Long term seagrass monitoring in the Port of Thursday Island, March 2006.

Helen Taylor
Michael Rasheed
Tonia Sankey

Department of Primary Industries and Fisheries
Marine Ecology Group
Northern Fisheries Centre

DPI&F Publication PR06-2546

Queensland Government
Department of Primary Industries and Fisheries

PCQ
Ports Corporation of Queensland

CRC TORRES STRAIT

DPI&F Publication PR06-2546

Long term seagrass monitoring in the Port of Thursday Island

March 2006

Taylor, H.A., Rasheed, M.A. and Sankey, T.L.

Marine Ecology Group
Northern Fisheries Centre

Department of Primary Industries & Fisheries
PO Box 5396 Cairns Qld 4870

Queensland Government
Department of Primary Industries and Fisheries

PCQ
Ports Corporation of Queensland

CRC TORRES STRAIT

MARINE ECOLOGY GROUP

First Published 2006
PR06-2546
ISSN 0727-6273

Enquiries should be directed to:
Marine Ecology Group
Department of Primary Industries and Fisheries
Northern Fisheries Centre
PO Box 5396
Cairns, QLD, 4870, Australia

The correct citation of this document is:
Taylor, H.A., Rasheed, M.A. and Sankey, T.L. (2006). *Long term seagrass monitoring in the Port of Thursday, March 2006*. DPI&F Publication PR06-2546. (DPI&F, Northern Fisheries Centre, Cairns), 27 pp.

Acknowledgments

This was a joint project between Ports Corporation Queensland (PCQ), Department of Primary Industries and Fisheries (DPI&F), and the CRC Reef Research Centre / CRC Torres Strait. We thank Ross Thomas for assistance with fieldwork, and the services of Cape York Helicopters for the aerial survey.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

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. Successful long term seagrass monitoring programs are currently conducted at various port locations throughout Queensland. Results from these monitoring programs have enabled port managers to make informed decisions regarding planning and development of port infrastructure. This report details the latest findings from the Port of Thursday Island long term seagrass monitoring program from the most recent survey conducted in March 2006.

A baseline survey of seagrass habitat was conducted at the Port of Thursday Island in March 2002. That survey identified some of the best examples of intertidal and subtidal seagrass habitat that have been found in Queensland port environments. From that baseline survey nine seagrass meadows were selected for long term monitoring. The meadows selected were representative of the range of seagrass communities identified in the baseline survey and were also located in areas likely to be vulnerable to impacts from port operations and developments. This current survey represents the second of planned biennial long-term seagrass monitoring surveys for the port of Thursday Island. In this survey, seagrass above ground biomass, individual meadow area and species composition (community types) were measured for comparison with previous surveys.

Results from this survey indicated that seagrass communities at the Port of Thursday Island were relatively healthy. Significant increases in seagrass biomass were recorded for three of the nine monitoring meadows and area of all monitoring meadows was within the ranges previously recorded in the program. However some meadows had declined in biomass (density) since the 2004 survey. The three monitoring meadows adjacent to port and community infrastructure on the southern side of Thursday Island all had biomass declines since 2004, but generally only to levels observed in the 2002 survey. The declines in this type of meadow (*Enhalus* dominated) were consistent with climate driven changes that had occurred in other Queensland monitoring locations. While the changes were unlikely to be due to human or port activities a close watch on these meadows should be maintained in future surveys in case the trend continues.

Caution should be applied when interpreting changes to seagrass meadows at this early stage of the monitoring program as we are still establishing the ranges of natural change for Thursday Island seagrass communities. Despite this, the changes observed to date appear to be consistent with other areas of Queensland (Cape and Gulf) where annual monitoring programs have been established over longer periods of time.

INTRODUCTION

Seagrass habitats are important fisheries resources providing habitat for juvenile commercial and recreational species as well as food for endangered and threatened species such as dugong and turtle. Some of the best examples of seagrass meadows in Queensland occur in the sheltered waters associated with commercial ports and harbours. Seagrasses also show measurable responses to changes in water quality making them ideal candidates for monitoring the “health” of port environments. Seagrass meadows in other tropical Queensland ports that have been studied show marked seasonal and inter-annual changes such as Weipa (Roelofs *et al.,* 2006), Karumba (Rasheed *et al.,* 2006a), Mourilyan (Thomas *et al.*, 2006) and Cairns (McKenzie, 1994; Rasheed *et al*., 2006b). Results from long term monitoring programs at other Queensland port locations have provided valuable information on the relationships between climatic changes, anthropogenic disturbance and seagrass abundance. They have also indicated that healthy and productive seagrass habitats can co-exist with appropriately managed port facilities. Long term seagrass monitoring programs have enabled port managers to make informed decisions regarding planning and development of port infrastructure that will have minimal impact on the marine environment.

Due to the high reliance on fishing in the Thursday Island area, habitats that support commercial and traditional fisheries such as seagrasses are of critical importance to the region. Seagrass meadows occur in close proximity to port facilities at the Port of Thursday Island. A fine-scale baseline survey of seagrass habitat conducted at the port in March 2002 identified seagrass as the dominant benthic habitat with over 1500 ha of seagrass habitat mapped in the survey area (Rasheed *et al*., 2003). This has important implications for future port and coastal developments that may impact on these extensive meadows.

Ports Corporation of Queensland (PCQ) is the authority responsible for management of the Port of Thursday Island and they have recognised the importance of maintaining the health of seagrasses located within the port environment. Based on results of the 2002 baseline survey, the Queensland Department of Primary Industries and Fisheries (QDPI&F) in conjunction with PCQ implemented a biennial long term seagrass monitoring program to ensure that the ongoing health of the port’s marine environment could be maintained.

This was the second annual survey since the baseline survey and was a joint project between PCQ, QDPI&F and the CRC Torres Strait Ports and Shipping program. The objectives of the survey were to:

1. Monitor the seagrass species composition, area and abundance of the nine seagrass meadows identified for monitoring within the port limits; and,

2. Assess changes in these seagrass meadows that have occurred since the baseline survey; and,

3. Incorporate the results into the PCQ/QDPI&F Geographic Information System (GIS) developed for the Port of Thursday Island.

PCQ will use the results of seagrass monitoring to help in long term management of the port to minimise potential impacts on seagrass. The information should also prove useful to other organisations involved in management of community use of the inshore area.

METHODOLOGY

Seagrass surveys of the Port of Thursday were conducted between the 6th and 12th of March 2006. Nine seagrass meadows were selected from the baseline survey (Rasheed *et al.* 2003) 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.

Seagrass habitat observations 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 walking surveillance (Plate 1). A detailed description of the methods used to characterise the monitoring meadows is provided in Rasheed *et al*. (2003).

Plate 1. Seagrass monitoring methodology utilising (a) walking surveillance and (b) helicopter aerial surveillance, Thursday Island, March 2006.

