). For this reason, seagrass community monitoring also provides a basis for assessing long term changes in water quality.

1.2 Aims and Objectives

The aims of the SMP are to describe:

- Current broad-scale patterns in seagrass extent and species distribution at the Port of Brisbane (Fisherman Islands), and at the Manly, Cleveland and Deception Bay control locations;
- Spatial variations in seagrass extent and species distribution occurring at the four monitoring locations; and
- Temporal trends in seagrass extent and species distribution at the monitoring locations.

The specific objectives of the SMP were to:

- Map the distribution and extent of seagrass meadows adjacent to Fisherman Islands;
- Characterise spatial and temporal patterns in the vertical (depth, accuracy measured in tens of centimetres) distribution of seagrass meadows at the Port and at control areas;

[1] This assumes that levels of physical disturbance by waves/currents is within the tolerance limits of the seagrass under consideration

- Determine whether broad-scale spatial and/or temporal patterns in seagrass extent are consistent among the Port and control areas; and
- On the basis of the above, identify possible broad-scale operational impacts of port activities on the distribution and extent of seagrass meadows.

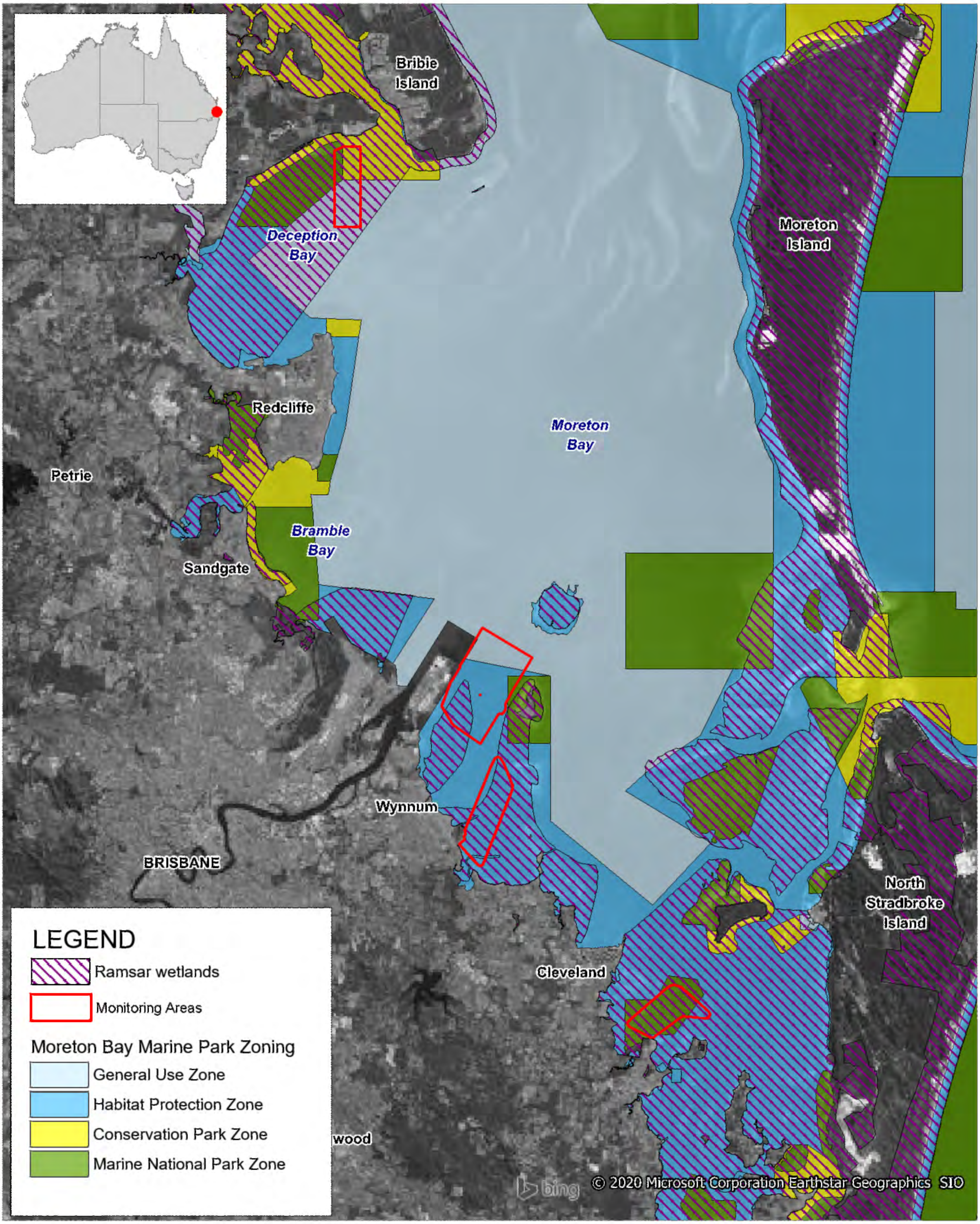
1.3 Study Area

The Port of Brisbane is located on Fisherman Islands which is situated at the mouth of the Brisbane River on the western foreshore of Moreton Bay, Queensland. Port facilities located at the Brisbane River mouth have been established on land reclaimed over a shallow sub-tidal river delta containing a series of low-lying mangrove islands, collectively called the Fisherman Islands. The area was reserved for harbour purposes in the 1940's. Reclamation commenced in the late 1960's and the decision was made to re-locate port facilities from the city reaches in the 1970's. The Port of Brisbane is now Queensland's largest container port facility and continues to expand by progressive filling within the existing perimeter bund.

Construction of the present-day port facilities over intertidal and subtidal areas has resulted in extensive changes to the environmental attributes of the Fisherman Islands area. However, significant areas of mangrove, saltmarsh and seagrass have also been retained, and form part of the Fisherman Islands wetland complex on the south eastern side of the Port of Brisbane. Moreton Bay Marine Park is situated to the south and east of the FPE seawall, this area is thought to contain one of the largest semi-contiguous seagrass meadows in western Moreton Bay. A Ramsar listed wetland is situated only kilometres to the south of the Port facilities, comprising intertidal portions of the Fisherman Islands wetland complex (Figure 1-1). The seagrass and mudflats of this site are recognised for their importance to dugong, marine turtles and migratory and resident shorebirds (BMT WBM 2008).

On the northern side of the Port of Brisbane, dredging occurs within the shipping channel through the Bar Cutting, the Swing Basin and berth areas, which are presently maintained to a declared depth of 14 m (relative to Port Datum – Lowest Astronomical Tide, hereafter referred to as LAT). The Port facilities are situated at the mouth of the Brisbane River, which comprises the largest river catchment in Moreton Bay, and experiences freshwater flows and ongoing inputs of sediments and contaminants derived from human activities in its catchment. Two major sewage treatment plants also have their sewage discharges within kilometres of the Port facilities (Luggage Point and Wynnum North wastewater treatment plant).

Control sites are located on the western foreshore of Moreton Bay at Manly, Cleveland and Deception Bay (see Figure 2-2). At Manly, seagrass meadows extend from the intertidal areas adjacent to the Manly Boat Harbour and Fig Tree Point to the subtidal area close to Green Island. At Cleveland the seagrass habitat extends throughout the bay which is formed between Toondah Harbour and Coochiemudlo Island. Growing conditions at Manly and Cleveland are similar to those experienced at the Fisherman Islands and western Moreton Bay generally. Deception Bay was included as an additional site in the 2020 and 2021. Previous surveys of Deception Bay have characterised this seagrass community as light to moderate coverage consisting of the following species: *Zostera capricorni*, *Halodule uninervis*, *Halophila ovalis* and *Syringodium isoetifolium* (Kirkman 1975; OzCoasts 2004).



Title:
Moreton Bay Ramsar Wetlands and Marine Park Zoning

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2 Methodology

2.1 Timing

Field monitoring in 2021 was undertaken between the 13th of July to the 12th of August. Tidal data from the Tidal Unit, Maritime Safety Queensland was obtained for the Brisbane Bar throughout this study period (Figure 2-1) and was used to correct depth soundings to Australian Height Datum (AHD). Average annual rainfall for 2001-2020, and rainfall recorded in January to July 2021

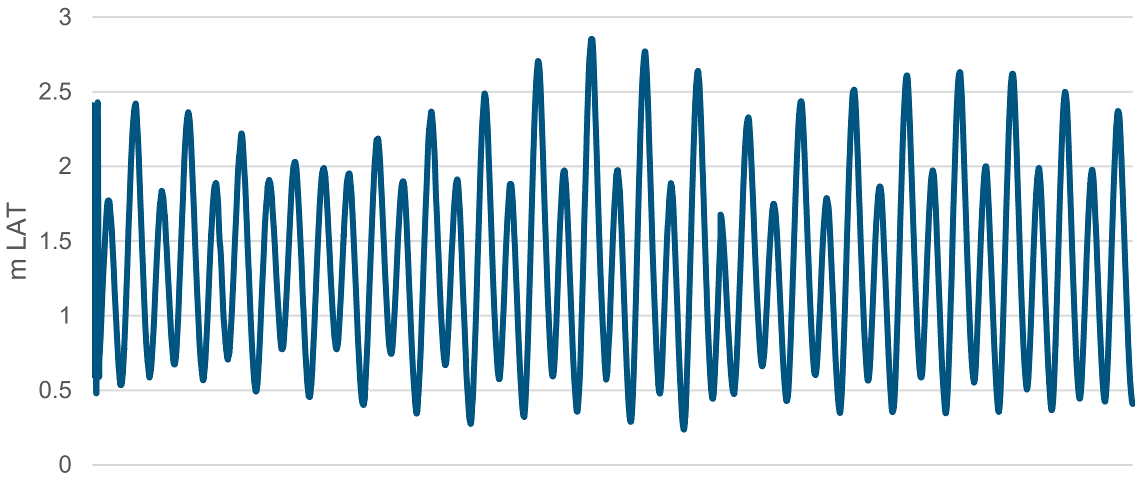


Figure 2-1 Tidal heights of Brisbane Bar during the 2021 survey

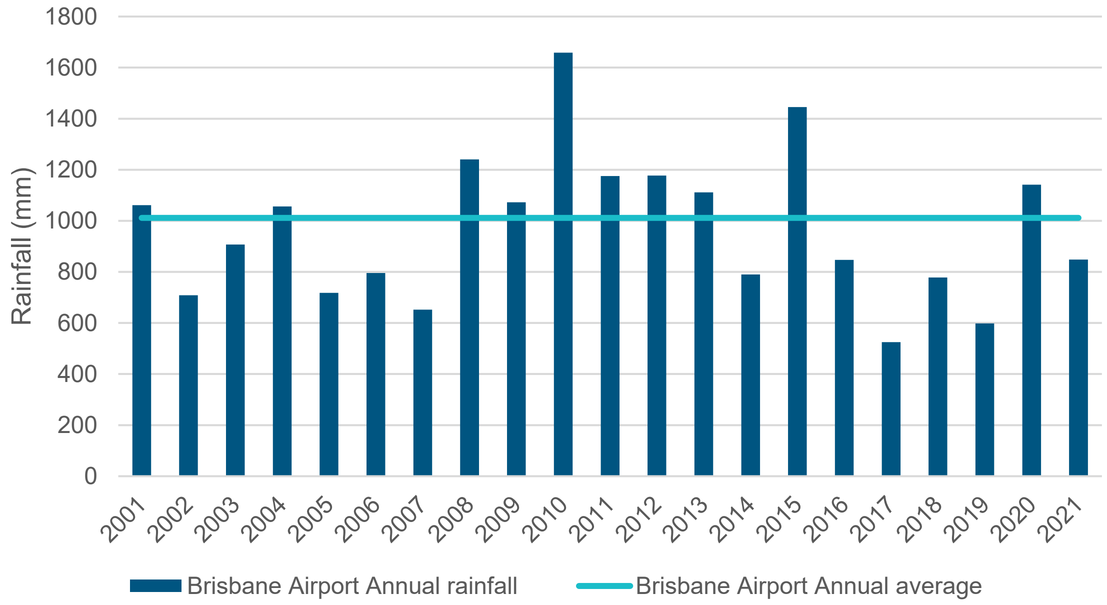


Figure 2-2 Annual rainfall from 2001 to 2020 and 2021 (to date) at Brisbane Airport (Source: BoM station: 040842)

2.2 Survey Vessel and Positioning

All sampling was carried out using the BMT research vessel 'Resolution II.' Location and navigation to sites was undertaken using a Garmin GPS.

2.3 Monitoring Locations, Sites and Approach

Monitoring locations for this survey were:

- Test and control locations as defined when the SMP was developed in 2002 (WBM Oceanics Australia 2002), namely Fisherman Islands (putative impact/test), Manly (control), Cleveland (control); and
- An addition control location was included in 2020 and 2021 (Deception Bay) to better define 'background' conditions in western Moreton Bay, north of the Brisbane River.

Since its development in 2002 the SMP has evolved from edge of bed monitoring to a systematic grid sampling approach. This has developed to utilise remote sensing advances and to allow the mapping of the extent and composition of both intertidal and subtidal seagrass meadows. The seagrass depth profile transects have been maintained to allow consistency in long-term comparisons.

The term 'sites' refers to individual transects at each location.

2.3.1 Ground-truthing

Field sampling was conducted using a systematic grid style sampling approach. 500 m survey grids were developed at each study area and are shown in Figure 2-3 (Fisherman Islands), Figure 2-4 (Manly), Figure 2-5 (Cleveland) and Figure 2-6 (Deception Bay).

At each point in the survey grids the following parameters were recorded: time, water depth (using the survey vessel's sounder), position (GPS), seagrass species present and macroalgae community composition (a video image was recorded at each point). The depth at each point was converted to Australian Height Datum to enable comparisons between locations.

Ground truthing data were then used along with remote sensing data to develop mapping of the extent and composition of seagrass meadows at Fisherman Islands (Figure 2-3).

2.3.2 Seagrass Depth Profiles

Seagrass depth profiles are used to monitor any variations in seagrass depth distribution and extent of seagrass species at each of the study locations. Depth profiles were originally monitored on a six-monthly basis throughout the FPE project but were unable to be completed in 2004 due to adverse weather conditions. Subsequent sampling has occurred in 2005, 2006, 2010, 2013, 2014, 2016, 2017, 2018, 2019 and 2020.

Two depth profile transects occur at each survey location and run approximately perpendicular to the shoreline (Figure 2-3 to Figure 2-6). At each point along the profile transect, the following parameters were recorded: time, water depth (using the survey vessel's sounder), position (GPS), seagrass species present and macroalgae community composition (a video image was recorded at each point). The depth at each point was converted to Australian Height Datum to enable comparisons between locations.

The alignments of the two Manly depth profiles were adjusted in May 2003 to ensure each profile extended beyond the outer edge of the seagrass meadows. These alignments end near Green Island, which acts as a natural barrier to seagrass distribution.

2.4 Data Analysis

2.4.1 Seagrass Assemblages

Seagrass assemblages were determined according to species composition within a meadow. A standard nomenclature system based on Carter and Rasheed (2016) was to assign the community types to each of the sampling sites (Table 2-1). Assemblages correspond with percent composition that each seagrass contributes to the meadow. Seagrass meadow landscape category (

Table 2-2) is a method established by James Cook University (see Carter *et. al.* 2015) for long-term monitoring of seagrass meadows over a large area. Nomenclature from Carter *et. al.* (2015) has been adopted, however in many instances' seagrass patches have been mapped at a scale of metres based on the field validation and high-resolution aerial imagery. Therefore, for the present survey some areas of "patchy" cover have been mapped as smaller isolated or aggregated patches with dense or continuous cover, as opposed to broader meadows with aggregated or isolated patches within the meadow boundaries.

Table 2-1 Nomenclature for seagrass community classes

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 C	Species A is <40%

Table 2-2 Seagrass meadow categories (Carter *et. al*. 2015)

Meadow landscape category	Description
Isolated seagrass patches	The majority of area within the meadows consisted of unvegetated sediment interspersed with isolated patches of seagrass
Aggregated seagrass patches	Meadows are comprised of numerous seagrass patches but still feature substantial gaps of unvegetated sediment within the meadow boundaries
Continuous seagrass cover	The majority of area within the meadows comprised of continuous seagrass cover interspersed with few gaps of unvegetated sediment

2.4.2 Seagrass Abundance

Consistent with previous monitoring, seagrass species at each survey site was assigned to abundance categories according to overall seagrass percent cover, as described in Figure 3-1 to Figure 3-3. In addition, groupings of overall seagrass cover were used to provide context to the broad community categories described in Section 2.4.1 (Table 2-3).

