

**INCREASE THE UNDERSTANDING OF THE GREEN TURTLE POPULATION IN PORT
CURTIS: REPORT FOR 2018
GPC ERMP CONTRACT No. CA14000241**



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DEPARTMENT OF ENVIRONMENT AND SCIENCE



Cover photographs:

Scenes from the population monitoring of green turtles, *Chelonia mydas*, at Port Curtis, April - October 2018.

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Executive summary

- The study has continued satisfactorily with 500 captures of 457 separate turtles during 2018. 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 when deployed in areas with an aggregation of foraging turtles in turbid waters.
- The team was unable to locate any area with a concentration of foraging green turtles within the turbid waters of the western Basin or at the southern end of The Narrows that would have been suitable for netting during the 2018 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 South Trees and off southern Wild Cattle Island.
- The turtles continue to display differences in diet among the study sites.
- The Port Curtis population sex ratio is biased to females as has been typical for green turtles at all foraging areas previously sampled in eastern Queensland.
- Approximately 7% of both the adult females and adult males are estimated to have prepared for breeding during the 2018-2019 season.
- Turtles with external fibropapilloma tumours were most frequently encountered in the Boyne River – South Trees estuary area.
- Port Curtis again was not a significant courtship area for green turtles.
- Green turtles tracked via GPS satellite telemetry are displaying differences in habitat use within different foraging areas within Port Curtis.
- Green turtles foraging at Pelican Banks and Colosseum Creek estuary display regular movements between adjacent open waters and the “estuarine” waters within the port.
- Green turtles foraging at South Trees make little use of the adjacent port infrastructures (wharves, dredged channels) for foraging or resting areas.

**INCREASE THE UNDERSTANDING OF THE GREEN TURTLE
POPULATION IN PORT CURTIS: REPORT FOR 2018
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; Gaus *et al.* 2012; Flint *et al.* 2014; Flint *et al.* 2017).

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), now restructured within the Department of Environment and Science (DES) 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 that satellite telemetry study have been reported independently by JCU.

GPC ERMP contracted the Queensland Department of Environment and Heritage Protection 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 (ELA) subsequently has contracted the 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.

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

Methods

The standard methods of the DES Queensland Turtle Conservation Project developed for assessing the population dynamics of foraging marine turtles (Limpus *et al.* 2005) were used in the present study. Table 1 summarises the composition of the field team for the 2018 field studies: 4-13 April; 12-23 May; 14-23 June; 15-21 August; 3-12 October.

Table 1. Field team for the 2018 studies of foraging green turtles in Port Curtis.

Coxswains

- Dr Colin Limpus (DES)
- Dr Nancy FitzSimmons (DES)
- Duncan Limpus (DES)
- John Sergeev (DES)

Veterinarians

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

James Cook University, College of Earth and Environmental Science

- Dr Takahiro Shimada;
- Daniel Gonzalez, PhD student

Griffith University, School of Environment

- Dr Kimberley Finlayson.
- Matthew Johnson: BScHon student

DES registered volunteers

- Christiaan van de Wetering

Gidarjil Land and Sea Rangers

- Des Purcell, 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 300 m long 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 DES Marine Parks Workshop at the Gladstone Marina where they were processed for the required data and tissue samples.

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 DES 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 2018.

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. During 2018, it has been extended to include collaboration with the Seagrass Ecology Group: Centre for Tropical Water & Aquatic Ecosystem Research (TropWater), lead by Dr Michael Racheed and Eco Logical Australia as an extension of the project funded via the Long Term Turtle Monitoring Program:

- GPS satellite telemetry tags (Figure 4) were deployed on eight green turtles for mapping habitat use and behaviour within Port Curtis during the 2018 field trips:

Department of Environment & Science funded

- PELICAN BANKS x1
 - PTT 176006: *SPLASH10-BF-297B*; 19 June – 24 December 2018
- SOUTH TREES x1
 - PTT 40934: *SPLASH10-BF-297*; 17 June – 24 December 2018

James Cook University (JCU) funded

- SOUTH TREES x2
 - PTT 61689: *SPLASH10-F-344*, 17 August – 29 October 2018
 - PTT 61690: *SPLASH10-F-344*, 17 August 2018 – 16 January 2019
- COLOSSEUM CREEK – WILD CATTLE ISLAND x2
 - PTT 61691: *SPLASH10-F-344*, 19 August – 11 December 2018
 - PTT 61692: *SPLASH10-F-344*, 19 August – 09 December 2018

Eco Logical Australia funded

- SOUTH TREES x2
 - PTT 64747: *SPLASH10-BF-334D*, 06 October 2018 – 20 February 2019
 - PTT 64748: *SPLASH10-BF-334D*, 06 October – 22 December 2018

- 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 tags 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 the general tag surface 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:

A previous 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 a DES 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.

A collaborative study between DES and Griffith University led by Dr Jason van de Merwe is investigating several aspects of trace element uptake in green turtles foraging within Port Curtis:

- Temporal changes in trace elements in green turtles using samples collected from selected turtles captured on multiple occasions across the years 2011-2018.
- Toxicology of contaminants in green turtles using cell culture techniques.

Additional funding support for these health studies is being provided by the LNG Long Term Turtle Monitoring Program (LTTMP) funded through Ecological 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 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 Jason van de Merwe, Dr Mark Flint and Dr Colin Limpus will provide the overarching supervision of the associated post-graduate studies.

Green turtle population genetics:

Small skin samples (~2 mm³) 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 DES 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.

Study sites and water conditions within Port Curtis

The long-term standard study sites within Port Curtis were sampled during 2018.

- Pelican Banks inter-tidal and sub-tidal habitats in North-eastern Port Curtis
- Wiggins Island inter-tidal flats within the Western Basin;
- Quoin Island inter-tidal rocky reef and mangrove habitats;

- Facing Island inter-tidal rocky reef and mangrove habitats along the western side of the island
- Boyne Island estuary inter-tidal flats

Based on advice from the JCU Seagrass Ecology Group, two new study sites were included for sampling during 2018:

- South Trees inter-tidal and sub-tidal habitats and
- Sub-tidal flats off the southern end of Wild Cattle Island adjacent to Colesseum Creek estuary.

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

Low turbidity water was encountered outside the immediate port area off the southern end of Wild Cattle Island. Occasional low turbidity water was found on the Pelican Banks, at Southend 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. Except for the intertidal flats adjacent to Wiggins Island, 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 2018 field work.

The southern end of the Narrows was searched for turtles during two field trips: 19 May and 8 October 2018.

Water temperature recording:

A Vemco Minilog II temperature data logger was deployed in Port Curtis to record water temperature at the surface of the benthos in a very shallow channel that retains a thin layer of flowing water at low tide. The data logger was programmed to record temperature 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 in the northern drainage channel on the Pelican Banks (23.7618° S, 151.3035° E) to commence readings at 18:00 hr, 10 May 2018.

