Annual report on green turtle tracking and habitat use in Port Curtis – Year 2 (2015)

Project number – CA12000293

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This report has been produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program. The study was undertaken through a Consultancy Agreement (CA12000293) between Gladstone Ports Corporation and James Cook University to increase understanding of green turtle habitat use in the Port Curtis and Port Alma region: using satellite telemetry.

This publication has been compiled by James Cook University

Executive summary

We aimed to examine the movement patterns of green turtles residing in Port Curtis to understand their patterns of habitat use and short-term site fidelity. This report summarises data collected using GPS satellite tags between July 2015 and February 2016.

In July 2015, 11 green turtles were caught in the intertidal habitats of Pelican Banks, Port Curtis. Each turtle was weighed, measured and examined for external signs of disease and injury. Each turtle was taken back to Gladstone Marina and held overnight so we could attach the satellite tag. The tags were configured to transmit GPS location, water temperature and depth.

To examine habitat use we examined the distribution and density of GPS locations for each turtle to determine individual habitat utilisation distributions - 95% utilisation distribution areas explain where an individual turtle spends 95% of its time.

Once released two of the 11 tracked turtles remained in Port Curtis. Eight turtles spent some time outside of Port Curtis – comprising seven that moved in and out of the channel that exists between Curtis and Facing Island and one turtle spent the entire tracking period outside of Port Curtis. All 11 turtles were released at sites removed from their capture site. Ten of the displaced turtles went home to the vicinity of their capture location indicating that capture location is a strong predictor of habitat use.

Home ranges were small (median = 7 km^2) and comparative to other home range data from green turtles in Queensland. The implications of these results are that if you want to know whether a particular localised pressure will impact turtles, the turtles need to be caught within the appropriate footprint.

Diving data revealed that the turtles spent most of their time at water depths of less than 4 metres. However, because the depth records are not linked to GPS points and each of the turtles spent most of their time on, or near, the intertidal zone the binned dive data is challenging to interpret. We are aiming to combat this issue in 2016 using additional data loggers such as accelerometers and time-depth recorders in the last year of this project.

Introduction

In 2013, Gladstone Ports Corporation (GPC) completed a substantial dredging project in Port Curtis (Western Basin Dredging and Disposal Project - WBDDP). The purpose of the dredging project was to deepen and widen existing shipping channels and swing basins and create new shipping channels, swing basins and berth pockets.

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

The scope of this work is to deploy satellite tags on green turtles and examine the movement, behaviour, and habitat use in the Port Curtis region within the ERMP survey area (Figure 1). Ultimately, this work will increase the understanding of green turtles use of marine habitats in the Port Curtis and Port Alma regions.

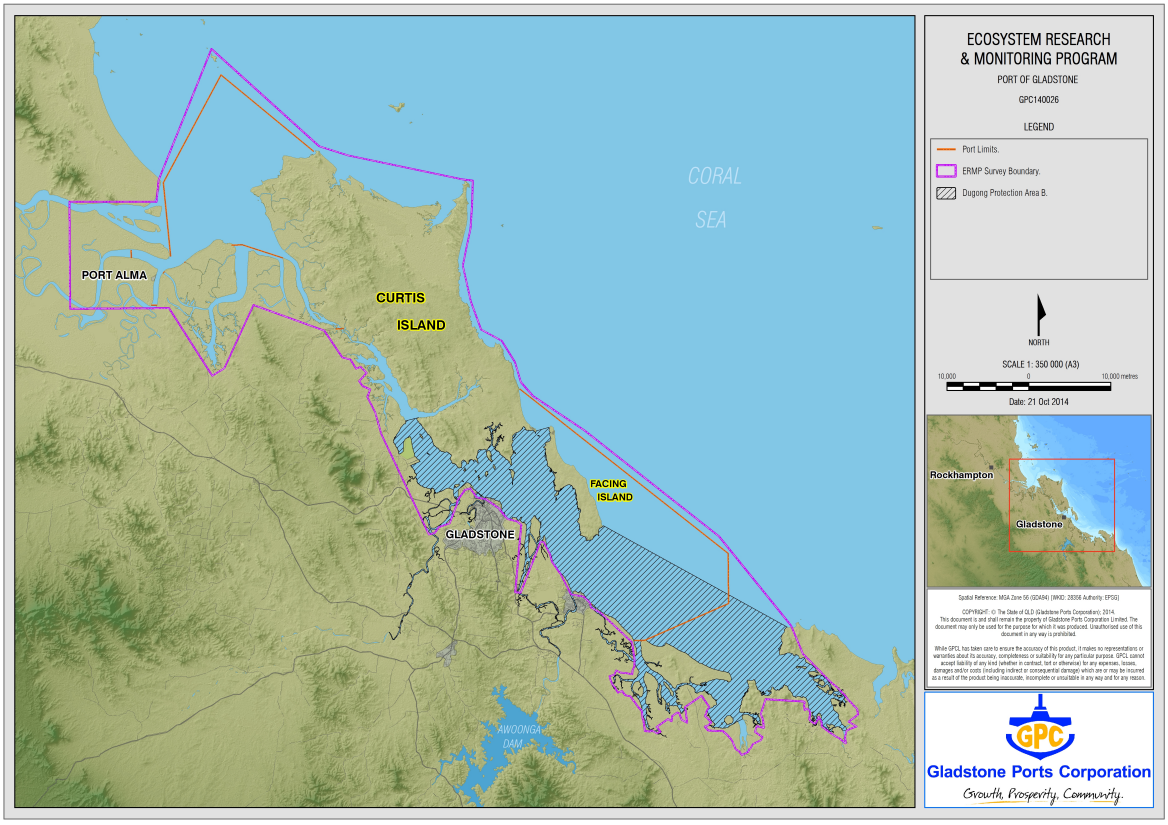

Figure 1. Port of Gladstone and the boundary of the Gladstone Ports Corporation's Ecosystem Research and Monitoring Program

Methods

In July 2015, we used two custom designed turtle catch boats to search the intertidal and immediately adjacent sub-tidal sea grass meadows for foraging green turtles. The Pelican Banks were the main sites searched for turtles. Two catching methods were used; blocking nets and turtle rodeo (Hamann and Limpus 2015).

Blocking net: Blocking nets were used on a mid falling tide and approximately parallel to the low tide line across the drainage area between two banks. Each net was around 50 metres in length and made with braided 3 mm cord. The nets had a 2 metre fall and 21 cm mesh size. Turtles were captured as they attempted to swim through or became entangled in the blocking net.

Turtle rodeo: The turtle rodeo followed the standard methods used by the Queensland Government.

All analyses and mapping were conducted using R software and associated packages.

