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Port of Brisbane - Seagrass Monitoring Report 2014

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Synopsis: **Findings of the 2014 seagrass monitoring program at the Port of Brisbane.**

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Executive Summary

The Fisherman Islands area contains one of the largest seagrass meadows in western Moreton Bay, and supports a range of biodiversity and fisheries habitat values. Port of Brisbane Pty Ltd (PBPL) undertakes routine monitoring of seagrass meadows adjacent to the port at Fisherman Islands, as well as control locations at Manly and Cleveland. This monitoring forms a component of the PBPL Environmental Monitoring Program, and is intended to provide port management with information on the condition and status of seagrass meadows, and to identify whether there is any evidence that port operations are having an impact on these seagrass meadows.

A seagrass survey was carried out in July 2014 using an underwater video system to:

- Record the maximum depth of seagrass meadows along transects established in 2002
- Characterise spatial patterns in seagrass and macroalgae communities along a depth gradient
- Ground-truth seagrass habitat mapping developed through interpretation of remote imagery.

The methods used were consistent with those adopted in previous surveys carried out for PBPL since 2002.

General findings from the 2014 survey were broadly consistent with previous monitoring events and show that:

- Species of the genus *Halophila* tended to form deeper subtidal communities at the seaward edge of seagrass beds at each of the survey locations.
- The distribution of *Halophila ovalis* was more limited in 2014 than recorded previously, whereas *Halophila decipiens* and *H. spinulosa* both increased their distribution at Manly and Cleveland.
- *Zostera muelleri* formed dense beds in the intertidal zone at the landward edge at each location and often extended slightly into the shallow subtidal. Intertidal beds were comprised largely of dense mono-specific *Z. muelleri* meadows with occasional patches of *H. ovalis*. Subtidal beds were usually mixed with other species, including *H. ovalis, H. spinulosa* and *Halodule uninervis*.

Despite these changes in meadow composition, overall meadow extent at all sites remained broadly consistent with 2013 results and was similar to pre-2010 patterns. This is following on from a period of seagrass meadow expansion in 2010, and subsequent seagrass meadow declines in 2011 and 2013 that were coincident with flooding events.

The results of the present study suggest that the gross-scale changes in the extent of seagrass beds at Fisherman Islands were likely due to natural processes operating at spatial scales measured in tens of kilometres, rather than any localised impacts resulting from PBPL activities. It is suggested that the FPE seawall may be continuing to play a role in the expansion of seagrass extent at Fisherman Islands through the provision of more protected conditions, enhanced sediment and nutrient entrapment, and/or greater separation from adverse influences of the Brisbane River.

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1 Introduction

1.1 Background

The Fisherman Islands area contains one of the largest seagrass meadows in western Moreton Bay (Dennison and Abal 1999). These seagrass meadows have high biodiversity and fisheries habitat values, and are also located within an internationally significant wetland (Moreton Bay Ramsar site) and Moreton Bay Marine Park.

The Port of Brisbane is located directly adjacent to the Fisherman Island seagrass meadows. In recognition of the values of local seagrass meadows, the Port of Brisbane Pty Ltd (PBPL) undertakes routine monitoring of seagrass meadows adjacent to the port and more broadly at Manly and Cleveland. This monitoring forms a component of the PBPL Environmental Monitoring Program, and is intended to provide port management with information on the condition and status of seagrass meadows, and to identify whether there is any evidence that port operations are having an impact on these seagrass meadows.

Seagrass distribution and extent has been identified as a useful bio-indicator of water quality degradation because it can "*integrate changes in aquatic light climate caused by various factors, and because seagrasses themselves are important and highly-valued elements of marine and estuarine environments*." (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

This study describes:

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

The specific objectives of this study were to:

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

- Identify and describe broad-scale (accuracy measured in tens of metres) spatial and temporal patterns in the vertical (depth) and horizontal distribution of seagrass beds at the Port and at control areas;
- 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 PBPL activities on the distribution and extent of seagrass beds.

1.3 Study Area Context

The Port of Brisbane is located at Fisherman Islands (the study area), 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 1974. 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 beds 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. The seagrass and mudflats of this Ramsar area 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 14m (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 for the study are located adjacent to Manly and Cleveland on the western foreshore of Moreton Bay and to the south of the Fisherman Islands monitoring location (see Figure 1-1). 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 site and in western Moreton Bay more generally.

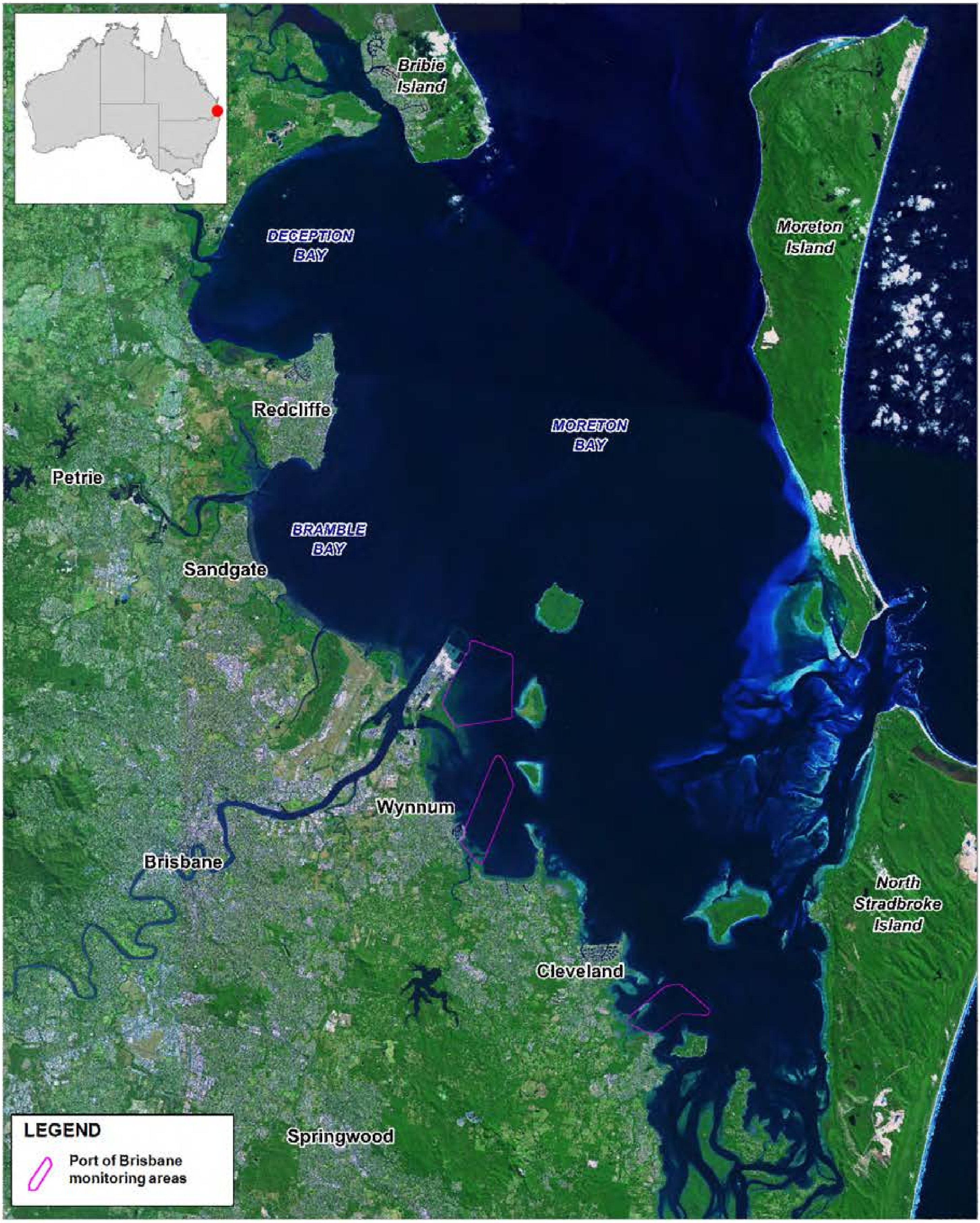
1.4 Monitoring Program Context

The Port of Brisbane seagrass health monitoring program commenced in 2002. The 2002 pilot study (WBM Oceanics 2002) aimed to test and develop appropriate sampling protocols and sites for ongoing monitoring, and to commence the development of a baseline data-set for the Future Port Expansion project. Sampling was undertaken at Fisherman Islands (designated as a putative impact location) as well as control locations at Manly and Cleveland in this and subsequent surveys.

Seagrass monitoring was undertaken using the same methodologies (albeit with some adjustments to the position of sampling sites) between 2003 and 2013 (see WBM Oceanics Australia 2002; 2003a; 2003b; 2004; 2005; BMT WBM 2006, 2010b, 2013). With the exception of some targeted surveys undertaken during the FPE construction (2003-2005) and seasonal surveys in 2002-03 (see below), surveys were typically undertaken post summer, mostly due to higher water clarity outside the wet season.

Monitoring throughout the PBPL survey area between 2002 and 2006 found consistency in the size and composition of most meadows. This period included the completion of seawall construction for the Future Port Expansion (FPE) project in 2005. The 2010 monitoring event saw an expansion in the distribution of *Halophila ovalis* at all three survey locations.

Seagrass meadows naturally expand and contract seasonally and between years in Queensland waters (Mellors *et al*. 1993; Lanyon and Marsh 1995; McKenzie 1994). These fluctuations reflect in part seasonal variation in growth conditions. For example, seagrass WBM Oceanics Australia (2002, 2003a, 2003b) documented an increase in maximum depth distribution and biomass of *Halophila ovalis* during late winter-spring compared with autumn, in contrast to patterns observed by Preen (1992). In 2011 and 2013, major floods occurred in south east Queensland which affected the Brisbane River and other catchments which flow into southern Moreton Bay and influence the Study Area. The 2011 flood event resulted in the loss of approximately half of the seagrass area within parts of Moreton Bay. CSIRO estimated that seagrass cover had recovered within a year of the floods, but this estimate was based on LandSat imagery which has difficulty discerning deepwater seagrass distributions. The 2013 monitoring event was the first assessment of the study locations since the flooding events in 2011 and 2013. Monitoring between 2006 and 2010 had seen large increases in seagrass cover at all locations, with a retraction back to pre-2010 levels observed in 2013. The increases in seagrass extent that were seen in 2010 may have helped to buffer impacts of the flooding events.



Title:

Locality Plan

Figure: **1-1**

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2 Methodology

2.1 Timing

The field program for the 2014 seagrass monitoring event was undertaken on the 26th August, 27th August and 1st September. 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).

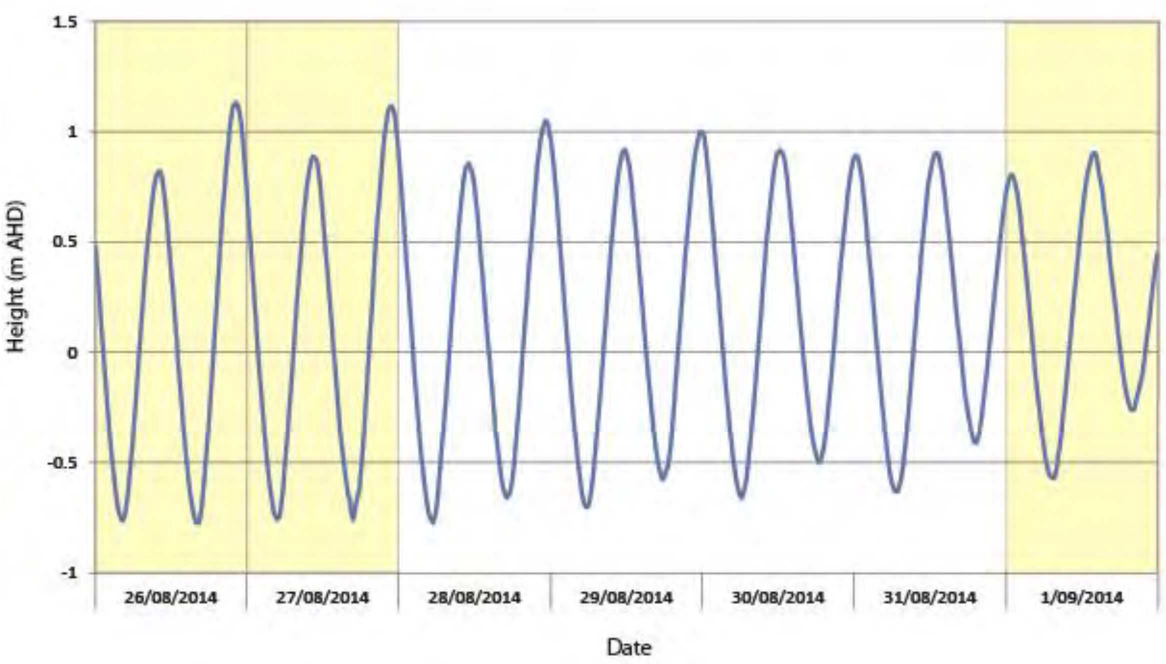


Figure 2-1 Tidal heights at Brisbane Bar during the study period (yellow highlights indicate field days)

2.2 Survey Vessel and Positioning

All sampling was carried out using BMT WBM vessel '*Resolution II*'. Location and navigation to the sampling sites was undertaken using a real time differential Global Positioning System (dGPS) to provide position-fixing accuracy's of ±1m.

2.3 Monitoring Sites and Approach

Monitoring sites for this survey were based on those previously used for the Port of Brisbane seagrass monitoring program which was developed in 2002 (WBM Oceanics Australia 2002). A pilot study for this monitoring program identified depth profiling and edge of bed monitoring as the most suitable monitoring techniques. Putative impact and control locations were chosen at Fisherman Islands (putative impact), Manly (control) and Cleveland (control) and monitoring sites for edge of bed, depth profiling and general mapping were established at these locations (see Figure 2-3 to Figure 2-5).

2.3.1 Edge of Seagrass Bed Monitoring

Sites were established at intervals along transects that traverse the known seasonal fluctuations in the deep-water edge of the seagrass bed at each location. The approximate edge of each seagrass bed was identified during the ground truthing of the mapping exercise undertaken during the pilot study (WBM Oceanics Australia 2002). The general distribution and extent of seagrass beds was initially established by depth profiling (see WBM 2003a; b), which was used as guidance for positioning sites for this assessment method.

Along each transect, a number of permanent survey points were positioned at roughly 50-100m intervals (Figure 2-2), and recorded using a dGPS to ensure repeatability between surveys.

At each point along these transects, the seabed was surveyed using one (or both) of the following techniques. High-resolution cameras (capable of working under low-light conditions) with direct connection to a surface laptop were used to observe and record seabed features in real time. Video imagery was recorded and stored on an external hard drive by BMT WBM. At sites where poorer water quality or cryptic species were encountered, a van Veen grab sampler was used to collect samples of the seabed to confirm identifications made from the video imagery.

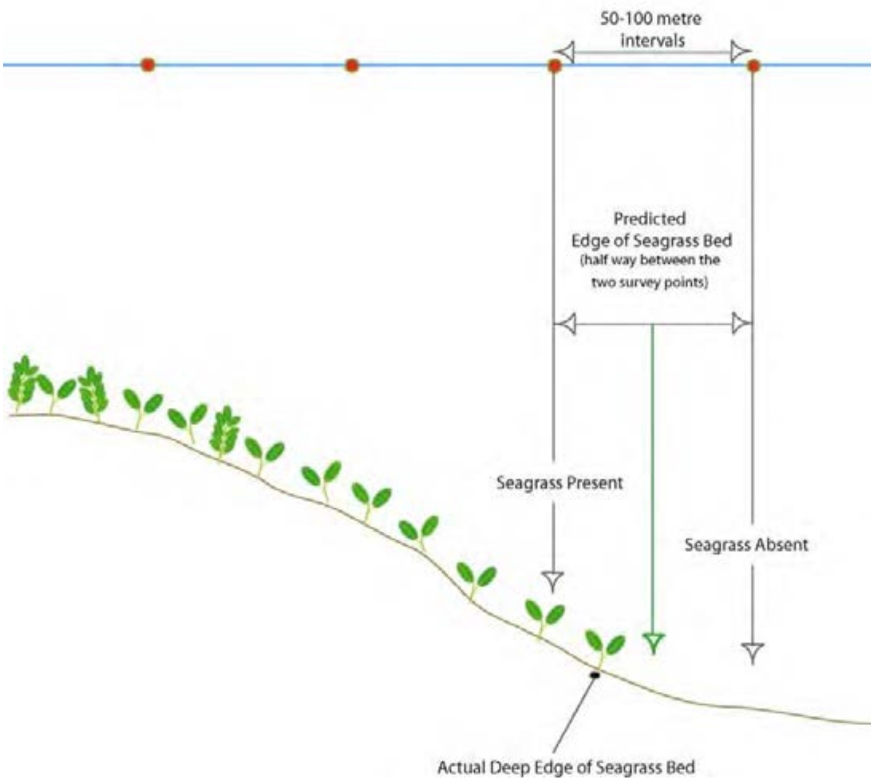


Figure 2-2 Permanent survey point method for identifying the edge of seagrass bed

The surveys initially began at a shallow survey point where seagrass was thought to be present. The survey vessel then moved to the next point along the transect until seagrass could no longer be found on the seabed. The deep water edge of the seagrass bed was assumed to be located mid-way between these two points. At each site, the depth of the seagrass and the time of survey were noted. Using this information and Brisbane Bar tidal data (Maritime Safety Queensland; 10

min interval), the depth of the seagrass bed relative to the Australian Height Datum was calculated, enabling standardised depth comparisons between sites, locations and survey times.

