

RTA WEIPA PTY LTD

AMRUN PROJECT MARINE TURTLE NESTING SURVEYS

SEPTEMBER 2016



Prepared by

Pendoley Environmental Pty Ltd

For

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- Appendix A: Location of predated nests by beach section, September 2016.
- Appendix B: Summary of predation, predator activity and predator species by beach section, September 2016.

Acronyms and Abbreviations

AEC	Animal Ethics Committee
AS/NZS	Standards Australia/Standards New Zealand
ATV	All - Terrain Vehicles
DAF	Queensland Department of Agriculture and Fisheries
DEHP	Department of Environment and Heritage Protection
LSMP	Land and Sea Management Program
PALM	Permits and Licensing Management (Queensland)
PENV	Pendoley Environmental Pty Ltd
PPE	Personal Protective Equipment
QLD	Queensland
QTRP	Queensland Turtle Research Project
QTCP	Queensland Turtle Conservation Project
RTAW	RTA Weipa Pty Ltd
SIMOPS	Simultaneous Operations
SOP	Standard Operating Procedure
TBC	To be confirmed
UNID	Unidentified

1 SURVEY BACKGROUND, OBJECTIVES AND METHODS

1.1 Survey Background and Objectives

This survey has been designed to address marine turtle nest monitoring commitments within the RTA Weipa Pty Ltd (RTAW) Marine Turtle Offset Plan (referred to herein as the 'Plan') and a Feral Pig Management Offset Strategy (referred to herein as the 'Strategy'). The commitments within the Plan and Strategy are in accordance with Condition (J42) (b) of the RTAW Environmental Authority (EA) No EPML00725113, and Condition 45 of the RTAW Environmental Protection and Biodiversity Conservation Act (EPBC Act) Approval (EPBC 2010/5642) respectively. The execution of the survey was in alignment with EA Condition (J43) and EPBC Act Approval Condition 44, which requires that the Plan, and the Strategy, are implemented.

The Plan and Strategy were designed to reduce annual levels of feral pig predation on marine turtle nests, thereby increasing hatchling survivorship and the Plan and Strategy commit to annual monitoring of marine turtle nests.

The primary objective of this marine turtle nesting survey was therefore to obtain sufficient data to detect long-term trends in nest predation rates by feral pigs.

1.2 Survey Design and Methods

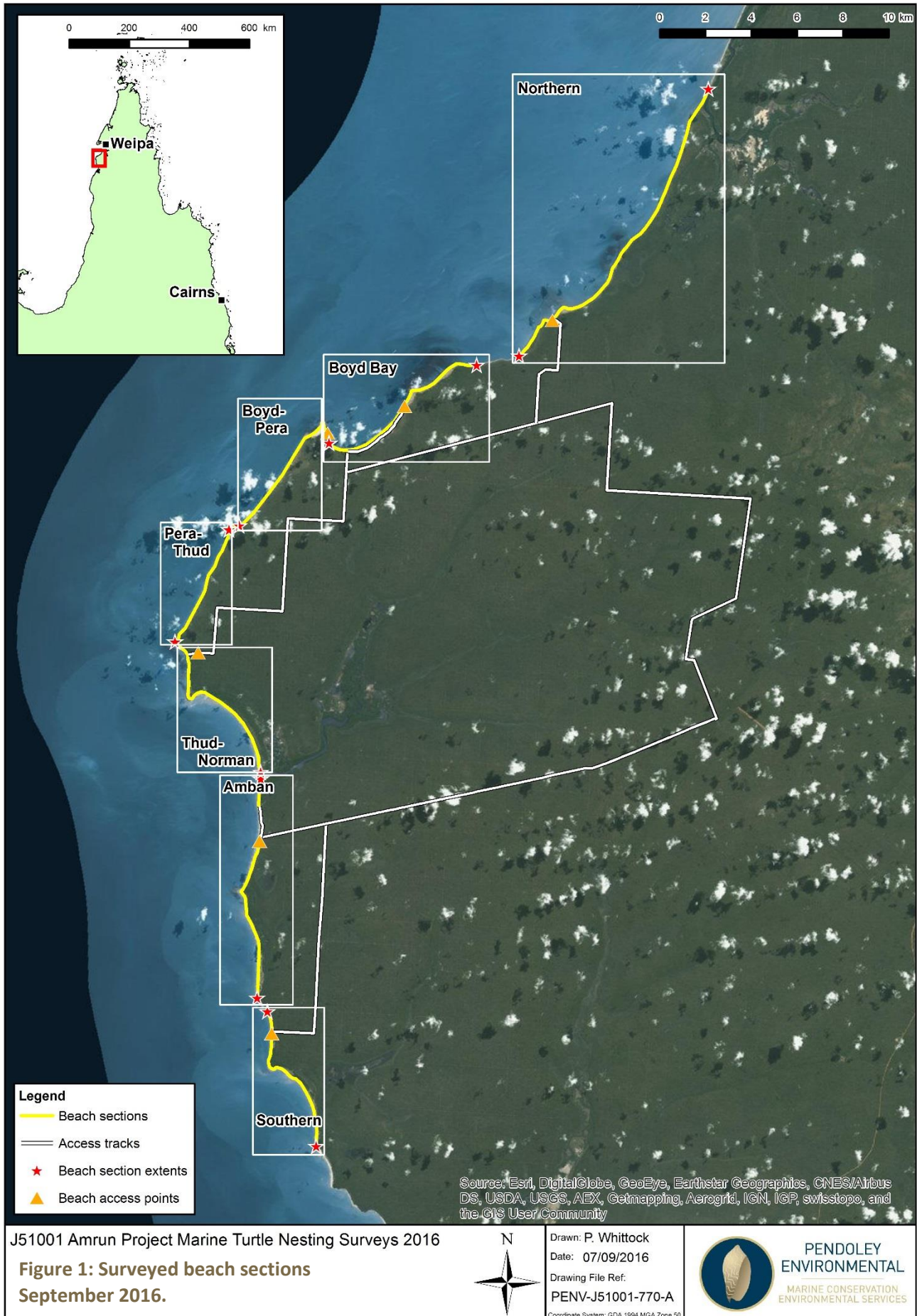
To ensure the objective was met and for consistency with baseline surveys, survey design was per Guinea (2014). Survey approach was based on the relevant Pendoley Environmental (PENV) Standard Operating Procedures (SOPs). Variation from methods detailed in the SOPs and those detailed herein were allowed to facilitate collection of additional data to meet specific scope requirements. Further modifications were incorporated to ensure data collection methods and data recording aligned with those of the Department of Environment and Heritage (DEHP) Queensland Turtle Research Project (QTRP).

