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Long Term Seagrass Monitoring in the Port of Mourilyan

November 2006




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DPI&F Publication No. PR07-2915

Queensland Government
Department of Primary Industries and Fisheries

PCQ
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First Published 2007
PR07-2915
ISSN 0727 6273

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The correct citation of this document is:
McKenna, S.A., Rasheed, M.A., and Sankey, T.L. (2007). Long term seagrass monitoring in the Port of Mourilyan - November 2006. DPI&F Publication number PR07-2915, (DPI&F, Northern Fisheries Centre, Cairns), 21 pp.

Acknowledgments:
We would like to thank Helen Taylor and Kara Dew for their assistance with this project. This was a joint project between Ports Corporation of Queensland and the Department of Primary Industries and Fisheries (DPI&F). The Marine Ecology Group is partially funded through the Australian Government's Marine and Tropical Sciences Research Facility represented in North Queensland by the Reef and Rainforest Research Centre. Seagrass illustrations on page 4 are by Ruth Berry.

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EXECUTIVE SUMMARY

This report details results from the November 2006 seagrass monitoring survey for the Port of Mourilyan conducted as part of the annual long term monitoring program as well as results from the post tropical Cyclone Larry survey conducted in May 2006. The monitoring program was developed following a baseline survey in December 1993 and examines selected representative seagrass meadows in Mourilyan Harbour. Total area of each monitoring meadow, species composition and seagrass density (above ground biomass) were measured for comparison with previous surveys.

In 2006 seagrass meadows in Mourilyan Harbour remained in a fair condition despite the impacts of a severe category 5 cyclone in March. While declines had occurred for some meadows there had been evidence of recovery for most, with the densest intertidal meadow remaining largely unaffected and increases occurring for the major subtidal monitoring meadow. Despite this most intertidal meadows remained in a highly vulnerable state and were at their lowest area and biomass since the beginning of seagrass monitoring in 1993.

The major drivers of seagrass change in Mourilyan Harbour appear to have been related to climate, flood and storm events. These events combined with the effects of local catchment use explain much of the seagrass change observed. The continued stress on these meadows and decline in meadow density left them in a far less resilient state in 2005 than had previously been the case. Many of these intertidal meadows suffered further major declines following tropical Cyclone Larry in March 2006, but most had begun to recover by November. While the recent changes to seagrass meadows at Mourilyan Harbour were most likely related to climatic conditions and the effects of cyclone Larry, human activities in the broader Moresby River catchment had the potential to exacerbate the effects of these natural events through agricultural and other disturbances resulting in high turbidity, nutrients, herbicides and acid sulphate runoff.

The beginnings of post-cyclone recovery of seagrasses indicate that the marine environment in Mourilyan Harbour appeared to be relatively healthy although seagrass meadows still remained in a vulnerable state. We would expect the recovery of seagrass meadows to continue should regional conditions remain favourable for seagrass growth.

INTRODUCTION

Background

Seagrass forms an ecologically valuable component of Mourilyan Harbour's marine environment. Seagrasses also provide a good indicator of overall marine environmental health and as they show measurable growth responses to a broad range of water quality parameters they are a good "integrator" of water quality conditions. In recognition of this importance, Ports Corporation of Queensland (PCQ) (the port authority for the Port of Mourilyan) in conjunction with the Queensland Department of Primary Industries and Fisheries (DPI&F) has developed a long term seagrass monitoring program for the Port of Mourilyan. This program aims to monitor the health of Mourilyan Harbour's marine environment and fisheries habitats while providing for the ecologically sustainable use and development of the associated port and shipping facilities.

Seagrass baseline surveys and a three year monitoring program for the Port of Mourilyan seagrasses from December 1993 through to July 1997 established a range of seasonal and inter-annual variation in seagrass distribution and abundance (McKenzie *et al*. 1998). The current annual monitoring program commenced with surveys in 2000 which identified widespread declines in subtidal seagrass since 1997 that were likely due to flooding of the Moresby River (Thomas and Rasheed 2001). Since 2000 surveys have been carried out annually with changes to seagrass meadows generally linked to local and regional climate conditions or non-point source inputs in the broader Moresby River catchment (Thomas and Rasheed 2003; 2004; McKenna *et al*. 2005).

A major cyclone (Cyclone Larry) crossed the coast near Innisfail in March 2006 potentially affecting seagrasses in Mourilyan Harbour. In order to capture any cyclone related changes an additional survey of the intertidal seagrass meadows in Mourilyan Harbour was conducted after the cyclone in May 2006. Changes recorded in the post cyclone survey were used to assist in explaining seagrass trends recorded in the regular monitoring conducted in November 2006.

This report details the results of the seventh annual long term seagrass monitoring survey conducted in November/December 2006 and the additional post cyclone survey of the intertidal monitoring meadows conducted in May 2006.

Objectives

The specific objectives of this seagrass monitoring survey were to:

1. Map the distribution and abundance of seagrass monitoring meadows in the Port of Mourilyan.
2. Assess changes in these monitoring meadows since November 2005, and compare results with previous seagrass monitoring surveys.
3. Incorporate the results into the PCQ Geographic Information System (GIS) database for the Port of Mourilyan.

METHODOLOGY

Five seagrass meadows have been the subject of periodic monitoring at Mourilyan Harbour since baseline surveys of the entire port limits in 1993 (see McKenzie *et al*. 1998). The five meadows were selected on the basis that they represent the range of seagrass species and habitats within the port limits. These five meadows were again targeted for the November/December 2006 survey. The additional post cyclone survey conducted in May 2006 only examined the four intertidal monitoring meadows.

Seagrass surveys were conducted using two field techniques: intertidal seagrasses were surveyed from helicopter at low tide on November 3rd, 2006 when these habitats were exposed. Helicopter surveys are an effective and efficient means to survey large areas of intertidal seagrass habitat. Four of the five monitoring meadows were intertidal and surveyed using this technique. These included: Bradshaw (1), Lily (2), Seaforth Edge (4) and Seaforth Bank (3). Subtidal seagrasses in the Channel (5) meadow were surveyed from boat using real-time underwater video camera and sediment grabs on December 18th, 2006. This technique provides an image of the sea floor from which visual estimates of above ground biomass were made. A detailed description of methodology and survey techniques can be found in McKenzie *et al*. (1998) and Thomas and Rasheed (2001). In addition to the annual seagrass survey, a post Tropical Cyclone Larry survey of the monitoring meadows was conducted on May 24th, 2006. In this survey only the intertidal meadows were surveyed, using the above technique.

Some seagrasses encountered outside of the monitoring meadows in this survey were documented but this survey only intended to target the five monitoring meadows rather than the entire port limits. The last survey of seagrasses in the entire port limits was conducted in 2000 (Thomas and Rasheed 2001).

Geographic Information System

Spatial data from the field surveys were incorporated into the Geographic Information System (GIS) established for Mourilyan Harbour. This database includes data from all previous baseline and monitoring surveys. Two GIS layers were created for this survey:

- **Site data** - contains above ground biomass (for each species present), depth below mean sea level (dbMSL) (for subtidal meadows), sediment type, time, differential Global Positioning System (dGPS) fixes (± 5 m) 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 (Thomas and Rasheed 2003) (Table 1). Abundance categories (light, moderate, dense) were assigned to community types according to above ground biomass of the dominant species (Table 2).

Table 1 Nomenclature for community types in Mourilyan Harbour, May & November 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 Mourilyan Harbour, May and November 2006

Density	Mean above ground biomass (g DW m^{-2})			
	H. uninervis (narrow)	*H. ovalis/ H. decipiens*	*H. uninervis* (wide)	*Z. capricorni*
Light	< 1	< 1	< 5	< 20
Moderate	1 - 4	1 - 5	5 - 25	20 – 60
Dense	> 4	> 5	> 25	> 60

Each meadow was assigned a mapping precision estimate (in metres) based on mapping methodology utilised for that meadow (Table 3). Mapping precision ranged from ± 5 m for the intertidal meadows to ± 30 m for the subtidal Channel meadow (Table 3). 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 dGPS fixes for survey sites were embedded within the meadow reliability estimates.