2.3.2 Seagrass Depth Profiles

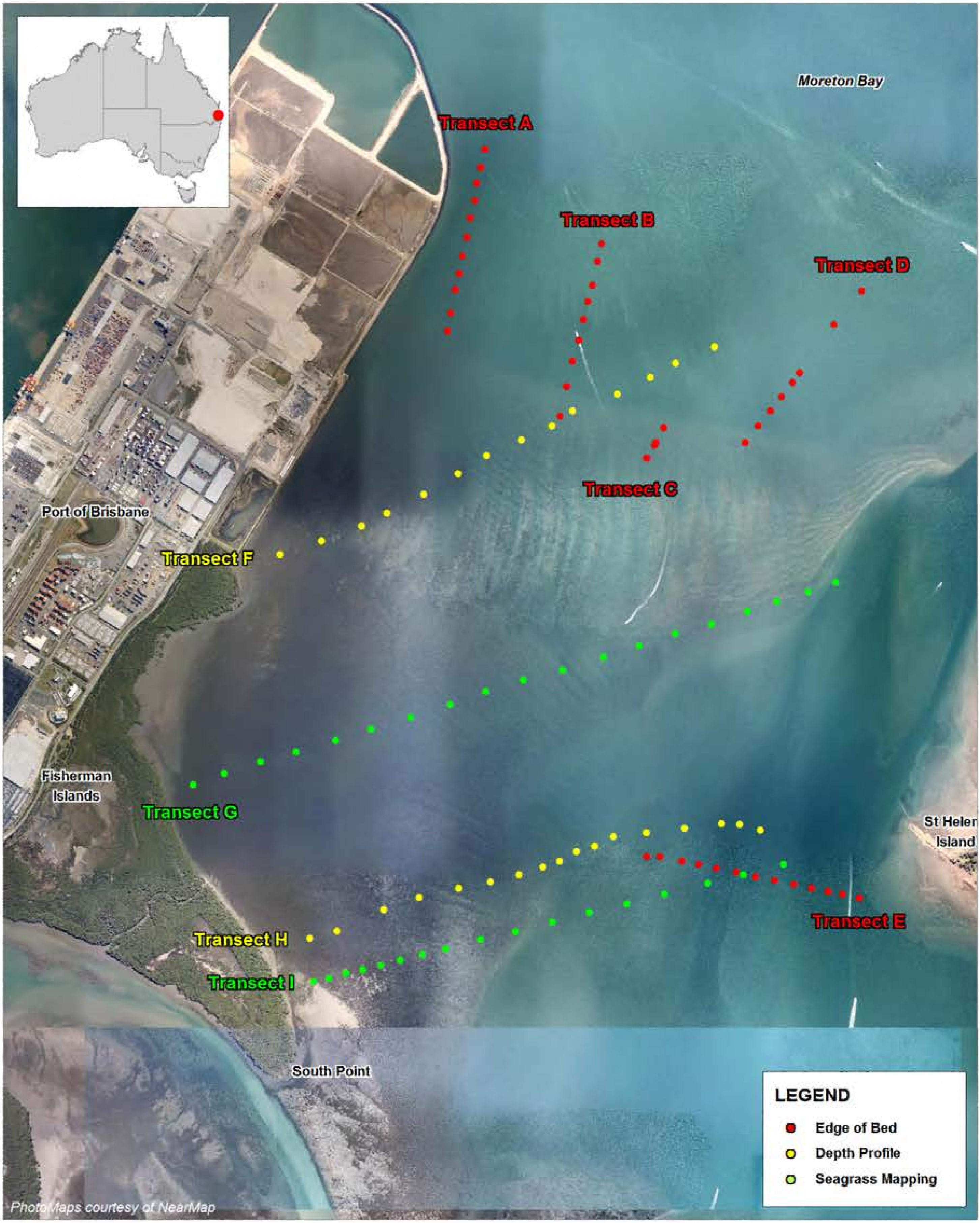
Seagrass depth profiles are used to monitor any variations in seagrass depth distribution and extent of seagrass species at each of the study locations. Depth profiles were originally monitored on a six monthly basis throughout the FPE project but were unable to be completed in 2004 due to adverse weather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

Two depth profile transects occur at each survey location, and run approximately perpendicular to the shoreline (Figure 2-3). At each point along the profile transect, the following parameters were recorded: time, water depth (using the survey vessel's sounder), position (dGPS) and seagrass species (a video image was recorded at each point). The depth at each point was reduced 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 beds. These alignments end near Green Island, which acts as a natural barrier to seagrass distribution.

2.3.3 Additional Seagrass Mapping in the Study Area

Information from two seagrass mapping transects at the Port, in conjunction with depth profile transects and edge of bed monitoring transects were also used to map the extent of seagrass beds at Fisherman Islands, Manly and Cleveland (Figure 2-3 to Figure 2-5). Consistent with depth profiling, at each point along the seagrass mapping transects the following parameters were recorded: time, water depth (using the survey vessel's sounder), position (dGPS) and seagrass species (a video image was also recorded at each point). The depth at each point was reduced to Australian Height Datum to enable comparisons between locations.



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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Title:
Survey Points Used to Map the Distribution of Seagrass Adjacent to Manly

Figure: 2-4

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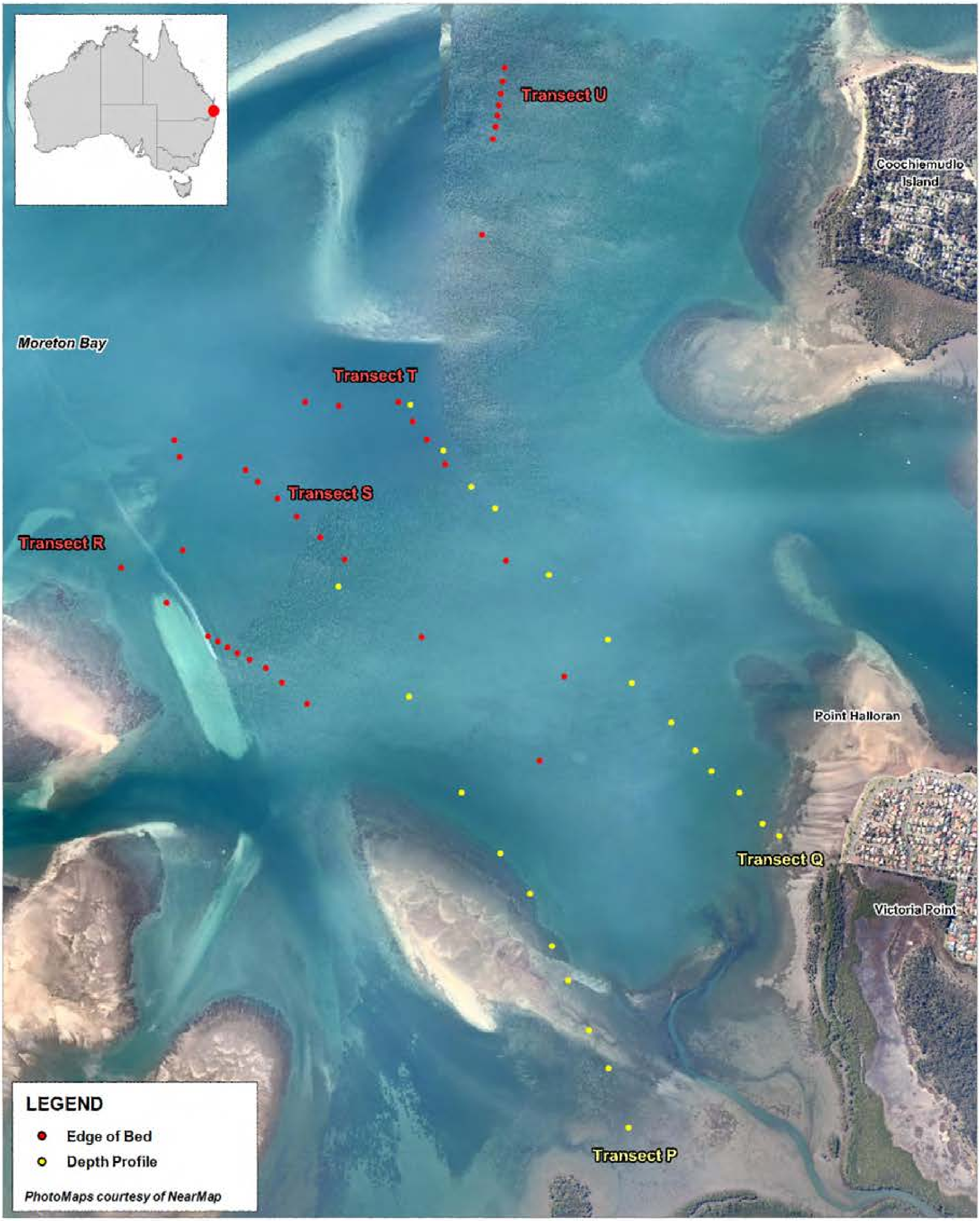

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Survey Points Used to Map the Distribution of Seagrass Adjacent to Cleveland

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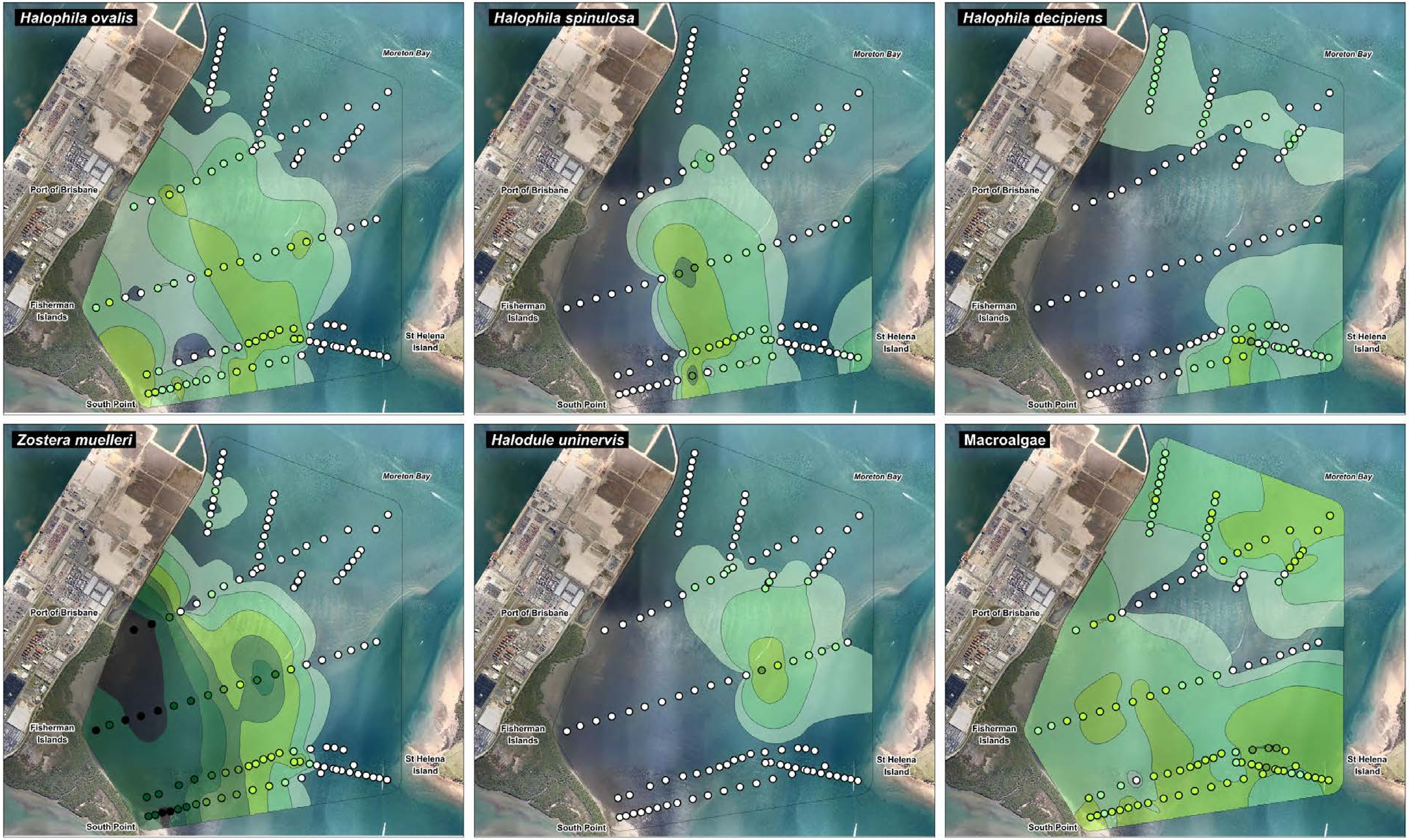
3 Results

3.1 Seagrass Species Distribution Mapping

Seagrass species encountered during the 2014 surveys were consistent with those observed in previous years, namely *Halophila ovalis, Halophila spinulosa, Halophila decipiens, Halodule uninervis* and *Zostera muelleri.*

Maps showing the spatial distribution of *H. ovalis, H. spinulosa, H. decipiens, Z. muelleri, H. uninervis* and total macroalgae are shown in Figure 3-1 to Figure 3-3. A composite seagrass community map at the Port of Brisbane location is shown in Figure 3-4. General findings from this mapping were broadly consistent with previous monitoring events and show that:

- *Zostera muelleri* formed dense beds in the intertidal zone at the landward edge at each location and often extended slightly into the shallow subtidal. Intertidal beds were comprised largely of dense mono-specific stands of *Z. muelleri* with occasional patches of *H. ovalis*. Subtidal beds were usually mixed with other species, including *H. ovalis, H. spinulosa* and *H. uninervis.*
- Species of the genus *Halophila* tended to form deeper subtidal communities at the seaward edge of *Zostera* dominated seagrass beds at each of the survey locations.
- The distribution of *Halophila ovalis* was more limited this year than it has been previously although this species still occupies a wide habitat range at the Port, being distributed from shallow intertidal (mixed with *Z. muelleri*) to deep subtidal.
- *Halophila decipiens* and *H. spinulosa* broadened their depth range at Manly, Cleveland and the Port but still tended to occur at the greatest densities in the deeper subtidal zone.
- *H. uninervis* was present in shallow subtidal areas at Fisherman Islands and Cleveland. *Halodule uninervis* was not recorded at Manly.
- Macroalgae was widely distributed at all sites but had greatest densities at Cleveland and Manly.