1.2.1 Survey Area

Surveys assessed activity at all known marine turtle nesting habitat in proximity to the Amrun project (Guinea 2014). The survey area was divided into seven discrete survey sections and included all accessible nesting beaches between Winda Winda Creek in the north and Ina Creek to the south. The survey area is shown in **Figure 1** with detail on each surveyed section provided in **Table 1**. For a detailed description of the natural features and conditions at each survey section, see Guinea (2014).

Table 1: Surveyed beach sections.

Beach Section		Section Access		
Name	Length (km)	Approach	Timing	Permissions
Northern	14.5	Vehicular	Low-tide only (access to northern 1 km of this section restricted at high tide)	None required
Boyd Bay	9.2	Vehicular	Not restricted	Restricted access without traditional owner
Boyd - Pera	6.5	Vehicular	Not restricted	Restricted access without traditional owner
Pera – Thud	6.0	Foot	Not restricted	Restricted access without traditional owner
Thud - Norman	7.3	Foot	Not restricted	None required
Amban	9.5	Vehicular	Low-tide	None required
Southern	5.1	Vehicular	Low-tide	None required



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**Figure 1: Surveyed beach sections
September 2016.**

1.2.2 Species Identification

Species identification was primarily via assessment of track and nest morphology. Track width (mm) and plastron width (mm) were measured using a straight ruler (Lufkin 1000 mm). Each event was assigned to species using a combination of information supplied in the Queensland Government Environmental Protection Agency / Queensland Parks and Wildlife Service 'Turtle Species Identification' and 'Adult Marine Turtle Track Identification' guides. In addition to this, field staff experience in assessing track width and gait, position of the activity on the beach and where possible, assessment of nest morphology, was utilised.

1.2.3 Nesting Activity

During daytime track surveys, all observed nesting activity was recorded and where possible, assigned to species.

The position of each activity relative to the beach profile, was recorded as per the QTRP, as either:

- Dune;
- Slope;
- Below slope (beach flat); or
- Below mean high water mark.

The specific location of each activity was recorded by documentation of GPS position. GPS of each activity was recorded at either:

- Nest: taken at the nest site; or
- Track only: taken at the highest point reached on the beach, i.e. greatest distance from the mean high water mark in the direction of the dunes.

The presence of a clutch of eggs within a nest can only be confirmed by sighting the eggs. In these surveys, eggs were sighted and nesting confirmed when either:

- The turtle was observed laying ($n = 2$); or
- Egg shells were seen scattered at the sand surface ($n = 76$).

Where the turtle was not observed laying and no egg shells were seen at the surface of the sand (due to predation), the disturbed area was carefully assessed to infer behaviour. Where it was concluded that the turtle had most likely laid, a 'potential nest' was recorded. For the purpose of analysis, once categorised, a potential nest was treated in the same group as a nest, but for accuracy, could not be recorded as a confirmed nest.

Nesting activity was categorised as either a 'nest', including both nests and potential nests, or an 'attempt', including both 'false-crawl u-turns' (FCU: track only, no attempt made) and 'false-crawl attempts' (FCA: tracks associated with digging but no nest mound or other signs of covering).

1.2.4 Predator Activity and Predation

Predator species were identified by careful study of tracks and traces left in the sand, at and around the nest area. Where activity could not be assigned to a separate category ('unidentified') to avoid over or underestimation of abundance.

1.2.4.1 Daytime beach surveys

During daytime beach surveys, predator activity, defined as activity that indicated predators were actively seeking the nest, was identified by tracks and traces left in the sand in the vicinity of the turtle tracks and turtle nest. Predator behaviour at the nest site was described by assigning observations to one or more indicator categories. Indicators, or signs of predator activity included:

- Predator tracks running over and around the turtle tracks;
- Predator tracks at the site of the nest/nesting attempt; or
- Digging along the turtle's tracks.

Predation, defined as activity that indicated predators had successfully located the nest, was also identified by careful study of the nest area. Signs of predation included:

- Digging at and around the nest site; or
- Egg shells scattered at the sand surface.

1.2.4.2 Night-time beach survey

To monitor for predation and predator activity, ten field cameras (Reconyx PC900 HyperFire Professional Covert Camera Traps) were deployed at freshly laid nests where no previous predation or predator activity was observed.

Field cameras were positioned approximately one meter behind the known or estimated location of the clutch. A 'clutch' being the term for the group of eggs, which are located within the nest mound, which is substantially larger and is comprised of sand. Where nesting was not observed, the estimated clutch location was determined by examination of track and nest morphology and inferred nesting behaviour.

Field cameras were mounted on metal star pickets using cable ties approximately one meter above the sand surface. Detection range was tested using the cameras' 'Walk Test' function to ensure capture of activity within a 40° field of view and up to 30 m from the camera's location. Predator activity was captured when the motion sensor was triggered using either daylight or infra-red technology (at night).

The motion sensor function was set at high sensitivity, and camera function set to 'HyperFire' which recorded ten images each time the motion sensor was triggered, at a minimum rate of one image per second, with 'no delay' between triggers. Field cameras recorded the date, time, temperature, moon phase and the number of the image/motion in the sequence (e.g. M1 – M10) each time the sensor was triggered.

At each deployment location, the Field Team recorded the date, time, beach, GPS position (of the field camera and the clutch), beach position, distance of camera from clutch, position of camera in relation to the clutch and nesting turtle species. Where possible, the following information was extracted from images.

Predator activity:

- Species identification;
- Predators (*n*);
- Clutch location method (e.g. olfactory – sniffed out, other predator seen at nest site, turtle seen nesting, nest seen hatching);
- Time of approach; and
- Activity (predation attempt: scratch, sniff; predation success: dig, extract).

Predation:

- Time first dig start / end;
- Approximate depth dug;
- Remains left at surface: eggs extracted;
- Eggs extracted (*n*);
- Eggs consumed (*n*);
- Remains left at surface: hatchlings extracted;
- Hatchlings extracted (*n*); and
- Hatchlings consumed (*n*).

1.2.5 Hatched Nests and Hatchlings

Hatched nests were identified by either a small cone-shaped depression in the sand or observation of hatchling tracks which were followed to locate the emergence point, or clutch location. Hatchling size (Straight Carapace Length; SCL and Straight Carapace Width; SCW) were measured (± 0.1 mm) using Vernier callipers (527). Hatchling mass (± 1.0 g) was measured with Pesola Micro-Line (20060) scales.

