

**INCREASE THE UNDERSTANDING OF THE GREEN TURTLE POPULATION IN PORT  
CURTIS: ANNUAL REPORT FOR 2017  
GPC ERMP CONTRACT No. CA1400241**



Colin J. LIMPUS, Nancy N. FITZSIMMONS, Kimberley FINLAYSON, Christabel HARMONN,  
Allan McKINNON, John M. SERGEEV and Takahiro SHIMADA.

DEPARTMENT OF ENVIRONMENT AND SCIENCE



Cover photographs:

Scenes from the population monitoring of green turtles, *Chelonia mydas*, at Port Curtis, April - September 2017.

This report should be cited as:

Colin J. Limpus, Nancy N. FitzSimmons, Kimberley Finlayson, Christabel Harmonn, Allan McKinnon, John M. Sergeev and Takahiro Shimada. (2017). Increase the Understanding of the Green Turtle Population in Port Curtis. Brisbane: Department of Environment and Science, Queensland Government. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation Ecosystem Research and Monitoring Program. 28 pp.

This report is produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation Ecosystem and Monitoring Program. The study was undertaken under a Consultancy Agreement (CA14000241) between Gladstone Ports Corporation and the Department of Environment and Heritage Protection to better understand the green turtle foraging population in Port Curtis.

This publication has been compiled by the Queensland Department of Environment and Science (DES).

© Gladstone Ports Corporation

**Disclaimer:**

Except as permitted by the Copyright Act 1968, no part of the work may in any form or by any electronic, mechanical, photocopying, recording, or any other means be reproduced, stored in a retrieval system or be broadcast or transmitted without prior written permission of Gladstone Ports Corporation and/or the Ecosystem Research and Monitoring Program Advisory Panel. This document has been prepared with all due diligence and care, based on the best available information at the time of publication, without peer review, and the information contained herein is subject to change without notice. The copyright owner shall not be liable for technical or other errors or omissions contained within the document. The reader/user accepts all risks and responsibility for losses, damages, costs and other consequences resulting directly or indirectly from using this information. Any decisions made by other parties based on this document are solely the responsibility of those parties. Information contained in this document is from a number of sources and, as such, does not necessarily represent the policies of GPC or the government/department.

Enquiries about reproduction, including downloading or printing the web version, should be directed to [ermp@gpcl.com.au](mailto:ermp@gpcl.com.au).

## Executive summary

- The study has continued satisfactorily with 401 captures of 367 separate turtles. Captures occurred consistently at multiple study sites within the Port.
- The use of 300 m of blocking net has increased the numbers of turtles captured using a net when deployed in areas with an aggregation of foraging turtles.
- The team was unable to locate any area with a concentration of foraging green turtles within the western Basin or at the northern end of The Narrows that would have been suitable for netting during the 2017 field work.
- The turtles are displaying seasonal movements with respect to where they aggregate for foraging between trips. These local shifts in foraging appear to be primarily in response to availability of suitable forage.
- Most juvenile turtles were caught in the shallow intertidal areas around mangroves or rocky reef during the higher tide levels. Most larger turtles were caught in deeper inter-tidal and sub-tidal waters at the Pelican Banks.
- The turtles continue to display differences in diet among the study sites.
- The population is strongly biased to females as has been typical of green turtles at all foraging areas previously sampled in eastern Queensland.
- Approximately 5% of the adult females are estimated to have prepared for breeding during the 2017-2018 season.
- Approximately 38% of the adult males are estimated to have prepared for breeding during the 2017-2018 season.
- Port Curtis again was not a significant courtship area for green turtles.
- An adult female preparing for her first breeding season was successfully tracked via GPS satellite telemetry from her foraging area on the Pelican Banks and adjacent waters outside the Port to her courtship area at Llewellyn Reef and on to her nesting beach at Lady Musgrave Island.
- The majority of the turtles with healed or healing fractures resulting from impacts with vessels were captured on the Pelican Banks.
- Turtles with external fibropapilloma tumours were most frequently encountered in the Boyne River estuary area.
- There were significant differences in body condition (as an index of health measured via length-weight analysis) between males and females for large turtles (approximately CCL >88 cm) but no significant differences in body condition among the smaller turtles (approximate CCL <88 cm).
- There were no significant differences in body condition of turtles between those foraging on the Pelican Banks and those foraging at the Boyne River mouth, nor by study years (2016 and 2017), nor by maturity for adults and immature turtles.

**INCREASE THE UNDERSTANDING OF THE GREEN TURTLE  
POPULATION IN PORT CURTIS: REPORT FOR 2017  
GPC ERMP CONTRACT No. CA14000241**

Port Curtis, a major port in central Queensland, receives outflow from the Calliope and Boyne Rivers. The Port also receives some outflow from the Fitzroy Catchment via The Narrows. Port infrastructure supports coal, LNG, and grain export, bauxite import and alumina export, an alumina smelter, a power station, tourism to the Great Barrier Reef, vessel transport between Gladstone and the numerous islands of the Port and diverse light industry. The Port also supports commercial and recreational fishing. Servicing the needs for large vessel movements within Port Curtis has escalated since the 1880s and particularly since the 1960s. Sections of intertidal habitat in the western and southern perimeter of the Port have been converted to infilled land behind rock walls with associated reduction in intertidal habitat. Channels and turning basins have been dredged to facilitate access for large vessels.

The turtle population foraging in the modified coastal embayment of Port Curtis has been the focus of increased studies since the extreme weather events of the 2010-2011 summer that resulted in an abnormal elevation of turtle and dugong mortality and strandings (Meager and Limpus, 2012; Limpus *et al.* 2012; Flint *et al.* 2014; Gaus *et al.* 2012).

As part of the approval for dredging operations associated with the construction of three LNG plants on south west Curtis Island, the Gladstone Ports Corporation (GPC) was conditioned to implement a range of studies monitoring the ecology and wildlife of Port Curtis under the auspices of an Environmental Research and Monitoring Program (ERMP). GPC ERMP has previously contracted the James Cook University (JCU) in partnership with Queensland Department of Environment and Heritage Protection (EHP) to deploy GPS satellite tags on green turtles foraging in Port Curtis over three consecutive years, 2014-2016. The intent of these studies has been to define the behaviour and habitat utilisation of green turtles within Port Curtis. The results of the satellite telemetry study will be reported independently by JCU.

GPC ERMP contracted the Queensland Department of Environment and Heritage Protection (EHP) to undertake a four year tagging-recapture population study of green turtles resident in Port Curtis and an associated assessment of their health. The study requires the sampling of turtles from a range of sites within the Port including Pelican Banks, Facing Island, Boyne Estuary and the Western Basin.

As part of the approval for the construction of three LNG plants on south west Curtis Island, the LNG projects also were conditioned to implement a range of studies monitoring the ecology and wildlife of Port Curtis. The combined LNG projects were approved to implement a Long Term Turtle Monitoring Program (LTTMP). Eco Logical Australia was contracted to implement the LTTMP. Eco Logical Australia subsequently has contracted EHP to provide access to a representative sample of foraging green turtles within Port Curtis for in depth

health studies by contracted investigators at University of Queensland School of Veterinary Science and Griffith University School of Environment. These health studies will encompass the assessment of green turtle haematology, blood chemistry, toxicology and disease and will reported independently to the present report.