LEGEND

Coverage %

- 0
- < 1
- 1 to 5
- 5 to 15
- 15 to 25
- 25 to 50
- 50 to 75
- > 75

Survey Site

PhotoMaps courtesy of NearMap

Title:

Species Distributions at Fisherman Islands, adjacent to the Port of Brisbane in 2014

Figure **3-1**

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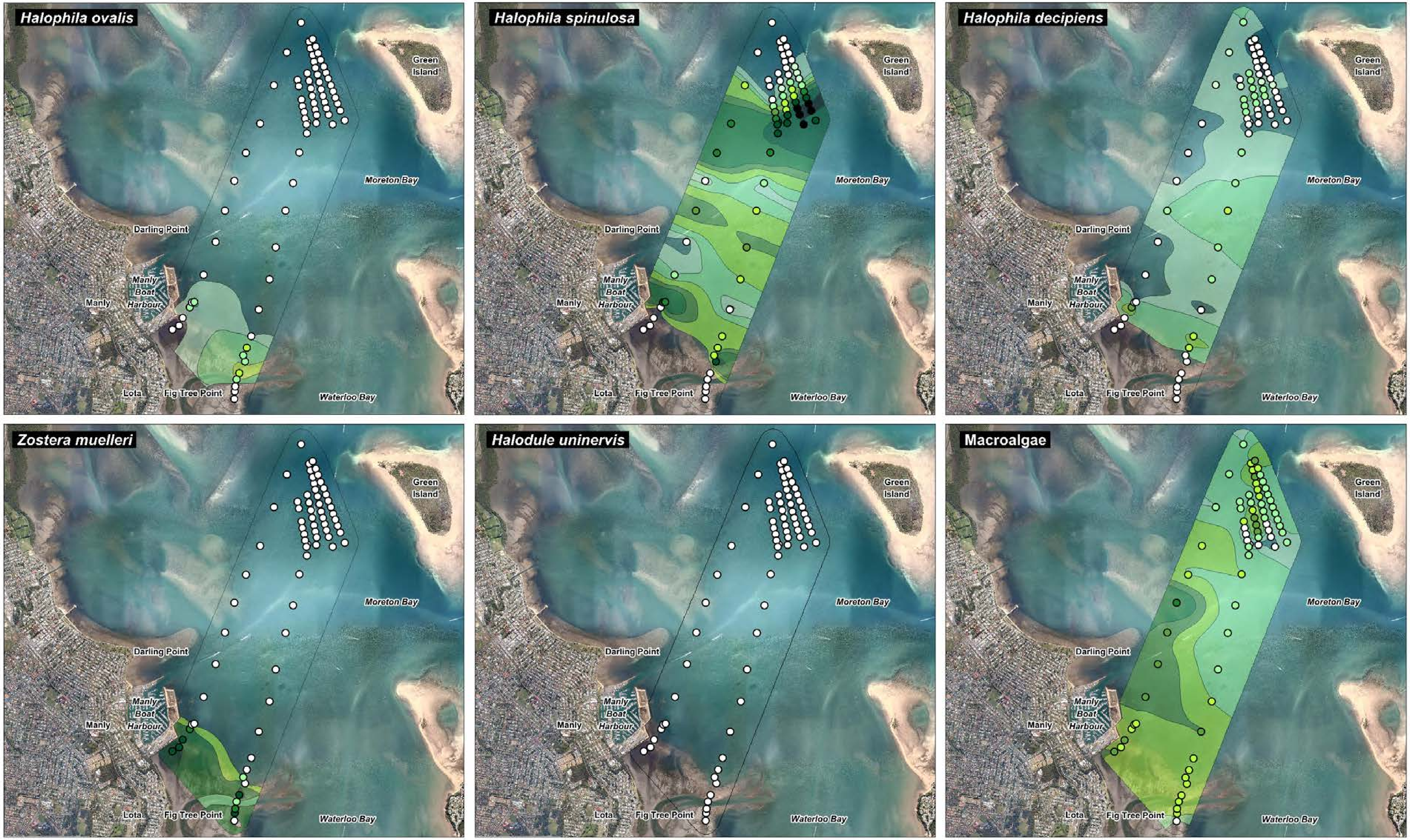

LEGEND

Coverage %

- 0
- < 1
- 1 to 5
- 5 to 15
- 15 to 25
- 25 to 50
- 50 to 75
- > 75

Survey Site

PhotoMaps courtesy of NearMap

Title:

Species Distributions at Manly in 2014

Figure: **3-2**

Rev: **A**

N

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Approx. Scale

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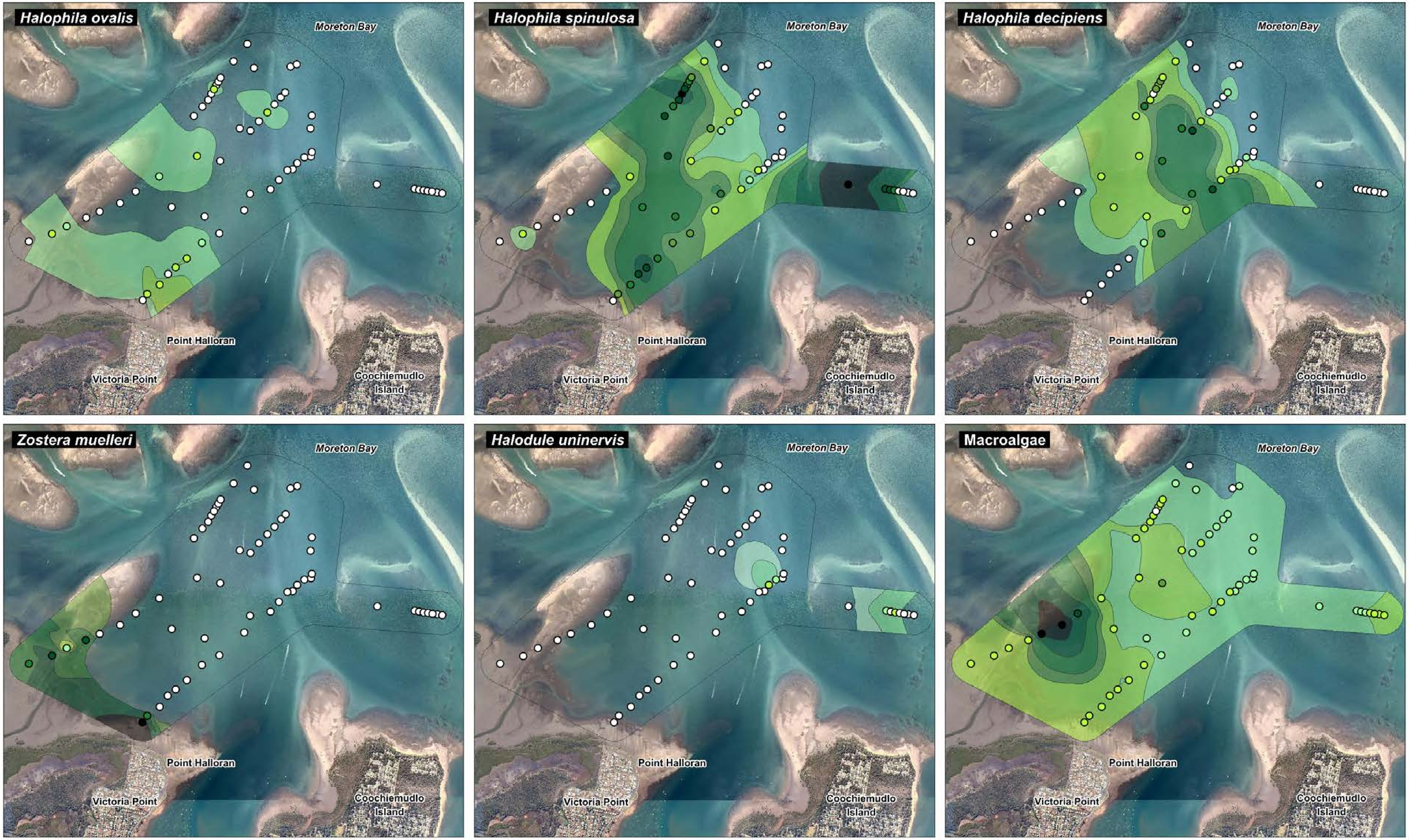

LEGEND

Coverage %
- 0
- < 1
- 1 to 5
- 5 to 15
- 15 to 25
- 25 to 50
- 50 to 75
- > 75

Survey Site

PhotoMaps courtesy of NearMap

Title:
Species Distributions at Cleveland in 2014

Figure 3-3

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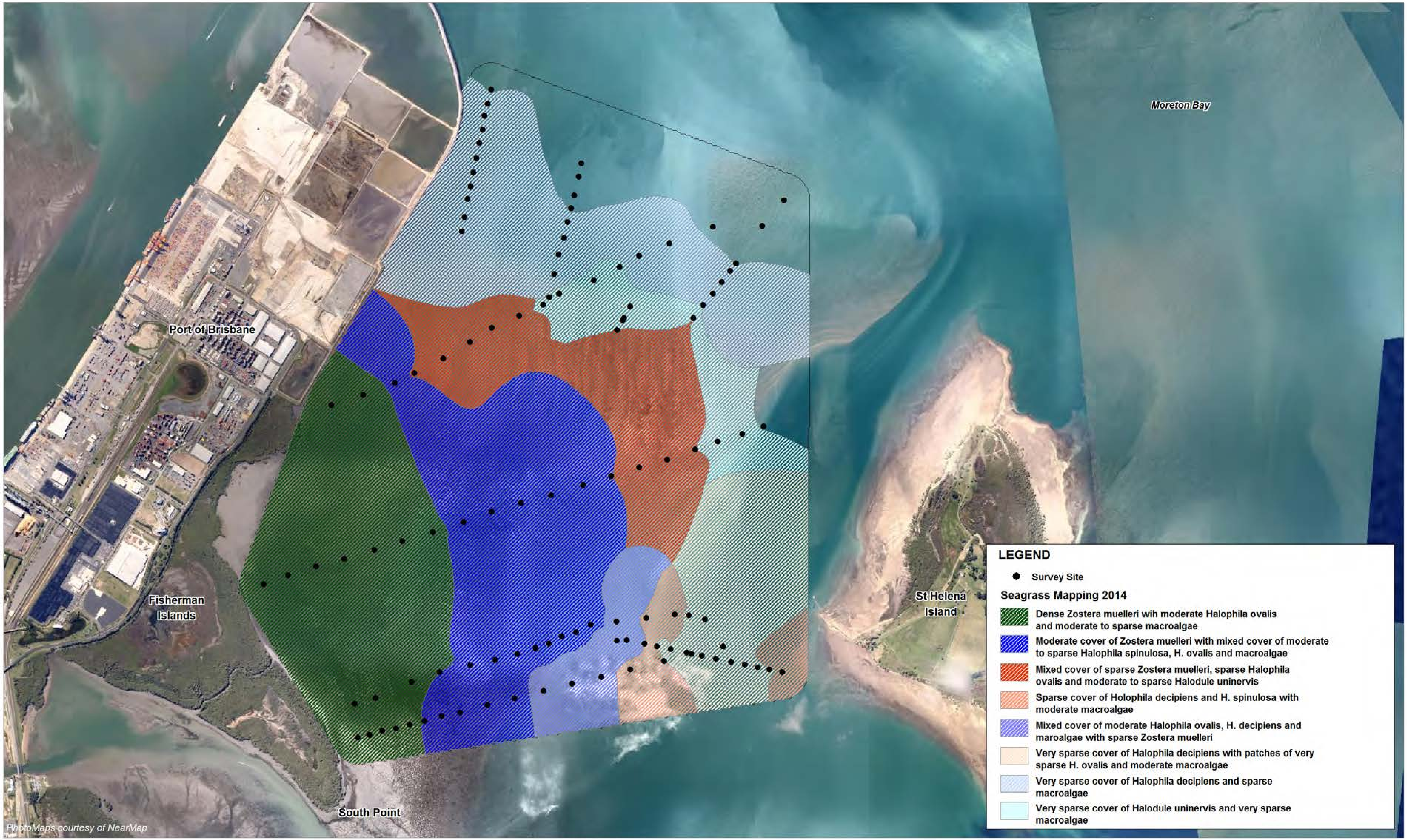

Title:

Seagrass Distribution and Community Structure Adjacent to Port of Brisbane in 2014

Figure 3-4

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3.2 Seagrass Depth Profiles

Figure 3-5 to Figure 3-10 are pictorial representations of seagrass assemblages along depth profile transects. Spatial and temporal patterns are discussed below.

3.2.1 Spatial Patterns in 2014

Key patterns in the species distributions of marine vegetation along the depth profiles during the August 2014 monitoring episode are as follows:

- *Zostera muelleri* was present on all depth profiles but was confined to intertidal and shallow subtidal sections of these transects. The distribution of *Z. muelleri* at Fisherman Islands was wider than at Manly or Cleveland, mostly due to the shallow gradient which occurs at this site resulting in a much wider spatial distribution for a given depth range.
- At Fisherman Islands *H. ovalis* occurred in mixed beds with *Z. muelleri* in intertidal and shallow subtidal areas and with *H. decipiens*, *H. spinulosa* and *H. uninervis* in deeper subtidal areas up to -2.43m AHD.
- At Cleveland and Manly the distribution of *H. ovalis* across the depth profiles was limited to intertidal and shallow subtidal areas except for some sparse meadows occurring in depths up to -4.83 m AHD at Cleveland.
- At Fisherman Islands *H. spinulosa* occurred in moderate depths up to -2.43m AHD while the distribution of this species was much broader at Manly and Cleveland. At Manly *H. spinulosa* occurred from shallow subtidal areas, along the length of both depth profiles to -3.93m AHD while at Cleveland it was present up to depths of -4.83m AHD. *H. spinulosa* not only occurred to greater depths at Manly and Cleveland but was also present at much higher densities compared with Fisherman Islands.
- The distribution of *H. decipiens* was similar to that of *H. spinulosa* at Manly and Cleveland, although it did not occur at the same densities as *H. spinulosa*. At Fisherman Islands *H. decipiens* occurred in deeper areas than *H. spinulosa* but was more confined to these areas and occurred only sparsely.
- *H. uninervis* was also limited to moderately deep subtidal regions at Fisherman Islands where it occurred in mixed beds with *H. ovalis* and *H. spinulosa*. *H. uninervis* did not occur at Manly but was seen in shallow to moderate depths at Cleveland, mostly in the area to the north of Coochiemudlo Island.
- Macroalgae was widely distributed at all study sites, but was denser at Manly and Cleveland than at Fisherman Islands.

3.2.2 Temporal Patterns

3.2.2.1 Differences in Temporal Patterns among Locations

Each profile is compared to previous seagrass depth profile surveys conducted in July 2006, July 2010 and August 2013. Further comparisons with surveys from May 2003 are also made in previous monitoring reports (BMT WBM 2013). Maps showing the composition of seagrass communities at each sample location for 2014 are displayed in Figure 3-1 to Figure 3-4.

Maximum recorded growing depths of seagrass species[2] at each monitoring location are displayed in Table 3-1. The greatest growing depths were typically recorded during the 2010 survey where favourable conditions saw an expansion in the range and depth of meadows at all sites compared with previous years (BMT WBM 2010). Despite this, there have been small increases from 2010 levels in the maximal growing depth of *H. decipiens* and *H. spinulosa* observed in the present survey at Fisherman Islands and Cleveland (Table 3-1). Table 3-1 also shows that there has been a large decrease in the maximum growing depth of *H. ovalis* at Manly and Cleveland but that the maximum growing depth of *H. ovalis* at Fisherman Islands has remained relatively constant.

In 2013 and 2014, here was an increase in the maximum growing depth of *H. decipiens* and *H. spinulosa* at Cleveland, and *H. decipiens* at Fisherman Islands, while maximum growing depths of *H. spinulosa* and *H. decipiens* at Manly and *H. spinulosa* at Fisherman Islands remained consistent during this time. Maximum growing depth of *H. ovalis* declined at Cleveland and Manly, and remained consistent at Fisherman Islands.

These changes in the distribution of *Halophila* species represent a shift in community composition. There has been a differential change in the distribution of *Halophila* species at control locations compared with the putative impact site at Fisherman Islands but that the overall coverage of *Halophila* species throughout the study area remains high and has increased from 2013 at all locations.

Halophila decipiens and *H. spinulosa* remain the deepest growing species while *Z. muelleri* remains the most depth restricted species, being confined to intertidal and shallow subtidal areas only. *H. ovalis* continued to occupy the broadest depth range at Fisherman Islands but was confined to shallow environments at Manly and Cleveland.

[2] All depths in this document are in meters relative to Australian Height Datum (AHD)

Table 3-1 Comparison of maximum recorded growing depths of seagrass species from depth profiles at each location in 2010, 2013 and 2014. Maximum depths are shaded for *H. ovalis* (Ho), *H. spinulosa* (Hs) and *Z. muelleri* (Zm). *Halophila decipiens* (Hd) was not differentiated from *H. ovalis* in surveys before 2013[3] and so maximum growing depth for this species is only show for 2013 and 2014

Location	Transect	Seagrass Species	Max. growing depth 2010	Max. growing depth 2013	Max growing depth 2014
Cleveland	P	Ho	-6.4	-6.2	-4.8
		Hd		-5.1	-6.4
		Hs	-3.4	-3.5	-4.8
		Zm	-0.8	-0.6	-0.7
	Q	Ho	-6.2	-5.7	-2.7
		Hd		-4.6	-4.6
		Hs	N/A	-3.7	-4.0
		Zm	-1.5	-1.8	-1.4
Manly	J	Ho	-4.9	-4.5	-2.0
		Hd		-4.5	-4.4
		Hs	-4.0	-3.4	-3.4
		Zm	-2.3	-1.6	-1.5
	K	Ho	-8.8	-5.0	-2.1
		Hd		-5.0	-3.7
		Hs	-4.4	-4.0	-3.9
		Zm	-2.2	-0.4	-2.1
Port of Brisbane	F	Ho	-5.7	-2.2	-2.0
		Hd		N/A	-4.0
		Hs	-4.3	-2.2	-1.6
		Zm	-2.5	-1.8	-1.7
	H	Ho	-4.6	-2.5	-2.4
		Hd		-2.9	-5.1
		Hs	-2.3	-2.5	-2.4
		Zm	-2.3	-1.5	-2.4

[3] In previous surveys, video transects did not provide sufficiently detailed imagery to discern *H. ovalis* and *H. decipiens.* Given the similar ecology and morphology of these species, they were collectively referred to as *H. ovalis* in previous reports.

