Annual report on dugong tracking and habitat use in Gladstone in 2014

Christophe Cleguer[1], Colin J. Limpus[2], Christian Gredzens[3], Mark Hamann[1], Helene Marsh[1]

[1.] College of Marine and Environmental Sciences, James Cook University, Townsville, Australia.
[2]. Threatened Species Unit, Department of Environment and Heritage Protection, Block C1, 41 Boggo Rd., Dutton Park Qld 4102, ESP, PO Box 2454 City, Qld, 4001, Australia
[3]. Fuentes Lab, Florida State University, Department of Earth, Ocean, and Atmospheric Sciences, 117 North Woodward Avenue, Room 404B, Tallahassee, FL, 32306

Dugong feeding trial in seagrass bed near Gladstone coal loader. DEEDI photo.

This report should be cited as:

Cleguer, C., Limpus, C.G., Gredzens, C., Hamann, M., Marsh, H. (2015). *Annual report on dugong tracking and habitat use in Gladstone in 2014*. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

This report has been produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program. The study was undertaken through a Purchase Order between Gladstone Ports Corporation and James Cook University to Increase understanding of dugong habitat use in the Port Curtis and Port Alma region: using satellite telemetry. This publication has been compiled by James Cook University.

Disclaimer:

Executive Summary

- Port Curtis supports a relatively small dugong population. Under a consultancy agreement with GPC, JCU and EHP we are using GPS-satellite telemetry on an opportunistic basis to examine the heterogeneity in movements and habitat use of dugongs in the Gladstone region. This report summarises data collected in 2014 from two dugongs caught on the Pelican Banks and equipped with GPS-satellite telemetry devices.

- The two dugongs, an adult female and a sub-adult male, were tracked for 76 days and 32 days respectively. Both dugongs remained in the Port Curtis throughout the period for which they were tracked but used different but overlapping activity spaces that were similar in size to those of dugongs tracked in other regions along the southern and central sections of the east coast of Queensland, such as Shoalwater Bay and Moreton Bay.

- The areas frequented by these two tracked dugongs were close to the shore and included areas close to the main port.

- If combined with studies of the distribution of seagrasses and dugong feeding trials, quantifying the areas used by satellite-tracked dugongs can inform the design of strategies to mitigate the impacts of human activities on dugongs and on their habitats in the Gladstone region.

Introduction

Gladstone Ports Corporation (GPC) completed the Western Basin Dredging and Disposal Project in September 2013. The project removed a total of 22 million m^3 of material during 2011-2013. The project increased port access by deepening, widening and creating new shipping channels with depths of up to 13 metres to allow vessels to enter and exit the Western Basin. The project also included the construction of a bund wall and reclamation area at Fisherman's Landing.

To obtain the permit required to undertake these dredging activities, GPC was required to meet environmental conditions, including the development and implementation of an Ecosystem Research and Monitoring Program (ERMP). The ERMP was developed to acquire a detailed ecological understanding of the marine environment of Port Curtis and Port Alma to be used as the basis to monitor, manage and/or improve the regional marine environment and to offset potential impacts from the project on listed threatened and migratory species and values of the Great Barrier Reef World Heritage Area and National Heritage Place, including the dugong, *Dugong dugon*.

The scope of this work is to deploy satellite tags on dugongs and examine the movement, behaviour, and habitat use in the Gladstone region as opportunity permits to increase understanding of habitat use by dugongs in Port Curtis.

This report summarises data collected in 2014 through a purchase order between Gladstone Ports Corporation and James Cook University to increase understanding of dugong habitat use in the Port Curtis and Port Alma region: using satellite telemetry.

Methods

Dugong capture and tag attachment

Two dugongs were captured on the Pelican Bank in the Gladstone region (Figure 1) in October 2014. One dugong was caught as planned using the rodeo method originally developed for sea turtles (Limpus 1978) and adopted for dugongs (Marsh and Rathbun 1990, Lanyon et al. 2006); the second animal was obtained opportunistically using a net deployed to catch sea turtles. The dugongs were secured as described in Lanyon et al. (2006) while their body length was measured and a tethered satellite/GPS unit attached via a peduncle belt. The dugongs, which appeared healthy, were released within 15 minutes of capture in the area where they were captured.