Results

Over the five field trips during 2018, a total of 1120 sightings of green turtles were recorded within the Port Curtis Study area (Figure 1). A total of 500 captures were made of green turtles from 457 individual turtles (Table 2; Figure 1) with 43 occurrences of turtles being recaptured on more than one occasion within 2018 (within year recaptures). 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 (Figure 1b). Most turtles were captured on the Pelican Banks (25%), South Trees (28%) Boyne Estuary and mouth (24%) followed Boyne River Estuary (20%). The western side of Facing Island (4.0%), Quoin Island (2%) and Western Basin (4%) have consistently given limited access to catchable turtles. The low capture rate off Wild Cattle Island (10%) does not accurately reflect the abundance of large green turtles foraging on that seagrass pasture. The site was only sampled during the last two trips for the year and the distance involved in relocating numerous large turtles to a suitable research base using our existing vessels, limited the number of turtles that could be brought ashore.

Table 3 summarises the broad tagging history of the turtles captured during 2018. The recapture rate of turtles previously tagged within Port Curtis is encouraging from the perspective of the long term capture-mark-recapture study with 13% of turtles being recaptures from all turtles captured within the Port. The recapture rates at Pelican Banks and Boyne Estuary are particularly encouraging: 25% and 24% of the turtles captured at these respective study sites.

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 and off Wild Cattle Island. At the mouths of the Boyne River and South Trees Inlet, the accessible turtles were strongly biased to small immature turtles. At these latter sites, 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.

The turtles continued to show high fidelity to their respective foraging sites within the Port. None of the 61 recaptured turtles that had been previously recorded within Port Curtis had made major shifts between study sites.

Green turtles recruited from the open ocean dispersal life history phase to residency as benthic foraging turtles within Port Curtis with mean CCL = 43.3 cm (Table 4). Adult green turtles had a mean CCL of 95.6 cm for males and 101.8 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 403 of the turtles captured within Port Curtis during 2018: 155 males, 248 females and 1 asexual turtle with no detectible gonads (Table 5). An additional 31 turtles were not examined to determine their gender. The combined sex ratio (proportion of females) for all maturity classes was 0.58 ± 0.05 . This is 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). However when considering the three maturity classes of green turtles captured, there was a trend for an increasing proportion of females across adult to large immature to small immature turtles (Table 5), i.e. female proportion was highest among younger turtles. This issue warrants further analysis when the four years of this study are completed. The majority of the green turtle foraging population in Port Curtis consists of immature turtles of both sexes (Table 5). 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 6 summarises the proportion of resident adult female and male green turtles foraging within Port Curtis which were in preparation for the 2018-2019 breeding season (commencing vitellogenesis for females, commencing spermatogenesis for males).

The proportion of adult turtles that prepare for breeding in any one year is strongly linked to the regional climate cycle, ENSO (Limpus and Nicholls, 2000). Breeding rates decline some two years following La Nina events (flood years) and increase some two years after El Nino event (drought years). The modest annual sample sizes of captured adult male and female green turtles limit the capacity for comprehensive analyses of breeding rates at this time. Analytical strength should improve with subsequent years of sampling. The low breeding rate of adult females and males foraging in Port Curtis for 2018 was consistent with the low total annual nesting population at Heron Island for the 2018-2019 nesting season (Figure 3). Heron Island is the principle index monitoring site for the sGBR green turtle genetic stock breeding (Limpus, 2007; Limpus *et al.* 2013). This issue will be re-visited as sample sizes improve with future years of this study.

During the 3-12 October study period within Port Curtis:

- 145 green turtles were captured and an additional 231 sightings were made of green turtles that were not captured. None of these 376 observations of green turtles involved turtles engaged in courtship/mating behaviour and members of the public reported one green turtle courting pair in Rodd's Bay (Table 7).

The breeding status of adult green turtles during 3-12 October 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 2018-2019 breeding season had already migrated to breeding locations outside of Port Curtis.

Collectively these data continue to indicate 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

Five adult female green turtles were captured during 2018 for which breeding locations have been recorded:

T30096: CCL = 99.9 cm

- Originally tagged when nesting at Northwest Island, 28 December 1986
- Recaptured after 6 yr remigration interval, nesting at Northwest Island, 18 December 1992.
- Recaptured foraging on the Pelican Banks, 18 May 2018.

T70052: CCL = 99.8 cm

- Originally tagged when nesting at Lady Musgrave Island, 3 January 1993;
- Recaptured after 10 yr, nesting at Lady Musgrave Island, 27 December 2002.
- Recaptured after 11 yr, nesting at Lady Musgrave Island, 29 December 2013.
- Recaptured foraging on the Pelican Banks, 7 June 2016.
- Recaptured foraging on the Pelican Banks, 4 November 2017.
- Recaptured foraging on the Pelican Banks, 20 May 2018.
 - Not breeding for 5 consecutive breeding seasons, 2014-2018.

T84899: CCL = 105.0 cm

- Originally tagged when nesting at North West Island, 22 December 1994.
- Recaptured foraging on the mouth of the Boyne River, 8 April 2018.

K57038: CCL = 108.4 cm

- Originally tagged when nesting at Heron Island, 30 November 2002.
- Recaptured foraging off the south end of Wild Cattle Island, 4 October 2018.

QA52698: CCL = 106.3 cm.

- Originally tagged when breeding for her first breeding season at the courtship area of Sandy Cape, Fraser Island, 29 October 2016.
- Recaptured on the Pelican Banks on 08 April 2018.

These data are consistent with the previous post-breeding 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

The following are a sample of the data being gathered on stranded marine turtles within Port Curtis, based on StrandNet data and turtle mark-recapture records from the GPC ERMP green turtle project. These data illustrate the temporal changes in health status that can occur with individual turtles foraging within the Port:

QA61469: pre-pubescent immature male green turtle:

- **11 April 2018:** captured by turtle rodeo method at mouth of Boyne River; CCL = 42.6 cm; very poor condition, weight = 7.8 kg.
- **21 May 2018:** captured by turtle rodeo method at mouth of Boyne River; very Poor condition, weight = 7.2 kg.
- **22 June 2018:** floating recently dead carcass at the Boyne River estuary, emaciated.

QA64255: pre-pubescent immature male green turtle:

- **2 May 2017:** captured by turtle rodeo method at mouth of Boyne River; CCL = 44.3 cm; very poor condition, weight = 9.3 kg.

