Department of Employment, Economic Development and Innovation

Deepwater Seagrass Dynamics in the Torres Strait Dugong Sanctuary

Interim Report

March & November 2010

Taylor, H.A. & Rasheed, M.A.

Toward Q2 Tomorrow's Queensland

Queensland Government

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The March and November 2010 seasonal baseline surveys were the most comprehensive assessment of seagrass distirbution and abundance that have been conducted within the Torres Strait Dugong Sanctaury. The Dugong Sanctaury contains the largest recorded single continuous seagrass meadow in Australia and is likely to play a vital role for local dugong and turtle populations as an important food resource. Seagrass species found included those known to be important for dugong and turtles as well as nursery grounds for commercial fisheries species. Seagrass was found to be in a healthy and productive condition during both sampling events.

The seasonality of subtidal seagrasses within the Torres Strait has not been established. The results of this study showed some changes to seagrass abundance (biomass) and percent cover between March 2010 and November 2010, however, these changes were not consistent between the North and South representative areas. The results provide the first information on the extent of natural seasonal change and highlight the need for more frequent, detailed monitoring to help cement the seasonality pattern and to determine the degree of inter-annual change in seagrasses in the sanctuary. Developing a better understanding of natural change will be important in planning for dugong and turtle management in the region. Fisheries Queensland and the Torres Strait Regional Authority are working to implement a regular monoitoring program for seagrasses in the Dugong Sanctury to be conducted by the Torres Strait Land and Sea Rangers.

INTRODUCTION

Background

Torres Strait comprises 247 islands, eighteen of which are permanently inhabited. Local island communities in the Torres Strait are deeply connected to their sea country through their culture, economy, spirituality and social way of life. The health of their marine resources has been, and continues to be, vital to Torres Strait Islanders from a subsistence, commercial and cultural point of view.

In 1985, Australia and Papua New Guinea ratified the Torres Strait Treaty to resolve the maritime boundaries in this region. The Treaty established the Torres Strait Protected Zone and provides a framework for the management, conservation and sharing of fisheries resources in the region, whilst aiming to acknowledge and protect the traditional way of life and livelihood of the Torres Strait Islanders. The Treaty requires the two governments to protect and preserve the marine environment and indigenous flora and fauna. A segment of the Torres Strait Protected Zone and adjacent area was designated as a Dugong Sanctuary, in which all hunting of dugong was banned from 1985. The Dugong Sanctuary covers an area in excess of 1.3 million hectares in the western Torres Strait region, from parallel to Latitude 11°10’ South, north to the Fisheries Jurisdiction line between Papua New Guinea and Australia in the north.

Very little information is known on the distribution and abundance of important subtidal seagrass habitat within and around the Dugong Sanctuary, despite the value of these habitats as a food source for dugong and turtle. Subtidal seagrasses have been studied at nearby Badu, Moa and Mabuiag Islands and the Orman Reefs where an extensive coverage of highly diverse seagrasses were identified as one of the most important areas of seagrass habitat in the Torres Strait and Queensland for dugong (Rasheed et al. 2008; Chartrand et al. 2009; Taylor & Rasheed 2010a). The above-ground productivity of Orman Reefs seagrass meadows was high compared with other tropical seagrass communities and was likely to be a key contributor to fisheries, dugong and turtle and carbon cycling in the central Torres Strait (Rasheed et al. 2008).

The Importance of Torres Strait Seagrasses

The importance of seagrasses as structural components of coastal ecosystems is well recognised. Seagrass/algae beds have been rated the third most valuable ecosystem globally (on a per hectare basis) for ecosystem services, preceded only by estuaries and swamps/flood plains (Costanza et al. 1997).

The Torres Strait is estimated to contain between 13,425km^2 (Coles et al. 2003) and 17,500km^2 (Poiner and Peterkin 1996) of seagrass habitat, providing critical habitat for commercial and traditional fishery species as well as important food resources for endangered dugong and green turtle populations (Marsh and Kwan 2008; Sheppard et al. 2008; Coles et al. 2003). The largest population of dugongs in the world is in Torres Strait (Marsh et al. 1997, 2002), where the long-standing importance of dugongs for subsistence by Torres Strait Islanders has been traced in archaeological deposits dating back at least 2000 years (Vanderwal 1973). For the Indigenous people of Torres Strait, dugong is the most significant and highest ranked marine food source in the traditional subsistence economy (Nietschmann 1984; Raven 1990; Johannes and MacFarlane 1991; Kwan 2002).

The dynamics of seagrasses in Torres Strait may be strongly influenced by extremes in weather. Studies have shown substantial seagrass dieback (up to 60%) on two occasions in central Torres Strait (Long and Skewes 1996; Marsh et al. 2004). The causes for these diebacks are unclear. Although suggested to be the result of flooding (Long and Skewes 1996), recent investigations have shown that neither the movements of large sandbanks nor turbidity from rivers on the south coast of Papua New Guinea are likely to affect seagrass communities of Torres Strait on a regional scale (Daniell et al. 2006). Nevertheless, these diebacks have been linked to declines in the population of dugong (Marsh et al. 2004).

Despite the considerable ecological and economical value of the Torres Strait marine ecosystem, the subtidal benthic communities remain understudied. Limited broad-scale assessment of subtidal benthic habitats were undertaken in 2005 (Sheppard et al. 2008) and 1995 (Long and Poiner 1997) and identified seagrass as an important component of these regions. These studies, however, provided only a snapshot of seagrass species distribution and abundance, as survey sites were limited and spread out over large distances. Lack of detailed, fine-scale studies, which map and quantify seagrass abundance in the Torres Strait has limited our ability to predict the consequences of disturbances on seagrass habitats and their associated ecosystems and fisheries. This is especially relevant within the Dugong Sanctuary, a largely subtidal area set aside for the protection of Dugong. Prior to these baseline surveys there has been relatively little data available on the extent of seagrass within the Dugong Sanctuary as well as its suitability as food for dugong.