Because dugongs lack dorsal fins, their peduncle is the only secure attachment point for external devices (Marsh and Rathbun 1990, Reid et al. 1995). Each GPS-satellite transmitter was attached to a dugong peduncle via a 3m long flexible tether attached to a padded tailstock belt. This system, which was developed for the Florida manatee (Reid et al. 1995), has been used on dugongs since the 1980s and enables the tag to float to the surface when the animal is in shallow water, increasing the frequency of signals successfully transmitted to satellites. The harness assembly incorporates a weak link that can be broken by the dugong if the assembly becomes entangled in marine biota such as coral or mangroves and a corroding link that slowly corrodes in a galvanic reaction in seawater and releases the harness.

Global positioning system

We used the Gen4 GPS receiver technology developed by Telonics. Gen4 systems incorporate a GPS receiver for obtaining positional data. The fix time of this GPS receiver ranges between 30 and 90 sec assuming a clear view of the sky (http://www.telonics.com). Typical GPS position accuracy is 2-10m. The units also contained a fast acquisition GPS tracking technology, Quick Fix Pseudoranging (QFP), which has been developed for marine mammals, such as dugongs, that surface for only short periods of time. The QFP technology obtains location fixes with $\geq$3 sec of surfacing time. QFP locations are classified into three categories on the basis of by locational accuracy: resolved QFP, resolved QFP (uncertain), and unresolved QFP. Telonics (2012) states that 98.4% of resolved QFP positions are within 30m of the actual position, resolved QFP (uncertain) positions are generally within 75m, and unresolved QFP positions are over 100m.

Data processing

Each GPS unit was programmed to obtain a location fix every 60 min. The raw data were transmitted via the ARGOS network (http://www.argos-system.org) and then converted into GPS locations using manufacture-supplied software (Telonics Data Converter). We used ArcGIS 10.2 (ESRI 2013) for spatial analysis unless otherwise stated. ESRI imagery was used for visual inspection of location fixes and as background images for the maps. Statistical analysis was conducted using Microsoft Excel and the R software (R Development Core Team).

The data were initially filtered by location class, using only successful GPS, and resolved QFP location classes to maintain location accuracy of 30m. After initial filtering, the data were corrected for over-speed errors, temporal duplicates, and fixes obtained inland as explained in Gredzens et al. (2014) and using the data-driven method described by Shimada et al. (2012). After filtering and correcting the dataset, the location data from each dugong were standardised by dividing the remaining location points into 3 hour duty-cycles and selecting the most accurate location within each duty-cycle (detailed in Gredzens et al. 2014). Three hours was chosen to retain as many location points as possible while minimising differences in the number of location points per day per animal. In addition, duty cycles were used to reduce the effects of autocorrelation and effects resulting from differences in transmitter performance. These measures were necessary as sample size has been shown to significantly affect home-range estimates (Boyle et al. 2009).

Extent of movements, home-ranges and core areas

Minimum convex polygons (MCP) were calculated using the Minimum Bounding Geometry tool in ArcGIS 10.2 (ESRI, 2013) to define the extent of movement of each tracked dugong. The mean (±SD), minimum and maximum distances from the nearest land was determined for each tracked dugong using the near analysis tool in ArcGIS 10.2.

We calculated utilisation distributions (UD) to define the core areas and home ranges of the tracked dugongs. The UDs areas quantify where an individual dugong spends 5 to 95% of its time. The fixed Kernel density estimation and isopleth tools were used in the Geospatial Modelling Environment software (GME; Beyer, 2012) at a resolution of 30 m. This resolution was selected because the mean accuracy of each filtered QFP GPS location is within 30 m of the true location. After exploring different types of smoothing parameters, the CVh smoothing parameter was chosen as the most biologically relevant smoothing parameter for the dataset. This approach is consistent with other recent analyses of dugong home-ranges and core areas (Gredzens et al. 2014, Cleguer 2015, Zeh et al. 2015). Utilisation distribution was calculated for: (1) each animal using data from the entire period in which it was tracked, (2) the two tracked dugongs combined using data from the combined period in which both animals were tracked. Any areas of the 95% and 50% polygons that overlapped with land were removed before the size of each polygon was calculated using the dataset representing the period in which each animal was tracked.

Results

Dugong capture, tagging and tracking information

A 2.84m adult female dugong, hereafter individual A (tag number 652608A), was captured on the Pelican Banks and equipped with a Telonics GPS-satellite transmitter on 18th October 2014 (Figure 1 and Table 1) and tracked over 76 days. The second dugong (individual B; tag number 652612A) was a 2.18m sub-adult male captured on the Pelican Banks and released on 19th October 2014 and tracked for 32 days. Neither transmitter was retrieved before it ceased transmitting.

