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Port of Weipa Long Term Seagrass Monitoring

August 2006


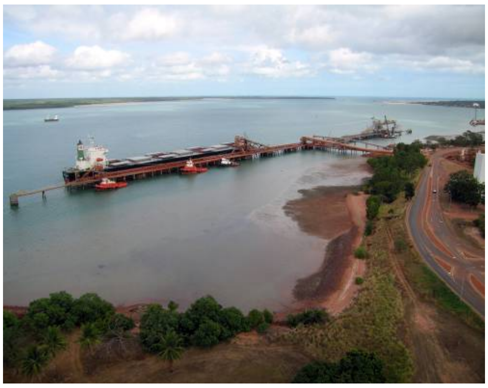


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Table of Contents

EXECUTIVE SUMMARY

This report details results of the August 2006 seagrass survey which forms part of the established annual long term seagrass monitoring program for Weipa.

The results of the 2006 seagrass survey revealed that seagrass densities for many of the meadows were low compared with densities recorded in the previous 6 years of monitoring at Weipa. Intertidal *Enhalus acoroides* meadows that have continued to decline in density since 2000, showed little or no signs of recovery in 2006. Meadows dominated by *Halodule uninervis* (thin) also had some density declines; however these were generally within the ranges of previous years. The observed changes appeared to be a response to regional and local climate conditions rather than port or other anthropogenic factors. Despite the density declines appearing to be caused by natural factors, DPI&F are concerned that some of the meadows are now at such low density levels, that they are particularly vulnerable to additional stresses and will require close monitoring in the future.

Drought-like conditions, typified by low rainfall, high air temperatures and high solar irradiation, have continued in Weipa. These conditions are likely to have caused stress associated with desiccation of plants when seagrass are exposed at low tide. For the past four years of surveys, DPI&F have observed evidence of ‘burning’ or ‘browning’ of intertidal *Enhalus acoroides* plants. Of greatest concern is the increased patchiness and decline of the large *Enhalus* meadow in the Embley River on the opposite bank to the port. This intertidal meadow has been the most severely effected by ‘burning’ in recent years, and is likely to have greatly reduced the meadow’s capacity to withstand further climate related or any other new impacts.

The 2006 monitoring survey recorded the first signs of recovery of intertidal *Halodule uninervis* meadows in Pine River Bay (outside of the Intensive Monitoring Area (IMA)) since their complete loss in 2002. Existing low biomass meadows in Pine River Bay had increased in area and density, and seagrass had recolonised bare areas to form new meadows. *Halodule uninervis* meadows within the IMA however remained at low densities with one meadow also reducing significantly in area.

Results of this survey indicate that human activities in Weipa including dredging and other port and urban activities were unlikely to have had a significant impact on seagrasses in 2006. The continued decline of some of the most dense meadows in the area may have implications to their value as a fisheries habitat and may warrant closer inspection in future surveys should trends continue.

BACKGROUND

Ports Corporation Queensland (PCQ) is the organisation responsible for managing and monitoring Weipa's port environment. PCQ has recognised that seagrasses are ecologically important and environmentally sensitive habitats and established a long term seagrass monitoring program for the Port in 2000 (Roelofs *et al*. 2001, 2003, 2005). Seagrass habitats are valuable fisheries resources that show measurable responses to changes in water quality. These attributes make seagrass meadows ideal candidates for monitoring the long term health of marine environments. The goals of the program are to minimise impacts of port activities and development on these habitats and to assess the health of Weipa's port environment.

The first three years (2000 to 2002) of the seagrass monitoring program provided important baseline information on the distribution, abundance and seasonality of seagrasses within the greater port limits. Due to the large area of the port, the approach for long term monitoring was to focus monitoring effort on seagrass meadows located near port and shipping infrastructure and activities (the Intensive Monitoring Area or IMA). In August / September each year all seagrass meadows within the IMA are mapped and a selection of "core monitoring meadows" representing the range of seagrass meadow types are assessed for biomass and species composition. At the time of the IMA survey an aerial reconnaissance of seagrasses in the greater port limits is conducted with re-mapping of the entire port limits occurring every 3 years (next full survey due 2008).

This report presents the results of the long term seagrass monitoring survey conducted in August 2006. The objectives of the 2006 long term seagrass monitoring of the Port of Weipa were to:

1. Map the distribution and abundance of selected seagrass monitoring meadows;
2. Map the distribution and confirm species composition of seagrass meadows in the Intensive Monitoring Area (IMA);
3. Assess changes in seagrass meadows and compare results with previous monitoring surveys;
4. Incorporate the results into the Geographic Information System (GIS) database for the Port of Weipa.

Results of the seagrass monitoring are used by PCQ to help identify any possible detrimental effects of port operations and developments (eg. dredging) on seagrasses and assist in formulating management measures for the port. The program also forms part of DPI&F's network of long term monitoring sites for important fish habitats.

METHODS

Seagrass surveys of the Port of Weipa were conducted between the 19th and 23rd of August 2006. Five core seagrass meadows were selected from the baseline survey (Roelofs *et al.* 2001) for long term monitoring. These meadows were representative of the range of seagrass meadows communities identified in the baseline survey, and were also located in areas likely to be vulnerable to impacts from port operations and developments.

Three levels of sampling were used in the August 2006 survey:

1. Assess seagrass distribution, species composition and abundance in the five core monitoring meadows (A2, A3, A5, A6, A7) (Map 1).
2. Map seagrass distribution and confirm species composition in the other seagrass meadows within the Intensive monitoring meadow in the Embley and Hey River systems (Map 1).
3. Confirm presence by helicopter reconnaissance at low tide of other seagrass meadows previously mapped in the 2005 whole of port limit survey.

Seagrass habitat observations in the core meadows included species composition, above ground biomass, percent algal cover, sediment type, time and position (Global Positioning System (GPS)). Monitoring meadows were surveyed using a combination of helicopter aerial surveillance and boat based camera surveys.

A detailed description of the methods used in this survey is provided in Roelofs *et al*. 2001.

Geographic Information System

Spatial data from the August 2006 survey were entered onto the PCQ / QDPI&F Weipa Geographic Information System (GIS). Three GIS layers were created:

- **Site information** – site data containing above ground biomass (for each species), sediment type, time, Global Positioning System (GPS) fixes (±10m) and sampling technique.

- **Seagrass meadow biomass and community types** – area data for seagrass meadows with summary information on meadow characteristics. Seagrass community types were determined according to species composition from nomenclature developed for seagrass meadows of the Queensland region (Table 1).