- **26 May 2018:** Beach-washed dead carcass in advanced decay at the Boyne River estuary, CCL = 45.0 cm.
- QA66762:** pre-pubescent immature male green turtle:
- **13 Oct 2016:** captured by turtle rodeo method at mouth of Boyne River; CCL = 44.4 cm; weight = 9.4 kg.
 - **29 September 2017:** captured by turtle rodeo method at mouth of Boyne River; CCL = 43.8 cm; weight = 9.3 kg.
 - **16 April 2018:** Floating debilitated at mouth of Boyne River; rescued & transferred to Quoin Island Turtle Rehabilitation Centre for care.
 - **22 June 2018** released back to the Port at Boyne Island.
- QA75304:** pre-pubescent immature female green turtle:
- **30 August 2017:** beach washed in poor body condition on Boyne Island, CCL = 42.2 cm; weight = 8.3 kg. After unsuccessful release, rescued and transferred to Quoin Island Turtle Rehabilitation Centre for care.
 - **14 September 2017:** released back to the Port at Boyne Island; weight = 8 kg.
 - **9 April 2018:** captured while foraging at the mouth of the Boyne River; no external signs of poor health; CCL = 43.3 cm; weight = 8.76 kg.
- QA80325:** pre-pubescent immature female green turtle:
- **15 May 2018:** captured by turtle rodeo method at Pelican Banks; CCL = 46.9 cm; poor condition, weight = 10.2 kg.
 - **10 August 2018:** beach washed on Southend, Curtis Island, poor condition.
 - Rescued and transferred to Quoin Island Turtle Rehabilitation Centre for care.
- QA80361:** pre-pubescent immature green turtle:
- **9 April 2018:** captured while foraging at the mouth of the Boyne River; CCL = 54.3 cm; weight = 8.76 kg; very poor condition.
 - **22 June 2018:** captured while foraging at the mouth of the Boyne River; very poor condition.
 - **8 September 2018:** beach washed dead on Boyne Island,.
- QA84231:** pre-pubescent immature female green turtle:
- **20 April 2018:** captured while foraging at the mouth of the Boyne River; CCL = 46.5 cm; weight = 9.69 kg; appeared to be in good body condition but was a floater when released back at mouth of Boyne River.
 - **20 April 2018:** Rescued and transferred to Gladstone Area Water Board Turtle Rehabilitation Centre for care.
- QA84319:** pre-pubescent immature male green turtle:
- **15 June 2018:** captured while foraging on the rocky shore of Quoin Island; CCL = 45.7 cm; weight = 9.04 kg; in poor body and a floater when released.
 - **15 June 2018:** Rescued and transferred to Gladstone Area Water Board Turtle Rehabilitation Centre for care.
 - **17 August 2018:** Released at South Trees Inlet.
- QA86215:** pre-pubescent immature green turtle:
- **20 June 2018:** captured while foraging at South Trees Inlet; CCL = 42.8 cm; weight = 7.1 kg; poor condition.
 - **13 July 2018:** beach washed recently dead on Boyne Island,.

Table 8 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 fifteen turtles with healed or healing fractures resulting from impacts with vessels were captured on the Pelican Banks (7/15) and Boyne Estuary (4/15). These represent only turtles that have been hit by vessels and survived. It does not include the presumed unquantified number of turtles that died as a result of the vessel related injuries.
- Turtles with external fibropapilloma tumours were most frequently encountered in the Boyne River – South Trees 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.

Habitat and methods summary

Figure 5 provides a summary of foraging habitat use by eight green turtles within Port Curtis defined by GPS satellite telemetry tracking of turtles captured during 2018.

Captured on Pelican Banks:

QA86202, immature male,

- Displayed strong homing to his Pelican Banks foraging site on release south of Quoin Island.
- Displayed the typical bimodal foraging behaviour of turtles from the Pelican banks to repetitively move between foraging on the Pelican Banks and on the reefal habitat outside Curtis Island.

Captured off South Trees:

QA86189, adult male and **QA87017**. Immature, sex not determined

- Following release off South Trees, both turtles moved over to southern Facing Island before displayed strong homing to their South Tree foraging site on release.
- Both made repeated foraging excursions back to southern Facing Island from South Trees.

QA86125, immature male;

- Following release off South Trees, this turtle foraged primarily within South Trees inlet and only made a few brief excursions around the South Trees seagrass flats where he was captured.

QA86190, immature male and **QA87018**, immature, sex not determined

- Following release off South Trees, both these turtles foraged in close proximity of the South Trees seagrass flats where each had been captured.

Captured off southern end of Wild Cattle Island:

QA86302, adult male and **QA86247**, immature male

- Displayed strong homing to his Pelican Banks foraging site on release south of Quoin Island.
- Displayed bimodal foraging behaviour with repetitive movement between foraging on the outside of Wild Cattle Island and inside the estuary of Colosseum Creek.

None of the five turtles from South Trees displayed any significant use of the Port infrastructure as foraging or resting habitat, even though each occupied foraging habitat within a few hundred metres of port infrastructure. None made any significant use of the dredged shipping channel within 0.5-1.0 km of their respective main foraging areas.

Figure 6 illustrates some of the habitats utilised by foraging turtles within Port Curtis.

Water temperature over the intertidal flats on the Pelican Banks shows wide daily fluctuations influenced by depth of water over the flats and time of day or night (Figure 7).

Figure 8 provides a photographic illustration of a range of study methods being employed within this study.

Other Marine Megafauna in Port Curtis

Marine mammals

Opportunistic observations were made of dugong 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 1b)
- All dugong sightings occurred within the outer southern parts of the Port (Figure 1b). No Dugong were encountered in a situation where they were suitable for capture.

Acknowledgements

The Department of Environment and Science Marine Parks has supported this project by provision of work space with the Marine Parks Workshop at the Marina for the duration of each study trip.

The field teams (Table 1) included numerous university staff and students and DES 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.

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Table 2. Summary of green turtles (*Chelonia mydas*) captured by tagging history and study areas in Port Curtis (PC) and adjacent waterways for the first three years of the GPC funded study: 2016, 2017 and 2018.

Month	Pelican Banks			Quoin Island			Facing Island			Western Basin & Narrows			South Trees			Boyne River mouth & Wild Cattle Is flats			Boyne River: Benaraby & South Trees Inlet			TOTAL
	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	
2016																						
May	17	-	-	3	-	-	18	-	-	8	1	-	-	-	-	21	2	-	8	-	-	78
June	52	4 (1)	1	9	-(2)	-	30	-(1)	-	5	-	-	-	-	-	7	-(3)	-	-	-	-	108 (7)
September	22	2 (4)	-	-	-	-	4	-	-	1	-	-	-	-	-	6	-(2)	-	1	-(3)	-	36 (9)
October	71	8 (15)	2	1	-	-	2	-	-	-	-	-	-	-	-	20	2 (4)	-	2	-	-	110 (19)
TOTAL	162	14 (20)	3	13	-(2)	-	54	-(1)	-	14	1	-	-	-	-	54	4 (9)	-	11	-(3)	-	332 (35)
2017																						
April-May	27	12	-	-	-	-	-	2	-	-	-	-	-	-	-	31	10	-	-	-	-	83
June	45	14 (2)	-	1	1	-	9	3	-	1	-	-	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)
TOTAL	201	67 (23)	4	3	1	-	10	5	-	1	-	-	1	-	-	59	16 (11)	-	-	-	-	367 (34)

Table 2 Continued.