Use of space

The two tracked dugongs remained in the Gladstone region during the period for which they were tracked. There were some differences in the areas frequently used by each tracked dugong. Individual A frequently used the area between the Pelican Banks and Quoin Island (Figure 1A and 2A). This animal also made a return trip to the southeast to Bushy Island Reef and to the west to The Narrows (Figure 1A). Individual B also frequently used the Pelican Banks, as well as the area between Barney Point and Parsons Point to the south and The Narrows to the west (Figure 1B and 2B).

The two dugongs remained close to the coast during the tracking period: individual A was not detected more than 2.4 km from the coast (mean distance from any land = 0.9km ± 0.5; Table 2). Individual B remained within a mean distance of any land of 0.6km (± 0.5km) (Table 2).

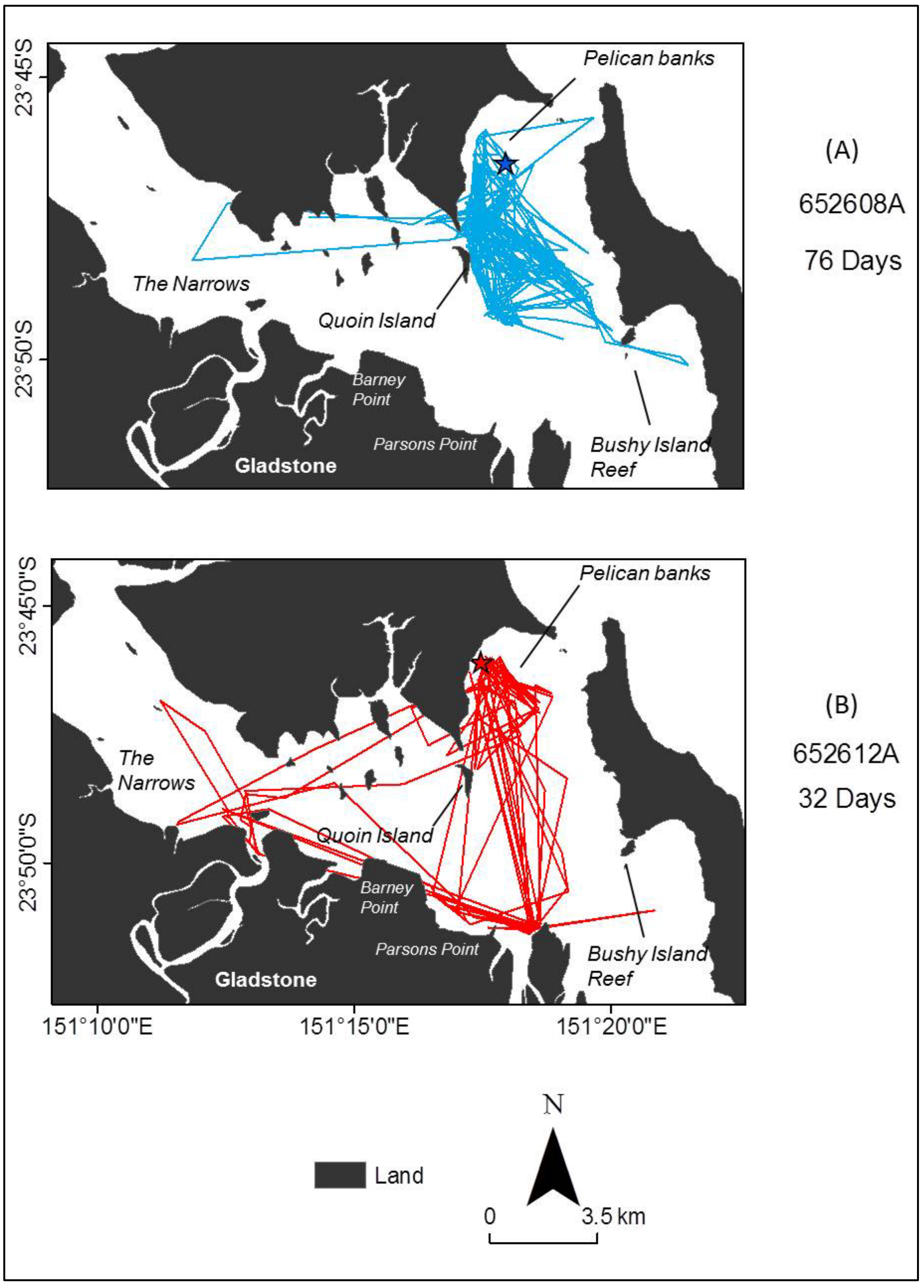

Figure 1: Movement patterns of the two dugongs captured in the Port Curtis in 2014.represnted by coloured lines. Individual A, (tag number 652608A) was tracked for 76 days; individual B, (tag number 652612A) for 32 days. The coloured stars indicate the capture location of each dugong.