Table 3 Mapping precision and methodology for seagrass meadows in Mourilyan Harbour, May & November 2006

Mapping precision	Mapping methodology
± 5 m	Meadow boundaries mapped in detail by dGPS from helicopter. Intertidal meadows completely exposed or visible at low tide. Relatively high density of mapping and survey sites. Recent aerial photography aided in mapping.
± 10 m	Some intertidal meadow boundaries mapped in detail by dGPS from helicopter. Most meadow boundaries determined by camera survey sites. Reliability based on distance between survey sites.
± 30 m	Meadow boundary interpreted from camera surveys. Meadow (in the channel) entirely subtidal. Relatively high density of survey sites. Recent aerial photography aided in mapping.

RESULTS

Seagrass distribution and abundance in 2006

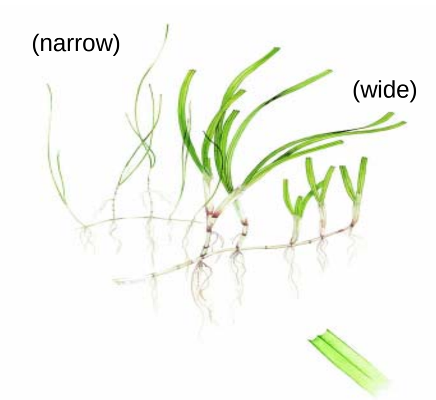
Two seagrass species (*Zosteria capricorni* and *Halophila ovalis*) were present in the intertidal monitoring meadows in the May post-cyclone survey and four species present in the complete monitoring survey (including sub-tidal meadows) in November:

Family CYMODOCEACEAE Taylor:
Halodule uninervis (wide and narrow leaf morphology) (Forsk). Aschers. in. Boissier

Family HYDROCHARITACEAE Jussieu:
Halophila decipiens Ostenfeld
Halophila ovalis (R. Br.) Hook. F.

Family ZOSTERACEAE Drummortier:
Zostera capricorni Aschers.

Zostera capricorni



Halodule uninervis

Halophila ovalis

Halophila decipiens

(Note: seagrass images not to scale)

Long term seagrass monitoring survey

A total of 138 sites (54 subtidal and 84 intertidal) were surveyed in November and December 2006, 51% of which had seagrass present. The total area of seagrass habitat mapped was 48.2 ± 13.1ha (Table 5) in the four monitoring meadows present (Seaforth Edge meadow was not present). Each monitoring meadow comprised a different community type with a different composition of seagrass species (Table 4; Map 1). The mean above ground biomass for the meadows ranged from 0.06 ± 0.02 to 46.5 ± 4.2 g DW m^{-2} (Table 5) and was dependent on the mix of species present. Two of the meadows were classified as light biomass for their community type and two were classified as moderate biomass, while the Seaforth Edge (4) meadow disappeared completely in 2006 (Map 1). Areas for the remaining monitoring meadows ranged from 0.5 ± 0.2 ha to 40.9 ± 11.2 ha (Table 5; Map 1).

The largest monitoring meadow identified was the subtidal Channel (5) meadow which comprised 85% (40.9 ± 11.2 ha) of the total seagrass area mapped (Table 5; Map 1). This meadow was dominated by *Halophila decipiens* (87% of the species composition) and had an above ground biomass of 2.4 ± 0.6.g DW m^{-2} (Table 5; Figure 1). Other species found in the meadow included *Halophila ovalis* and *Halodule uninervis* (wide and narrow) (Table 4; Figure 1).

Only three of the four intertidal monitoring meadows were present in 2006, two *Zostera capricorni* dominated meadows (Bradshaw (1) and Lily (2)) and the Seaforth Bank (3) meadow which was dominated by *Halophila decipiens* (Map 1; Figure 1). Of the two *Zostera* monitoring meadows Bradshaw (1) was the larger (2.7 ± 0.6 ha) and continued to be the densest of all the monitoring meadows (46.5 ± 4.2 g DW m^{-2}) in Mourilyan (Table 5; Map 1). The second smaller *Zostera* dominated meadow, Lily (2) (0.5 ± 0.2 ha), had a substantially lower biomass (2.4 ± 0.9 g DW m^{-2}) than the Bradshaw meadow (Table 5; Map 1). *Halophila ovalis* also comprised a very small component of the Lily meadow while the Bradshaw meadow was comprised entirely of *Zostera capricorni* (Table 4; Figure 1).

The largest intertidal monitoring meadow, Seaforth Bank (3) (4.1 ± 1.1ha), was comprised entirely of isolated patches of *Halophila decipiens* (Table 4; Figure 1). The density of seagrass within this meadow was classified as light as a result of having a very low biomass (0.06 ± 0.02 g DW m^{-2}) for this community type (Table 2 and 4; Map 1). In 2006 the Seaforth Edge (4) monitoring meadow had completely disappeared with no seagrass identified in the area (Map 1).

Some additional isolated patches of seagrass that often comprised a single plant were found on the north-west corner of the Channel (5) meadow in the small gutters at the mouth of Walter Creek (Map 1). These patches were made up of *Halophila ovalis* and *Halophila decipiens* plants and were not mapped as they were not part of the monitoring meadows.

Table 4 Community type, seagrass cover and species present in the five Mourilyan Harbour monitoring meadows, November 2006

Monitoring Meadow	No. of sites	Community Type	Species Present
Bradshaw (1)	30	Moderate *Z. capricorni*	*Z. capricorni*
Lily (2)	21	Light *Z. capricorni*	*Z. capricorni*, *H. ovalis*
Seaforth Bank (3)	26	Light *H. decipiens*	*H. decipiens*
Seaforth Edge (4)	0	Meadow Not Present	Meadow Not Present
Channel (5)	33	Moderate *H. decipiens* with mixed species	*H. ovalis, H. uninervis* (wide and narrow), *H. decipiens*

Post cyclone intertidal survey

A total of 67 sites (all intertidal) were surveyed as part of the post cyclone survey on May 24th, 49% of which had seagrass present (Map 2). Of the four intertidal monitoring meadows that are surveyed each year only the Bradshaw (1) meadow remained after the cyclone (Map 2; 4). This meadow was comprised entirely of *Zostera capricorni* and had a biomass of 30.54 ± 3.38 g DW m^{-2}, and an area of 2.5 ± 0.5 (Figure 2). Remnants of the Lily (2) meadow were present with *Zostera capricorni* and *Halophila ovalis* rhizomes being found, however no above ground biomass was located (Map 2; Figure 2). Both *Halophila* dominated intertidal meadows on Seaforth Bank had been completely lost.

Comparison with previous monitoring surveys

In general terms intertidal seagrasses had declined in biomass and area in recent years while the subtidal (Channel) seagrass meadow had increased (Figure 1; Map 3; Table 5). However, the dense (highest biomass) intertidal *Zostera capricorni* meadow near Bradshaw Island, has remained at a relatively consistent area and biomass throughout the monitoring program (Figure 1; Table 5; Appendix 1). Of most concern is the substantial decline of the second small *Z. capricorni* meadow within the harbour, near Lily Island and the declines in the two intertidal *Halophila* meadows on Seaforth Bank.

The largest changes in biomass and area have occurred in the Seaforth Bank (3 & 4) and Lily (2) intertidal meadows. The *Halophila* dominated meadows on Seaforth Bank (Seaforth Bank (3) and Seaforth Edge (4)) had significant declines between 2002 and 2003, with the Seaforth Bank (4) meadow being completely lost and the Seaforth Edge meadow contracting to one small isolated patch in 2003 (Table 5; Map 3; Appendix 1). Both of these meadows had begun to recover in 2004 and 2005 with increases in area and biomass (Table 5; Map 3). However, these meadows were particularly affected by Cyclone Larry, with the post cyclone survey revealing that above ground components of the meadows had been completely lost in May 2006 (Map 4; Figure 2).