- **Seagrass landscape category** – area data showing the seagrass landscape category determined for each meadow

<u>Isolated seagrass patches</u>
The majority of area within the meadows consisted of unvegetated sediment interspersed with isolated patches of seagrass

<u>Aggregated seagrass patches</u>
Meadows are comprised of numerous seagrass patches but still feature substantial gaps of unvegetated sediment within the meadow boundaries

<u>Continuous seagrass cover</u>
The majority of area within the meadows comprised of continuous seagrass cover interspersed with a few gaps of unvegetated sediment.

Table 1 **Nomenclature for community types in the Port of Weipa, August 2006**

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

RESULTS

Seagrass species, distribution and abundance

Four seagrass species (from 2 families) were identified in the August 2006 monitoring survey (for a complete list of species present in the Weipa (6 species) area refer to Roelofs *et al.* 2001):

Family **Cymodoceaceae** Taylor

Halodule uninervis (narrow leaf morphology) (Forsk.) Aschers

Family **Hydrocharitaceae** Jussieu

*Enhalus acoroides (*L.*f*.) Royle
Halophila ovalis (Br.) D.J. Hook.
Thalassia hemprichii (Ehrenb.) Aschers. in Petermann

Halodule uninervis

Enhalus acoroides

Halophila ovalis

Thalassia hemprichii

Intensive Monitoring Area

A total of 1002 ± 71 ha of seagrass habitat, comprising sixteen seagrass meadows, was mapped within the Intensive Monitoring Area (IMA) in August 2006 (Map 1). Communities dominated by *Enhalus acoroides* were the most common, with twelve of the sixteen monitoring meadows dominated by this species (Map 2). Large *Enhalus accoroides* meadows dominated the intertidal banks and shallow sub-tidal areas of the Embley River (Map 1). Lower biomass *Halodule uninervis* dominated meadows also occurred in the Hey River (A3) and southern section of the Embley River (A4 and A5). Meadow area ranged from 0.007 ha to 245 ha with the smallest meadow an isolated patch of *Enhalus accoroides* between Evans Landing and Lorim Point and the largest located along the western bank of the Embley River (meadow A2) (Map 2). Seagrass cover for the monitoring meadows was a mix of aggregated and isolated patches (Map 2). The exception to this was the *Enhalus acoroides* dominated meadow on the western shore of the Embley River (meadow A2), which had a continuous cover of seagrass (Map 2).

Core monitoring meadows

The five core monitoring meadows made up a combined area of 358 ± 23 ha in August 2006 (Table 2; Map 1). Meadow area ranged from 7 ha to 245 ha with the smallest meadow located at Lorim Point (meadow A6) and the largest located along the western bank of the Embley River (meadow A2) (Table 2; Map 2). A total of 201 seagrass habitat characterisation monitoring sites were surveyed within the meadows, 80% of which (161 sites) had seagrass present. Of these monitoring sites, 183 were surveyed from helicopter and the remaining 18 were surveyed by underwater camera from a boat.

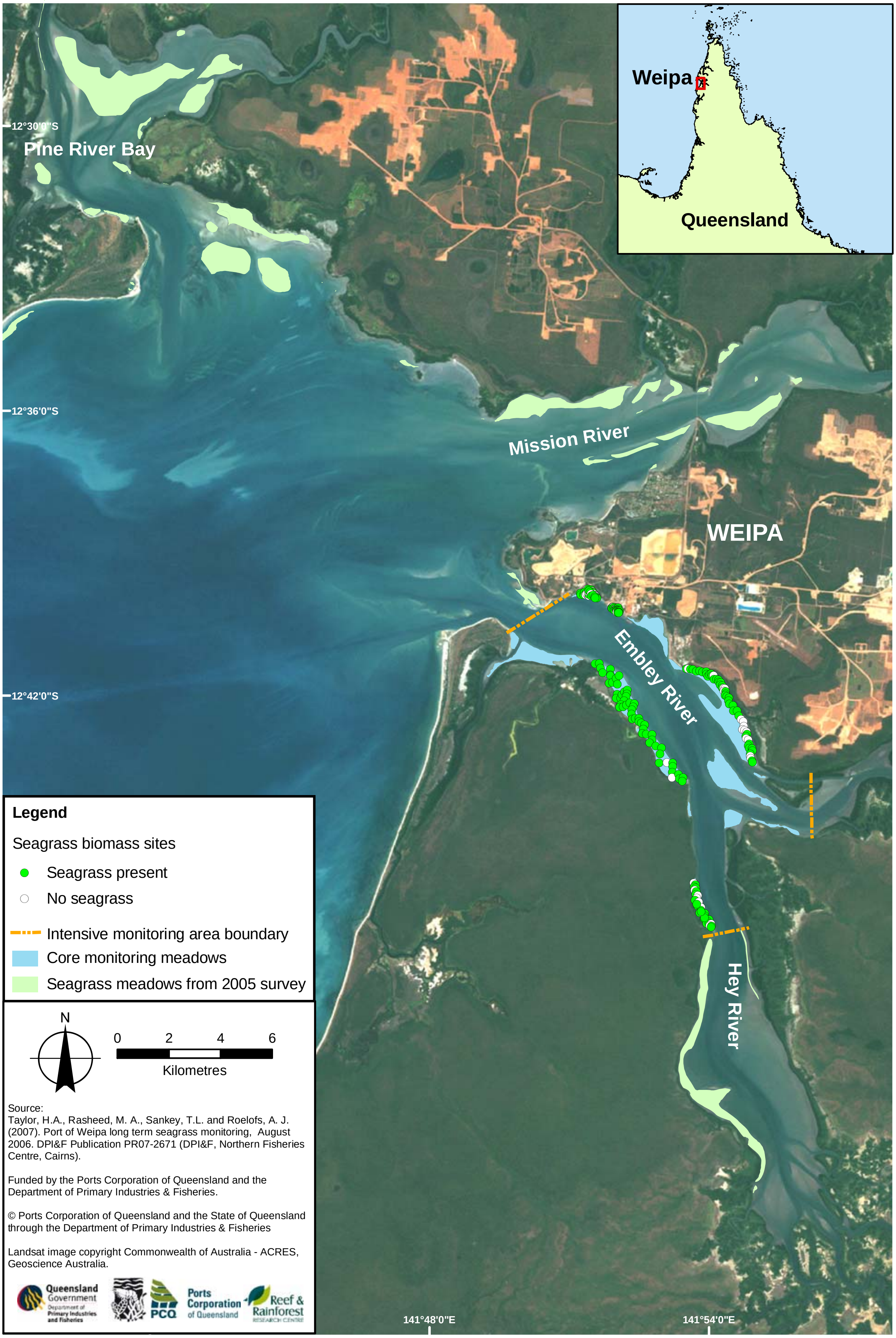
Mean above ground biomass in five of the monitoring meadows (A2, A3, A5, A6 & A7) ranged from 0.11 ± 0.05 g DW m^{-2} for the *Halodule uninervis* (thin) dominated meadow in the Hey River (meadow A3), to 6.43 ± 1.03 g DW m^{-2} for the *Enhalus acoroides* dominated meadow on the western shore of the Embley River (meadow A2) (Table 1; Figure 1).