Table 2-3 Broad seagrass density categories

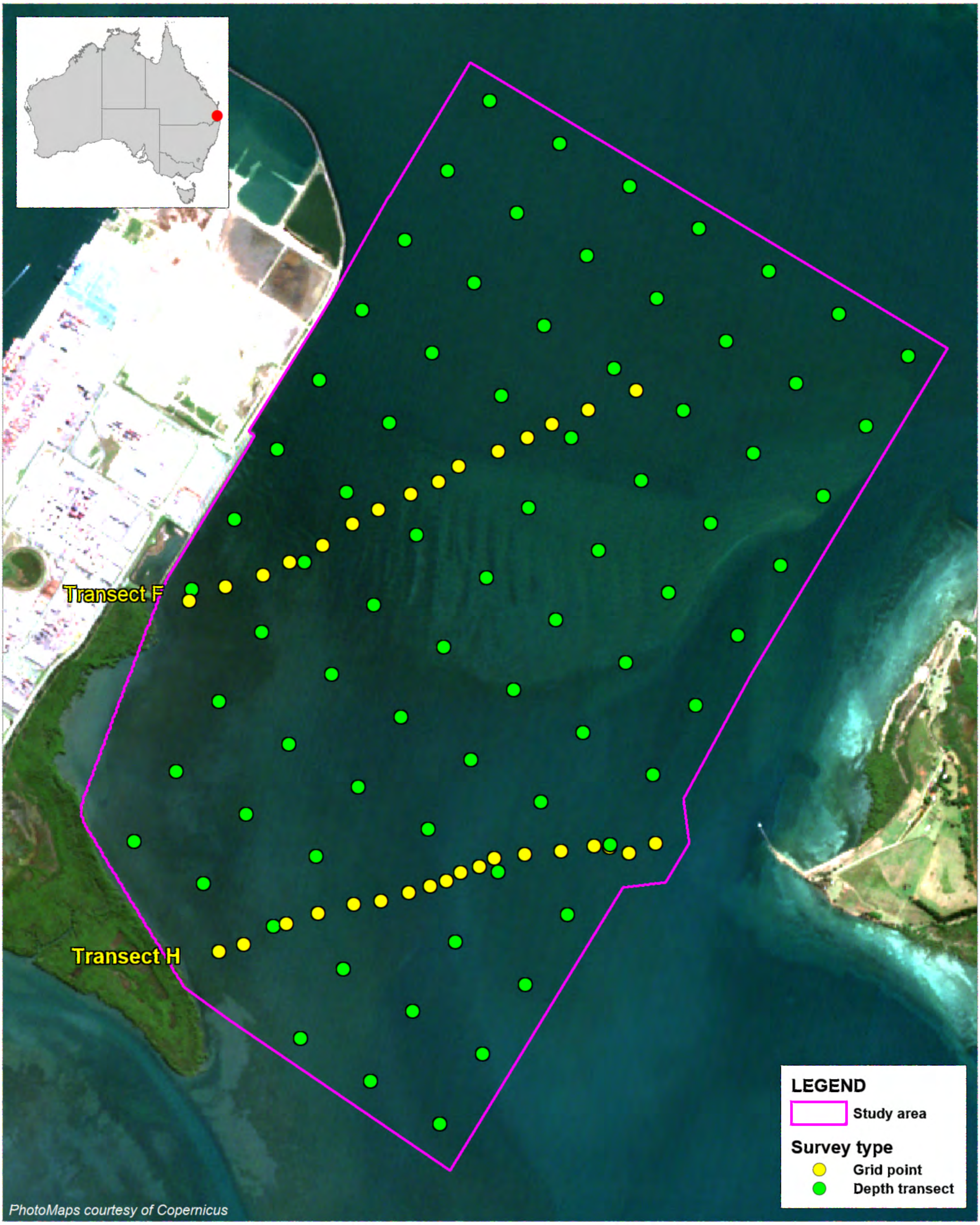
Density Category	Overall Cover (%)
Light	0-10%
Moderate	10-50%
Dense	>50%

2.4.3 Algae

Algae relative abundance was estimated for the following groups: (i) filamentous algae including epiphytic and turfing algae; and (ii) other macroalgae (non-filamentous). Abundant macroalgae species were documented.

2.5 Seagrass Meadow Extent Mapping

The extent of seagrass meadows was mapped adjacent to Fisherman Islands using a combination of remote sensing (aerial imagery) and field observations.



Title:

Survey points used to map the distribution of seagrass at Fisherman Islands, adjacent to the Port of Brisbane

Figure: 2-3

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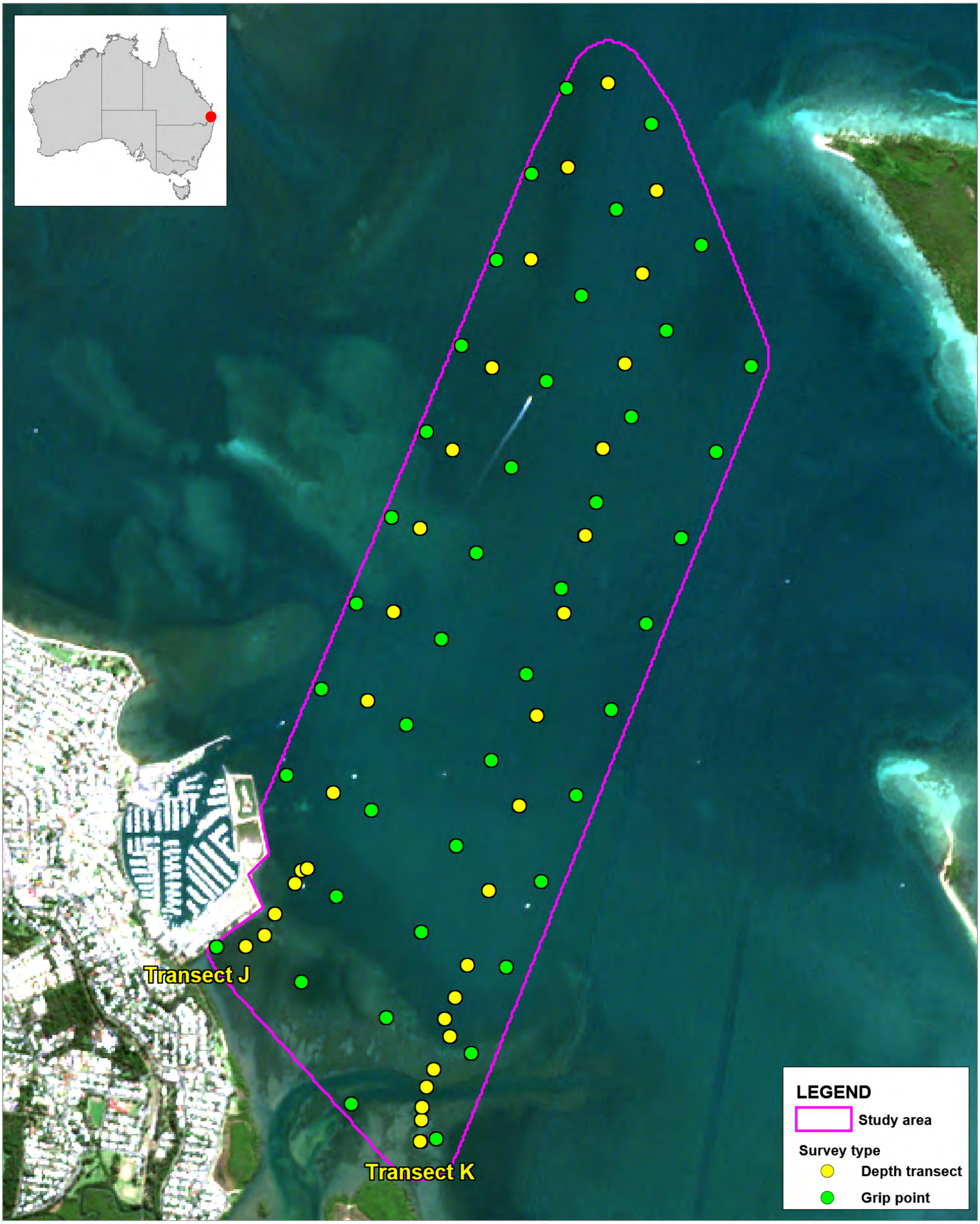

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Survey points used to map the distribution of seagrass adjacent to Manly

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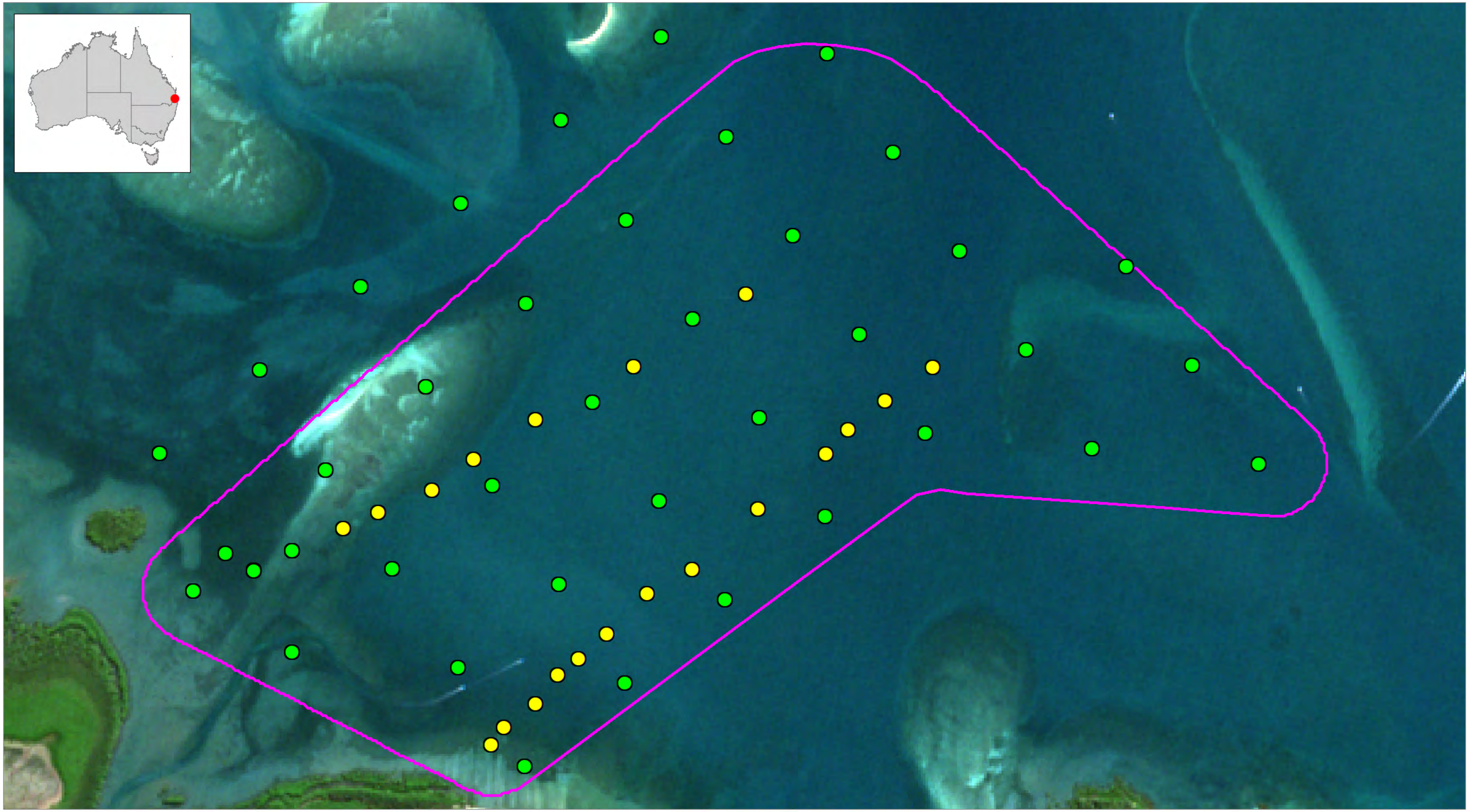

LEGEND

Study area

Grid points

Depth transects

Title:

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

Figure: **2-5**

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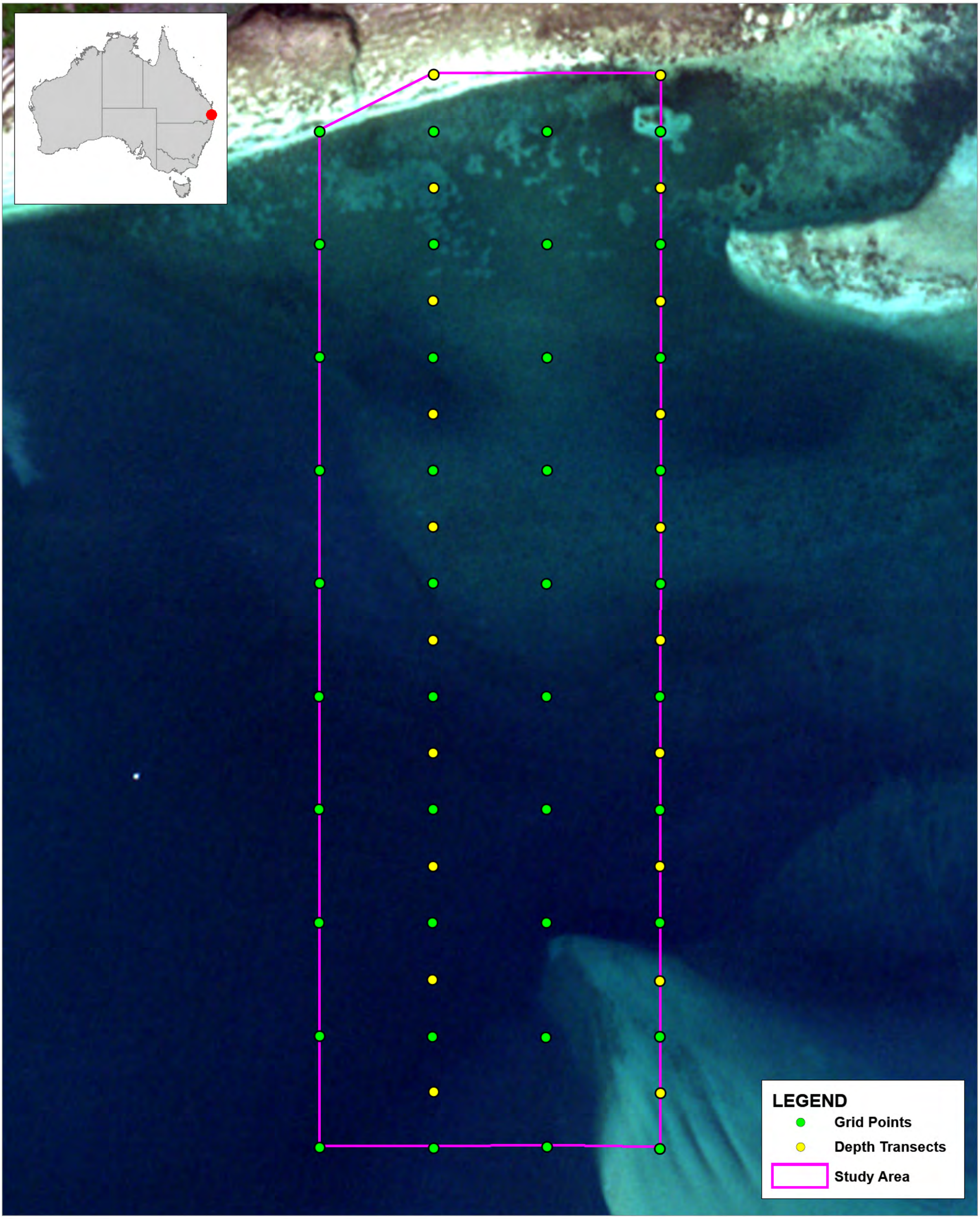

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Survey points used to map the distribution of seagrass in Deception Bay

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3 Results

3.1 Seagrass Spatial Distribution and Percentage Cover

Six of the eight seagrass species known to occur in Moreton Bay were recorded in the 2021 survey: *Zostera muelleri (*subsp. *capricorni), Halophila ovalis, Halophila spinulosa, Halophila decipiens, Halodule uninervis* and *Cymodocea serrulata*. *Cymodocea serrulata* has not previously been recorded in the SMP.

Maps showing the spatial distribution of each seagrass species in 2021 survey are shown in Figure 3-1 to Figure 3-4. Seagrass assemblage types at Fisherman Islands derived from survey data are shown in Figure 3-5.

The general pattern of assemblage structure across the depth zones was as follows (Figure 3-5):

- *Zostera muelleri* numerically dominated intertidal and shallow subtidal waters*;*
- *Halophila spinulosa* was numerically dominant or co-dominant in the intertidal - subtidal transitional zone;
- Subtidal areas were numerically dominated by sparse *H. ovalis* and *H. decipiens*.

In comparison to previous surveys there was a contraction of seaward *Halophila* meadows. The following describes trends in species distribution and cover.

3.1.1 Species Distribution

The findings from the 2021 survey were largely consistent with the 2020 survey, as follows:

- Seagrass was recorded at 75% of the Fisherman Island sites (*n* = 110), 81% of Manly sites (*n* = 75), 69% of Cleveland sites (*n* = 59) and 47% of Deception Bay sites (*n* = 60). The frequency of seagrass detections in 2020 was 75%, 85%, 81% and 50% of the sites at Fisherman Islands, Manly, Cleveland and Deception Bay respectively. A chi-square test of independence was performed to examine the relation between seagrass detections at each location (Fisherman Islands, Manly, Cleveland, Deception Bay) and year (2020, 2021). The relationship between these variables was not significant (χ^2=0.51, df=3, p=0.92). This suggests that seagrass detections at each location did not vary over time.
- *Halophila spinulosa* was the most frequently recorded species in 2021, which was consistent with the 2020 results (Table 3-1).
- *Halodule uninervis* was recorded at 7% of Fisherman Island sites in 2021, and not recorded in 2020. This species also had low to moderate cover at Deception Bay.
- *Zostera muelleri* dominated meadows were mainly located within the intertidal zone, extending from above LAT at the landward edge into shallow subtidal areas (-3.6 m LAT). Intertidal meadows were compromised of mixed meadows of all four present species. Mixed meadows of *Halophila* were more common within subtidal areas.
- Isolated patches of *H. ovalis* and *H. decipiens* were recorded on exposed sandy shoals. The frequency of *Halophila* detections showed no consistent trends between 2020 and 2021.

