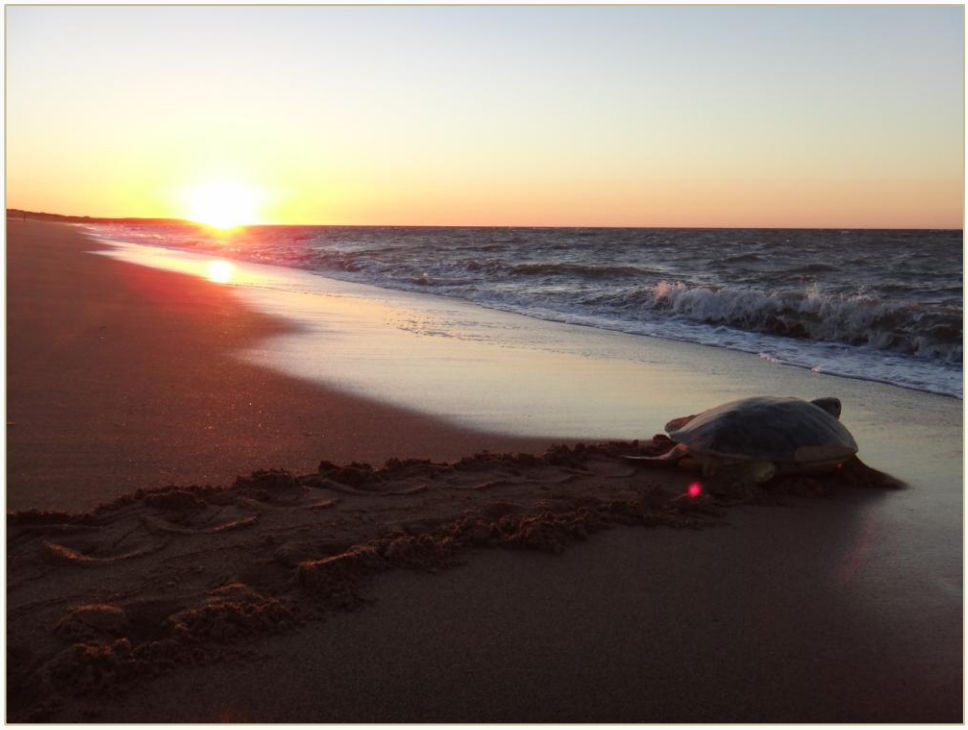
FORGE RESOURCES LTD

BALLA BALLA TRANSHIPMENT FACILITY

AERIAL SURVEYS 2012/13



Prepared by

Pendoley Environmental Pty Ltd

For

Forge Resources Ltd

January 2013

PENDOLEY ENVIRONMENTAL

MARINE CONSERVATION ENVIRONMENTAL SERVICES

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EXECUTIVE SUMMARY

The survey area was located in Balla Balla, Western Australia, on the mainland coast between the towns of Port Hedland and Karratha. A section of approximately 60 km of mainland coastline and 22 km (east-west length) of offshore island coastline (including Depuch, Ronsard, Sable and West Moore Islands) was covered daily by aerial transect.

The survey area covered a total of 838 km^2 (551 km^2 offshore and 287 km^2 inland). Aerial surveys were conducted over five days from 11th – 15th December 2012. Survey start time (hh:mm) on days two to five was 10:35 ± 0.0 (09:43 – 11:34, *n* = 4) elapsed since the previous high tide.

Low-level (≤ 3 tracks.day^{-1}) flatback turtle nesting activity was documented on Beach 2 on the mainland coast. No nesting activity by this species was seen at other surveyed locations (mainland beaches 1, 3, 4, 5 and Depuch, Ronsard, Sable or West Moore Islands). Clutch predation was identified from aerial photographs.

Low-level (≤ 3 tracks.day^{-1}) green turtle nesting activity was documented on the north-western coast of Ronsard Island. No nesting activity by this species was seen at other surveyed locations (mainland beaches 1, 2, 3, 4, 5 and Depuch, Sable or West Moore Islands).

Phoenix Environmental documented nesting activity by flatback turtles on the mainland coast and by an unidentified species on Depuch and Ronsard Islands during 27th November– 7th December2012 and two strandings of green turtles in the immediate vicinity of the Project site. LeProvost contributed observation of tracks on mainland Beach 2 to the immediate west of the project site.

