

**INCREASING THE UNDERSTANDING OF THE GREEN TURTLE POPULATION
IN PORT CURTIS: FIELD REPORT FOR 2019
GPC ERMP CONTRACT No. CA14000241**



Colin J. LIMPUS, Nancy N. FITZSIMMONS, Kimberly FINLAYSON, Christabel HAMMON and Emily WEBSTER

DEPARTMENT OF ENVIRONMENT AND SCIENCE



Cover photographs:

Scenes from the population monitoring of green turtles, *Chelonia mydas*, at Port Curtis, April - October 2019.

This report should be cited as:

Colin J. Limpus, Nancy N. FitzSimmons, Kimberly Finlayson, Christabel Hammon and Emily Webster (2019). Increasing the Understanding of the Green Turtle Population in Port Curtis: Field report for 2019. 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. `17 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 in part under a Consultancy Agreement (CA14000241) between Gladstone Ports Corporation and the Department of Environment and Heritage Protection (now within Department of Environment and Science) to better understand the functioning of 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.

Executive summary

- The 2019 study has continued satisfactorily with 296 captures of 277 separate green turtles during 2019. Captures occurred consistently at multiple study sites within the Port.
- There were an additional 580 observations of green turtles foraging within Port Curtis that were not captured during the four field trips.
- Most turtles were captured by the turtle rodeo method but the use of 300 m of blocking net remained the only effective means for capture of 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 2019 field work, except in the vicinity of Wiggins Island.
- Port Curtis again was not a significant courtship area for green turtles.
- These tracked turtles from the western Basin have displayed a strong fidelity to a restricted foraging range within the Western Basin rather than utilising a broadly distributed foraging range throughout Port Curtis.
- These tracked turtles did not utilise the adjacent port infrastructure or adjacent dredged channel as foraging habitat.

**INCREASING THE UNDERSTANDING OF THE GREEN TURTLE POPULATION
IN PORT CURTIS: FIELD REPORT FOR 2019
GPC ERMP CONTRACT No. CA14000241**

MILESTONE 11

**QUEENSLAND TURTLE CONSERVATION PROJECT
PORT CURTIS COLLABORATIVE TURTLE STUDIES**

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 this 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 that commenced in 2016. The study required 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 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 encompass the assessment of green turtle haematology, blood chemistry, toxicology and disease.

This 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 fourth year of the GPC funded study and the third year of the ELA funded study.

The Department of Environment and Science (DES) Aquatic Species Program successfully continued its collaborative studies on green turtles in Port Curtis during 2019. These studies were funded in part by DES with additional support:

- Funding support under contracts from Gladstone Ports Corporation in collaboration with James Cook University (JCU) and Griffith University (GU):
 - DES: INCREASE THE UNDERSTANDING OF THE GREEN TURTLE POPULATION IN PORT CURTIS; GPC ERMP CONTRACT No. CA14000241
 - JCU: GREEN TURTLE TRACKING AND HABITAT USE IN PORT CURTIS; GPC ERMP CONTRACT No. CA12000293.
- Logistical support under an Australian Research Council (ARC) Linkage Grant: LP160100492
 - JCU: TROPHIC VALUATION TOOLS TO PROTECT SEAGRASS DURING COASTAL DEVELOPMENT
- Funding support under an agreement between Eco Logical Australia and DES for implementation of the green turtle health components of the LNG LONG TERM TURTLE MANAGEMENT PLAN (LTTMP) for Gladstone
 - University of Queensland School of Veterinary Sciences and Griffith University
 - Deployment of 10 GPS satellite tags on foraging green turtles in Western Basin.

Elevated winds resulted in high turbidity during several trips, hindering effective turtle rodeo capturing of turtles, but extensive efforts to find and catch turtles were made every day. Netting continued to be the only effective method for capturing turtles on Wiggins Island flats. Sampling of green turtle diets by gastric lavage of turtles captured at each study area within the port was continued.

Methods

The emphasis for 2019 was directed to the continued increase in the number of tagged turtles within the Port to enhance the long-term tagging-recapture study and continued collaborative support for University of Queensland School of Veterinary Science turtle health studies and Griffith University turtle toxicology studies.