Month	Pelican Banks			Quoin Island			Facing Island			Western Basin & Narrows			South Trees			Boyne River mouth & Wild Cattle Is flats			Boyne River: Benaraby & South Trees Inlet			TOTAL
	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	New tagging	recapture from PC (within year recapture)	Migration recapture from a breeding area	
2018																						
April	15	1	-	-	-	-	-	-	-	-	-	-	-	-	-	44	17 (7)	2	5	-	-	84 (7)
May	57	21 (3)	1	6	-	-	6	6	-	8	0 (1)	-	22	0 (1)	-	11	5 (5)	-	4	-	-	147 (10)
June	5	3 (1)	-	2	-	-	5	2	-	1	-	-	66	-	-	9	2 (8)	-	-	-	-	95 (9)
August	-	-	-	-	-	-	-	-	-	-	-	-	14	0 (3)	-	2 26	- (1)	-	-	-	-	42 (4)
October	10	4 (2)	-	3	0 (1)	-	2	0 (1)		8	-	-	34	0 (7)		6 20	0 (2) 0 (1)	- 1	1	-	-	89 (13)
TOTAL	87	29 (6)	1	11	0 (1)	-	13	8 (1)	-	17	0 (1)	-	136	0 (11)	-	72 46	24 (22) 0 (1)	2 1	10	-	-	457 (43)

Table 3. Summary of the tagging status and tagging history of foraging green turtles (*Chelonia mydas*) captured in Port Curtis during 2018.

Tagging status and history of turtles	No. of turtles
• 1 st time tagged turtles	389
• Recaptured turtles from previous years from the same area	61
• Recaptured turtles with tags scars indicating a turtle that has been previously tagged but lost its tag(s)	2
• Recaptured after release from rehabilitation	2
• Recapture of a turtle tagged at a breeding site.	3
TOTAL	457

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.

Cohort	Curved carapace length (cm)				
	Year	Mean	SD	Range	Sample
Adult females					
	2016	102.27	4.878	96.0 – 114.6	24
	2017	101.23	5.520	93.0 – 118.5	39
	2018	101.76	5.291	91.5 – 113.3	29
Adult males					
	2016	95.62	4.846	85.9 – 105.3	27
	2017	94.93	4.005	86.9 – 104.2	56
	2018	95.62	4.46.4	87.7 – 104.8	30
New recruits to foraging					
2016					
	Female	42.57	3.101	40.3 – 46.1	3
	male	43.65	0.354	43.4 – 43.9	2
	combined sex*	44.80	6.122	40.3 – 59.3	8
2017					
	Female	43.15	2.724	39.8 - 48.1	14
	male	42.45	1.328	40.4 – 44.3	8
	combined sex	42.90	2.302	39.8 – 48.1	22
2018					
	Female	43.39	1.037	37.6 – 46.2	29
	male	43.43	2.048	40.3 – 46.9	10
	combined sex*	43.33	1.896	37.6 - 46.9	42

Table 5. Comparison of green turtle sex ratio by age class of turtles and study site within Port Curtis.

	Immature, CCL ≤ 65 cm					Immature, CCL > 65 cm					Adult				
	Male	Female	Not sexed	Total	Sex ratio Proportion female	Male	Female	Not sexed	Total	Sex ratio Proportion female	Male	Female	Not sexed	Total	Sex ratio Proportion female
Pelican Banks	12	31	2	46 ^a	0.70 ± 0.13	20	26	3	49	0.57 ± 0.14	17	6	-	23	0.26 ± 0.18
Quoin Is flats	4	6	1	11	0.80 ± 0.25	-	-	-	-	-	-	-	-	-	-
Facing Is flats	9	10	-	19	0.53 ± 0.22	-	-	-	-	-	-	-	-	-	-
South Trees	27	71	11	109	0.72 ± 0.09	11	11	2	24	0.50 ± 0.21	3	2	-	5	0.40 ± 0.43
Boyne Estuary	28	59	8	95	0.68 ± 0.10	2	5	-	7	0.71 ± 0.33	-	-	-	-	-
Wild Cattle Is	2	3	4	9	-	6	4	-	6	-	2	9	-	11	0.82 ± 0.23
Wiggins Is flats	3	3	-	6	-	6	1	-	7	-	-	-	-	-	-
Western Basin	1	0	-	1	-	-	-	-	-	-	-	-	-	-	-
Narrows	2	1	-	3	-	-	-	-	-	-	-	-	-	-	-
TOTAL	88	184	26	298	0.68 ± 0.06	45	47	5	97	0.51 ± 0.10	22	17	-	39	0.44 ± 0.16

^a includes 1 turtle that was neither male or female.

Table 6. 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)
Females			
2013	6	22	0.27 (0.19)
2014	3	37	0.08 (0.09)
2015	4	50	0.08 (0.08)
2016	6	72	0.08 (0.07)
2017	8	63	0.13 (0.08)
2018	2	29	0.07 (0.09)
Males			
2014	4	25	0.16 (0.14)
2015	-	-	-
2016	4	26	0.15 (0.14)
2017	19	49	0.39 (0.14)
2018	2	29	0.07 (0.09)

Table 7. Observations of green turtle (*Chelonia mydas*) courtship within the Port Curtis region during 2018.