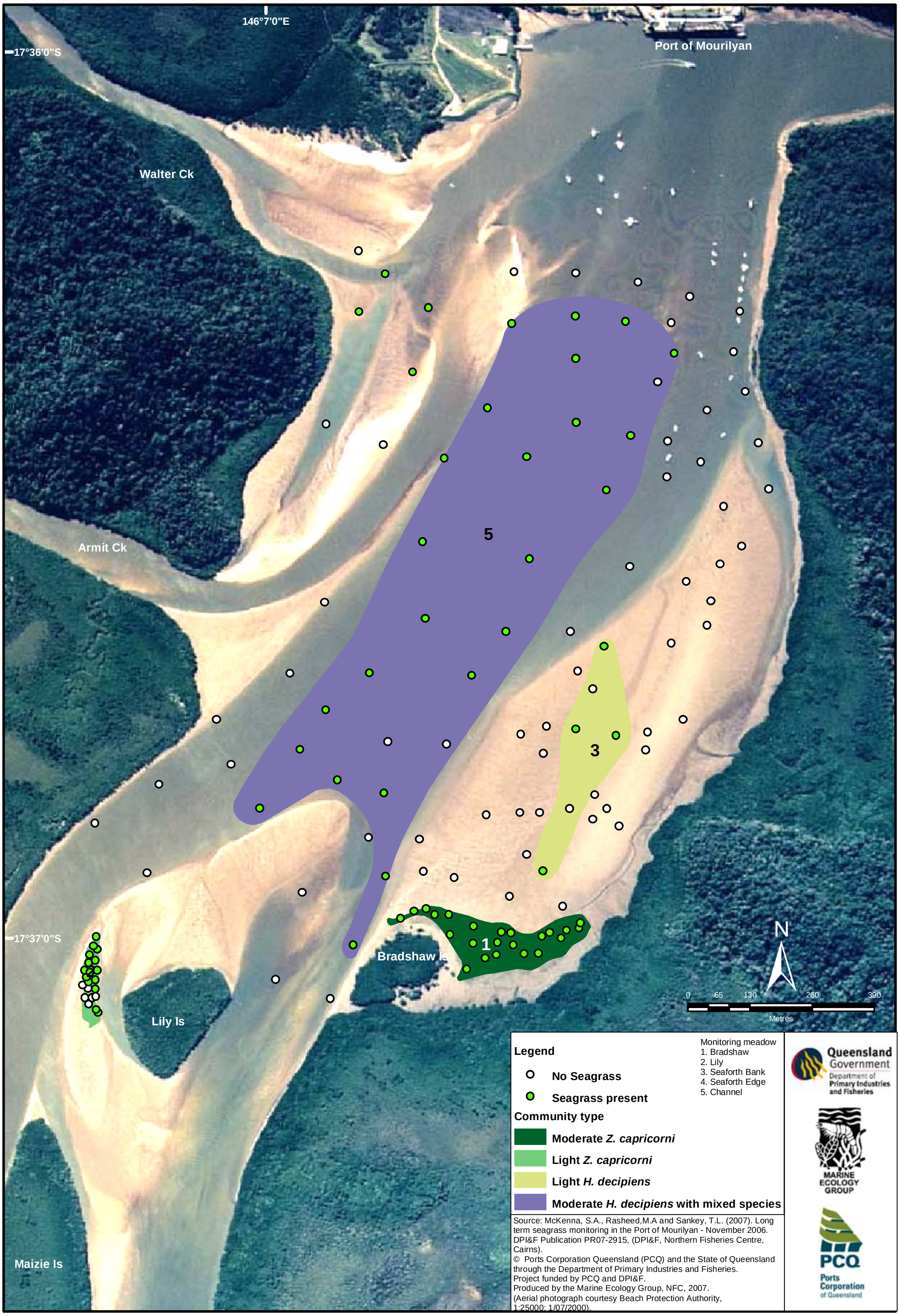
The density of the Lily *Zostera* meadow has been consistently lower and more variable since 2000 compared with the initial four years of monitoring between 1993 and 1996 (Table 5; Map 3). As with the two intertidal *Halophila* meadows the Lily meadow severely declined following tropical Cyclone Larry with all above ground components lost and only a small area of rhizome material remaining in May 2006 (Map 4; Figure 2). By the November 2006 survey there were signs of recovery for some of these intertidal meadows. The Seaforth Bank *Halophila* meadow and the Lily *Zostera* meadow had begun to re-establish, however the Seaforth Edge meadow was still absent. While recovery had occurred, the Lily *Zostera* meadow remained at its smallest recorded area and the Seaforth Bank meadow had one of its lowest biomass and areas recorded in the monitoring program (Table 5; Map 3; Figure 1 & 2).

In 2005 the species composition for the Seaforth Bank (3) meadow had changed with *Halophila decipiens* displacing *Halophila ovalis* as the dominant species and this trend had continued in 2006 (Figure 1).

In contrast to the Lily meadow the larger, higher biomass, Bradshaw *Zostera* meadow did not show any significant declines in biomass from 2005 in either the post cyclone survey or the November monitoring survey. Although the area of the Bradshaw (1) meadow decreased in November 2006, it remained within the range of previously recorded values (Table 5; Map 3; 4; Appendix 1).

In 2006 the subtidal Channel (5) meadow recorded its' highest biomass since 1996 (Table 5). This meadow has been consistently recovering in area and biomass since its complete loss in 2000 associated with flooding of the Moresby River (Table 5; Map 3). The most recent increase in biomass for this meadow was accompanied by a substantial change in species composition. The meadow changed from being dominated by *Halodule uninervis* to a *Halophila decipiens* dominated meadow (87% of biomass). It is not known what impacts the cyclone had on this deeper meadow as sampling in the area was not possible as part of the post cyclone survey in May.

Map 1. Port of Mourilyan seagrass distribution and community types November 2006



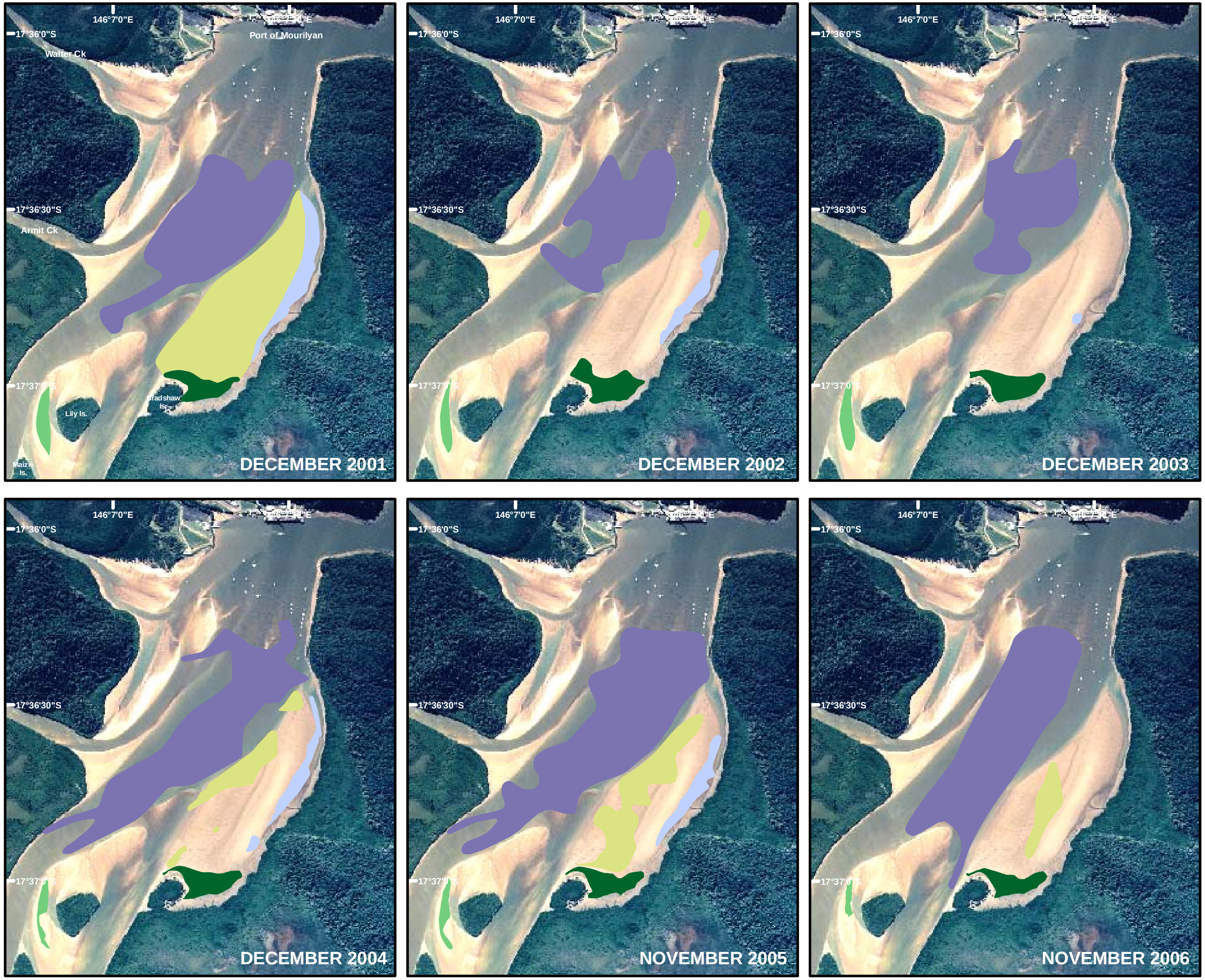
Map 2. Port of Mourilyan seagrass deistribution and community types post Cyclone Larry May 2006