A total of 206 turtles of unidentified species were sighted at the sea surface within the transect area over the five day survey period equalling total of 572 turtles present over the entire survey area. Mean daily sightings (sightings.day^{-1}) over the transect area were 41.2 ±37.0 (18 – 105, *n* = 5) and over the entire survey area were 114 ± 103 (50 - 291, *n* = 5).

A cumulative 3.5 % of all in-water sightings were made within 2 km of the coastal crossing of the project site and 24 % were more than 15 km from this location the project site. Forty-six per cent of all turtles were sighted between West Moore and Ronsard Islands with a heavier observation loading on the sea-ward side of the Islands within a 15 km (east-west) distance of one another, and an additional another 30 % were observed to the eastern side of this point, spread more evenly between the coastline and the furthest offshore extent of the survey area.

Dugong (*n* = 17), shark spp. (*n* = 2), dolphins (*n* = 15), stingray spp. (*n* = 4) and manta ray *spp.* (*n* = 2) were seen on two of five surveys days. Additional rays were seen during assessment of coastal nesting habitat in the shallows of West Moore Island but were not quantified.

Two juvenile turtles (either green or hawksbill; unconfirmed), were observed by Phoenix Environmental in the creek and mangrove habitat in the vicinity of the project site; no observations were made during our surveys as it was not possible to observe these animals from the air.

There was a strong positive correlation between the number of turtles and other mega-fauna observed offshore in each survey day. There was no correlation between the number of observations of turtles and tidal state (r^2 = 0.00), wind speed (knots) (r^2 = 0.06), wind direction (˚) (r^2

= 0.34) or cloud cover (%) (r^2 = 0.05). Similarly there was no correlation between the number of observations of all fauna and tidal state (r^2 = 0.00), wind speed (knots) (r^2 = 0.05), wind direction (˚) (r^2 = 0.37) or cloud cover (%) (r^2 = 0.00).

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1 INTRODUCTION

1.1 The Balla Balla Transhipment Facility

Forge plans to develop a mine, processing plant, shipment stockyard and barge loading facility near Balla Balla in the Pilbara Region of Western Australia (**Figure 1**).

The development will produce and export 6.0 Mtpa of magnetite concentrate.

The magnetite concentrate will be loaded onto barges for transhipment to larger Ocean Going Vessels (OGV) with a typical shipment size of 165,000 tonnes (Forge Resources, 2013).

1.2 Marine Turtle Populations in the Pilbara Region

A desktop review (Pendoley Environmental 2012) of marine turtle nesting activity in the Balla Balla region revealed:

- A total of 3,386 nesting female flatback turtles have been individually identified at Mundabullangana since 2005. Population modelling indicates the Mundabullangana and Mundabullangana West flatback turtle (*Natator depressus*) nesting population comprises an annual nesting cohort of greater than 1,700 females; combined these beaches host the largest flatback turtle rookery in Western Australia. These beaches are therefore considered of regional significance.
- Assessment of habitat type indicated potential nesting habitat for flatback and green (*Chelonia mydas*) turtle nesting that cumulatively may be of importance.
- Juvenile green, hawksbill (*Eretmochelys imbricata*) and potentially flatback turtles may be found in the creeks and inlets associated with coastal mangrove habitat.
- Offshore aggregations of adult and juvenile flatback and green turtles were likely present within the embayment and further offshore on the seaward side of the coastal islands.

Reliable estimates of abundance were therefore required for monitoring for potential risks to flatback turtles associated with the BBTF. Aerial survey was determined to be the most effective method to obtain these data and was scheduled for and completed during December of the 2012/13 reproductive season.

2 SCOPE OF WORKS

Based on the outcome of a desktop review (**Section 1.2**; Pendoley Environmental 2012), Forge Resources Ltd commissioned Pendoley Environmental to conduct field surveys of potential marine turtle habitat in the proximity to the Balla Balla Transhipment Facility Area of Interest to assess spatial distribution and abundance of:

- Marine turtle (*Cheloniidae*) nesting activity at all potential nesting habitat (**Figure 1**) as identified in Pendoley Environmental 2012 (Forge Resources 2012);
- Offshore aggregations of marine turtles in near shore waters (Forge Resources 2012);
- Juvenile turtles in mangrove/creek (juvenile developmental) habitat; and
- Dugong (*Dugong dugon*).