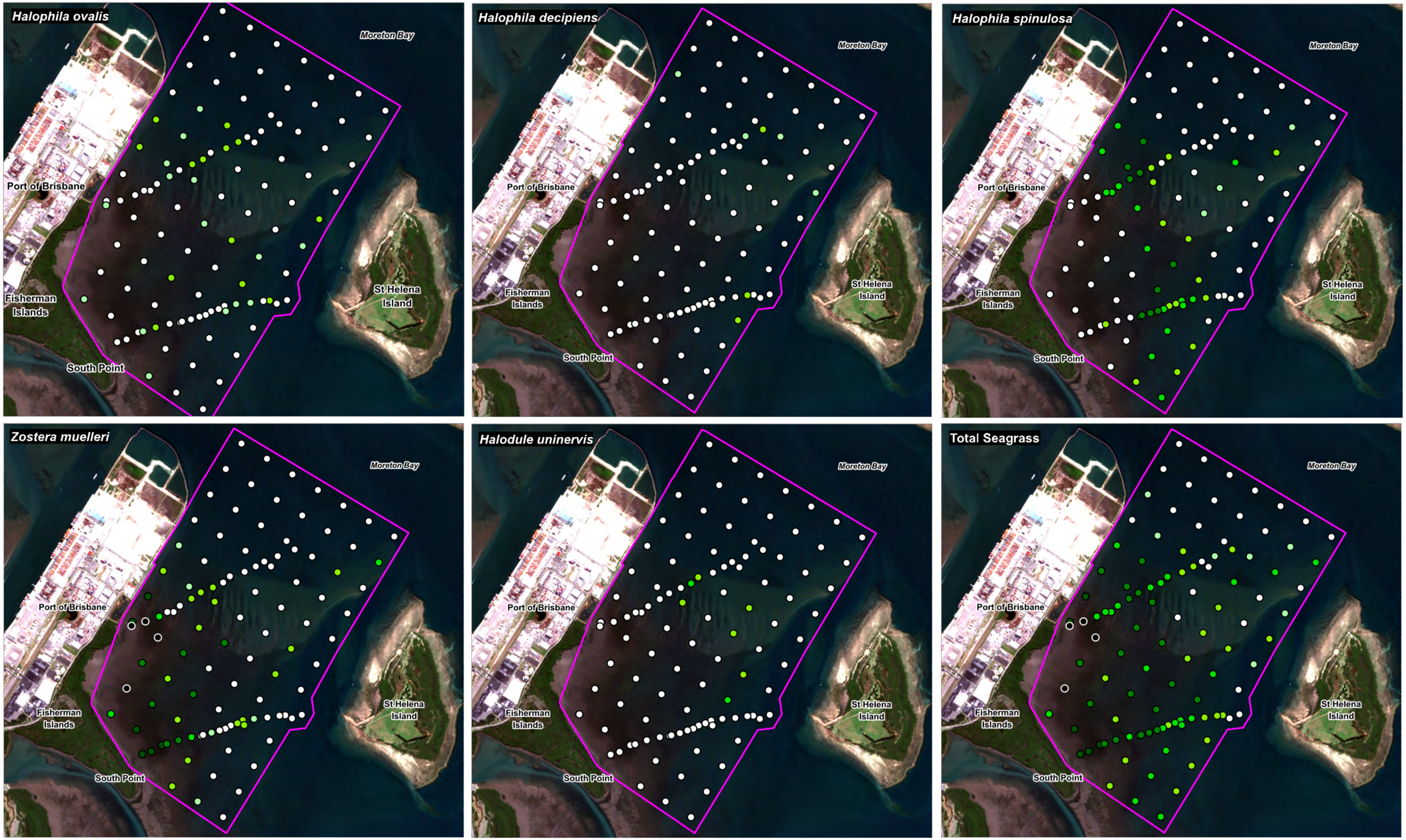
- The frequency of *H. spinulosa* detections at Fisherman Islands between 2020 and 2021, but increased at Manly and Cleveland (Table 3-1).
- Macroalgae coverage generally decreased at all sites, and were numerically dominated by a range of species algae.

Table 3-1 Seagrass presence at study sites (%)

Site	Species	No. of sites (%) 2019	No. of sites (%) 2020	No. of sites (%) 2021	Trend 2020-21
Fisherman Islands	*H. decipiens*	24	13	6	↓
	H. ovalis	36	27	25	↓
	H. spinulosa	53	42	39	↔
	H. uninervis	20	-	7	↑
	Z. muelleri	40	46	38	↓
	C. serrulata	-	-	1	↑
Manly	*H. decipiens*	14	6	24	↑
	H. ovalis	34	11	23	↑
	H. spinulosa	51	49	56	↑
	Z. muelleri	17	16	20	↑
Cleveland	*H. decipiens*	21	21	17	↓
	H. ovalis	23	-	2	↑
	H. spinulosa	29	30	51	↑
	Z. muelleri	14	9	12	↑
Deception Bay	*H. decipiens*	-	-	8	↑
	H. ovalis	-	32	18	↓
	H. spinulosa	-	3	18	↑
	Z. muelleri	-	25	18	↓
	H. uninervis	-	10	30	↑

3.1.2 Seagrass Cover

Temporal patterns in seagrass cover varied among species and locations. The main trend of seagrass cover was a decrease in contraction of seaward areas (Figure 3-6).



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Seagrass Cover (%)
- 75 to 100
- 50 to 75
- 25 to 50
- 15 to 25
- 5 to 15
- 1 to 5
- 0 to 1

Study Area

Title:

Species Distribution at Fisherman Islands, Adjacent to the Port of Brisbane 2021

Figure: 3-1

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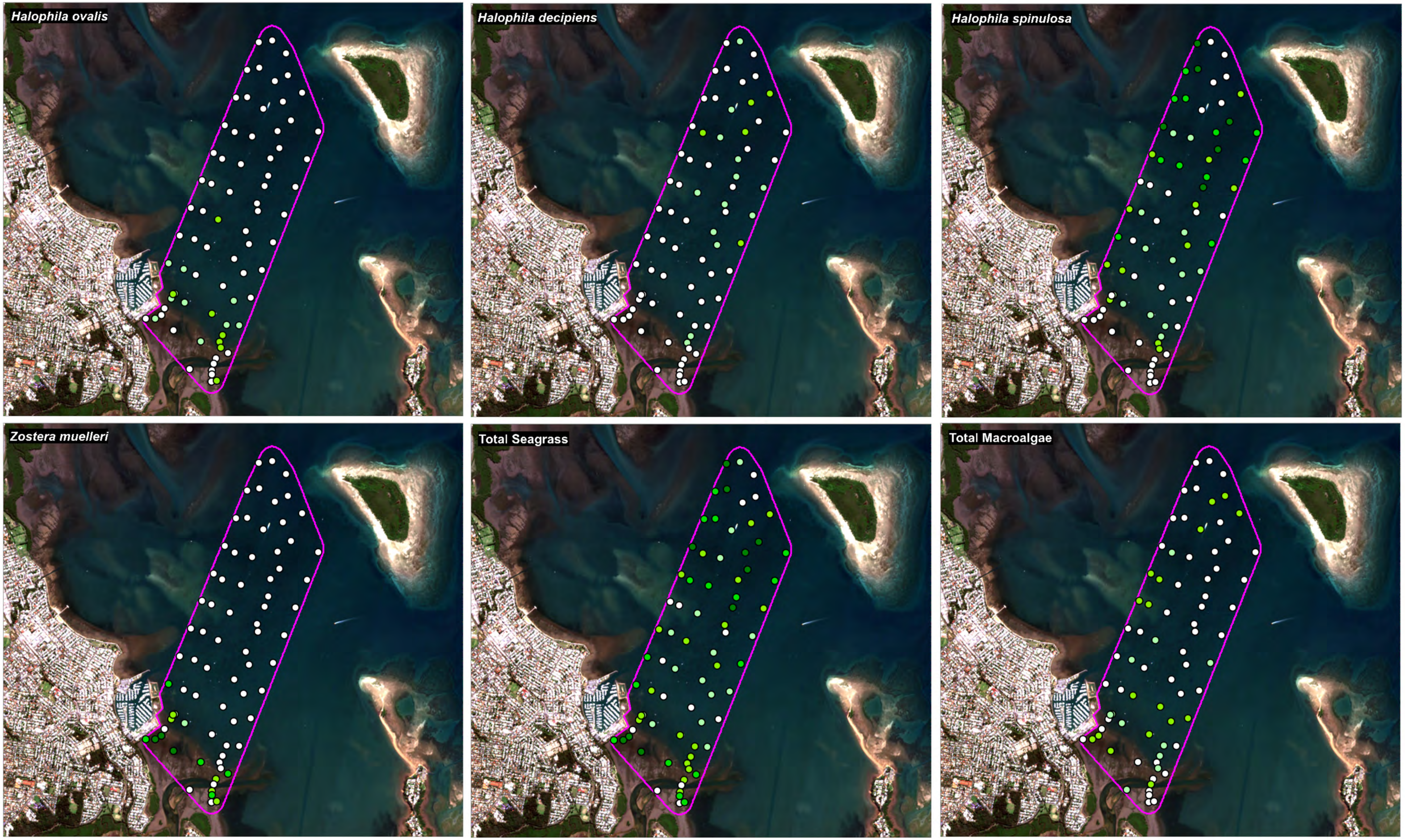

LEGEND

Seagrass Cover (%)

- 75 to 100
- 50 to 75
- 25 to 50
- 15 to 25
- 5 to 15
- 1 to 5
- 0 to 1

Study Area

Title:

Species Distribution at Manly, in Moreton Bay 2021

Figure: 3-2

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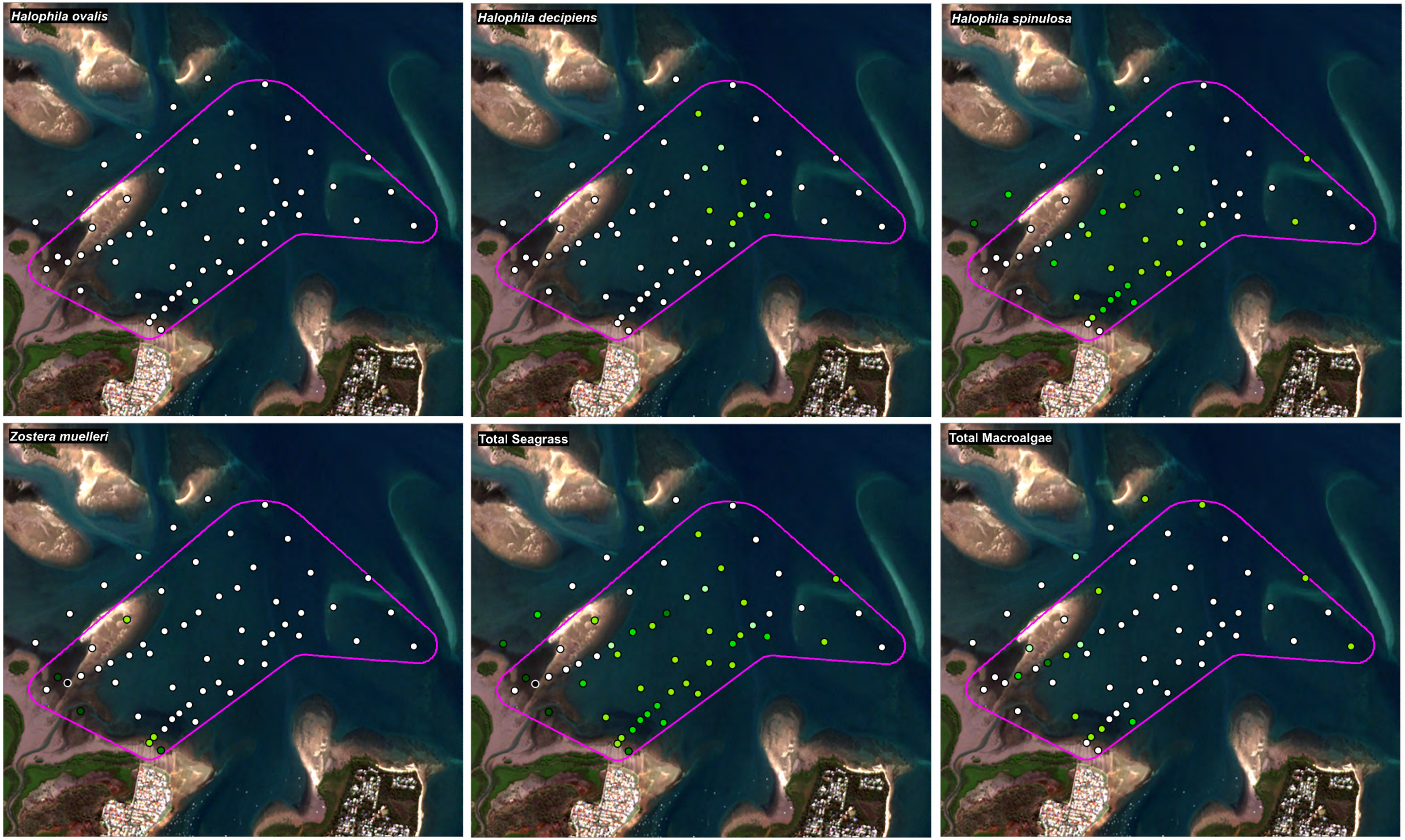

LEGEND

Seagrass Cover (%)

●	75 to 100
●	50 to 75
●	25 to 50
●	15 to 25
●	5 to 15
●	1 to 5
○	0 to 1

Study Area

Title:

Species Distribution at Cleveland, in Moreton Bay 2021

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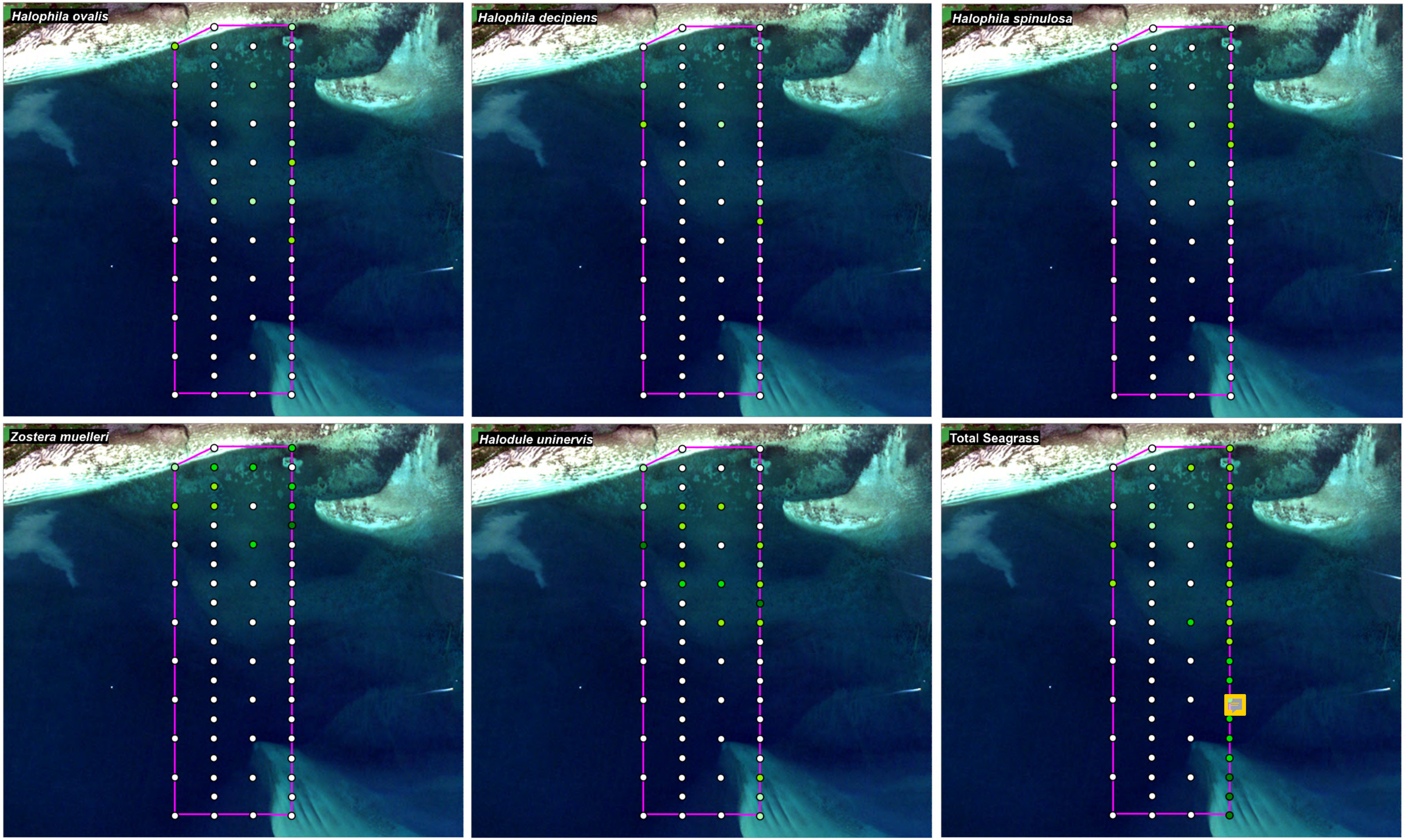

LEGEND

Percent Cover

- 75 to 100
- 50 to 75
- 25 to 50
- 15 to 25
- 5 to 15
- 1 to 5
- 0 to 1

Study Area

Title:

Species Distribution at Deception Bay 2021

Figure: 3-4

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 1 2km

Approx. scale

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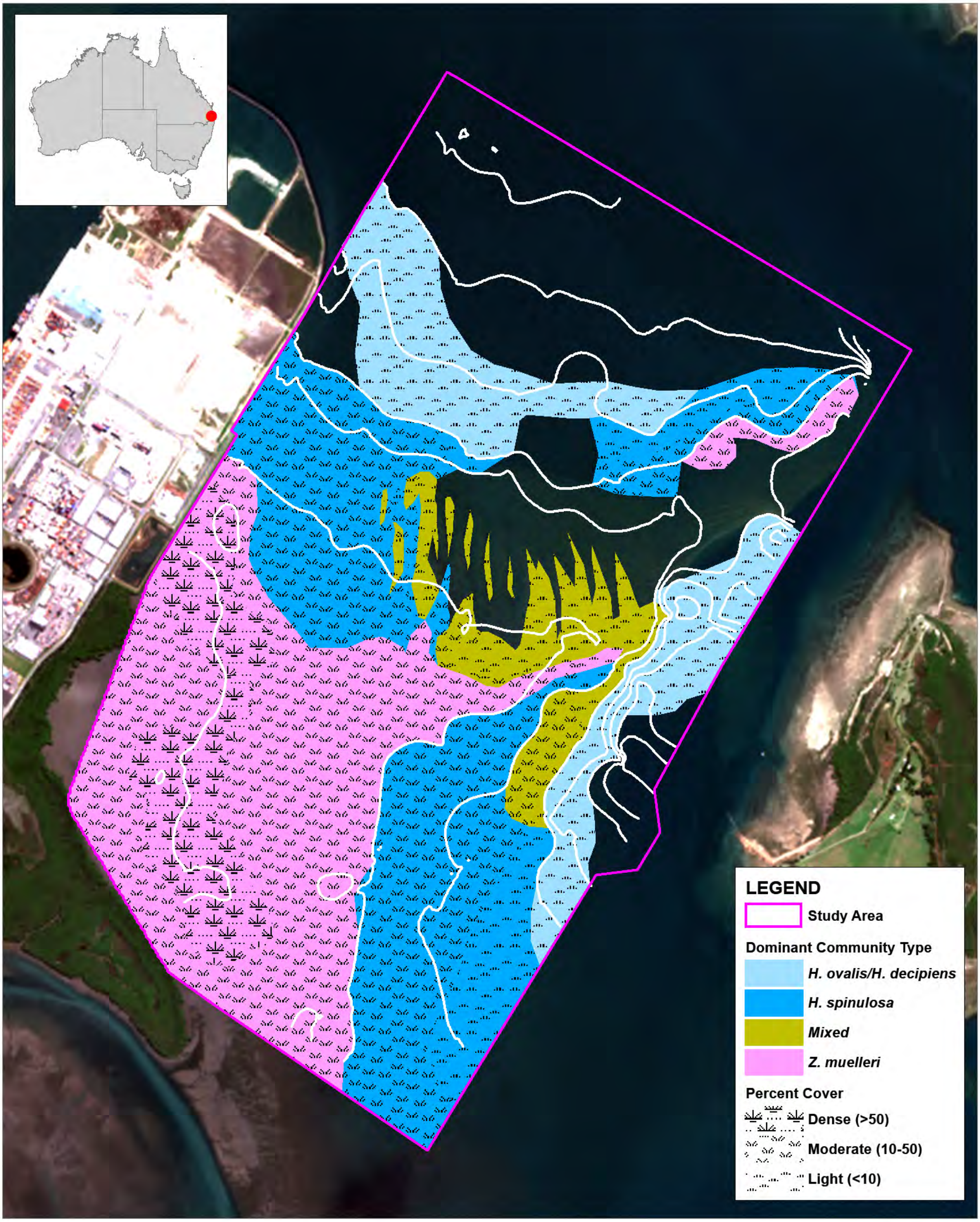

Title:

Seagrass Distribution and Composition Adjacent to Fisherman Islands 2021, Showing 1m LAT Contours

Figure: 3-5

Rev: A

N

0 0.5 1km

Approx. scale

BMT

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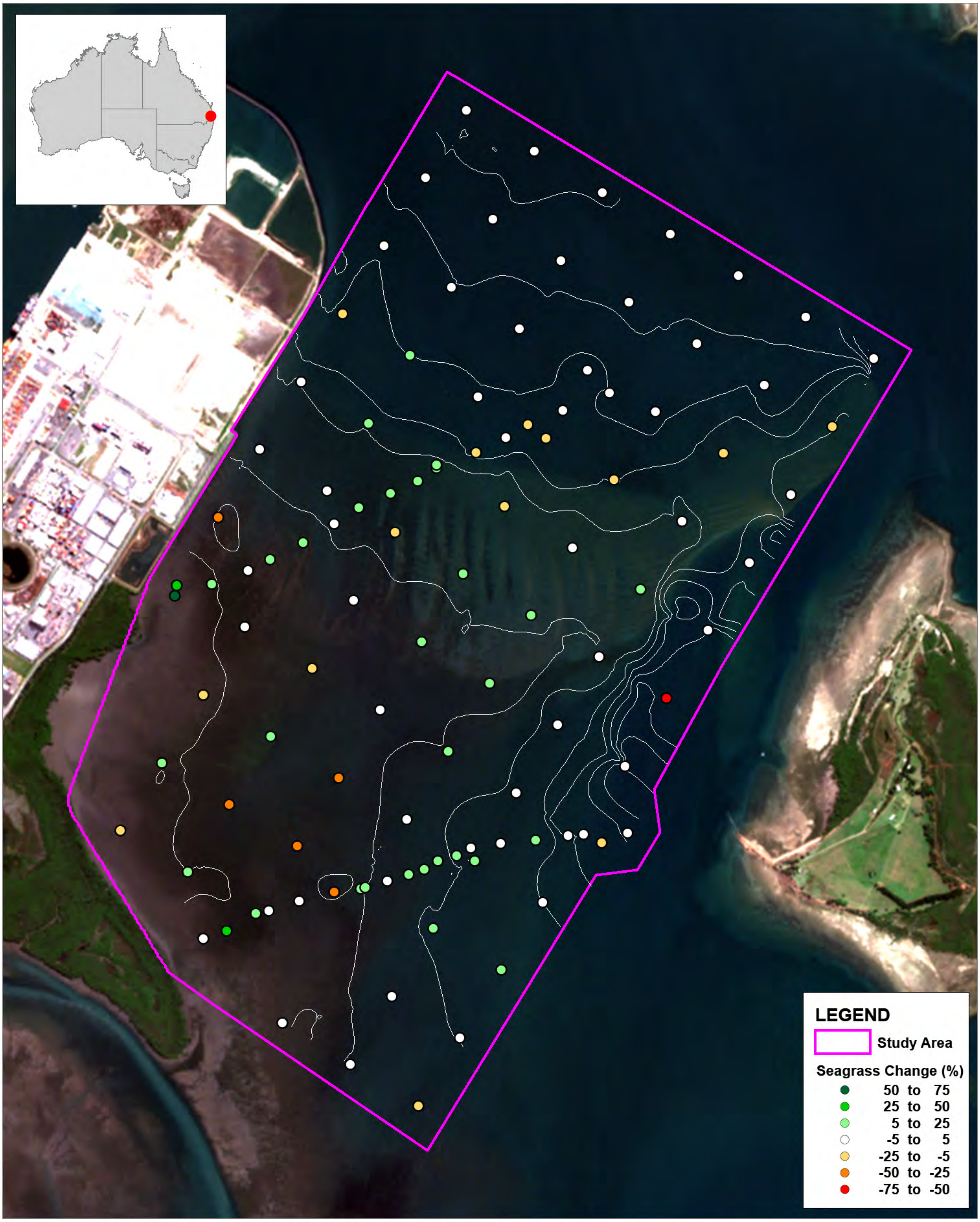

Title:

Changes in Total Seagrass Cover Between 2020 and 2021, Fisherman Islands

Figure: 3-6

Rev: A

N

0 0.5 1km
Approx. scale

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Filepath: I:\B23621.PoB Monitoring 2019-25\DRG\2021_Seagrass\ECO_005_210726_PoB_Change.WOR

3.2 Seagrass Depth Range (SDR) and Assemblage Structure

Table 3-2 presents the maximum recorded depths of seagrass species (seagrass depth range – SDR) on depth transects in the period 2006 to present, along with a rating based on the SDR for each period relative to the historical maximum recorded SDR. The mean and coefficient of variation (CoV) is also displayed. Note that as *H. ovalis* and *H. decipiens* were grouped together prior to 2013, the SDR rating for these species is based on the maximum value recorded SDR for either of these species.

Seagrass assemblage composition and percent cover for the depth transects is shown in Figure 3-7 for Fisherman Islands, Cleveland and Manly and Figure 3-8 for Deception Bay. The majority of the sites have a percent cover between the historical minimum and maximum.

Figure 3-7 Percent cover distribution across depth transects at Fisherman Islands (H & F), Cleveland (P & Q) and Manly (J & K)

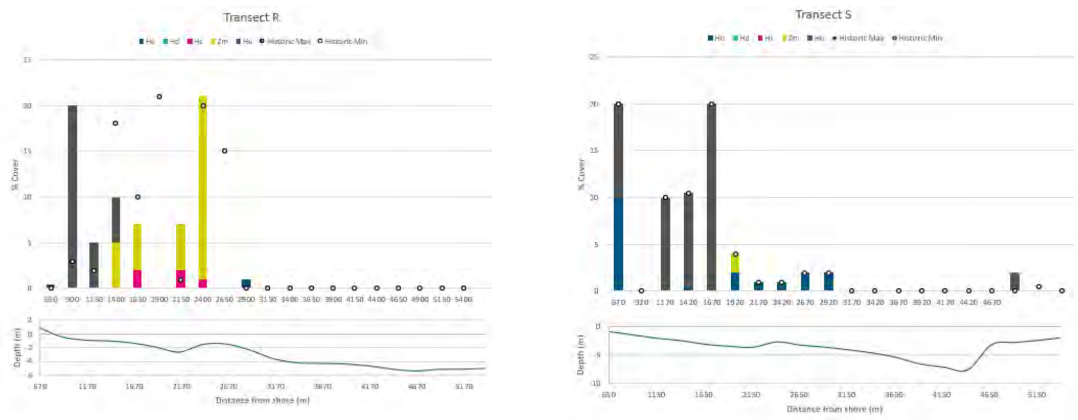


Figure 3-8 Percent cover distribution across depth transects at Deception Bay (R & S)

3.2.1 Spatial Patterns in 2021

Key patterns in seagrass composition and distribution along depth transects are as follows:

- *Zostera muelleri* was observed at all locations, with the maximum depths at Fisherman Islands, Cleveland, Manly and Deception Bay of –3.1 m, -1.6 m, -2.6 m and -3.3 m (AHD) respectfully. At Fisherman Islands, Manly, Cleveland and Deception Bay, average cover was highest within intertidal meadows (above LAT) than subtidal meadows (below LAT). The greatest depth recorded for *Z. muelleri* was -3.3 m AHD at Deception Bay. *Z. muelleri* formed mono-specific meadows or mixed assemblages with *H. spinulosa*.
- *Halodule uninervis* was recorded at a small number of Fisherman Islands sites and at Deception Bay. Previously it has also been observed at both Cleveland and Fisherman Islands predominately between -1 m and -2 m LAT in mixed communities at low cover.
- *Halophila spinulosa* was observed at moderate densities at all locations with a maximum depth of -5 m, -4.6 m, -5.4 m and -4.5 m AHD at Fisherman Islands, Cleveland, Manly and Deception Bay respectively. This species was present at a variety of depths and community compositions, found predominately between -1 m and -4 m AHD.
- *Halophila ovalis* was present at all sites in a range of depths and formed predominately mixed communities with *Z. muelleri* and *H. spinulosa*. The depths that had *H. ovalis* present were: -0.3 m to -5.8 m, 0 m to -4.2 m, -3 m, -0.6 m to -5.2 m AHD at Fisherman Islands, Manly, Cleveland and Deception Bay respectively. The highest densities were generally found between -1 m and -3 m AHD.
- *Halophila decipiens* was observed at all locations and the maximum depth range was -5.1 m, -5.5 m, -5.4 m and -4.6 m AHD at Fisherman Islands, Manly, Cleveland and Deception Bay respectively. *H. decipiens* generally occurred between -3 m and -4 m AHD. The coverage was predominately sparse to moderate and was generally either in monospecific stands or mixed communities with *H. spinulosa*.

3.2.1.1 Temporal Patterns

Table 3-2 shows SDR values for each species over time on permanent transects. *Zostera muelleri* SDR, a key indicator of long-term patterns in water quality, showed complex spatial and temporal patterns. Figure 3-9 shows that:

- - Fisherman Islands had the highest *Zostera muelleri* SDR values.
- The SDR on Transect H has been variable through time with 2010, 2014-2017 and 2020 having the highest values. Between 2020 to 2021 there was a slight increase in SDR, with the control sites staying stable.
- The SDR on Transect F was variable between 2006 and 2018 but has remained relatively stable in 2019 and 2020 before slightly increasing in 2021, with the control sites staying stable.

Table 3-2 shows that:

- *Halophila ovalis/decipens* – Manly tended to have the lowest SDR values
- *Halophila spinulosa* – Cleveland had the highest number of non-detects. Where detected, Fisherman Islands (Transect F) had the lowest SDR values

Pearson Product-Moment correlation analysis was undertaken to assess potential associations between antecedent 12 month rainfall and periods of potential low seagrass condition (SDR non-detects/bottom 20% of historical values). There was no significant correlation between the frequency of SDR non-detects/lowest 20% of historical values and antecedent rainfall r = 0.17, p >0.1).

3.2.1.2 SDR Water Quality Objective

The *Z. muelleri* SDR water quality objective (WQO) for Waterloo Bay (Figure 3-9) was used as a benchmark[2] to assess seagrass condition. Compliance with the WQO varied over time and at a variety of spatial scales. Transects that met the WQO were (Table 3-2):

- Fisherman Islands Transect H (2010, 2014, 2016-18, 2020 and 2021) and F (2006, 2010, 2019, 2020, 2021);
- Manly Transect J (2006, 2010, 2016, 2018, 2019, 2020 and 2021) and K (2006, 2010, 2014, 2016, 2017, 2019 and 2020);
- Cleveland Transect P (2019); and
- Deception Bay Transect R (2020 and 2021) and Transect S (2020 and 2021).

In 2021 the SDR met WQO less frequently than the 2020 survey.

[2] the WQO was derived based on the median value using reference site data. While the WQO applies only to High Ecological Value waters in the State Protection Policy, it has been adopted here as a general benchmark of seagrass condition

Table 3-2 Comparison of SDRs (maximum recorded depth m AHD) of seagrass on permanent transects at each location from 2006 to 2021

Species*	Location	Transect	2006	2010	2013	2014	2016	2017	2018	2019	2020	2021	Mean	CoV
Zm	Fisherman Island	F	-2	-2.5	-1.8	-1.7	-1.6	-1.7	-1.4	-2.1	-2	-2.2	-1.9	-17
		H	-1.3	-2.3	-1.5	-2.4	-2.4	-2.5	-2.2	-1.7	-2.3	-2.7	-2.1	-22
	Manly	J	-2.2	-2.3	-1.6	-1.5	-2.1	-1.6	-2.1	-1.9	-2.1	-2.4	-2.0	-16
		K	-2.1	-2.2	-0.4	-2.1	-2.2	-2	-0.7	-3.3	-2.1	-0.7	-1.8	-51
	Cleveland	P	-1.3	-0.8	-0.6	-0.7	-0.7	-0.9	-1.7	-1.9	-0.5	-1.1	-1.0	-47
		Q	-0.6	-1.5	-1.8	-1.4	-1	-1.4	-1.2	-1.8	-1.2	-1.7	-1.4	-28
	Deception Bay	R	-	-	-	-	-	-	-	-	-3.8	-2.8	-3.3	-21
		S	-	-	-	-	-	-	-	-	-3.3	-3.3	-3.3	0
Ho	Fisherman Island	F	-3.8	-5.7	-2.2	-2	-1.8	-4.7	-1.6	-5.1	-1.9	-4.2	-3.3	-48
		H	-2.6	-4.6	-2.5	-2.4	-2.4	-5.5	-2.2	-4.4	-1.2	-3.2	-3.1	-43
	Manly	J	-2.2	-4.9	-4.5	-2	-2.1	-2.9	-2.1	-3.3	-2.1	-2.8	-2.9	-36
		K	-0.4	-8.8	-5	-2.1	-2.2	-2.4	-1.8	-7.9	-2.5	-2.9	-3.6	-76
	Cleveland	P	-5.9	-6.4	-6.2	-4.8	-3.6	-3.3	-2.1	-3.6	Absent	Absent	-4.5	-35
		Q	-5.7	-6.2	-5.7	-2.7	-2.5	-5	-2.4	-2.8	-2.5	Absent	-3.9	-42
	Deception Bay	R	-	-	-	-	-	-	-	-	-4.2	-0.8	-2.5	-96
		S	-	-	-	-	-	-	-	-	-3.8	-4.0	-3.9	-4
Hd	Fisherman Island	F	-3.8	-5.7	Absent	-4	-4.1	-4.3	-4.1	-4.2	-4	-4.6	-4.3	-13
		H	Absent	Absent	-2.9	-5.1	-5	Absent	-7.2	Absent	-5.4	-3.7	-4.9	-30
	Manly	J	-2.2	-4.9	-4.5	-4.4	-3.5	-4.8	-4.5	Absent	Absent	-3.6	-4.1	-22
		K	-0.4	-8.8	-5	-3.7	-4	-5.3	-7.7	-4.1	-5	-2.7	-4.7	-51
	Cleveland	P	-5.9	-6.4	-5.1	-6.4	Absent	Absent	-4.4	Absent	-3.4	-4.0	-5.1	-23
		Q	-5.7	-6.2	-4.6	-4.6	-5.9	Absent	-5.6	-5.8	-5.7	-5.1	-5.5	-10
	Deception Bay	R	-	-	-	-	-	-	-	-	Absent	Absent		
		S	-	-	-	-	-	-	-	-	Absent	-4.6	-4.6	
Hs	Fisherman Island	F	-3.8	-4.3	-2.2	-1.6	-1.8	-3.8	-2.0	-5.1	-2	-2.5	-2.9	-42
		H	-2.5	-2.3	-2.5	-2.4	-3	-2.5	-3.9	-4.7	-2.8	-3.2	-3.0	-26
	Manly	J	-2.6	-4	-3.4	-3.4	-4.1	-3.4	-4.5	-4.8	-2.1	-4.3	-3.7	-23
		K	Absent	-4.4	-4	-3.9	-2.2	-2.3	-3.9	-8	-3.8	-5.5	-4.2	-41
	Cleveland	P	Absent	-3.4	-3.5	-4.8	Absent	-0.9	Absent	-3.1	-3.4	-4.0	-3.3	-36
		Q	-3.2	Absent	-3.7	-4	-2.9	-3.3	-2.6	-3.1	-3.5	-3.8	-3.4	-14
	Deception Bay	R	-	-	-	-	-	-	-	-	Absent	Absent		
		S	-	-	-	-	-	-	-	-	Absent	-4.0	-4.0	
Hu		F	Absent	Absent	Absent	Absent	Absent	Absent	-2.0	-1.6	Absent	-2.5	-2.0	-23