Table 5 Area and mean above ground biomass for Mourilyan Harbour monitoring meadows from December 1993 to November 2006

(Values in brackets for area are the estimate of reliability (R) and for biomass are the percent changes since the previous survey)

Meadow	Area (ha) (R)										
	Dec 1993	Dec 1994	Dec 1995	Dec 1996	Dec 2000	Dec 2001	Dec 2002	Dec 2003	Nov 2004	Nov 2005	Nov 2006
Bradshaw (1)	3.8 (1.9-6.2)	2.6 (1.8-3.4)	2.8 (2.0-3.7)	3.1 (2.1-4.1)	3.5 (2.2-4.8)	3.0 (2.5-3.5)	4.2 (3.7-4.7)	3.6 (3.1-4.1)	3.3 (2.8-3.8)	3.0 (2.5-3.5)	2.7 (2.2-3.3)
Lily (2)	1.0 (0.1-2.3)	1.1 (0.7-1.6)	0.8 (0.6-1.2)	0.7 (0.5-0.9)	1.1 (0.9-1.4)	1.8 (1.4-2.2)	1.4 (1.0-1.8)	1.9 (1.5-2.3)	1.1 (0.7-1.5)	1.2 (0.8-1.6)	0.5 (0.3-0.7)
Seaforth Bank (3)	22.3 (16.0-29.0)	27.7 (22.4-33.3)	23.2 (17.5-29.3)	19.9 (14.1-25.7)	8.4 (2.5-14.3)	30.0 (27.2-32.8)	0.8 (0.3-1.3)	0	6.5 (5.4-7.6)	13.1 (10.4-15.8)	4.1 (2.9-5.2)
Seaforth Edge (4)	2.7 (2.6-7.4)	3.1 (1.8-4.5)	3.4 (1.5-5.6)	3.4 (0.9-5.9)	0	5.3 (1.1-9.5)	3.0 (1.7-4.3)	0.2 (0.1-0.3)	3.3 (2.4-4.2)	3.3 (2.6-4.0)	0
Channel (5)	20.2 (15.9-24.8)	37.3 (31.1-43.7)	55.7 (46.7-64.9)	30.5 (15.5-45.5)	0	34.3 (24.4-44.2)	24.4 (15.5-33.3)	20.1 (12.5-27.7)	38.5 (23.2-53.8)	47.9 (34.0-61.8)	40.9 (29.7-52.1)
COMBINED	49.9 (36.6-69.7)	71.6 (57.3-85.6)	85.9 (68.2-104.6)	57.6 (33.2-82.0)	13.0 (6.3-19.7)	74.4 (56.6-92.2)	35.4 (23.1-47.7)	25.8 (17.2-34.4)	52.7 (34.5-70.9)	68.5 (50.3-86.7)	48.2 (35.1-61.3)
Meadow	**Mean biomass ± SE (g DW m^{-2})**										
	Dec 1993	**Dec 1994**	**Dec 1995**	**Dec 1996**	**Dec 2000**	**Dec 2001**	**Dec 2002**	**Dec 2003**	**Nov 2004**	**Nov 2005**	**Nov 2006**
Bradshaw (1)	42.2 ± 6.0	45.1 ± 2.1 (+8%)	49.3 ± 1.3 (+9%)	59.5 ± 2.0 (+21%)	17.6 ± 1.3 (-70%)	35.9 ± 5.4 (+104%)	32.1 ± 2.0 (-11%)	21.6 ± 3.4 (-33%)	59.3 ± 7.2 (+175%)	34.1 ± 3.7 (-42%)	46.5 ± 4.2 (+36%)
Lily (2)	16.1 ± 4.4	30.5 ± 2.2 (+89%)	29.1 ± 0.9 (-5%)	29.8 ± 1.5 (+3%)	7.7 ± 0.6 (-75%)	5.6 ± 1.6 (-27%)	20.7 ± 3.1 (+271%)	5.1 ± 2.4 (-76%)	12.3 ± 3.6 (+144%)	0.2 ± 0.1 (-98%)	2.4 ± 0.9 (+1105%)
Seaforth Bank (3)	1.0 ± 0.1	0.7 ± 0.2 (-23%)	1.1 ± 0.1 (+45%)	2.8 ± 0.2 (+160%)	0.2 ± 0.04 (-92%)	2.5 ± 0.5 (+933%)	0.3 ± 0.2 (-88%)	0	0.6 ± 0.2	0.03 ± 0.01 (-95%)	0.06 ± 0.02 (+100%)
Seaforth Edge (4)	2.2 ± 0.3	2.2 ± 0.3 (+8%)	1.6 ± 0.1 (-25%)	3.4 ± 0.3 (+109%)	0	2.8 ± 0.4	1.6 ± 0.3 (-41%)	0.02 ± 0.02 (-99%)	1.2 ± 0.4 (+6050%)	0.2 ± 0.1 (-83%)	0
Channel (5)	0.5 ± 0.1	1.8 ± 0.3 (+280%)	1.3 ± 0.1 (-31%)	3.8 ± 0.3 (+271%)	0	0.6 ± 0.1	1.0 ± 0.2 (+67%)	0.7 ± 0.3 (-30%)	1.0 ± 0.3 (+42%)	1.3 ± 0.5 (+30%)	2.4 ± 0.6 (+84%)

Map 3. Port of Mourilyan seagrass monitoring meadows, December 2001 to November 2006