In addition Pendoley Environmental documented and described all mega-fauna observed offshore. Findings are described with reference to the potential impact to marine turtle and other marine mega-fauna populations from construction and operation of the Balla Balla Transhipment Facility.

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3 METHODOLOGY

3.1 Survey Area

The survey area was located in Balla Balla, Western Australia, on the mainland coast between the towns of Port Hedland and Karratha (**Figure 1**).

3.2 Survey Schedule, Duration and Conditions

Aerial surveys were conducted over five consecutive days from 11th – 15th December 2012.

Daily start time was determined primarily by tidal regime to capture potential variation in observations under fluctuating tidal regimes. The area has large (>6 m) tides and spatial abundance and distribution of marine fauna were expected to vary substantially with tidal regime. Daily survey schedule, duration and high tides are detailed in **Table 1** below. Offshore transects ran from west – east, as did survey of coastal habitat. See **Figure 1** for detail.

Prior to initiation of each survey, wind speed (knots), direction (˚), cloud cover (%) and Beaufort Sea State (BSS) were recorded. Weather conditions were favourable with increasing cloud cover (%) during days four and five (**Table 1**). This proved beneficial for observation by reducing oceanic glare. Increased cloud cover during this survey was also associated with extremely calm ocean conditions ideal for observation.

Table 1: Weather conditions and Beaufort Sea State (BSS).

Survey Day	Wind speed (knots)	Wind direction (˚)	Cloud Cover (%)	BSS
1	14	335	10	1
2	12	3	30	0
3	9	37	50	0
4	9	284	50	0
5	7	283	60	0

3.3 Survey Design

A survey section of approximately 60 km of mainland coastline and 22 km (east-west length) of offshore island coastline (including Depuch, Ronsard, Sable and West Moore Islands) fell within the potential impact area of the Balla Balla Transhipment Facility footprint. Potentially suitable nesting habitat was remotely identified on five sections of mainland coast (beaches 1 – 5, Pendoley Environmental 2012) and on all four islands (**Appendix 1**). Survey flights therefore included coastal (beaches 1 – 5) and island (Ronsard, Sable, Depuch and West Moore) nesting habitat ('nesting surveys') and survey of offshore, coastal and inland creek areas westward and landward of Ronsard Island and to the end of Beach 5 (**Figure 1**).

The polygon selected for the transect area extended 25 km east and west of the proposed jetty location and up to 7 km inland and 11 km offshore at its widest point and included 22 transects. Transect lines extended inland over sections of mangrove creek habitat to capture juvenile turtle populations known to be present in ecologically similar and proximal locations. Start and end points of each transect were spaced 5 km apart. To maximise coverage, transect lines were laid out in a 'sawtooth' design (Buckland et al. 2001) as per **Figure 1**.