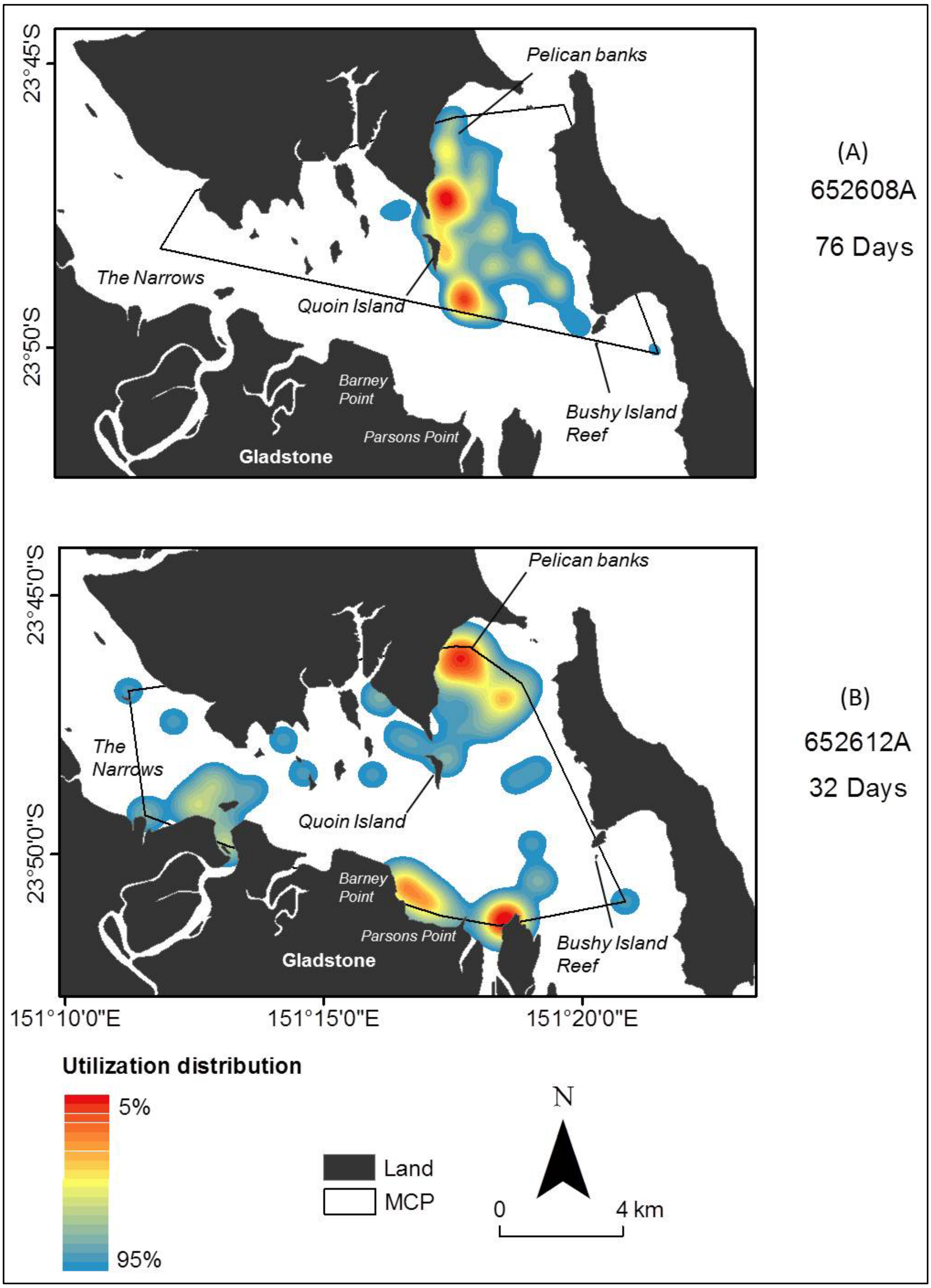

Figure 2: Utilisation distribution (UD) and extent of the movements (MCP) of the two dugongs captured in the Gladstone region in 2014 for their tracking periods. Dugong density ranges from red (high) to blue (low).