Collection of data from turtles

All captured turtles were taken back to the Queensland Parks and Wildlife Service workshop at the Gladstone Marina to be tagged, weighed, measured and examined for external signs of disease and injury. Each turtle was tagged with standard titanium flipper tags in the axillary tagging position on the front flippers or on the hind flipper if the front flipper was too thick. Midline curved carapace length (CCL ± 0.2 mm) was recorded for each turtle. The smaller turtles less than 32 kg were weighed on an electric balance (± 0.01 kg); turtles heavier than 32 kg were weighed on Salter spring scales (± 0.5 kg). Each turtle was also examined for external signs of disease and injury.

Attachment of satellite tags

Eleven turtles were selected for satellite tracking (Table 1). Each of the turtles was taken back to the QPWS workshop in Gladstone to be fitted with the satellite tag. The turtles had their carapaces cleaned of algae, and the tag (Wildlife Computers GPS satellite tag: SPLASH10-F-296A) was positioned on the carapace using Sika (®Anchor Fix 3) two-part epoxy. Once the epoxy was touch dry, the tag and epoxy were painted with anti-fouling paint to minimise algal and barnacle growth on the tag. Turtles were then kept overnight in shallow tubs to allow the epoxy to harden. Prior to release of the turtles into Port Curtis the following morning, we used a PTT beeper to establish that the tags were transmitting.

Table 1. Tag and capture details of the eleven turtles fitted with satellite transmitters in Port Curtis 2015.

Tag number	Tracking tag number	Sex	Age class	CCL	Notes
K28651	149082	M	Adult	98.9	Not breeding
QA43123	149087	F	Adult	108.2	Not breeding
QA58206	149088	F	Sub-adult	81.5	Not breeding
QA58209	149081	M	Adult	89.1	Not breeding
QA58210	149086	M	Sub-adult	80.1	Not breeding
QA58211	149085	F	Sub-adult	99.7	Not breeding
QA58221	149080	F	Adult	95.1	Not breeding
QA58239	149083	M	Sub-adult	77.8	Not breeding
QA58284	149084	M	Adult	92.2	Not breeding
QA58291	149090	M	Adult	94.1	Not breeding
QA58295	149089	F	Sub-adult	83.8	Not breeding

Data acquisition and preparation

The satellite tags provide two types of location data; ARGOS PTT locations and Fast-loc GPS (FGPS) locations. ARGOS locations are less accurate (~250 m for the best quality locations) (CLS 2011) compared to FGPS locations (~30 m for the best quality locations) (Hazel 2009; Shimada et al. 2012). Once the raw FGPS data are downloaded from the ARGOS website, the raw locations were converted to GPS data by using the Wildlife Computers software.

Both the FGPS locations and ARGOS locations were associated with quality indices; residual error and location class (LC) respectively. FGPS fixes were removed if the residual error value was greater than 30 or if fewer than four satellites were used to estimate locations. We also retained only high quality ARGOS fixes (LC 3, 2, 1). Location data were thoroughly screened by spatial and temporal duplicates, water depth, and a data driven filter (Shimada et al. 2012; Shimada et al. 2016). We used the R package SDLfilter (Shimada 2016a) to execute the screening.

Analysis of satellite-derived location data

We calculated 95% utilisation distributions (UD) to define home ranges of tracked turtles. The 95% UD areas explain where an individual turtle spends 95% of its time. We calculated UDs for each turtle using the movement-based kernel density estimator based on a biased random bridge to minimise the potential effects of autocorrelation in the location data (Benhamou 2011). The resulting UDs were averaged to estimate a collective UD of all turtles. The R package adehabitatHR was used to estimate the UDs.

We excluded locations during post-release phase from UD calculation. Post-release phase of each track was defined to begin at the point of release and to end at the point of resettlement in the habitat (Shimada et al. 2016). The post-release phase and the following resettled phase were delineated by using the combination of UDs and residence time method (Barraquand and Benhamou 2008) as described in details in Shimada et al. (2016). Residence time was calculated using the R package adehabitatLT (Calenge 2006, 2015).

Analysis of depth data

Depth data are collected by the satellite tag and transmitted in one of 13 categories (data bins). Data bins are user set and we selected 2 metre depth intervals from <2 to >26 metres. Data bins for dive duration were in 1 minute intervals from <1 minutes to 5 minutes, 5 minutes intervals from >5 minutes to 30 minutes, and then 10 minutes interval from >30 minutes to >60 minutes. We excluded from analysis the depth data obtained prior to turtle's arrival to foraging habitat (i.e. before release, during post-release phase).

Results

All turtles were released at sites removed from their capture sites. Ten of the displaced turtles went home to the vicinity of their capture location (e.g. Figure 2a). Another turtle travelled away from the capture site to south of Port Curtis and settled in Baffle Creek during the tracking period (Figure 2b).

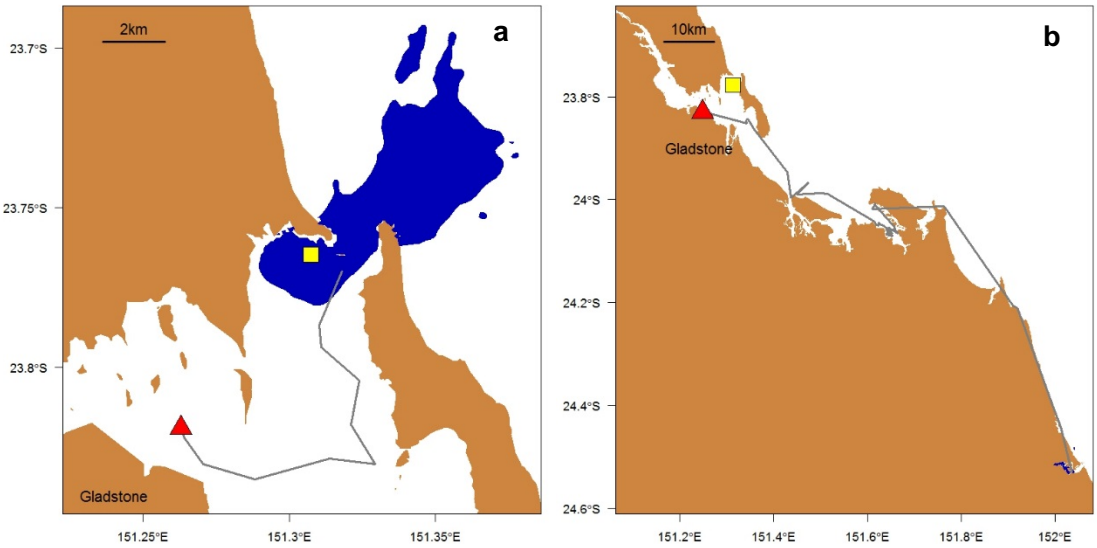

Figure 2. Example of green turtles **a)** returning 'home' (QA58221) and **b)** not returning home (QA58291) following relocation for satellite tag attachment. Square = capture site, triangle = release site, line = turtle track reconstructed by connecting consecutive satellite-derived locations, and blue polygon = home range (95% UD).