3.3.1 Aviation

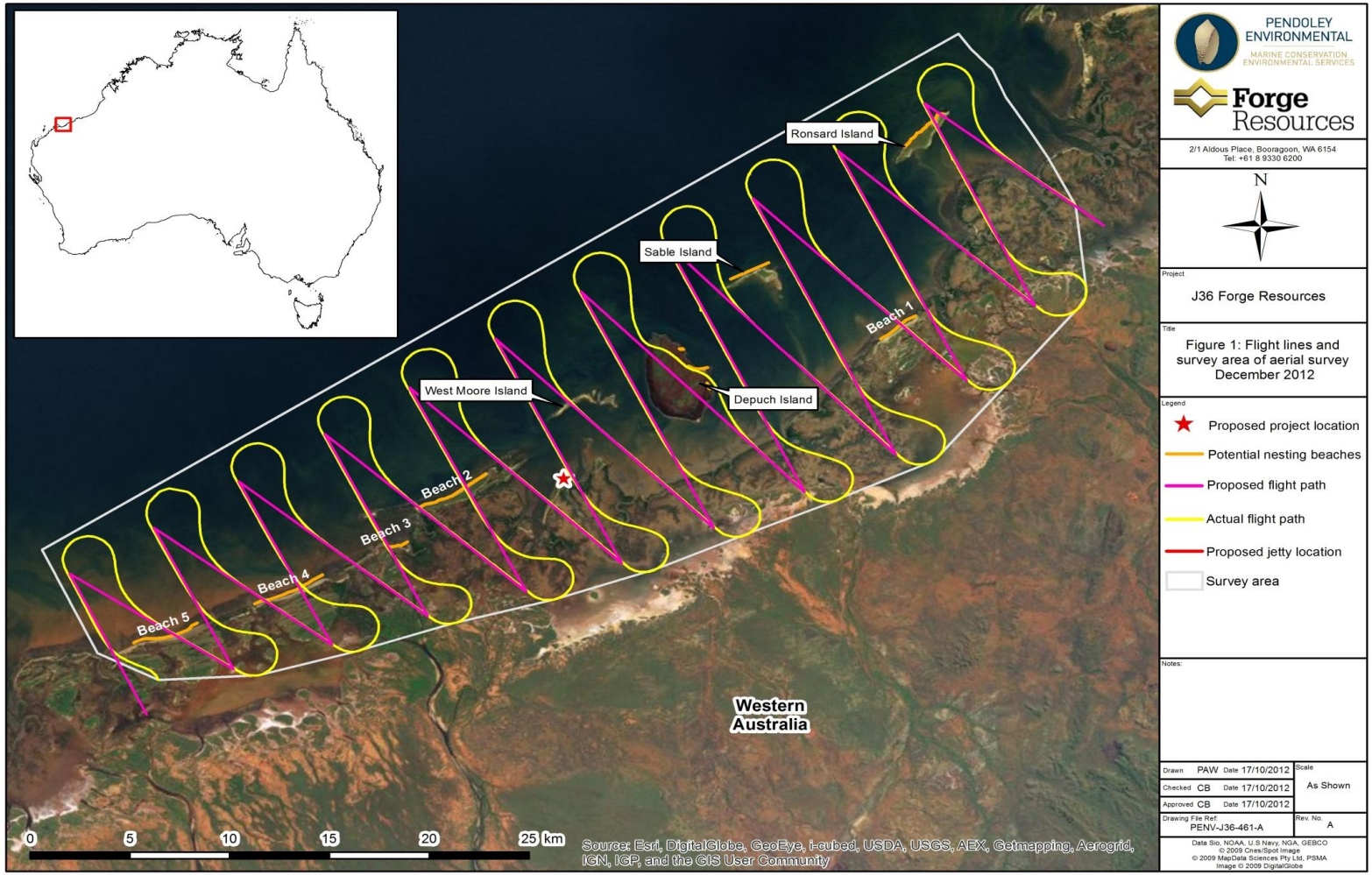
Flights were conducted from a Cessna (VH-PNB) fixed wing aircraft flying at a minimum altitude of 500 ft (153 m) and a true ground speed of 120 knots. Ground speed is variable dependent upon prevailing wind, adding either a head or tail wind component and thus true air speed (knots) was 136 ± 5.6 (130 - 144, *n* = 5). Transect line end points were entered into the fight management system to form a flight plan flown by autopilot in RNAV mode (GPS). Transect lines were reacquired by the auto pilot executing a rate 1 ½ turn to intersect the next line at 30˚; at 120 knots this turn had a diameter of about 2.6 km (**Figure 1)**. Also shown is the deviation around Depuch Island which rises above the lowest legal flight height and thus flight path diverted and re-joined the flight path when it was safe to do so.

Using this procedure the flight path of the aircraft differed to that dictated by the transect lines, covered a greater portion of the survey area for increased observation and was repeatable with a high degree of accuracy on consecutive survey days. Length (km) of aerial survey flight path lines, being different therefore to transect lines created during design, was 17.0 ± 3.0 (9.9 – 20.6, *n* = 22); total length 373.6 km (**Appendix 2**).

3.3.1 Observations

Two observers seated either side of the plane independently scanned survey strips of 163 m on each side of the aircraft. The 200 m transect width was marked by a divet (change in width) on the wing struts. Each sighting was called and position in decimal degrees (dd.ddddd˚) marked using an on-board position marker that allowed rapid documentation of multiple sightings and linked recorded latitude and longitude with position documented in the metadata of each photo file.