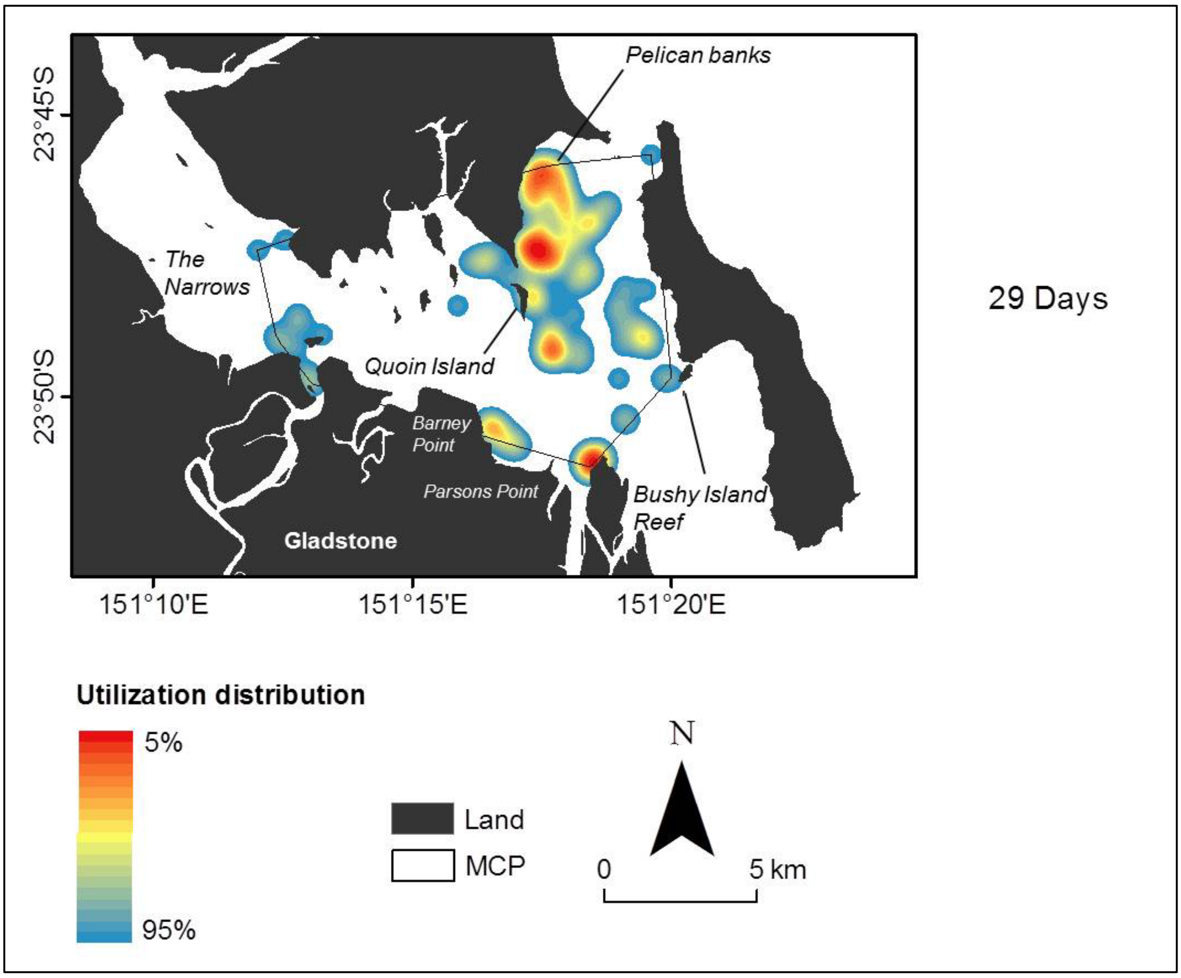

Figure 3: Combined utilisation distribution (UD) and extent of the movements (MCP) of the two dugongs captured in the Port Curtis in 2014. Density ranged from high (red) to low (blue). The combined UD and MCP displayed in this figure were generated for a period of 29 days of tracking during which the two dugongs were tracked simultaneously.

Table 1: Data summary for the dugongs tracked using GPS-satellite units in Gladstone in 2014.