Seagrass above ground biomass was determined using a modified "visual estimates of biomass" technique described by Mellors (1991). This technique involves an observer ranking seagrass biomass in the field in three random placements of a 0.25m^2 quadrat at each site. Ranks were made in reference to a series of quadrat photographs of similar seagrass habitat for which the above ground biomass has previously been measured. Three separate biomass ranges were used: low-biomass; high-biomass; and an *Enhalus* range. The relative proportion of the above ground biomass (percentage) of each seagrass species within each survey quadrat was also recorded. Field biomass ranks were then converted into above ground biomass estimates in grams dry weight per square metre (g DW m^{-2}). At the completion of sampling each observer ranked a series of calibration quadrats that represented the range of seagrass biomass in the survey. After ranking, seagrass in these quadrats was harvested and the actual biomass determined in the laboratory. A separate regression of ranks and biomass from these calibration quadrats was generated for each observer and applied to the field survey data to determine above ground biomass estimates.

As part of the DPI&F / CRC Torres Strait Shipping Lane Program, we were able to record biomass information for the two Madge Reef meadows (meadows 26 & 27) in March 2005. This information has been incorporated into this report.

Habitat Mapping and Geographic Information System

Spatial data from the field surveys were incorporated into the PCQ/QDPI&F Thursday Island 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 (±1.5m) 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). Abundance categories (light, moderate, dense) were assigned to community types according to above ground biomass of the dominant species (Table 2).
- **Seagrass landscape category** – area data showing the seagrass landscape category determined for each meadow

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 a few gaps of unvegetated sediment.

Table 1 Nomenclature for community types in the Port of Thursday Island, March 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

Table 2 Density categories and mean above ground biomass ranges for each species used in determining seagrass community density in the Port of Thursday Island, March 2006

Density	Mean above ground biomass (g DW m^{-2})					
	H. uninervis **(narrow)**	***H. ovalis***	***H. uninervis*** **(wide)** ***C. serrulata*** ***S. isoetifolium***	***H. spinulosa***	***Z. capricorni***	***E. acoroides*** ***T. ciliatum***
Light	< 1	< 1	< 5	< 15	< 20	< 40
Moderate	1 - 4	1 - 5	5 - 25	15 - 35	20 - 60	40 - 100
Dense	> 4	> 5	> 25	> 35	> 60	> 100

Each meadow was assigned a mapping precision estimate (in metres) based on mapping methodology utilised for that meadow (Table 3). Mapping precision ranged from ±5m to ±10m for the monitoring meadows. The mapping precision estimate was used to calculate a range of meadow area for each meadow and was expressed as a meadow reliability estimate (R) in hectares. Additional sources of mapping error associated with digitising and rectifying aerial photographs onto base maps and with GPS fixes for survey sites were embedded within the meadow reliability estimates.

Table 3. Mapping precision and methodology for seagrass meadows in Thursday Island, March 2006

Mapping precision	Mapping methodology
±5m	All meadow boundaries mapped in detail by GPS using a combination of the helicopter, divers and/or walking; Intertidal meadows completely exposed or visible at low tide; Relatively high density of mapping and survey sites; Recent aerial photography aided in mapping.
±10m	Inshore meadow boundary mapped in detail by GPS using a combination of the helicopter and/or walking; Offshore meadow boundary mapped by GPS using a combination of the helicopter and divers; Relatively high density of mapping and survey sites; Recent aerial photography aided in mapping.

RESULTS

Seagrass species, distribution and abundance for monitoring meadows in 2006

Eight seagrass species (from three families) were identified in the nine seagrass monitoring meadows (Plate 2). For a complete list of species found within the port limits see Rasheed *et al*. (2003).

Family CYMODOCEACEAE Taylor:

Cymodocea rotundata Ehrenb. et Hempr. ex Aschers
Cymodocea serrulata (R.Br.) Aschers and Magnus
Halodule uninervis (wide and narrow leaf morphology) (Forsk.) Aschers. in Boissier
Thalassodendron ciliatum (Forsk.) den Hartog

Cymodocea serrulata

Cymodocea rotundata

Thalassodendron ciliatum

Halodule uninervis

Family HYDROCHARITACEAE Jussieu:

Enhalus acoroides (L.F.) Royle
Halophila ovalis (R. Br.) Hook. F.
Thalassia hemprichii (Ehrenb.) Aschers. in Petermann

Enhalus acoroides

Thalassia hemprichii

Halophila ovalis

Family ZOSTERACEAE Drummortier:

Zostera capricorni Aschers.

Zostera capricorni

A total of 133 ± 12 ha of seagrass habitat was mapped in the nine seagrass monitoring meadows in March 2006 (Table 4; Map 1). Meadow area ranged from 0.3 ha to 89 ha with the smallest meadow located between the Engineers and Main Wharves on Thursday Island (meadow 3) and the largest located on Madge Reef (meadow 26) (Table 5; Maps 2 & 4). A total of 176 monitoring sites (excluding meadow boundary mapping sites) were surveyed, 97% of which (170 sites) had seagrass present. Of these monitoring sites 107 were surveyed from helicopter and the remaining 63 were surveyed on foot at low tide.

The nine monitoring meadows that were surveyed included eight different community types (Maps 2, 3 & 4; Table 4). Communities that were dominated by *Enhalus acoroides* were the most common, followed by communities that were dominated by *Halodule uninervis* (thin). The *H. uninervis* dominated meadows were all located high up on the intertidal banks on the southern and northern foreshores of Thursday Island, while *E. acoroides* meadows were found in the lower intertidal region. *E. acoroides* dominated meadows were also located on Madge Reefs.

A total of eight different seagrass species were recorded in the monitoring meadows (Table 4). Although individual meadows were dominated by either *E. acoroides* or *H. uninervis*, the species composition of each meadow often consisted of between two to six other species.

Seagrass cover in the monitoring meadows was comprised of aggregated patches with the exception of continuous cover for the three *E. acoroides* dominated meadows on the southern foreshore of Thursday Island (meadows 2, 4 & 6) (Map 2; Table 4). The majority of monitoring meadows were located on intertidal substrates dominated by either mud or sand, with a smaller component of either mud/sand and/or shell. A number of meadows also contained areas that were dominated by reef structure.

Mean above ground biomass for the monitoring meadows in March 2006 ranged from 1.0 ± 0.1 g DW m^{-2} for the *H. uninervis* (thin) dominated meadow on the southern foreshore (meadow 3), to 41.9 ± 4.7 g DW m^{-2} for the *E. acoroides* dominated meadow near Madge Reef (meadow 26) (Table 5; Figure 1a & 1b).

Table 4. Community type, seagrass cover and species present in the nine Thursday Island monitoring meadows, March 2006.