The EHP led study builds on knowledge gained during previous studies within the Port with respect to access to green turtles foraging within a range of habitats. This report summarises the results of the second year of the GPC funded study and the commencement of the ELA funded study.

## Methods

The standard methods of the Queensland Turtle Conservation Project developed for assessing the population dynamics of marine turtles (Limpus *et al.* 2005) were used in the present study. Table 1 summarises the composition of the field team for the 2017 field studies: 26 April – 5 May; 22 June – 1 July; 19 – 30 September, 1-8 November.

**Table 1. Field team for the 2017 studies of foraging green turtles in Port Curtis.**

### **Coxswains**

- Dr Colin Limpus (EHP)
- Dr Nancy FitzSimmons (EHP)
- John Sergeev (EHP)

### **Veterinarians**

- Allan McKinnon (EHP)
- Christobelle Hammon (UQ SVS)

### **James Cook University, College of Earth and Environmental Science**

- Justin Smith, PhD student;
- Hector Barrios-Garrido, PhD student

### **Griffith University, School of Environment**

- Kimberley Finlayson, PhD student.
- Gulsah Dogruer, PhD student

### **EHP registered volunteers**

- Dr Simone Bosshard, Christiaan van de Wetering and Nikky Ritter

### **Eco Logical Australia team**

- Jeni Morris

### **Gidarjil Land and Sea Rangers**

- Des Purcell and Ron Blair, Charles Coleman, Tobias Flinn, Jessie Holland, Matty Johnson and Ian Twist

Turtles were captured by the turtle rodeo method of jumping from catch boats to restrain the turtle (Limpus, 1978) or captured in a blocking net set on the Pelican Banks or on the intertidal flats adjacent to Wiggins Island on falling tides. Captured turtles were lifted into the turtle catch boats for transport back to the NPSR Marine Parks Workshop at the Gladstone Marina where they were processed for the required data and tissue samples.

The EHP research team has increased the length of blocking net being deployed to capture turtles on the inter-tidal flats on falling tides from 100 m to 300 m in length with a corresponding increase in the size of the anchor gear necessary to hold the nets in the strong tidal currents.

The turtles were tagged with standard titanium turtle tags, one on each front flipper (Limpus, 1992), measured for midline curved carapace length (CCL.  $\pm$  0.2 cm) with a flexible fibreglass tape measure and weighed (WT  $\pm$  0.1 kg with an electric balance). Turtles were scored for severity of fibropapillomatosis tumours (Work and Balazs, 1999) and for general body condition (Limpus *et al.* 2012).

The sex, maturity and breeding status were determined via examination of the gonads and associated ducts of the turtles using laparoscopy and/or ultrasonography. The interpretation of the gonad observation followed the standard defined procedures within the EHP Queensland Turtle Conservation Project (Limpus *et al.* 1994, Limpus, 1993; Limpus and Limpus, 2003; Limpus *et al.* 2005). Immature turtles for which the sex and maturity had been determined in a previous year were not re-assessed in 2017.

Additional collaborative studies were undertaken to enhance our understanding of the population dynamics of this foraging green turtle population in Port Curtis and to support other contracted studies by GPC ERMP:

#### **Green turtle habitat use study:**

This was an extension of a three year study funded by GPC ERMP to James Cook University (JCU) with EHP as collaborating partners.

- Two GPS satellite telemetry tags with depth data loggers funded via GPC ERMP were deployed on immature green turtles for mapping habitat use and behaviour within Port Curtis during the May 2017 field trip.
- An additional GPS satellite tag, funded by EHP, was deployed on an adult female green turtle preparing to breed for her first ever breeding season.
- All captured turtles were examined for previously attached satellite tags, depth data loggers and/or acoustic tags and were assessed for external damage associated with the use of these tags and photographed.
- Data analyses and communication of results from this telemetry study will be led by Dr Mark Hamann and Dr Taka Shimada at JCU.

The tags were applied to a well cleaned (sand papered) & dried carapace of the turtle, making sure that any flaking scute was scraped away. The satellite tag were glued to the anterior dorsal carapace of the turtle using a two-part epoxy, *Sika AnchorFix – 3+*. Fibre glass strips were imbedded into the epoxy passing along the sides, front and rear of the satellite tags to make for a broader area of attachment. The epoxy was allowed to set well beyond the minimum for touch before release, to avoid the risk of turtles rubbing the tags off. Before release, the tags were painted with *International Micron extra* anti-fouling paint to prevent over-growth of the GPS antenna and salt-water switch terminals with algae and other fouling organisms.

The data received via the ARGOS satellite system was accessed via the Wildlife Computers Portal (Wildlife Computers, 2015).

### **Green turtle diet study:**

This diet study has been conducted as part of PhD studies by Owen Coffee, University of Queensland, with supervision by Dr David Booth and Dr Colin Limpus.

- Food samples were collected opportunistically from the mouths of turtles at capture.
- Gastric lavage samples (Forbes and Limpus, 1993) were collected from a representative sample of turtles of all size classes across the study sites to assess dietary variation within the Port Curtis region.
- Skin tissue and blood samples (Owens and Ruiz, 1980) were also collected from these turtles as well as samples of food species for stable isotope analysis to assess food web dynamics.
- Samples were preserved and taken to UQ for analysis.
- The detailed analyses and reporting of results will be led by PhD student Owen Coffee.

With the completion of Mr Coffee's field sampling for his university studies, the gastric lavage sampling of green turtle diet within Port Curtis has continued as an EHP study.

### **Turtle health studies:**

A range of separate studies that will inform on the health of the turtles have been facilitated within the framework of the current GPC ERMP study. Additional funding support for these health studies is being provided by the LNG Long Term Turtle Monitoring Program (LTTMP) funded through Eco Logical Australia.

- *UQ School of Veterinary Science studies:* Turtles were examined for external indicators of their health and blood samples were collected for blood chemistry and haematological assessment of green turtle health within Port Curtis.
- *Griffith University (GU) analysis:* Blood and carapace scute samples were collected for investigating toxicological assays to assess the effects of chemical contaminants in turtles.

The analysis of the data and reporting of results from these two studies will be led by staff and Post-graduate students at UQ in the School of Veterinary Science and the Griffith University School of Environment. Professor Paul Mills, Dr Mark Flint and Dr Colin Limpus will provide the overarching supervision of these PhD studies.

### **Green turtle population genetics:**

Small skin samples (~2 mm<sup>3</sup>) were collected from in excess of 100 foraging green turtles in Port Curtis and stored in 20% DMSO in saturated NaCl solution. These samples have been banked within EHP for future extension of green turtle population genetics studies.

### **Fisheries permit and Animal Research Ethics approvals**

- All turtle research activities were undertaken in accordance with the standard practices approved under the DAFF Animal Experimentation Ethics Committee: **Queensland Turtle Conservation Project Queensland Turtle Conservation Project SA 2015-11-524, 525, 526, 528, 529, 531.**
- The use of nets for the capture of turtles was in accordance with DAFF General Fisheries Permit 191182, issued to EHP.