Sampling Approach

A lack of information on the distribution and abundance of seagrass, coupled with reported low density of dugongs in the Dugong Sanctuary (Marsh & Saalfeld 1988), have raised questions about the efficacy of the sanctuary as a component of management for dugongs in the region. The Fisheries Queensland Marine Ecology Group in collaboration with the Torres Strait Regional Authority (TSRA) Land and Sea Management Unit launched a program to deliver the baseline information on the subtidal seagrass communities within and immediately surrounding the Dugong Sanctuary. The first baseline survey of the entire Dugong Sanctuary was conducted in March 2010 and found the largest single continuous seagrass meadow so far recorded in Australia (see Taylor & Rasheed 2010b). As seagrasses are known to undergo seasonal changes in many areas of tropical Australia, a second baseline survey of representative areas of seagrass within the Dugong Sanctuary was commissioned for November 2010 to determine how much the resource changes seasonally.

The specific objectives of the present study were to:

1. Conduct a seasonal survey of a subset of representative areas of subtidal seagrass within the Dugong Sanctuary;
2. Use the baseline information to design and establish a long-term seagrass monitoring program for the Dugong Sanctuary;
3. Provide information on the importance of Dugong Sanctuary marine habitats to dugong, turtle and local fisheries.

This interim report details the results of the November 2010 survey. It briefly discusses the results in comparison to the March 2010 survey. The first long-term monitoring event is due to take place in May 2011 with the full report on the program expected in mid 2011.

METHODS

Sampling Methods

The survey of the representative areas was conducted between the 9th – 13th November 2010. Sampling methods applied were the same as those employed during the baseline survey in March 2010 (see Taylor & Rasheed 2010b for full methodology).

Due to the large area of the Dugong Sanctuary and the associated logistical difficulties in re-surveying the entire area, two representative areas of the sanctuary were identified to be sub-sampled. These areas represented the range of seagrass species identified within the baseline survey, contained high seagrass cover and were spatially distributed to cover both the north and south of the sanctuary. Transect sites were placed randomly within each representative area.

At each transect site an underwater CCTV camera system with real-time monitor was towed from the Fisheries research vessel "*Ovalis*". For each transect the camera was towed for 100 metres at drift speed (less than one knot). Footage was observed on a TV monitor and recorded to digital tape. The camera was mounted on a sled that incorporated a sled net 600 mm width and 250 mm deep with a net of 10 mm-mesh aperture (Plate 1). Surface benthos was captured in the net (semi-quantitative bottom sample) and used to confirm seagrass, algal and benthic macro-invertebrate (BMI) habitat characteristics and species observed on the monitor. A Van Veen sediment grab was used to confirm seagrass species identification and sediment type.

Habitat Characterisation Sites

Data recorded at each site included:

1. **Seagrass species composition** – Seagrass identifications in the field and from video according to Kuo and McComb (1989). Species composition measured from the sled net sample and from the video screen when species were distinct.
2. **Seagrass biomass** – Above ground biomass was determined using a modified "visual estimates of biomass" technique described by Mellors (1991) and was based on ten random time frames allocated within the video footage for each transect site. The video was paused at each of the ten random time frames selected then advanced to the nearest point on the tape where the bottom was visible and sled was stable on the bottom. From this frame, an observer recorded an estimated rank of seagrass biomass and species composition. To standardise biomass estimates, a 0.25 m^2 quadrat scaled to the video camera lens used in the field, was superimposed on the screen. Where seagrass was present in the sled net but not visible in the transect's video footage, the lowest biomass rank (0.05) was assigned to one of the 10 ranks for the transect. On completion of the videotape analysis, the video observer ranked five additional quadrats that had been previously videoed for calibration. These quadrats were videoed in front of a stationary camera, and then harvested, dried and weighed. A linear regression was calculated for the relationship between the observer ranks and the actual harvested value. This regression was used to calculate above ground biomass for all estimated ranks made from the survey sites. Biomass ranks were then converted into above ground biomass estimates in grams dry weight per square metre (g DW m^{-2}).
3. **Algae** – Presence/absence, algae type and percent cover (identified according to Cribb 1996). Percent cover was estimated from the video grab. Algae collected in the sled net and grab provided a taxa list.
4. **Sediment type** – A one-litre Van Veen grab was used to obtain a sediment sample at each site. Grain size categories were then identified visually as; shell grit, rock, gravel shell grit,

rock, gravel (>2000µm), coarse sand (>500µm), sand (>250µm), fine sand (>63µm) and mud (<63µm).

5. **Site details** – Location by GPS, weather conditions at the time of sampling and depth below mean sea level (MSL).

Plate 1. Offshore video sampling sled, Van Veen sediment grab and sorting benthic samples from the sled net

Habitat Mapping and Geographic Information System

All survey data were entered into a Geographic Information System (GIS) for presentation of marine plant information. Rectified satellite images of the area assisted with mapping. Other information including depth below mean sea level (dbMSL), substrate type, and the shape of existing geographical features such as reefs and channels was also interpreted and used in determining habitat boundaries.