Monitoring Meadow	Community Type	Cover	Species Present
1	Moderate *H. uninervis* (thin) with *H. ovalis*	Aggregated patches	*H. uninervis* (thin), *H. ovalis*, *T. hemprichii*
2	Light *E. acoroides*	Continuous	*E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. uninervis* (wide), *H. uninervis* (thin), *H. ovalis*
3	Light *H. uninervis* (thin) with *H. ovalis*	Aggregated patches	*E. acoroides*, , *H. uninervis* (thin), *H. ovalis, T. hemprichii*
4	Light *E. acoroides*	Continuous	*E. acoroides*, *T. hemprichii*, *H. uninervis* (thin), *H. ovalis*
5	Mod. *H. uninervis*(thin) with *H. ovalis / T. hemprichii*	Aggregated patches	*H. uninervis* (thin), *H. ovalis*, *T. hemprichii*
6	Light *E. acoroides* with mixed species	Continuous	*E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. uninervis* (thin), *T. ciliatum*, *H. ovalis*
8	Dense *H. uninervis* (thin) with mixed species	Aggregated patches	*T. hemprichii*, *C. rotundata*, *H. uninervis* (wide), *H. uninervis* (thin), *H. ovalis*
26	Light *E. acoroides* with *H. uninervis* (thin) / mixed species	Aggregated patches	*E. acoroides*, *T. hemprichii*, *C. rotundata*, *C. serrulata*, *H. uninervis* (wide), *H. uninervis* (thin), *Z. capricorni*, *H. ovalis*
27	Light *E. acoroides* with *T. ciliatum* / mixed species	Aggregated patches	*E. acoroides*, *T. hemprichii*, *C. rotundata*, *H. uninervis* (wide), *H. uninervis* (thin), *T. ciliatum*

Map 1. Port of Thursday Island seagrass monitoring meadows and survey sites, 2006

Legend

- No seagrass
- Seagrass present
- Port limit
- Non monitoring meadows

Community type of monitoring meadows

- Light E. acoroides
- Light E. acoroides with mixed species
- Light E. acoroides with T. cilliatum / mixed species
- Light E. acoroides with H uninervis (thin) / mixed species

Background: Beach Protection Authority, 1:50,000, 19/6/92

- Light H. uninervis (thin) with H. ovalis
- Moderate H. uninervis (thin) with H. ovalis
- Moderate H. uninervis (thin) with H. ovalis / T. hemprichii
- Dense H uninervis (thin) with mixed species

Source: Taylor, H.A., Rasheed, M.A., and Sankey, T.L. 2006. Long term seagrass monitoring in the Port of Thursday Island, March 2006. DPI&F Publication PR06-2546 (DPI&F, Cairns).

Funded by Ports Corporation Queensland, CRC Torres Strait and the Queensland Department of Primary Industries and Fisheries.

Produced by the Marine Ecology Group, Queensland Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns, 2006.

Map 2. Port of Thursday Island southern foreshore seagrass monitoring meadows, 2006

Legend

Port limit

Cover

Aggregated patches

Continuous

Community type

- Light *E. acoroides*
- Light *E. acoroides* with mixed species
- Light *H. uninervis* (thin) with *H. ovalis*
- Moderate *H. uninervis* (thin) with *H. ovalis*
- Moderate *H. uninervis* (thin) with *H. ovalis / T. hemprichii*

NB: This is not a complete seagrass distribution
Backgraound image: Beach Protection Authority 1:50000, 19/6/92

0 0.2 0.4
Kilometres

N

Source: Taylor, H.A., Rasheed, M.A., and Sankey, T.L. 2006. Long term seagrass monitoring in the Port of Thursday Island, March 2006. DPI&F Information Series PR06-2546 (DPI&F, Cairns).

Funded by Ports Corporation Queensland, CRC Torres Strait and the Queensland Department of Primary Industries and Fisheries.

Produced by the Marine Ecology Group, Queensland Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns, 2006.

Map 3. Port of Thursday Island northern foreshore seagrass monitoring meadow, 2006

Legend

- Port limit
- Aggregated patches
- Dense *H. uninervis* (thin) with mixed species

NB: This is not a complete seagrass distribution
Backgraound image: Beach Protection Authority 1:50000, 19/6/92

0 0.2 0.4
Kilometres

N

Source: Taylor, H.A., Rasheed, M.A., and Sankey, T.L 2006. Long term seagrass monitoring in the Port of Thursday Island, March 2006. DPI&F Publication PR06-2546 (DPI&F, Cairns).

Funded by Ports Corporation Queensland, CRC Torres Strait and the Queensland Department of Primary Industries and Fisheries.

Produced by the Marine Ecology Group, Queensland Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns, 2006.

Map 4. Port of Thursday Island seagrass monitoring meadows at Madge Reef, 2006

Legend

Port limit

Aggregated patches

Community type

Light *E. acoroides* with *H. uninervis* (thin) / mixed species

Light *E. acoroides* with *T. cilliatum* / mixed species

N

NB: This is not a complete seagrass distribution
Backgraound image: Beach Protection Authority 1:50000, 19/6/92

Source: Taylor, H.A., Rasheed, M.A., and Sankey, T.L. 2006. Long term seagrass monitoring in the Port of Thursday Island, March 2006. DPI&F Publication PR06-2546 (DPI&F, Cairns).

Funded by Ports Corporation Queensland, CRC Torres Strait and the Queensland Department of Primary Industries and Fisheries.

Produced by the Marine Ecology Group, Queensland Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns, 2006.

Comparison with previous monitoring surveys

While there were some changes to seagrass biomass and area from 2004 to 2006, the values recorded in 2006 were generally within the previously recorded range for the monitoring program (2002, 2004 & 2006). Higher biomass meadows dominated by *Enhalus acoroides* generally declined from 2004 to 2006 but remained similar to the 2002 baseline survey. The lower biomass meadows dominated by *Halodule uninervis* (thin) and *Halophila ovalis* however remained unchanged or had increased from 2004 (Figure 1).

Biomass had significantly declined since 2004 for three of the *E. acoroides* dominated monitoring meadows (46% - 49% decline) (Table 5; Figure 1; Appendix 1). All three meadows were in the lower intertidal region on the southern foreshore of Thursday Island (meadows 2, 4, & 6). While all three had declined since 2004 only meadow 6 (between the Engineers and Main wharves) was significantly lower than both the baseline and 2004 monitoring surveys. The area of all three meadows had remained within the reliability range but meadow 4 has shown a small but consistent declining trend over the three sampling events (Table 5; Map 5).

There was no significant change in biomass or area for the remaining two *E. acoroides* dominated meadows located on Madge Reefs (between Thursday and Horn Islands) from 2004 to 2006 (Table 5; Map 7; Appendix 1). However, we were able to perform additional biomass monitoring in March 2005 for the largest of the Madge Reef meadows (meadow 26) which showed that there was a significant decline in biomass from 2004 to 2005 (51% decline) and subsequent recovery from 2005 to 2006 (Table 5; Figure 1b; Appendix1). Biomass for the meadow still remained lower than the 2002 baseline level.

The intertidal lower biomass *Halodule* and *Halophila* dominated meadows had remained similar or had slightly increased in biomass and area since 2004 (meadows 1, 3, 5 & 8; Table 5; Map 5 & 6; Appendix 1). The two largest of these meadows (meadow 1 on the southern foreshore & 8 on the northern foreshore) were significantly denser than in the 2002 baseline survey, and were at their highest biomass levels recorded in the program to date. Both meadows 3 and 5 had shown small fluctuations in biomass over the three years of surveys, however changes had not been significant.

The species composition of the monitoring meadows remained relatively consistent between surveys (Figure 1). All meadows were dominated by the same species in the three sampling years, however some variation to the composition of the minor species had occurred. The changes to the minor species composition were usually related to a small increase or decrease of one or two species. Of particular note was the absence of *S. isoetifolium* in the 2006 survey (Table 3). This species had previously been identified as a minor component in meadows 2, 4, 6 & 26 in 2002 or 2004.

Table 5. Number of survey sites, area and mean above ground biomass for Thursday Island monitoring meadows, March 2002, 2004 and 2006; 2005 for Meadow 26 and 27 only.