The core monitoring meadows were made up of three meadow community types:

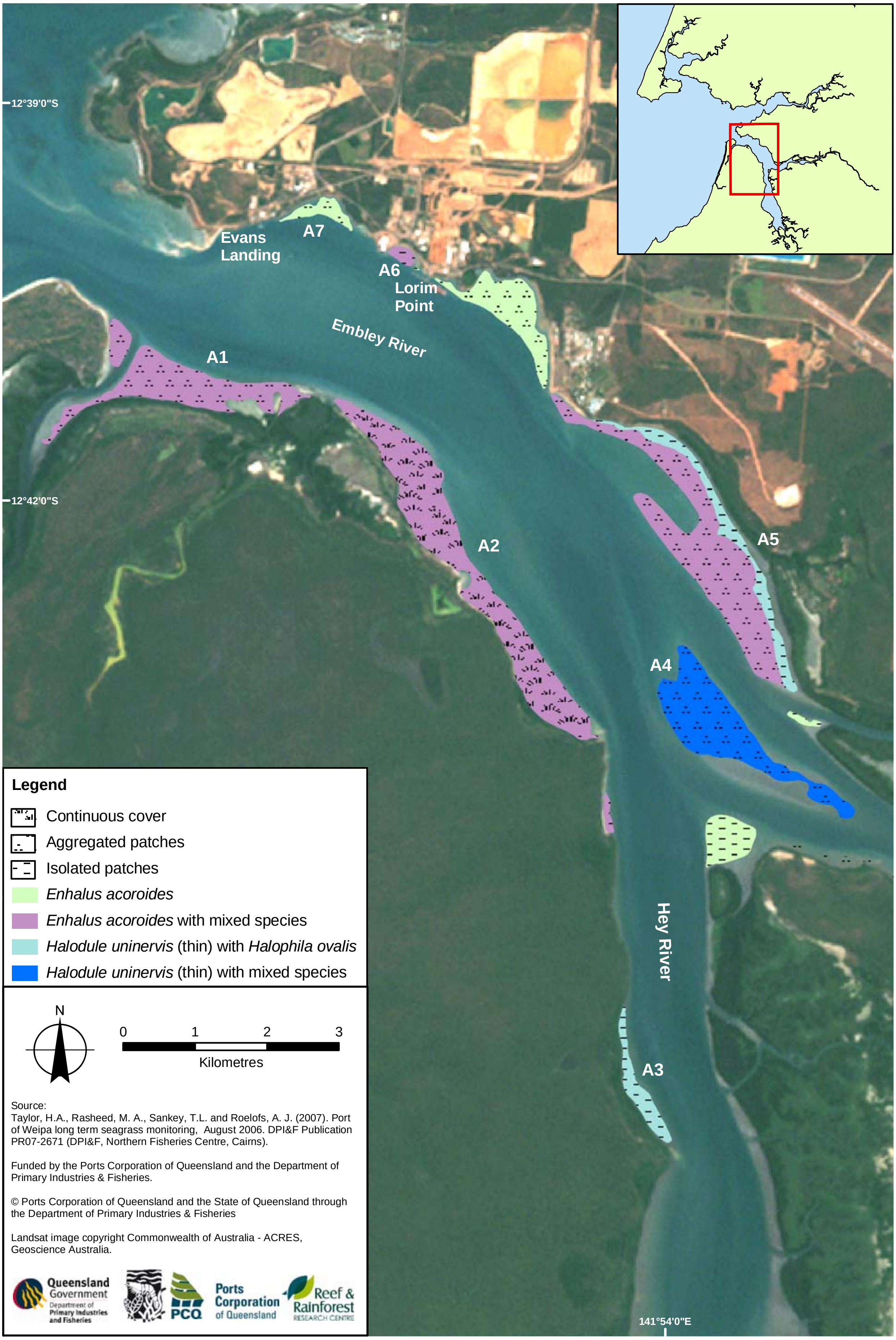
1. *Enhalus acoroides*
2. *Enhalus acoroides* with mixed species
3. *Halodule uninervis* (narrow form) with *Halophila ovalis*

The majority of monitoring meadows were located on intertidal substrates dominated by mud, with a smaller component of shell.

Map 1. Location of 2006 seagrass monitoring sites and seagrass meadows in the Port of Weipa



Map 2. Meadow type and cover for seagrass meadows within the Intensive Monitoring Area 2006



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Funded by the Ports Corporation of Queensland and the Department of Primary Industries & Fisheries.

Table 1 Mean above-ground seagrass biomass and number of biomass sampling sites for each core monitoring meadow within the Port of Weipa, 2000 to 2006.

Monitoring Meadow	Mean biomass ± SE (g DW m^{-2}) (No. of sites)						
	September 2000	**September 2001**	**September 2002**	**September 2003**	**August 2004**	**August 2005**	**August 2006**
A2 Intertidal *Enhalus* dominated	33.63 ± 5.82 (17)	29.73 ± 2.88 (51)	22.84 ± 2.99 (50)	13.91 ± 1.96 (54)	11.47 ± 1.77 (51)	7.04 ± 0.72 (51)	6.43 ± 1.03 (55)
A3 Intertidal *Halodule/Halophila* dominated	3.34 ± 0.87 (11)	2.04 ± 0.33 (26)	0.37 ± 0.07 (30)	1.63 ± 0.61 (26)	0.31 ± 0.23 (26)	1.08 ± 0.41 (25)	0.11 ± 0.05 (31)
A5 Intertidal *Halodule/Halophila* dominated	6.45 ± 1.90 (9)	3.11 ± 0.31 (51)	2.49 ± 0.52 (51)	2.29 ± 0.23 (50)	4.18 ± 0.61 (50)	4.11 ± 0.54 (50)	1.75 ± 0.38 (56)
A6 Intertidal *Enhalus* dominated	9.63 ± 5.52 (9)	10.4 ± 2.79 (26)	9.5 ± 2.54 (25)	8.31 ± 2.91 (24)	1.14 ± 0.40 (26)	3.37 ± 1.00 (26)	3.45 ± 1.1 (26)
A7 Shallow subtidal *Enhalus* dominated	9.63 ± 4.12 (14)	18.89 ± 3.88 (30)	10.03 ± 2.34 (33)	15.57 ± 3.39 (31)	10.56 ± 2.82 (30)	2.84 ± 0.58 (30)	3.06 ± 0.76 (33)

Table 2 Total meadow area for each core monitoring meadow within the Port of Weipa, 2000 to 2006.