Three types of GIS layers were created in ArcGIS® to describe Dugong Sanctuary seagrasses:

- **Habitat characterisation sites** – point data recorded at the start of each transect containing percent cover of seagrass, above ground biomass (for each species), algae and benthic macro-invertebrate percent cover and proportion of functional group, dbMSL, sediment type, time, latitude and longitude from GPS fixes, sampling method and any comments.
- **Seagrass meadow area** – area data for seagrass meadows with summary information on meadow characteristics.
- **Seagrass biomass and density** – seagrass percent cover for each seagrass meadow and biomass of individual species within seagrass meadows.

Each seagrass meadow was assigned a mapping precision estimate (±m) based on the mid-point between the last site where seagrass was present and the next non-seagrass site or survey limit, as well as topographical changes in seafloor structure (i.e. reef tops versus deepwater channels). 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 aerial photographs onto basemaps and with GPS fixes for survey sites were embedded within the meadow reliability estimates.

Seagrass percent cover and species biomass layers were generated from an ArcGIS® spatial analyst tool in which habitat survey sites are interpolated. Interpolating is a method of calculating a new point between two or more existing points (i.e. two habitat survey sites). A type of interpolation called Inverse Distance Weighted (IDW) was applied to seagrass and algae meadows generated (as described above). This then estimates new values among habitat survey sites by taking a weighted average of seagrass cover or biomass from surrounding habitat survey sites (i.e. in the neighbourhood). The weighted average calculated for each new point diminishes as the distance from the new point to the habitat survey sites increases. This tool provides an indication of the likely spread of seagrass (percent cover or species biomass) across a meadow based on the coverage of habitat survey sites and the relationship of the values among sites.

RESULTS

Seagrass Species, Distribution and Abundance in November 2010

A total of seven seagrass species (from 2 families) were identified in the representative areas in November 2010:

Family	Species			
CYMODOCEACEAE Taylor	*Cymodocea serrulata* (R.Br.) Aschers and Magnus		*Halodule uninervis* (wide leaf morphology) (Forsk.) Aschers. in Boissier	
	Syringodium isoetifolium (Ashcers.) Dandy		*Thalassodendron ciliatum* (Forsk.) den Hartog	
HYDROCHARITACEAE Jussieu	*Halophila decipiens* Ostenfield		*Halophila ovalis* (R. Br.) Hook. F.	
	Halophila spinulosa (R. Br.) Aschers. in Neumayer			

A total of 51 subtidal habitat characterisation transects were surveyed in the two representative areas in November 2010. Seagrass was found at 85% of sites surveyed (Map 1). A total of 111,764 ± 45,728 ha of seagrass was mapped in the two representative areas (Table 1; Map 2). Seagrass extended to the limits of the North representative area covering an area of 61,804ha whilst seagrass only covered around 75% of the South area, recording a total of 51,959ha (Table 1; Map 2).

Mean above-ground biomass of the seagrass in the *Halophila spinulosa* dominated North area was 8.67 ± 2.02 g DW m^{-2}, which was much higher than the 0.42 ± 0.2 g DW m^{-2} biomass recorded in the *Cymodocea serrulata* dominated South area (Table 1). Similarly, mean seagrass percent cover was much higher in the North (20%) compared to the South (4%).

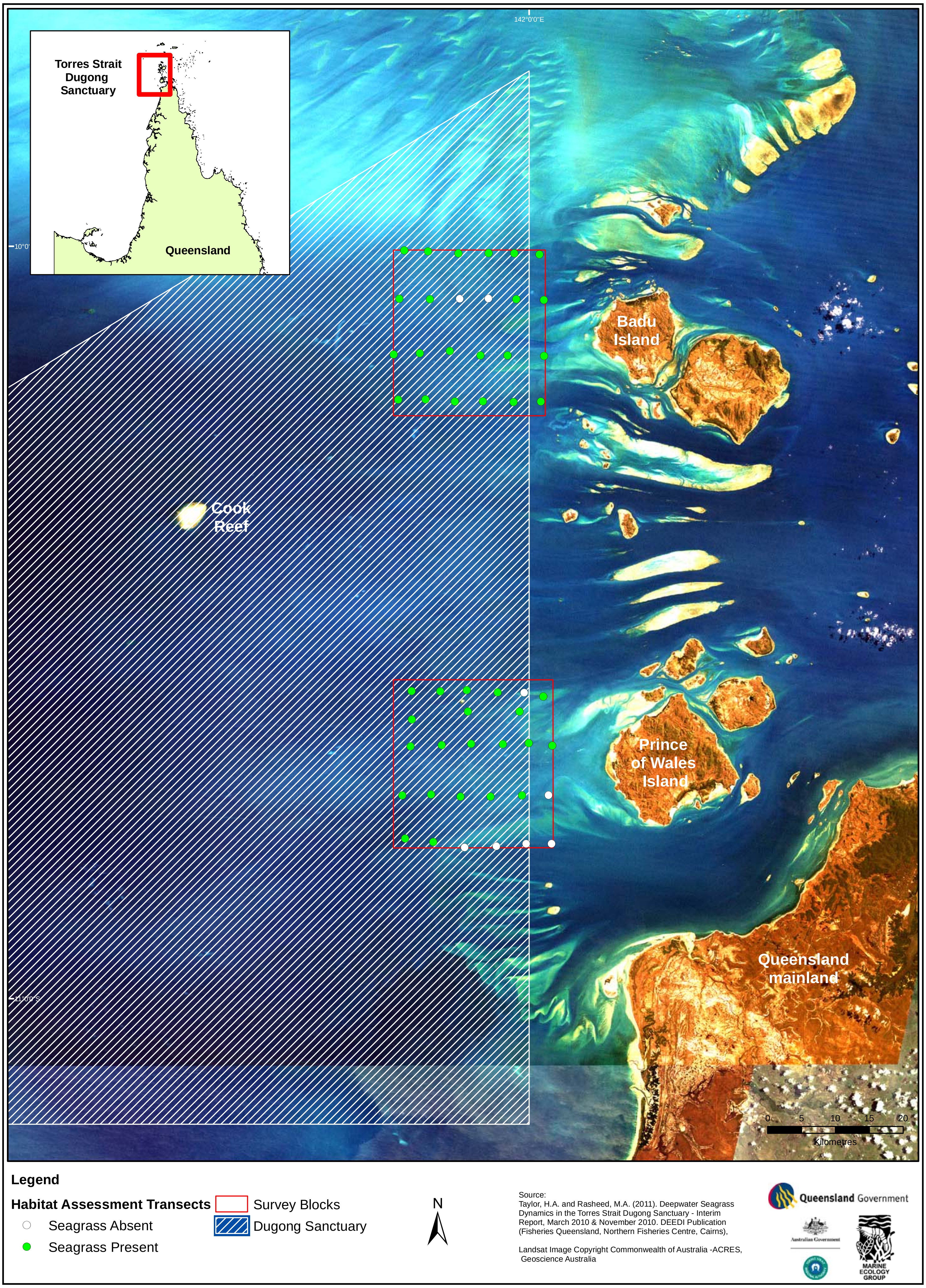
The majority of the North representative area was covered in seagrass of greater than 15% cover. Additionally, it contained two density hotspots where seagrass percent cover was between 60-85% of the substratum: both were directly west of Badu Island (Map 2). Seagrass cover was much lower in the South area, reaching a peak of 18-20% in two small locations in the south west quadrant of the representative area (Map 2). The south east corner contained no seagrass.