Home range and habitat use

The 11 turtle's transmitters sent an average of between two and six GPS locations and four to 10 ARGOS locations per day (Table 2). Home ranges (95% UDs) of all turtles were small, ranging from 4 to 81 km^2 with a median of 7 km^2 (Table 1). They predominantly used inter-tidal and shallow water habitats (Figure 3) including areas of the Port that coincide with high levels of human use (vessel activity, fishing etc).

Two of 11 turtles remained in the vicinity of areas (i.e. Pelican Banks) where they were originally captured and resettled after displacement (Appendix – Figures A1e, f). Eight turtles spent some time outside of Port Curtis – comprising seven that moved in and out of the channel that exists between Curtis and Facing Island (Appendix – Figures A1a, b, c, d, g, h, k), and one that shifted habitat away from its initial home (capture) foraging area; turtle QA58284 shifted between the Pelican Banks to the Western Basin (Appendix - Figure A1i). One turtle did not return to the area of capture after release but traveled south to Baffle Creek, approximately 110 km in straight distance south from Gladstone, where it remained during the entire tracking period (Appendix - Figure A1j).

Table 2. Summary of the tracking duration, location data and home range size (95% UD) for the 11 green turtles captured and released in Port Curtis. Provided statistics are of raw data (i.e. unfiltered locations). Home range outputs of each turtle are included as Appendix.

Tag number	Turtle release date	Days tracked	Date of last GPS	Number of GPS locations	Average number of GPS locations per day	Date of last ARGOS location	Number of ARGOS locations	Average number of ARGOS locations per day	Home range (km^2)
149082	15/7/2015	182	08/01/2016	858	5	12/01/2016	1610	9	6
149087	12/7/2015	221	14/02/2016	446	2	18/02/2016	1423	6	81
149088	12/7/2015	142	25/11/2015	379	3	01/12/2015	1167	8	15
149081	12/7/2015	98	13/10/2015	546	6	18/10/2015	889	9	7
149086	12/7/2015	186	28/12/2016	546	3	14/01/2016	787	4	4
149085	13/7/2015	133	16/11/2015	355	3	23/11/2015	942	7	3
149080	15/7/2015	176	05/01/2016	602	3	07/01/2016	1180	7	28
149083	16/7/2015	164	11/12/2015	450	3	27/12/2015	1082	7	6
149084	13/7/2015	127	14/11/2015	761	6	17/11/2015	1190	9	8
149090	11/7/2015	144	30/11/2015	530	4	02/12/2015	851	6	4
149089	11/7/2015	160	12/12/2015	692	5	18/12/2015	1616	10	7

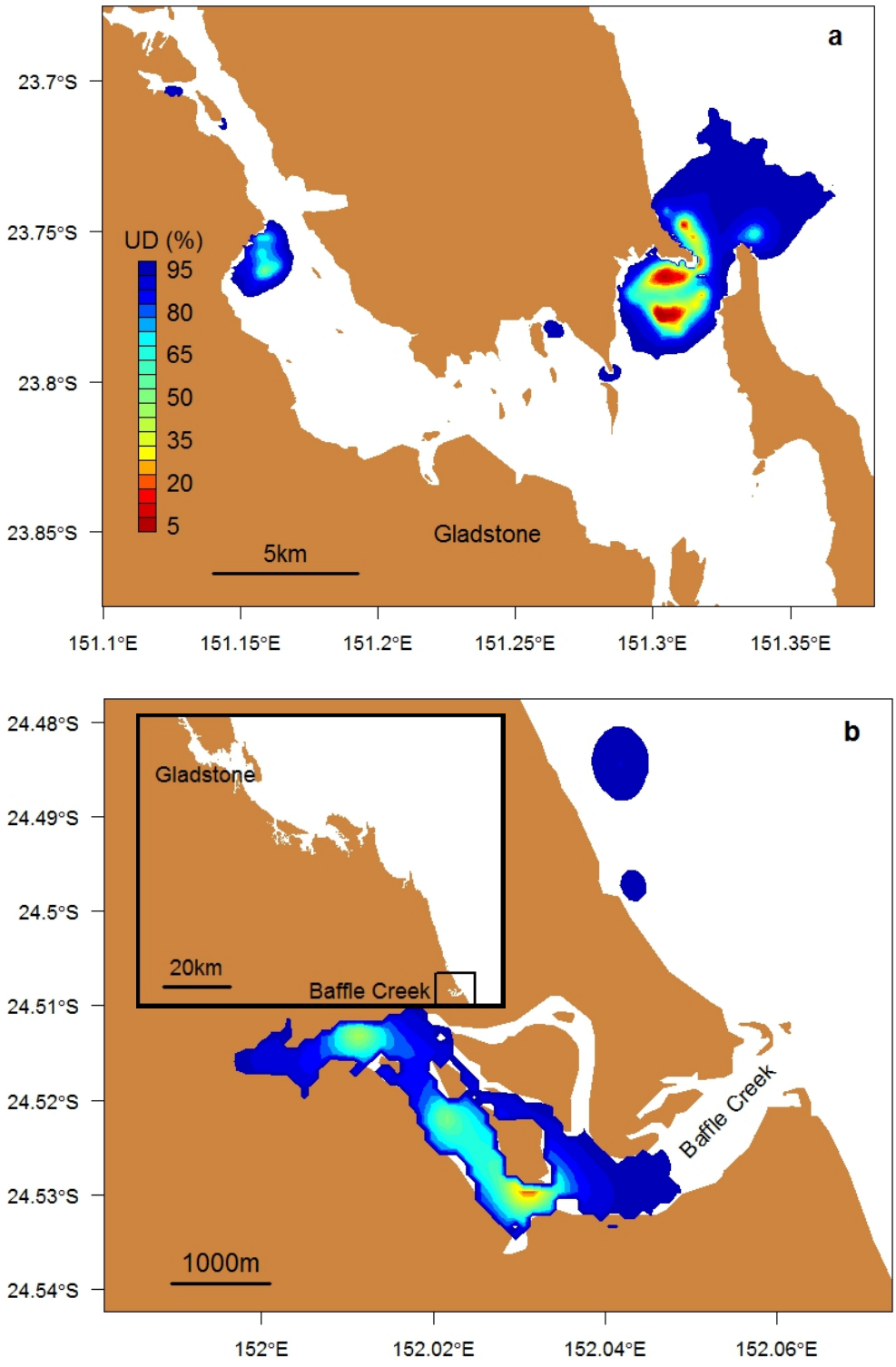

Figure 3. Combined home ranges of 11 green turtles captured and released in Port Curtis between July 2015 and February 2016. After displacement, **a)** ten turtles resettled in the vicinity of the original capture points in Port Curtis and **b)** one turtle moved to south and settled in Baffle Creek. Percent UD refers to the percent of time each 100 metre grid is used by the 11 turtles during the tracking period. Locations received between release and arrival at their home foraging area is not included in the home range estimates.