Species*	Location	Transect	2006	2010	2013	2014	2016	2017	2018	2019	2020	2021	Mean	CoV
	Fisherman Island	H	Absent	Absent	Absent	Absent	Absent	Absent	Absent	-2.8	Absent	Absent	-2.8	
	Deception Bay	R	-	-	-	-	-	-	-	-	-3.2	-4.5	-3.9	-24
		S	-	-	-	-	-	-	-	-	-3.6	-4.0	-3.8	-7
Rainfall (12months before the survey)			823.6	864.6	1317.5	548.4	689.5	952.2	848.8	572.2	1053	1138.6		

SDR relative to historical maximum:

Max	99-80% max	79-50% max	49-20% max	<20% max	Absent

Trend since 2019: ↑ improvement, ↔ stable (within 0.1 m of 2019), ↓ decline

* Ho *Halophila ovalis*, Hd *Halophila decipiens*, Hs *Halophila spinulosa*, Zm *Zostera muelleri*. Note video transects in 2006-10 did not provide sufficiently detailed imagery to discern *H. ovalis* and *H. decipiens species.*

Red text – SDR does not achieve the SDR WQO for HEV waters in Waterloo Bay of -1.9m AHD (generic benchmark for the purpose of this study)

1 – Rainfall data sourced from BoM station 040913 (Brisbane)

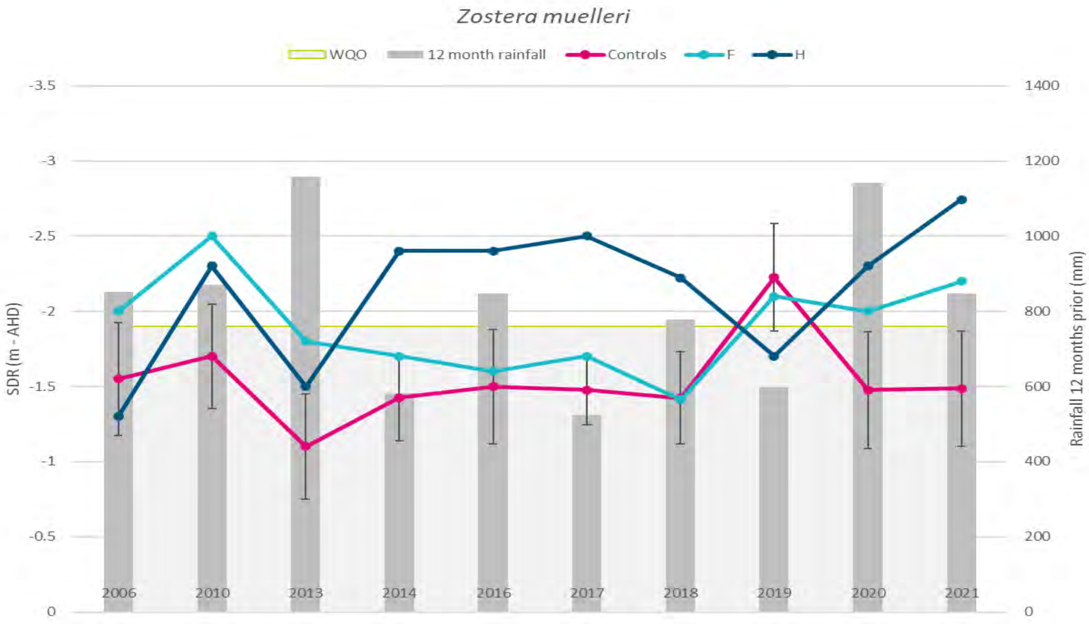


Figure 3-9 ***Zostera muelleri*** **seagrass depth range for Transect F and H at Fisherman Islands and the average (±SE) for control sites. Rainfall in the 12 months leading to the survey is also shown (BoM station number 040913 – Brisbane)**

4 Discussion

4.1 Overview

The SMP demonstrates that seagrass meadows at Fisherman Islands and western Moreton Bay had the following ecological characteristics:

(1) Meadows are numerically dominated by a core set of widely distributed tropical and tropical-temperate species. Tropical vagrants occur from time to time but are uncommon.

(2) All species have adaptations that allow rapid recovery following disturbance (Kilminster *et al*. 2015).

(3) *Zostera muelleri* is restricted to shallow waters (<2 m below LAT), forming dense meadows that are comparatively stable over time in subtidal waters, but more dynamic near the landward margin.

(4) Sparse *Halophila* species meadows extend to depths down to -8 m below LAT and show great variability in assemblage structure among years.

(5) Seagrass meadows show cyclic changes in extent in response to flood-drought cycles. There has been a long-term expansion in overall seagrass meadow extent at Fisherman Islands (Figure 4-1).

These are described in the following section.

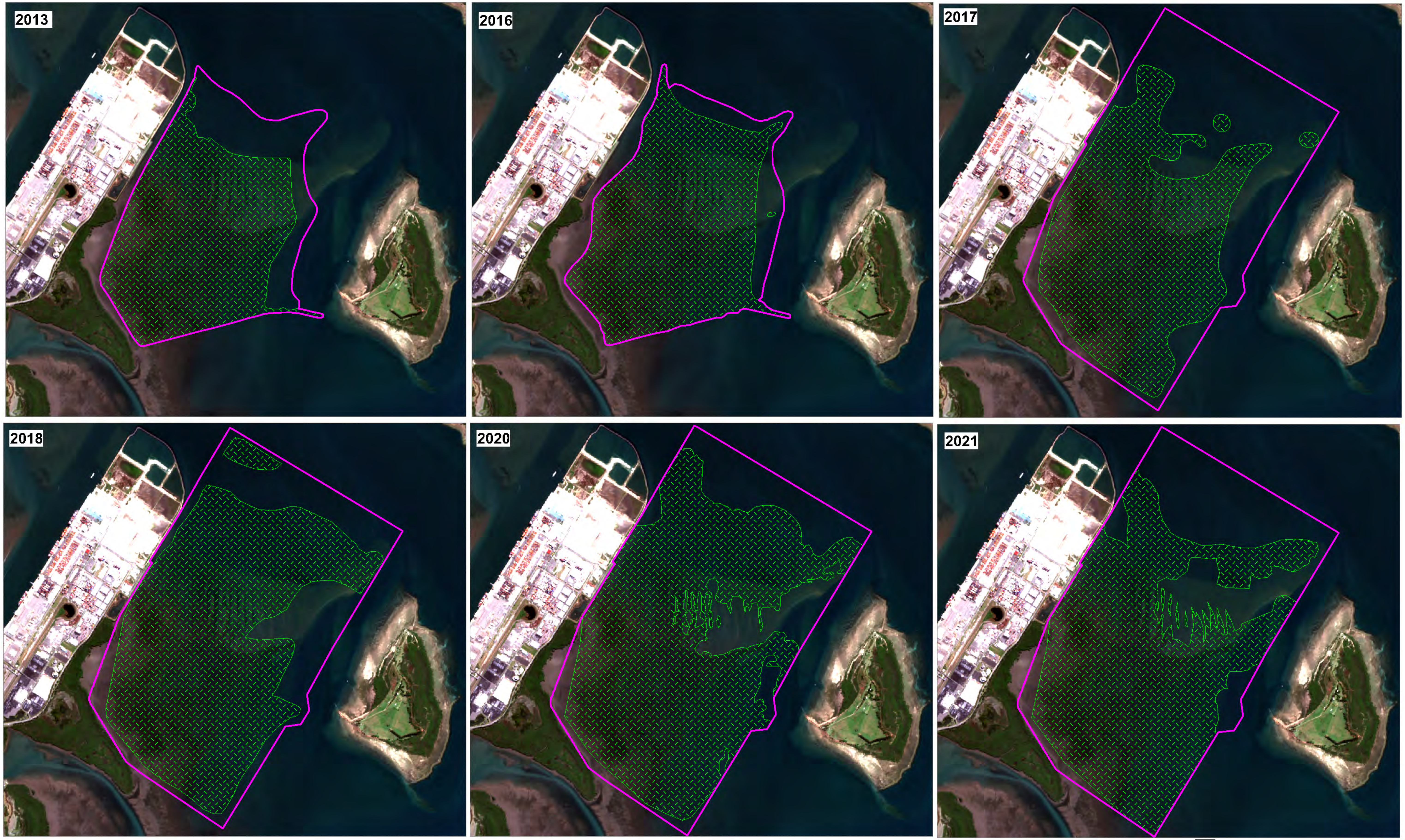
4.2 Species Composition

Eight seagrass species have been reported within Moreton Bay (Young and Kirkman 1975; Hyland *et al.*1989, Davie 2011): *Zostera muelleri (subsp. capricorni), Halophila ovalis, Halophila decipiens, Halophila spinulosa, Halodule uninervis, Cymodocea serrulata, Syringodium isoetifolium* and *Halophila minor.*

Syringodium isoetifolium and *Halophila minor* have not been recorded in the Port of Brisbane SMP. Moreton Bay is the southern-most distribution limit of *S. isoetifolium*, *H. uninervis*, *H. spinulosa C. serrulata* and *H. minor* (Kirkman, 1997). *Halophila minor* was detected in the Broadwater, Gold Coast in 2006 by GHD and is considered uncommon, possibly having a similar disjunct geographical distribution as *C. serrulata* and *S. isoetifolium* (Davie and Phillips 2008). *Cymodocea serrulata*, which was recorded at Fisherman Island in the present study. This species has not previously been recorded in the SMP, but it is known to occur in eastern Moreton Bay.

4.3 Spatial and Temporal Patterns in Assemblages

Overall, seagrass meadows at Fisherman Islands slightly decreased in extent between 2020 and 2021 by 1.2 km^2 to 12.8 km^2 in 2021. This range reduction was seen in the loss of sparse *Halophila* in a few of the deeper study sites. This is different to the trends observed in previous years of a long-term seagrass meadow expansion at this location (Figure 4-1), notwithstanding changes to study area boundaries and survey methodologies over time. Seagrass meadow extent mapping is limited by both the grid spacing and ability to detect sparse seagrass communities in deep water.



LEGEND

Study Area

Seagrass Meadow Extent

Title:

Seagrass Meadow Extent between 2013-21

Figure:

4-1

Rev:

A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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0 1 2km

Approx.Scale

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4.3.1 *Halophila*

In 2021, there was a slight increase *H. ovalis* extent in the deeper extents and a slight contraction of *H. spinulosa* at Fisherman Islands. While *H. spinulosa, H. ovalis* and *H. decipiens* remained relatively stable at Manly and Cleveland. At Deception Bay *H. spinulosa* expanded and *H ovalis* contracted and *H. decipiens* was noted which was not present in 2020. At Fisherman Islands, there was a contraction of *H. decipiens.*

Halophila species are among the least tolerant species of seagrass to reductions in light availability, with declines occurring during sustained wind events and sediment re-suspension, events which are common in western Moreton Bay. These species are also primary colonisers that can rapidly colonise deep water areas during extended periods of clear water, or high light availability (Longstaff *et al.*1999).

There was also a high degree of small-scale heterogeneity in the distribution of different *Halophila* species (i.e. differences among transects within locations). Several processes can interact to control small-scale heterogeneity in seagrass meadows, most notably biological interactions including competition for space with other seagrass species and macroalgae, and grazing (by dugongs and green turtles). Differences in TSS concentrations (and light availability) can also occur among transects, varying in response to proximity to channels and sand banks.

4.3.2 *Halodule*

Halodule uninervis was not recorded in the 2020 SMP, but was recorded in 2021 SMP at:

- Fisherman Islands - eight sites, ~10 % cover. All sites were located between 1 m to 3 m depth.
- Deception Bay - 18 sites, ~10 % cover, 1.1 m to 4.4 m depth.

Halodule uninervis, like *H. ovalis*, is an ephemeral, pioneer species that grows rapidly and survives well in unstable or depositional environments (Carruthers *et al.* 2002). This species has adaptations that enable it to grow in the intertidal zone (Waycott *et al.* 2004) and unstable subtidal shoals, as occurs in the study area. As *Halodule* has a similar growth form to *Z. muelleri*, it is possible that this species may go undetected due to misidentified when viewed *in situ* via underwater camera (a sample is generally needed to confirm identification).

Several drivers control *H. uninervis* growth and recruitment, including:

- Seasonality - In tropical environments *H. uninervis* exhibits strong seasonality, with a minima occurring in August to September (Lanyon *et al.* 2004). Seasonal patterns in *H. uninervis* abundance in Moreton Bay are undefined. Assuming seasonal patterns in the local population are similar to those in tropical environments, the SMP (July-August) would occur around the time of the *H. uninervis* seasonal minima.
- Temperature, light and exposure - *H. uninervis* abundance is sensitive to a range of stressors, such as high temperatures, too much or too little light, variations in rainfall and high wind (Lanyon *et al.* 1994; Collier *et al.* 2016). *Halodule uninervis* was recorded exclusively in subtidal environments in 2019, and therefore not subject to atmospheric exposure and associated stressors (desiccation, high temperatures). *Halodule uninervis* has a higher light requirement

than *Halophila* species (Longstaff and Dennison 1999), and may therefore be sensitive to periods of low light conditions the deeper waters in which it was recorded in 2019 may have been near its minimum light requirement. Periods of low light during 2019-20 could conceivably have resulted in the loss of this species.

4.3.3 *Zostera*

Zostera muelleri predominately occurred in intertidal and shallow waters of the study area (landward of 2.5 m AHD). *Zostera muelleri* has a high light requirement compared to other seagrass species found within the study area (e.g. Abal and Dennison, 1996; Collier and Waycott 2009). This limits *Z. muelleri* to intertidal and shallow subtidal habitats where it is a dominated species.

SDR was found to vary among the site locations, ranging from 0 m to -3.1 m AHD adjacent to Fisherman Islands, 0 m to -1.6 m AHD at Cleveland, -1 m to -2.6 m at Manly and -0.9 m to -3.3 m at Deception Bay. *Z. muelleri* depth range was variable at the majority of the sites with the largest notable change being the decrease at both Manly transects. Differences in SDR among locations are likely to reflect:

- Differences in the availability of suitable (and stable) habitat - Physical habitat conditions, including hydrodynamic processes and substrate stability, are key controls on seagrass meadows. Fisherman Islands has broad intertidal and subtidal sand and mud banks, within the preferred depth zone of *Z. muelleri*. By contrast, Manly and Cleveland have short and steep intertidal/shallow subtidal shore profiles and coarse sediments, and therefore less potential *Z. muelleri* habitat. A consequence of this has been that the depth distributions among locations may reflect changes in sediment quality and other factors (e.g. exposure to wave re-suspension/ boat wash and channels) as well as being driven by the availability of light in deeper waters.
- Differences in water quality conditions among (and possibly within) locations. The four sampling locations are influenced to different degrees by river flows and wave-generated sediment resuspension.

SDR along the depth transects is varied between years at both Fisherman Islands and the control sites. Within the 2021 survey it was observed that Fisherman Island and Cleveland depth range was variable while Manly observed a decrease on both transects. Overall transect F, H and the combination of controls all observed a decrease in SDR. This suggests that the reduction of SDR at Fisherman Island is due to environmental variables.

Zostera muelleri depth range is more stable at Fisherman Islands (CoV -17 to -20), Cleveland (CoV -43 to -52) and Deception Bay (CoV –19 to -23) than Manly (CoV -15 to -60). This suggests that Manly is more prone to disturbance and/or habitrat heterogeneity compared to the other sites, which is consistent with the 2020 survey. In comparison to previous years Fisherman Islands transect H was showed a similar trend to transect F which previously differed. While both the Fisherman Islands transects had a decreased SDR this was also observed at the combined control sites.

4.3.3.1 Decrease in Nearshore *Zostera muelleri*

In recent years of the SMP it has been noted that the extent of the dense nearshore Z. muelleri meadows are variable through time with a recent trend of retraction in the nearshore zone. As hypothesised by BMT (2020) this may be the result of a number of environmental factors namely: rainfall and increased exposure during hot days. Between July 2020 and July 2021 there was a large retraction of the upper boundary of seagrass meadows (Figure 4-2). This new 2021 extent represents a nearshore historic minimum in some extents of the shoreline however, 2010, 2011 and 2020 show larger retraction in other areas. This may also be related to small scale difference/changes in either hydrology, nutrient regimes or bathymetry.

4.3.4 *Cymodocea*

A small inshore patch of *Cymodocea serrulata* was recorded at Fisherman Islands in 2021. This is the first record of this species in the SMP. This species typically lives in intertidal and shallow subtidal areas with either sandy or muddy substrates, and is often found in mixed communities. This species can rapidly out-compete *Halophila* species as part of a natural succession (Young & Kirkman 1975) and is considered an opportunistic species (Kilminster *et al*. 2015).

This species has been recorded elsewhere in Moreton Bay. Young and Kirkman (1975) recorded a monospecific *C. serrulata* meadow in eastern Moreton Bay in similar habitat conditions to the Fisherman Islands meadow (sandy substrate, approximately 3 m deep). The Atlas of Living Australia has less than 15 records of this species in Moreton Bay with the most recent being at the tip of North Stradbroke Island in 2020.