Turtles were sampled at the established study sites within Port Curtis: Wiggins Island flats, Quoin Island mangroves and rocky reef, Pelican Banks, western Facing Island mangroves, South Trees flats, Boyne Island estuary, and off Colosseum Creek

estuary (Wild Cattle Island). Searches were conducted intermittently, particularly in the Western Basin, to locate, if possible, new sites where turtles were accessible for capture. Standard methods for tagging, measuring, weighing, gonad examination, health assessment, blood sampling, and gastric lavage continued to be used.

High velocity currents associated with the very high tides occurring with some spring tides hindered effective netting on the Pelican Banks and Wiggins Island flats.

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 2019 field studies: 4-14 April; 15-28 May; 30 June-10 July; 12-25 September.

Table 1. Field team for the 2019 studies of foraging green turtles in Port Curtis.

Coxswains

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

Veterinarians

- Christobelle Hammon (UQ SVS)

James Cook University, College of Earth and Environmental Science

- Emily Webster, PhD student (Telemetry)
- Daniel Gonzalez, PhD student

SEAGRASS ECOLOGY GROUP: Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER)

- Christiaan van de Wetering

Griffith University, School of Environment

- Dr Kimberley Finlayson.
- Arthur Barraza: PhD student

University of Florida

- George Glen, PhD student:

DES registered Qld Turtle Conservation Volunteers (* Port Curtis local residents)

- Ian Anderson* . Megan Ellis*, Karl French*, Kim Wells, Steve #####*

ECO LOGICAL AUSTRALIA (ELA)

- Renee Whitchurch, Patrick Lynch

Gidarjil Land and Sea Rangers

- Greg Appo, Senior Ranger,
- 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. The net was set on the inter-tidal flats of Pelican Banks, adjacent to Wiggins Island and at South Trees 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. ± 0.2 cm) with a flexible fibreglass tape measure and weighed with an electric balance (WT ± 0.1 kg for turtles over 30 kg or ± 0.01 kg for turtles under 30 kg). 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 2019.

Study sites and water conditions within Port Curtis

The long-term standard study sites within Port Curtis were sampled during 2019.

- 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
- Inter-tidal flats adjacent to the Boyne River estuary

Based on advice from the JCU Seagrass Ecology Group, two new study sites were included for sampling during 2018 and sampling continued during 2019:

- 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 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 were selected on a daily basis in respects to the tidal cycle, wind direction and speed for the day.

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 previous DES telemetry studies since 2013 and the three year study funded by GPC ERMP to James Cook University (JCU) with EHP as collaborating partners. During 2019, ten GPS satellite tags funded by ELA as part of the LNG LTTMP were deployed on foraging green turtle captured on the inter-tidal flats adjacent to Wiggins Island coal terminal (Table 2).

- Data analyses and communication of results from this telemetry study will be led by Dr Mark Hamann, Dr Taka Shimada and Emily Webster 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 (2015-2017) 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 LTTMP via ELA.

- *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 state-wide 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 2018-11-660, 661, 662, 663, 664. The use of nets for the capture of turtles was in accordance with DAF 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.

Results

2019 Field Trip #1, 4-14 April:

A total of 71 captures were made for 71 separate green turtles (Table 1).

2019 Field Trip #2, 15-28 May:

A total of 90 captures were made for 86 separate green turtles (Table 1). There was an atypical low density of turtles detected on the Pelican Banks and western Facing Island.

21 May: During a boat-based search for turtles around the perimeter of western Basin, turtles were recorded aggregated only at the algal/seagrass flats at Wiggins Island.

2019 Field Trip #3, 1-9 July:

A total of only 44 captures of 42 separate green turtles were made (Table 1).

6 July; A search for turtles was conducted using three vessels operating independently along approximately 13km of The Narrows and adjacent side branches of the stream from -23.62971°S, 151.04688°E to -23.67160°S, 151.12207°E (north and south of Ramsay's Crossing) during 11:30 – 13:30hr. Only two juvenile green turtles were observed during this survey. None could be captured by the rodeo capture method.

GPS satellite tags were deployed on five green turtles captured while foraging in the Western Basin adjacent to the Wiggins Coal Terminal.