(R is an estimate of reliability associated with mapping meadow boundaries)

Monitoring Meadow	Total meadow area ± R (ha)						
	September 2000	**September 2001**	**September 2002**	**September 2003**	**August 2004**	**August 2005**	**August 2006**
A2 Intertidal *Enhalus* dominated	253 ± 19	248 ± 19	255 ± 19	250 ± 20	255 ± 19	251 ± 20	245 ± 13
A3 Intertidal *Halodule/Halophila* dominated	30 ± 5	48 ± 5	34 ± 4	36 ± 4	41 ± 5	37 ± 5	31 ± 2
A5 Intertidal *Halodule/Halophila* dominated	95 ± 10	91 ± 10	102 ± 6	87 ± 9	93 ± 10	86 ± 10	58 ± 5
A6 Intertidal *Enhalus* dominated	5 ± 1	7 ± 1	7 ± 1	7 ± 1	7 ± 1	7 ± 1	7 ± 2
A7 Shallow subtidal *Enhalus* dominated	19 ± 2	23 ± 1	19 ± 1	19 ± 1	18 ± 1	17 ± 1	17 ± 1
Total	**402 ± 37**	**417 ± 36**	**417 ± 31**	**399 ± 35**	**414 ± 36**	**398 ± 37**	**358 ± 23**

Comparison with previous monitoring surveys

Core monitoring meadows

In 2006 seagrass meadows in Weipa were generally at their lowest density (biomass) recorded in the monitoring program with one meadow also substantially declining in area. The low biomass of many of the monitoring meadows was a continuation of the declines that had been recorded in recent years (Figure 1). Despite this, biomass of many of the meadows in 2006 still remained within the range of previously recorded values for the monitoring program (2000 – 2006)(Table 1 & 2; Figure 1).

Higher biomass meadows dominated by *Enhalus acoroides* remained at the low levels recorded in the 2005 survey, and had shown little or no sign of recovery from previous declines. Biomass of the two *Enhalus acoroides* monitoring meadows located adjacent to Lorim Point and Evans Landing (meadows A6 and A7) had remained unchanged from 2005 to 2006. These meadows, however, were still at levels much lower than those recorded in surveys between 2000 and 2004 (Appendix 1; Table 1; Figure 1; Map 3). The biomass of the large Embley River *Enhalus acoroides* meadow (A2) also remained stable from 2005 to 2006. This meadow has been declining consistently over the course of the monitoring program, with biomass at its lowest ever recorded level in 2005 & 2006. Within this meadow *Enhalus acoroides* has gradually become patchier in distribution, and in 2006 the southern end of the meadow was nearly devoid of *Enhalus* plants (Figure 1; Table 1; Map 4). This section of the meadow was instead dominated by *Halodule uninervis* (thin) with some *Halophila ovalis*.

The biomass of the two lower biomass *Halodule uninervis* (thin) monitoring meadows located in the Embley River (A5) and the Hey River (A3) has fluctuated greatly over the course of the monitoring program. In 2006 biomass had significantly declined from 2005 for both meadows (Appendix 1; Figure 1). The biomass of meadow A3 was still within the range of biomass values previously recorded (lowest level in 2004) but meadow A5 was at its lowest biomass to date, and significantly lower than all previous monitoring events (Appendix 1, Figure 1; Table, 1; Map 3).

Unlike biomass, area of core monitoring meadows has remained relatively constant throughout the monitoring program (Table 2; Map 3), although seagrass within those meadows had often become patchier (particularly meadow A2). The only meadow to have changed significantly in area has been the *Halodule uninervis* (thin) meadow, A5, which had substantially declined in area in 2006 to be at its smallest size measured to date (Figure 1; Map 3).

Species composition in the core monitoring meadows was similar in 2006 to previous surveys (Map 3). Desiccation or ‘burning’ of *Enhalus acoroides* plants was noted in a number of intertidal meadows, making this the fourth year in a row that this condition had been recorded.

Other seagrass meadows in the Port of Weipa

Seagrass meadows in the greater port limits area located in the Embley, Hey and Mission Rivers and in Pine River Bay were also inspected during the 2006 survey. Although no biomass or area data was collected, visual reconnaissance of the meadows indicated that the majority of the meadows were similar to previous monitoring surveys.

The most notable changes occurred in the *Halodule uninervis* (thin) and *Halophila ovalis* dominated meadows located in Pine River Bay. In previous years, these meadows had declined dramatically to all but disappear in a number of cases (see Roelofs *et al.* 2006). In

2006, there was recovery and expansion of existing seagrass meadows and seagrass had recolonised many of the intertidal sand banks where they had previously occurred.