1.2.6 Night-time Tagging Surveys

Nesting turtles were approached only when they had finished laying. One titanium flipper tag was attached to each of the front flippers (axial scale, closest to the body) as per Limpus (1971), Limpus et al. (1983), Pendoley Environmental (2016) and with reference to the Queensland Government DEHP guidelines for Tagging and Measuring Turtles. Curved carapace length (CCL) and curved carapace width (CCW) were measured (± 1.0 mm) with a flexible fiberglass tape. All data were recorded as per Pendoley Environmental (2016) and in compliance with the Queensland Turtle Conservation Project (QLD DEHP) requirements (Limpus 2013). A sample of 10 eggs from each clutch were weighed (mass: ± 0.1 g) and measured (diameter: ± 0.1 mm).

1.2.7 Traditional Owner Engagement

Two Traditional Owners accompanied the Field Team, fulfilling support roles, with direction and on-the-job training provided by PENV field staff.

1.3 Data Handling and Presentation

For meaningful comparison of findings among seasons, all data were collected and analysed in alignment with the approach detailed in the previous (baseline) survey report (Guinea, 2014).

1.3.1 Nesting Activity and Density

Total nesting activity included both categories i.e. 'nests' and 'attempts' (**Section 1.2.3**).

On the initial survey day, assessment of all visible nesting activity provides a 'snapshot' of activity on the beach up to approximately two weeks prior to the survey. For accuracy and consistency with baseline surveys, the 'snapshot' data were excluded from analysis of nesting density. Nesting density, excluding the initial 'snapshot' day is referred to as overnight nesting density.

Consistent with baseline surveys, overnight nesting density was calculated by conversion of the number of overnight nests per km of surveyed beach over the duration of the survey and is presented within as 'nests/km/night'. Survey duration is defined as the number of days between the first and last survey to assess overnight nesting activity on each beach section (inclusive). A single tailed t-test was used to determine significant variation in nesting density on all surveyed beach sections between baseline (2013) and the current (2016) survey.

1.3.2 Species-specific Morphological Measurements

Individual turtle and track morphological measurements are given as mean \pm standard deviation (range, *n*) for each stated parameter.

1.3.3 Predation and Predator Activity

Rate of predation was analysed to determine the influence of three primary covariates: beach section, nesting turtle species and predator species. The rate of predation is given as the proportion of all recorded nesting events (nests and potential nests) where predation, as defined in **Section 1.2.4**, was observed. Observations that could not be assigned to species, listed separately within, were included in estimates of predation rates.

1.4 Ethics Approval and Permit to Conduct Works

All works were conducted under, and in accordance with, the appropriate licenses issued by the Department of Environmental and Heritage Protection (DEHP) License No. WISP17503116 and with the approval of the relevant Animals Ethics Committee (AEC) (Department of Agriculture and Fisheries; DAF) Approval Reference No. CA2016/08/996.

1.5 Survey Schedule

Survey scheduling was successfully planned around a number of variables influencing survey timing, frequency and duration including the impact of lunar phase and predicted tidal cycles on nesting activity and beach access, resource availability and other logistical factors such as training and inductions. These variables were accounted for and did not impact survey success.

All factors with the potential to influence survey execution were broadly grouped into three categories:

Timing and duration:

- Lunar phase;
- Sunset and sunrise times;
- Beach length;
- Travel time to each section; and
- Level of activity at each section.

Accessibility:

- Daily scheduling of activities associated with implementation of the annual feral pig control activities;
- Access points and access tracks; and
- Availability of traditional owners.

Available resources and safety considerations:

- Logistical, resource and personnel requirements;
- Safety at night; and
- Fatigue management requirements.

1.6 Limitations

Estimates of abundance and assigning of both nesting and predator activity to species was in some cases constrained by either high winds and rain erasing tracks or by predator activity or predation, which obliterated track detail.

2 RESULTS

2.1 Survey Timing, Schedule and Effort

Survey timing (16th – 26th September 2016) fell within the peak nesting period for this region (August/September; Guinea 2014).

2.1.1 Daytime Beach Surveys

Daytime survey effort ranged from two teams of three field staff, to three teams of two field staff, depending on available resources. Total survey duration was 11 days. It was not possible to survey all sections on each survey day as noted in **Section 1.5** and therefore average survey duration on each section was nine days (**Table 2**).

2.1.2 Night-time Tagging Surveys

The night-time tagging survey focused on nesting habitat from Boyd Point to Pera Head in the vicinity of the proposed wharf, for consistency with baseline surveys (**Figure 1**). Survey effort ranged from one team of two field staff to two teams of three field staff. Available resources for night-time surveys were influenced by management of fatigue and were therefore dependant on scheduling of the previous and following days' daytime beach surveys.

The total number of tagging nights was five (Boyd-Pera: $n = 4$; Northern: $n = 1$) (**Table 2**).

Table 2: Survey schedule for daytime track (track) and night-time tagging (tag) surveys.

Day	Northern	Boyd Bay	Boyd - Pera	Pera - Thud	Thud - Norm.	Amban	Southern
1	track ^{TO}						
2		track ^{TO}		track ^{TO}			
3			track ^{TO}			track ^{TO}	track ^{TO}
4	track ^{TO}					track ^{TO}	
5			tag ^{TO}				
6		track ^{TO}	tag ^{TO}		track		
7	tag			track ^{TO}		track ^{TO}	track ^{TO}
8			tag ^{TO}				
9			tag ^{TO}				
10						track	track
11	track	track ^{TO}	track ^{TO}	track ^{TO}	track		
Visits	4	3	6	3	2	4	3
Duration	11	10	9	10	6	8	8

Table 2 Notes: track: daytime track survey; tag: night-time tagging survey; ^{TO}: Traditional Owner engagement; Visits: frequency of surveys on each section; Duration: total duration of survey on each section.

2.2 Marine Turtle Nesting Activity

Initial recorded activity on the 'snapshot' day (day one) indicated higher numbers of nests (**Table 3**) and false-crawls (**Table 4**) in previous weeks than was recorded throughout the remainder of the survey period. Abundance on each section therefore remained stable throughout or decreased from the start to the end of the survey.

Table 3: Total nests (confirmed and potential) recorded on each beach section on each survey day.

Beach Section	Survey Day											Total Activity	
	1	2	3	4	5	6	7	8	9	10	11	o/n	All
Northern	12			4			2				1	7	19
Boyd Bay		6				5					3	8	14
Boyd - Pera			33		5			1			1	7	40
Pera - Thud		21					1				0	1	22
Thud - Norman						0					1	1	1
Amban			10				2			2		4	14
Southern			11				4			4		8	19
Total	12	27	54	4	5	5	9	1		6	6	36	129

Table 3 Notes: 'Nests' includes nests and potential nests, combined; Total Activity o/n: Total overnight activity which therefore excludes data captured on the initial 'snapshot' survey day; Total Activity All: Total of all activity recorded on each surveyed section, including snapshot day.

Table 4: Total nesting attempts (FCA and FCU) recorded on each beach section on each survey day.