Argos	Secondary tag	Individual ID	Sex	Size (m)	Capture location lat/lon (decimal degrees)	Date tagged	Tracking period	Tracking days	Number of filtered fixes
652608A	QA45857	A	Female	2.84	-23.777 / 151.300	18/10/2014	19 Oct 2014 - 2 Jan 2015	76	454
652612A	QA45866	B	Male	2.18	-23.768 / 151.291	19/10/2014	19 Oct 2014 - 18 Nov 2014	32	436

Table 2: Core habitats (50% KDE), home ranges (95% KDE) and distances to nearest land for the two dugongs tracked using GPS satellite units in Gladstone in 2014.

Individual ID	50% KDE (km^2)	95% KDE (km^2)	Distance to nearest land (km)	
			Max	Mean ± SD
A	3.4	20.9	2.4	0.9 ± 0.5
B	5.5	37.9	2.1	0.6 ± 0.5

Discussion

We obtained information on activity spaces of two dugongs captured on the Pelican Banks for periods of one month (sub-adult male) and 2.5 months (adult female) respectively. Both animals remained in the Port Curtis region undertaking only small scale movements (< 15km from capture location; Sheppard et al. 2006). In other regions of Queensland, the Northern Territory and Western Australia dugongs have exhibited heterogeneous movement patterns ranging from small scale commuting movements (< 15km, n = 26 individuals) to large scale moves (> 15km, n = 44 individuals; Sheppard et al. 2006, see Marsh et al. 2011 for a list of relevant papers). Both small scale commuting movements and exploratory large scale movements were also reported in Torres Strait (Gredzens et al. 2014). In the tropical Lease Islands in east Indonesia, dugongs exhibited similar heterogeneous movement patterns ranging 17-65km from their capture sites (De Iongh et al. 1998). In the lagoons of New Caledonia, some animals displayed sedentary behaviour and others swam over large distances and moved up to 70km from their capture site (Cleguer 2015). As evidenced by the dugong we tracked in 2015 (Cleguer et al. 2015b), some dugongs also move in and out of the Gladstone region and Individuals A and B may have moved from the region if tracked for longer.

The sizes of the core areas and home ranges of the two dugongs tracked in Port Curtis were within the range reported in other studies from south and central Queensland such as Shoalwater Bay, north of the Gladstone region e.g. (Gedzens et al. 2014) and in Moreton Bay (Zeh et al. 2015) and New Caledonia (Cleguer 2015). Nonetheless, the ranges of the two dugongs tracked in Port Curtis are substantially smaller than that of dugongs in Torres Strait, a vast dugong habitat (median range = 942.6km^2; Gredzens et al. 2014). Regional differences in geomorphology and the distribution of seagrasses may explain the differences in dugong range sizes.

Areas most frequently used by and movement patterns of the two tracked dugongs likely reflect the distribution of seagrass in the Gladstone region because the distribution of dugongs generally overlaps seagrass beds (Marsh et al. 2002, 2011). Dugongs also use areas devoid of seagrass for purposes other than feeding, as reported in other regions. In Moreton Bay during winter, dugongs frequently undertake short trips outside the bay to rest for a few hours in warmer oceanic waters (Preen 1992, Daniel Zeh unpublished data). Similarly in New Caledonia during the cool season, dugongs form resting herds over the fore reef shelf outside the lagoon at low tide, presumably as a behavioural thermoregulatory response to changes in water temperature combined with the inaccessibility of inner-lagoon intertidal foraging sites at low tide (Cleguer 2015). Given that both Individual A and Individual B were tagged in mid-October, it is unlikely that they would have experienced thermal stress in Port Curtis.

The areas frequently used by the two tracked dugongs were close to the shore, presumably reflecting the distribution of seagrasses. Dugongs mostly feed on seagrasses in shallow coastal waters although they also feed on subtidal seagrasses farther from the shore (Sheppard et al. 2009). The use of near shore habitats by dugongs increases exposure to anthropogenic threats (e.g., risks of collisions with vessels, by-catch in fishing nets, disturbance of seagrass feeding grounds, see Marsh et al. 2011 for a comprehensive discussion). Dugongs continue to use regions highly impacted by human activities such as the Johor Strait between Singapore and Malaysia (Marsh et al. 2012) and ports such as Townsville and Brisbane (Sobtzick et al. 2012). Wilderness is not a necessary feature of dugong habitat (Marsh et al. 2011) and dugongs can be expected to continue to use the Port of Gladstone despite the increased port activities. Our findings have the potential to contribute to the knowledge base required to inform the mitigation of impacts to dugongs from port and boating activities in the Port Curtis in conjunction with the research on seagrasses and dugong feeding trials in the region.