The most abundant species (i.e. greatest biomass) throughout the North representative area was *Halophila spinulosa* which peaked at a high of 54.2 g DW m^{-2}. *Cymodocea serrulata* was the most abundant in the South although it peaked at a much lower 2.2 g DW m^{-2} (Table 1; Figure 3). Both areas contained a mix of up to seven species which accounted for a small proportion of the seagrass composition.

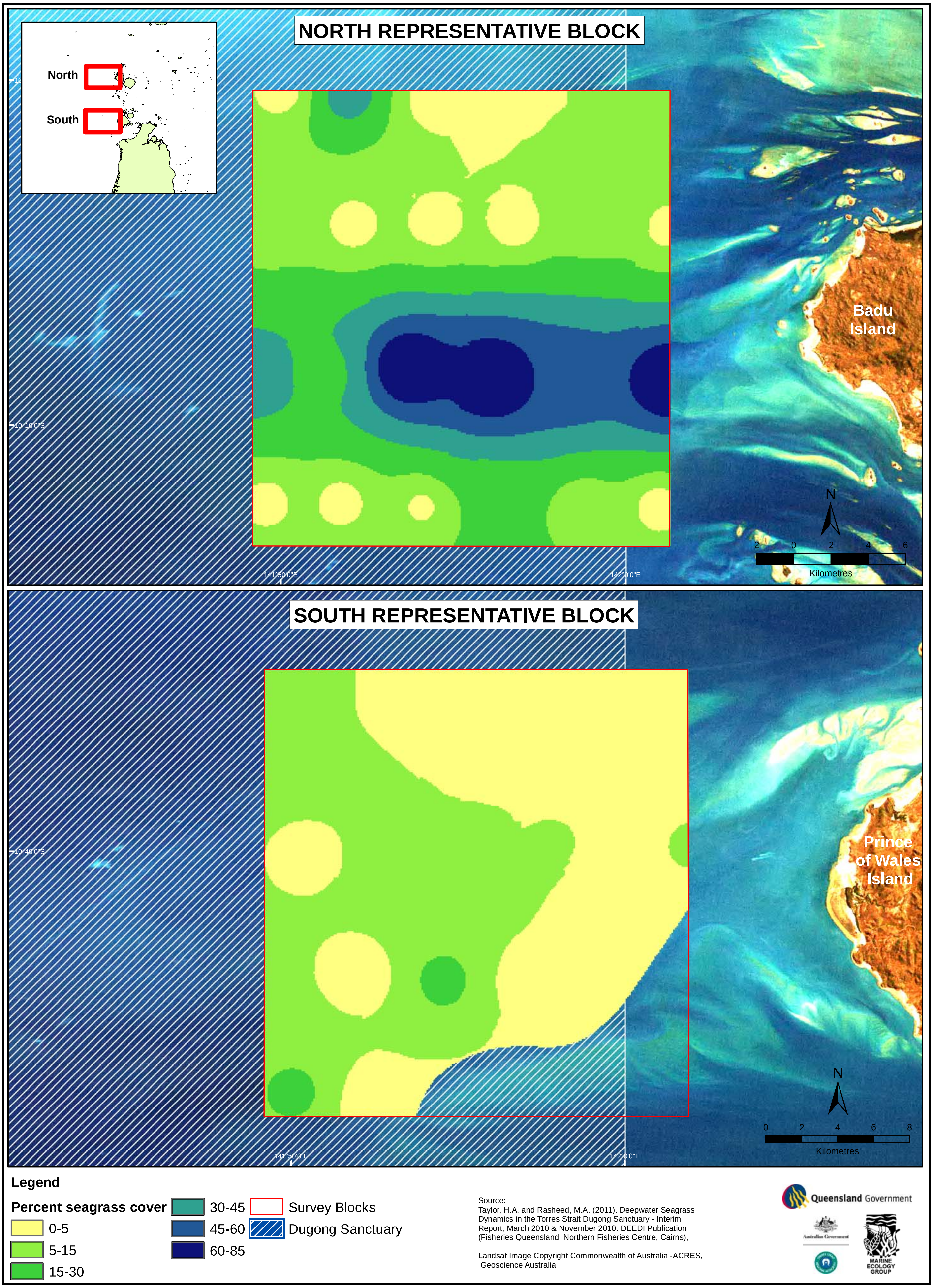
Table 1 Mean above-ground biomass, number of sampling sites and total area for seagrass within representative areas, March 2010 and November 2010.