2019 Field Trip #4, 12-25 September:

A total of 91 captures of 78 green turtles were made (Table 1).

14 & 16 September: A boat-based search for turtles around the perimeter of western Basin from the Charles Tanner wharf to Fisherman's landing in the south and the LNG wharves on the Curtis Island shore only recorded turtles aggregated at the algal/seagrass flats at Wiggins Island.

GPS satellite tags were deployed on five green turtles captured while foraging in the Western Basin adjacent to the Wiggins Coal Terminal.

Three searches of the entire perimeter of the Western Basin were conducted during 2019 in search of suitable study areas for turtles. No site has 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 2019 field work.

Across the five study trips to Port Curtis there were 296 captures of 277 separate green turtles for the year. There were an additional 580 observations of green turtles foraging within Port Curtis that were not captured during the four field trips. The primary factors limiting our capacity to catch these turtles were turbidity and depth of water.

During all four field trips in 2019, there was scarcity of green turtles foraging in the shallow intertidal/subtidal areas where depth and turbidity permitted turtles foraging/resting on the bottom to be visible from the catch vessels. However, turtles were still present in the immediately adjacent waters as demonstrated by the regular sighting of turtles coming to the surface for a breath, but not captured (Figure 1).

In addition to the regular observations of green turtles within Port Curtis, five records of other marine turtle species foraging within the Port were made for the year.

- 2x large immature flatback turtles, *Natator depressus*

- 1x large immature and 1x adult sized loggerhead turtle, *Caretta caretta*
- 1x small immature female hawksbill turtle, *Eretmochelys imbricata*; captured and tagged **QA91763**

Turtles that made substantial spatial shifts within Port Curtis:

Of the 284 green turtles captured within Port Curtis during 2019, 47 were recaptures of turtles tagged while foraging within Port Curtis in previous years. Only 2 (4%) of these 47 between-year-recaptures had changed their foraging area within the Port:

QA80274: immature, pre-pubescent male green turtle.

- Originally tagged foraging on 9 April 2018 on the intertidal flats outside the Boyne River estuary and recaptured on the inter-tidal flats at South Trees, 13 April 2019.

QA45421: adult male green turtle, carapace length = 98.8 cm

- Originally tagged foraging on the intertidal flats on 17 May 2014 at Pelican Banks; and recaptured on the subtidal flats outside Colosseum Creek estuary, 27 May 2019.

Courtship and mating observations

Among the 882 recorded observations of green turtles within Port Curtis for 2019, there were only three observations of courting pairs.

- 5 September 2019: mating pair of green turtles at the surface off Boyne Island, 23.9417°E, 151.4510°S
- 12 September 2019: mounted pair of green turtles at the surface off Boyne Island, 23.8753°E, 151.3299°S
- 22 September 2019: mounted pairs captured by turtle rodeo in the shallows off Boyne Island, 23.9171 °E, 151.3444 °S.
 - **QA91899:** adult male, CCL = 101.1 cm
 - **QA81900:** adult female, CCL = 93.9 cm

Observations on turtle health and injury:

Two small immature green turtles that were extremely emaciated and assessed to be moribund were passed to University of Queensland School of Veterinary Sciences for euthanasia and necropsy to assess why they were in such poor health.

- **20 May** South Trees flats, **QA87208**, male, CCL = 45.8 cm, weight = 8.47 kg
- **26 May** Boyne River estuary, **QA75304**, female, CCL = 43.5 cm, weight = 6.39 kg

One tagged immature green turtle in poor health was transferred to Quoin Island Turtle Rehabilitation Centre for care.

- **4 July:** South Trees, **QA91609**, female, CCL = 80.0 cm, weight 40.9 kg. Blood sampled for analysis by UQ School of Veterinary Science for blood chemistry, haematology, toxicology; a large immature green turtle; emaciated and swimming weakly but assessed as being likely to recover in the wild. She was released with other turtles at the mouth of Auckland Creek at dusk.

- **5 July:** at noon, captured at inlet pool to Callide Power Station where she was diving but coming to the surface; transferred to Quoin Island Turtle Rehabilitation Centre for care.