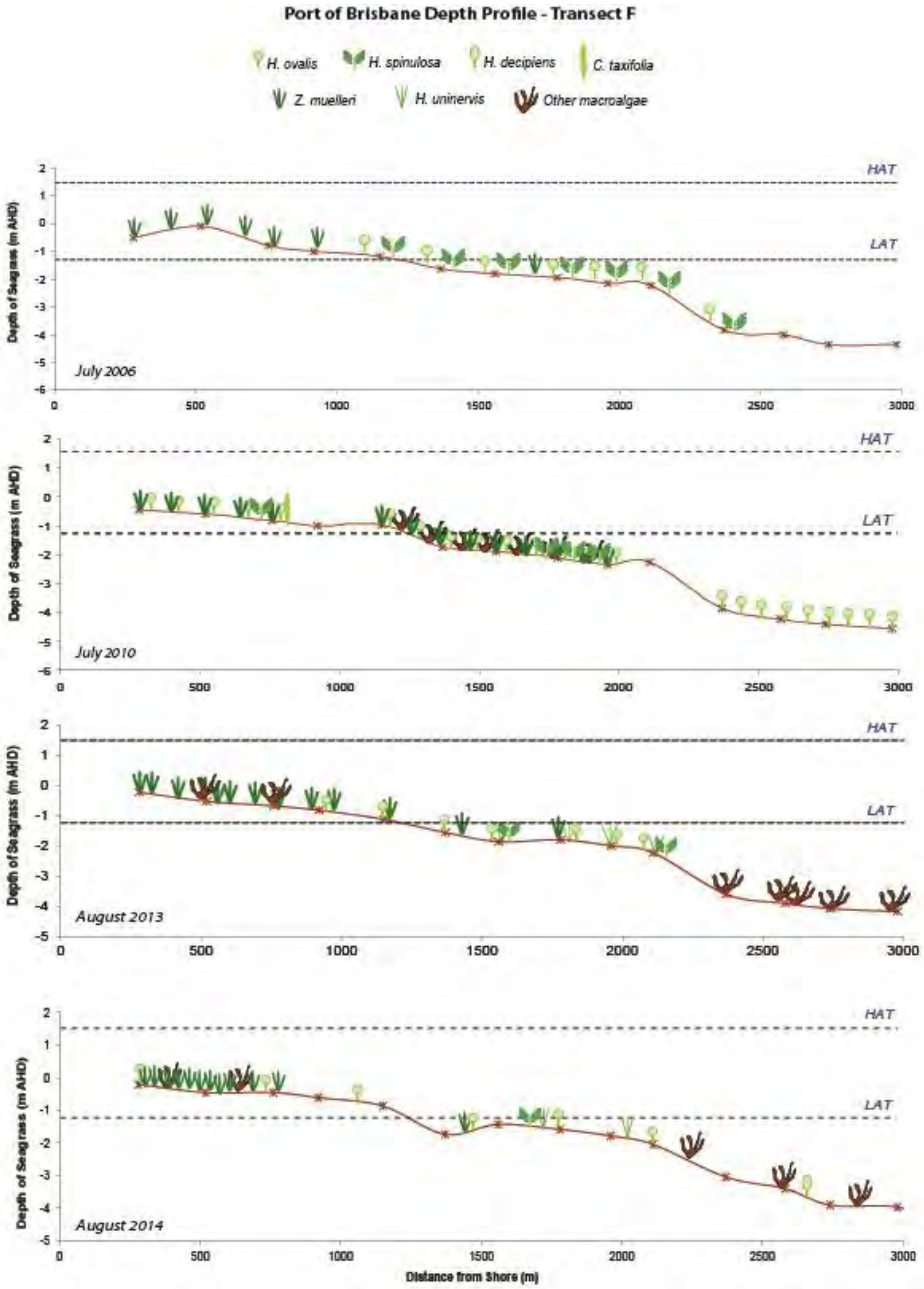

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Figure 3-5 Schematic representation of seagrass species distributions from 2010, 2013 and 2014 from depth profiling at Transect F at Fisherman Islands. Note that macroalgae was not studied in detail prior to July 2010

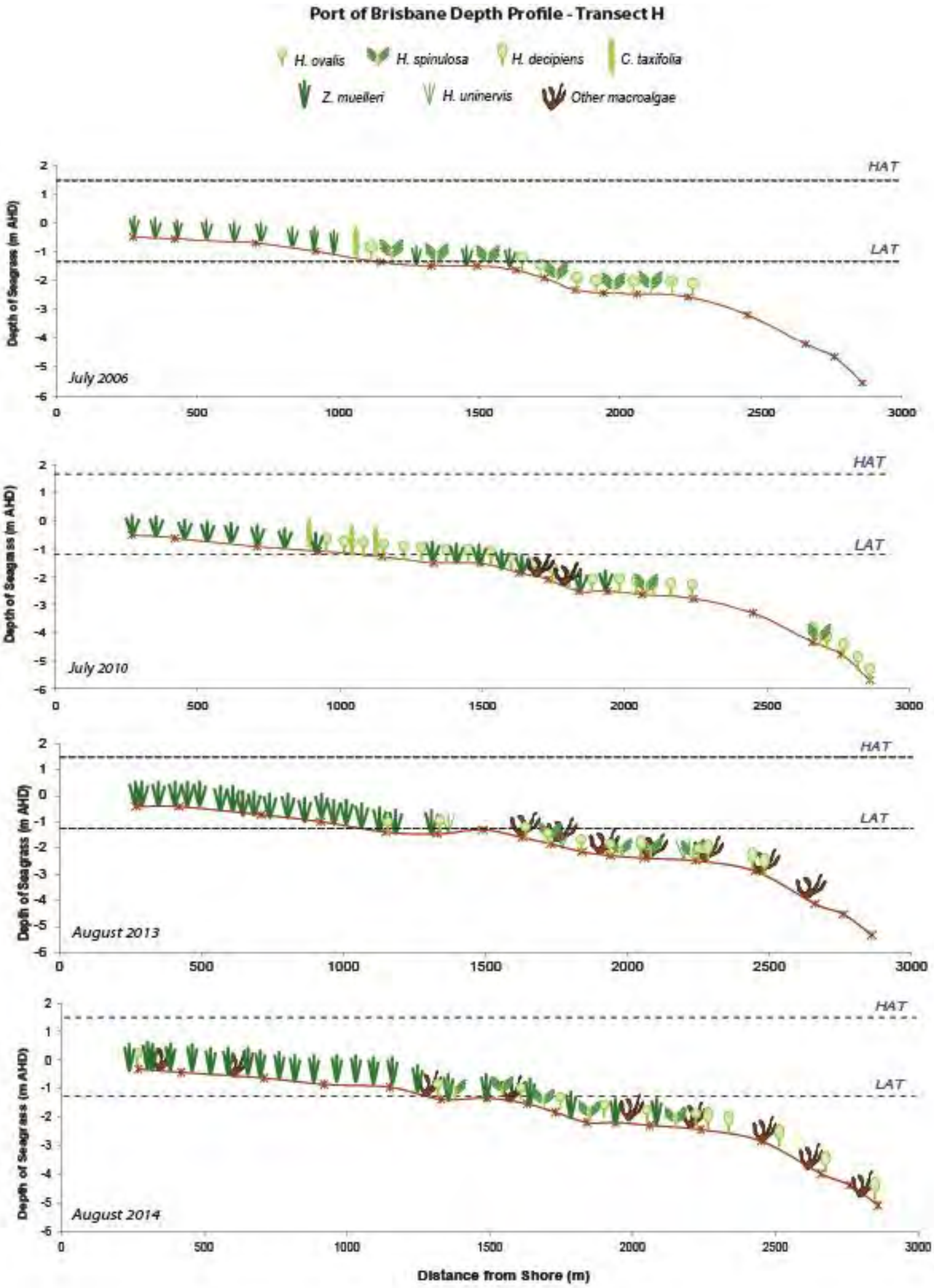

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Figure 3-6 Schematic representation of seagrass species distributions for 2006, 2010, 2013 and 2014 from depth profiling at Transect H at Fisherman Islands. Note that macroalgae was not studied in detail prior to July 2010

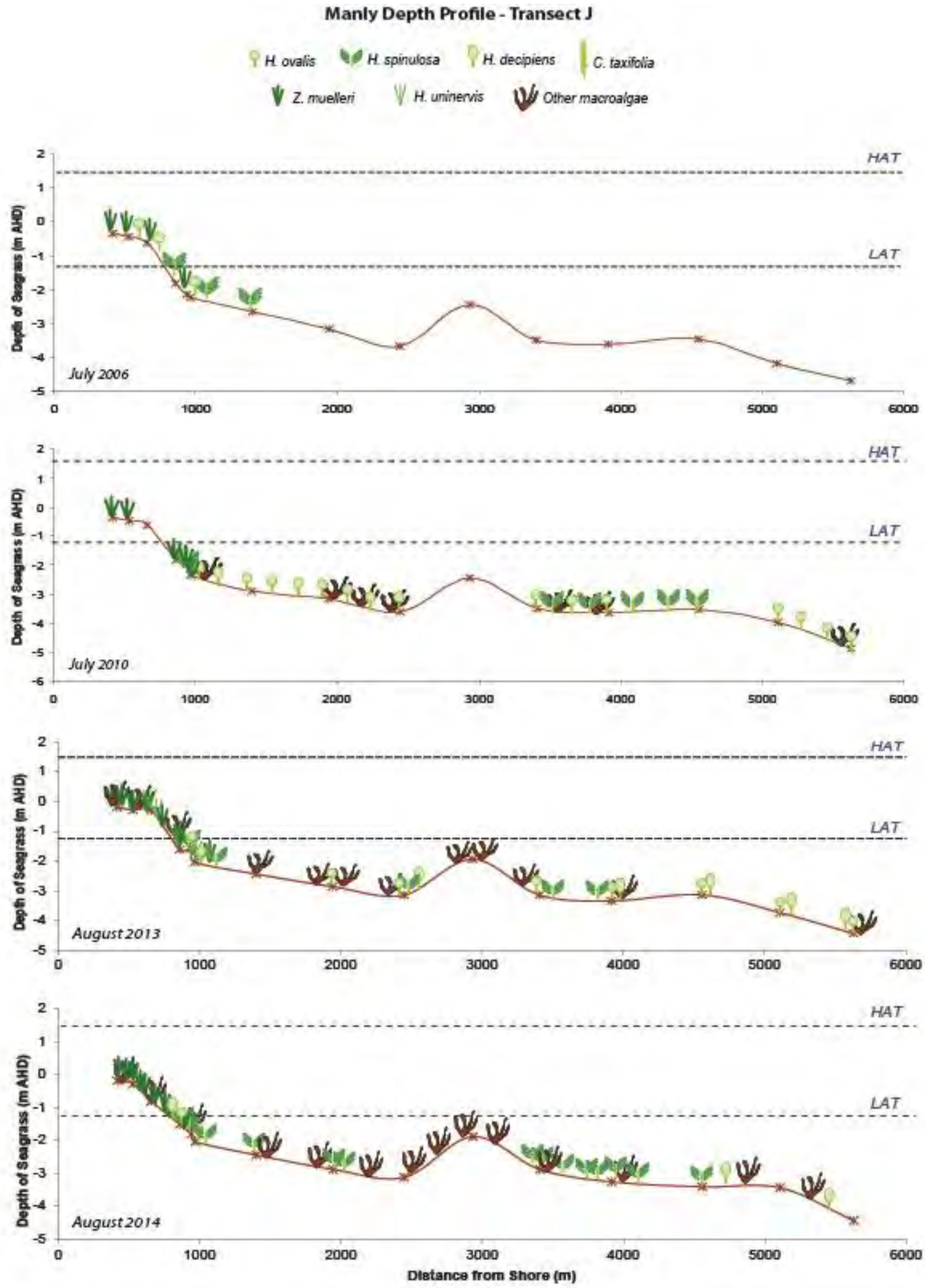

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Figure 3-7 Schematic representation of seagrass species distributions for 2006, 2010, 2013 and 2014 from depth profiling at Transect J at Manly. Note that macroalgae was not studied in detail prior to July 2010

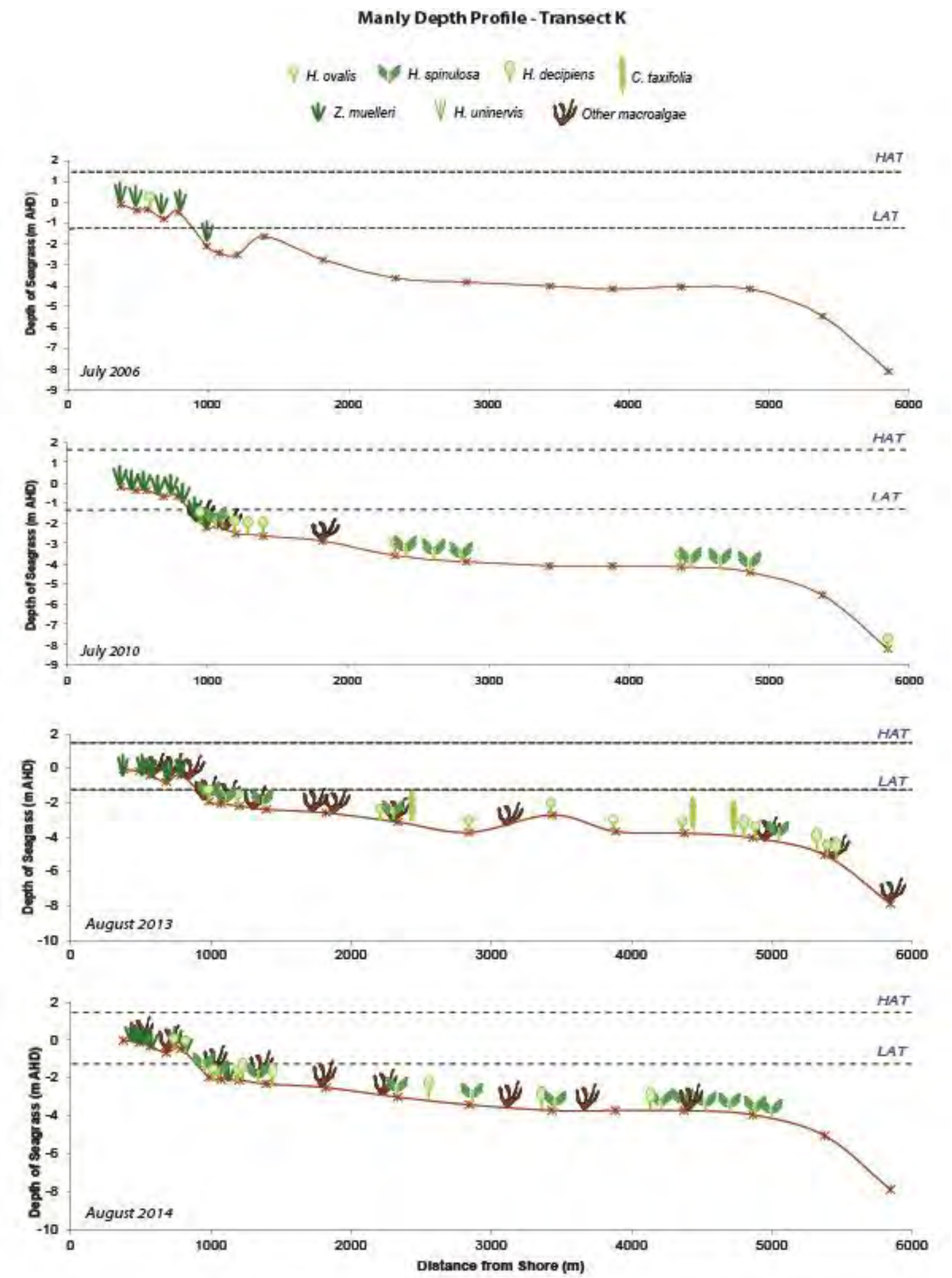

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Figure 3-8 Schematic representation of seagrass species distributions for 2006, 2010, 2013 and 2014 from depth profiling at Transect K at Manly. Note that macroalgae was not studied in detail prior to July 2010