Rep Area (ID number)	Meadow Type	Seagrass Species (in order of dominance)	Meadow Cover	Mean Biomass ± SE in g DW m^{-2} (no. of sites)		Total Meadow Area ± R in hectares	
				Mar-10	Nov-10	Mar-10	Nov-10
North	Light *Halophila spinulosa* with *Cymodocea serrulata*	*Halophila spinulosa, Cymodocea serrulata, Halophila ovalis, Syringodium isoetifolium, Thalassodendron ciliatum, Halodule uninervis (wide), Halophila decipiens*	Aggregated patches	2.92 ± 0.73 (17)	8.67 ± 2.07 (24)	58,180.5 ± 22,674.0	61,804.4 ± 21,098.6
South	Light *Cymodocea serrulata* with *Halophila spinulosa*	*Cymodocea serrulata, Halophila spinulosa, Halodule uninervis (wide), Halophila ovalis, Syringodium isoetifolium, Halophila decipiens*	Aggregated patches	2.91 ± 0.73 (10)	0.42 ± 0.2 (27)	52,953.3 ± 23,054.1	51,959.2 ± 19,832.0
Total of Representative Areas (avg biomass, sum area)				**2.9 ± 0.7**	**4.5 ± 1.1**	**111,132.8 ± 45,728.1**	**113,763.6 ± 45,728.1**

Map 1 Location of November 2010 seagrass assessment sites with the North and South representative areas, Dugong Sanctuary, Torres Strait



Map 2 The distribution and percent cover of seagrasses within the North and South representative areas, November 2010, Dugong Sanctuary, Torres Strait



Temporal Changes in Seagrass: March 2010 – November 2010

Some changes to seagrass abundance (biomass) and percent cover were recorded between March 2010 and November 2010, however, these changes were not consistent between the North and South representative areas.

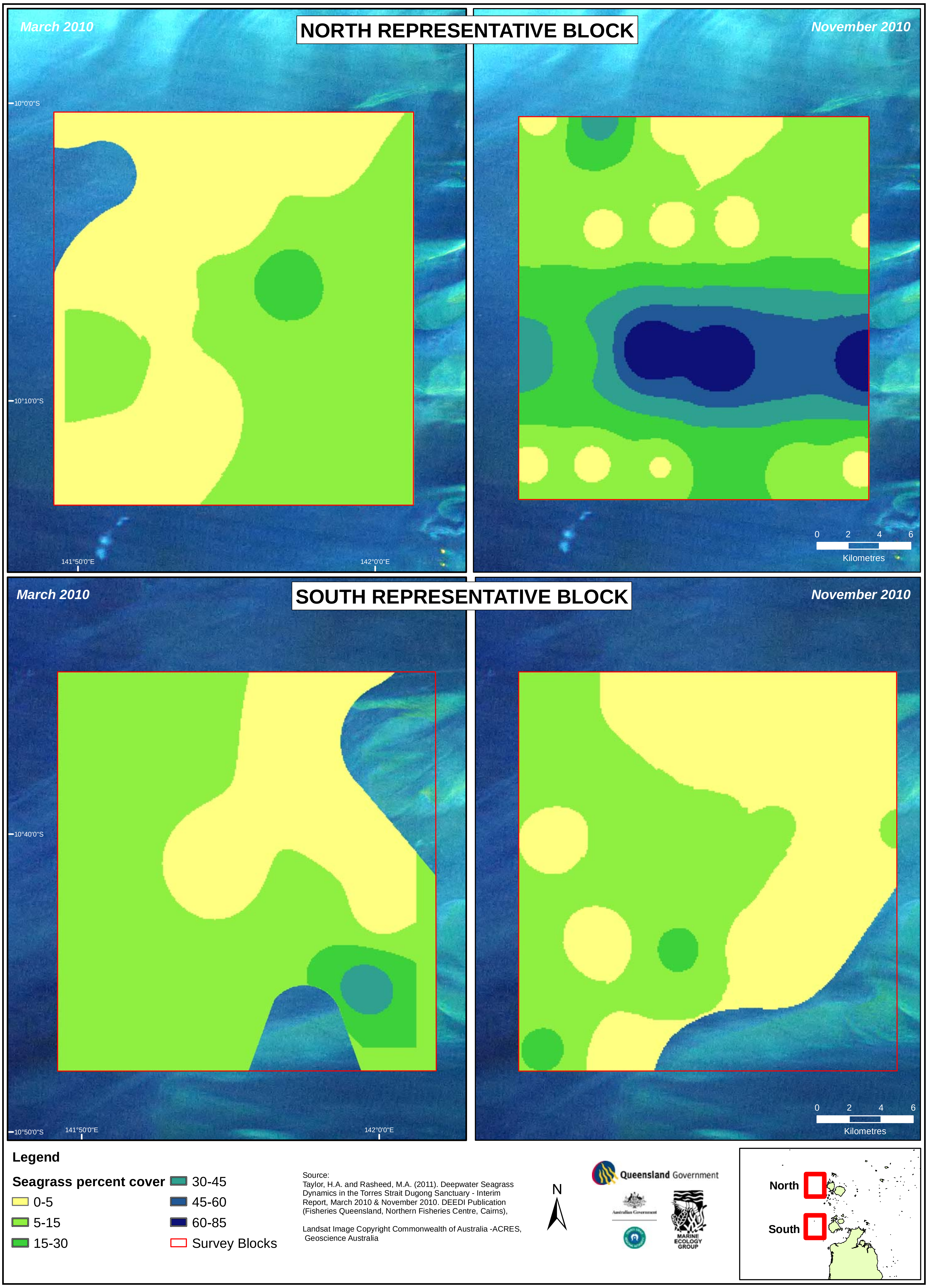
In the initial March 2010 survey seagrass abundance was similar in the North and South areas (2.92 ± 0.73 g DW m^{-2} and 2.91 ± 0.73 g DW m^{-2} respectively). In November this was no longer the case, with biomass in the North area increasing (to 8.67 ± 2.07 g DW m^{-2}) whilst decreasing in the South (to 0.42 ± 0.2 g DW m^{-2}) (Table 1; Figure 1; Appendix 1).