05 Oct 2018	Mounted pair of green turtles off shore in Rodd's Bay (24.04117°S, 151.60985°E). No photograph available
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Table 8. 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	South Trees	Boyne River mouth	Off Wild Cattle Island	Boyne River at Benaraby	Western Basin	Total
Turtles in poor health									
2016	7	6	5		8				26
2017 (Changed methods)	83	1	1		7		-	1 ^b	93
Turtles in very poor health									
2016		1	1					1 ^b	3
2017	4 ^a				1 ^b				5
2018	5		1	4	13	1			24
Turtles with vessel related injuries									
2016	8							1	9
2017	10	1							11
2018	7			1	4	1		2	15
Turtles entangled in fishing gear									
2016					1		2 ^c	1	4
2017	1 ^d	1 ^d							2
2018							1 ^d		1
Fibropapillomatosis									
2016	1				8		7	1	17
2017					13				13
2018				4	6				10

a. Moribund, passed to QU SVS for pathology assessment

T87632
QA61424
QA64201
QA77400

b. Rescued, sent to rehabilitation:

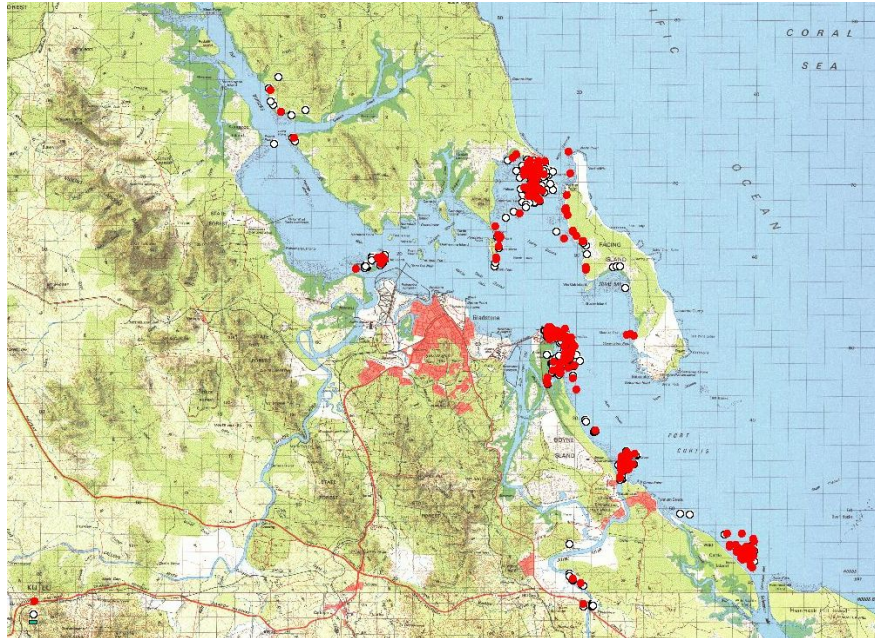
QA64203
QA64929
QA64254

e. Rescued, sent to rehabilitation and euthanased

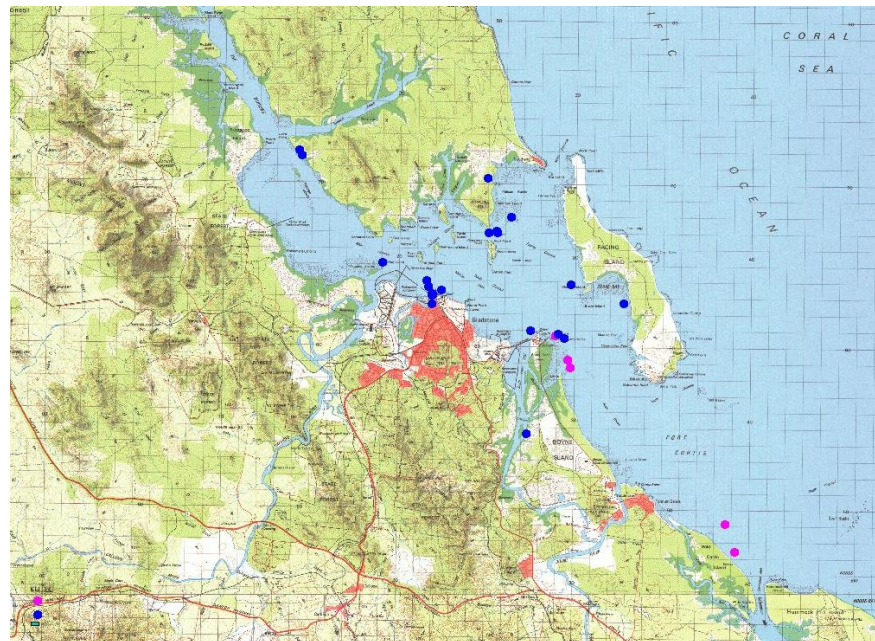
QA65076:

d. Rescued by removal of life threatening entanglement

QA61452
QA80266
QA80222



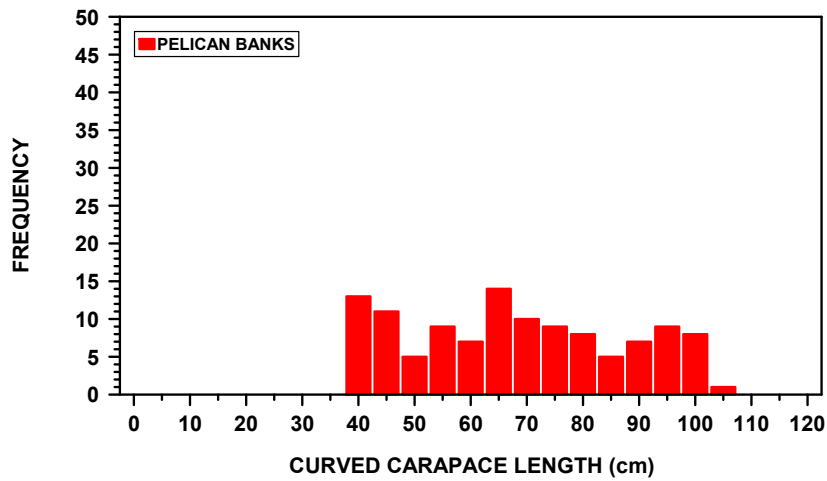
1a. Locations where green turtles were recorded: red dots denote captures; white dots denote sightings.



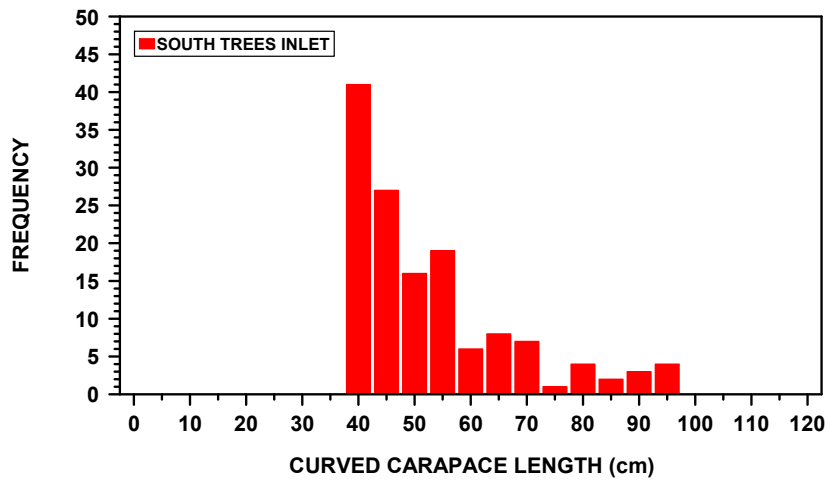
1b. Locations where marine mammals were observed: blue dots denote humpback dolphins; mauve dots denote dugongs.