Monitoring Meadow #	Number of survey sites				Area (ha) (Reliability)			Mean biomass ± SE (g DW m^{-2}) (±% change)			
	Mar-02	Mar-04	Mar-05	Mar-06	Mar-02	Mar-04	Mar-06	Mar-02	Mar-04	Mar-05	Mar-06
1	10	28	-	23	2.3 (1.5-3.1)	2.5 (1.6-3.4)	2.2 (1.4-3.0)	0.3 ± 0.1	3.7 ± 0.8 (+1133%)	-	4.3 ± 1.2 (+16%)
2	12	14	-	20	7.7 (5.4-10.0)	7.8 (6.2-9.4)	7.8 (6.2-9.4)	43.3 ± 6.3	75.4 ± 6.9 (+74%)	-	38.2 ± 3.7 (-49%)
3	3	7	-	8	0.1 (0.05-0.15)	0.2 (0.1-0.3)	0.3 (0.1-0.5)	0.8 ± 0.1	2.5 ± 1.2 (+212%)	-	1.0 ± 0.1 (-60%)
4	14	6	-	5	1.3 (0.7-1.9)	1.0 (0.5-1.5)	0.8 (0.3-1.3)	32.8 ± 8.5	56.2 ± 13.1 (+71%)	-	30.2 ± 5.7 (-46%)
5	8	26	-	25	2.1 (1.3-2.9)	1.9 (1.1-2.7)	2.0 (1.1-2.9)	3.4 ± 1.3	7.9 ± 1.2 (+132%)	-	5.7 ± 1.1 (-28%)
6	15	18	-	22	13.2 (10.6-15.8)	12.4 (10.0-14.8)	12.7 (10.2-15.2)	55.7 ± 8.9	48.2 ± 8.5 (-13%)	-	25.6 ± 6.0 (-47%)
8	5	31	-	3	12.3 (10.3-14.3)	10.4 (8.2-12.6)	12.2 (10.4-14.0)	0.4 ± 0.3	7.4 ± 1.3 (+1750%)	-	10.5 ± 1.6 (+42%)
26	18	31	25	32	94.5 (93.0-96.0)	87.7 (84.2-91.2)	89 (85.9-92.1)	68.8 ± 9.8	48.8 ± 5.4 (-29%)	24.1 ± 3.0 (-51%)	41.9 ± 4.7 (+74%)
27	1	13	8	10	6.1 (5.4-6.8)	7.0 (6.1-7.9)	5.8 (5.1-6.5)	175.9 ± 0.0*	47.8 ± 10.6 (n/a)**	24.4± 5.7 (-23%)	32.4 ± 6.2 (-32%)
Total	**86**	**174**	**33**	**176**	**139.6 (128.2-151.0)**	**130.9 (117.9-143.9)**	**132.8 (120.7-144.9)**	**-**	**-**	**-**	**-**

*Based on one site not representative of entire community
**Too few sites surveyed in March 2002 to allow reasonable biomass comparison

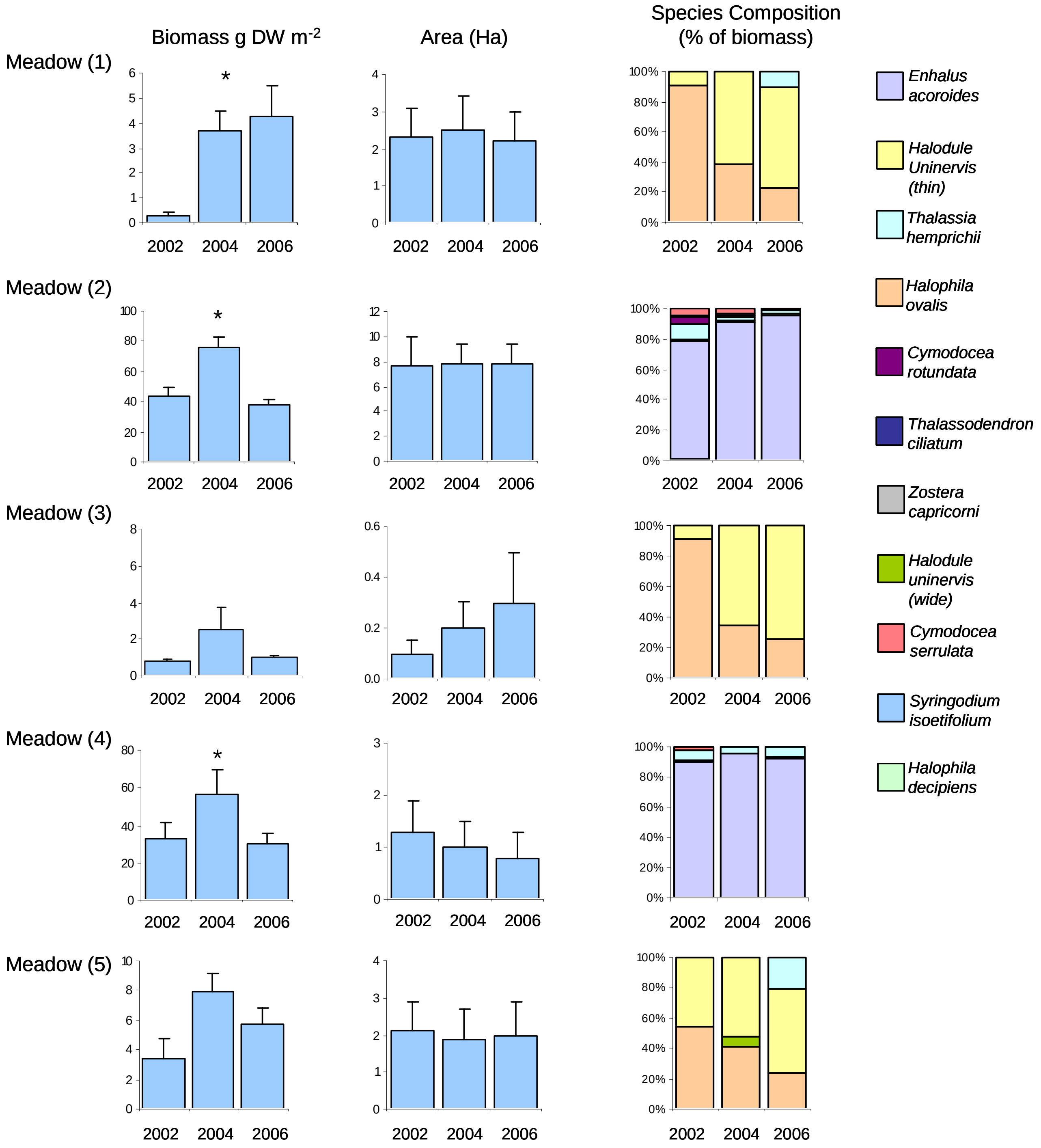


Figure 1 (a) Changes in biomass, area and species composition for monitoring meadows in 2002, 2004 and 2006 (Biomass error bars = SE; Area error bars = "R" reliability estimate).

* Represents Meadows displaying significant differences in above ground biomass between years (Appendix 1 – LSD results).N.B. 2002 data for Meadow 3 was excluded from statistical analysis. Data was based on three sites and not representative of entire community.