Dive behaviour

We received 2212 six-hour histograms for the 11 turtles tracked with the GPS tag (range 121 to 296 per turtle). However, because the depth records are not linked to GPS points and each of the turtles spent most of their time on or near the intertidal zone the binned dive data is challenging to interpret. In general terms, the turtles spent 33% of their time in water <2 metres deep, 31% of their time between 2 and 4 metres deep and 96% of their time in water less than 10 metres deep (Figure 4). Dive durations ranged from <5 minutes through to more than one hour, median dive length was in the bin of 15 to 20 minutes (Figure 5).

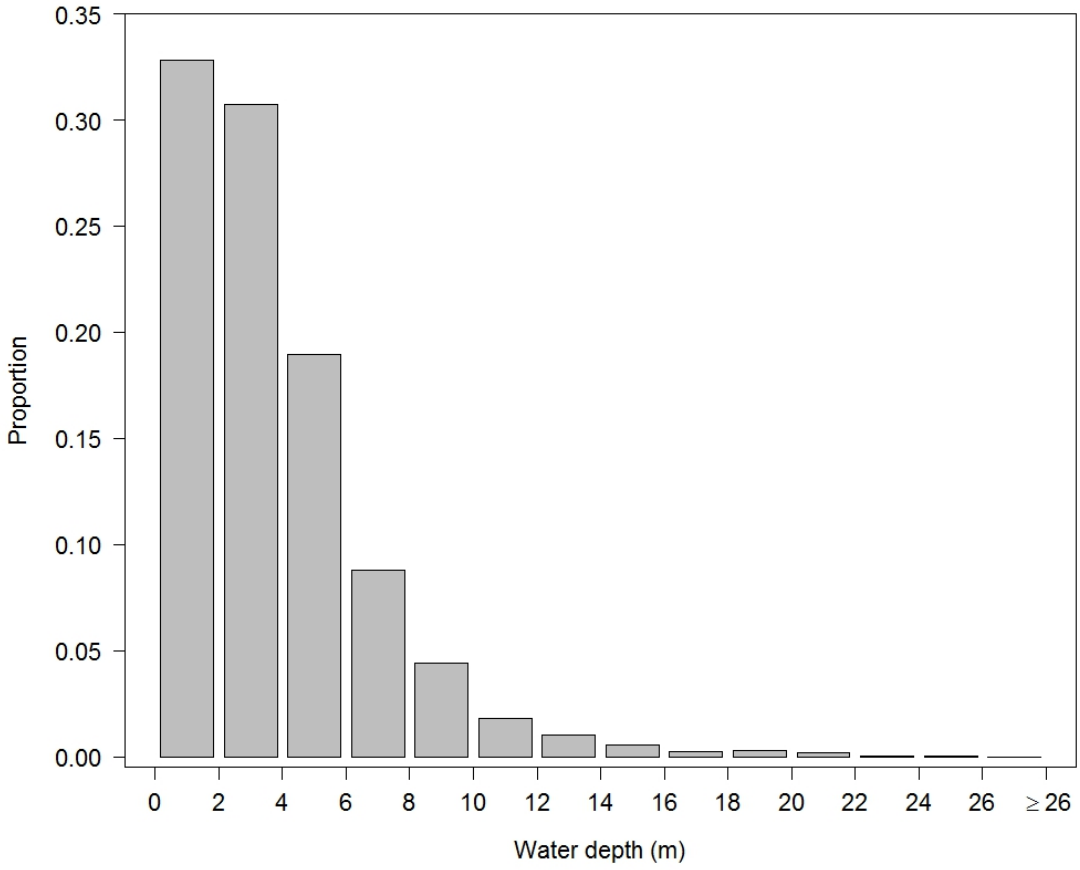

Figure 4. Proportion of water depth used by 11 green turtles tracked in the Port Curtis region between July 2015 and February 2016.

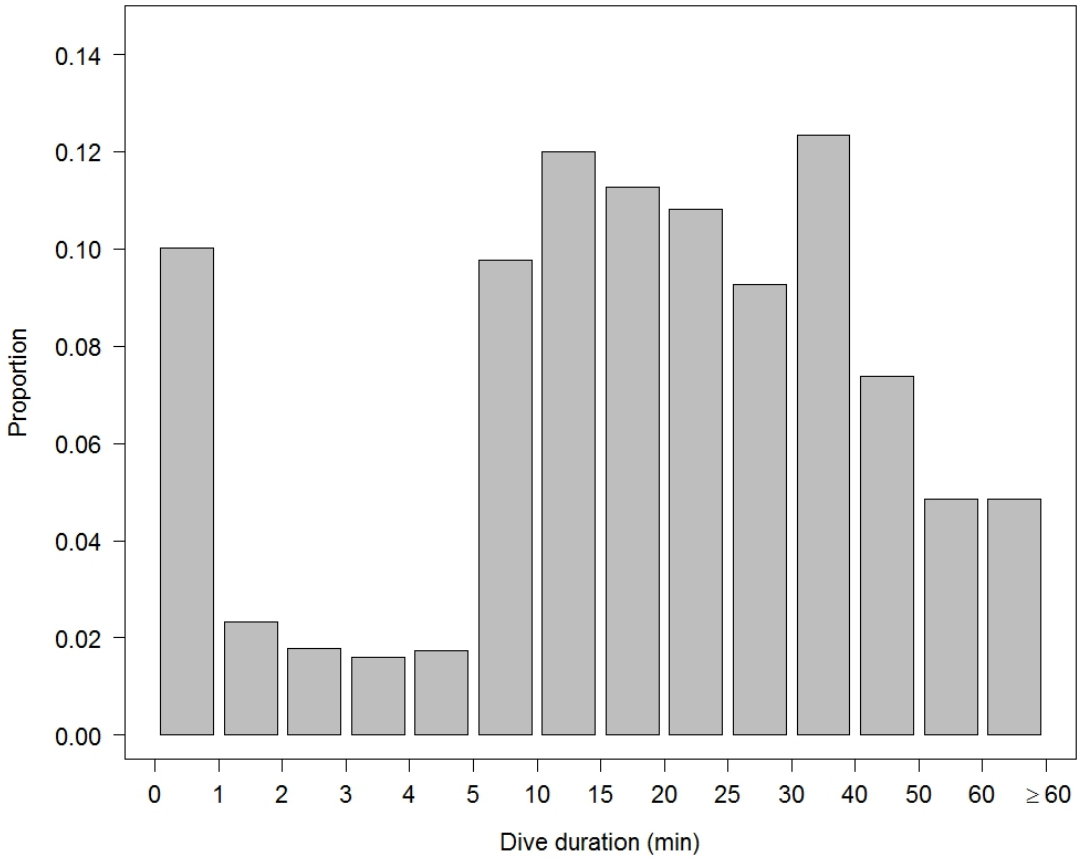

Figure 5. Proportion of dive duration by 11 green turtles tracked in the Port Curtis region between July 2015 and February 2016.