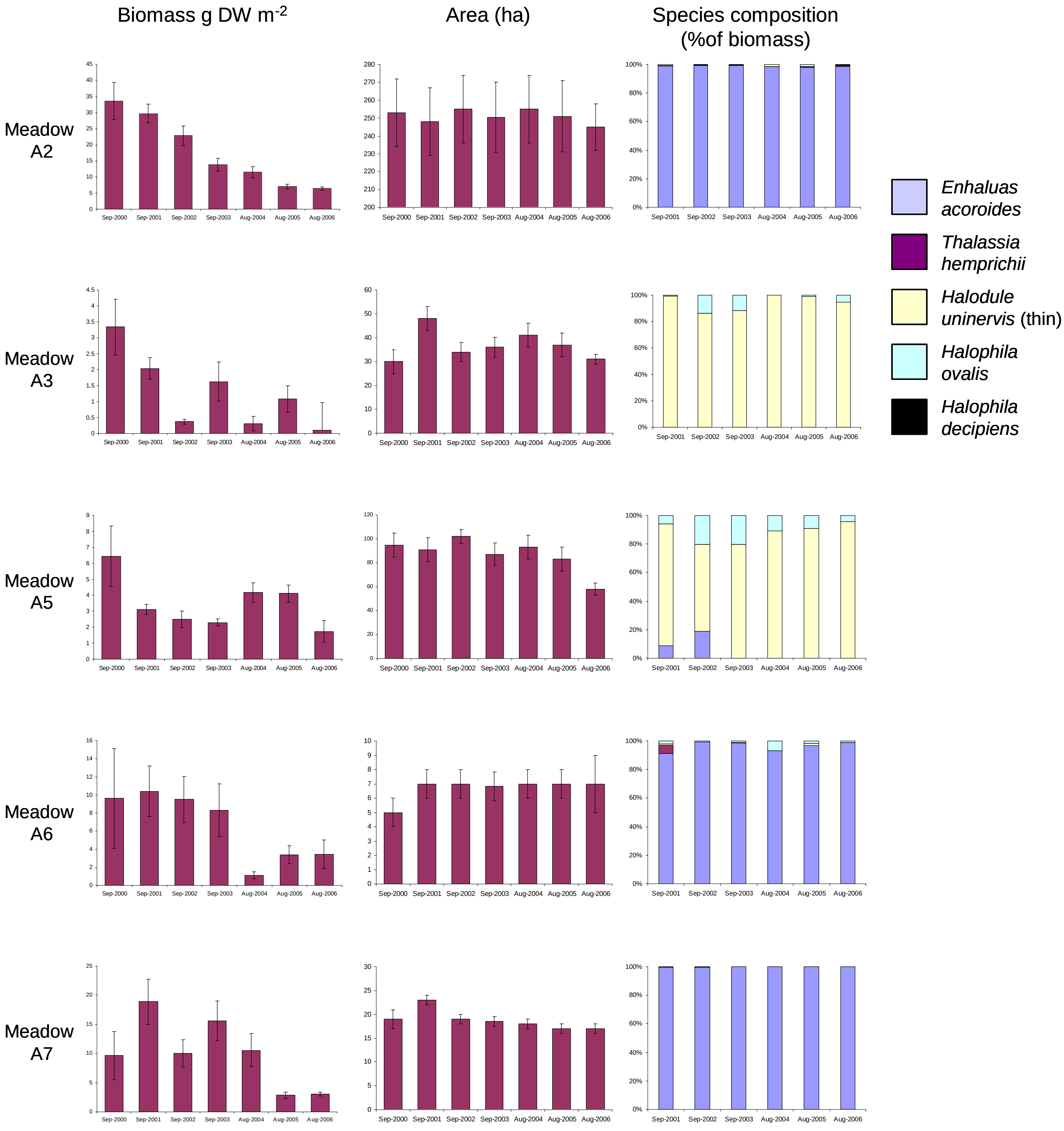
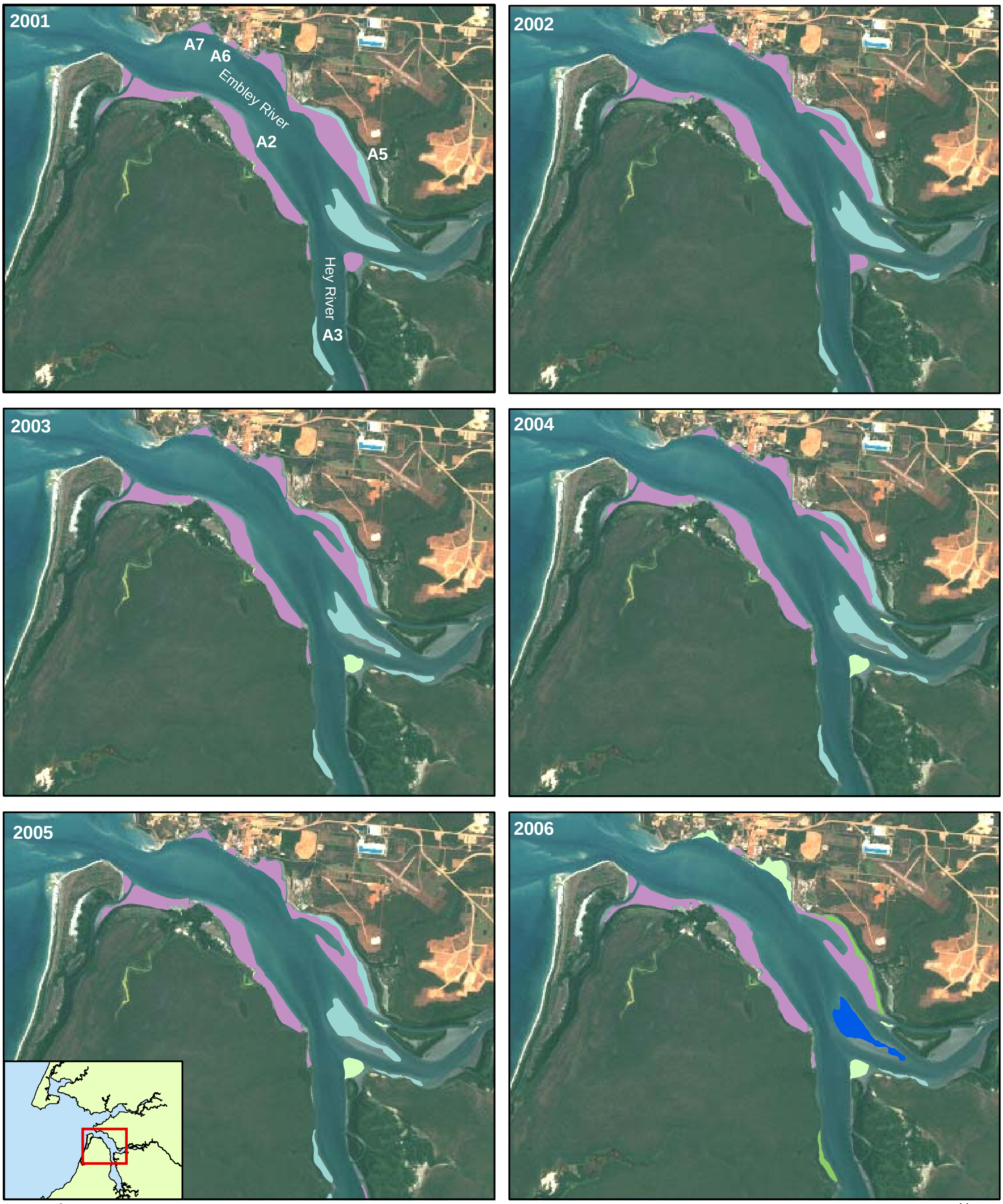


Figure 1 Changes in biomass, area and species composition for the core monitoring meadows in Weipa from 2000 to 2006 (biomass error bars = SE; Area error bars = “R” reliability estimate).