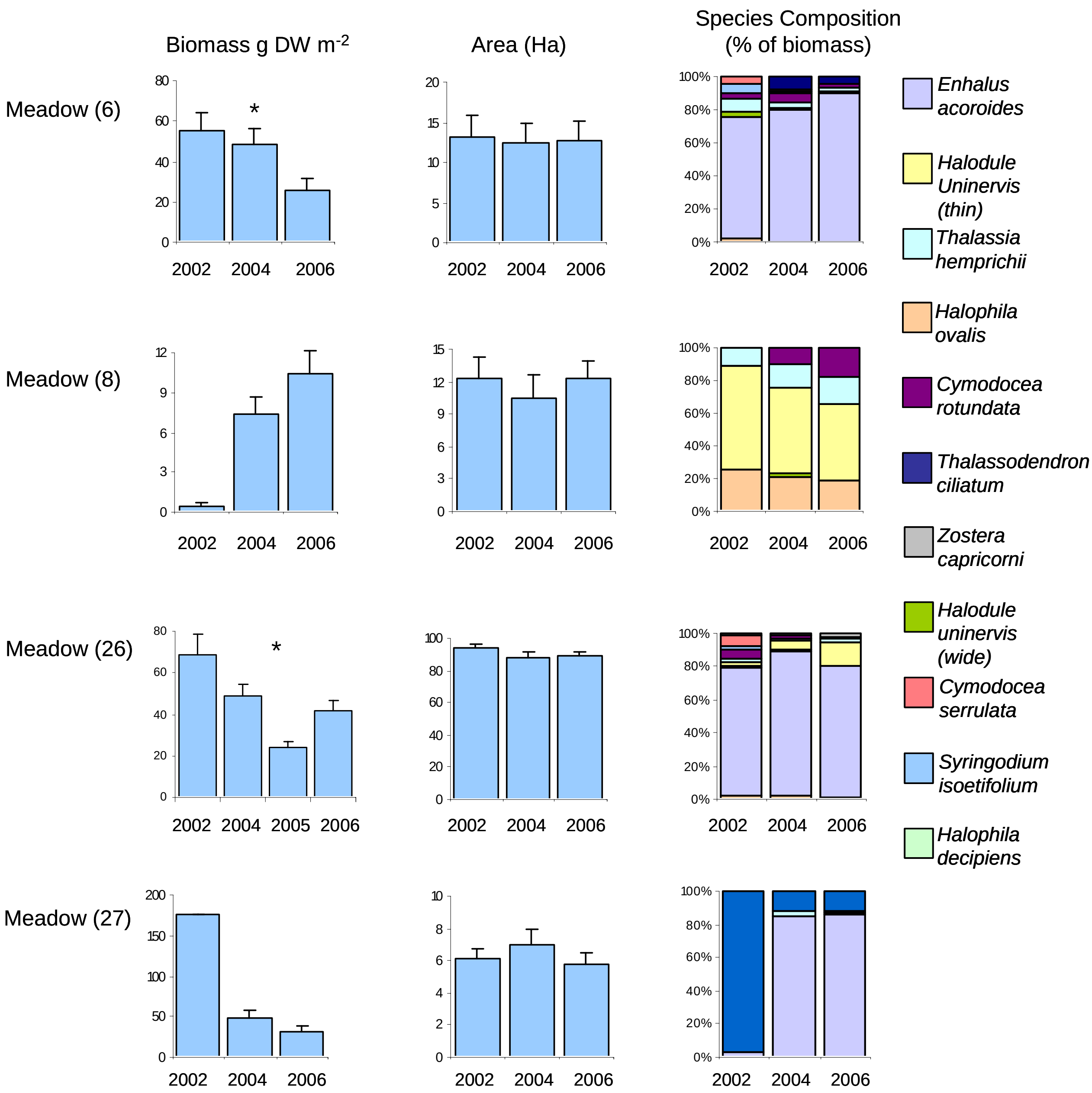
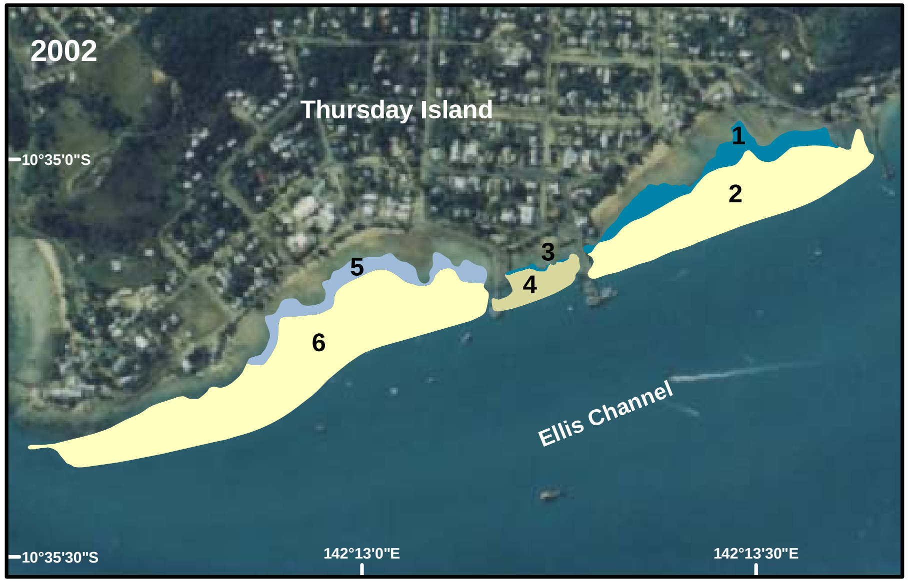


Figure 1 (b) Changes in biomass, area and species composition for monitoring Meadows 6 and 8 in 2002, 2004 and 2006, monitoring Meadow 26 in 2002, 2004, 2005 and 2006, monitoring Meadow 27 in 2004, 2005 and 2006 (Biomass error bars = SE; Area error bars = “R” reliability estimate).

*Meadows significantly different in above ground biomass between years (Appendix 1).

Map 5. Comparision of the southern foreshore seagrass montiroing meadows in the Port of Thursday Island in 2002, 2004 & 2006



Legend

Cover

- Aggregated patches
- Continuous

Community type

- Light *H. uninervis* (thin) with *H. ovalis*
- Moderate *H. uninervis* (thin) with *H. ovalis*
- Moderate *H. uninervis* (thin) with *H. ovalis / T. hemprichii*
- Light *E. acoroides*
- Light *E. acoroides* with mixed species
- Moderate *E. acoroides* with mixed species
- Light *H. ovalis* with *H. uninervis* (thin)
- Moderate *H. ovalis* with *H. uninervis* (thin)

0 0.25 0.5
Kilometres

N

NB: This is not a complete seagrass distribution
No landscape information was collected in 2002
Backgraound image: Beach Protection Authority 1:50000, 19/6/92

Source: Taylor, H.A., Rasheed, M.A., and Sankey, T.L. 2006. Long term seagrass monitoring in the Port of Thursday Island, March 2006. DPI&F Publication PR06-2546 (DPI&F, Cairns).

Funded by Ports Corporation Queensland, CRC Torres Strait and the Queensland Department of Primary Industries and Fisheries.

Produced by the Marine Ecology Group, Queensland Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns, 2006.