Discussion

We obtained GPS data from 11 turtles as they foraged in Port Curtis between July 2015 and February 2016. The size of the key habitats they used ranged from 3 to 81 km^2, which is within the range reported by other researchers on green turtles in Queensland (Hazel et al. 2013; Gredzens et al. 2014; Shimada 2016b). We confirmed that green turtles use a variety of habitats, from estuarine areas, mangroves, intertidal zones and deeper water areas associated with channels or rocky reefs. We also found that one turtle shifted habitats during the tracking period, presumably in relation to shifts in seagrass.

Ten of the tracked green turtles returned back to their capture sites after displacement and remained in, or close to, Port Curtis during the tracking periods. This short-term fidelity was expected because almost all turtles that were displaced and tracked with satellite-linked devices (n = 59) returned to their home foraging habitat (Shimada et al. 2016), and long-term capture-mark-recapture projects in Queensland have also found few turtles that shift foraging habitats (Limpus 2008). This has implications for mitigating future impacts to foraging turtles in relation to Port and recreational boating activities. Assessing the vulnerability of impacts to green turtles will require a detailed comparison of turtle home range data with bathymetry, vessel use areas and habitat types. Our data, plus data to be collected in 2016, will enable us to compare

home range data from the green turtles with spatial layers on high-resolution bathymetry, sea surface temperature, tidal cycles and associated water movement, habitat type and vessel use data, including presence of seagrass, mangroves, sub-tidal rocky reefs, anchoring zones and future planned dredging areas.

The tracking revealed two unexpected results. First, a turtle initially caught on the Pelican Banks did not return to its capture site – instead it swam nearly 110 km to the south and took up residence in a mangrove fringed estuary (Baffle Creek). Although turtles often use estuarine and mangrove environments this result was not expected because the turtle switched habitats even though seagrass resources were in good condition on the Pelican Banks and there are other closer mangrove systems used by turtles. Our second unexpected result was the periodic movement of turtles from the Pelican Banks, out through the passage between Curtis and Facing Islands into open water and then back again. Some turtles made this journey several times. We will examine the data in more detail to investigate whether there is a temporal pattern and possibly determine whether the turtles are moving with tides, making the movements to take advantage of warmer waters or for foraging.

Progress towards future work

We have begun collaboration with Dr Mike Rasheed from James Cook University's Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Seagrass Ecology Group and discussions have begun to determine the best approach to compare seagrass distribution and abundance with data on turtle behavior. Similar collaborations could occur with research groups focusing on mangroves of other near-shore habitat types. In 2016 we will also target the mangrove lined estuary areas – such as the Boyne and Calliope Rivers to look for foraging turtles.

Additionally, during the 2016 – 2017 survey, we will examine turtle behaviour in more details by using accelerometers which provide vital information about where turtles feed and rest. Our final analysis will use the combined data obtained by satellite telemetry units and data loggers, together with seagrass distribution, bathymetry and vessel movements. This multi-scale analysis will enable us to accurately identify where turtles feed, rest, or travel within their home ranges, and where risk may occur.