GU, JCU and UQ research teams have their own University AEC approvals for aspects of the work not addressed under EHP approvals.

### **Water temperature recording:**

A Vemco Minilog II temperature data logger was deployed in Port Curtis to record water temperature at ~20 cm above the benthos and programmed to record at 30 min intervals.

- The data logger was attached to a steel ring in a concrete block with a 1 m tether to a small float labelled “EHP 0427 002 633”.
- It was deployed on 11 October 2016 in the southern drainage channel on the Pelican Banks (23° 46.520’S, 151° 18.125’E) to commence readings at 18:00 hr, 19 September 2016.

On our return to download the data in April 2017, the concrete block and data logger had been removed from the site and no water temperature data were obtained. This water temperature data logger was not replaced.

### **Water conditions within Port Curtis**

Water turbidity varied widely across the spatial scale of the Port and temporally in response to the twice daily tidal cycle, the changing tidal range across the lunar cycle, wind speed and direction and runoff from recent rains.

The lowest turbidity water was found on the Pelican Banks and at the mouth of the Boyne River, especially with an incoming tide. Capture of turtles by the turtle rodeo method is restricted to the shallower waters where it is possible to see the bottom and hence see foraging turtles at the bottom. Sites for attempted capture of turtles are selected on a daily basis in respects to the tidal cycle for the day and wind direction and speed.

No sites have yet been found within the Western Basin and The Narrows where the water was clear enough to capture turtles by the turtle rodeo method.

On one to three days during each field trip, generalised transects are conducted through potential habitats where netting could be applied for the capture of turtles within the Western Basin. The team was unable to locate any area with a concentration of foraging green turtles within the western Basin that would have been suitable for netting during the 2017 field work.

Our first vessel based assessments of the northern end of The Narrows were conducted during 31 July – 1 August and 9-10 November 2017 to identify suitable areas for the capture of marine turtles (Table 1a). No areas of intertidal habitat with a concentration of foraging marine turtles were identified.



Isolated green turtles were observed but all were within turbid channels with a water depth exceeding 3.5 m.

## Results

Over the four field trips during 2017, a total of 728 sightings of green turtles were recorded within the Port Curtis Study area (Figure 1). A total of 401 captures were made of green turtles from 367 individual turtles (Table 2; Figure 1) with 34 captures of turtles being recaptured on more than one occasion within 2017. Most turtles (74%) were captured on the Pelican Banks, followed Boyne River Estuary (20%) and the western side of Facing Island (4.0%). Capture locations covered a broad area within the sample sites (Figure 1a). Locations of observed but not caught green turtles included areas where the turbidity and/or depth of the water, precluded the capture turtles, including in The Narrows (Figure 1b).

Table 3 summarises the broad tagging history of the turtles captured during 2017. The recapture rate of turtles previously tagged within Port Curtis is encouraging from the perspective of the long term capture-mark-recapture study with 22.3% of turtles being recaptures from within the Port.

The size of the turtles captured at the various study sites within the port are summarised in Figure 2. Turtles across the full spectrum of size range, from those recently recruited to coastal foraging up to large adults, were accessible for capture on the Pelican Banks. At the mouth of the Boyne River, the accessible turtles were strongly biased to small immature turtles. Although large turtles were seen in the adjacent deeper waters, they were not easily captured by the turtle rodeo method. Small immature turtles dominated those seen in the rocky shore and mangrove margin of the western shoreline of Facing Island and around Quoin Island.

None of the 67 recaptured turtles that had been previously recorded within Port Curtis had made major shifts between study sites within the Port.

Green turtles recruited from the open ocean dispersal life history phase to residency as benthic foraging turtles within Port Curtis with mean CCL = 42.9 cm (Table 4). Adult green turtles had a mean CCL of 94.9 cm for males and 101.2 cm for females (Table 4). These sizes lie within the size range for the respective life history phases recorded at other foraging areas for green turtles within the southern GBR region (Limpus *et al.* 2013).

### Sex and maturity

Sex and maturity was determined by gonad examination and/or morphology and body condition for 367 of the turtles captured within Port Curtis during 2017: 145 males, 219 females and 2 asexual turtles with no detectible gonads. One poor-health turtle was not examined to determine its sex. These results are within the range recorded with other green turtle foraging populations in the southern GBR region within recent decades (reviewed by Limpus, 2007, Limpus *et al.* 2013). The majority of the green turtle foraging population in Port Curtis consists of immature turtles of both sexes (Figure 3).

The immature turtles are showing a female bias within the range that has been recorded for green turtles at other foraging areas in the central and southeast Queensland.

### **Breeding biology**

Table 5 summarises the proportion of adult female and male green turtles that are foraging residents within Port Curtis and were recorded preparing to breed for the year (commencing vitellogenesis for females, commencing spermatogenesis for males).

The modest annual samples sizes of captured adult male and female green turtles limit the capacity for comprehensive analyses of breeding rates at this time. The sample sizes will improve with subsequent years of sampling. The males showed a higher annual breeding rate than occurred with the adult females in the same year (Figure 4). This is typical of foraging green turtle populations in eastern Australia (Limpus *et al.* 2005). There is an indication that the annual breeding rate for females in Port Curtis is lower than that has been recorded for adult females foraging elsewhere in eastern Australia (Limpus *et al.* 2005, Limpus and Nicholls, 2000). A similar conclusion is implied when the breeding rate of the adult females foraging in Port Curtis is compared with the size of total annual nesting population at Heron Island (Figure 4). Heron Island is the principle index monitoring site for the sGBR green turtle genetic stock (Limpus, 2007; Limpus *et al.* 2013; Limpus and Nicholls, 2000). This issue will be re-visited as sample sizes improve with future years of this study.

During the 20-29 September study period within Port Curtis:

- 145 green turtles were captured and an additional 111 sightings were made of green turtles that were not captured. Only one of these 256 observations of green turtles involved turtles engaged in courtship/mating behaviour and members of the public reported two other green turtle courting pairs (Table 6). During the same period, numerous courting pairs of green turtles were reported from recognised courtship areas at Masthead Island and Lady Musgrave Island (EHP QTC field records).
- During September 2017, when the majority of the breeding males were expected to have departed to their respective courtship areas, only 3 (17%) of the 18 adult males were in breeding condition. This contrasted with the April – June sampling prior to the commencement of breeding migration when there were 8 (44%) of the 18 adult males preparing for breeding. These data support the view that breeding males did not aggregate in Port Curtis for courtship.
- During September 2017, none of the 15 adult females were very fat and none carried mature (fully yolked) ovarian follicles as would occur if they were females that had aggregated for courtship on route to their nesting beaches and none of them had fresh courtship injuries on their anterior carapace. This contrasted with the April – June sampling prior to the commencement of breeding migration when there were 2 (20%) of the 10 adult females preparing for breeding.

The breeding status of these adult green turtles during 20-29 September in Port Curtis was consistent with:

- Non-breeding adult green turtles for the year had remained within their home foraging area in Port Curtis.
- The majority of the adult green turtles preparing for the 2017-2018 breeding season had already migrated to breeding locations outside of Port Curtis.