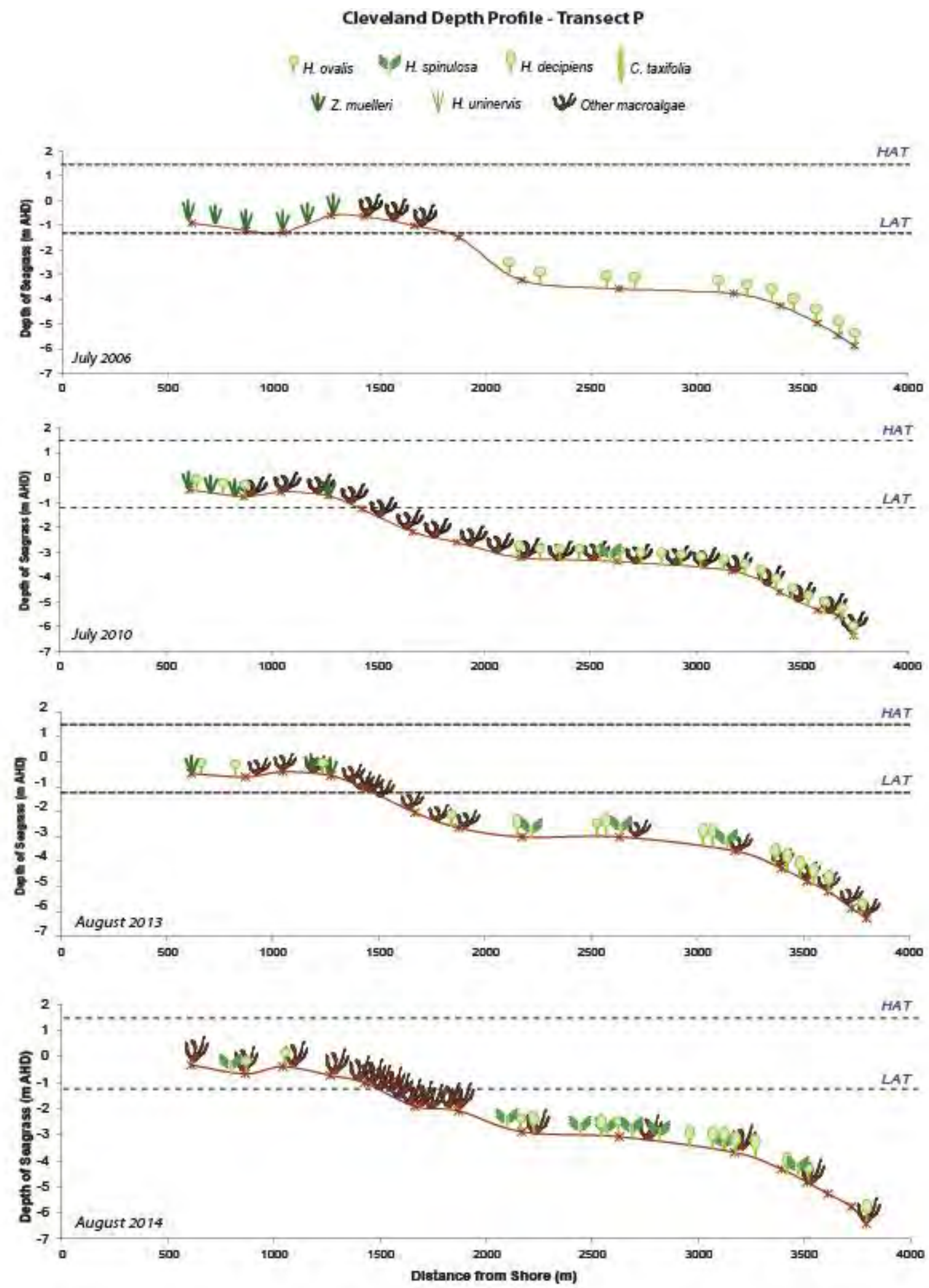

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Figure 3-9 Schematic representation of seagrass species distributions for 2006, 2010, 2013 and 2014 from depth profiling at Transect P at Cleveland. Note that macroalgae was not studied in detail prior to July 2010

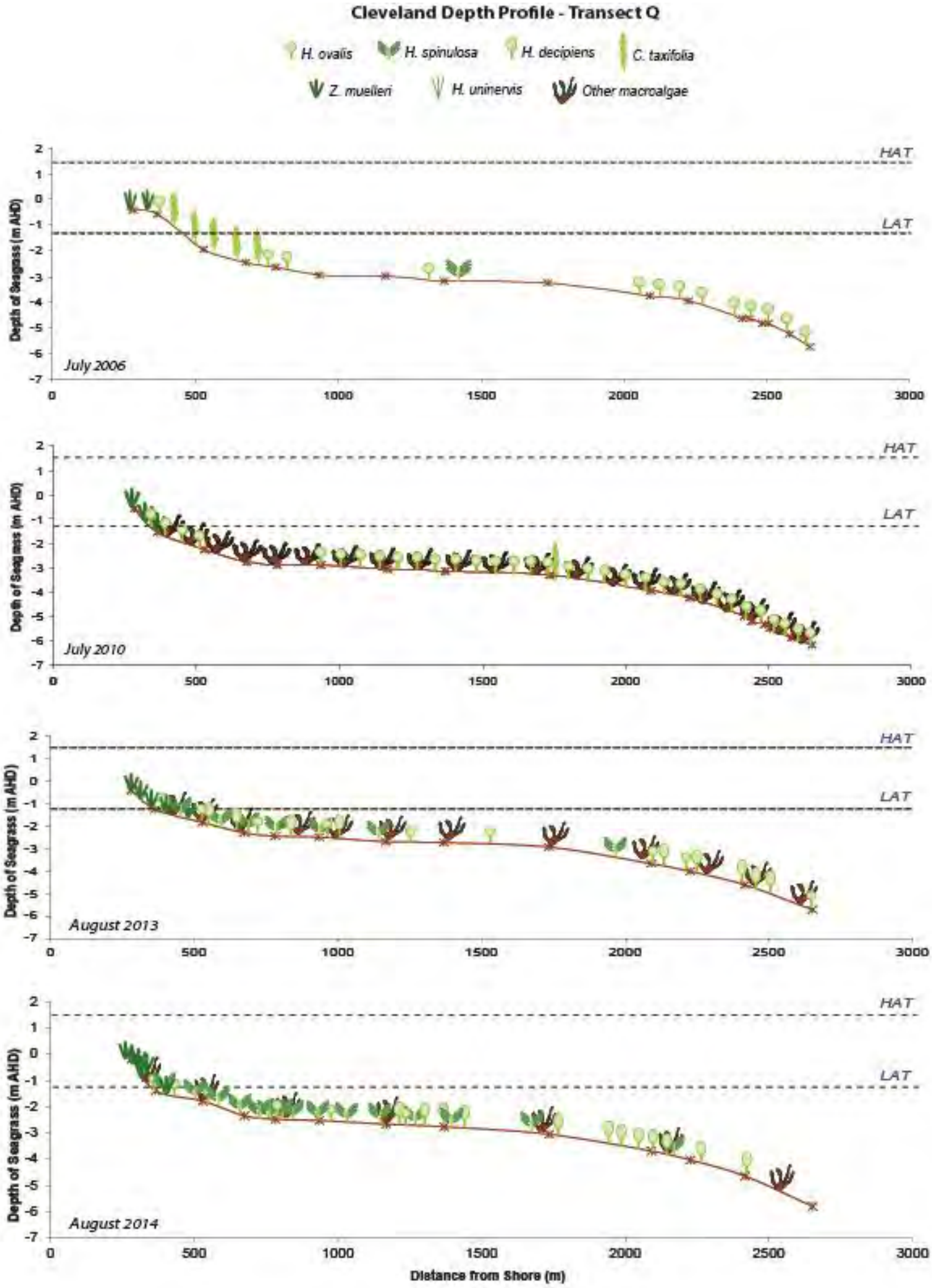

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Figure 3-10 Schematic representation of seagrass species distributions for 2006, 2010, 2013 and 2014 from depth profiling at Transect Q at Cleveland. Note that macroalgae was not studied in detail prior to July 2010

3.2.2.2 Temporal Patterns within Locations

Key temporal changes in the distributions of marine vegetation on individual transects are as follows:

- The maximum growing depth of *Z. muelleri* was less than that seen in 2010 at all locations except at Transect H (Fisherman Islands) where there was a modest increase from the maximal depth seen in 2010. This increase in growing depth at Transect H also represents a significant increase from the maximum depth from the previous years' monitoring (Table 3-1), along with a similar increase from 2013 at Transect K (Manly) and a minor increase at Transect P (Cleveland). However, only half of the depth profiles showed such increases in maximum depth from the previous year, with modest decreases in the maximal growing depth of *Z. muelleri* reported at Transect F (Fisherman Islands), Transect J (Manly) and Transect Q (Cleveland).
- Consistent with previous years, the most dense cover of *Z. muelleri* was in the intertidal areas where this species often formed mono-specific meadows (Figure 3-6) but it was also observed in mixed beds with *H. ovalis* and various macroalgae species (Figure 3-5; Figure 3-7 and Figure 3-8). In the shallow subtidal zone at Fisherman Islands survey site, *Z. muelleri* occurred as patchy to dense mixed beds with *H. ovalis*, *H. spinulosa* and macroalgae (most likely *H. mitchelliae* and *S. comosus*) (Figure 3-5 and Figure 3-6).
- Consistent with 2010 and 2013 results, *H. ovalis* continued to occur over a wide depth range at Fisherman Islands, occurring in mixed beds with *H. spinulosa* and *H. decipiens* in deeper waters (max depth -2.43m) and extending into mixed beds with *Z. muelleri* in the intertidal and shallow subtidal. However, there was a shift in numerical dominance in *Halophila* species at Manly and Cleveland with the distribution of *H. ovalis* becoming very limited (intertidal and shallow subtidal areas only) while *H. spinulosa* and *H. decipiens* have both undergone large increases in their distribution and density at these control locations.
- *H. uninervis* increased in its distribution along depth profiles at Fisherman Islands relative to 2010 and 2013, occurring in mixed beds with *Halophila* species. Hu did not extend into shallower subtidal meadows with *Z. muelleri,* consistent with 2013. *H. uninervis* did not occur previously at Cleveland but was seen in the present survey. In contrast *H. uninervis* did occur at Manly in 2013 but was absent from this site in the present survey.
- Various species of macroalgae were seen across all locations and all depths. Consistent with 2013, macroalgae was more widely distributed at Cleveland and Manly and was less dense at Fisherman Islands. The most common species of macroalgae identified in 2014 were consistent with previous years and include *Sporochnus comosus, Hypnea spinella, Spyridia filamentosa* and other filamentous alga comprising *Hincksia (Giffordia) mitchellae, Ectocarpus fasciculatus* and *Lyngbya majuscula* (see Figure A-2).

3.3 Edge of Seagrass Beds

The extent of the seaward (deep) edge of seagrass beds at Fisherman Islands, Manly, and Cleveland between May 2003 and August 2014 are shown in Figure 3-12 to Figure 3-14. Key findings of edge of bed monitoring for August 2014 and patterns over time are provided below:

- There was an overall extension of the maximum extent of seagrass meadows at Fisherman Islands in the 2014 survey compared with 2013 (Figure 3-12). The maximum extent of the seagrass meadow in 2014 was greater than all years except the peak in 2010, when excellent growing conditions saw a major increase in meadow extent.
- Edge of Bed location at Manly declined slightly since the previous survey (Figure 3-11) however there has been minor extension along some edge of bed transects. There was sparse seagrass cover at outer survey points of depth profile transect J (Figure 2-4, Figure 3-2) which made exact determination of the Edge of Bed position difficult, similar to 2013 surveys. There appears to have been broad consistency in the winter maximal edge of bed position at Manly in all survey years (see Figure 3-13) excluding those affected by the dramatic declines observed at this location in 2005 and 2006.
- At Cleveland, there was a minor expansion in edge of bed overall (Figure 3-11) with extension along some Edge of Bed transects and retraction along others. Overall however this location showed little variation in the edge of bed position over time.
- Transect E at Fisherman Islands traverses a boating channel. Seagrass distribution at this site is limited to very sparse and patchy cover of *H. decipiens* below 5.0m AHD in the channel but there is more consistent coverage above 5.0m AHD on either side of this channel.

In looking at longer-term changes in maximum growing depth of seagrasses (see Figure 3-11), there are several key points to consider.

- There were differences in the timing of seagrass surveys, with winter/early spring sampling occurring post-2005, and autumn sampling in 2004-05.
- The Fisherman Islands (Port of Brisbane) maximum growing depth has been consistently shallower than the other two control sites.
- Temporal trends in maximum depth between Cleveland and Fisherman Islands have been very similar (Figure 3-11), suggesting that changes in maximum growing depth have been affected more by broad scale environmental changes occurring in Moreton Bay than from the activities of the Port.
- There was a significant decline in seagrass cover at Manly between the 2003 and the 2005 monitoring events which is thought to have been due to changes in local hydrological patterns at this site (BMT WBM 2010), independent of conditions at Fisherman Islands and Cleveland.
- Recovery at Manly was not noted until 2010. Seagrass at Manly stabilised in 2013 and has remained consistent in 2014.

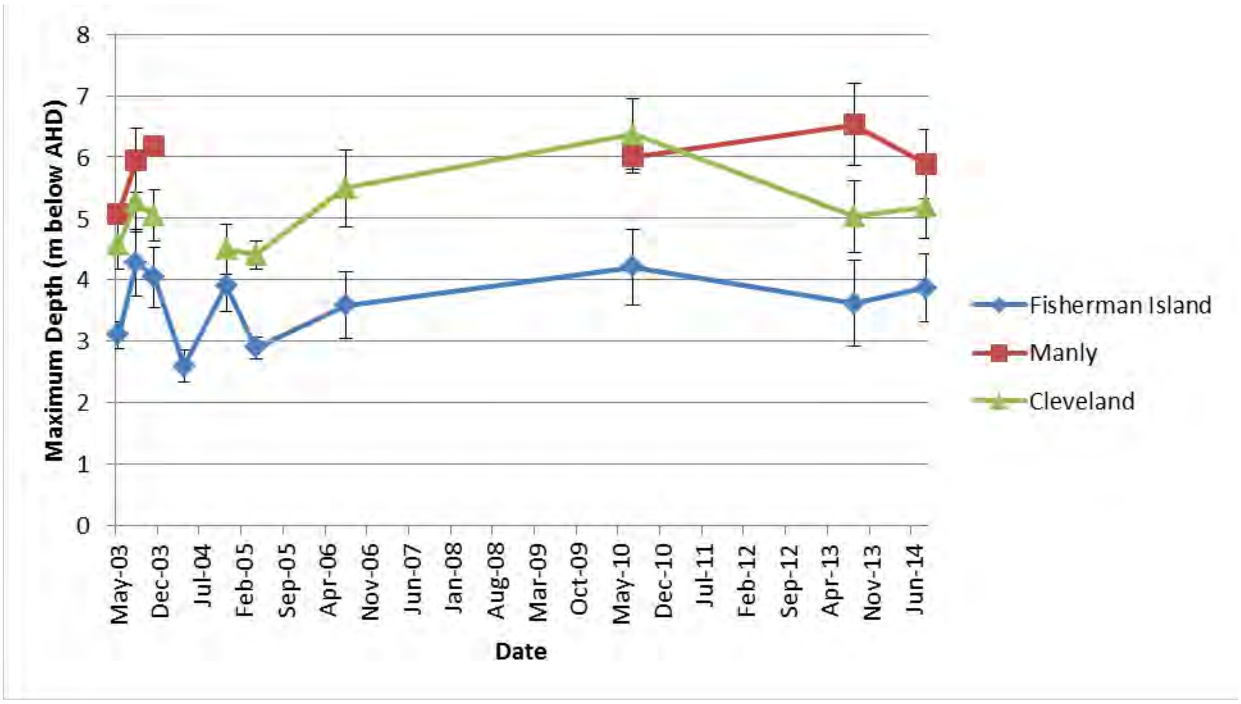
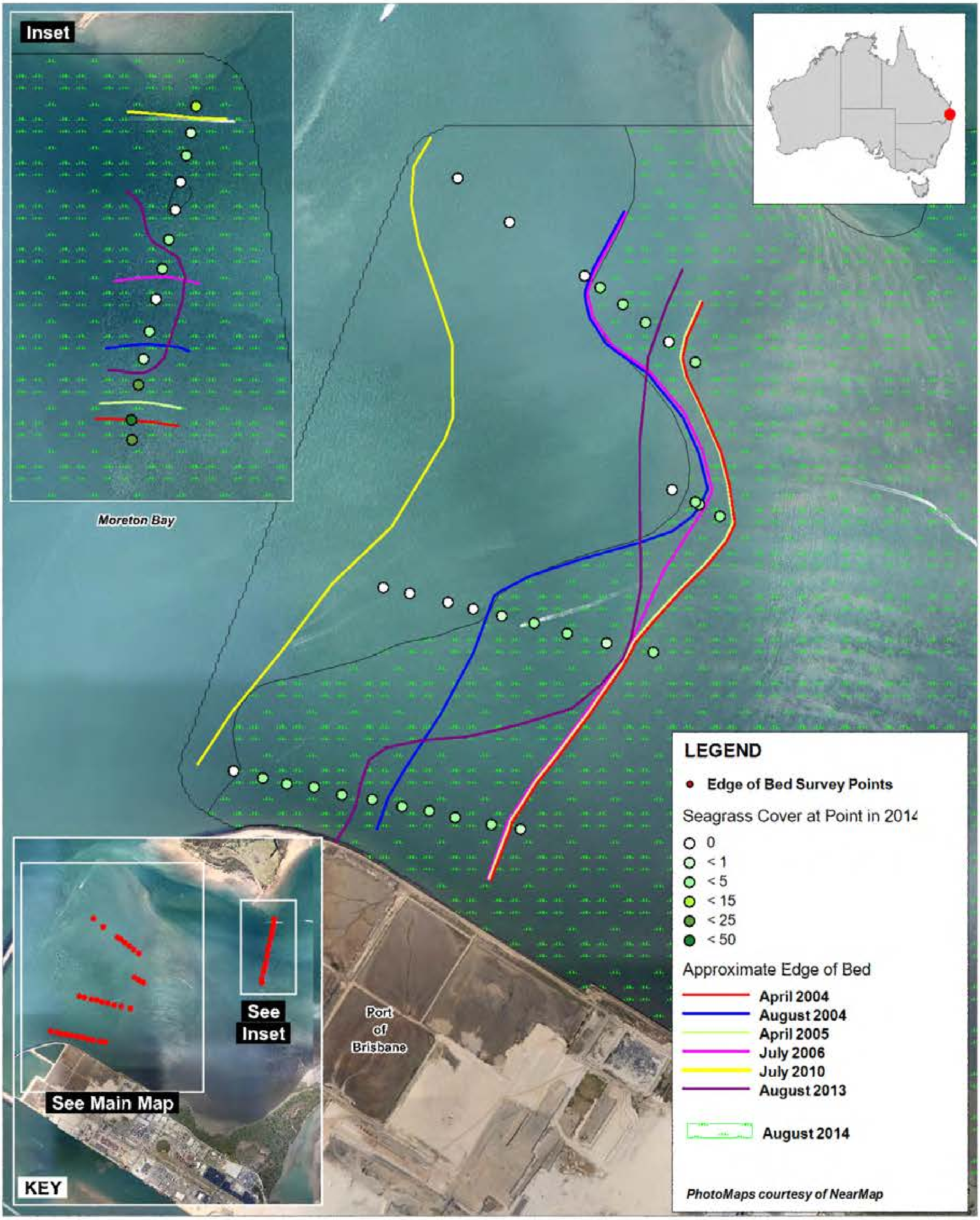