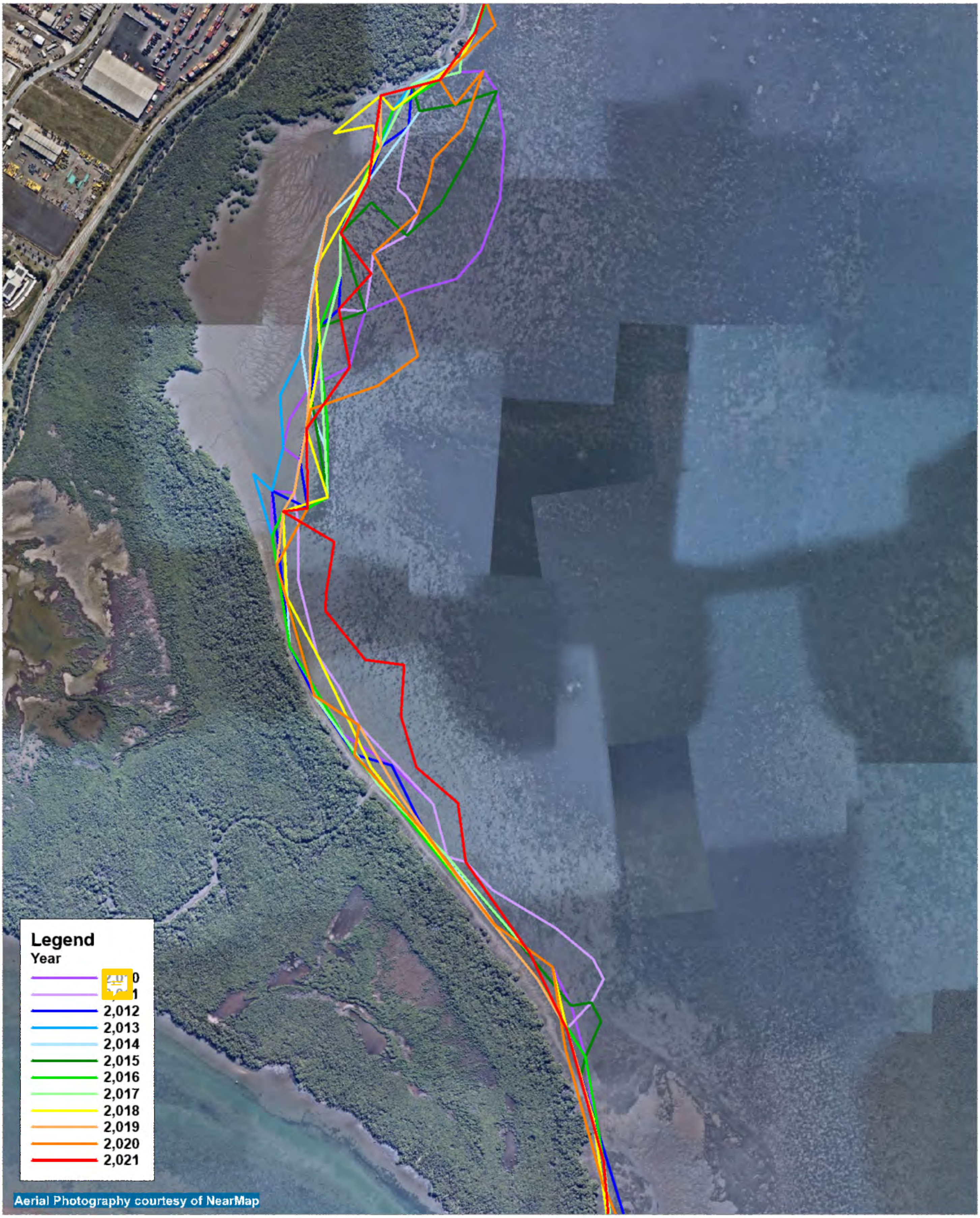
4.3.5 Filamentous Algae and Other Macroalgae

The dominant algae type observed across the survey locations was filamentous algae, other macroalgae observed included *Hydroclathrus clathratus*, *Hypnea* and *Sargassum*. Filamentous algae can proliferate under nutrient enriched conditions, leading to reductions in available light and loss of seagrass (Han and Liu 2014). Fisherman Islands is located directly adjacent to several major nutrient sources (i.e. Luggage Point WWTW, Wynnum WWTW and catchment inflows from the Brisbane River), which likely to promote filamentous algae productivity at this location. Like seagrass, different macroalgae species show great variation in distribution and cover over time and space.

Fisherman Islands continued to have the dominant macroalgae of Hydroclathrus. The dominant macroalgae species included *Sargassum* and *Udotea* which were observed in the highest densities in nearshore areas. While Manly and Cleveland contained mixed communities of macroalgae.

The average macroalgae cover was highest at Fisherman Islands (3.2%) compared to Cleveland (2.8%), Deception Bay (2.6%) and Manly (1.5%). However, Deception Bay had the greatest proportion of sites with a recorded presence of macroalgae (54%) compared to Fisherman Island, Manly and Cleveland (39%, 37% and 29% respectively). This is an overall decrease in macroalgae presence at all sites. Macroalgae was present at a variety of depths at Fisherman Islands (-0.9 m to -6.9 m AHD), Cleveland (0 m to -5.6 m AHD), Deception Bay (-0.5 m to -7.6 m AHD) and Manly (0 m to -8.1 m AHD).

The SMP monitoring sites offer a range of available habitat types for macroalgae beds. For example Cleveland had small areas of reef and cobble banks, providing suitable habitat for reef associated species such as *Sargassum*, *Hydroclathrus clathratus* and *Laurencia majuscule.* Shell and rubble fragments at Fisherman Islands, Deception Bay and Manly also provide small habitat patches for several macroalgae species. Deception Bay also had larger rocks containing dense *Sargassum* patches.



Title:

Historical Nearshore Seagrass Extent

Figure:

4-2

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The most notable temporal change observed over time has been cyclic changes in the green alga *Caulerpa taxifolia. Caulerpa taxifolia* was a dominant component of the benthic community throughout the study area during the 2000's when *El Niño* conditions prevailed, and sewage discharges were of a poorer quality than present day. The distribution and density of *C. taxifolia* declined across the study area post-2010. *Caulerpa taxifolia* was recorded at Cleveland and Deception Bay in low abundance.

Epiphytes that grow on seagrass leaves include a range of small algae species. Like seagrass, these epiphytes are primary producers and therefore contribute to the productivity of seagrass meadows. However, if epiphyte cover becomes too high then this can restrict the light available to the seagrass, therefore limiting growth. Epiphyte cover was observed at 25% of Fisherman Island sites at an average cover of 4%. Compared to Cleveland which had an average of 8% cover on 8% of sites and Manly which had an average of 1% cover and was observed at 3% of sites.

4.4 Existing Seagrass Condition

Seagrass meadow condition was assessed with reference to:

- SDR water quality objective (WQO) for Waterloo Bay (State Protection Policy – HEV waters for Waterloo Bay)
- Local 'reference' value; in this instance, the maximum recorded SDR for each species on individual transects.

The following sites met the SDR (WQO) of -1.9 m AHD: Fisherman Island transects H and F, Manly transect J and both Deception Bay transects. Deception Bay has been surveyed twice to date and met the WQO on both occasions. Of the other sites, Manly transects most frequently met the SDR WQO, followed by Fisherman Islands and Cleveland. Fisherman Islands transect F infrequently met the WQO, most likely as local hydrodynamic conditions were not favourable for *Z. muelleri* growth (mobile sandy bed).

The SDR WQO was met less frequently in 2021 than 2020, possibly due to higher antecedent rainfall in 2021. As shown in Table 3-2, the 12 month cumulative antecedent rainfall in 2021 (1139 mm) was higher than in all years between 2014-20. There was no correlation between long term SDR and antecedent rainfall, however further analysis is required.

4.5 Impacts of the FPE Seawall

The results of the SMP again indicate an overall long-term trend of a net expansion in seagrass meadow extent at Fisherman Islands since the FPE seawall construction (see BMT WBM 2016 for details). Consistent with the predictions of the FPE IAS (WBM 2000), the results of the Port of Brisbane SMP suggest that port expansion activities (both the FPE and previous reclamations at Fisherman Islands) have led to localised alterations to hydrodynamic processes that favour the development of seagrass meadows. Key controlling processes are expected to include:

- Enhanced protection from northerly waves. The FPE seawall provides more protection from prevailing wind generated waves from the northerly direction.

- Deposition of fine sediment. The extension of the FPE seawall appears to be enhancing the deposition of fine sediments within the embayment north and east of Fisherman Islands (BMT WBM 2010; 2015; 2016; 2017, 2018, 2019, 2020). The effects of fine sediment deposition on the ambient light climate and nutrients availability, and flow on effects to seagrass, remains unresolved.
- Separation from the Brisbane River. The seawall extension has effectively moved the mouth of the Brisbane River further from the Fisherman Islands seagrass meadows, possibly enhancing water clarity and reducing the impacts of low salinity flood waters.

5 Conclusion

The key findings of the 2021 are:

- Seagrass community composition remains relatively consistent with previous surveys, with *Z. muelleri* dominating intertidal habitat and *Halophila* dominating subtidal areas.
- Overall meadow extent decreased at Fisherman Islands in both the upper (i.e. intertidal) and lower (deep-water seagrass in the northern and eastern sectors) distribution limit.
- SDR increased at transect H and transect F. Similar trends were observed at control sites, and changes recorded at Fisherman Island were within the range of natural variability. This suggests that the driver/s leading to changes between 2020 and 2021 were operating over broad scales throughout western Moreton Bay, and were therefore unrelated to Port activities.
- *Zostera muelleri* SDR WQO for Waterloo Bay was used as a benchmark to assess seagrass condition. Fisherman Island transects H and F, Manly transect J and both Deception Bay transects met the WQO, all other transects at control sites did not.
- The results of the Port of Brisbane SMP suggest that there was a long-term expansion in seagrass meadows at Fisherman Islands which has stabilised in recent years. This trend is consistent with the predictions of the FPE IAS (WBM 2000) that port expansion activities (both the FPE and previous reclamations at Fisherman Islands) have led to localised alterations to hydrodynamic processes that favour the development of seagrass meadows.

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Appendix A Photo Plates

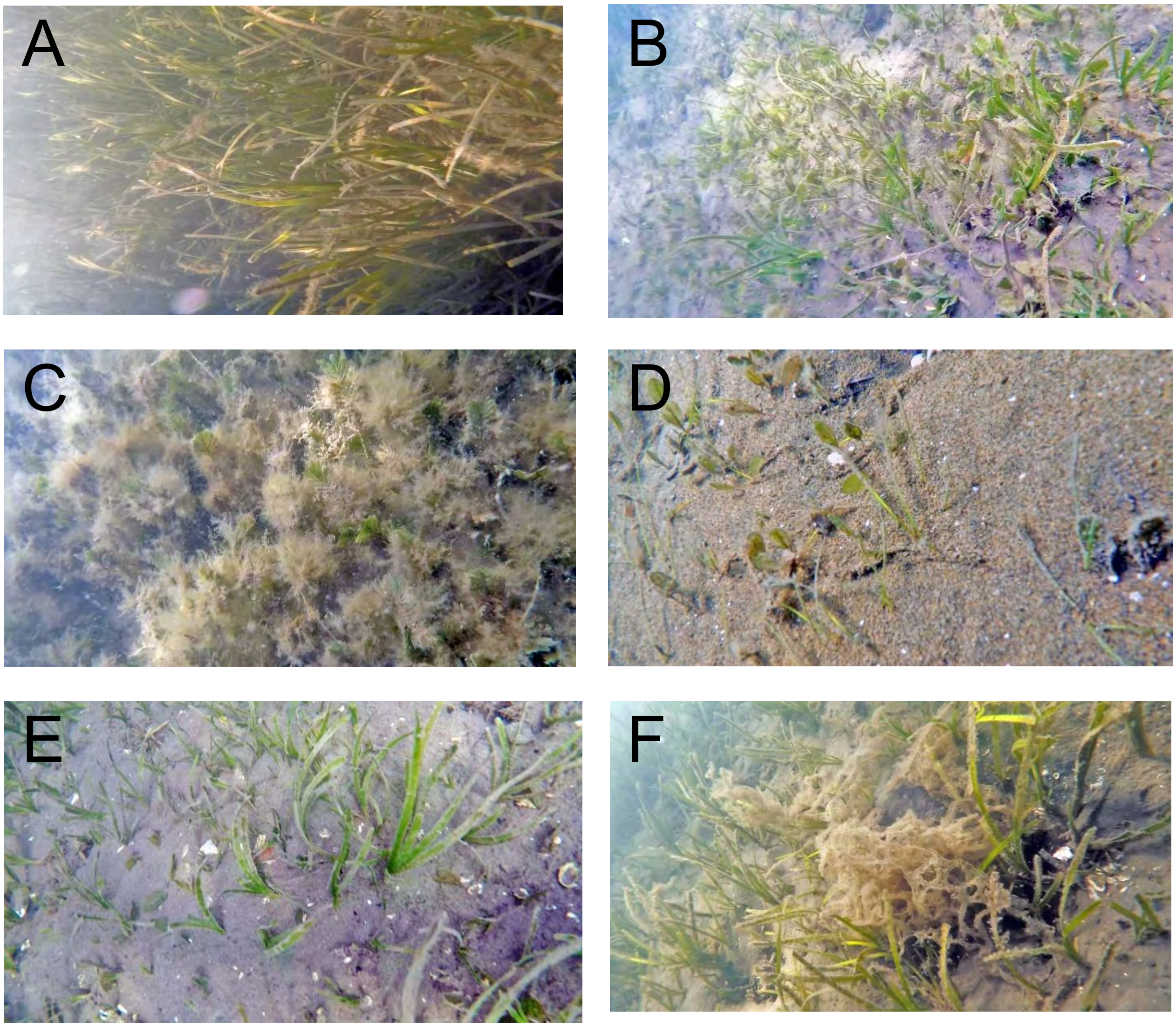


Figure A-1 Fisherman Islands: inshore *Zostera muelleri* (A), mixed community of *Zostera muelleri* and *Halophila ovalis* (B), *Halophila spinulosa* covered in epiphytic algae (C), sparse mixed community of *Halophila ovalis* and *Haoldule uninervis* (D), mixed community of *Cymodocea serrulata* and *Halophila ovalis* (E) and *Zostera muelleri* and *Hydroclathrus clathratus* (F).

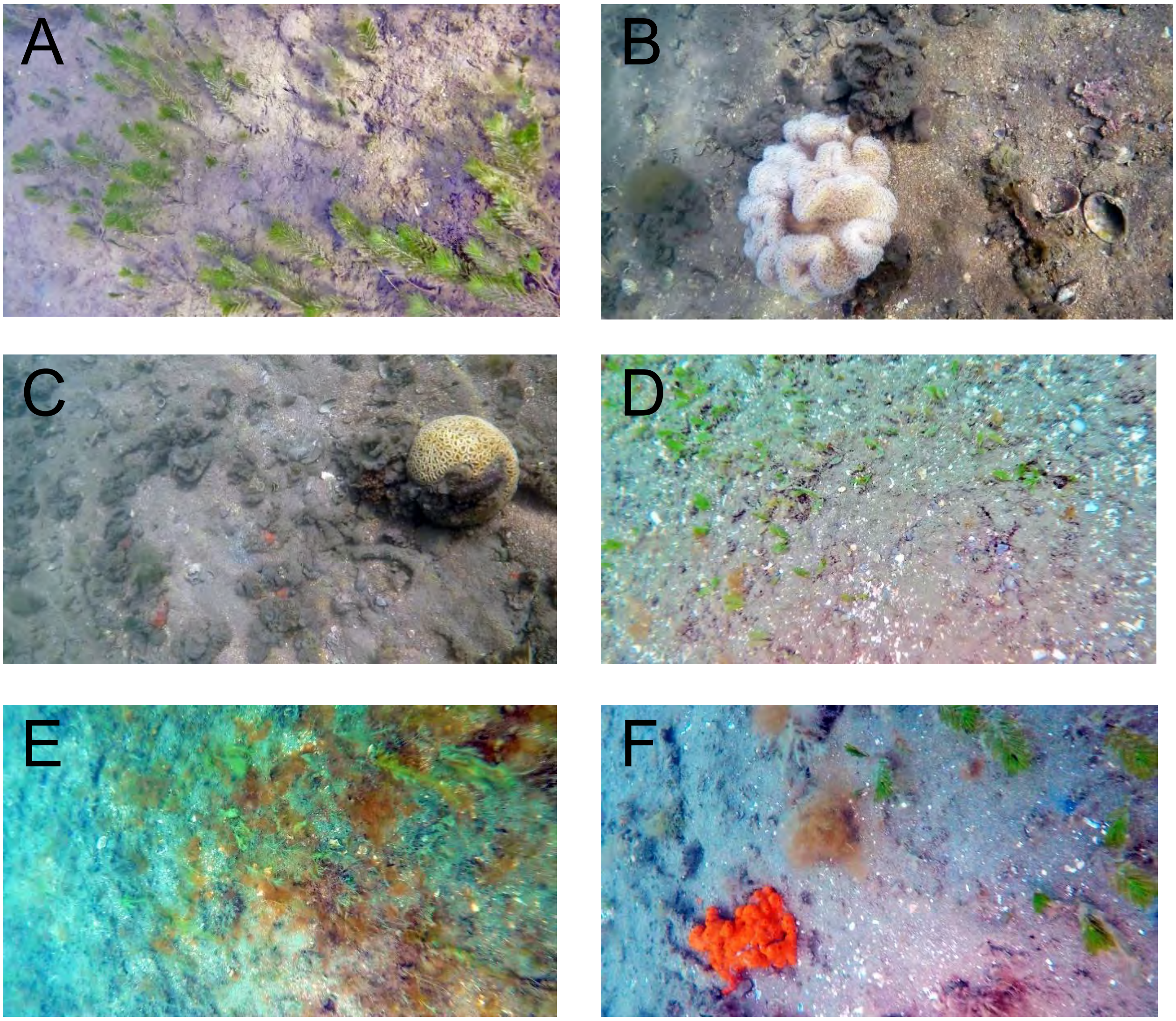


Figure A-2 Manly: *Halophila spinulosa* (A), Lobophytum (B), Favites (C); Cleveland: *Halophila decipiens* (D), mixed macroalgae (E) and *Halophila spinulosa*, macroalgae and sponge (F)