Collectively these data indicated that Port Curtis is not a significant area for aggregation of breeding green turtles for courtship and mating.

This does not preclude the possibility that some breeding males from other foraging areas may migrate for courtship within the Port Curtis.

### **Breeding migration records**

Eight adult green turtles (1 male, 7 females) were captured during 2017 for which breeding locations have been recorded:

#### **Male**

**K28651:** CCL = 94.8 cm

- Originally tagged when breeding in the courtship area of Heron Island Reef, 15 October 1999.
- Recaptured on the Pelican Banks on 15 July 2015 and 7 November 2017.

#### **Female**

**T70052:** CCL = 99.5 cm

- Originally tagged when nesting at Lady Musgrave Island, 3 January 1993.
- Recaptured nesting on Lady Musgrave Island, 27 December 2002.
- Recaptured nesting on Lady Musgrave Island, 29 December 2013.
- Recaptured foraging on the Pelican Banks, 7 June 2016 and 4 November 2017.

**T82632:** CCL = 98.2 cm

- Originally tagged when nesting at Lady Musgrave Island, 24 December 1994.
- Recaptured foraging on the Pelican Banks, 3 November 2017.

**T96692:** adult female green turtle, CCL = 105.5 cm (Table 3).

- Originally tagged when breeding in the courtship area of Sandy Cape, Fraser Island, 19 November 1996.
- Recaptured on the Pelican Banks on 27 September 2017.

**K306:** CCL = 101.9 cm

- Originally tagged when foraging on the Pelican Banks, 1 May 2013.
- Recaptured nesting on Lady Musgrave Island, 25 December 2013.
- Recaptured foraging on the Pelican Banks, 5 November 2017.

**K98103:** CCL = 104.2 cm

- Originally tagged when nesting on Heron Island, 10 December 2008.
- Recaptured foraging on the Pelican Banks, 3 November 2017.

**QA34792:** CCL = 101.3 cm

- Originally tagged when nesting at Heron Island, 26 December 2002.
- Recaptured nesting on Heron Island, 08 December 2013.

- Recaptured foraging on the Pelican Banks, 6 November 2017.
- **QA64318**, 24 June: adult female green turtle that was in vitellogenesis for her first breeding season, CCL = 94.5cm (Figure 5).
- Captured foraging on the Pelican Banks on 24 June.
- This telemetry was given a priority within the EHP work program because of the paucity of data on how marine turtles select the nesting beach as they begin their breeding life. This turtle was fitted with a GPS satellite tag (Figure 5).
  - Tracked for approximately 2 months in her foraging area within Port Curtis.
  - She began her breeding migration, departing the Pelican Banks on 31 August and eventually spent 19-21 September within Llewellyn Reef, a known courtship area.
  - She moved from the courtship area and travelled in the vicinity of several nesting beaches before settling on Lady Musgrave Reef on 26 September.
  - She was ashore on Lady Musgrave Island on 1 October and is presumed to have laid her first clutch of eggs for the season.

These data are consistent with the migration recapture data from adult green turtles previously recorded in Port Curtis. The majority of green turtles foraging in Port Curtis migrate to courtship areas and nesting beaches within the southern GBR – Sandy Cape region.

### Health and health problems

One turtle was recaptured which had previously been moribund and stranded in 2013 and after rehabilitation released back into the Port:

**QA27885**: pre-pubescent immature female green turtle:

- 6 July 2013: beach washed in poor body condition on Curtis Island, adjacent to the Pelican Banks, CCL =56.0 cm, weight = 11.7 kg. Rescued and transferred to Quoin Island Turtle Rehabilitation Centre for care.
- 17 Oct 2013: released back to the Port at Quoin Island; weight = 20.1 kg.
- 17 Sept 2017: captured while foraging on the Pelican Banks; CCL = 59.6 cm, weight = 22.9 kg; no external signs of poor health.

Table 7 summaries the number of foraging green turtles captured in Port Curtis by study site and year with identified external evidence of health problems:

- The majority of the turtles with healed or healing fractures resulting from impacts with vessels were captured on the Pelican Banks. These represent only turtles that have been hit by vessels and survived. It does not include those that died as a result of the vessel related injuries.
- Turtles with external fibropapilloma tumours were most frequently encountered in the Boyne River estuary area.

- Turtles in poor health as identified by partly emaciated with concave plastrons were widely distributed across the study sites. The relative change in occurrence under this category between 2016 and 2017 is a result of a change in methodology in response to direct veterinary involvement in assessing body condition that commenced during 2017.

This report provides the first analysis of body condition from substantial sample sizes of length-weight data for green turtles foraging in Port Curtis. Figure 6a illustrates the distribution of the curved carapace length with respect to turtle weight for green turtles captured within Port Curtis by study site.

Generalised additive models were fitted to the carapace length by body weight of green turtles captured at two sites in Port Curtis. The carapace-length relationship is being used as an index of body condition and hence the general health of the turtles. Model parameters included sex (female and male), study site (Boyne River mouth and Pelican Banks), study year (2016 and 2017), age class (mature adults and immature turtles), interactions between year and age class, and between CCL and sex. CCL was allowed to have a non-linear effect. Because the data did not conform to a Gaussian distribution, a Gamma distribution with a log link function was used in the GAM analysis. The results of these analyses are summarised in Table 8 and illustrated in Figure 6b.

CCL was significantly correlated with weight as expected. There were significant differences in weight between males and females for large turtles (approximately CCL >88 cm) but no significant differences in weight by sex detected for smaller turtles (approximate CCL <88 cm). There were no significant differences in body condition of turtles between those captured while foraging on the Pelican Banks and those foraging at the Boyne River mouth, nor by study years (2016 and 2017), and not within adults or within immature turtles.

### **Habitat and methods summary**

Figure 7 illustrates some of the habitats utilised by foraging turtles within Port Curtis. Figure 8 provides a photographic illustration of a range study methods being employed within this study.

## **Other Marine Megafauna in Port Curtis**

### **Marine mammals**

Opportunistic observations were made of dugongs and dolphins in Port Curtis.

- Humpback dolphins were observed in the vicinity of several sampling sites, with multiple observations during each study trip in Auckland Creek and near Quoin Island (Figure 1d)
- All dugong sightings occurred on the Pelican Banks in the immediately adjacent channels (Figure 1e). No dugongs were encountered in a situation where they were suitable for capture.

## Acknowledgements

The Department of National Parks, Sport and Racing has supported this project by provision of work space with the Marine Parks Workshop at the Marina for the duration of each study trip. Dr Megan Ellis and Gladstone Ports Corporation have provided storage facilities for equipment between study trips.

The field teams (Table 1) included numerous university staff and students and EHP Queensland Turtle Conservation Volunteers who assisted with the capture and processing of the turtles.

Gidarjil Land and Sea Rangers assisted with capture and processing of turtles during each study trip and in a training capacity for improving their skills and capacity for monitoring marine turtle populations.

This assistance is gratefully acknowledged.