Map 3. Meadow type for the seagrass monitoring meadows 2001 to 2006.



Legend

- *Enhalus acoroides*
- *Enhalus acoroides* with mixed species
- *Halodule uninervis* (thin) with mixed species
- *Halodule uninervis* (thin) with *Halophila ovalis*
- *Halodule uninervis* (thin) / *Halophila ovalis* with mixed species
- *Halodule uninervis* (thin) / *Halophila ovalis*
- *Halophila ovalis* with mixed species
- *Thalassia hemprichii* with mixed species

Source:
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Funded by the Ports Corporation of Queensland and the Department of Primary Industries & Fisheries.

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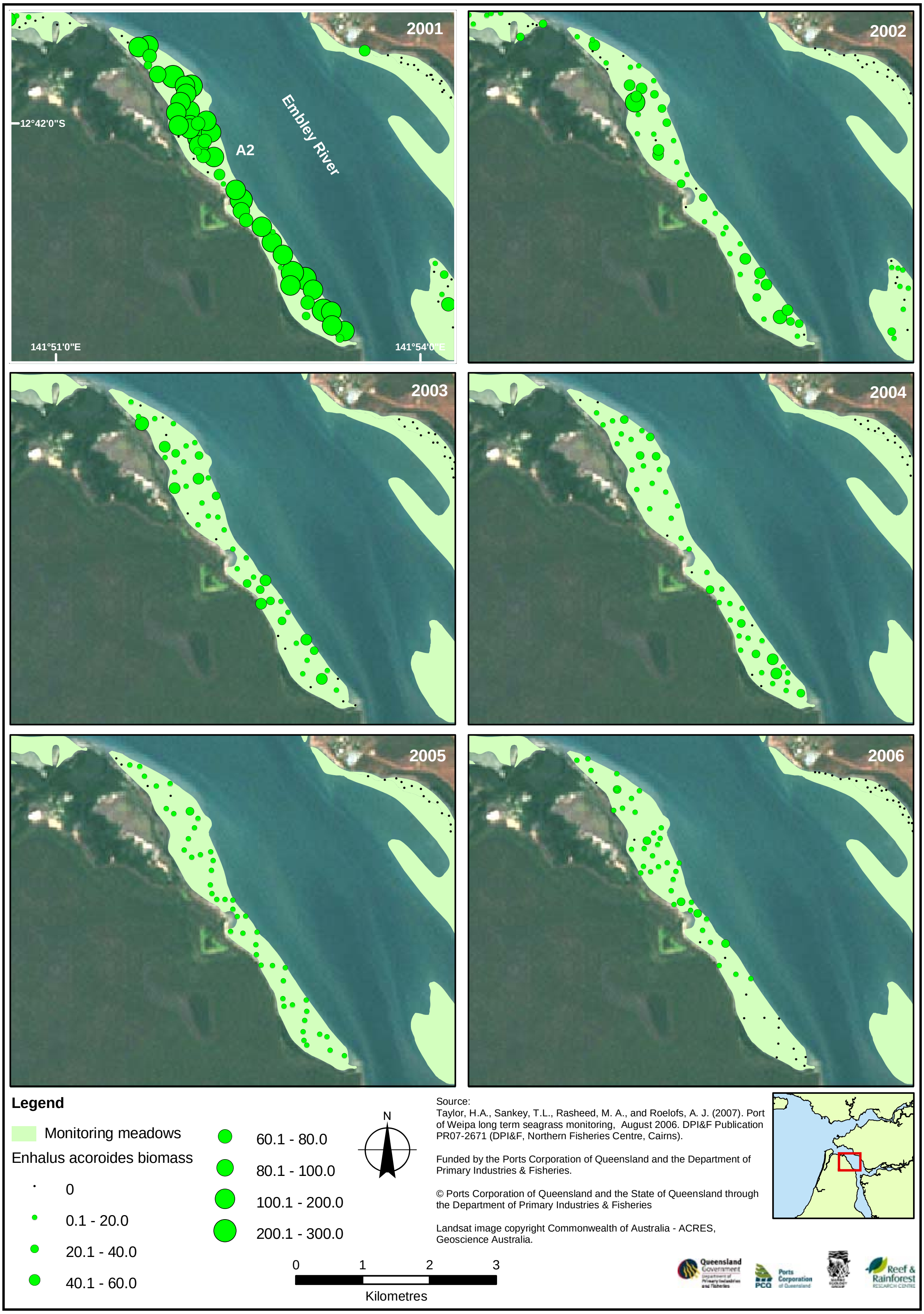
0 3 6 9
Kilometres

Map 4. The biomass of *Enhalus acoroides* at each seagrass characterisation site in meadow A2, 2001 to 2006.



Weipa climate data

Total annual rainfall at Weipa in 2006 was well below the average rainfall level (since 1973). In the past five years Weipa has been in drought-like conditions, with the rainfall only reaching above average once, in 2004 (Figure 2). Total monthly rainfall has been trending downwards since January 1999 while the intensity of solar radiation has been on the increase (Figure 3). The maximum average monthly air temperature was also trending upwards in the same period, although the maximum air temperature during the cooler dry season months was lower in 2006 than in 2004 and 2005 (Figure 4).