Figure 3-11 Mean (± SE) maximum depth at each location, where edge of bed transects are replicates



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Temporal Variation in Seagrass Edge of Bed Adjacent to Port of Brisbane

Figure: 3-12

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

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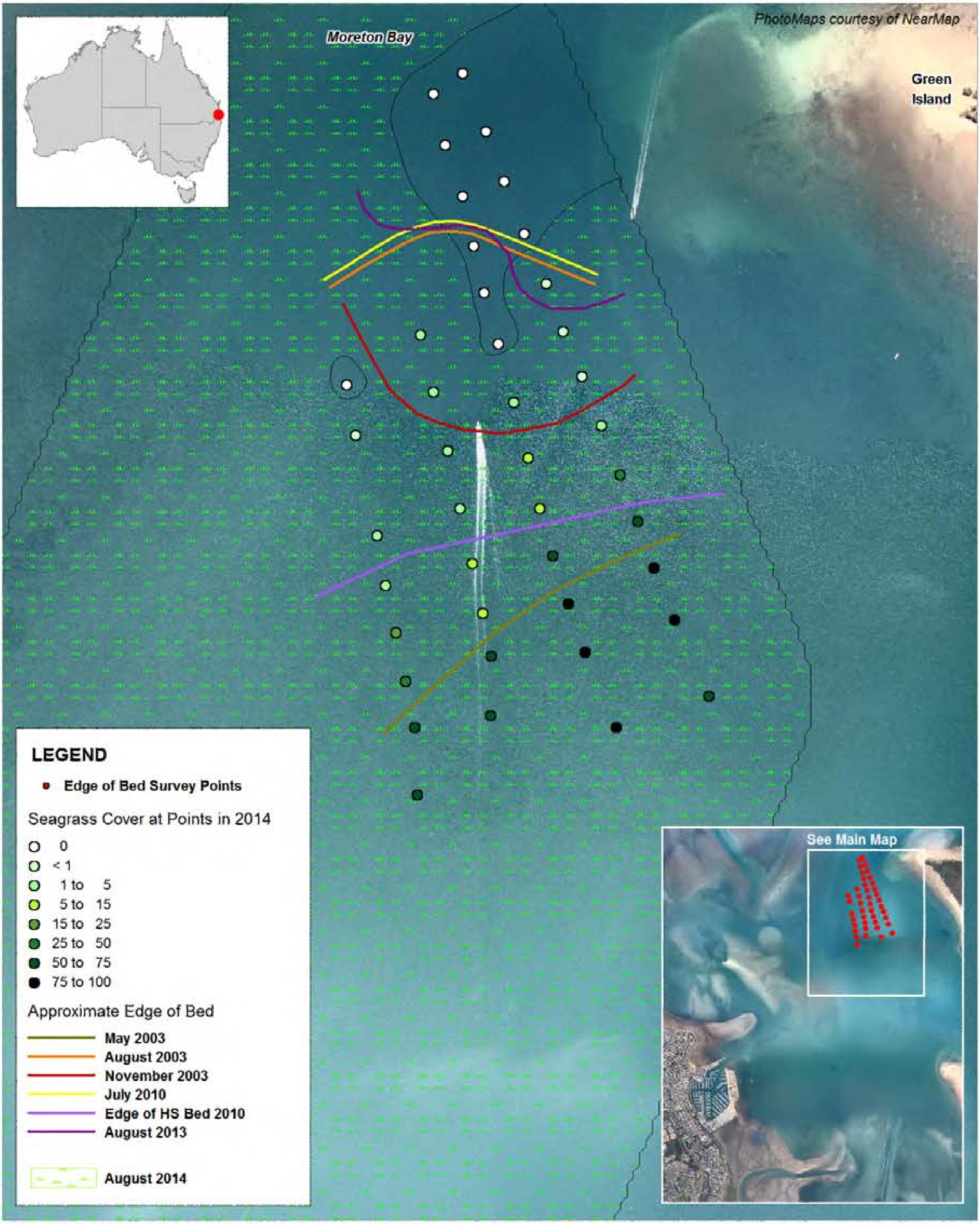

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Temporal Variation in Seagrass Edge of Bed Adjacent to Manly

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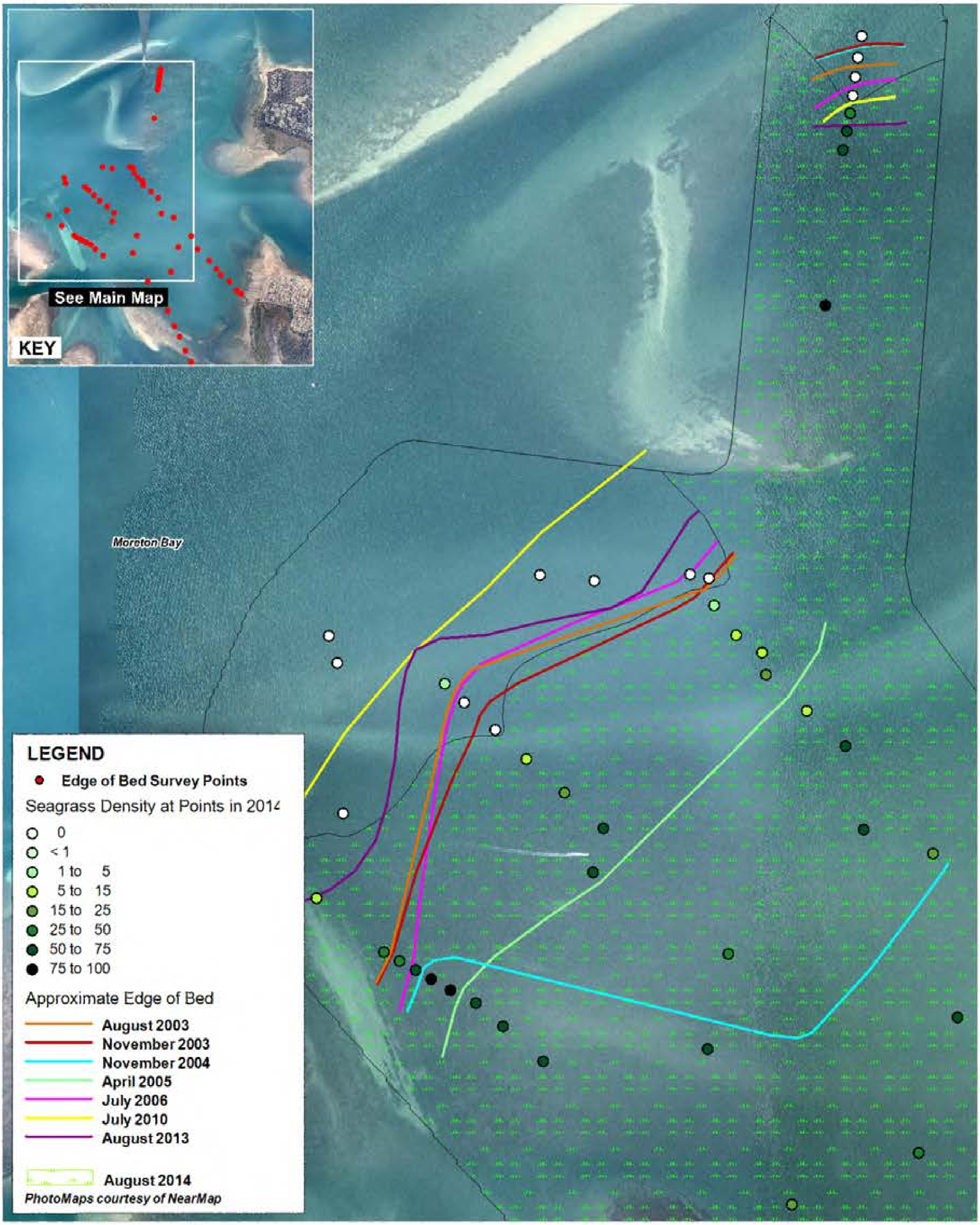

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4 Discussion

4.1 Spatial Patterns in Distribution

The distribution of seagrasses throughout the study area has been broadly consistent among sampling locations and over time. Six species of seagrass are known in Moreton Bay (Young and Kirkman 1975). Five of these species have been previously identified at Fisherman Islands, Manly and Cleveland through the Port of Brisbane seagrass monitoring program. All five of these species where recorded in the present survey.

A range of environmental conditions control the extent, distribution and abundance of seagrasses in Moreton Bay (Longstaff and Dennison 1999). These factors include light availability, sediment condition and type, nutrient availability, water motion, and grazing, as well as different growth strategies and tolerances to exposure of the seagrasses themselves. Different combinations of these factors are responsible for the different distributions that are seen throughout the Port of Brisbane seagrass monitoring area.

The key processes controlling spatial patterns at broad spatial scales (measured in kilometres to 10s of kilometres) will include:

- Substrate depth and sediment type - Fisherman Islands has broad intertidal and subtidal sand and mud banks, which have gently sloping bathymetric profiles and consistent gradients in sediment particle size with depth. These physical habitat conditions have allowed the development of extensive *Zostera muelleri* meadows at Fisherman Islands. By contrast, Manly and Cleveland does not contain broad shallow mud banks, and benthic habitats are more diverse including coral rubble banks, mud and sand banks, and steep sided boating channels. Consequently, seagrass meadows at these two control locations are smaller in area and tend to be more patchy and fragmented.

- Water quality conditions - Bramble Bay has excellent water quality conditions (BMT WBM 2014), which have allowed the development of extensive seagrass meadows at all three locations. Since the commencement of the monitoring program, Fisherman Islands has had a lower maximum seagrass depth range than the other two monitoring locations. This could suggest that turbidity is greater at Fisherman Islands than the other two locations (e.g. Abal and Dennison 1996), although other processes may also be important. Given its close proximity to the river mouth, it is likely that Fisherman Islands would be more influenced by turbid discharges from the Brisbane River than the other two locations.

- Physical disturbance by currents, waves and boat wash - these processes can lead to plant removal and burial by sediment, and complex changes in community structure in space and time. Consequently, seagrass is restricted to relatively quiescent (sheltered) nearshore areas within the study area. As discussed in Section 4.2, it is hypothesised that reclamation activities at Fisherman Islands has provided favourable hydrodynamic conditions for seagrass meadows at this location.

These processes also control patterns in community structure within locations. In particular, the changes to seagrass community structure with depth are to a large extent controlled by differences in light requirements among species (Carruthers et al. 2002). It is hypothesised that the maximum seagrass depth distribution at Fisherman Islands is also controlled in part by hydrodynamic processes. The north-eastern boundary of seagrass meadows at Fisherman Islands is coincident with an area that experiences strong currents, as evidenced by large sand ripples here (Figure 4-1). Similarly seagrass is absent from the Aquarium Passage channel, possibly in response to greater depth but also strong currents at this location.

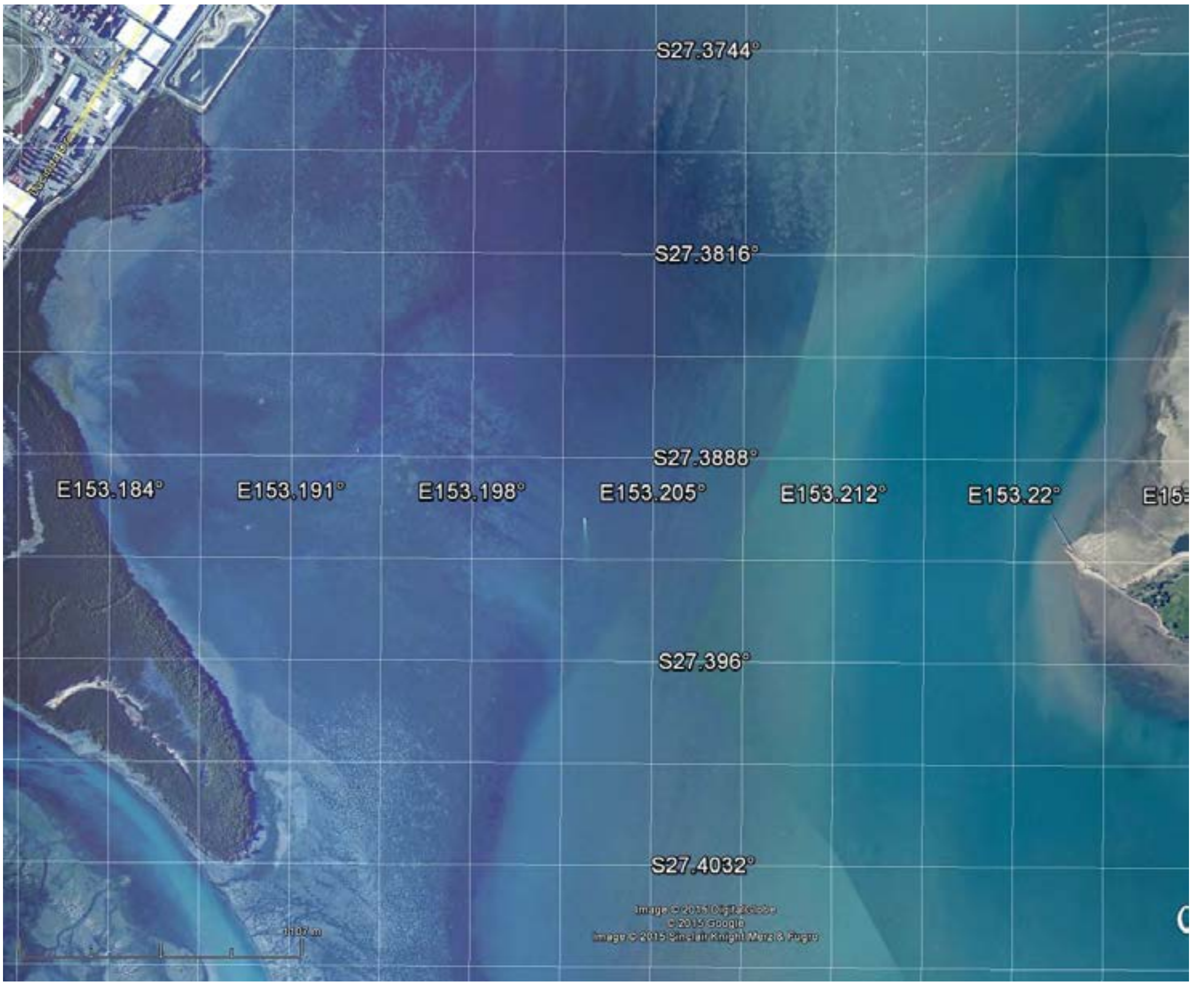

Figure 4-1 Northern boundary of seagrass meadows at Fisherman Islands (false colour imagery from PBPL - 2006)

4.2 Long-term Variations in Seagrass

4.2.1 Community Structure

Seagrass depth profiling has demonstrated that subtidal seagrass meadows at Fisherman Islands, Cleveland and Manly can show considerable change in composition measured over a range of time scales (seasonal, inter-annual). Mono-specific beds of *H. ovalis* can be replaced by mono-specific beds of *H. spinulosa*, and then form mixed assemblages with the two species combined months later. Changes of this nature have been documented elsewhere in Moreton Bay (Young and

Kirkman 1975). Dieback of *H. spinulosa* and concurrent expansion of *H. ovalis* has been observed at several Port of Brisbane seagrass depth profile sites previously (Table 4-1).