Figure 1. Locations of green turtles and marine mammals observed within Port Curtis during 2018.

Figure 2. Size distribution of green turtles (*Chelonia mydas*) captured by study sites in Port Curtis during 2018.

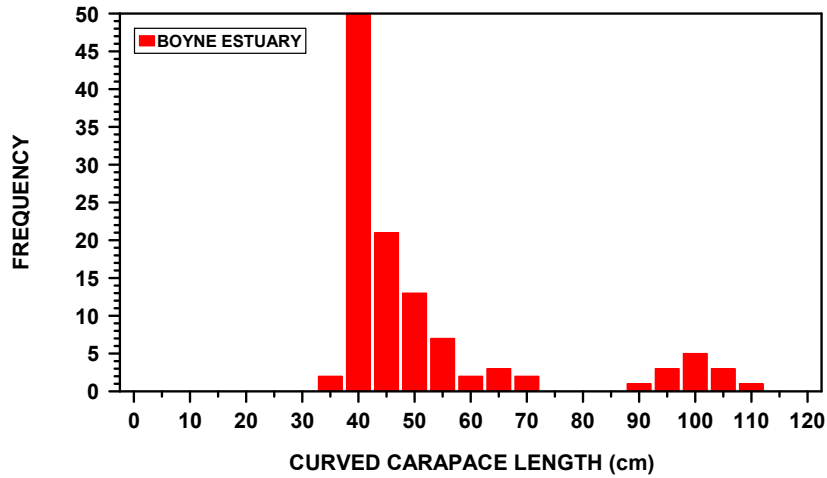


2a. Pelican Banks in the north eastern area of Port Curtis, encompassing seagrass-meadows, rocky reefs and mangrove forest fringe.

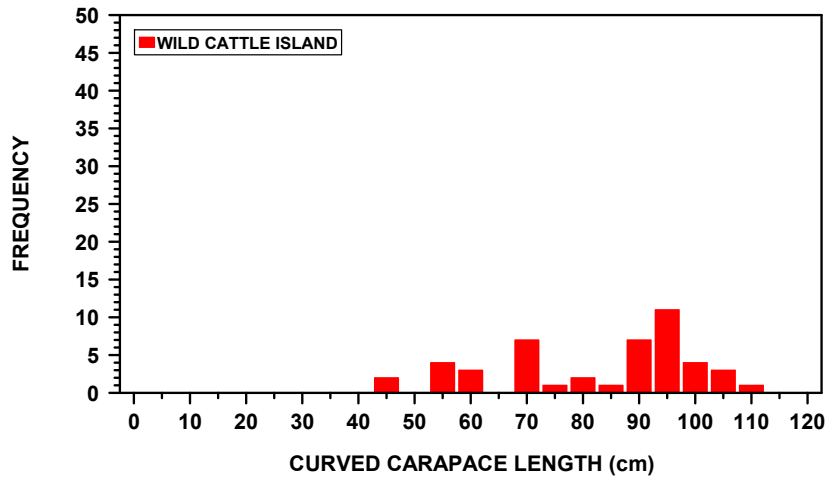


2b. Intertidal seagrass-algal meadows at the mouth of South Trees Inlet.

Figure 2. Continued.

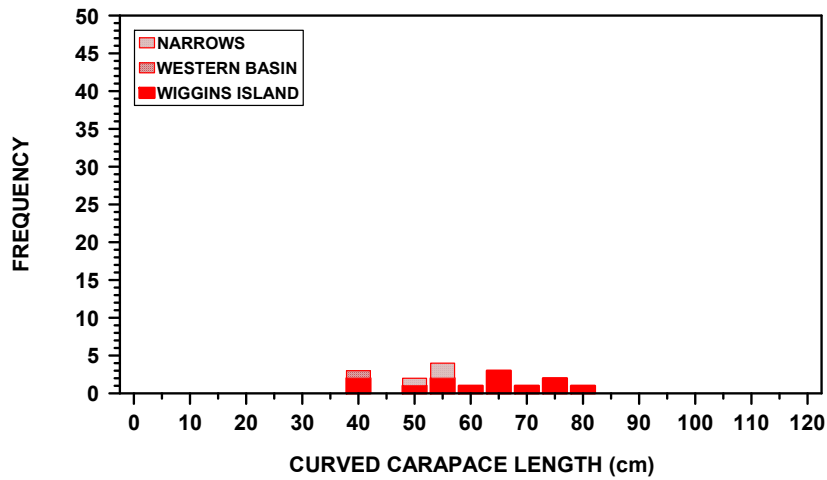


2c. Intertidal seagrass-algal meadows at the mouth of the Boyne River. Although observed, no turtles were captured foraging on the algal turfs on the rocky riffle zone in the Boyne River at the highway bridge.

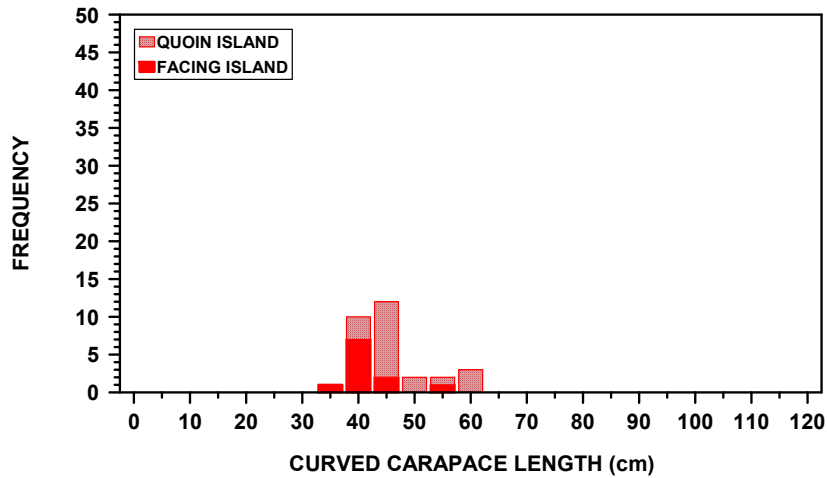


2d. Subtidal and intertidal seagrass-algal meadows off Wild Cattle Island adjacent to the mouth of the Colosseum Creek.

Figure 2. Continued.



2e. Rocky reefs and mangrove fringe surrounding Western Basin and the Narrows and the intertidal flats adjacent to Wiggins Island.



2f. Rocky reefs and mangrove fringe surrounding Quoin Island and the western side of Facing Island.