A beach-washed carcass of a tagged immature green turtle was taken to necropsy by UQSVS veterinarian.

- **10 July:** Lillys Beach, Boyne Island at the mouth of the Boyne River, **QA45571**, A small immature female green turtle that appeared to be in good body condition was beach-washed dead (D2 carcass condition)
 - This turtle had been previously captured by turtle rodeo on the adjacent intertidal flats in 2014, 2017 and May 2019.
 - She presented with a large number of moderate sized fibropapilloma tumours in May 2019 that were still in evidence on 10 July.

Two incidents of turtle death were recorded following vessel interactions within the Port.

- **22 May:** A crew member reported a turtle hit and killed by a tug heading out beyond South Trees. It was indicated that this tug strike on a turtle was not an isolated occurrence.
- **07 July:** Beach washed dead (D3) green turtle on the beach at northern end of Boyne Island at South Trees outlet; **QA91698**, adult female, CCL = 102.5 cm, wt = 151 kg; four fresh propeller cuts to the right rear carapace (cut lengths: 13.0, 24.3, 22.7, 13.0 cm; cut spacing 11.0, 11.5, 11.5 cm). Could not measure depth of cuts.
 - Necropsy by UQSVS: one propellor cut penetrated into coelomic cavity but did not damage lung or kidney; sea-water uptake into coelomic cavity; evidence of internal infection. Conclusion: the turtle did not die soon after being hit by a vessel but died an undetermined number of days later.
 - Injury is consistent with cuts from a propeller on a 40-100 HP outboard.

Satellite telemetry

Ten green turtles that ranged in size from small immature to adult male and female were deployed with Wildlife Computers GPS satellite tags, SPLASH10-F-385A-01, on the sea grass flats surrounding Wiggins Island and adjacent to the Wiggins Island Coal Terminal: 5 in July and 5 in September (Figure 2A and 2B respectively).

Seven of these ten turtles occupied foraging areas in close proximity to the Wiggins Island flats. The remaining three, while having the majority of their foraging areas at the Wiggins Island flats, foraged more widely into adjacent areas: two occupied additional foraging habitat within the Western Basin; the remaining turtle occupied additional foraging habitat within the lower Calliope River estuary.

These tracked turtles from the Western Basin have displayed a strong fidelity to a restricted foraging range within the Western Basin rather than utilising a broadly distributed foraging range throughout Port Curtis.

In addition, these tracked turtles did not associate with the adjacent port infrastructure for foraging or resting and they did not utilise the nearby dredged channel associated with the port infrastructure in any significant way.

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.

References

Flint, J., Flint, M., Limpus, C. J. and Mills, P. C. (2017). The impact of environmental factors on marine turtle stranding rates. *PLoSone* doi.org./10.1371/journal.pone.0182548.

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.)
- Work, T. M. and Balazs, G. H. (1999). Relating tumor scores to haematology in green turtles with fibropapillomatosis in Hawaii. *Journal of Wildlife Diseases* **35**(4):804-807.