Acknowledgements

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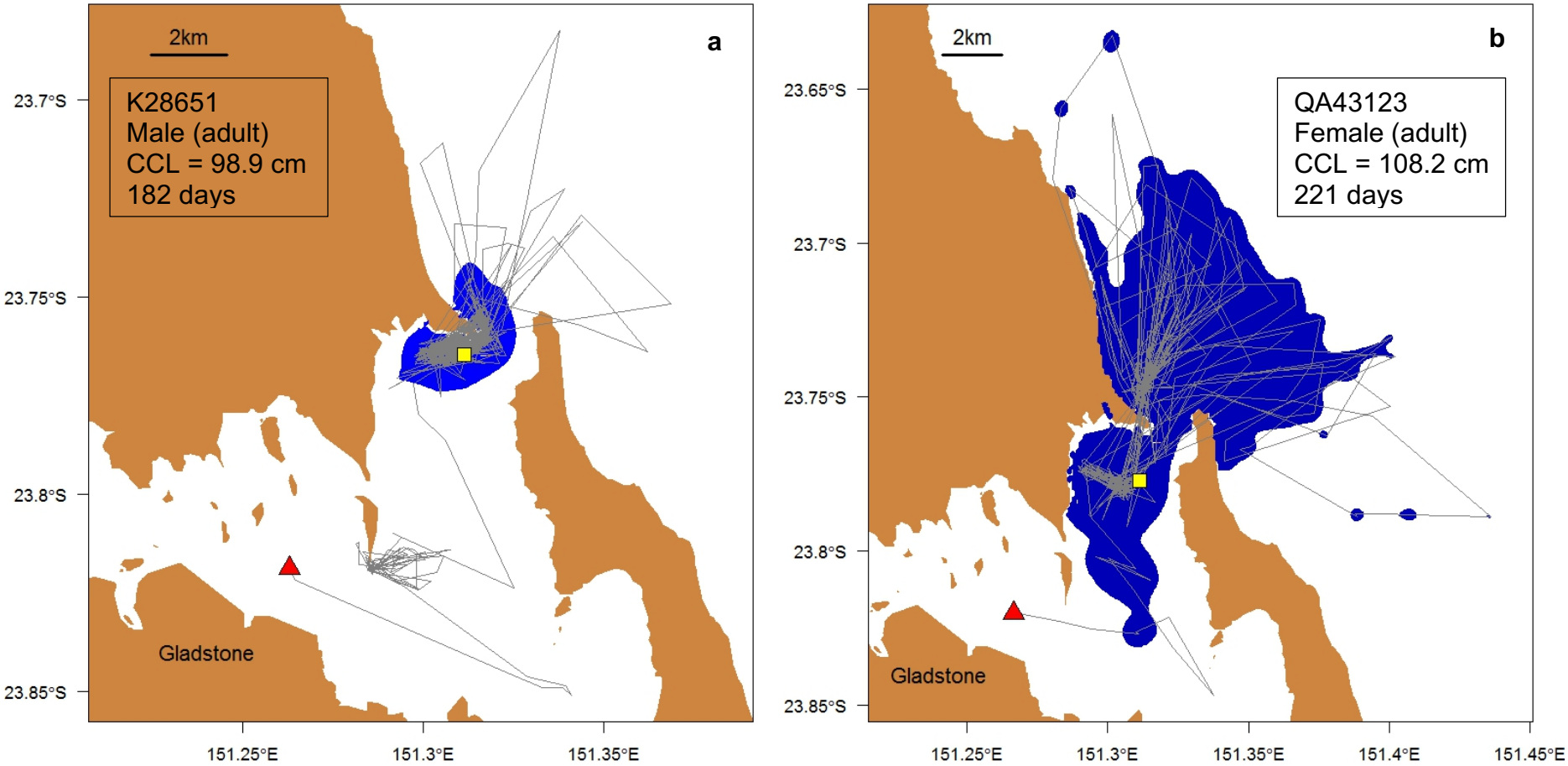
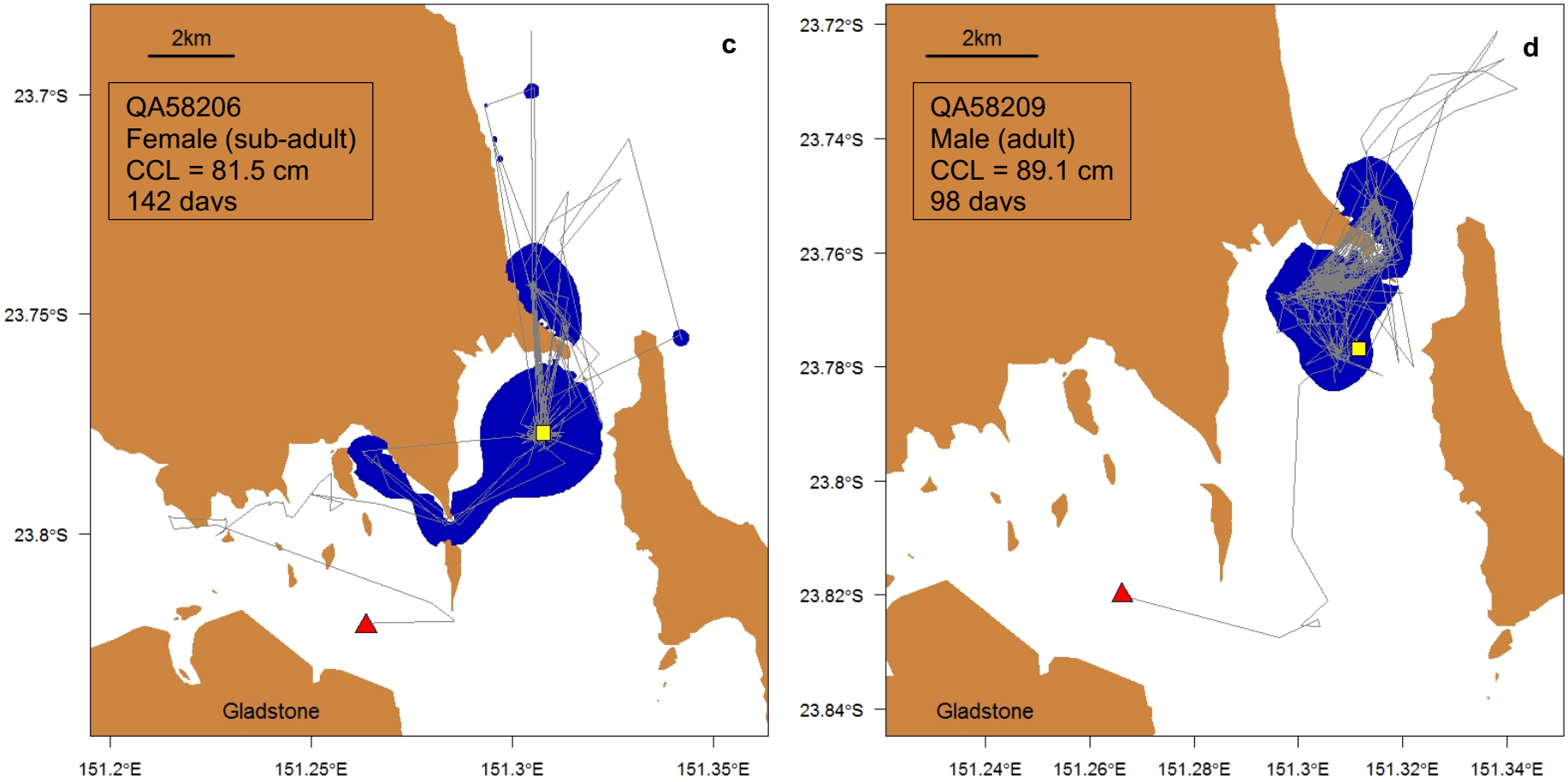