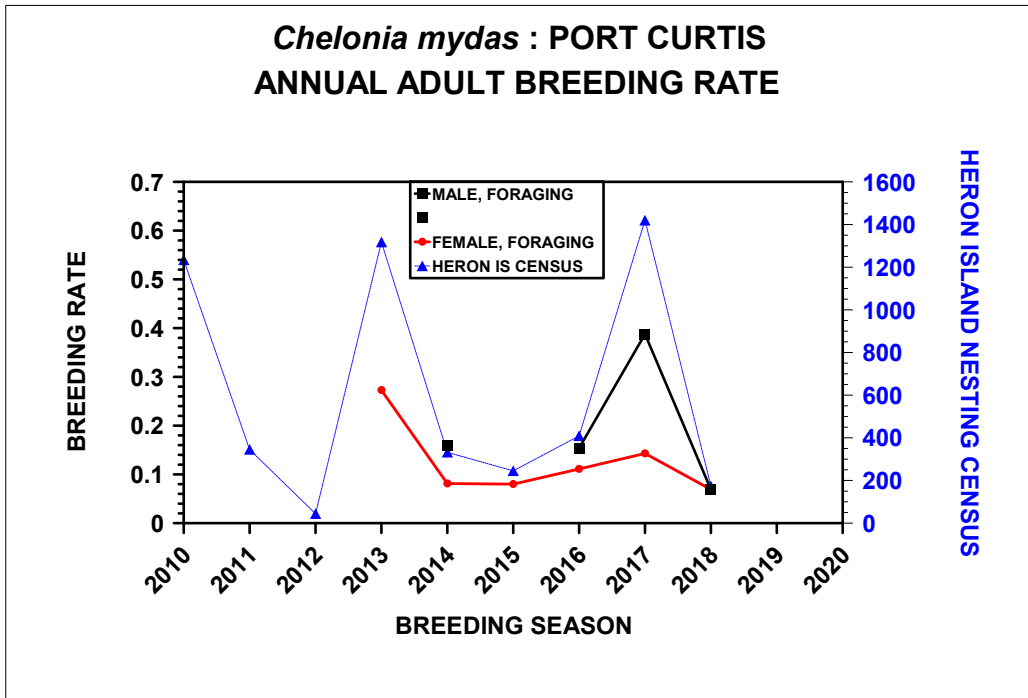


Figure 3. Annual breeding rates of adult female and adult male green turtles (*Chelonia mydas*) foraging in Port Curtis compared with the annual numbers of green turtles recorded nesting at Heron Island.

RELEASE OF TURTLES WITH GPS SATELLITE TAGS: PORT CURTIS 2018

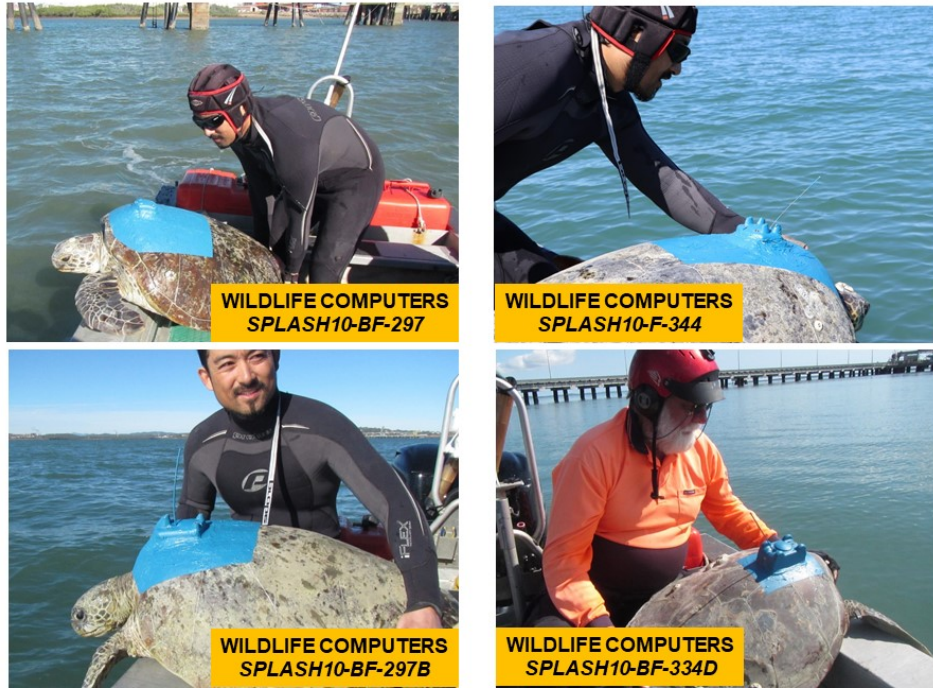


Figure 4. Green turtles were released with a variety of GPS satellite tags during the 2018 field studies.

A. Capture on Pelican Banks

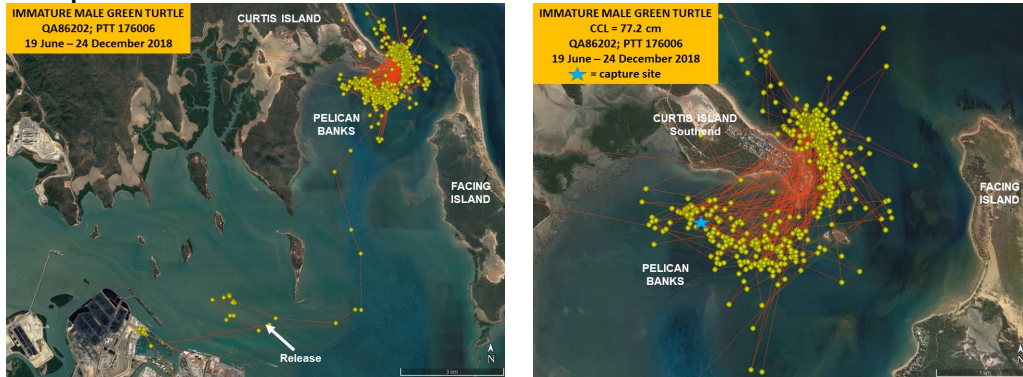


Figure 5. GPS satellite telemetry defined habitat use by Green turtles foraging within Port Curtis during 2018.