Intra-annual changes to the composition of shallow subtidal seagrass beds have been demonstrated in the present study, prior to 2005. These changes have occurred primarily between *H. ovalis, H. decipiens* and *H. spinulosa* but also in some instances with *Halodule uninervis* and the alga *C. taxifolia*. These changes have once again occurred in the present survey, with dieback of *H. ovalis* at Manly and Cleveland (Table 4-1) and expansion of *H. decipiens* and *H. spinulosa*. Although this represents a differential change in community composition between Fisherman Islands and the Manly and Cleveland control sites, overall growth at all sites has remained consistent. These changes represent an interesting event in the 2014 survey and for the monitoring program as a whole but they do not warrant concern given the previous occurrences of such changes elsewhere in the Bay (Young and Kirkman 1975), the presence of healthy seagrass meadows at all locations for the current survey and consistency with previous growth patterns at Fisherman Islands.

Table 4-1 Direction of change in maximum depth of seagrass between 2013 and 2014 surveys

Location	*Zostera muelleri*	*Halophila ovalis*	*Halophila decipens*	*Halophila spinulosa*
Fisherman Islands	↑↑ and ↔	↔ and ↓	↑↑↑ and ↑↑↑	↓↓ and ↔
Manly	↔ and ↑↑↑	↓↓↓ and ↓↓↓	↓↓↓ and ↔	↔ and ↔
Cleveland	↔ and ↓	↓↓↓ and ↓↓↓	↑↑↑ and ↔	↑↑↑ and ↑

↓ or ↑ = 0.1 to 0.5 m change; ↓↓ or ↑↑ = 0.6 to 1.0 m change; ↓↓↓ or ↑↑↑ > 1 m change

Bi-directional changes in community structure, (i.e. *H. spinulosa* dominating *H. ovalis* and vice versa) could be explained by the following key processes:

- Tolerance among seagrass species to seasonal nutrient loading, i.e. as a result of periodic catchment flows (e.g. Abal and Dennison 1996).
- The partial or complete removal of seagrass by marine megafauna (including dugong and turtle grazing) (e.g. Preen 1995). Subtidal seagrass beds at Fisherman Islands are suspected to provide feeding habitat to a significant population of green turtles and also dugong, although these animals are present in far fewer numbers than populations in eastern Moreton Bay (Lanyon and Morris 1997). Dugongs can remove a large proportion (up to 95%) of above and below ground seagrass biomass (Preen 1995), leaving distinctive feeding trails. These were observed from the surface at Fisherman Islands in previous survey events. Dugongs graze

extensively on *H. uninervis* and *H. ovalis* (Marsh *et al*. 1982). High growth rates may enable *H. ovalis* to persist under dugong grazing pressure.

- Periodic or seasonal light deprivation (e.g. Abal and Dennison 1996). The community response of seagrass beds to light deprivation may vary depending on the nature of the event (i.e. is it a pulsed or seasonal occurrence or longer-term changes to water quality) and the species of seagrass and its light requirements for growth.

Because seagrass depth distributions extend well into the subtidal zone, there has been no variation in the depth range of intertidal seagrass beds but there has been inter-annual variation in the extent to which these beds encroach into the subtidal zone. In 2014 and in previous years there have been fluctuations in the seaward encroachment of *Z. muelleri*, and the shoreward colonisation of *H. ovalis* and to a lesser extent, *H. spinulosa*. In 2014 *H. ovalis* was recorded well into the intertidal zone and *Z. muelleri* expanded its overall subtidal range at Fisherman Islands. Lee Long *et al*. (1993) suggested that *Z. muelleri* colonised intertidal areas due to its competitive advantage over other species with lesser tolerance to varying salinity. In Deception Bay, this species has been found growing in salinities of three parts per thousand (Young and Kirkman, 1975), while exposure to fresh water can cause considerable stress in *H. ovalis* (Ralph 1998). *Z. muelleri* may also be more tolerant to desiccation and thermal stress than other seagrasses in Moreton Bay.

4.2.2 Temporal Variations in Seagrass Extent

Despite temporal variation in seagrass composition, the overall spatial distribution of seagrasses at Fisherman Islands, Manly and Cleveland has been relatively stable over the monitoring period (2002-2014), with the exception of two major variations as detailed below. This result has been consistent with long-term LandSat comparisons of seagrass over the last 30 years (Lyons *et al*. 2012.) These comparisons show that there has been minimal change in overall seagrass extent throughout Moreton Bay, but that seagrass cover is extremely dynamic; there have been large scale migrations of higher seagrass cover and several sudden and significant changes in cover (Lyons *et al*. 2012).

There have been two major variations in seagrass extent observed throughout the monitoring period, one in 2004 which saw a major decline in seagrass at Manly and to a lesser extent Cleveland; and another in 2010 which saw an increase in seagrass extent across all monitoring sites. The decline observed at Manly in 2004 is thought to be due to local scale variation in water quality and growing conditions while an extended period of drought leading up to the 2010 monitoring event, along with improvements in water quality due to catchment improvement works, are likely to have resulted in a positive growing conditions leading up to the monitoring event in 2010. Apart from these fluctuations the edge of bed positions have remained relatively stable, particularly at Manly and Cleveland where constant positioning has been maintained in 2003, 2004, 2006, (not including Manly), 2013 and now in 2014.

There has been slightly greater variability in the maximum seagrass growing depth of bed at Fisherman Islands than at Manly and Cleveland. Potential improvements to growing conditions as a result of the FPE Seawall construction (see Section 4.3) as well as proximity to the Brisbane River mouth and associated turbidity and nutrient input are probably the main drivers of this variability. Light has been cited as the most important driver of seagrass distribution and extent in nearshore or estuarine environments (Abal and Dennison 1996; Collier *et al*. 2012; Chartrand *et al*. 2012; Dennison *et al*. 1993; Longstaff and Dennison 1999) and may also explain this patchiness. In addition, the slight bathymetric gradient at Fisherman Islands means that small changes in the light environment and vertical distribution of seagrass can be manifested as large changes in the associated horizontal distribution and greater apparent variability in edge of bed position.

Since 2010 there have been two major flood events in South East Queensland (early 2011 and 2013). These events represent pulsed disturbance on a large scale, resulting in medium to long-term changes to the light regimes and nutrient loads at these sites over a time period of weeks to months. Major reductions in seagrass extent were reported throughout Moreton Bay following these flooding events with unpublished data from CSIRO suggested that seagrass extent halved after the 2011 floods, but had recovered within 12 months. This is consistent with observations from the Port of Brisbane monitoring program where seagrass extent stabilised in 2013 following on from flood impacts. The 2014 survey event shows that seagrass meadows have continued to increase in spatial extent.

There is also evidence that there has been an overall expansion in seagrass meadows at Fisherman Islands and reduction in *Zostera* meadows at Manly over long timeframes (1987-present). For example, seagrass mapping by Hyland *et al.* (1988) (refer to Figure 4-2) shows that seagrass meadow extent at Fisherman Islands was far smaller than recorded in the 1992-1998 (WBM Oceanics 1998) and the 2000's (Figure 3-4). Seagrass mapping suggests that there has been both landward and offshore expansions in seagrass at Fisherman Islands between 1987/91 (i.e. prior to port expansion works in the 1990s) and 1998 (post port expansion works in the 1990's), as well as increases in maximum depth range of seagrass (WBM Oceanics 1998). By contrast, the once extensive *Zostera* meadows at Manly mapped by Hyland *et al.* (1988) have significantly declined in size over this period (see Figure 3-2). As discussed by WBM Oceanics (1998, 2000) mapping error, particularly in deeper waters, is likely to explain at least some of these differences in mapped seagrass extents.

4.2.3 Light Availability and Deep Water Seagrass Extent

Lee Long *et al.* (1993) showed that *Halophila* species were the deepest occurring seagrass species from surveys throughout Queensland. *Halophila* species are also common in deep water areas in Moreton Bay.

Halophila ovalis is one of the least tolerant species of seagrass to reductions in light availability (Longstaff *et al.* 1999), but it frequently colonises deep water areas during extended periods of clear water, or high light availability. As such, it is the most dynamic species in terms of its distribution, with declines occurring during sustained wind events and sediment re-suspension, events which are common in western Moreton Bay. Extended periods of light deprivation (i.e. greater than 1 month) can cause death, which probably explained some of the dieback periods witnessed earlier in the monitoring program and also the dramatic changes to meadow composition which have been witnessed this year. *H. spinulosa* and *H. decipiens* may be more tolerant to such changes and often undergo shifts with H. ovalis in Moreton Bay (Young and Kirkman 1975).

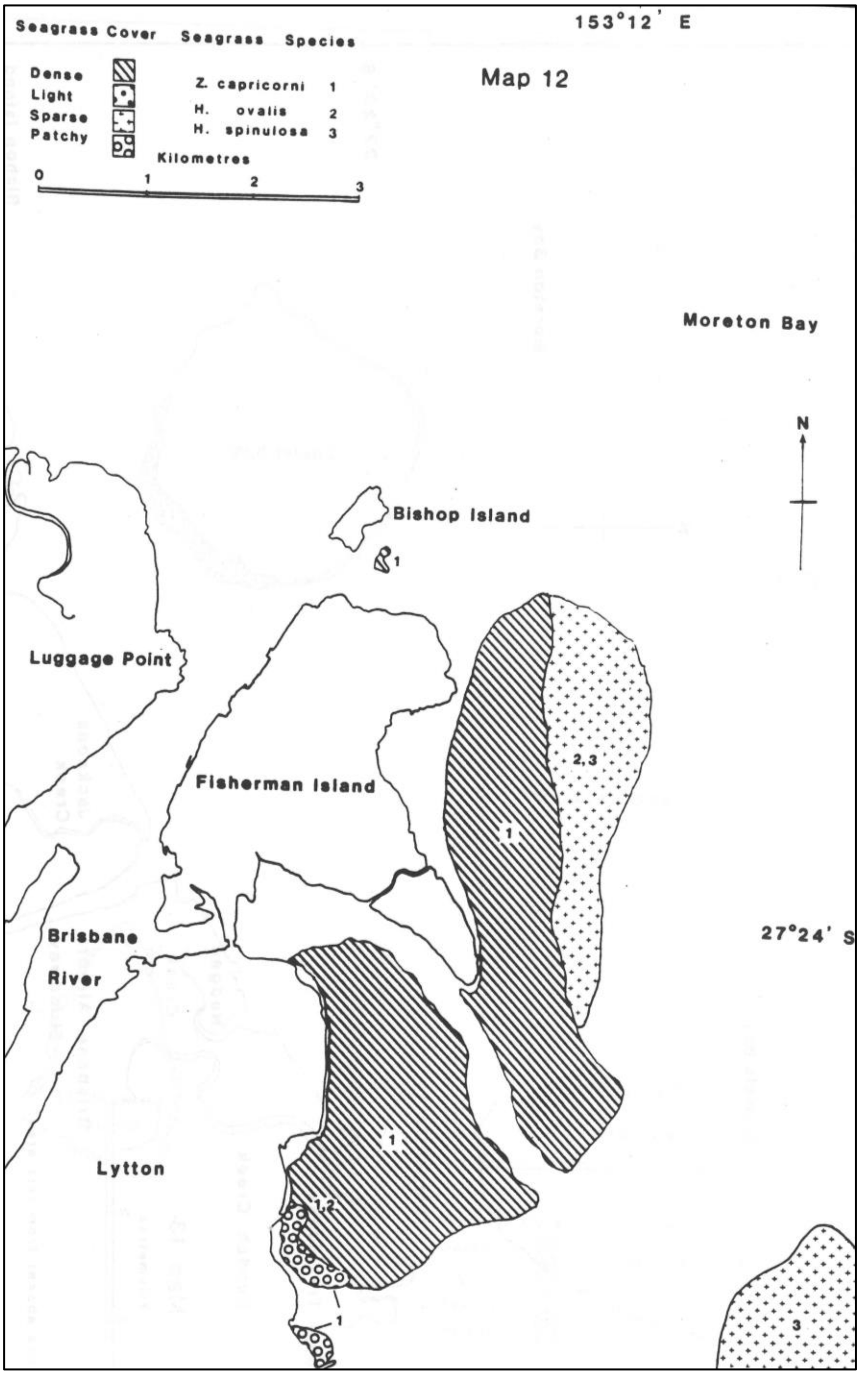

Figure 4-2 Distribution of seagrass at Fisherman Islands in 1987 (Hyland *et al.* 1988)

4.3 Impacts of the FPE Seawall

One of the original objectives of the Port of Brisbane seagrass monitoring program was to identify whether the FPE reclamation had affected seagrasses at Fisherman Islands. Consistent with previous observations and impact predictions of the Impact Assessment Study (WBM 2000), the FPE seawall is likely to have influenced hydrodynamic conditions at Fisherman Islands through the provision of:

- More protected conditions. Seagrasses immediately to the south of FPE Seawall are now more protected from wind generated waves and waves from the northwest and westerly directions than they were prior to construction.
- 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.
- Potentially greater sediment deposition. The more quiescent conditions adjacent to the FPE seawall may have resulted in localised increases in fine sediment deposition (BMT WBM 2010), although the extent to which this could enhance or adversely affect seagrass meadows is not known.

Since the completion of the FPE seawall in 2005 there was a period of high growth over the entire study area. The extent of seagrass and the depth to which it grew increased substantially between 2006 and 2010, and again in 2014. It is likely that the FPE seawall (together with historical reclamations) had a role in the seagrass expansion growth observed at Fisherman Islands during this period. However, given the widespread expansion of seagrass meadows observed across all monitoring locations since 2010, other processes operating at broad scales (measured in kilometres to 10's of kilometres) would ultimately control this long-term expansion.

5 Conclusions

The key findings of the 2014 survey are:

- There have been differential changes to meadow composition at Manly and Cleveland compared with Fisherman Islands between 2014 survey and 2013.
- There was an increase in seagrass meadow extent between 2013 and 2014 at Fisherman Islands. This followed a period of seagrass meadow expansion in 2010, and seagrass declines in 2011 and 2013, which were coincident with flooding events.
- The maximum depth and spatial extent of seagrass meadows, an indicator of ambient water quality (turbidity) conditions, was similar in 2014 and 2013, except an expansion in *Halophila decipiens* at Fisherman Islands and Cleveland, increased *Zostera* at Fisherman Islands and Manly, and decreases in several species at all locations.
- The seagrass monitoring program has detected changes to seagrass meadows at Fisherman Islands over time. These temporal patterns have been broadly consistent with results for sites distant (>5km) to the port and at control locations at Manly (prior to February 2004) and Cleveland.
- These observations suggest that the gross-scale changes in the extent of seagrass beds at Fisherman Islands were likely due to natural processes operating at spatial scales measured in tens of kilometres, rather than any localised impacts resulting from PBPL activities.
- It is likely that the FPE seawall may be continuing to play a role in the expansion of seagrass extent at Fisherman Islands through the provision of more protected conditions and/or greater separation from the adverse influences of the Brisbane River. However, given the widespread expansion of seagrass meadows observed across all monitoring locations since 2010, other processes operating at broad scales (measured in kilometres to 10's of kilometres) would ultimately control long-term expansion across the study area. Further investigations would be required to allow further conclusions regarding the influence of the FPE seawall on seagrass growth to be drawn.