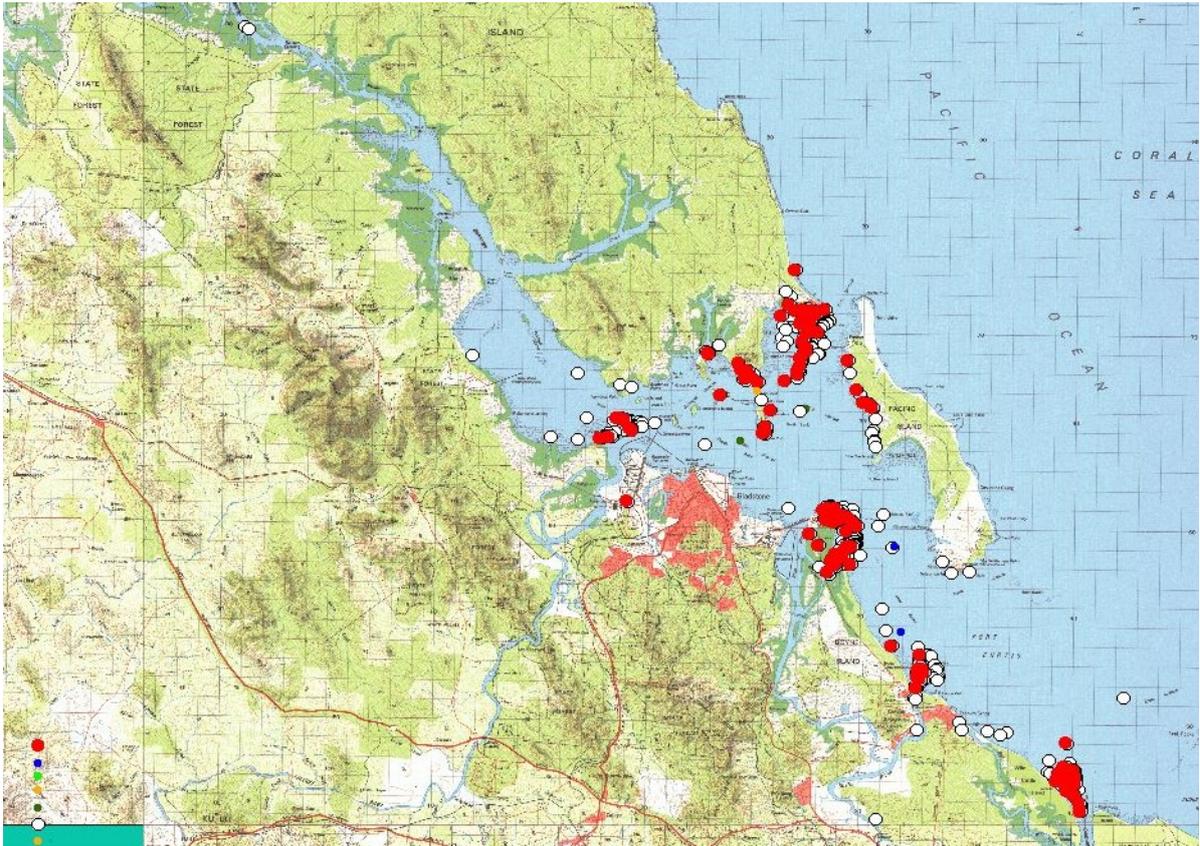
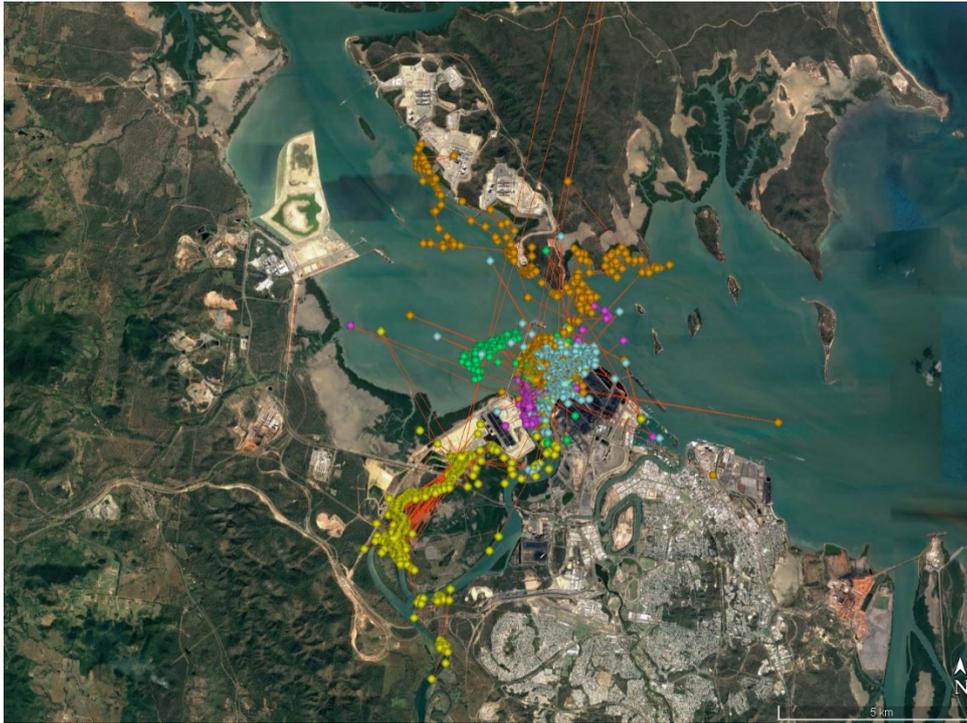
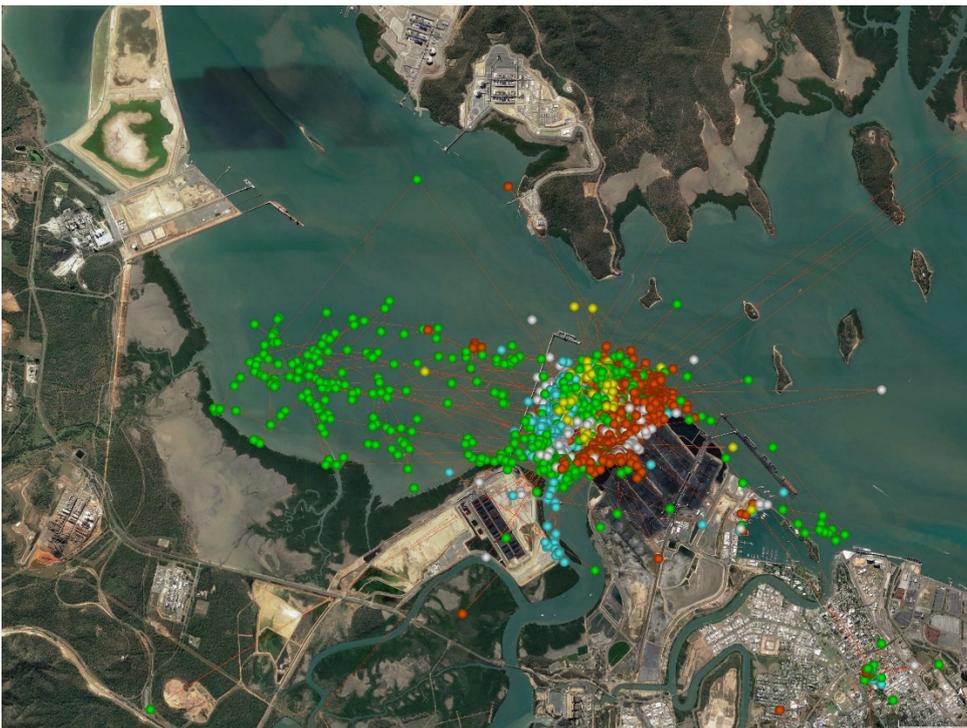