Legend

Monitoring meadows

- Bradshaw
- Lily
- Seaforth Bank
- Seaforth Edge
- Channel

N

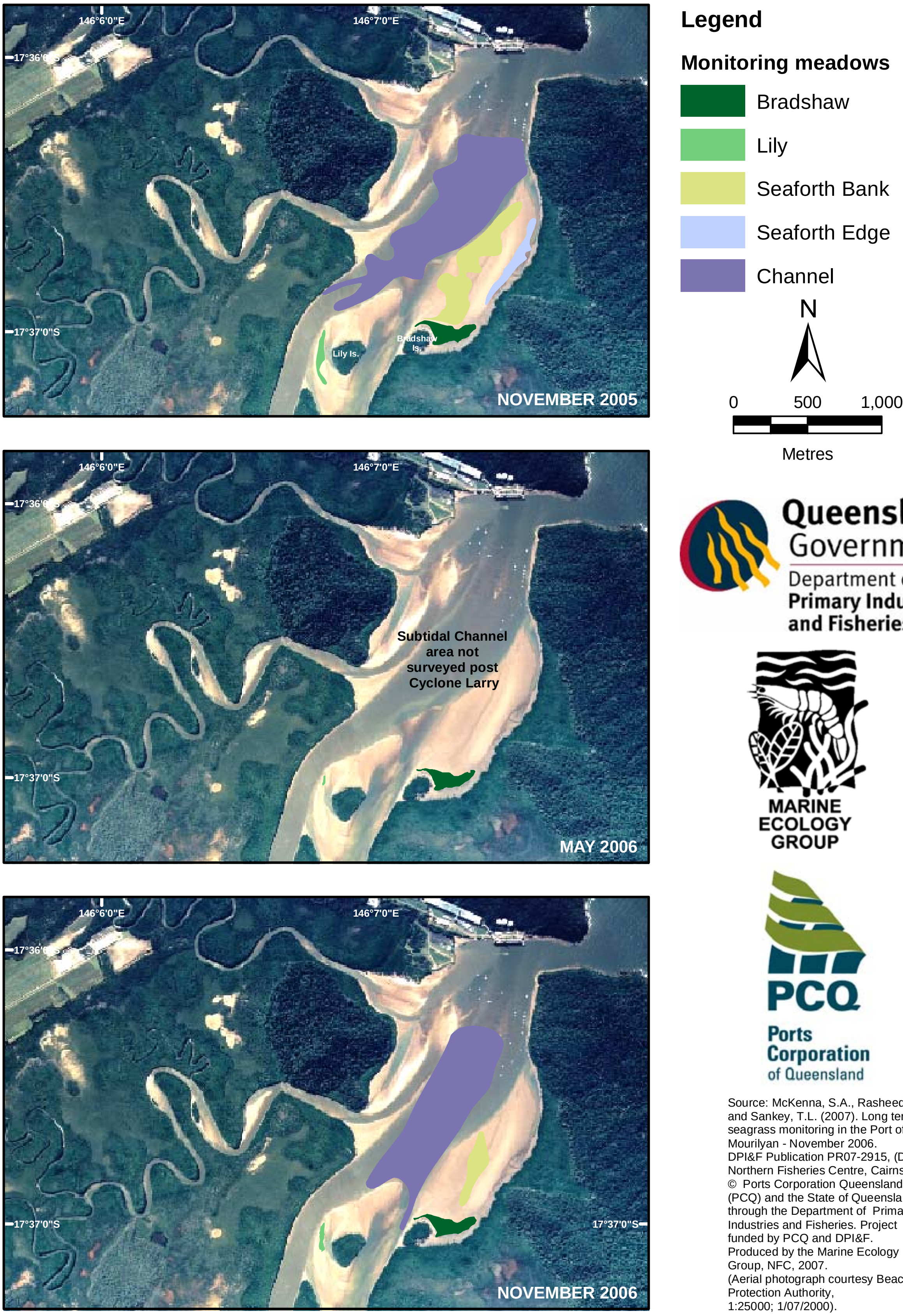
0 400 800

Metres

Source: McKenna S. A., Rasheed, M.A. and Sankey, T.L. (2007). Long term seagrass monitoring in the Port of Mourilyan - November 2006. DPI&F Publication number DPI&F (DPI&F, Northern Fisheries Centre, Cairns).

 Project funded by PCQ and DPI&F. Produced by the Marine Ecology Group, NFC, 2007. (Aerial photograph courtesy Beach Protection Authority, 1:25000; 1/07/2000).

Map 4. Port of Mourilyan seagrass monitoring meadows, November 2005, May 2006 and November 2006



Queensland Government Department of Primary Industries and Fisheries

MARINE ECOLOGY GROUP

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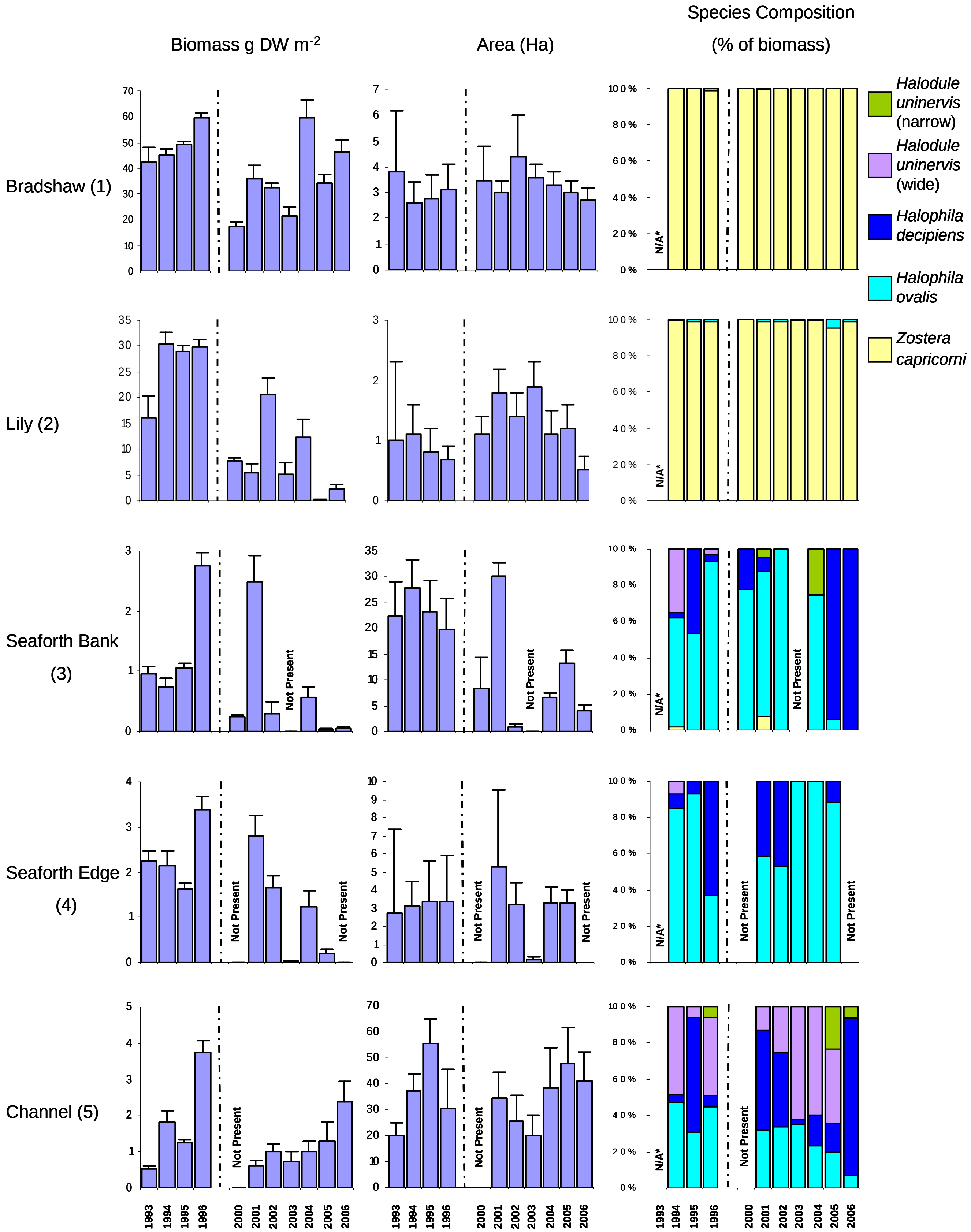


Figure 1 Changes in biomass, area and species composition for monitoring meadows from 1993 to 2006 (Biomass error bars = SE; Area error bars = "R" reliability estimate)
(Dashed line designates a four-year interval between surveys; N/A* % composition of biomass not available in 1993)