6 References

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Appendix A Photo Plates

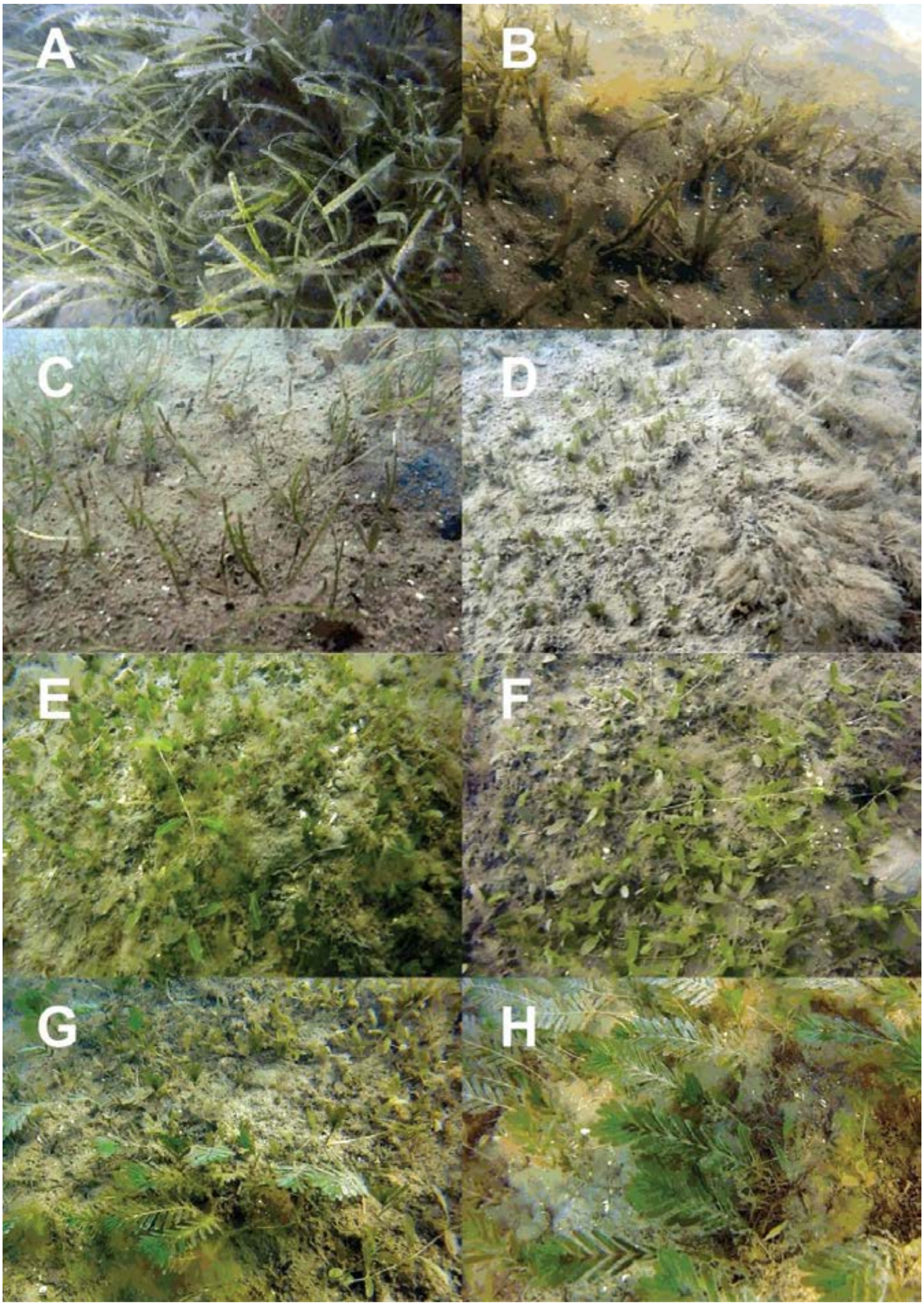


Figure A-1 Seagrass species: *Zostera muelleri* (A); *Z. muelleri* and filamentous algae (B); *Halodule uninervis* (C); *Halophila ovalis* with *Sporochnus comosus, Hypnea spinella* (D); *H. ovalis* and *Halophila decipiens* (E); *H. decipiens* (F); *H. decipiens* and *Halophila spinulosa* (G); *H. spinulosa* (H).

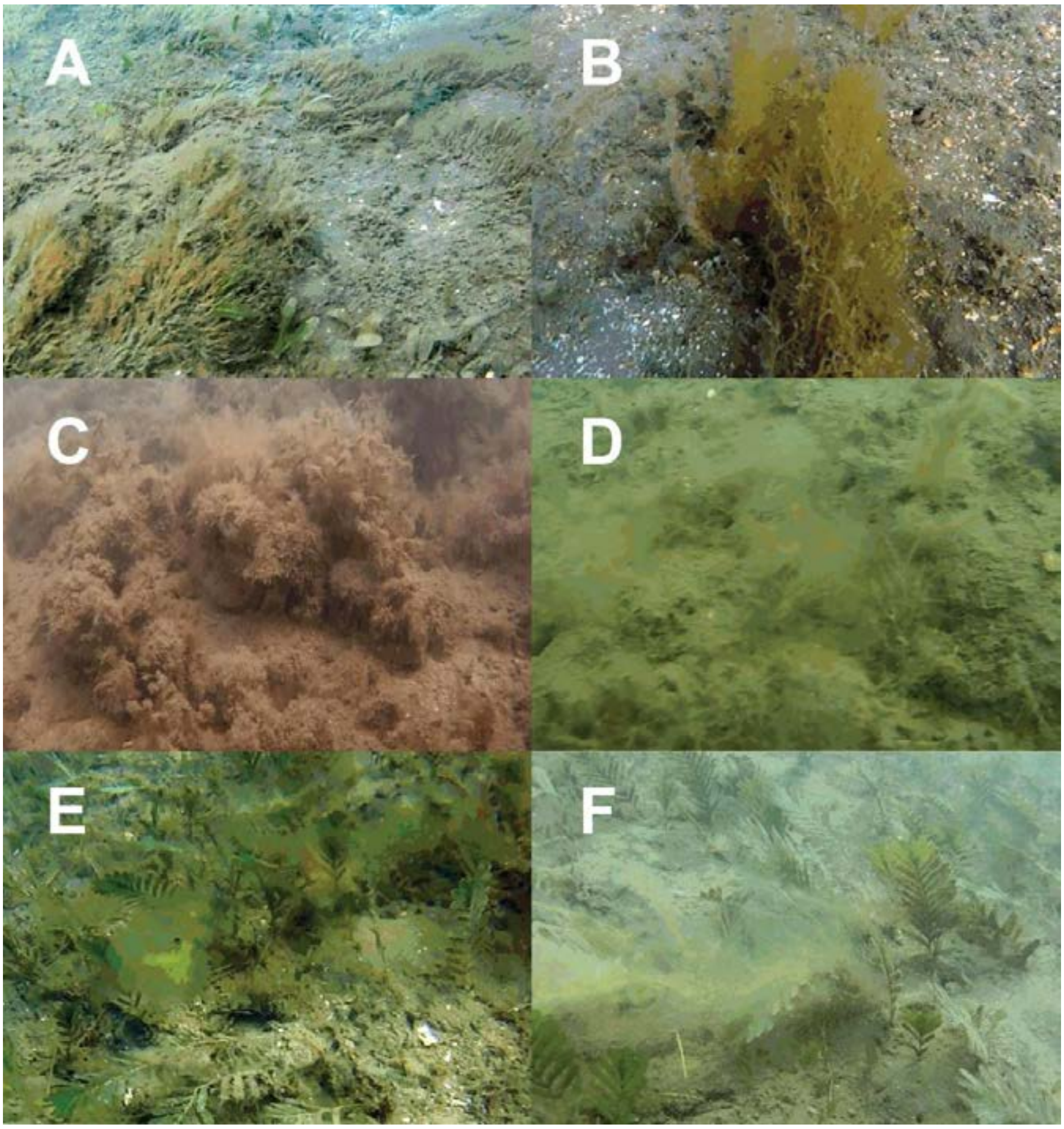
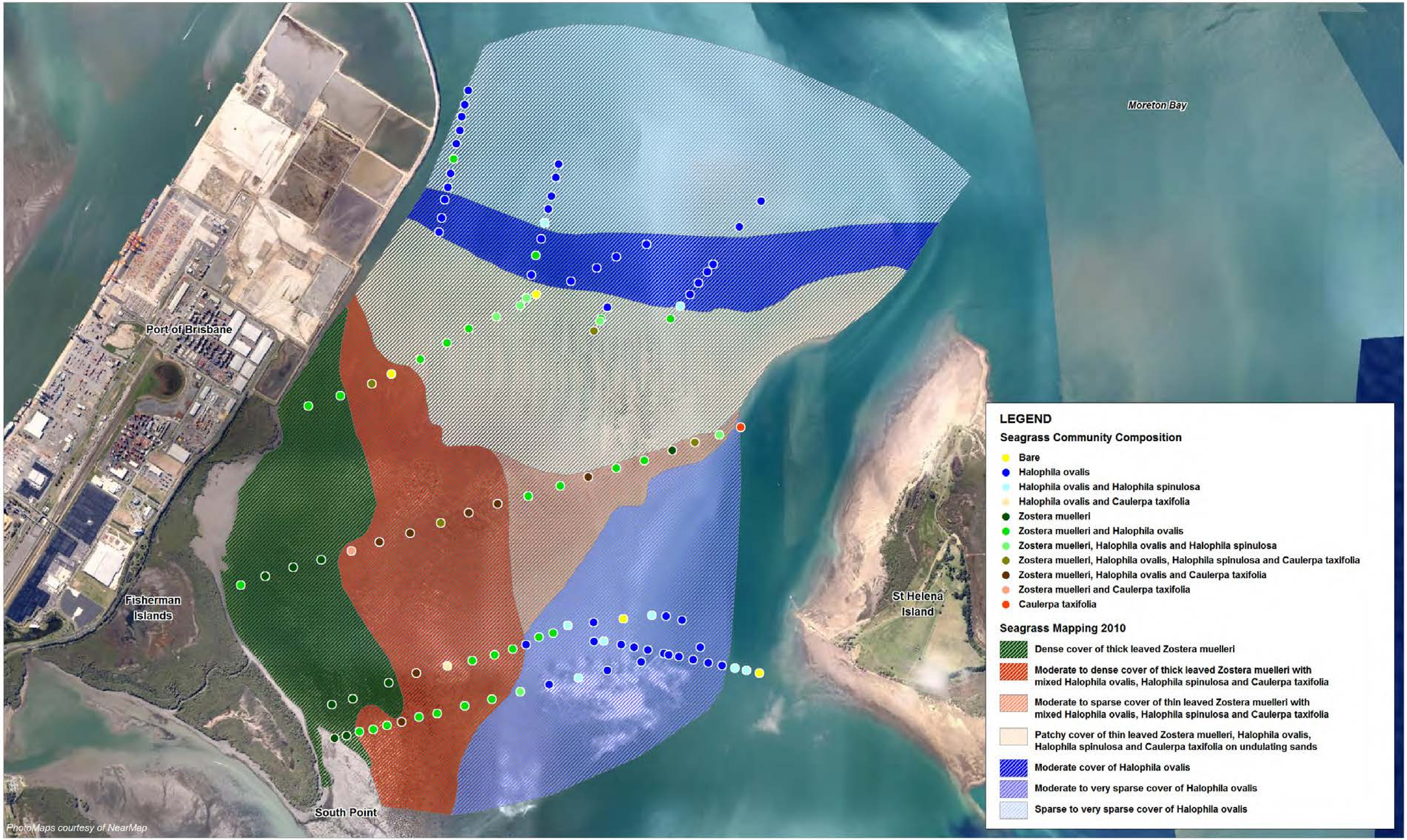


Figure A-2 Macroalgae: Brown algae *cf Hypnea spinella* with *Halophila decipiens* (A); *Sporochnus comosus* (B); high cover of mixed turfing algae (C); Filamentous algae c-f *Ectocarpus fasciculatus* (D); Filamentous algae *cf Ectocarpus fasciculatus* with *Halophila spinulosa* (E); Filamentous algae *cf Hincksia (Giffordia) mitchellae* with *H. spinulosa* (F).

Appendix B Broad scale patterns in seagrass species distribution at the Port of Brisbane from 2010 and 2013



Title:

Broadscale Patterns in Seagrass Distribution and Community Structure Adjacent to Port of Brisbane

Figure **B-1**

Rev: **A**

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N

0km 0.5 1
Approx. Scale

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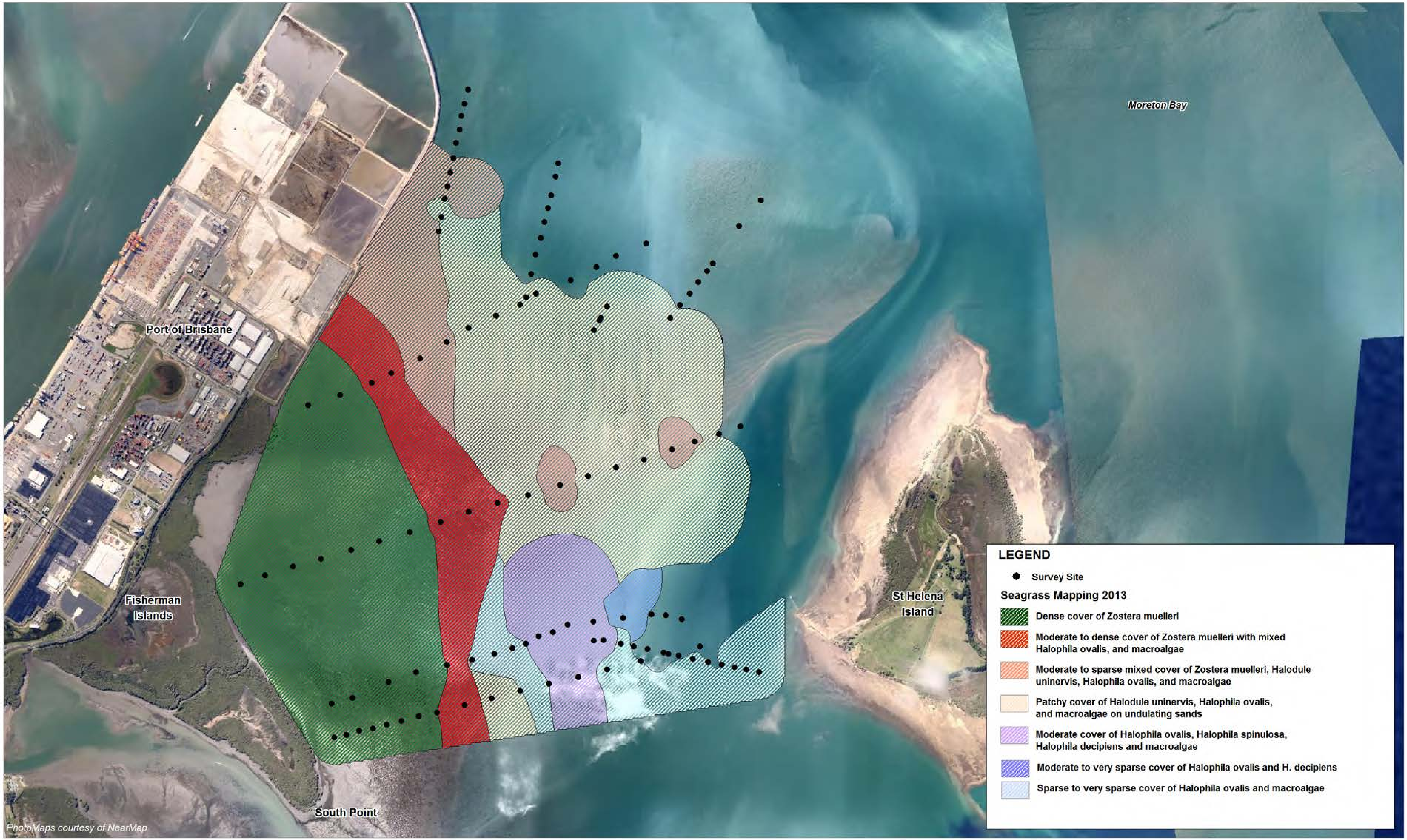

Title:

Seagrass Distribution and Community Structure Adjacent to Port of Brisbane

Figure 3-4

Rev: A

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0km 0.5 1

Approx. Scale

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