The angle of observation was as per **Appendix 3** and was equivalent to 36 % of the entire surveyed offshore area. The wing-cam captured an additional 46 m coverage of the offshore area and this information is available within the photo-documentation to be presented to the Client.


Ronsard Island
Sable Island
Beach 1
West Moore Island
Depuch Island
Beach 2
Beach 3
Beach 4
Beach 5
Western Australia
0
5
10
15
20
25 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
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N
Project
J36 Forge Resources
Title
Figure 1: Flight lines and survey area of aerial survey December 2012
Legend
Proposed project location
Potential nesting beaches
Proposed flight path
Actual flight path
Proposed jetty location
Survey area
Notes:
Drawn PAW Date 17/10/2012
Checked CB Date 17/10/2012
Approved CB Date 17/10/2012
Scale As Shown
Drawing File Ref: PENV-J36-461-A
Rev. No. A
Data Sio, NOAA, U.S Navy, NGA, GEBCO
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3.3.2 Potential nesting habitat

Marine turtle nesting activity as indicated by tracks left in the sand following overnight emergences was documented by Dr Catherine Bell (Field Team Leader and Senior Scientist) and Rob Ryan (Pilot, experienced in aerial survey techniques for detection of marine turtles and nesting activity). The track census survey methodology used for this program is based on techniques developed for beach surveys within the Barrow/Montebello/Lowendal Island complex (Pendoley 2005) and is consistent with IUCN SSC Marine Turtle Specialist Group methodology (Schroeder & Murphy 1999). Survey documented all nesting activity as follows:

- Daily survey of beach habitat was conducted prior to beginning offshore transects. Flight lines of nesting habitat ran parallel to each sandy section of mainland and island coastline. The 'wing-cam' was positioned in the wing of the plane and it was not possible to view the area being photographed; consequently each coastal flight line was conducted twice daily, once for photo-documentation and a second time for observer documentation.

Observed activity was documented as follows:

- Tracks below the high tide mark (BHT). These tracks indicate the number of animals attempting to nest since the overnight high tide. This is therefore an underestimation of the number of turtles traversing the beach overnight as it does not account for animals crawling up and down the beach before the high tide.
- Tracks above the high tide level (AHT). This information provides an indication of marine turtle nesting activity on the beach since the last high tide and prior to the last high spring tide.
- Tracks above the last high spring tide (ALHST). This information provides detail regarding all marine turtle nesting activity in the recent past. This could be days to months depending on the metocean conditions (e.g. cyclones, storms and tidal surge will wipe the beach clean).
- Nest predation. Nest predation is recorded for nests that clearly show evidence of animal foot prints and digging to egg/hatchling depth. Eggs, egg shell or hatchling remains may be visible.
- Quantification of nesting effort was assessed subjectively using the following scale:
    - low = ≤ 10 tracks per beach.day^{-1};
    - medium = 11 - 50 tracks per beach.day^{-1}; or
    - high = ≥ 50 tracks per beach.day^{-1}.

3.3.3 Potential mating, inter-nesting and developmental habitat

Marine habitat was surveyed as per **Section 3.3** and observations mapped and analysed using ArcMAP 10 (ESRI).

3.3.4 Juvenile developmental habitat (mangrove creeks)

Mangrove habitat was surveyed as per **Section 3.3.**No analyses were performed.

3.4 Photo-documentation

Photo-documentation was made using a Sony Alfa 99, 24 mega-pixel camera with a 28 mm lens linked to a controller box in the cockpit allowing the pilot to control shooting frequency, ensuring contiguous and uninterrupted photographic coverage. Position in decimal degrees (dd.ddddd) of each photo was documented and is stored in the in the metadata of each photo file. File size was ~ 16 MB to allow for zoom required to identify or confirm activity and provide images of adequate quality.

3.5 Data Analysis

The observable area of offshore strip transects ('marine transect area') was 198 km^2 equalling 36 % of the entire survey area of 550 km^2. Observations over the marine transect area were multiplied by 2.8 (100/36) to extrapolate findings and infer sea-surface abundance within the entire offshore area of the aerial survey polygon.

Data are presented as mean ± standard deviation (range, *n*) unless otherwise stated. No statistical analyses were required.