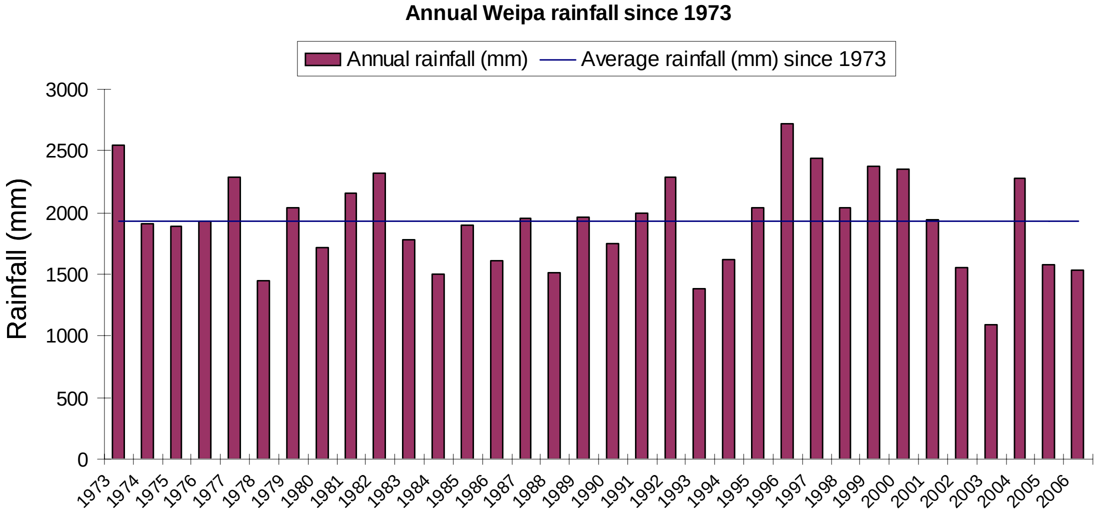


Figure 2 Total annual rainfall recorded at Weipa airport from 1973 to 2006 (Source: Bureau of Meteorology, 2007).

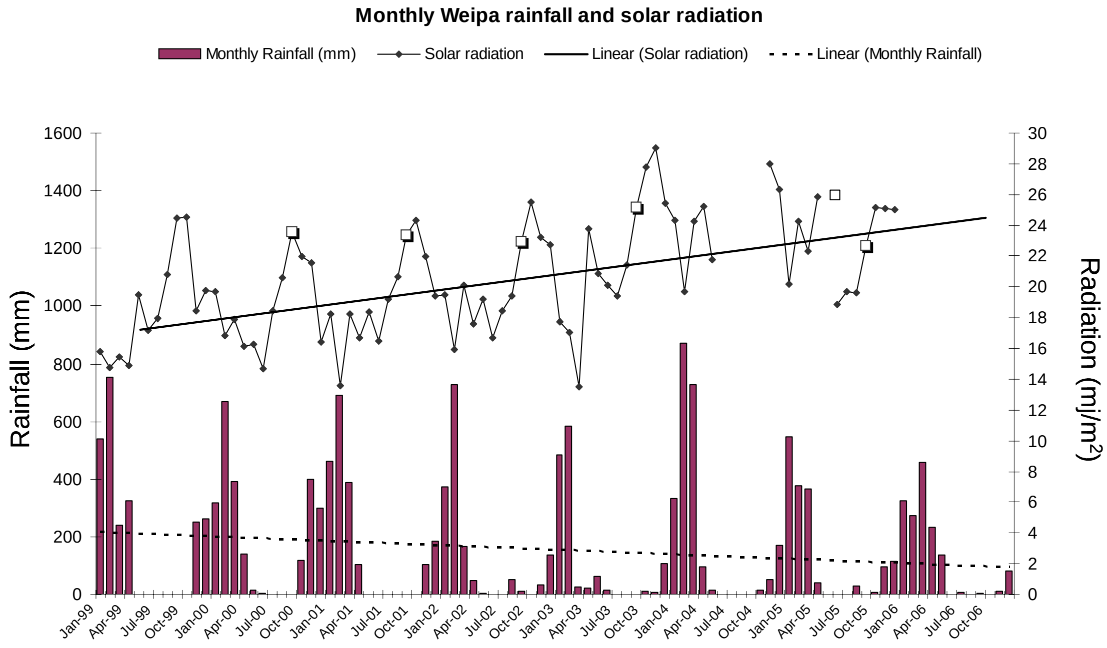


Figure 3 Average monthly rainfall (mm) and solar radiation (megajoules/metre^2) recorded at Weipa airport from January 1999 to December 2005. Boxed data points indicate seagrass survey periods (Source: Bureau of Meteorology, 2007).

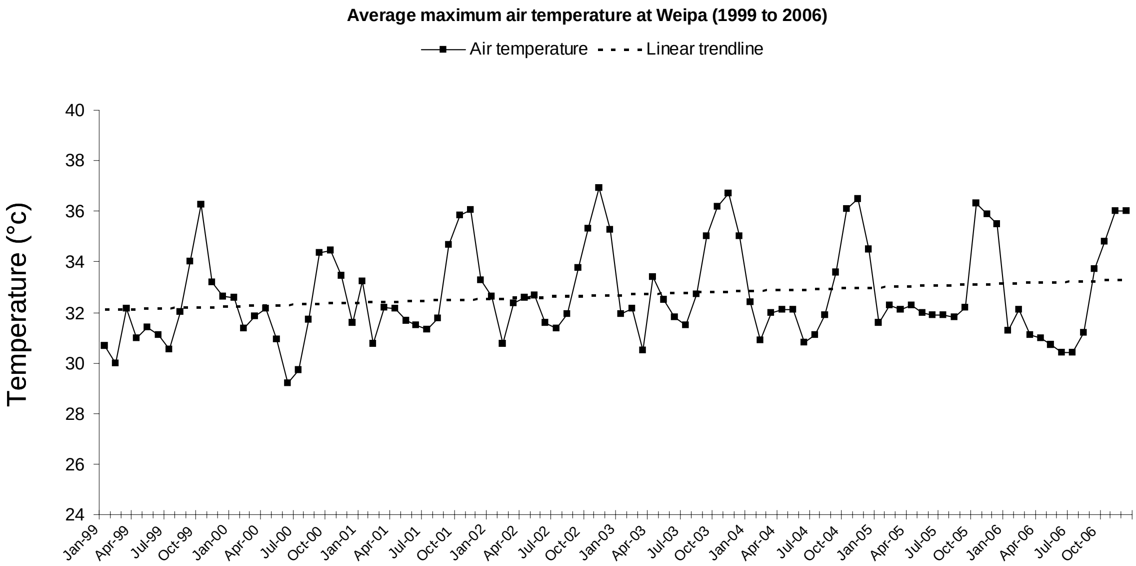


Figure 4 Average monthly maximum air temperature (°Celsius) recorded at Weipa airport from January 1999 to December 2005 (Source: Bureau of Meteorology, 2007).

DISCUSSION

The results of the 2006 seagrass survey revealed that seagrass densities for many of the meadows were low compared with densities recorded in the previous 6 years of monitoring at Weipa. Intertidal *Enhalus acoroides* meadows that have continued to decline in density since 2000, showed little or no signs of recovery in 2006. Meadows dominated by *Halodule uninervis* (thin) also had some density declines; however these were generally within the ranges of previous years. The observed changes appeared to be a response to regional and local climate conditions rather than port or other anthropogenic factors. Despite the density declines appearing to be caused by natural factors, DPI&F are concerned that some of the meadows are now at such low density levels, that they are particularly vulnerable to additional stresses and will require close monitoring in the future.