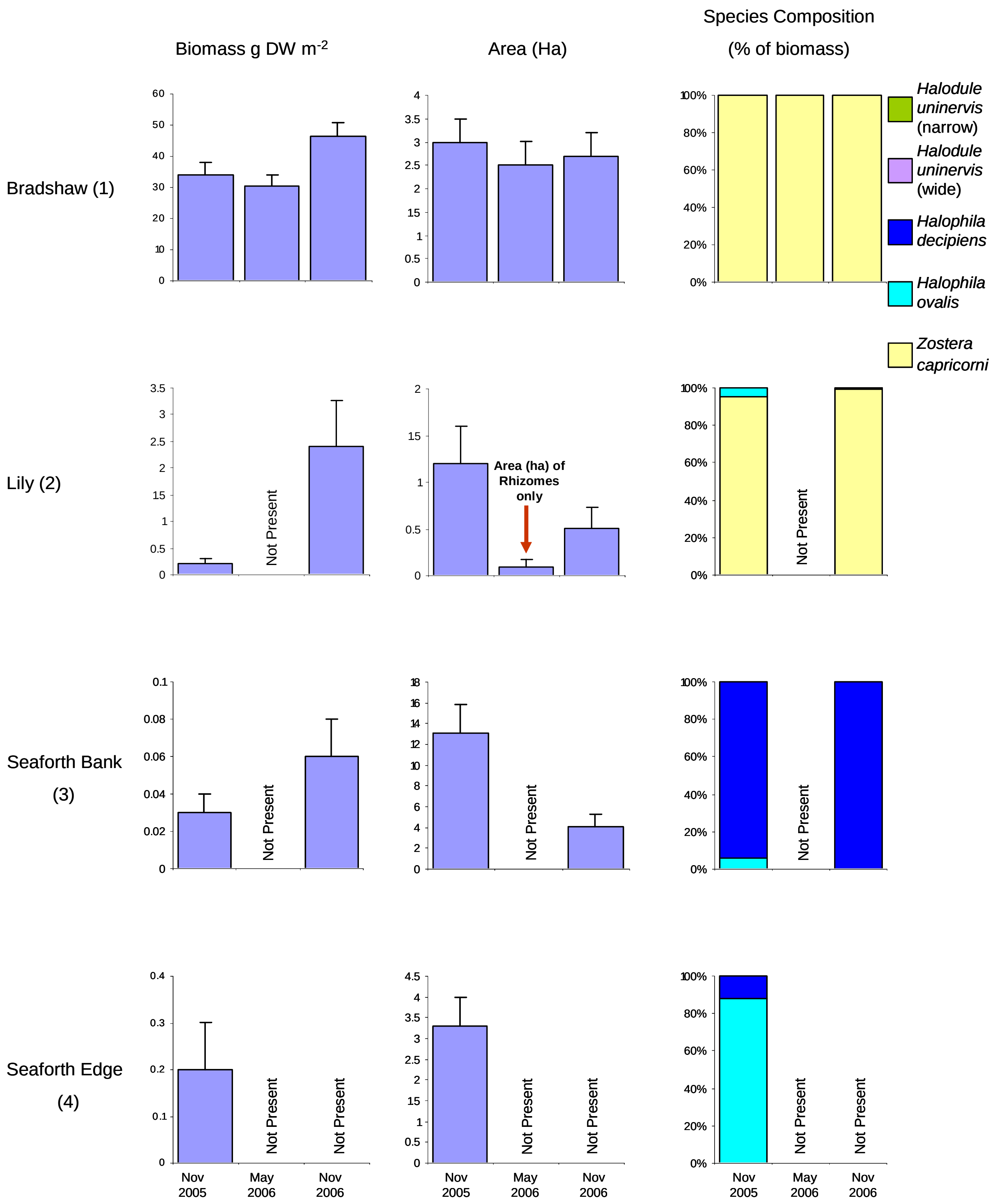


Figure 2 Changes in biomass, area and species composition for monitoring meadows from November 2005, May 2006 (post Cyclone Larry) and November 2006 (Biomass error bars = SE; Area error bars = “R” reliability estimate)

DISCUSSION

In 2006 seagrass meadows in Mourilyan Harbour remained in a fair condition despite the impacts of a severe category 5 cyclone in the area. While declines had occurred for some meadows there had been evidence of recovery for most, with the densest intertidal meadow remaining largely unaffected and increases occurring for the subtidal monitoring meadow. Despite this many intertidal meadows remained in a highly vulnerable state and were at the lowest area and biomass since the beginning of seagrass monitoring in 1993.

The major drivers of seagrass change in Mourilyan Harbour appear to have been related to climate and flood and storm events. These events combined with the effects of local catchment use explain much of the seagrass change observed (Thomas *et al.* 2006). “Drought” years of low rainfall and river flows, high temperatures and high solar irradiance led to declines in intertidal seagrasses that become exposed to higher temperatures and desiccation during daytime low tides. These same conditions benefited subtidal seagrasses that have more available light due to lower turbid river runoff, but are protected from tidal exposure (see Thomas *et al.* 2006 McKenna *et al.* 2005). During nearly 3 years of these conditions between 2001 and 2003 many of the intertidal meadows had declined dramatically and in some cases were lost altogether. The continued stress on these meadows and decline in meadow density left them in a far less resilient state in 2005 than had previously been the case.

On the 20th of March 2006 severe Tropical Cyclone Larry crossed the north Queensland coast near Innisfail as a category 5 cyclone. The central pressure of Larry was 915 hPa which produced winds of up to 290 km/hr and gusts of up to 320km/hr, with the radius of the destructive winds reaching 120km (Australian Bureau of Meteorology 2007). Rainfall associated with Tropical Cyclone Larry resulted in widespread flooding (200-300mm recorded each day between the 19th-22nd March) as well as storm surges of 1.34m in Mourilyan Harbour (Australian Bureau of Meteorology 2007). It was likely that the acute impacts of this storm combined with the low resilience of meadows were responsible for the substantial decline of the Lily *Zostera capricorni* meadow and loss of other intertidal seagrass areas in 2006. The post cyclone seagrass survey revealed that these meadows had lost all above ground structures (leaves and stems) with the Lily meadow reduced to a small area of exposed rhizomes in May 2006.

The fact that most of these seagrass meadows were able to recover to some extent by November 2006 was likely a reflection of favourable climate conditions for intertidal seagrass growth occurring following the acute cyclone impact. Maximum air temperatures remained substantially lower than those that had occurred in 2002/03, rainfall and number of cloudy days were higher leading to lower solar irradiance, and meadow exposure was not unusually high (Figure 3). These factors combine to create conditions where intertidal meadows were less likely to suffer the effects of thermal stress and desiccation at low tide, thought to be the primary driver of seagrass declines during 2002 and 2003.

While major storm and flood events have led to large impacts on seagrass meadows in Queensland, many appear to have a good capacity for recovery. In most areas where there has been a loss of seagrass habitat due to acute impacts, seagrass has recovered within 7 months to 5 years (Rasheed 2004; Fourqurean and Rutten 2004; McKenzie *et al*. 2000; Preen *et al*. 1995). Long-term seagrass monitoring in the Port of Karumba demonstrated that meadows were resistant to the effects of flooding and recovered within 1 to 2 years (Rasheed *et al*. 2001). The time frame for tropical seagrass recovery may be even faster when propagules/seeds are locally available (Rasheed 1999; 2004) or asexual colonisation through rhizome growth from remnant plants can occur (Rasheed 2004). The varying success of recovery for intertidal meadows in Mourilyan may be a function of the local availability of propagules. The section of the Lily *Zostera* meadow that recovered occurred where rhizome material had remained post cyclone. In contrast the lack of recovery for the Seaforth edge *Halophila* meadow may be due to the absence of a viable seed bank and the complete loss of all adult plants from which asexual colonisation could occur.