Acknowledgements

We thank the capture team for assistance with the fieldwork and GPC for funding the project. The dugongs were captured under and Animal Ethics permit from JCU and GBR Marine Parks permits.

References

BOYLE, S. A., LOURENÇO, W. C., DA SILVA, L. R. & SMITH, A. T. 2009. Home range estimates vary with sample size and methods. *Folia Primatologica,* 80**,** 33-42.

CLEGUER, C. 2015. *Informing dugong conservation at several spatial and temporal scales in New Caledonia.* Ph.D., James Cook University.

CLEGUER, C, LIMPUS, C.G., GREDZENS, C., HAMANN, M., MARSH, H. (2015b). *Annual report on dugong tracking and habitat use in Gladstone in 2015*. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

DE IONGH, H. H., LANGEVELD, P. & VAN DER WAL, M. 1998. Movement and Home Ranges of Dugongs Around the Lease Islands, East Indonesia *Marine Ecology,* 19**,** 179-193.

ESRI 2013. ArcGIS Desktop: Release 10.2. Redlands: CA: Environmental Systems Research Institute.

GREDZENS, C., MARSH, H., FUENTES, M. M., LIMPUS, C. J., SHIMADA, T. & HAMANN, M. 2014. Satellite Tracking of Sympatric Marine Megafauna Can Inform the Biological Basis for Species Co-Management. *Plos One,* 9**,** e98944.

LANYON, J. M., SLADE, R. W., SNEATH, H. L., BRODERICK, D., KIRKWOOD, J. M., LIMPUS, D., LIMPUS, C. J. & JESSOP, T. 2006. A method for capturing dugongs (Dugong dugong) in open water *Aquatic Mammals,* 32**,** 196-201.

LIMPUS, C. J. 1978. The reef. *In:* LAVERY, H. J. (ed.) *Australia's wildlife from desert to reef* Richmond, Victoria: Richmond Hill Press.

MARSH, H. & RATHBUN, G. B. 1990. Development and Application of Conventional and Satellite Radio Tracking Techniques for Studying Dugong Movements and Habitat Use. *Australian Wildlife Research,* 17**,** 83-100.

MARSH, H., PENROSE, H., EROS, C. & HUGUES, J. 2002. Dugong: status reports and action plans for countries and territories. . *In:* UNEP (ed.) *Early warning and assessment report series.* Nairobi :United Nations Environement Programme.

MARSH, H., REYNOLDS III, J. E., O'SHEA, T. J. & REYNOLDS III, J. E. 2011. *Ecology and conservation of the sirenia: dugongs and manatees*, Cambridge Univ Press.

PREEN, A. (1992). Interactions between dugongs and seagrasses in a subtropical environment. PhD Thesis, James Cook University, Townsville.

REID, J. P., BONDE, R. K. & O'SHEA, T. J. 1995. Reproduction and mortality of radio-tagged and recognizable manatees on the Atlantic Coast of Florida. *In:* O'SHEA, T. J., ACKERMAN, B. B. & PERCIVAL, H. F. (eds.) *Information and Technology Report.* National Biological Service.

SHEPPARD, J. K., PREEN, A. R., MARSH, H., LAWLER, I. R., WHITING, S. D. & JONES, R. E. 2006. Movement heterogeneity of dugongs, Dugong dugong (Müller), over large spatial scales. *Journal of Experimental Biology and Ecology,* 334**,** 64-83.

SHEPPARD, J. K., JONES, R. E., MARSH, H. & LAWLER, I. R. 2009. Effects of Tidal and Diel Cycles on Dugong Habitat Use. *Journal of Wildlife Management,* 73**,** 45-59.

SHIMADA, T., JONES, R., LIMPUS, C. & HAMANN, M. 2012. Improving data retention and home range estimates by data-driven screening. *Marine Ecology Progress Series*.

SOBTZICK, S., HAGIHARA, R., GRECH, A. & MARSH, H. 2012. Aerial survey of the urban coast of queensland to evaluate the response of the dugong population to the widespread effects of the January 2011 floods and Cyclone Yasi.