## References

- Flint, M., Eden, P. A., Limpus, C. J., Owen, H., Gaus, C., and Mills, P. C. (2014). Clinical and pathological findings in green turtles (*Chelonia mydas*) from Gladstone, Queensland: investigations of a stranding epidemic. *EcoHealth* DOI: **10.1007/s10393-014-0972-5**.
- Forbes, G. A. and Limpus, C. J. (1993). A non-lethal method for retrieving stomach contents from sea turtles. *Wildlife Research* **20**, 339-343.
- Gaus, C., Grant, S., Jin, N. L., Goot, K., chen, L., Villa, A., Neugebauer, F., Qi, L., and Limpus, C. (2012). Investigation of contaminant levels in green turtles from Gladstone. (ENTOX, University of Queensland : St. Lucia, Brisbane .)
- Limpus, C. J. (1978). The Reef. In *Exploration North*. Ed. Lavery, H. Pp. 187-222. (Richmond Hill Press: Melbourne)
- Limpus, C. J. (1992). Estimation of tag loss in marine turtle research. *Wildlife Research* **19**, 457-469.
- Limpus, C. J. (1993). The hawksbill turtle, *Eretmochelys imbricata*, in Queensland: population structure within a southern Great Barrier Reef feeding area. *Wildlife Research* **19**, 489-506.
- Limpus, C. J. (2007). A biological review of Australian marine turtles. 2. Green turtle *Chelonia mydas* (Linnaeus). (Queensland Environmental Protection Agency: Brisbane.)
- Limpus, C. J., Couper, P. J., and Read, M. A. (1994). The green turtle, *Chelonia mydas*, in Queensland: population structure in a warm temperate feeding area. *Memoirs of the Queensland Museum* **35**, 139-154.

Limpus, C. J. and Limpus, D. J. (2003). The biology of the loggerhead turtle, *Caretta caretta*, in southwest Pacific Ocean foraging areas. In "Biology and Conservation of Loggerhead Turtles." Eds Bolten, A. B. and Witherington, B. E. Pp. 93-113. (Smithsonian Institution Press: Washington, D. C.)

Limpus, C. J., Limpus, D. J., Arthur, K. E., and Parmenter, C. J. (2005). Monitoring green turtle population dynamics in Shoalwater Bay: 2000-2004. *GBRMPA Research Publication* **83**, 1-51.

Limpus, C. J., Limpus, D. J., Savige, M., and Shearer, D. (2012). Health assessment of green turtles in south and central Queensland following extreme weather impacts on coastal habitat during 2011. (Department of Environment and Resource Management : Brisbane.)

Limpus, C. and Nicholls, N. (2000). ENSO regulation of Indo-Pacific green turtle populations. In "Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems." (Eds Hammer, G., Nicholls, N., and Mitchell, C.) Pp. 399-408. (Kluwer Academic Publishers: Dordrecht.)

Limpus, C. J., Parmenter, C. J., and Chaloupka, M. (2013). Monitoring of Coastal Sea Turtles: Gap Analysis. 2. Green turtles, *Chelonia mydas*, in the Port Curtis and Port Alma region. (Ecosystem Research and Monitoring Program Advisory Panel to the Gladstone Ports Corporation 's Ecosystem Research and Monitoring Program: Gladstone.)

Meager, J. J. and Limpus, C. J. (2012) Marine wildlife stranding and mortality database annual report 2011. III. Marine Turtle. *Conservation Technical and Data Report* **2012** (3):1-46.

Owens, D. W. and Ruiz, G. J. (1980). New methods for obtaining blood and cerebrospinal fluid from marine turtles. *Herpetologica* **36**, 17-20.

Wildlife Computers (2015). Data Portal's Location Processing (GPE3 & FastLoc-GPS) User Guide. (Wildlife Computers: Redmond.)

Table 2. Summary of green turtles (*Chelonia mydas*) captured by tagging history and study areas in Port Curtis and adjacent waterways for 2017.

Month	Pelican Banks			Quoin Island			Facing Island			Western Basin			Boyne Estuary			Boyne River Benaraby			TOTAL
	New tagging	recapture from Port Curtis, (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from Port Curtis, (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from Port Curtis, (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from Port Curtis, (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from Port Curtis, (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from Port Curtis, (within year recapture)	Migration recapture from a breeding area	
April-May	27	12	-	-	-	-	-	2	-	-	-	-	31	10	-	-	-	-	83
June	45	14 (2)	-	1	1	-	9	3	-	1	-	-	5	1 (3)	-	-	-	-	80 (5)
September	75	24 (7)	1	1	-	-	1	-	-	-	-	-	23	5 (8)	-	-	-	-	129 (15)
November	54	17 (14)	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75 (14)
<b>TOTAL</b>	<b>201</b>	<b>67 (23)</b>	<b>4</b>	<b>3</b>	<b>1</b>	<b>-</b>	<b>10</b>	<b>5</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>59</b>	<b>16 (11)</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>367 (34)</b>



**Table 3. Summary of the tagging status and tagging history of foraging green turtles (*Chelonia mydas*) captured in Port Curtis during 2017.**

<b>Tagging status and history of turtles</b>	<b>No. of turtles</b>
• 1 <sup>st</sup> time tagged turtles	274
• Recaptured turtles from the same area	82
• Recaptured turtles with tags scars indicating a turtle that has been previously tagged but lost its tag(s)	6
• Recaptured at a different foraging area	1
• Recapture of a turtle tagged at a breeding site.	4
<b>TOTAL</b>	<b>367</b>


**Table 4. Summary of curved carapace length of definable cohorts of the foraging green turtles (*Chelonia mydas*) in Port Curtis. \* Sample includes some turtles for which sex was not determined.**

<b>Cohort</b>	<b>Curved carapace length (cm)</b>			
<b>Year</b>	<b>Mean</b>	<b>SD</b>	<b>Range</b>	<b>Sample</b>
<b>Adult females</b>				
<b>2016</b>	102.27	4.878	96.0 – 114.6	24
<b>2017</b>	101.23	5.520	93.0 – 118.5	39
<b>Adult males</b>				
<b>2016</b>	95.62	4.846	85.9 – 105.3	27
<b>2017</b>	94.93	4.005	86.9 – 104.2	56
<b>New recruits to foraging</b>				
<b>2016</b>				
<b>Female</b>	42.57	3.101	40.3 – 46.1	3
<b>male</b>	43.65	0.354	43.4 – 43.9	2
<b>combined sex*</b>	44.80	6.122	40.3 – 59.3	8
<b>2017</b>				
<b>Female</b>	43.15	2.724	39.8 - 48.1	14
<b>male</b>	42.45	1.328	40.4 – 44.3	8
<b>combined sex</b>	42.90	2.302	39.8 – 48.1	22

**Table 5. Annual breeding rate of adult female and male green turtles (*Chelonia mydas*) that forage in Port Curtis.**

Samples	No. of adults preparing for breeding.	Total no. of turtles assessed	Proportion of adults breeding (95% CI)
<b>Females</b>			
2013	6	22	0.27 (0.19)
2014	3	36	0.08 (0.09)
2015	4	48	0.08 (0.08)
2016	4	51	0.08 (0.07)
2017	2	38	0.05 (0.07)
<b>Males</b>			
2016	4	26	0.15 (0.14)
2017	18	48	0.38 (0.14)