A similar pattern of change was noted for seagrass percent cover, where cover was found to have increased in the North and decreased slightly in the South (Map 3). Seagrass cover was not uniform throughout both representative areas in either March or November 2010 and seagrass cover "hotspots" were clearly identifiable. In the North area, seagrass peaked in a similar location at 25% cover in March and a high 85% in November. The pattern was not repeated in the South area where seagrass "hotspots" did not overlap between March and November 2010 and the maximum recorded cover had reduced from 40% to 20% (Map 3).

The decline in both seagrass abundance and percent cover in the South representative area was a direct consequence of the loss of *Halophila spinulosa* and to a lesser extent *Syringodium isoetifolium* (Figure 3). *Halophila spinulosa* was the dominant seagrass species in the South in March 2010 accounting for 77% of the species composition; by November 2010 this had reduced to 20% leaving *Cymodocea serrulata* as the dominant species. *Syringodium isoetifolium* had similarly reduced from 13% to 3% (Map 3).

Total seagrass area within each representative area remained similar between March and November 2010 (Table 1; Figure 2). Seagrass distribution was more variable in the South representative area.

Map 3 Comparison of seagrass distribution and percent cover for March and November 2010, Dugong Sanctuary, Torres Strait



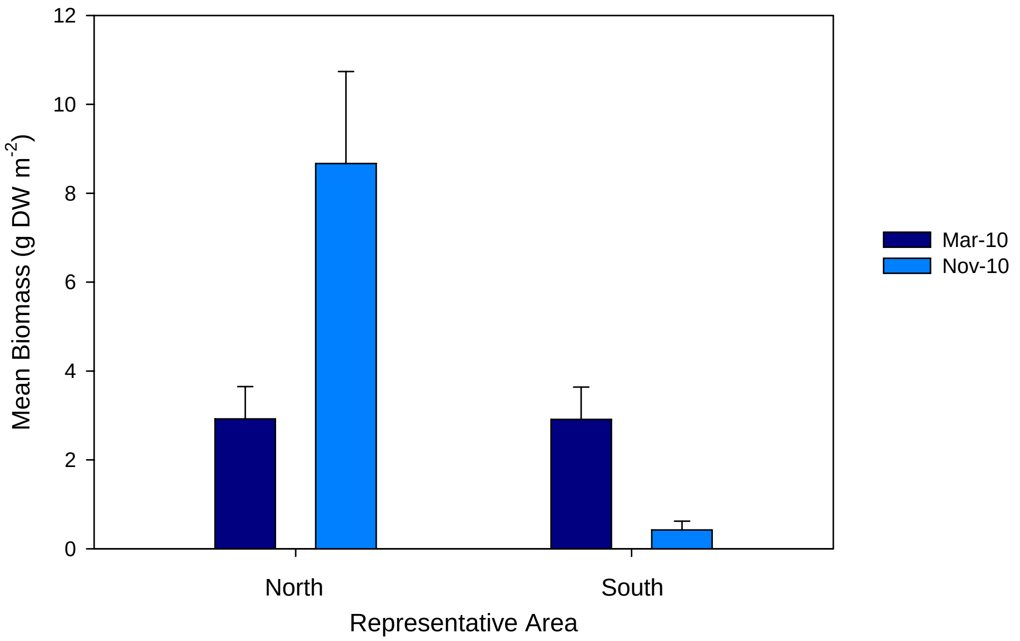


Figure 1 Changes in seagrass biomass in representative area North and South in the Dugong Sanctuary, March 2010 – November 2010