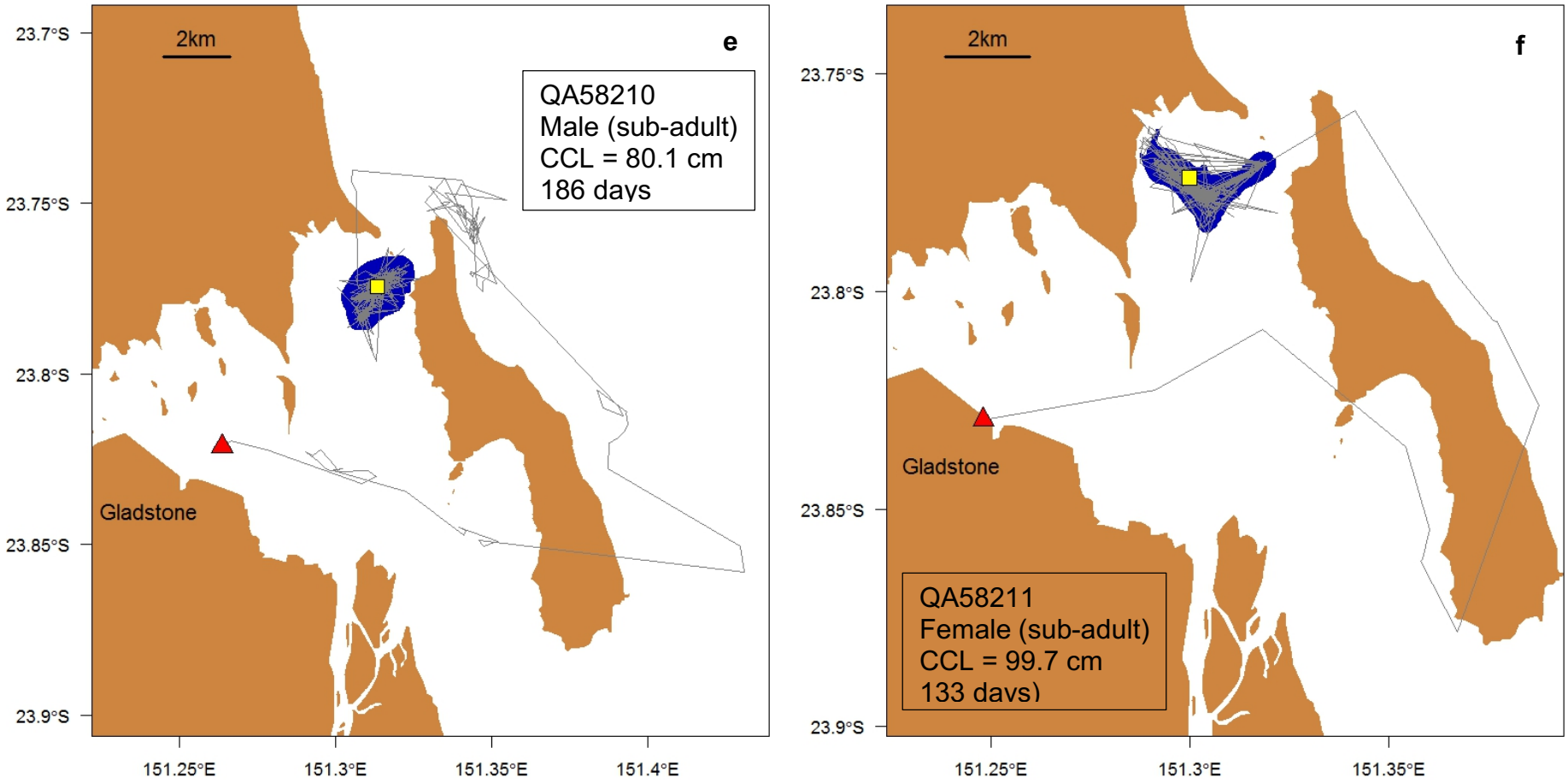
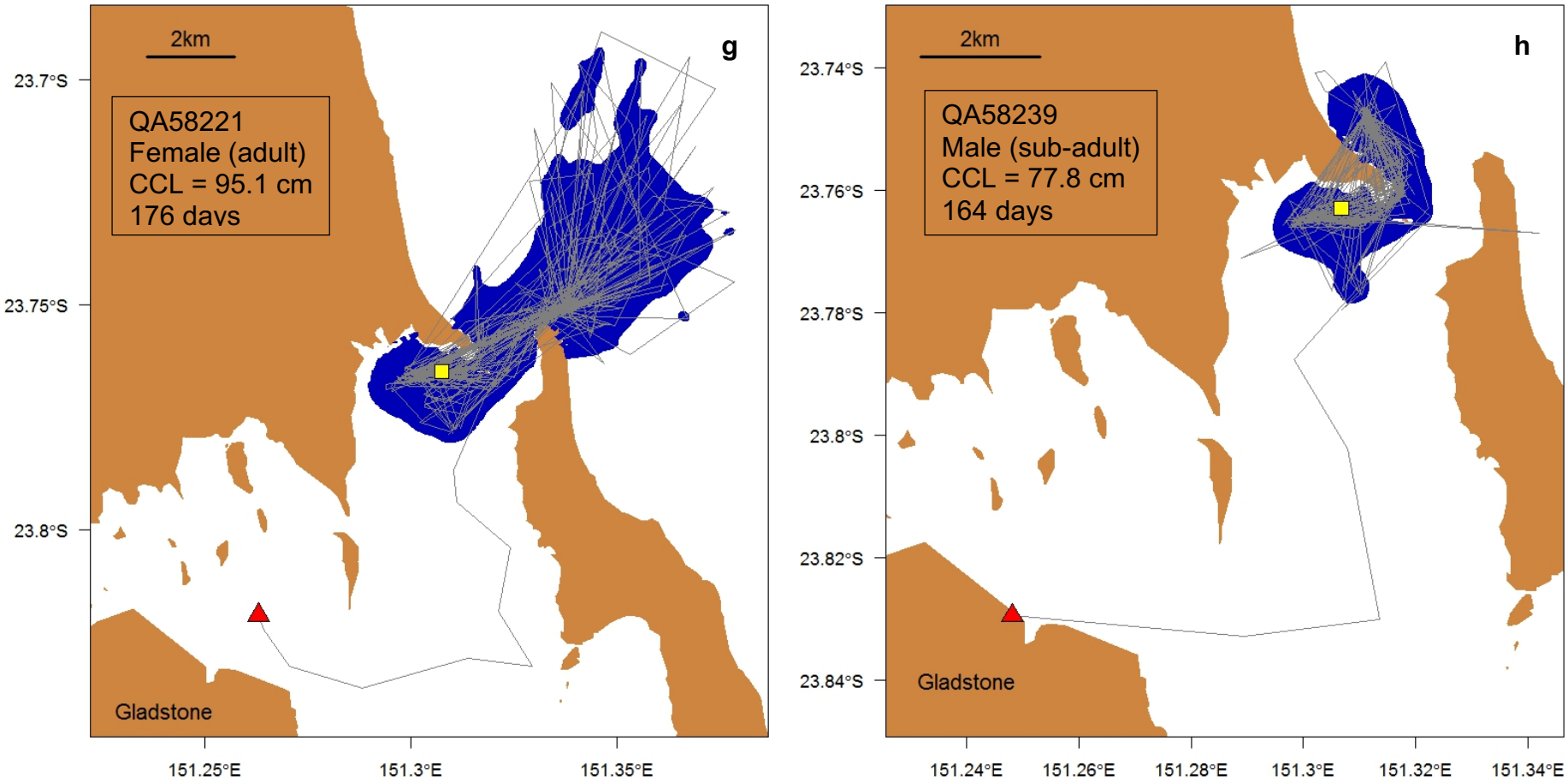
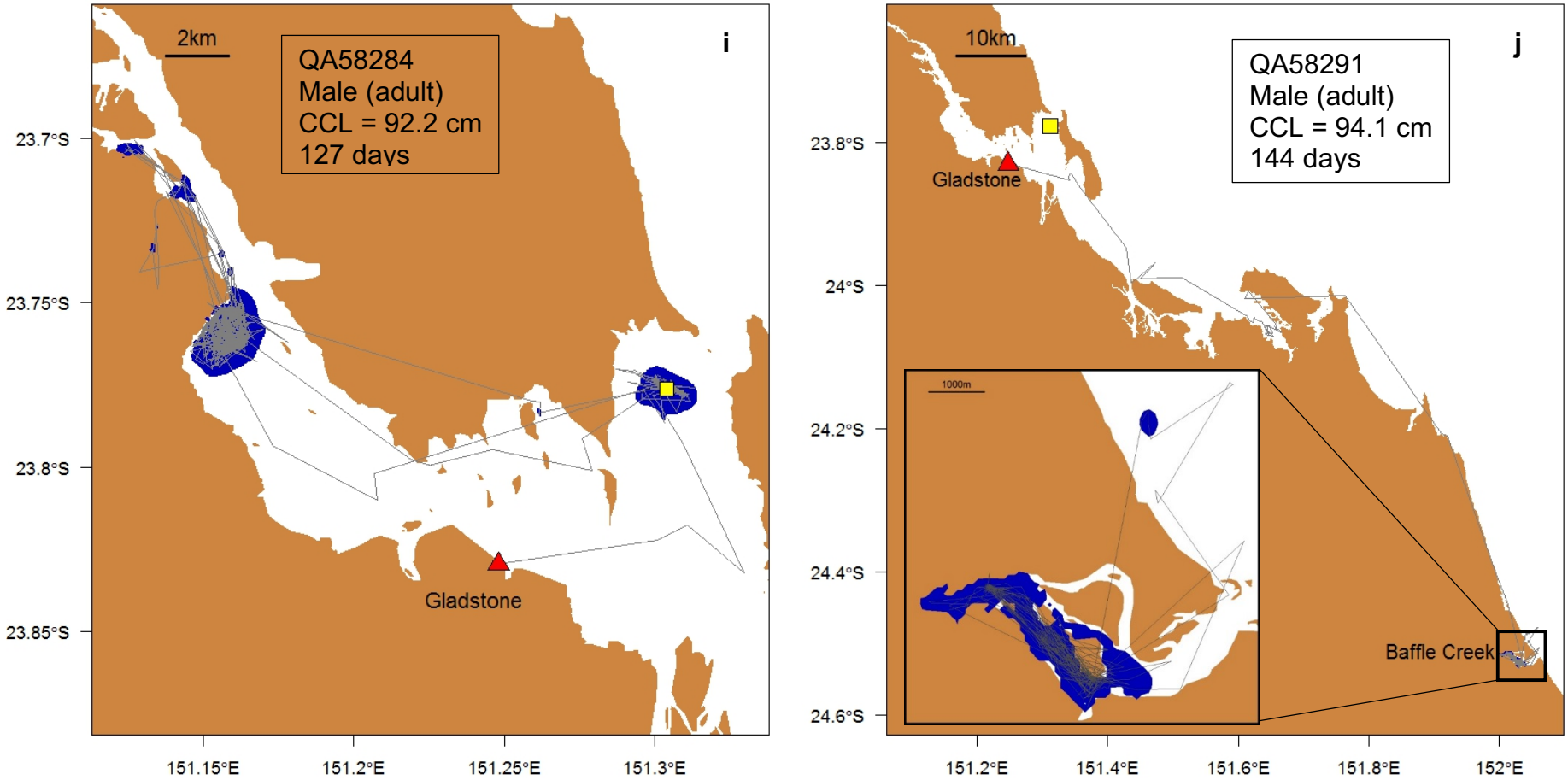
Appendix