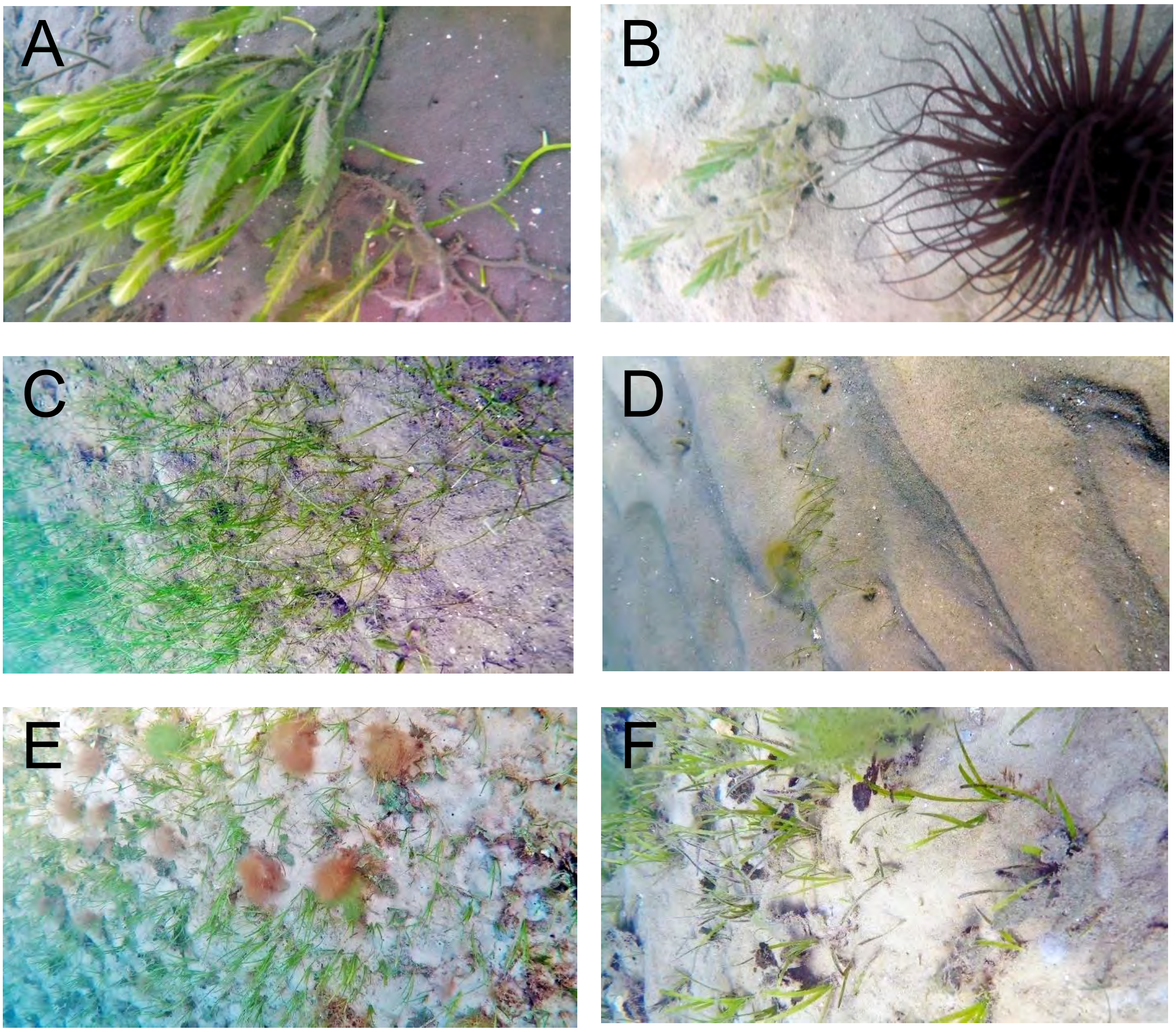
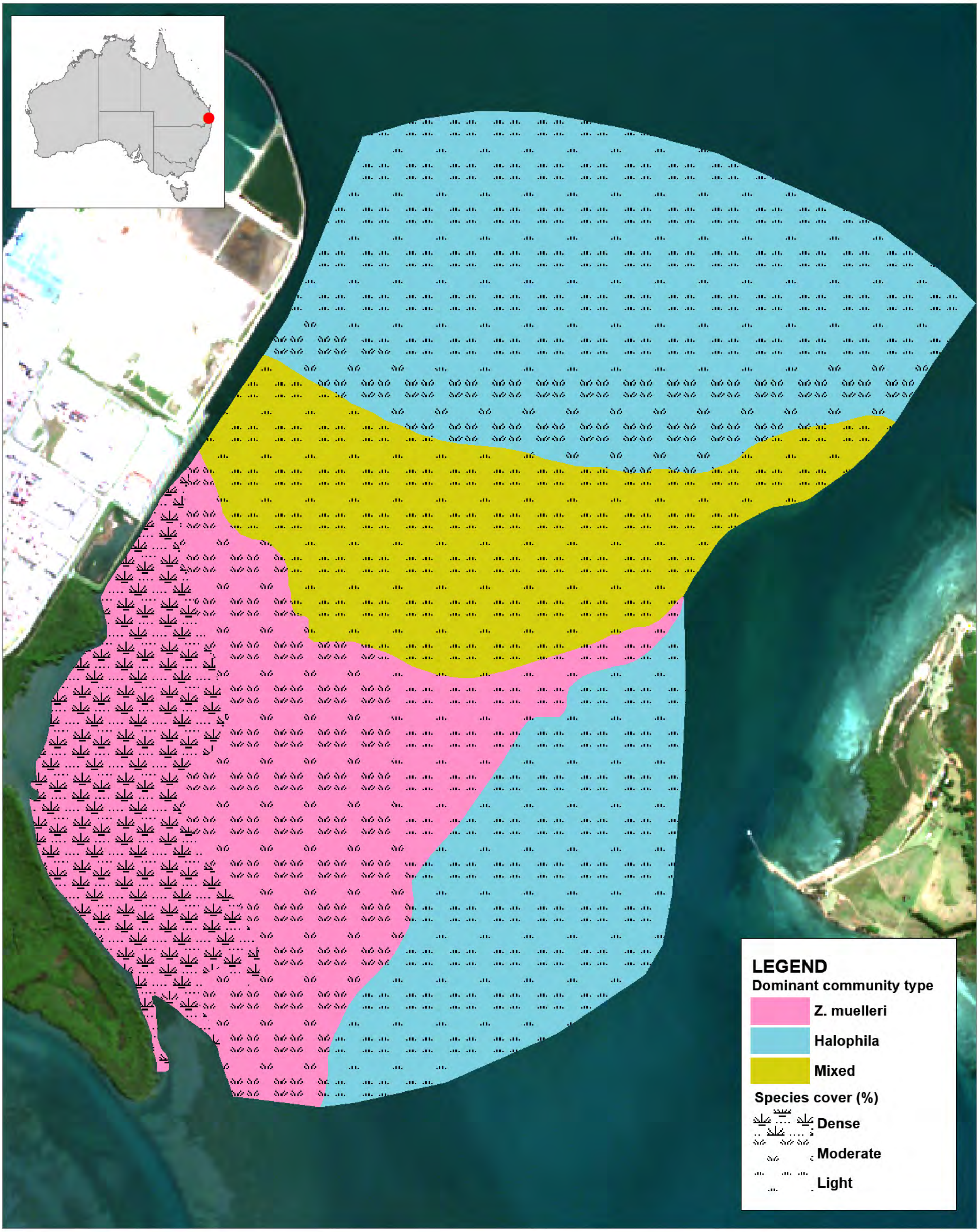


Figure A-3 Cleveland: *Caulerpa taxifolia* (A), sea urchin and *Halophila spinulosa* (B), Deception Bay: moderate *Halodule uninervis* (C), *Halodule uninervis* in active sand environment (D), mixed community of *Halodule uninervis* and macroalgae (*Udotea* and others) (E) and *Zostera muelleri* and macroalgae inshore community

Appendix B Broad scale patterns in seagrass species distribution at the Port of Brisbane 2010, 2013-2020



Title:
Seagrass distribution and community structure adjacent to Fisherman Islands 2010

Figure: **B-1**

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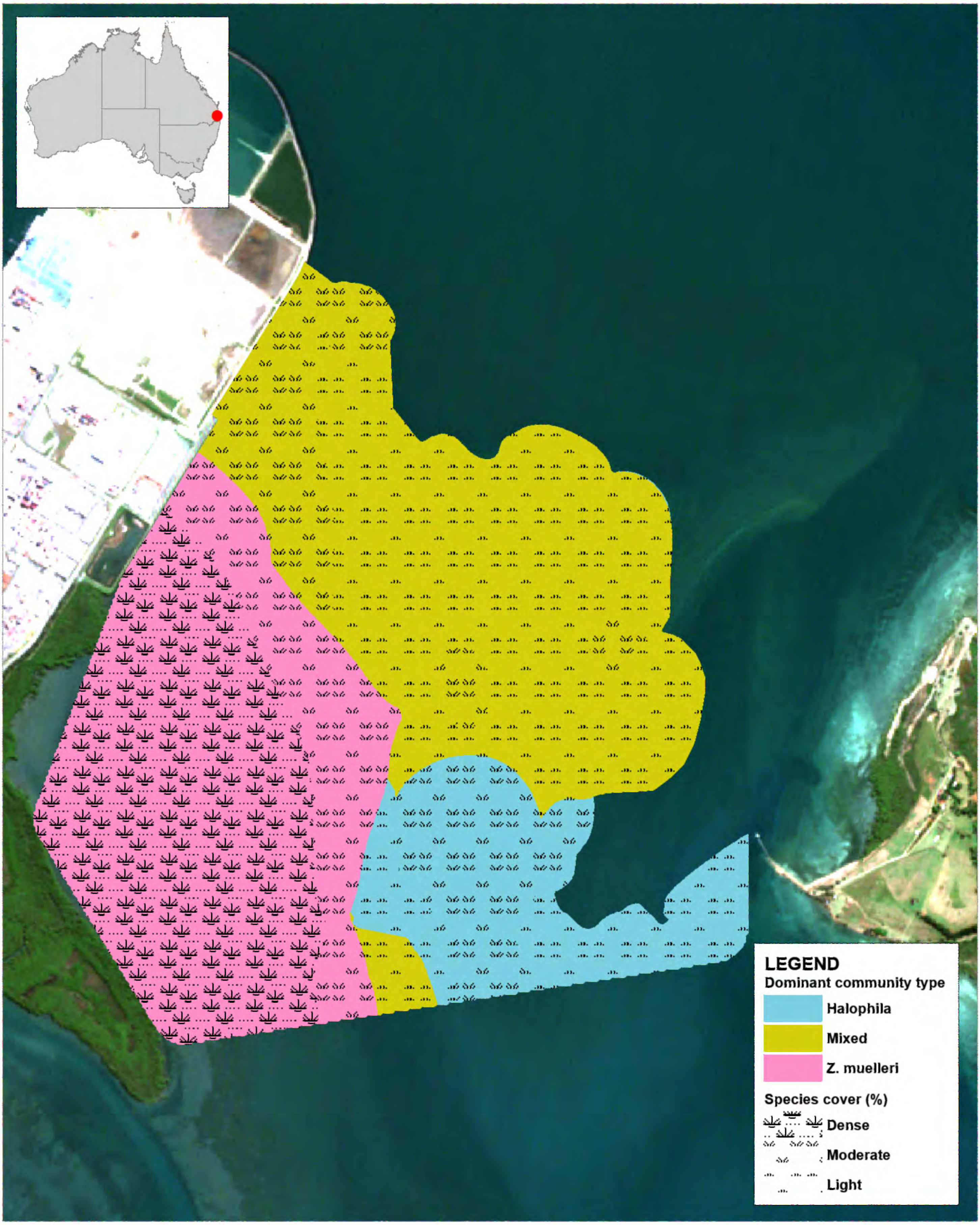

Title:

Seagrass distribution and community structure adjacent to Fisherman Islands 2013

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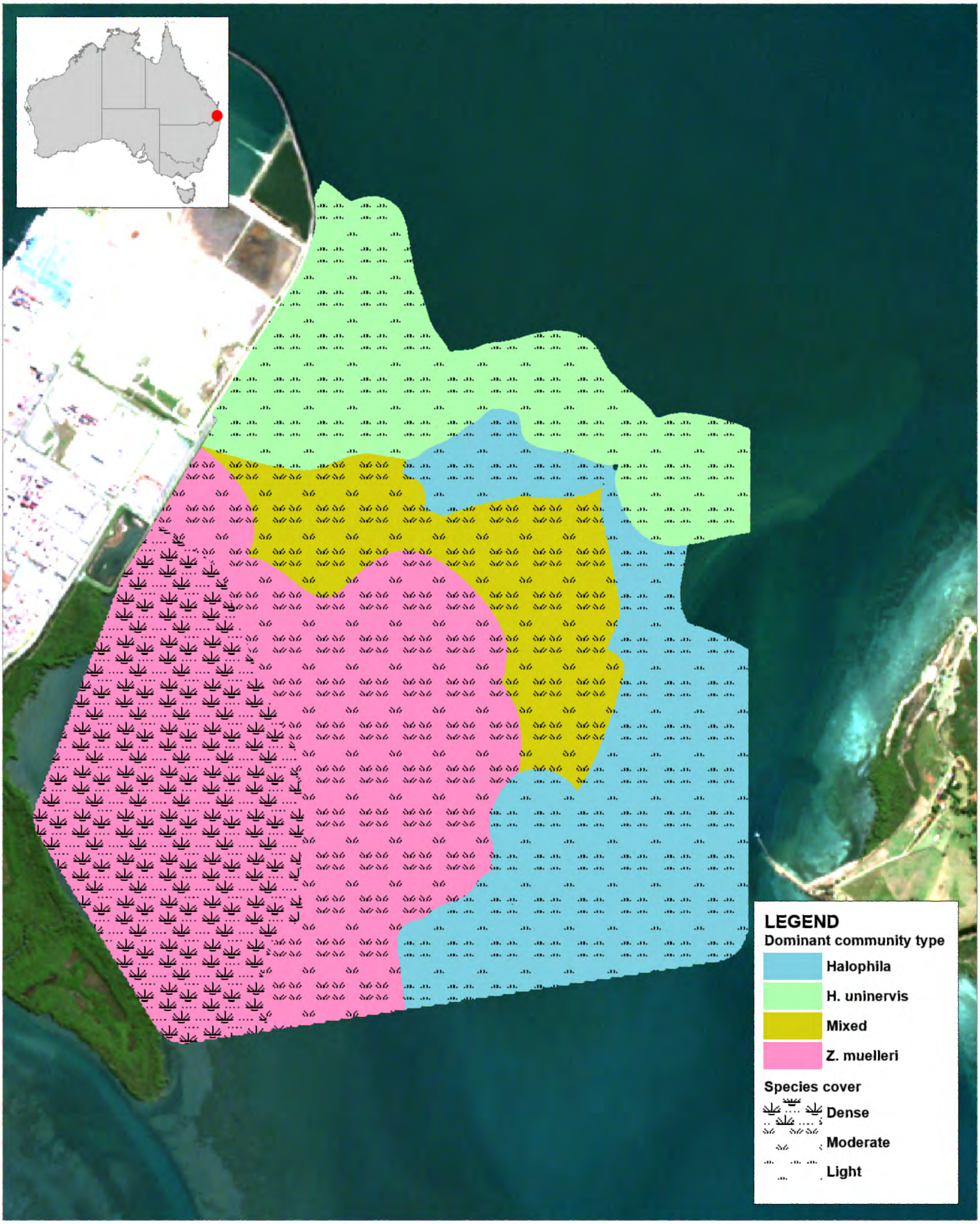

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Seagrass distribution and community structure adjacent to Fisherman Islands 2014