The most likely drivers of the seagrass changes in Weipa were related to regional and local climate rather than anthropogenic or port related factors. Low rainfall and a reduction in associated runoff, high air temperatures and greater exposure to more intense solar irradiation (drought conditions) were all likely to have contributed to the low biomass levels recorded. *Enhalus acoroides* dominated meadows had become patchier and had not recovered from the declines in previous years. These climate conditions were likely to have caused stress associated with high temperatures and desiccation of plants when exposed at low tide. For the past four years, evidence of 'burning' or 'browning' of intertidal *Enhalus acoroides* plants has been observed during surveys (see Roelofs *et al*. 2006).

The continued decline in density and increased patchiness of the largest *Enhalus* meadow in the area (meadow A2 opposite Lorim Point) is likely to have greatly reduced its resilience to further impacts. Research suggests that the reproductive capability of *Enhalus acoroides* decreases dramatically with increased fragmentation of seagrass cover (Vermaat *et al*. 2004). Given the likely fragile state of this meadow extra care should be taken when conducting activities in the region that could further stress the meadow.

The intertidal *Halodule uninervis* dominated monitoring meadows also remained at low densities with one meadow also reducing significantly in area. However these meadows did not seem to be affected to the same degree as the *Enhalus acoroides* meadows, with biomass remaining at similar levels to previous years. This may be due to differences in the morphology of these species, with the smaller, less rigid *Halodule uninervis* capable of lying fully prone on the moist sediment surface during the low tide (see Taylor *et al*. 2006; Roelofs *et al*. 2006). *Enhalus acoroides* plants are more rigid and their leaf base sits proud above the sediments at low tide, exposing it to the high air temperatures.

Intertidal meadows of *Halodule uninervis* and *Halophila ovalis* in Pine River Bay (outside of the intensive monitoring area) had shown the first signs of recovery from their complete loss in 2002. Existing low biomass meadows had increased in area and density, and seagrass had recolonised bare sediments to form new meadows. It is likely that this was driven by a combination of biological and environmental factors. Past surveys had indicated that there was a lack of seeds stored in the sediments in the Pine River Bay meadows from which recovery could be initiated (Roelofs *et al*. 2004). Once recruitment had occurred, however these species have the ability to rapidly spread through asexual reproduction (sending out rhizome runners) (Rasheed 2004).

The patterns of seagrass change recorded at Weipa were consistent with climate driven trends documented in other Queensland locations where monitoring programs are being conducted. In nearby Thursday Island intertidal *Enhalus acoroides* meadows also declined in biomass over the same period, while intertidal *Halodule uninervis* meadows remained largely unchanged (Taylor *et al*. 2006). Seagrass changes were not the same for all areas of

Queensland however, with some regions experiencing more benign climate conditions than Weipa and Thursday Island in 2006. In Karumba in the southern Gulf of Carpentaria for example, climate conditions had returned to more “normal” levels with higher local and catchment rainfall, lower temperatures and increased river flows between 2005 and 2006. During this period seagrass meadows in Karumba reached record high levels of biomass almost double that previously recorded (Dew *et al*. 2007).

Overall, seagrass communities in the Port of Weipa remained relatively healthy with most changes within the range of previous values. However, two meadows experienced changes that may require closer attention in future surveys if trends continue:

- Meadow A2 located in the western bank of the Embley River which has shown a downward trend in biomass and increased patchiness since 2000, and had a reduction in cover of *Enhalus acoroides* in 2006; and

- Meadow A5 located on the eastern bank of the Embley River which has been declining in both biomass and area for the past 3 years.

Since the baseline survey in 2000, we have been establishing the natural patterns of distribution and abundance of seagrass in Weipa. Through our state wide seagrass monitoring network we have been able to put these changes in a regional perspective and separate local versus regional drivers of seagrass change. As a result, we are in a good position to detect any anthropogenic causes of change to seagrass beyond natural change. Future monitoring will continue to enhance this ability and provide port and fisheries management with information on the status and trends of the marine environment within the Weipa region.

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APPENDIX

Results of one-way ANOVA for mean above-ground biomass versus year for the five monitoring meadows at Weipa 2001 to 2006 (2000 baseline was omitted due to unequal sample sizes)

Meadow A2	**DF**	**SS**	**MS**	**F**	**P**
Between Years	5	22033.4	4406.67	20.22	**<0.0001***
Within Years	305	66477.9	217.96		
Total	310	88511.2			
Meadow A3#					
Between Years	5	22.1444	4.42888	10.62	**<0.0001***
Within Years	158	65.8948	0.41706		
Total	163	88.0392			
Meadow A5#					
Between Years	5	26.0192	5.20384	5.56	**0.0001***
Within Years	303	283.541	0.93578		
Total	308	309.56			
Meadow A6*					
Between Years	5	3.88115	0.077623	2.87	**0.0168***
Within Years	147	39.7654	0.27051		
Total	152	43.6466			
Meadow A7*					
Between Years	5	5.16641	1.03328	2.86	**0.0163***
Within Years	181	65.3148	0.36086		
Total	186	70.4812			

# Indicates square root transformed data

* Indicates log transformed data

Results of Least Significant Difference (LSD) pairwise comparisons of mean above ground biomass (g DW m^{-2}) for five monitoring meadows at Weipa 2001 to 2006. Means that share the same letter group are not significantly different (P <0.05).

Meadow A2	
Year	**Mean Biomass**
2001	29.7 a
2002	22.8 b
2003	13.9 c
2004	11.5 cd
2005	7.0 d
2006	6.4 d

Meadow A3	
Year	**Mean Biomass**
2001	2.0 a
2002	0.4 cd
2003	1.6 b
2004	0.3 d
2005	1.1 bc
2006	0.1 d

Meadow A5	
Year	**Mean Biomass**
2001	3.1 ab
2002	2.5 b
2003	2.3 ab
2004	4.2 ab
2005	4.1 a
2006	1.7 c

Meadow A6	
Year	**Mean Biomass**
2001	10.4 a
2002	9.5 a
2003	8.3 a
2004	1.1 b
2005	3.4 ab
2006	3.4 ab

Meadow A7	
Year	**Mean Biomass**
2001	18.9 a
2002	10.0 ab
2003	15.6 a
2004	10.6 ab
2005	2.8 b
2006	3.1 b