Map 6. Comparison of the northern foreshore seagrass monitoring meadow in Port of Thursday Island in 2002, 2004 & 2006

NB: This is not a complete seagrass distribution
No landscape information was collected in 2002
Backgraound image: Beach Protection Authority 1:50000, 19/6/92

Legend

Port limit

Aggregated patches

Community type

Light *H. uninervis* with *H. ovalis / T. hemprichii*

Dense *H. uninervis* (thin) with mixed species

0 0.25 0.5
Kilometres

N

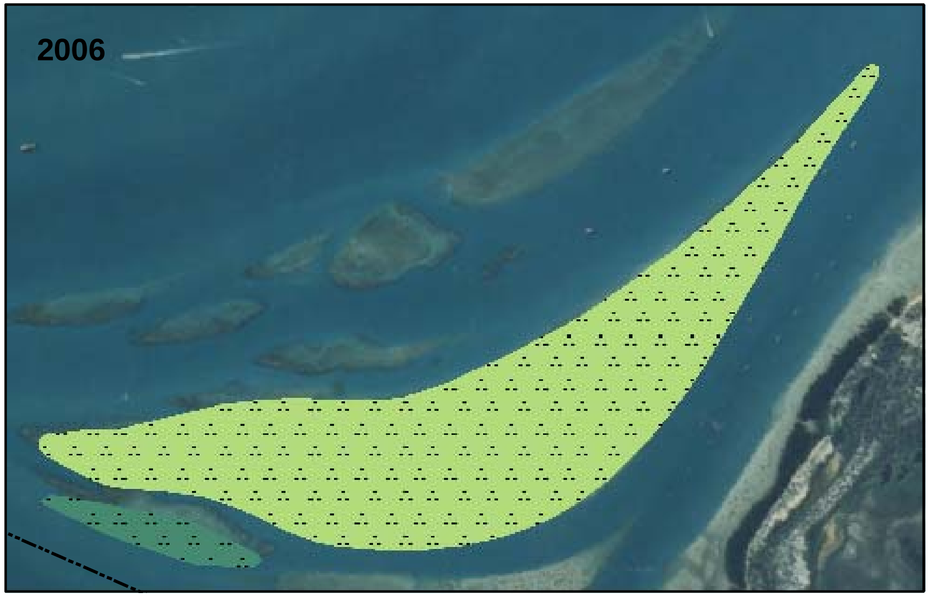
PCQ Ports Corporation of Queensland
Queensland Government Department of Primary Industries and Fisheries
CRC Torres Strait
Marine Ecology Group

Source: Taylor, H.A., Rasheed, M.A., and Sankey, T.L. 2006. Long term seagrass monitoring in the Port of Thursday Island, March 2006. DPI&F Publication PR06-2546 (DPI&F, Cairns).

Funded by Ports Corporation Queensland, CRC Torres Strait and the Queensland Department of Primary Industries and Fisheries.

Produced by the Marine Ecology Group, Queensland Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns, 2006.

Map 7. Comparision of the seagrass monitoring meadows at Madge Reef in the Port of Thursday Island in 2002, 2004 & 2006



NB: This is not a complete seagrass distribution
No landscape information was collected in 2002
Backgraound image: Beach Protection Authority 1:50000, 19/6/92

Legend

Port limit

Aggregated patches

TYPE

Light *E. acoroides* with *H. uninervis* (thin) / mixed species

Light *E. acoroides* with *T. cilliatum* / mixed species

Moderate *E. acoroides* with mixed species

Dense *T. cilliatum* with *E. acoroides*

0 0.5 1
Kilometres

N

Source: Taylor, H.A., Rasheed, M.A., and Sankey, T.L. 2006. Long term seagrass monitoring in the Port of Thursday Island, March 2006. DPI&F Publication PR06-2546 (DPI&F, Cairns).

Funded by Ports Corporation Queensland, CRC Torres Strait and the Queensland Department of Primary Industries and Fisheries.

Produced by the Marine Ecology Group, Queensland Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns, 2006.

DISCUSSION

The results of the 2006 monitoring survey revealed that seagrass meadows at Thursday Island were generally healthy. The most recent changes were mostly within the range of previous values and were consistent with climate driven variations noted in other similar seagrass communities in North Queensland. In general *Enhalus acoroides* meadows in lower intertidal to subtidal areas declined in density between 2004 and 2006 while lower biomass *Halodule* and *Halophila* meadows in the upper intertidal zone were unchanged or had increased.

Although a decline was recorded for some *Enhalus acoroides* meadows between 2004 and 2006, extra data collected for the two meadows on Madge Reefs in 2005 suggested that *Enhalus* meadows had actually recovered to a degree in 2006 from losses that occurred prior to March 2005. Therefore, it was possible that the decline recorded for the three *Enhalus acoroides* meadows on the southern foreshore of Thursday Island also had occurred prior to March 2005 and had actually recovered to some extent by March 2006.

While the exact cause of *Enhalus* declines in 2005 was not clear it was most likely the changes were related to climate rather than port or other anthropogenic (human) causes. Seagrasses in the Port of Thursday Island were likely to have been influenced by a number of different climatic factors including rainfall, wind, solar irradiance and temperature, which are known to affect seagrass growth, recruitment and mortality (e.g. Rasheed *et al*. 2006a; 2006b; 2006c; Thomas *et al*. 2006). The rainfall levels recorded in the three months prior to each monitoring survey (December, January and February) show that rainfall in 2005 was particularly low (Figure 2; Appendix 2). This may indicate that there was less cloud cover and potentially higher solar irradiation during the hottest time of the year. These conditions have lead to desiccation and thermal stress of intertidal *Enhalus acoroides* meadows in other Queensland locations (Roelofs *et al.* 2006).

The intertidal *Halodule uninervis* dominated monitoring meadows were not affected in the same manner as the *Enhalus* meadows. In 2006 the *Halodule* meadows had either increased or remained at similar densities and area to 2004, with two meadows (1 and 8) recording their highest biomass levels for the program. *Enhalus acoroides* and *Halodule uninervis* (thin) are morphologically quite different species, with the smaller, less rigid *Halodule uninervis* (thin) capable of lying flat on the moist sediment surface and are therefore less prone to desiccation and “burning off” than the rigid *Enhalus accoroides* (see Roelofs *et al.* 2006). *Halodule uninervis* (thin) is also capable of recovering much more rapidly from loss through asexual rhizome extension than the bigger slower growing *Enhalus*. It was possible that declines in *Halodule* meadows also occurred in 2005 when the Madge Reef *Enhalus* declined but the faster asexual spreading ability allowed *Halodule* meadows to make a more complete recovery by 2006.

The patterns of seagrass change recorded at Thursday Island were consistent with trends documented in other Queensland locations. Intertidal *Enhalus acoroides* meadows in Weipa also declined in biomass during the same period, while the intertidal *Halodule uninervis* meadows remained unchanged (Roelofs *et al*. 2006). At Karumba in the southern Gulf of Carpentaria, intertidal *Halodule uninervis (pinifolia)* meadows had expanded to record density and area in late 2005 (Rasheed *et al*. 2006c). In both cases, local and regional climate conditions were also the likely driver of the observed changes.