B. Captures off South Trees



C. Captures off Wild Cattle Island

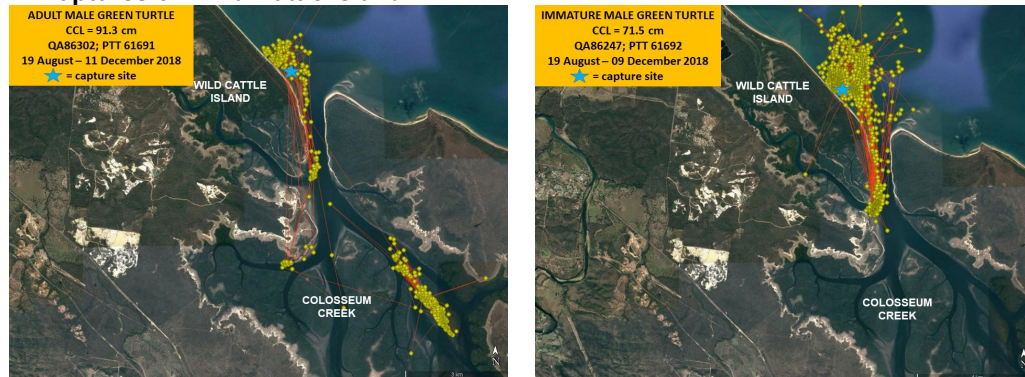
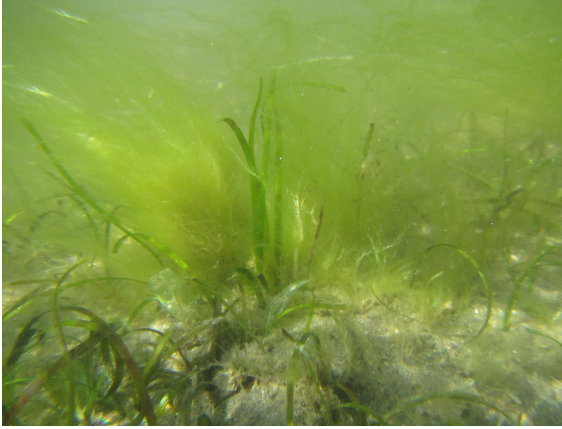


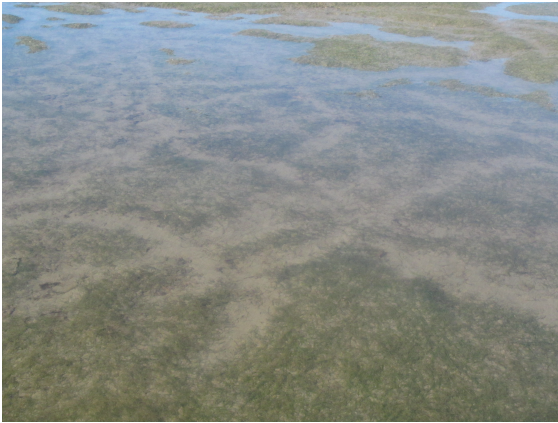
Figure 5. Continued



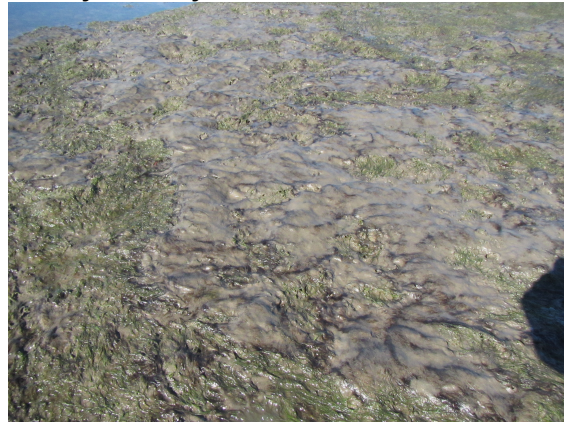
6a. 22 June 2018: *Ulva polyclada* over-growing seagrass on the eastern side of the Pelican Banks.



6b. April 2018: *Ulva polyclada* on the gravel substrate deposited on Wiggins Island intertidal flats by the early 2017 floods.



6c. 20 June 2018: Dugong feeding trails on intertidal seagrass flats, South Trees.



6c. 20 June 2018: Lyngbia bloom growing on intertidal seagrass flats, South Trees.

Figure 6. Green turtle (*Chelonia mydas*) foraging habitat at Port Curtis.

Source File: Minilog-II-T_358261_20181007_1.vld
Source Device: Minilog-II-T-358261
Study Description: gl: pelican banks water
Minilog Initialized: 2018-05-16 08:52:51 (UTC+10)
Study Start Time: 2018-05-16 16:00:00
Study Stop Time: 2018-10-07 11:00:00
Sample Interval: 00:30:00
Temperature (°C) Mean: 20.65 Min: 10.38 Max: 30.41

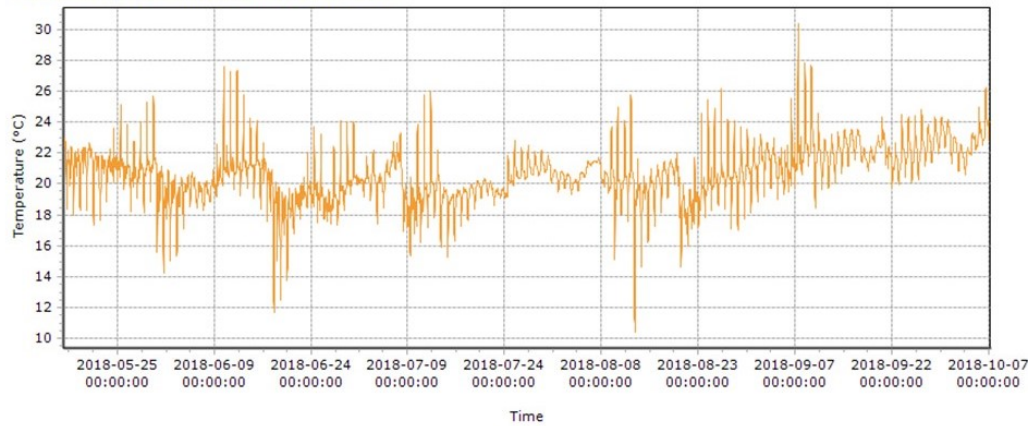


Figure 7. Water temperature measured with a *Vemco Minilog II* temperature data logger at ground level in a drainage channel across the Pelican Banks during 10 May – 7 October 2018. At low tide, the data loggers lies within the shallow veneer of water flowing in this channel at low tide. At high tide, the data logger is typically at approximately 2+ m depth.



8a. Gidarjil rangers assisting with processing immature green turtles brought ashore to the Marine Parks Workshop for tagging, measuring and tissue sampling.



8b. Gond examination of a female green turtle using ultrasonography to assess maturity and breeding status.



8c. Weighing an immature green turtle.



8d. Capturing immature green turtle on sea grass pastures at South Trees Inlet.



8e. Christobel Hannon (UQ SVS) sampling blood from the cervical sinus in the dorsal neck of a green turtle using her purpose built turtle restraining rack.



8f. Searching for turtles foraging within mangrove habitat.

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