Beach Section	Survey Day											Total Activity	
	1	2	3	4	5	6	7	8	9	10	11	o/n	All
Northern	4			2			0				0	2	6
Boyd Bay		3				0					0	0	3
Boyd - Pera			2		2			0			0	2	4
Pera - Thud		6					1				3	4	10
Thud - Norman						0					0	0	0
Amban			3				0			2		2	5
Southern			0				0			2		2	2
Total	4	9	5	2	2	0	1	0		4	3	12	30

Table 4 Notes: 'Nesting Attempts' includes both FCU and FCA combined; Total Activity o/n: Total overnight activity which therefore excludes data captured on the initial 'snapshot' survey day; Total Activity All: Total of all activity recorded on each surveyed section, including snapshot day.

2.3 Marine Turtle Nesting Density

Overnight nesting density (nests/km/night) in 2016 was highest on Boyd – Pera and Boyd Bay sections and lowest on Pera – Thud and Thud – Norman sections (**Table 5**).

Table 5: Total overnight nests and nesting density on each surveyed beach section in September 2016.

Beach Section	Overnight Nests	Survey Nights	Beach Length (km)	Overnight Nesting Density (Nests/km/night)
Northern	7	10	14.5	0.05
Boyd Bay	8	9	9.2	0.10
Boyd – Pera	7	8	6.5	0.13
Pera – Thud	1	9	6.0	0.02
Thud - Norman	1	5	7.3	0.03
Amban	4	6	9.5	0.07
Southern	8	7	5.1	0.22
Total	36	54	58.1	0.09

Compared to the previous August – September 2013 survey, overnight nesting density was lower on all surveyed sections with the exception of the Boyd Bay section (**Table 6**). On all beaches combined, mean overnight nesting density (nests/km/night) was significantly lower in 2016 (0.09 ± 0.07 , range = $0.02 - 0.22$, $n = 7$), compared to 2013 (0.38 ± 0.38 , range = $0.02 - 1.17$, $n = 7$) ($p < 0.05$, $df = 6$).

Table 6: Variation in overnight nesting density in 2016 compared to 2013.

Beach Section	Nests/km/night		Difference in 2016
	2016	2013	
Northern	0.05	0.23	-0.18
Boyd Bay	0.10	0.02	+0.08
Boyd – Pera	0.13	0.29	-0.16
Pera – Thud	0.02	0.19	-0.17
Thud – Norman	0.03	0.50	-0.47
Amban	0.07	0.26	-0.19
Southern	0.22	1.17	-0.95

2.4 Species-Specific Nesting Activity

In total, 159 events were recorded by three species of nesting marine turtles; flatback (*Natator depressus*), hawksbill (*Eretmochelys imbricata*) and olive ridley (*Lepidochelys olivacea*). Of nests that could be assigned to species ($n = 94$), 48% were flatback nests, 33% were hawksbill nests and 19% were olive ridley nests.

Flatback and hawksbill nesting activity was greatest on Boyd – Pera. Olive ridley nesting activity was greatest on Pera - Thud.

Among species, the rate of nesting success (proportion of all nesting activity: nests, potential nests, FCAs and FCUs) that resulted in a nest being laid (nests and potential nests) was greatest in hawksbill turtles (91.2%). Flatback and olive ridley turtle nesting success was 83.3% and 60.0%, respectively (**Table 7**).

Table 7: Number of overnight nests and nesting attempts recorded by species and beach section, September 2016.

Species	Flatback		Hawksbill		Olive Ridley		Unidentified	
Beach section	Nests	Attempts	Nests	Attempts	Nests	Attempts	Nests	Attempts
Northern	6	2	8	1	2	1	3	2
Boyd Bay	2	1	2	0	3	0	7	1
Boyd - Pera	13	1	12	1	4	2	11	0
Pera - Thud	8	3	3	1	6	4	5	2
Thud - Norman	1	0	0	0	0	0	0	0
Amban	8	1	4	0	1	4	1	0
Southern	7	1	2	0	2	1	8	0
Total	45	9	31	3	18	12	35	5

2.4.1 Species-specific Morphological Measurements

Mean \pm Standard deviation (range, n) flatback track and plastron widths were 770 ± 93 mm (625 – 1000, $n = 43$) and 206 ± 46 mm (133 – 323, $n = 41$), respectively. Mean hawksbill track and plastron widths were 746 ± 96 mm (560 – 962, $n = 30$) and 195 ± 26 mm (147 – 270, $n = 27$) respectively. Mean olive ridley track and plastron widths were 672 ± 100 mm (510 – 962, $n = 24$) and 177 ± 34 mm (120 – 243, $n = 21$), respectively.

2.5 Tagged Turtles

Two adult female flatback turtles were tagged following completion of nesting on the Boyd – Pera section.

At 19:38 on 20th September, tag numbers QA74223 (left) and QA74224 (right) were applied to the front flippers of a previously untagged adult flatback turtle measuring 861 mm (CCL) (**Figure 2**). Mean egg mass was 68.5 ± 2.3 g (range = 64.0 – 71.2, $n = 10$) and diameter was 49.8 ± 0.6 mm (range = 48.7 – 50.5, $n = 10$).

At 20:42 on 23rd September, tag numbers QA74201 (left) and QA74201 (right) were applied to the front flippers of a previously untagged adult flatback turtle measuring 848 mm (CCL). The turtle spent seven minutes in oviposition and total clutch size was 59 eggs. Mean egg mass was 68.4 ± 2.7 g (range = 62.5 – 71.3, $n = 10$) and diameter was 48.5 ± 0.3 mm (range = 48.0 – 48.9, $n = 10$). This turtle was not photographed.

2.6 Hatched Nests

One hatched nest was observed but not recorded at Boyd Point on 15th September (familiarisation day) prior to initiation of surveys. No hatched nests or hatchlings were observed or recorded during the survey period.



Figure 2: Tagged turtle QA74224 (front right flipper) on Boyd – Pera, 20th September 2016.

2.7 Predation and Predator Activity

The overall rate of predation of marine turtle nests was 69% with predation by feral pigs at 55 %. The rate of predation varied among beach sections and turtle species and ranged from 0% - 100% and 52% - 85%, respectively. Evidence of feral pig (*Sus scrofa*) activity was documented at every recorded event where predation and predator activity could be assigned to species..

See **Appendix A** for location of nests and predation events on each beach section.

See **Appendix B** for a detailed breakdown of all recorded predation and predator activity, by predator species and observation indicator recorded on each beach section.