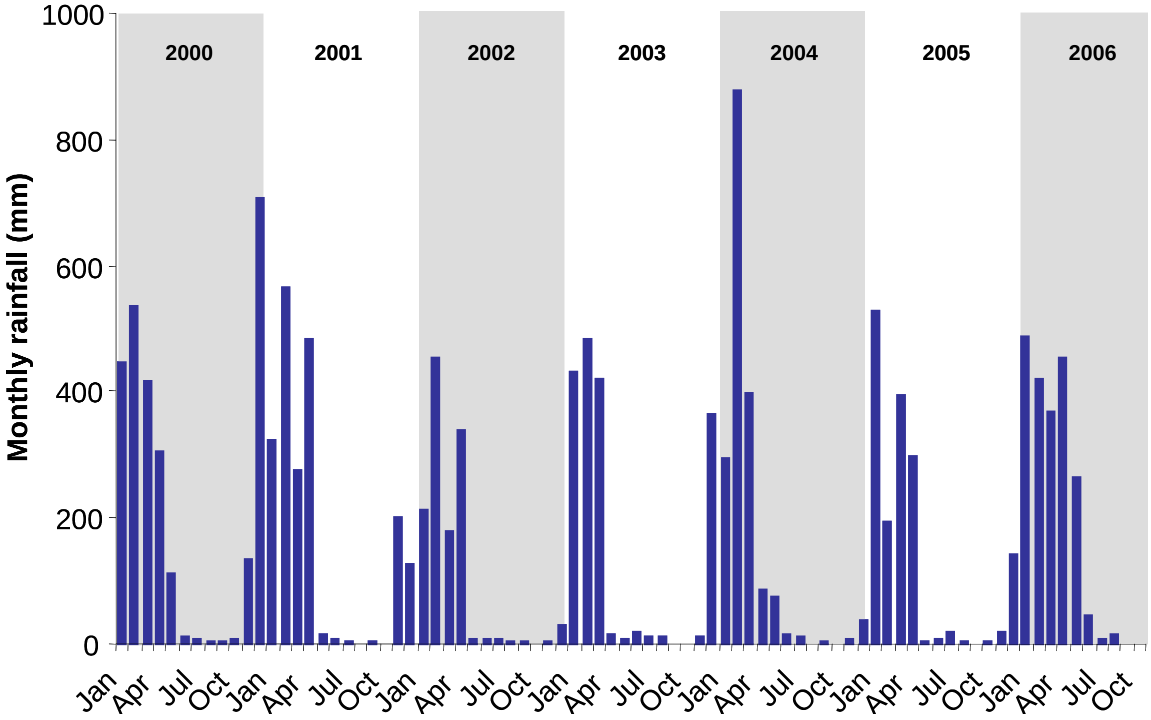
The absence of *Syringodium isoetifolium* from the 2006 survey was likely to be linked to changes in sampling methods that occurred in 2006 in conjunction with climatic factors. *Syringodium isoetifolium,* while only a very minor component of meadows, had been found previously in meadows 2, 4, 6 and 26 (Thomas & Rasheed, 2004). This seagrass species has been documented in a number of studies as being an outer intertidal and/or subtidal species (Gallegos & Kenworthy 1996; Jupp *et al*. 1996). Data from both 2002 and 2004 shows that the majority of sites in which *Syringodium isoetifolium* was found were located along the outer intertidal edge of meadows. Due to the presence of a large saltwater crocodile in the area in 2006 we were unable to conduct diving sampling in this zone of the meadows and consequently had fewer sites where *Syringodium* had been most commonly found. On Madge Reef however *Syringodium isoetifolium* had been found in sites scattered throughout the meadow (meadow 26) and despite sampling at all locations within the meadow in 2006 *Syringodium isoetifolium* was still absent. It is possible that *Syringodium isoetifolium* was affected by high light levels in 2005 in a similar way to *Enhalus acoroides*. Research has found that *S. isoetifolium* is highly light sensitive (Gallegos & Kenworthy 1996), particularly when located in the intertidal zone. Unlike the other meadows where *Syringodium* was previously found, all of the Madge Reef meadow was located in the exposed upper intertidal zone and thus *Syringodium* may have been more vulnerable to the influences of high light.

Overall, the seagrass communities in the Port of Thursday Island appear to be healthy. While the changes were generally within the range of previous values a couple of meadows experienced changes that may require closer attention in future surveys if trends continue:

- Meadow 6 located in the intertidal/shallow sub-tidal zone between the Thursday Island Engineers Wharf and Hospital Point was the only meadow where biomass was significantly lower than both the 2002 and 2004 surveys. This meadow is located in a region where a lot of boat anchoring occurs.
- Meadow 4 located between the Main and Engineers Wharves has had consistent small declines in area for each monitoring survey. While these declines were within the mapping reliability range a continued downward trend in the future would be a concern.

The baseline survey in 2002 gave a good foundation from which the biennial monitoring surveys could be based, however this was only the second monitoring event since the baseline and causes or significance of seagrass changes must be regarded carefully until the natural patterns are more firmly established in future surveys. Even so, we are starting to get a clearer picture of the natural inter-annual variations and the relationship between seagrass change and climate.

(A)



(B)

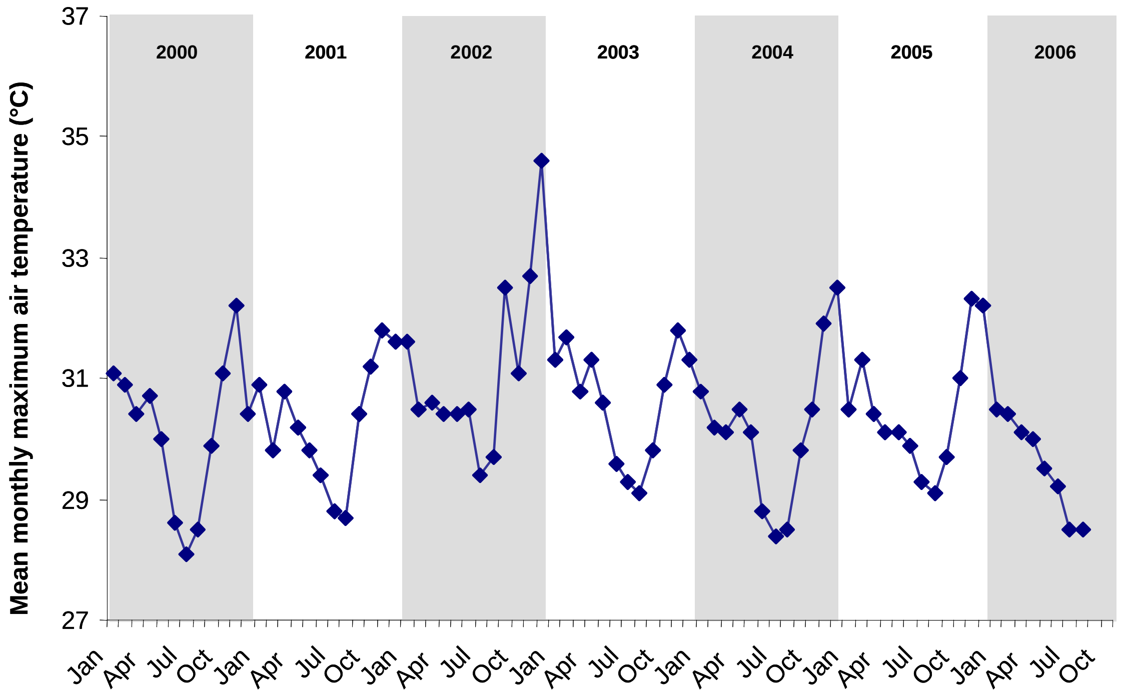


Figure 2. (A) Mean monthly rainfall and (B) Mean monthly maximum air temperature for Horn Island (January 2000 to September 2006).