**Table 6. Observations of green turtle (*Chelonia mydas*) courtship within Port Curtis during 2017.**

26 Aug 2017	<p>Mounted pair of green turtles in the Boyne River estuary (23.97010°S, 151.34620°E. Photograph by Peter Tremul).</p> 
23 Sep 2017	<p>Mounted pair of green turtles adjacent to Rat Island adjacent to South End, Curtis Island (23.76578°S, 151.31785°E).</p>
28 Sep 2017	<p>Courting pair of green turtles on the eastern margin of the Pelican Banks (23.78093°S, 151.30630°E).</p>

**Table 7. Summary of the number of foraging green turtles (*Chelonia mydas*) captured in Port Curtis with external evidence of health problems sorted by study area, year and health problem. Superscripts define turtles for which intervention was considered necessary.**

	Pelican Banks	Facing Island	Quoin Island	Boyne River mouth	Boyne River at Benaraby	Western Basin	Total
<b>Turtles in poor health</b>							
2016	7	6	5	8			26
2017 (Changed methods)	83	1	1	7	-	1 <sup>b</sup>	93
<b>Turtles in very poor health</b>							
2016		1	1			1 <sup>c</sup>	3
2017	4 <sup>a</sup>			1 <sup>d</sup>			5
<b>Turtles with vessel related injuries</b>							
2016	8					1	9
2017	10	1					11
<b>Turtles entangled in fishing gear</b>							
2016				1	2 <sup>e</sup>	1	4
2017	1 <sup>f</sup>	1 <sup>f</sup>					2
<b>Fibropapillomatosis</b>							
2016	1			8	7	1	17
2017				13			13

a. T87632: moribund, passed to QU SVS for pathology assessment

a. QA61424: moribund, passed to QU SVS for pathology assessment

a. QA64201: moribund, passed to QU SVS for pathology assessment

a. QA77400: moribund, passed to QU SVS for pathology assessment

b. QA64203: rescued, sent to rehabilitation

c. QA64929: rescued, sent to rehabilitation

d. QA64254: rescued, sent to rehabilitation

e. QA65076: rescued, sent to rehabilitation, euthanased

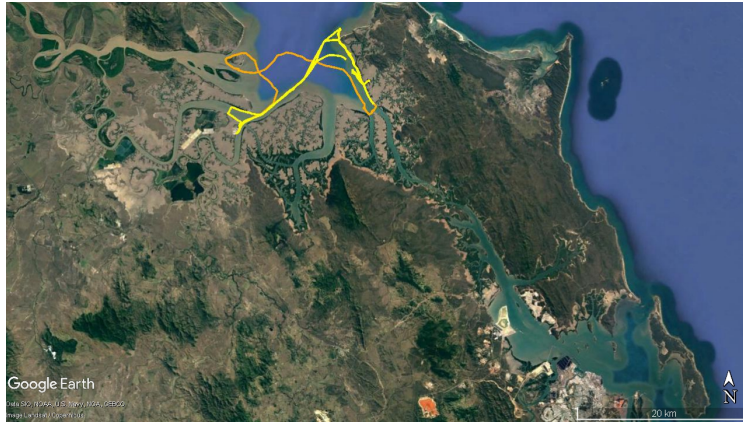
f. QA61452: rescued by removal of life threatening entanglement.

f. QA80266: rescued by removal of life threatening entanglement.

**Table 8. Summary outputs of the generalised additive models fitted to the body weight of green turtles captured at two sites in Port Curtis. Model parameters were sex (female and male), Site (Boyne River estuary and Pelican Banks), Year (2016 and 2017), Age class (Mature adult and immature juvenile), interactions between Year and Age class, and between CCL and Sex. CCL was allowed to have a non-linear effect. Effective degrees of freedom (edf) indicate the amount of smoothing used for the non-linear terms.**

Parameter	Parametric terms				Non-linear terms			
	Estimate	SE	<i>t-value</i>	Prob( <i>t</i> )	Parameter	edf	<i>F-ratio</i>	Prob( <i>F</i> )
<i>Constant</i>	3.5022	0.0214	163.182		CCL (Female)	8.297	2399	<0.0001
Sex	-0.0282	0.0086	-3.289	0.0011	CCL (Male)	3.725	2683	<0.0001
Site	0.0063	0.0116	0.548	0.5840				
Year	0.0048	0.0177	0.275	0.7836				
Age class	-0.0068	0.0221	-0.310	0.7566				
Year : Age class	-0.0207	0.0199	-1.038	0.2998				

Deviance explained = 99.3 %, n = 417.



1a. Survey transects during search for green turtles at the northern end of the Narrows during 2017.



1b. Locations where green turtles were captured.



1c. Locations where green turtles were observed but not captured.



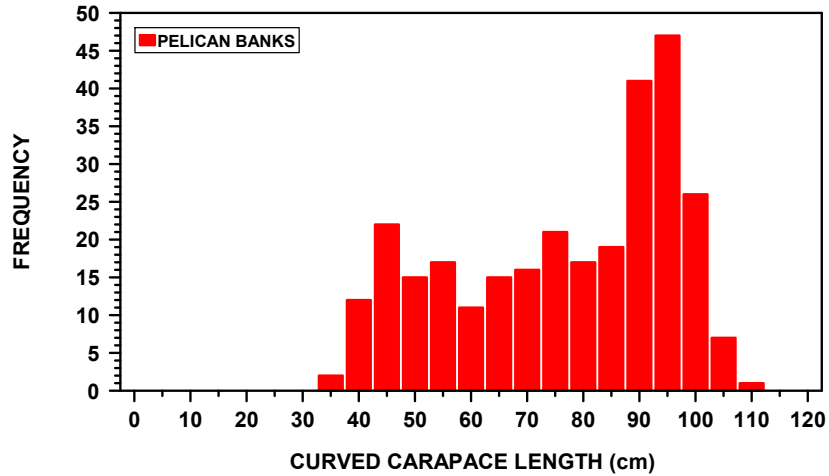
1d. Locations where humpbacked dolphins were observed.



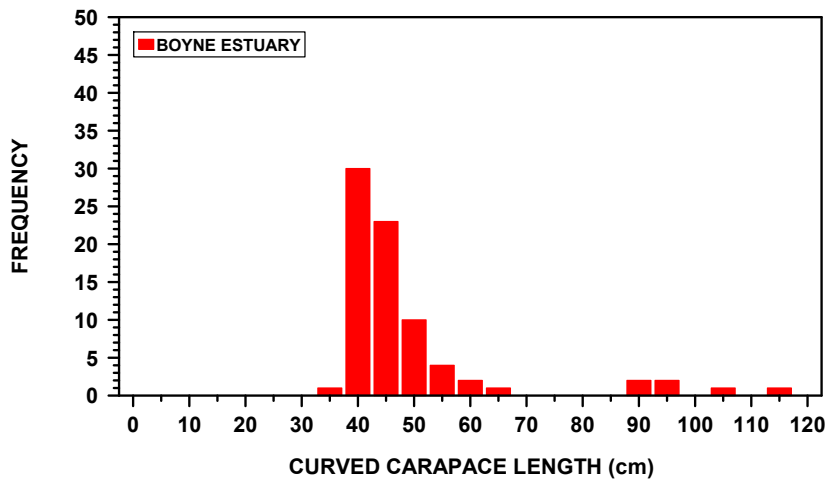
1e. Locations where dugongs were observed.