ZEH, D. R., HEUPEL, M. R., LIMPUS, C. J., HAMANN, M., FUENTES, M. M. P. B., BABCOCK, R. C., PILLANS, R. D., TOWNSEND, K. A. & MARSH, H. 2015. Is acoustic tracking appropriate for air-breathing marine animals? Dugongs as a case study. *Journal of Experimental Marine Biology and Ecology,* 464**,** 1-10.

Appendix A

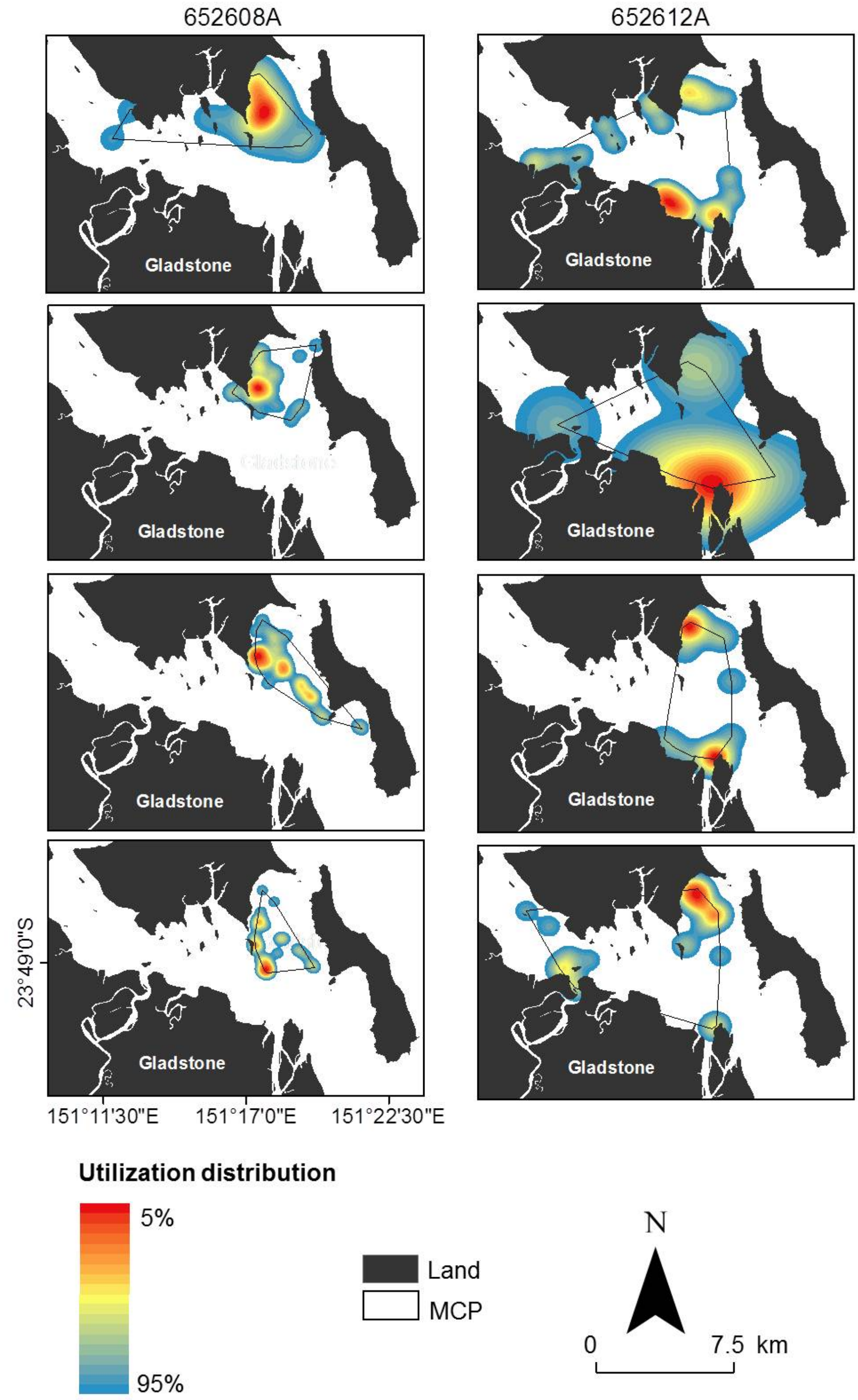

Figure A.1: Weekly utilization distribution (UD) of the two dugongs captured in Port Curtis in 2014 for the time period when they were tracked simultaneously. Density ranged from high (red) to low (blue).The black polygons (MCP) represent the extent of the movements of each tagged dugong.