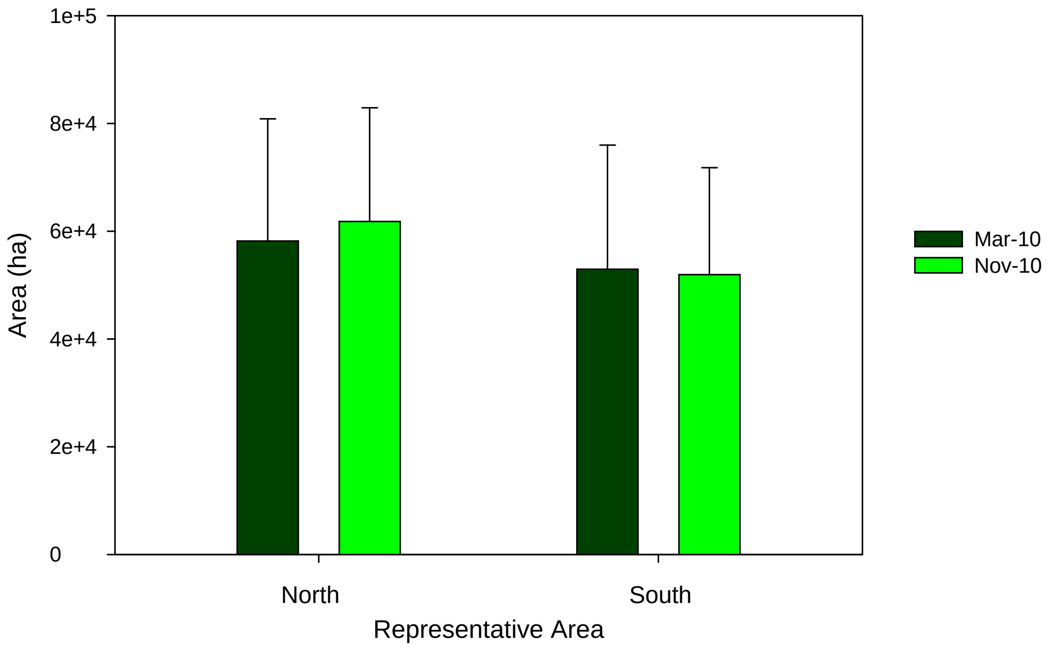


Figure 2 Changes in seagrass area within each representative area in the Dugong Sanctuary, March 2010 – November 2010.

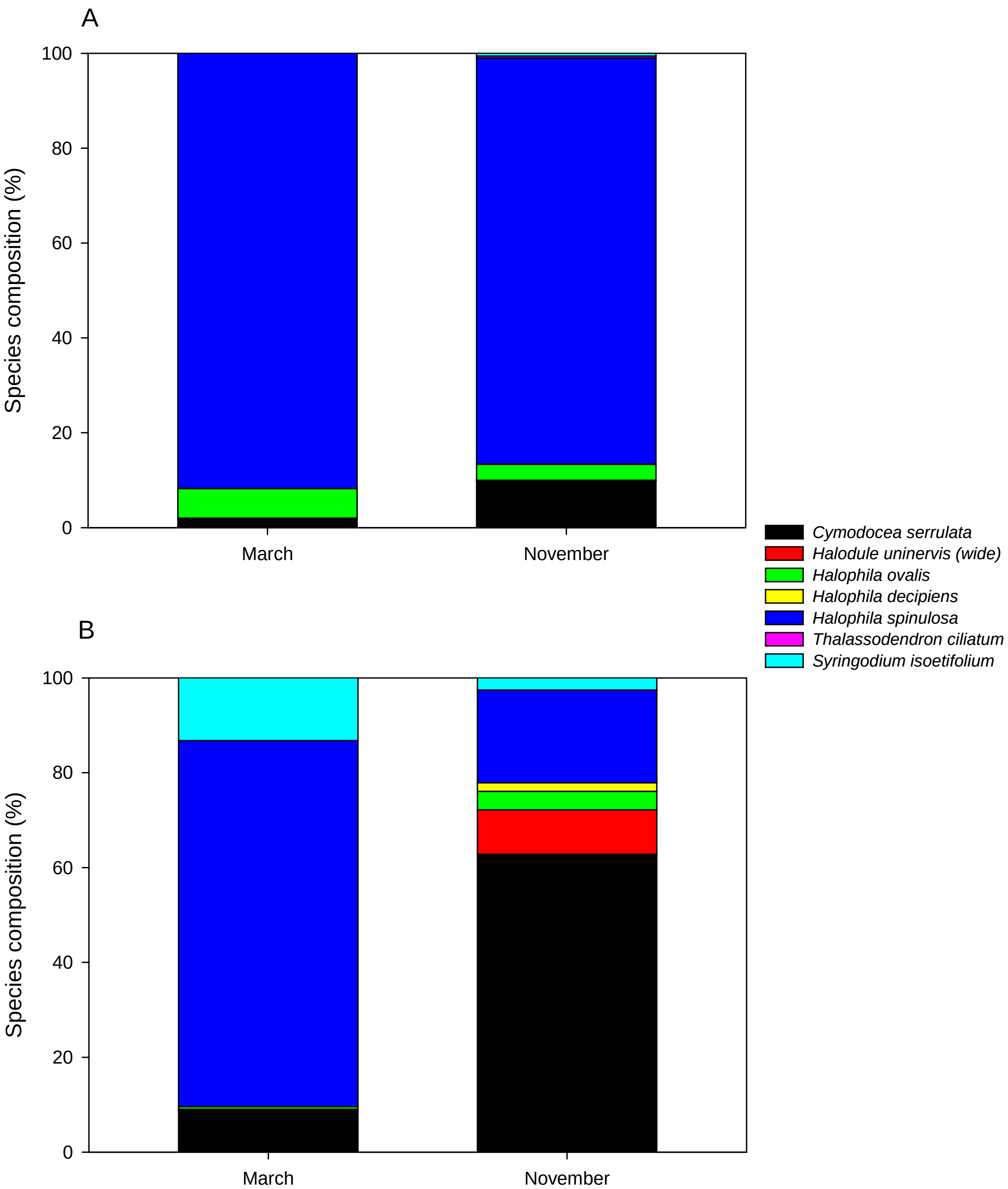


Figure 3 Changes in species composition for seagrass in the North representative area (A) and the South representative area (B) in the Dugong Sanctuary, March 2010 – November 2010.