Figure 1. Locations of captured green turtles (B), and observed green turtles (C), humpback dolphins (D) and Dugongs (E).

Figure 2. Size distribution of green turtles (*Chelonia mydas*) captured in Port Curtis during 2017.

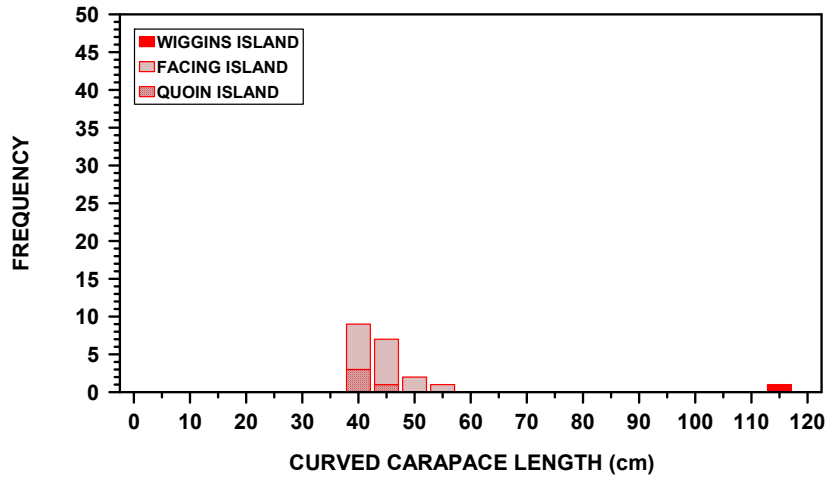


2a. Pelican Banks in the north eastern area of Port Curtis, encompassing seagrass-algal meadows, rocky reefs and mangrove forest fringe.

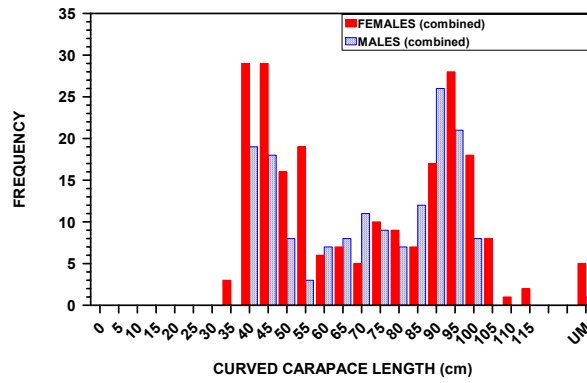


2b. Intertidal seagrass-algal meadows at the mouth of the Boyne River. Although observed, no turtles were captured foraging on the algal turfs on the rocky riffle zone in the Boyne River at the highway bridge.

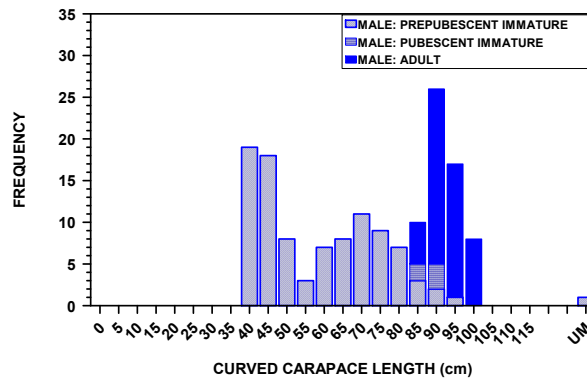
Figure 2. Continued.



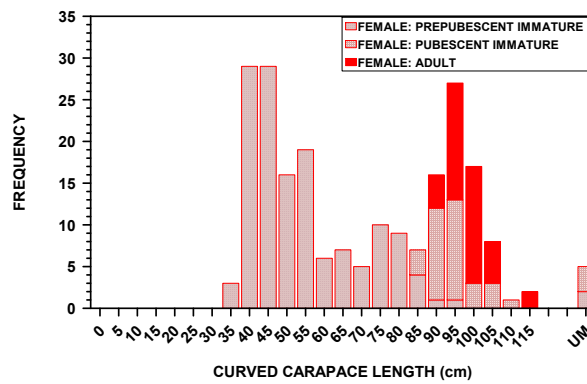
2c. Rocky reefs and mangrove fringe surrounding Quoin Island and the western side of Facing Island and the intertidal flats adjacent to Wiggins Island..



3a. Males and females combined.



3b. Males by maturity.



3c. Females by maturity.

Figure 3. Population structure by size and sex of foraging green turtles (*Chelonia mydas*) captured in Port Curtis during 2017.



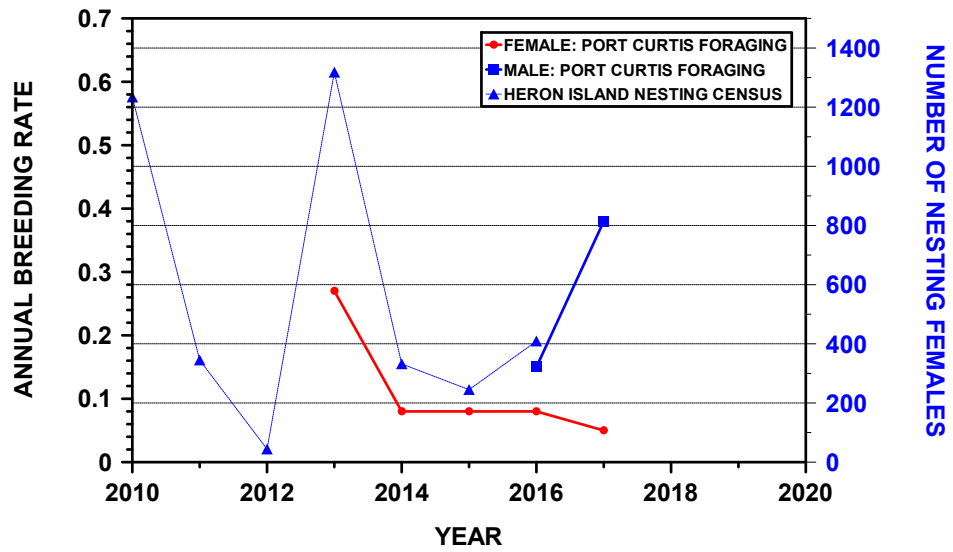


Figure 4. Annual breeding rates of adult female and male green turtles (*Chelonia mydas*) foraging in Port Curtis compared with the annual nesting number of green turtles recorded at Heron Island.