2km
a
K28651
Male (adult)
CCL = 98.9 cm
182 days
23.7°S
23.75°S
23.8°S
23.85°S
Gladstone
151.25°E
151.3°E
151.35°E
2km
b
QA43123
Female (adult)
CCL = 108.2 cm
221 days
23.65°S
23.7°S
23.75°S
23.8°S
23.85°S
Gladstone
151.25°E
151.3°E
151.35°E
151.4°E
151.45°E


c
2km
QA58206
Female (sub-adult)
CCL = 81.5 cm
142 days
23.7°S
23.75°S
23.8°S
Gladstone
151.2°E
151.25°E
151.3°E
151.35°E
d
2km
QA58209
Male (adult)
CCL = 89.1 cm
98 days
23.72°S
23.74°S
23.76°S
23.78°S
23.8°S
23.82°S
23.84°S
Gladstone
151.24°E
151.26°E
151.28°E
151.3°E
151.32°E
151.34°E


e
2km
QA58210
Male (sub-adult)
CCL = 80.1 cm
186 days
Gladstone
23.7°S
23.75°S
23.8°S
23.85°S
23.9°S
151.25°E
151.3°E
151.35°E
151.4°E
f
2km
QA58211
Female (sub-adult)
CCL = 99.7 cm
133 days)
Gladstone
23.75°S
23.8°S
23.85°S
23.9°S
151.25°E
151.3°E
151.35°E


2km
g
QA58221
Female (adult)
CCL = 95.1 cm
176 davs
23.7°S
23.75°S
23.8°S
Gladstone
151.25°E
151.3°E
151.35°E
2km
h
QA58239
Male (sub-adult)
CCL = 77.8 cm
164 days
23.74°S
23.76°S
23.78°S
23.8°S
23.82°S
23.84°S
Gladstone
151.24°E
151.26°E
151.28°E
151.3°E
151.32°E
151.34°E


2km
QA58284
Male (adult)
CCL = 92.2 cm
127 days
i
23.7°S
23.75°S
23.8°S
23.85°S
Gladstone
151.15°E
151.2°E
151.25°E
151.3°E
10km
QA58291
Male (adult)
CCL = 94.1 cm
144 days
j
23.8°S
24°S
24.2°S
24.4°S
24.6°S
Gladstone
1000m
Baffle Creek
151.2°E
151.4°E
151.6°E
151.8°E
152°E

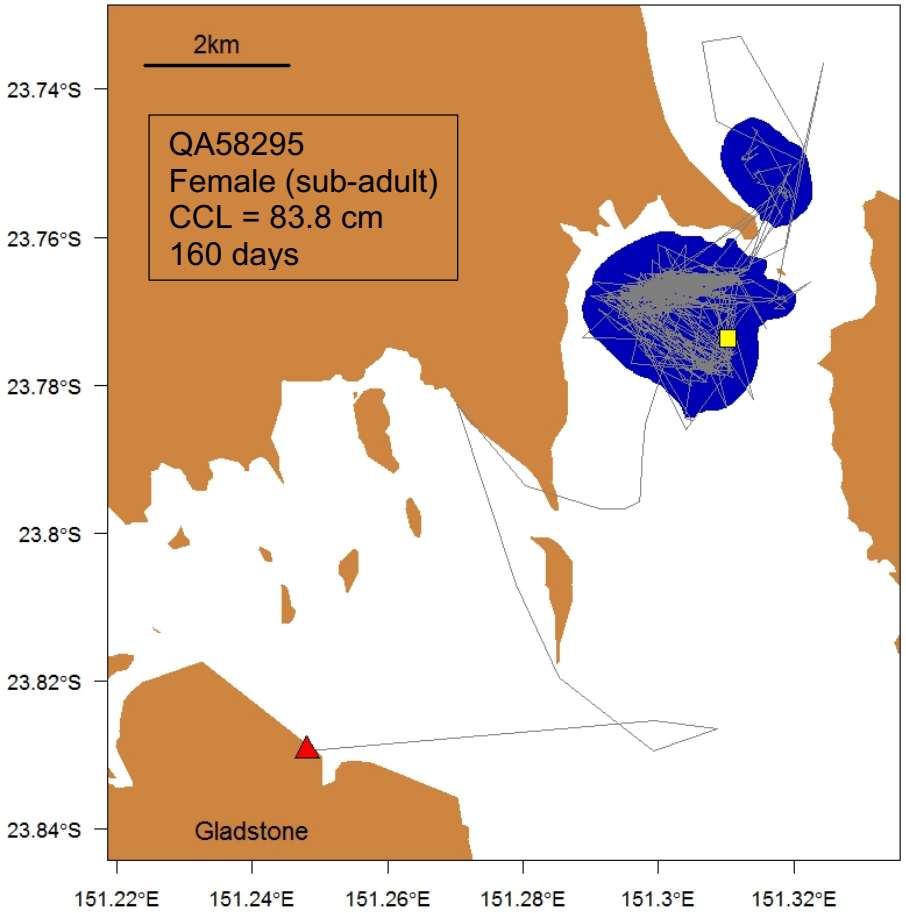


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Figure A1. Location data for 11 green turtles tracked with Argos-linked Fastloc GPS tags. Square = capture site, triangle = release site, line = turtle track reconstructed by connecting consecutive satellite-derived locations, and blue polygons = home range (95% UD).