2.7.1 Predation

Predation was highest on Thud - Norman (100%). This represents the single nest found on this section which had been predated. If Thud - Norman section is excluded, predation was highest on Southern section (100%) where there was evidence of predation at all observed nesting events (**Table 8**). Among nesting events that were assigned to species, a greater number of olive ridley nests were predated than those of other marine turtle species (**Table 9**).

Table 8: Nests/potential nests, predated nests/potential nests by beach section, September 2016.

Beach Section	Nests/Potential Nests (n)	Predation		
		Nests (n)	Potential Nests (n)	Total Nests (n)
Northern	19	0	0	0
Boyd Bay	14	9	1	10
Boyd – Pera	40	34	1	35
Pera – Thud	22	15	6	21
Thud - Norman	1	1	0	1
Amban	14	2	1	3
Southern	19	17	2	19
Total	129	78	11	89

Table 9: Nests/potential nests, predated nests/potential nests by nesting turtle species, September 2016.

Species	Nests (n)	Predated Nests (n)
Flatback	45	30
Hawksbill	31	16
Olive ridley	18	13
Unidentified	35	30
Total	129	89

2.7.2 Predator Species

Feral pigs were the predominant predator of marine turtle nests along this coastline. Evidence of feral pig activity was documented at every observation where predation and predator activity could be assigned to species ($n = 71$). In a limited number of cases, feral pig activity was recorded in combination with evidence of goanna ($n = 8$) and dingo ($n = 1$) activity (**Table 10**). Ants and ghost crabs were also observed at some predated nests but frequency was not recorded.

Predator species could not be identified at all events (see **Sections 1.2.4** and **Section 1.6**). These observations, listed separately in **Table 10**, were included in estimates of predation rates.

Table 10: Predator species and predation rate recorded on each beach section, September 2016.

Beach Section	Nests*	Predator Species				Total Feral Pig Predation Rate (%)	Unid. Predator Species	Total predation Rate (%)
		Feral Pig	Feral Pig and Goanna	Feral Pig and Dingo	Total Feral Pig			
Northern	19	0	0	0	0	0	0	0
Boyd Bay	14	4	0	0	4	29	6	71
Boyd - Pera	40	32	0	0	32	80	3	88
Pera - Thud	22	11	8	0	20	91	2	100
Thud - Norman	1	1	0	0	1	100	0	100
Amban	14	1	0	1	2	14	1	21
Southern	19	14	0	0	13	68	6	100
Total	129	64	8	1	71	55	18	69

Table 10 Notes: Nests* includes 'potential nests' Unid: Unidentified

2.7.3 Predator Activity

During daytime surveys, predator species were identified from tracks and evidence of digging for eggs, at and around each nesting event. Three predator species were recorded: feral pig, wild dog (*Canis lupus dingos*) and goanna (gen. *Varanus*). Feral pig activity was identified by rooting holes and tracks, wild dogs by tracks and goannas by tracks/tail drags in the sand.

The frequency of each of the four documented indicators of predation and predator activity (Predator Activity: sighting of the predator, evidence from tracks; Predation: signs of the nest being dug and egg shells scattered at the surface of the sand) on each beach section is given in **Table 11**. The location of all predation events is shown in **Appendix A** and a detailed breakdown of predation and predator activity observation indicators recorded on each beach section is shown in **Appendix B**.

Table 11: Frequency of predation and/or predator activity indicators recorded on each beach section, September 2016.

Beach Section	Activity Description			
	Predator Activity		Predation	
	Sighting	Tracks	Digging	Shells
Northern	0	0	0	0
Boyd Bay	0	4	8	9
Boyd-Pera	1	34	33	33
Pera - Thud	0	22	18	14
Thud - Norman	0	1	1	1
Amban	0	2	2	2
Southern	0	16	19	17
Total	1	79	81	76

2.7.4 Field Camera Observations

Ten field cameras were deployed at nests on Ambam ($n = 3$), Boyd – Pera ($n = 5$) and Northern ($n = 2$) beach sections for a maximum duration of nine days (**Table 12**). At two monitoring locations nesting was confirmed by the Field Team who observed the turtle laying during night time tagging surveys on Boyd-Pera. The remaining nests were ‘potential nests’.

Table 12: Field camera deployment schedule.

Nest details			Camera Number	Survey Day										
Beach Section	Species	Confirmed		1	2	3	4	5	6	7	8	9	10	11
Ambam	Flatback	No	9											
Ambam	Flatback	No	6											
Ambam	Flatback	No	5											
Boyd-Pera	Flatback	No	2											
Boyd-Pera	Hawksbill	No	4											
Boyd-Pera	Flatback	No	10											
Boyd-Pera	Flatback	Yes*	8											
Boyd-Pera	Flatback	Yes*	7											
Northern	Hawksbill	No	3											
Northern	Flatback	No	1											

Table 11 Notes: Grey box: deployment period; *Turtle observed laying.

None of the monitored nests were predated. Two cameras captured predator (feral pig) activity on the Boyd-Pera section (**Figures 3 and 4; Section 2.7.4.2**). One camera captured a bird in the nest area on Northern section but no interaction with, or awareness of, the nest was observed (**Figure 5; Section 2.7.4.2**). The remaining eight cameras did not capture either predation or predator activity.

2.7.4.1 Boyd - Pera

On 26th September at 02:27, camera 10 captured five images of a feral pig (*Sus Scrofa*) on Boyd – Pera section. The pig was moving along tracks left by the ATV during tagging survey earlier that evening. (**Figure 3**).

On 25th September between 21:30 and 21:40, camera 7 captured 160 images of a male feral pig (*Sus Scrofa*) using his snout to sniff and dig at the surface of the sand in the vicinity of the clutch on Boyd – Pera section (**Figure 4**). The turtle that laid the clutch was tagged on 20th September (see **Section 2.5**). The pig did not locate the clutch during this survey (see **Appendix A** for location map).



Figure 3: Feral pig (*Sus scrofa*), images from field camera 10, Boyd – Pera, 26th September 2016.
Left: ATV passes by on return from tagging survey at 23:20, Right: Feral pig follows the ATV tracks at 02:27.



Figure 4: Feral pig (*Sus scrofa*) images from field camera 7 on Boyd – Pera on 25th September 2016.
The search took place between 21:30 to 21:40 on 25th September 2016 and was not successful.

2.7.4.2 Northern Section

On 22nd September at 05:39, camera 1 captured two images of a bird (species unknown) passing by the nest site on Northern section. The bird was not recorded investigating the nest (**Figure 5**).



Figure 5: Bird captured at the nest site on Northern section on 22nd September. The event was coincidental; the bird did not show awareness of the clutch.

2.8 Traditional Owner Engagement

Two traditional owners were engaged for the duration of these surveys, making a valuable contribution to all aspects of the field program. Through engagement with the project, traditional owners gained first-hand experience of the impact feral pig populations are having on marine turtle nests and ultimately, populations through understanding the relationship between predation, hatchling output and population recruitment and stability.