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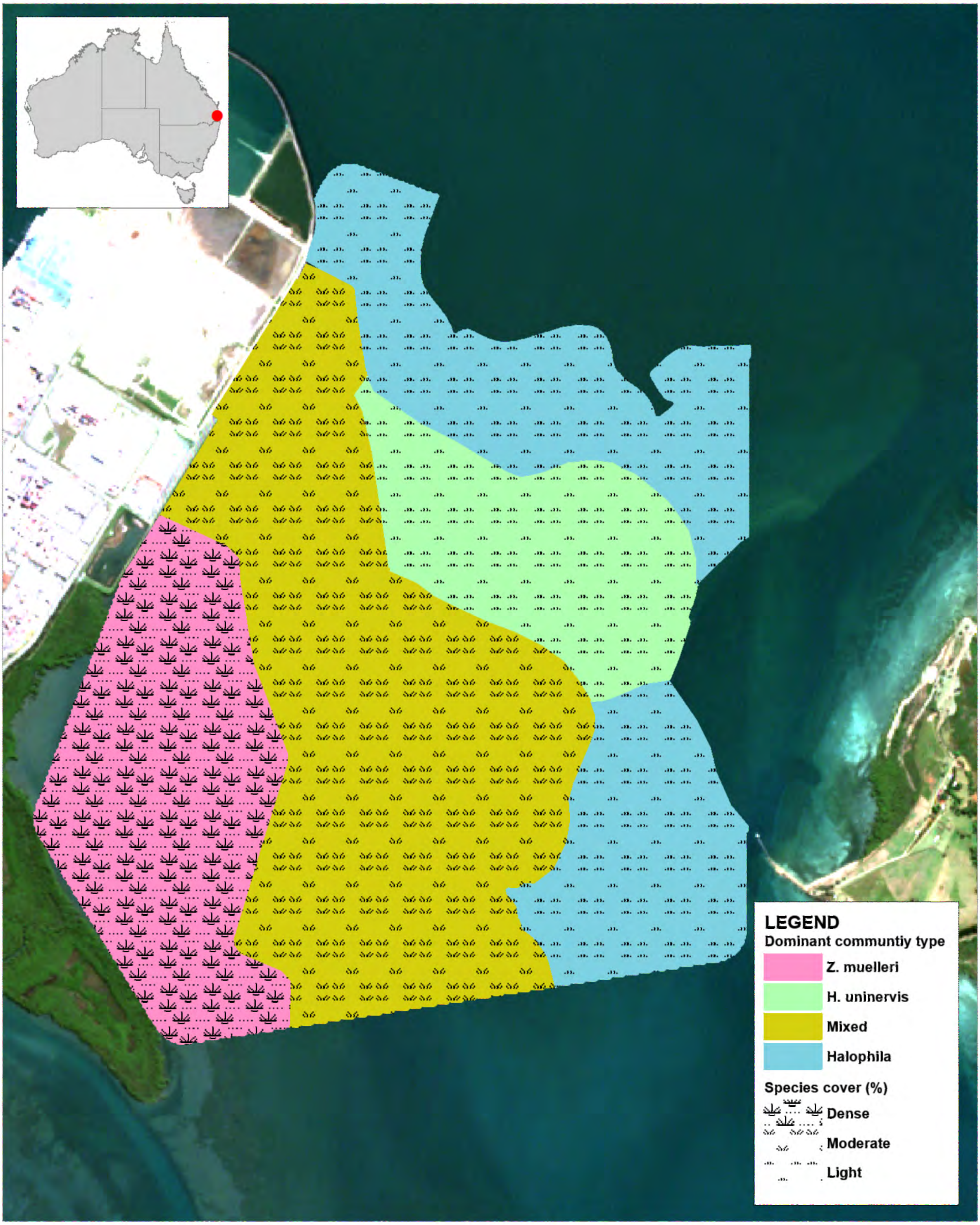

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Seagrass distribution and community structure adjacent to Fisherman Islands 2016

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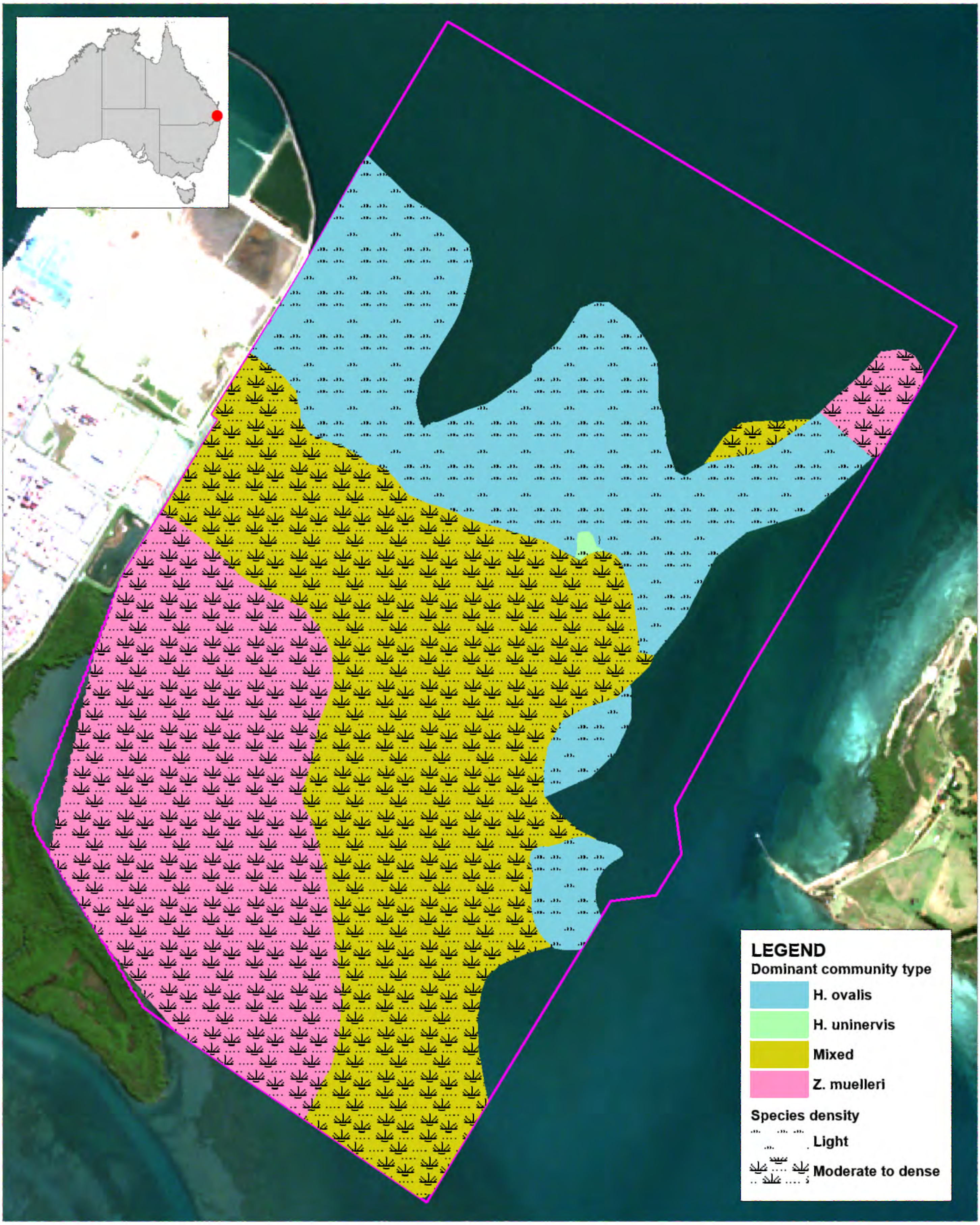

Title:

Seagrass distribution and community structure adjacent to Fisherman Islands 2017

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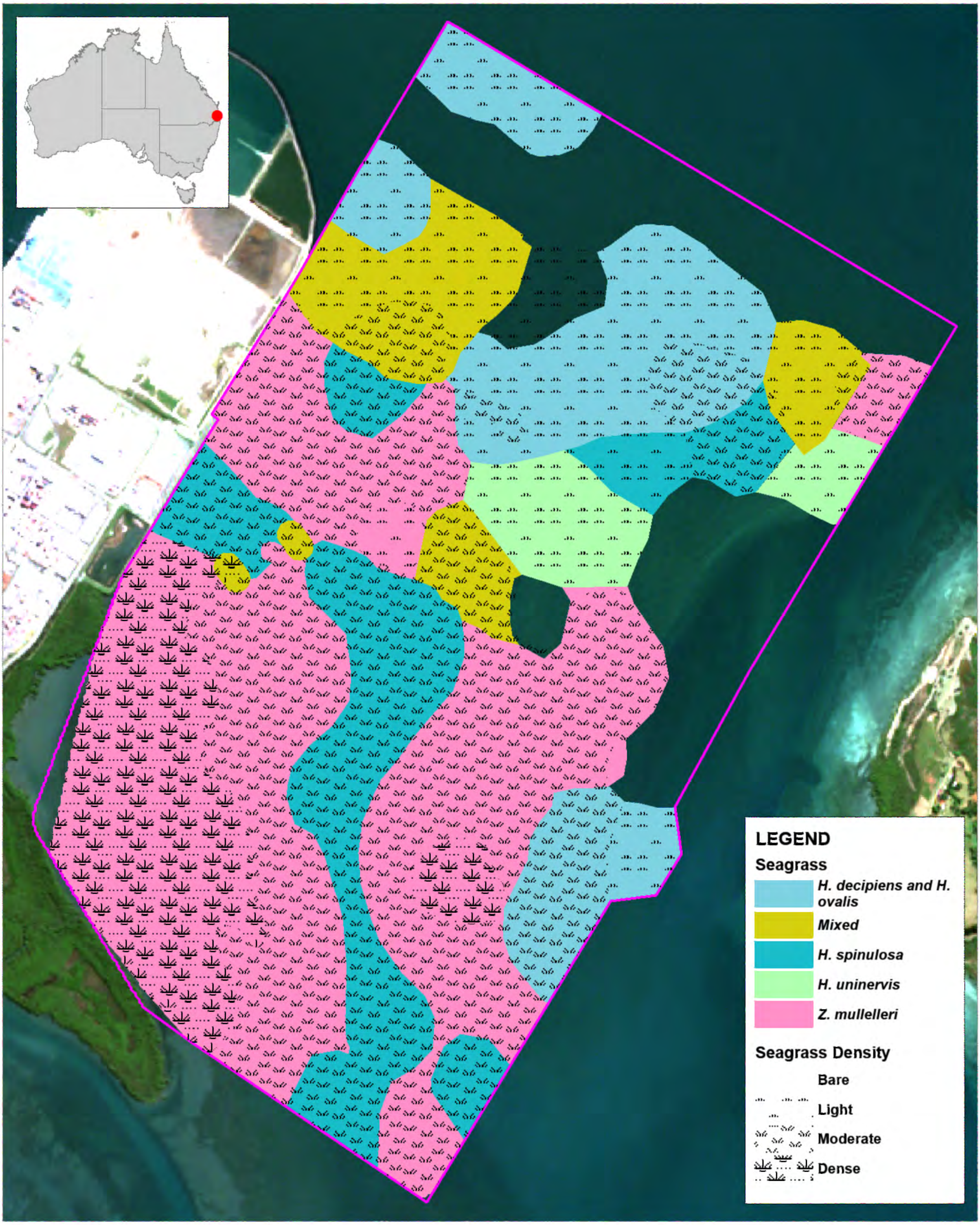

Title:

Seagrass distribution and community structure adjacent to Fisherman Island, 2018

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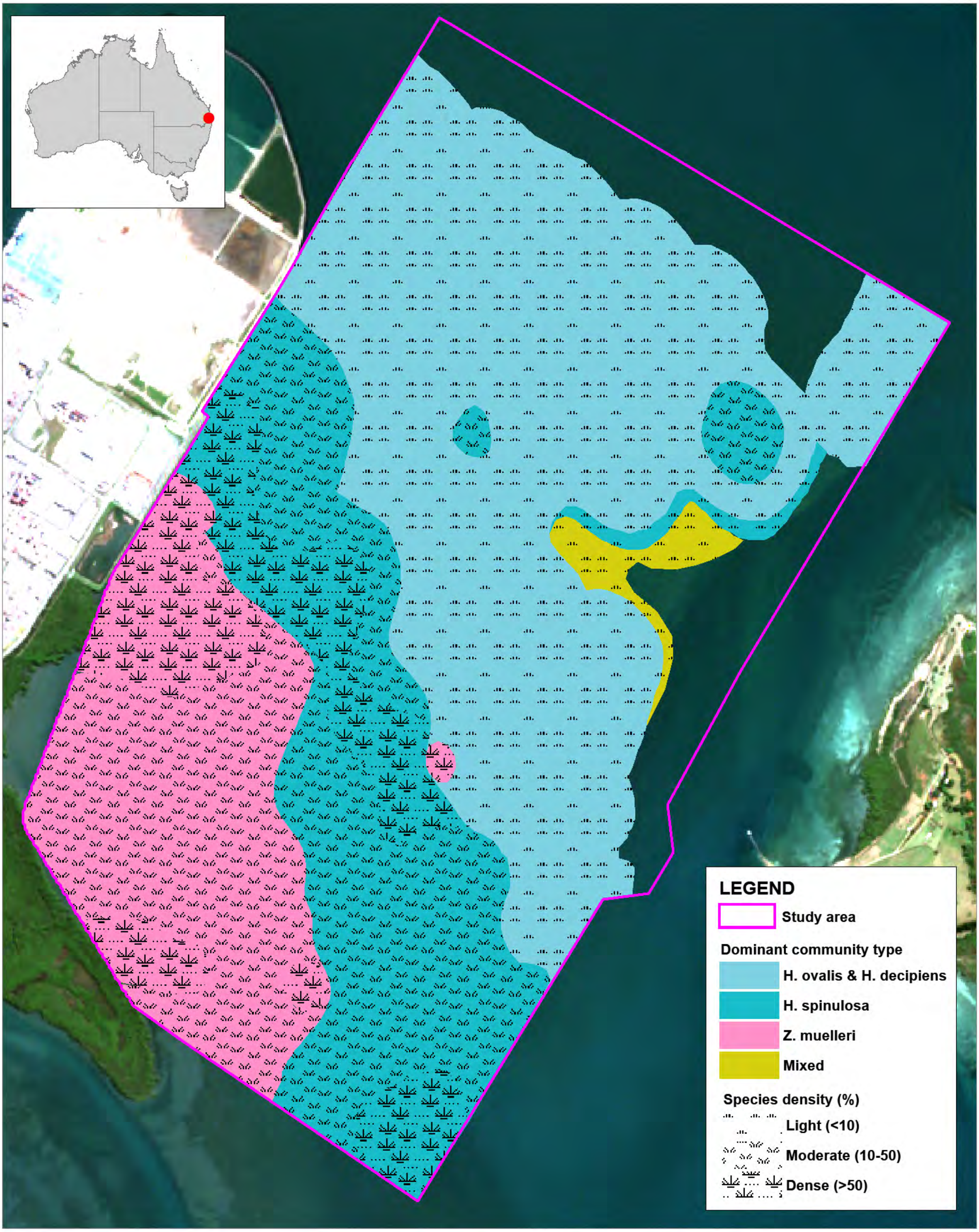

Title:

Seagrass distribution and community structure adjacent to Fisherman Islands 2019

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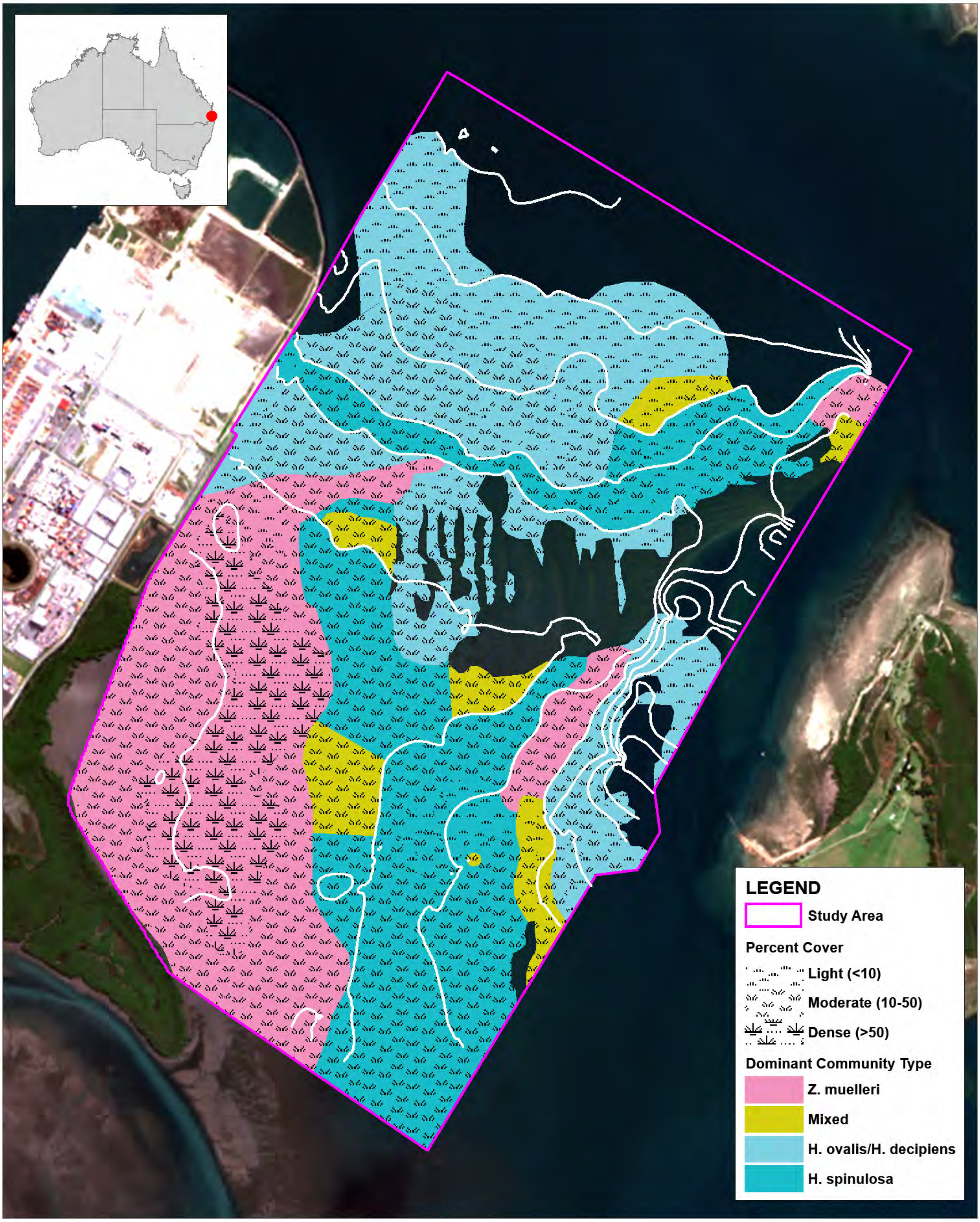

Title:

Seagrass Distribution and Composition Adjacent to Fisherman Islands 2020, Showing 1m LAT Contours

Figure: B-8

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