DISCUSSION

The March and November 2010 seasonal baseline surveys were the most comprehensive assessment of seagrass distirbution and abundance that have been conducted within the Dugong Sanctaury. The Dugong Sanctaury contains the largest recorded single continuous seagrass meadow in Australia and is likely to play a vital role for local dugong and turtle populations as an important food resource. Seagrass species found included those known to be important for dugong and turtles (Bjorndal 1985; Aragones et al. 2006) as well as nursery grounds for commercial fisheries species (Coles et al. 1993; Watson et al. 1993). Large areas of seagrass were found in both surveys indicating that seagrass may remain in the area throughout the year providing a food source for dugong and turtle. However longer term seasonal studies will be required to confirm seagrass persistance and seasonal change.

Seagrasses in the Dugong Sanctuary are likely to be regionally important as the area that they cover is several orders of magnitude greater than nearby subtidal seagrasses that have been described, such as Mabuiag (19,517 ha) (Chartrand et al. 2009), Badu (3,363 ha) (Taylor & Rasheed 2010a) and Moa Islands (Taylor et al. In press). The vast area of seagrasses mapped provides a year round, important source of primary production supporting the regions marine ecosystem. Studies at the nearby Orman Reefs have shown seagrass meadows to be incredibly productive, completely turning over their above-ground biomass every 9 to 25 days (Rasheed et al. 2008).

Deepwater seagrass communities are limited to species capable of growing under low light conditions and the species mix in the sanctuary seagrass meadow generally reflects these constraints. Change in the availability of light with increasing depth is a major factor shaping the distribution of subtidal seagrasses (Short et al. 2001; Erftemeijer and Herman 1994; Taylor et al. 2007; Rasheed et al. 2007a; Rasheed et al. 2007b). *Halophila* species for example, are well adapted to lower light conditions and typically dominate low light environments such as deepwater and highly turbid areas (Kenworthy et al. 1989; Chartrand et al. 2008). They display a typical colonising growth strategy with fast growth and high reproductive output (Birch & Birch 1984; Rasheed 2004) including the production of long lived seeds that remain viable in sediments (McMillan 1991). These traits however, make them more susceptable to showing high variability in location, shape and abundance between seasons.

Many of the factors that influence seagrass growth vary seasonally, and also change between years. This leads to tropical seagrass meadows typically varying substantially in density and area between seasons (Rasheed 1999; 2004; Rasheed & Unsworth 2011; McKenzie 1994) as well as between years (eg. Chartrand et al. 2008; Rasheed et al. 2007a; 2007b). Seagrasses of the East coast of tropical Queensland are generally at their peak in distribution and abundance during late spring/early summer and decline during winter months (Mellors et al. 1993; McKenzie 1994; Rasheed 1999; 2004). Seasonality may not be consistant, however, with seagrasses in the Gulf of Carpentaria where seargasses reaching their peak in late summer/early autumn (McKenna & Rasheed 2010; Rasheed et al. 2001) and deepwater seagrasses in the east coast peaking in late winter/early spring.

To date, the seasonality of subtidal seagrasses within the Torres Strait has not been established. Intertidal seagrass meadows in the Torres Strait have been found to show distinct seasonal patterns which mirror that of East coast seagrasses, peaking in late spring/early summer and dipping in winter (Seagrass Watch 2011). The results of this study indictated that seagrasses within the Dugong Sanctuary are variable between seasons, however further information is required to bolster this relationship. It is possible that the drivers of seasonal change, broadly identified as light and temperature (Duarte et al 2006), act differently in the North and South regions of the Dugong Sanctuary potentially as a result of the complex tidal streams and currents that are found within the Torres Strait.

The results of these surveys indicate that seagrass communities within and around the Dugong Sanctuary appear to be in a healthy and productive state. The two surveys provide a good baseline of information against which changes to seagrass distribution and abundance could be measured in the future. They provide the first information on the potential extent of natural intra-annual change and highlight the need for more frequent, detailed monitoring to further develop our understanding of seasonal change and its implications for dugong, turtle and fisheries that depend on this habitat. Regular seagrass monitoring would give a better picture of the health of the seagrass habitat and an understanding of the changing nature of the food source available to dugong and turtle populations. Fisheries Queensland and the TSRA Land and Sea Management Unit are developing a monitoring program to assess permanent sites within the sanctuary conducted by Torres Strait Rangers and Dugong and Turtle Officers, with the assistance of the Marine Ecology Group. The first quarterly monitoring survey is due for May 2011 and will be followed by a more comprehensive report that will include information on the value of Dugong Sanctuary seagrasses, their vulnerability to threats and any implications for management of this vital resource.

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APPENDIX 1 – STATISTICAL ANALYSIS

One-way ANOVA analysis of seagrass above-ground biomass for representative areas in the Dugong Sanctuary between March 2010 and November 2010.

Area 1	DF	SS	MS	F	P
Between Years	1	328.84	328.84	1.80	**0.188**
Within Years	39	7130.29	182.83		
Total	40	7459.13			
Area 2	**DF**	**SS**	**MS**	**F**	**P**
Between Years	1	45.19	45.19	2.72	**0.108**
Within Years	35	582.28	16.64		
Total	36	627.47			