Further, traditional owners gained an appreciation of the process of survey design, i.e. consistency in approach, consideration of information collected and how it is used, the value of biological windows and how survey data translates into meaningful information.

2.8.1 Specific Skills and Experience

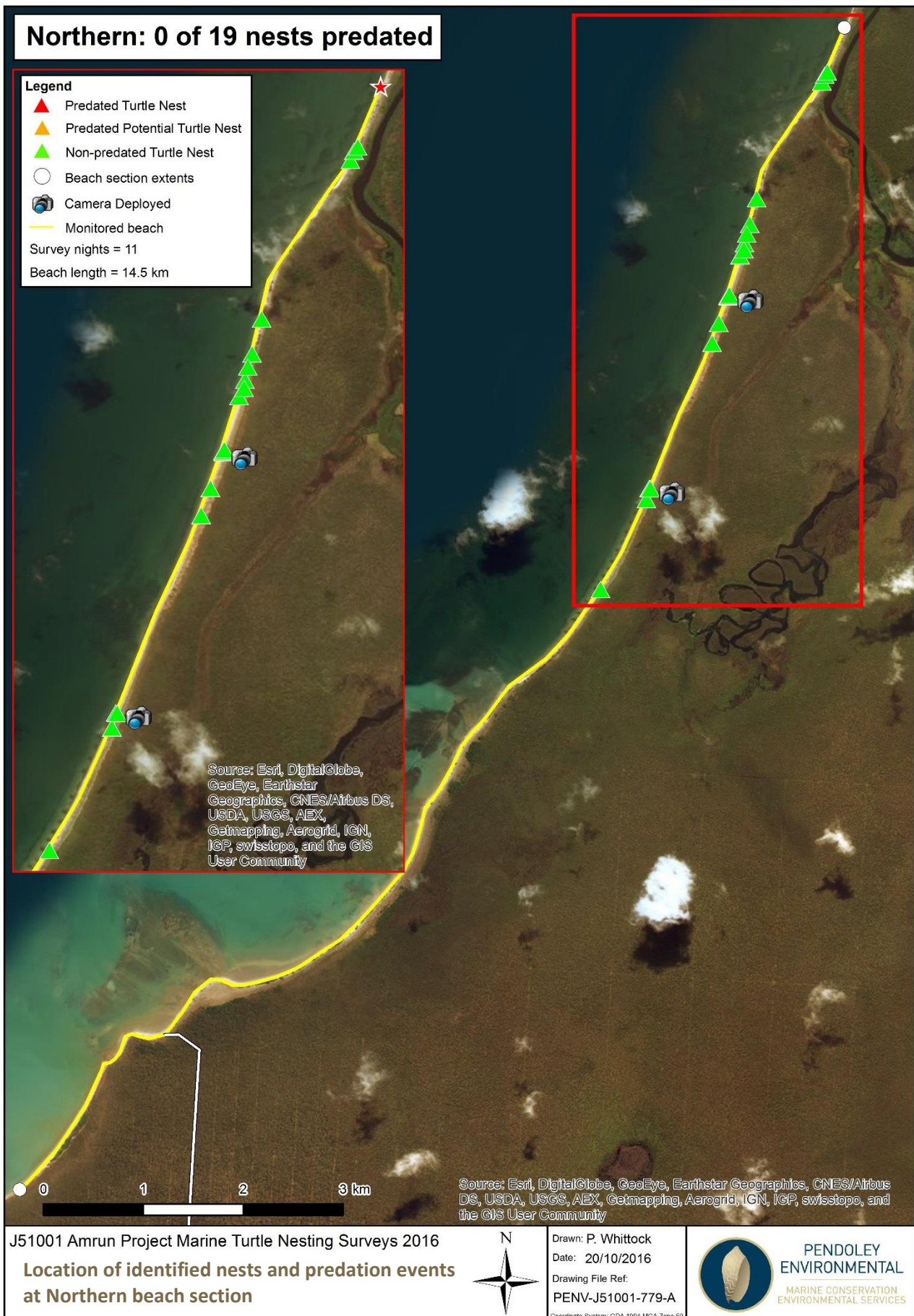
More specifically, the following skills were obtained:

- Understanding and identifying marine turtle nesting behaviour from tracks left in the sand;
- Species identification from track and nest morphology, observation of adult nesting females;
- Introduction to protocols for collecting and recording data in the field;
- Tagging and measuring adult female turtles;
- Capturing and restraining adult turtles to minimise disturbance;
- Restraining adult turtles to collect data;
- Gathering and handling eggs safely to collect data;
- Introduction to survey equipment;
- Weighing and measuring eggs;
- Deploying field cameras at the nest site to monitor for predation/predators;
- Risk assessment and JHA development;
- Safety awareness in the field: assessing new job tasks/steps; and
- Value of having the right PPE.

3 REFERENCES

- GUINEA, M (2014) Sea Turtle Monitoring South of Embley 2013 Report October 2014 in Appendix A: Marine Turtle Offset Plan 2016, RTA Weipa Pty Ltd.
- LIMPUS, C. J. (2013) TURDATA database manual: Queensland Turtle Conservation Project & monitoring of marine wildlife mortality & strandings. Department of Environment and Resource Management, Brisbane, Queensland Government.
- LIMPUS, C. J., PARMENTER, J. B. AND FLEAY, A (1983) The flatback turtle, *Chelonia depressa*, in Queensland: Post-nesting migration and feeding ground distribution. *Aust. Wildl. Res.* 10, 557 - 561.
- LIMPUS, C. J. (1971) the flatback turtle, *Chelonia depressa*, Garman in Southeast Qld Australia, *Herpetologica* 27(4): 431-446.
- PENDOLEY ENVIRONMENTAL (2016) Pendoley Environmental Marine Turtle Tagging Standard Operating Procedure PIMS-SOP01.
- PENDOLEY ENVIRONMENTAL (2015) Pendoley Environmental Track Census Standard Operating Procedure PIMS-SOP02_Rev5.