3.5.1.1 Image processing

Software to detect in-water observation was created but were not sufficient to detect fine-scale observations. Manual processing offshore images may be conducted in the future as all photo-documentation is held on file.

3.5.1.2 Cross-referencing

Observations of nesting activity were reviewed and where possible cross-referenced with photo-documentation of the same positions recorded by the observer during aerial survey. This process provided more accurate and detailed information than that observed during the survey, providing reliable confirmation and quantification of activity where signs of activity were old and/or weathered due to high winds and therefore less clear from the air.

3.5.1.3 Spatial analysis

Observations were mapped using ArcMap 10.1 (ESRI). Sighting frequency was analysed:

- per transect; and
- per 1 km 'buffer zone' up to 5 km, generated around the project location.

Marine turtle sighting density used ArcMap 10.1 to generate a 1 km x 1 km grid using Spatial Analyst in ArcGIS 10.1 (ESRI) and binned sightings into spatial units of 1 km^{-1}

3.6 Survey Limitations

The aerial survey had the following limitations:

- Neither species life-stage can be confirmed for offshore observations made by aerial survey.
- There are no dive data available regarding juveniles of either flatback, green or hawksbill turtles in the region. It is not possible therefore to develop a conversion factor to calculate the number of turtles that might be present three-dimensionally within the water column of the embayment.
- As individual animals are not uniquely identifiable, there is limited potential for resighting of the same animals across aerial flight lines. It is unlikely that this would have biased observations in any way, due to the speed of travel of observers and known swim speeds in marine turtles, but this consideration should be noted.
- It was not possible to accurately quantify or confirm predation. There are differences in presentation between a site where a nesting females who has dug an egg chamber and then chosen not the lay (abandonment) and a clutch that has been excavated by a predator and consumed, that can only be confirmed by micro-scale (ground-truthing) investigation of footprints and sand behaviour in the immediate vicinity of the event.
- Data kindly provided from Phoenix Environmental and LeProvost were not included in analyses as they fell largely outside the peak nesting period for this species, but are presented within the body of the report for completeness.
- Survey duration of five days is approximate to ~7 % of the annual nesting season for flatback turtles and less for other species with less temporally constrained reproductive periods that do not nest in every season. Caution must therefore be applied to interpretation of results regarding abundance. All findings within are therefore presented as a 'minimum' number.
- Variation in observation frequency among species described within should be approached with some caution, as little is known regarding the behavioural characteristics of other fauna observed and these species-specific traits may influence sighting abundance.
- Only animals at the sea surface could be accounted for and therefore all numbers observed offshore are conservative and should be considered a 'minimum number ie: there were '*at least' x* turtles within the survey area.

4 RESULTS

4.1 Survey Area

The survey area covered a total of 838 km^2 (551 km^2 offshore and 287 km^2 inland).

4.2 Survey Schedule and Duration

Start time (hh:mm) on survey days two to five was 10:35 ± 00.00 (9:43 – 11:34, *n* = 4) elapsed since the previous high tide. Survey on day one began ten minutes following the high tide. Survey start on day five was 3:20 before the high tide, to capture data capture under low tide conditions (**Table 2**).

Table 2: Survey schedule and duration (hh:mm)

Date		Mainland cost and Islands		Offshore transects		High Tide	Total
(2012)	Day #	Start Time	End Time	Start Time	End Time	Time	Duration
11-Dec	1	08:40	09:20	09:20	10:50	09:10	2:10
12-Dec	2	08:30	09:10	09:10	10:40	10:00	2:10
13-Dec	3	08:50	09:30	09:30	11:00	10:50	2:10
14-Dec	4	09:15	10:00	10:00	11:50	11:34	2:35
15-Dec	5	08:40	09:20	09:20	10:50	11:50	2:10

4.3 Nesting Habitat

4.3.1 Abundance and spatial distribution of nesting activity

4.3.1.1 Flatback turtles

Low-level (≤ 3 tracks.day^{-1}) flatback turtle nesting activity was documented Beach 2 on the mainland coast. On day one on Beach 2, a total of 36 flatback turtle tracks ALHST, 36 AHT and 1 BHT were documented. Nesting activity (tracks) was observed again on survey days three (*n* = 1) and four (*n* = 3). No nesting activity by this species was seen at other surveyed locations (mainland beaches 1, 3, 4, 5 and Depuch, Ronsard, Sable or West Moore Islands; **Figure 2** and **Table 3**).