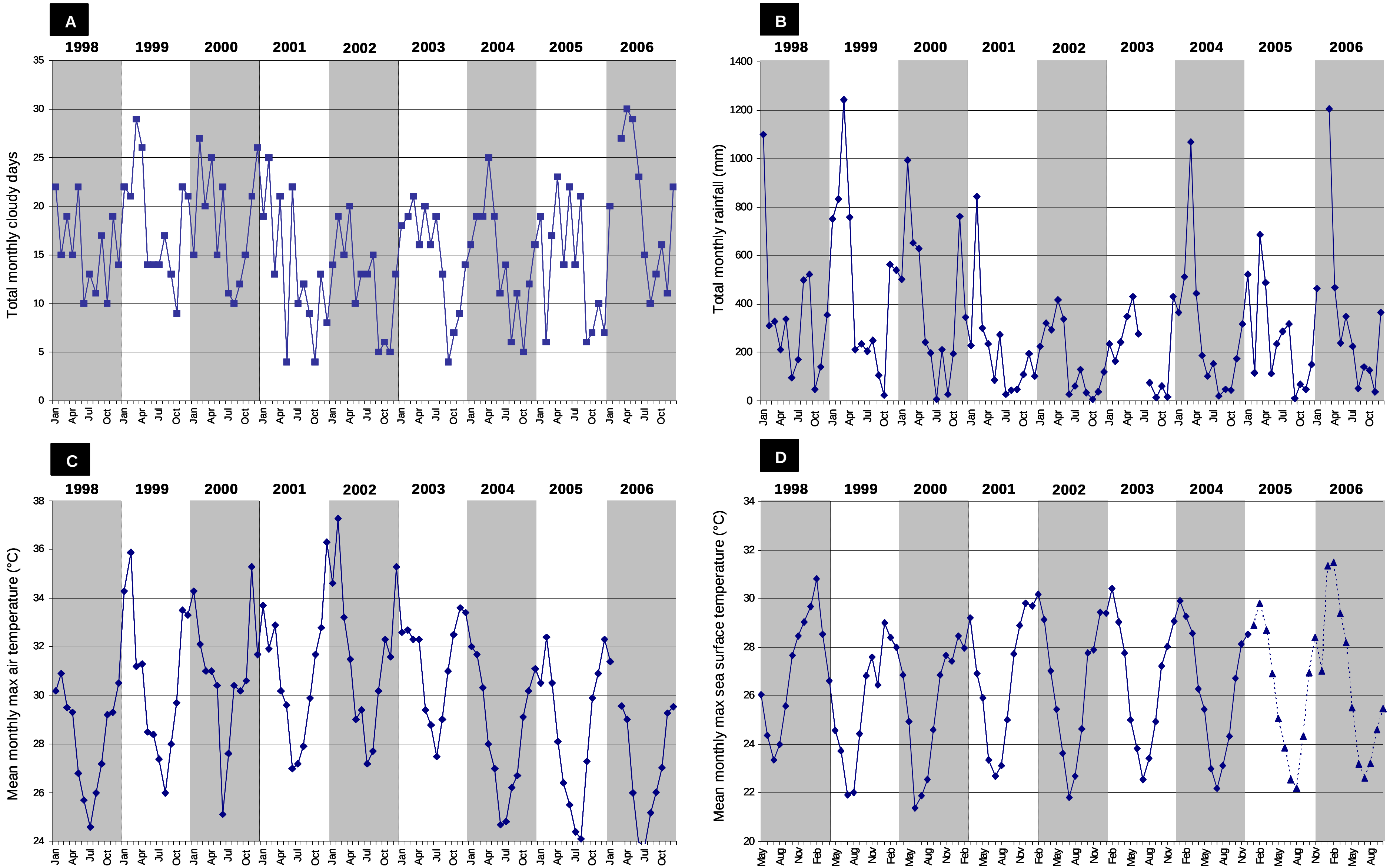
Despite the signs of recovery for some intertidal meadows their resilience to further stress was likely to be low. In recent years the intertidal meadows, with the exception of the dense Bradshaw *Zostera* meadow, had substantially reduced in biomass and area. These meadows have had to repeatedly recover or re-establish themselves which was likely to have considerably reduced their below ground stores of energy and seed banks which form the basis of their resilience. The complete loss of above-ground structures and subsequent re-colonisation in these meadows following the cyclone would have further reduced this resilience, leading to low levels of resistance to future stresses. The higher initial biomass of the Bradshaw *Zostera* meadow and its downstream protected location were likely to provide it with a higher resilience than the other meadows (see Thomas *et al.* 2006).

The change in species composition of the subtidal Channel meadow from *Halodule uninervis* to *Halophila decipiens* was also likely to be a response to the higher rainfall conditions and chronic cyclone related flood turbidity that occurred during 2006. *Halophila decipiens* is adapted to low light levels and highly turbid water conditions (Kenworthy *et al*. 1989; Birch & Birch 1984). The species has morphological and structural features that enable it to maximise its light harvesting capacity in a low light environment (Josselyn *et al*. 1986). *Halophila decipiens* also has a high fecundity and rapid rate of rhizome growth which enables it to colonise disturbed areas readily, such as those that may have been caused by the cyclone (Preen *et al*. 1995; Kenworthy *et al*. 1989). With a return to drier conditions this meadow may well revert to being dominated by higher light requiring species such as *Halodule uninervis,* as was the case during the “drought” years between 2002-2005.

Changes to seagrasses in Mourilyan Harbour differed to some other areas of Queensland where seagrasses are monitored. These differences were likely due to the local impacts of the cyclone and other local climate variations. For example, in Gladstone conditions had remained dry in the past year and solar irradiance, temperature and amount of daytime exposure of intertidal meadows was reduced (Taylor *et al*. 2007). This led to an expansion of both intertidal and subtidal meadows. Seagrass meadows in Karumba also saw significant increases in biomass and area due to locally favourable climate (Dew *et al*. 2007).

The recent changes to seagrass meadows at Mourilyan Harbour were most likely related to climatic conditions and the effects of cyclone Larry rather than any port related or anthropogenic activity. The beginnings of post cyclone recovery of seagrasses indicate that the marine environment appeared to be relatively healthy although seagrass meadows still remained in a vulnerable state. We would expect the recovery of seagrass meadows to continue should regional conditions remain favourable for seagrass growth, as many meadows had not yet reached previously observed levels of biomass or area.

Figure 3 (A) Monthly number of cloudy days, (B) Total monthly rainfall and (C) Mean monthly maximum air temperature for Innisfail. (D) Mean monthly maximum sea surface temperature for Mourilyan Harbour (dashed line for 2005 represents sea temperature at 5m depth)



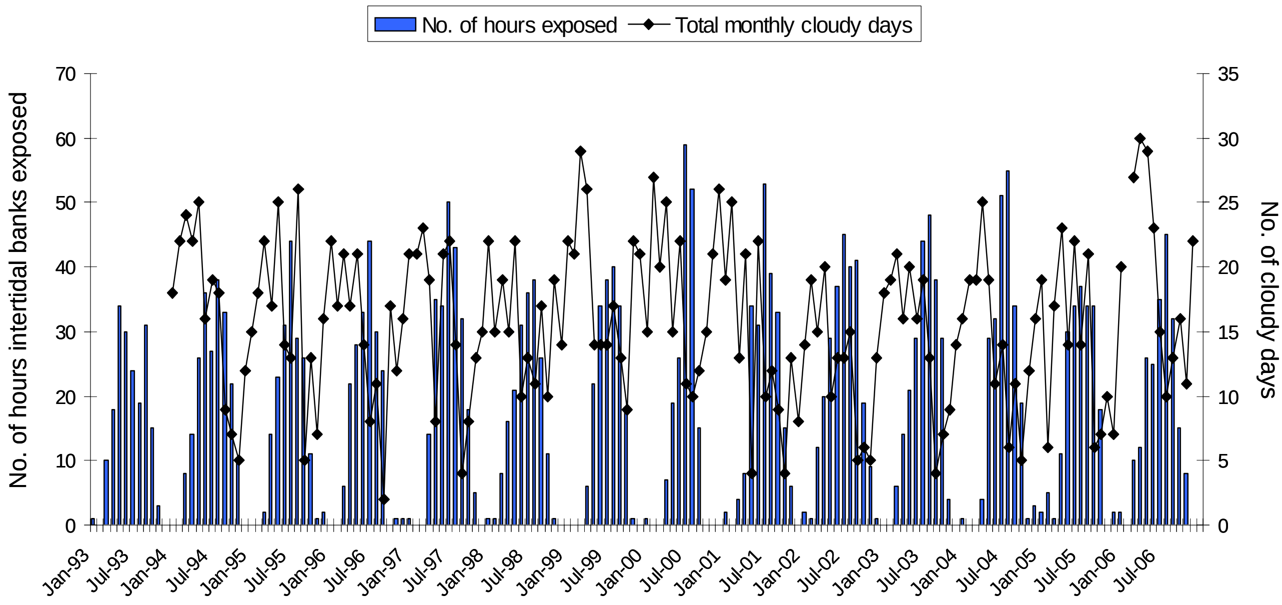


Figure 3 The total number of daylight hours per month that intertidal banks are exposed and the monthly number of cloudy days recorded from 1993 to 2006