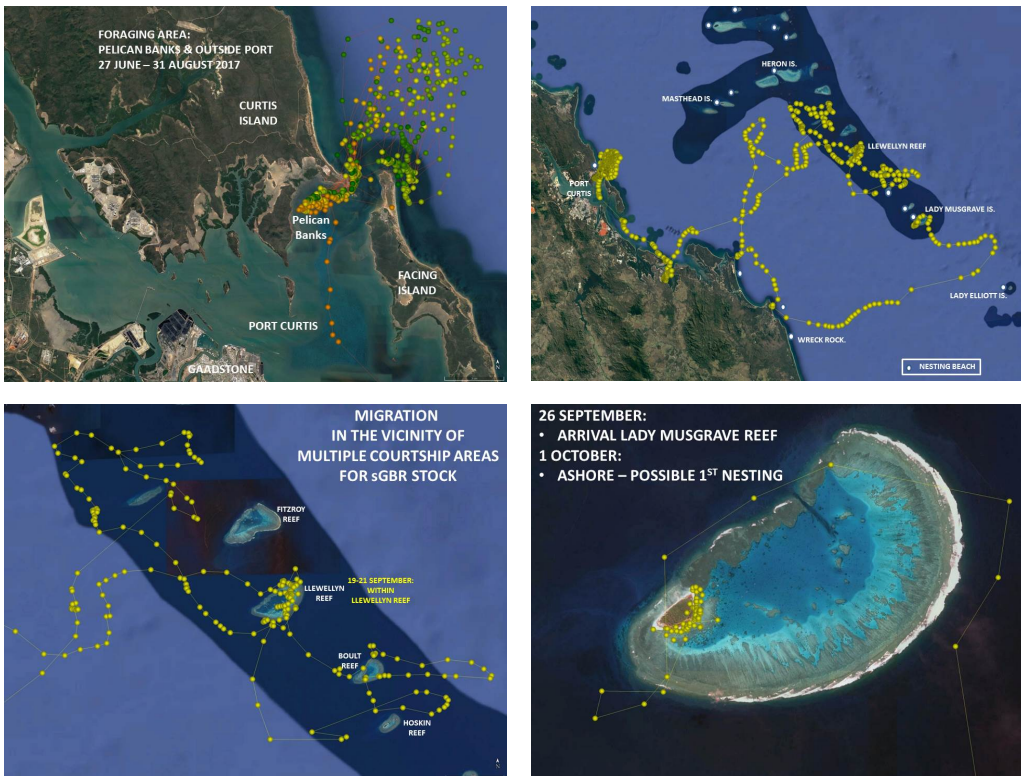
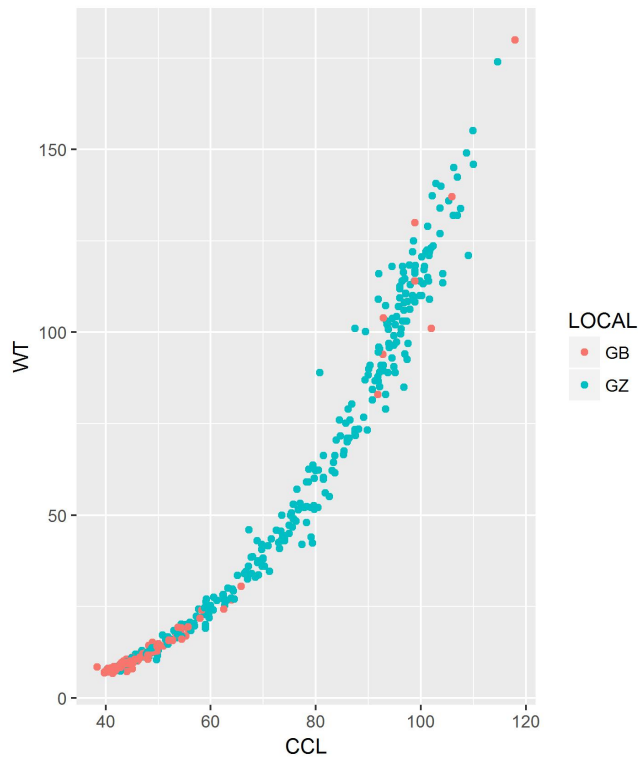
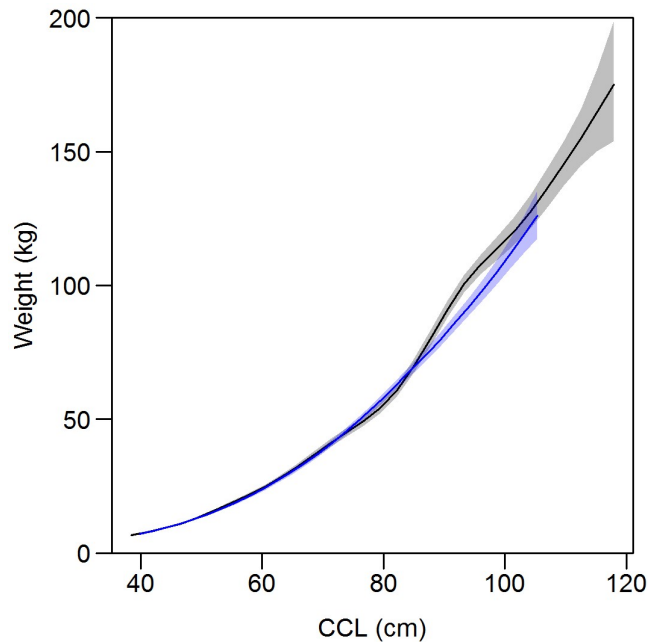


Figure 5. Satellite telemetry summary for adult female green turtle QA64318 during her preparation and migration for her first breeding season in 2017.



6a. Comparison of raw data for carapace length and weight of foraging green turtles. GB (red dots) denotes Boyne River estuary captures; GZ (blue dots) denotes Pelican Banks captures.



6b. GAM length-weight analysis comparison of foraging green turtles by sex (black identifies females; blue identifies males).

Figure 6. Analysis of curved carapace length (CCL) and weight of green turtles (*Chelonia mydas*) captured in Port Curtis during 2016 and 2017 as a measure of turtle body condition.



**7a. June 2017: Dugong feeding trails in the seagrass, *Zostera muelleri capricorni*, meadows on the eastern side of the Pelican Banks.**



**7b. April 2017: Dense *Ulva polyclada* on the gravel substrate deposited on Wiggins Island intertidal flats by the early 2017 floods.**

**Figure 7. Green turtle (*Chelonia mydas*) foraging habitat at Port Curtis.**



8a. Large green turtles brought ashore to the Marine Parks Workshop for tagging, measuring and tissue sampling.



8b. Allan McKinnon determining the sex of an immature turtle via visual examination of the gonad using laparoscopy.



8c. Hector Barrios-Garrido monitoring the blocking net to capture turtles as they swam into the net.



8d. Des Purcel capturing a green turtle in the blocking net on the Pelican Banks.



8e. Kim Finlayson sampling blood from the cervical sinus in the dorsal neck of a turtle.



8f. QA77327: Green turtle from the Boyne River estuary; fibropapilloma tumour on the front flipper, 29 September 2017.

Figure 8. Research activities with foraging green turtles (*Chelonia mydas*).