4.3.1.2 Green turtles

Low-level (≤ 3 tracks.day^{-1}) green turtle nesting activity was documented AHT (*n* = 2) and BHT (*n* = 2) on survey day one on the north-western coast of Ronsard Island. No further activity by this species was documented at this location until day five when two tracks were identified BHT. No nesting activity by this species was seen at other surveyed locations (mainland beaches 1, 2, 3, 4, 5, Depuch, Sable or West Moore Islands; **Figure 2**and **Table 3**).

4.3.1.3 Nesting Activity observations outside peak season

Nesting by an unidentified species was documented on Depuch (*n* = 1) and Ronsard (*n* =2) Islands and flatback turtle tracks (*n* = 4) were observed on the mainland (**Figure 2**) coast during November 27th – December 7th 2012 (Phoenix Environmental). Additional tracks (*n* =4) were sighted on mainland Beach 2 (Ian LeProvost, pers. comm.; 13th November 2012 (**Figure 2**).

4.3.1.4 Strandings

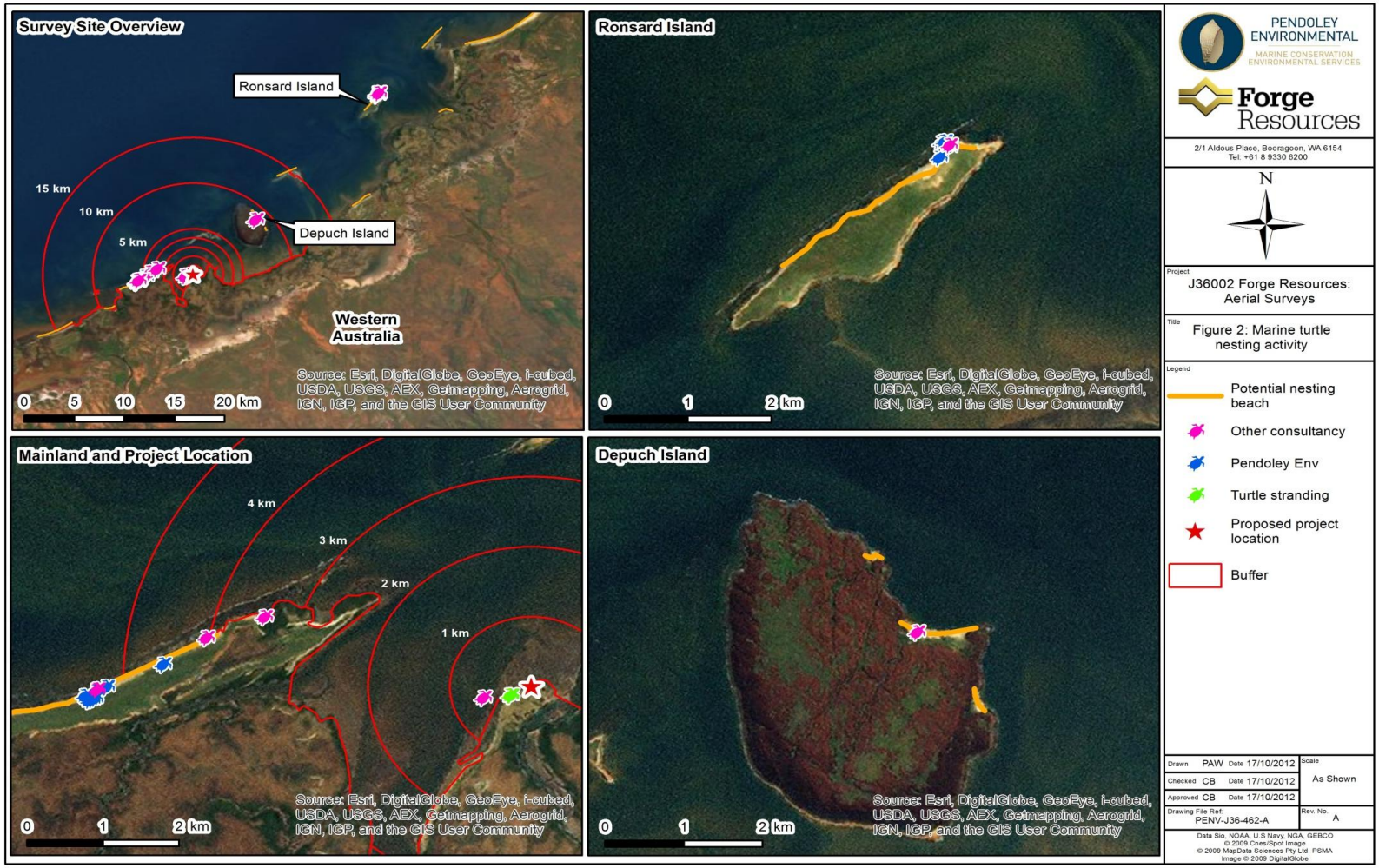
Phoenix Environmental contributed observation of two green turtle strandings in the immediate vicinity of the Project site (**Figure 2**). These data are being processed by Pendoley Environmental and will be submitted into the Western Australian Department of Conservation (DEC) strandings database.