References

Australian Bureau of Meteorology. (2007). http://www.bom.gov.au/

Birch, W.R. and Birch, M. (1984). Succession and pattern of tropical intertidal seagrasses in Cockle Bay, Queensland, Australia: A decade of observations. *Aquatic Botany*, **19**: 343-367

Dew, K.R., Rasheed, M.A., Taylor, H.A. and Sankey, T.L. (2007). Port of Karumba Long Term Seagrass Monitoring, October 2006. DPI&F Publication PR07-2670 (DPI&F, Northern Fisheries Centre, Cairns) 15 pp.

Fourqurean, J.W. and Rutten, L.M. (2004). The impact of hurricane Georges on soft-bottom, back reef communities: site- and species-specific effects in South Florida seagrass beds. *Bulletin of Marine Science*, **75**: 239-257.

Josselyn, M.N., Fonseca, M., Niesen, T. and Larson, R. (1986). Biomass, production and decomposition of a deep water seagrass, *Halophila decipiens* Ostenf. *Aquatic Botany*, **25**: 47-61.

Kenworthy, W.J., Currin, C.A., Fonseca, M.S. and Smith, G. (1989). Production, decomposition, and heterotrophic utilization of the seagrass *Halophila decipiens* in a submarine canyon. *Marine Ecology Progress Series*, **51**: 277-290.

Maritime Safety Queensland (2007). http://www.msq.qld.gov.au/qldtides

McKenna, S.M., Rasheed, M.A. and Thomas, R. (2005). Port of Mourilyan long-term seagrass monitoring - November 2004. Department of Primary Industries and Fisheries Information Series QI05037, (DPI&F, Northern Fisheries Centre, Cairns), 18 pp.

McKenzie, L.J., Roder, C.A., Roelofs, A.J. and Lee Long, W.J. (2000). Post-flood monitoring of seagrasses in Hervey Bay and the Great Sandy Strait, 1999: Implications for dugong, turtle and fisheries management. *DPI Informations series QI00059* (DPI, Cairns), 46pp.

McKenzie, L.J., Lee Long, W.J., Roelofs, A.J., Roder, C.A. and Coles, R.G. (1998). Port of Mourilyan Seagrass Monitoring – First 4 years. EcoPorts Monograph Series No 15. (Ports Corporation of Queensland, Brisbane), 34pp.

Preen, A.R., Lee Long, W.J. and Coles, R.G. (1995). Flood and cyclone related loss, and partial recovery, of more than 1000 km^2 of seagrass in Hervey Bay, Queensland, Australia. *Aquatic Botany* **52**: 3-17

Rasheed, M.A. (1999). Recovery of experimentally created gaps within a tropical Zostera capricorni (Aschers.) seagrass meadow, Queensland Australia. *Journal of Experimental Marine Biology and Ecology* **235**:183-200.

Rasheed, M.A. (2004). Recovery and succession in a multi-species tropical seagrass meadow following experimental disturbance: the role of sexual and asexual reproduction. *Journal of Experimental Marine Biology and Ecology* **310**:13-45.

Rasheed, M.A., Roelofs, A.J., Thomas, R. and Coles, R.G. (2001) Port of Karumba Seagrass Monitoring – First 6 Years. EcoPorts Monograph Series No. 20 (Ports Corporation of Queensland, Brisbane) 38pp.

Taylor, H.A., Rasheed, M.A., Dew, K. and Sankey, T.L. (2007). Long term seagrass monitoring in Port Curtis and Rodds Bay, Gladstone – November 2006. DPI&F Publication PR07- 2774 (DPI&F, Cairns), 28 pp.

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.

Thomas, R. and Rasheed, M.A. (2004). Port of Mourilyan long-term seagrass monitoring - December 2003. Report to Ports Corporation of Queensland. (Queensland Fisheries Service, Northern Fisheries Centre, Cairns), 20 pp.

Thomas, R. and Rasheed, M.A. (2003). Port of Mourilyan Long Term Seagrass Monitoring, Progress Report - December 2002. Report to the Ports Corporation of Queensland. (Queensland Fisheries Service, Northern Fisheries Centre, Cairns), 14 pp.

Thomas, R. and Rasheed, M.A. (2001). Port of Mourilyan seagrass monitoring winter (July) and Summer (December) 2000. Report to Ports Corporations of Queensland. (Queensland Fisheries Service, Northern Fisheries Centre, Cairns), 20pp.

Appendix 1

Results of one-way ANOVA for mean above ground biomass versus year for the Mourilyan Harbour monitoring meadows, 1993 to 2006

Bradshaw (1) [a^]	DF	SS	MS	F	P
Between years	9	453108	50345.4	13.28	**<0.0001**
Within years	245	928631	3790.33		
Total	254	1381740			
Lily (2) [a]					
Between years	9	26866.8	2985.20	22.11	**<0.0001**
Within years	198	26736.2	135.031		
Total	207	53603.0			
Seaforth Bank (3) [b]					
Between years	9	217.485	24.1650	8.62	**<0.0001**
Within years	205	574.723	2.80353		
Total	214	792.208			
Seaforth Edge (4) [c]					
Between years	7	99.6753	14.2393	4.09	**0.0006**
Within years	91	316.845	3.48182		
Total	98	416.521			
Channel (5) [d#]					
Between years	9	1.97011	0.21890	2.61	**0.0068**
Within years	265	22.2359	0.08391		
Total	274	24.2060			

[a] 1993 has been omitted from analyses due to low number of replicates
[b] Meadow was not present in 2003
[c] Meadow was not present in 2000, and 2003 has been omitted from analyses due to low number of replicates
[d] Meadow was not present in 2000
[^] Kruskal-Wallis ANOVA
[#] One-way ANOVA using log+1 transformed data

Results of Least Significant Difference (LSD) pair-wise comparisons of mean above ground biomass (g DW m^{-2}) for the Mourilyan Harbour monitoring meadows. Means that share a common letter for each meadow are not significantly different ($P < 0.05$)

Year	Mean Biomass (g DW m^{-2})				
	Bradshaw [^]	Lily	Seaforth Bank	Seaforth Edge	Channel [#]
1993	n/a	n/a	1.0 bc	2.2 ab	0.5 b
1994	45.1 ab	30.5 a	0.7 bc	2.2 ab	1.8 ab
1995	49.3 ab	29.1 a	1.1 b	1.6 ab	1.4 ab
1996	59.5 a	29.8 a	2.8 a	3.4 a	2.8 a
2000	17.6 c	7.7 c	0.2 bc	n/a	n/a
2001	35.9 bc	5.6 cd	2.5 a	2.8 a	0.6 b
2002	32.1 bc	20.7 b	0.3 bc	1.6 ab	1.0 ab
2003	21.6 c	5.1 cd	n/a	n/a	0.7 b
2004	59.3 ab	12.3 c	0.6 bc	1.2 ab	1.0 b
2005	34.1 bc	0.2 d	0.03 c	0.2 b	1.3 b
2006	46.5 ab	2.4 cd	0.06 bc	n/a	2.4 a

[^] Kruskal-Wallis pair-wise comparison
[#] One-way ANOVA using log+1 transformed data