REFERENCES

Gallegos, C.L. and Kenworthy, W.J. (1996). Seagrass depth limits in the Indian River Lagoon (Florida, USA): Application of an optical water quality model. *Estuarine, Coastal and Shelf Science* **42**, 267-288.

Jupp, B.P., Durake, M.J., Kenworthy, W.J., Thayer, G.W. and Schillak, L. (1996). Distribution, abundance, and species composition of seagrass at several sites in Oman. *Aquatic Botany* **53**, 199-213.

McKenzie, L.J. (1994). Seasonal changes in biomass and shoot characteristics of a Zostera capricorni Aschers. dominant meadow in Cairns Harbour, Northern Queensland. *Australian Journal of Marine and Freshwater Research* **45**: 1337-1352.

Mellors, J.E. (1991). An evaluation of a rapid visual technique for estimating seagrass biomass. *Aquatic Botany* **42**, 67-73.

Rasheed, M.A., Thomas, R., Roelofs, A. and Neil, K. (2003). Seagrass, benthic habitats and targeted introduced species survey of the Port of Thursday Island: March 2002. DPI Information Series QI03019 (DPI, Cairns), 28 pp.

Rasheed, M.A., Taylor, H.A. and Thomas, R. (2006a). Port of Karumba long term seagrass monitoring. DPI&F Information Series QI06029. (DPI&F, NFC, Cairns), 15pp.

Rasheed, M.A., Taylor, H.A., Dew, K.A. and Thomas, R. (2006b). Long term seagrass monitoring in Cairns Harbour and Trinity Inlet – December 2005. DPI&F Information Series QI06032. (DPI&F, NFC, Cairns), 25pp.

Rasheed, M.A., Taylor, H.A. and Thomas, R. (2006c). Long term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone – October 2005. DPI&F Information Series QI06030. (DPI&F, NFC, Cairns) 30pp.

Roelofs, A.J., Rasheed, M.A., Thomas, R., McKenna, S. and Taylor, H. (2006). Port of Weipa long term seagrass monitoring, 2003 - 2005. Ecoports Monograph Series No. 23 Ports Corporation of Queensland. 31pp.

Thomas, R. and Rasheed, M.A. (2004). Port of Thursday Island long term seagrass monitoring – March 2004. QDPI&F Information Series QI04082. (QDPI&F, NFC, Cairns) 22pp.

Thomas, R., Rasheed, M.A. and Taylor, H.A. (2006). Long term seagrass monitoring in the Port of Mourilyan - November 2005. DPI&F Information Series QI06031, (DPI&F, Northern Fisheries Centre, Cairns), 18 pp.

APPENDIX 1

Results of one-way ANOVA for mean above ground biomass versus year for the six seagrass monitoring meadows displaying significant differences between years at the Port of Thursday Island (March 2002, 2004 and 2006; 2005 Meadow 26 & 27 only) (H^o = no difference in meadow biomass between years).

NB: Biomass data for March 2002 for meadows 3, 8 and 27 was omitted from analyses due to the low number of replicates. As a result, a t-test was performed for meadows 3 and 8 as there was only 2 years of data available for analysis.

Meadow 1*	**DF**	**SS**	**MS**	**F**	**P**
Between Years	2	1.46385	0.73192	4.98	**0.01***
Within Years	59	8.67314	0.147		
Total	61	10.137			
Meadow 2					
Between Years	2	12334.8	6167.39	13.33	**<0.0001***
Within Years	43	19896	462.697		
Total	45	32230.8			
Meadow 4					
Between Years	2	5039.17	2519.59	3.65	**0.0428***
Within Years	22	15190	690.453		
Total	24	20229.1			
Meadow 5					
Between Years	2	132.096	66.0481	2.29	0.1105
Within Years	57	1644.13	28.8443		
Total	59	1776.22			
Meadow 6					
Between Years	2	8899.12	4449.56	4.85	**0.0118***
Within Years	51	46818.6	918.012		
Total	53	55717.7			
Meadow 26					
Between Years	3	21857.5	7285.84	9.91	**<0.0001***
Within Years	100	73514.8	735.148		
Total	103	95372.3			
Meadow 27					
Between Years	2	2938.84	1469.42	1.8	0.1845
Within Years	28	22905.3	818.047		
Total	30	25844.1			

Results of a Two-Sample T Test for mean above ground biomass versus year for Meadows 3 and 8 at the Port of Thursday Island (March 2004 and 2006). Data was log transformed to meet the assumption of equal variances.

Meadow 3	**T**	**DF**	**P**
	0.57	12	0.5802
Meadow 8*	**T**	**DF**	**P**
	-0.71	59	0.4796

* Indicates log transformed data.

Results of Least Significant Difference (LSD) pair-wise comparisons of mean above ground biomass for the six seagrass monitoring meadows displaying significant differences between years. Means that share the same letter group for each meadow are not significantly different (P < 0.05).

Meadow 1*	
Year	**Mean Biomass**
2002	0.09 b
2004	0.48 a
2006	0.52 a

Meadow 2	
Year	**Mean Biomass**
2002	43.26b
2004	75.38 a
2006	38.16 c

Meadow 4	
Year	**Mean Biomass**
2002	32.8 b
2004	67.43 a
2006	30.23 b

Meadow 6	
Year	**Mean Biomass**
2002	55.71 a
2004	48.22 a
2006	25.98 b

Meadow 26	
Year	**Mean Biomass**
2002	68.81 a
2004	48.78 b
2005	24.08 c
2006	41.69 b

APPENDIX 2

Total monthly precipitation for Horn Island from 2000 to 2006 (Australian Bureau of Meteorology, 2006).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2000	447.8	533.8	417.4	303.8	110.6	10.6	5.6	4.6	2.2	8.2	132.0	707.2	**2683.8**
2001	322.4	565.8	276.2	482.8	13.8	9.2	2.6	0.8	4.0	0.4	201.8	127.0	**2006.8**
2002	211.4	454.0	178.0	339.0	5.6	6.4	6.2	4.8	3.8	1.0	2.6	31.4	**1244.2**
2003	429.8	483.8	421.2	16.4	6.2	20.4	11.0	9.4	0.8	1.0	11.8	365.4	**1777.2**
2004	293.8	878.6	399.2	86.6	72.6	14.2	9.6	0	3.4	0	7.2	36.6	**1801.8**
2005	526.4	193.6	393	298.6	4.2	6.4	17.2	3.8	0.2	3.8	16.8	141.6	**1605.6**
2006	488.4	420.2	366.8	451.8	265.4	45	9	15.6					
n	7	7	7	7	7	7	7	7	6	6	6	6	**6**
Mean	388.6	504.3	350.3	282.7	68.3	16	8.7	5.6	2.4	2.4	62	234.9	**1853.2**
Lowest	211.4	193.6	178	16.4	4.2	6.4	2.6	0	0.2	0	2.6	31.4	**1244.2**
Highest	526.4	878.6	421.2	482.8	265.4	45	17.2	15.6	4	8.2	201.8	707.2	**2683.8**