APPENDIX A: LOCATION OF PREDATED NESTS, SEPTEMBER 2016

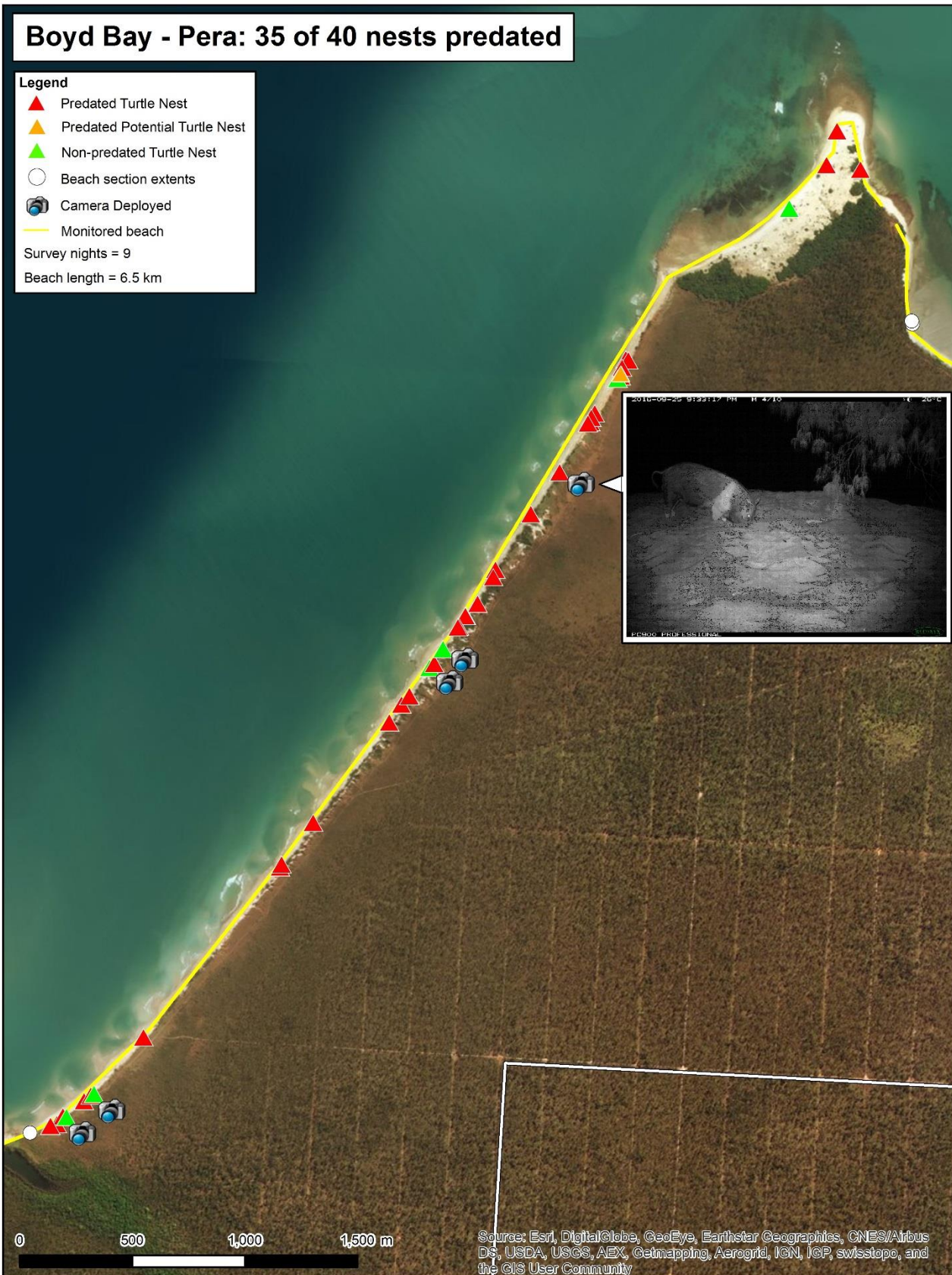




Boyd Bay - Pera: 35 of 40 nests predated

Legend

- ▲ Predated Turtle Nest
- ▲ Predated Potential Turtle Nest
- ▲ Non-predated Turtle Nest
- Beach section extents
-  Camera Deployed
- Monitored beach
- Survey nights = 9
- Beach length = 6.5 km



J51001 Amrun Project Marine Turtle Nesting Surveys 2016

**Location of identified nests and predation events
at Boyd - Pera beach section**



Drawn: P. Whittock

Date: 20/10/2016

Drawing File Ref:

PENV-J51001-781-A

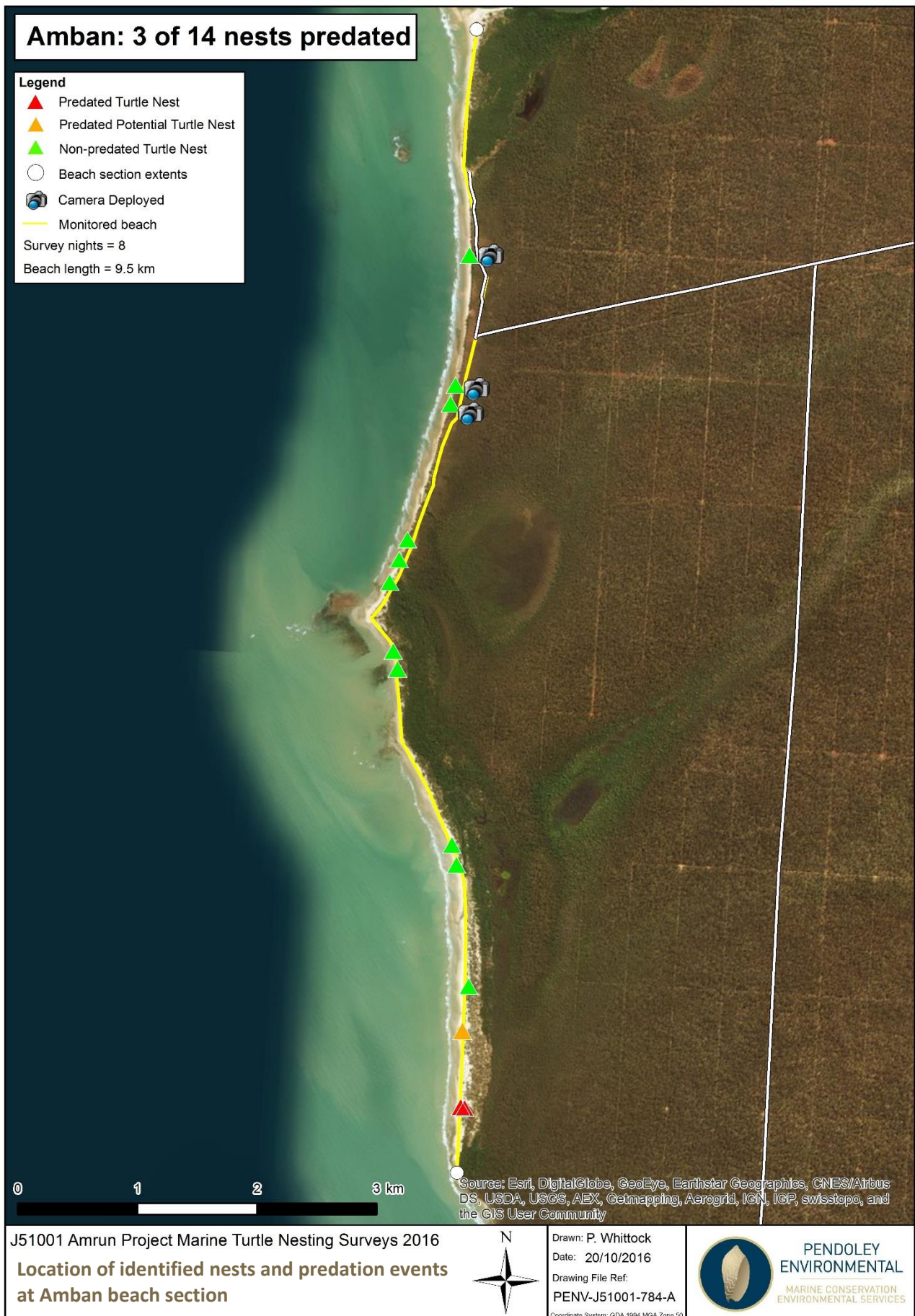
Coordinate System: GDA 1994 MGA Zone 50

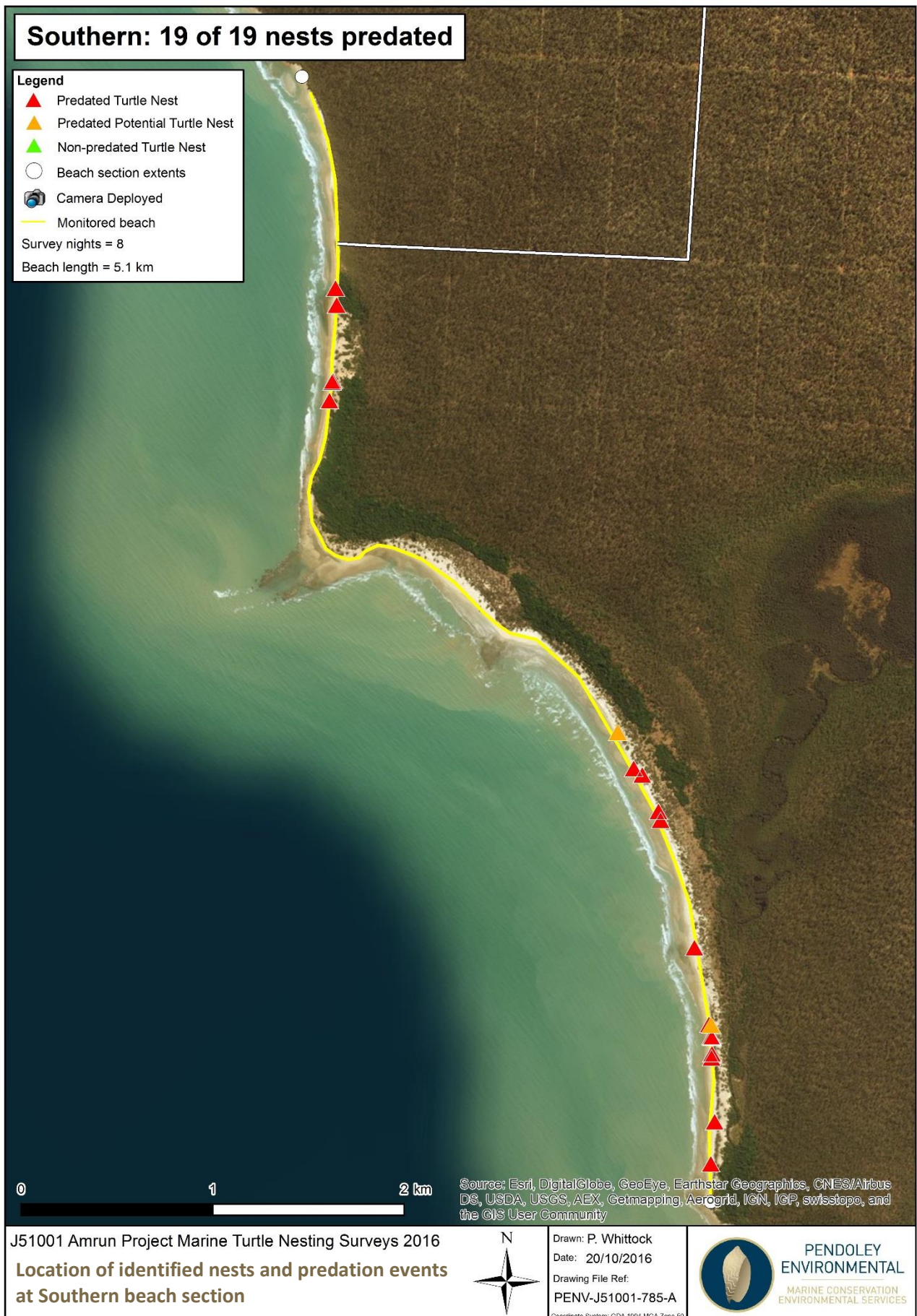


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**APPENDIX B: SUMMARY OF PREDATION AND PREDATOR ACTIVITY,
SEPTMEBER 2016**

Appendix B: Summary of predation, predator activity and predator species by beach section, September 2016.

Beach Section	All Nests (n)	Nesting Events with Predator Activity (n)				Nest Predation Rate (%)	Predator Species (n)					Predation and Predator Activity Indicators (n)				
		FCA/ FCU	Potential Nests	Nests	Total Nests		Feral Pig	Feral Pig and Goanna	Feral Pig and Dingo	Unid.	Total	Tracks	Sighting	Digging	Shells	Total
Northern	19	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0
Boyd Bay	14	0	1	9	10	71.4	4	0	0	6	10	4	0	8	9	21
Boyd - Pera	40	0	1	34	35	87.5	32	0	0	3	35	34	1	33	33	101
Pera - Thud	22	1	6	15	21	95.5	12	8	0	2	22	22	0	18	14	54
Thud - Norman	1	0	0	1	1	100.0	1	0	0	0	1	1	0	1	1	3
Amban	14	0	1	2	3	21.4	1	0	1	1	3	2	0	2	2	6
Southern	19	1	2	17	19	100.0	14	0	0	6	20	16	0	19	17	52
Total	129	2	11	78	89	69.0	64	8	1	18	91	79	1	81	76	237

Appendix B Notes: FCU: False Crawl U-turn: the turtle did not attempt to nest before leaving the nesting beach; FCA: False Crawl Attempt: The turtle made one or more unsuccessful nesting attempts before leaving the nesting beach; Unid: It was not possible to assign the activity to species.