Figure 1. Red dots denote where green turtles were captured and white dots denote where additional green turtles were seen but not captured during the four tagging-recapture study trips to Port Curtis during 2019.



2A. Five green turtles deployed with Satellite tags in July 2019



2B. Five green turtles deployed with Satellite tags in September 2019

Figure 2. Distribution of GPS satellite telemetry positions for ten green turtles captured on the intertidal seagrass flats adjacent to the Wiggins Island Coal Terminal and deployed with GPS satellite tags in 2019

Table 1. Summary of green turtles (*Chelonia mydas*) captured by tagging history and study areas in Port Curtis (PC) and adjacent waterways for the fourth year of the GPC funded study: 2019

Month	Pelican Banks & Curtis Island			Quoin Island & West Chinaman Is.			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	
2019																						
April	16 2	3 1	-	1	-	-	6	-	-	6	1	-	26	3	-	3 1	2 -	-	-	-	-	71
May	7	3	-	-	-	-	-	-	-	-	-	-	24	5+2	-	10 28	9+2 0	-	-	-	-	86+4
July	-	-	-	-	-	-	-	-	-	6	2	-	23	8+2	-	1 2	-	-	-	-	-	42+2
September	12	7+2	-	3 9	-	-	2	0+1	-	8	-	-	14	2+7	-	2 19	0+2 0+1	-	-	-	-	78+13
TOTAL	35 2	13+2 1	-	4 9	-	-	8	0+1	-	20	3	-	87	18+11	-	16 50	11+4 0+1	-	-	-	-	277 +19