4.3.1 Predation

Predation of clutches on mainland Beach 2 was observed in photo-documentation but has not been quantified.

Table 3: Flatback and green turtle nesting activity. Beach 2: flatback turtles; Ronsard Island: green turtles.

		Survey Day					
Location	**Tracks (n)**	**1**	**2**	**3**	**4**	**5**	**Total**
Time (hh:mm) since LHT		+0:10	11:34	10:53	10:13	09:43	-
Beach 2	**ALHST**	36	0	0	0	0	36
	AHT	36	0	0	0	0	36
	BHT	**1**	0	1	3	0	5
Ronsard Is	**AHT**	2	0	0	0	0	2
	BHT	2	0	0	0	2	4
Total		77	0	1	3	2	83


Survey Site Overview
Ronsard Island
15 km
10 km
5 km
Depuch Island
Western Australia
0 5 10 15 20 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
Ronsard Island
0 1 2 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
Mainland and Project Location
4 km
3 km
2 km
1 km
0 1 2 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
Depuch Island
0 1 2 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
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Tel: +61 8 9330 6200
N
Project
J36002 Forge Resources: Aerial Surveys
Title
Figure 2: Marine turtle nesting activity
Legend
Potential nesting beach
Other consultancy
Pendoley Env
Turtle stranding
Proposed project location
Buffer
Drawn PAW Date 17/10/2012
Checked CB Date 17/10/2012
Approved CB Date 17/10/2012
Scale
As Shown
Drawing File Ref.
PENV-J36-462-A
Rev. No.
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Data Sio, NOAA, U.S Navy, NGA, GEBCO
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4.4 Mating, Inter-nesting and Developmental Habitat

4.4.1 Marine turtle sightings

A total of 206 turtles of unidentified species were sighted at the sea surface within the transect area (**Figure 3**) equalling 84 % of all marine mega-fauna sightings over the five day survey period. Extrapolation (see **Section 3.5**) of data from transect strips indicated a total of 572 turtles may have been present at the sea surface in the survey area within the survey period. Mean daily sightings (sightings.day^{-1}) over the transect area were 41.2 ± 37.0 (18 – 105, *n* = 5) and over the entire survey area were 114 ± 103 (50 – 291, *n* = 5)

4.4.2 Spatial distribution

4.4.2.1 Distance from the project site

A cumulative 3.5 % of all in-water sightings were made within 2 km of the coastal crossing of the project site and 24 % were more than 15 km from this location. See **Table 4** and **Figure 3** (above) for further detail.

4.4.2.2 Distribution with the survey area

Forty-six per cent of all turtles were sighted between West Moore and Ronsard Islands with a heavier loading on the seaward side of the islands within a 15 km (east-west) distance of one another, and an another 30 % were observed to the east of this point, spread more evenly between the coastline and the furthest offshore extent of the survey area. Sighting density is shown in **Figure 4.**

4.4.3 Developmental habitat- mangrove/creeks

Sighting of two juvenile turtles by Phoenix Environmental have been identified as either green or hawksbill turtles. The image below (**Plate1**) shows two images of one sighting.

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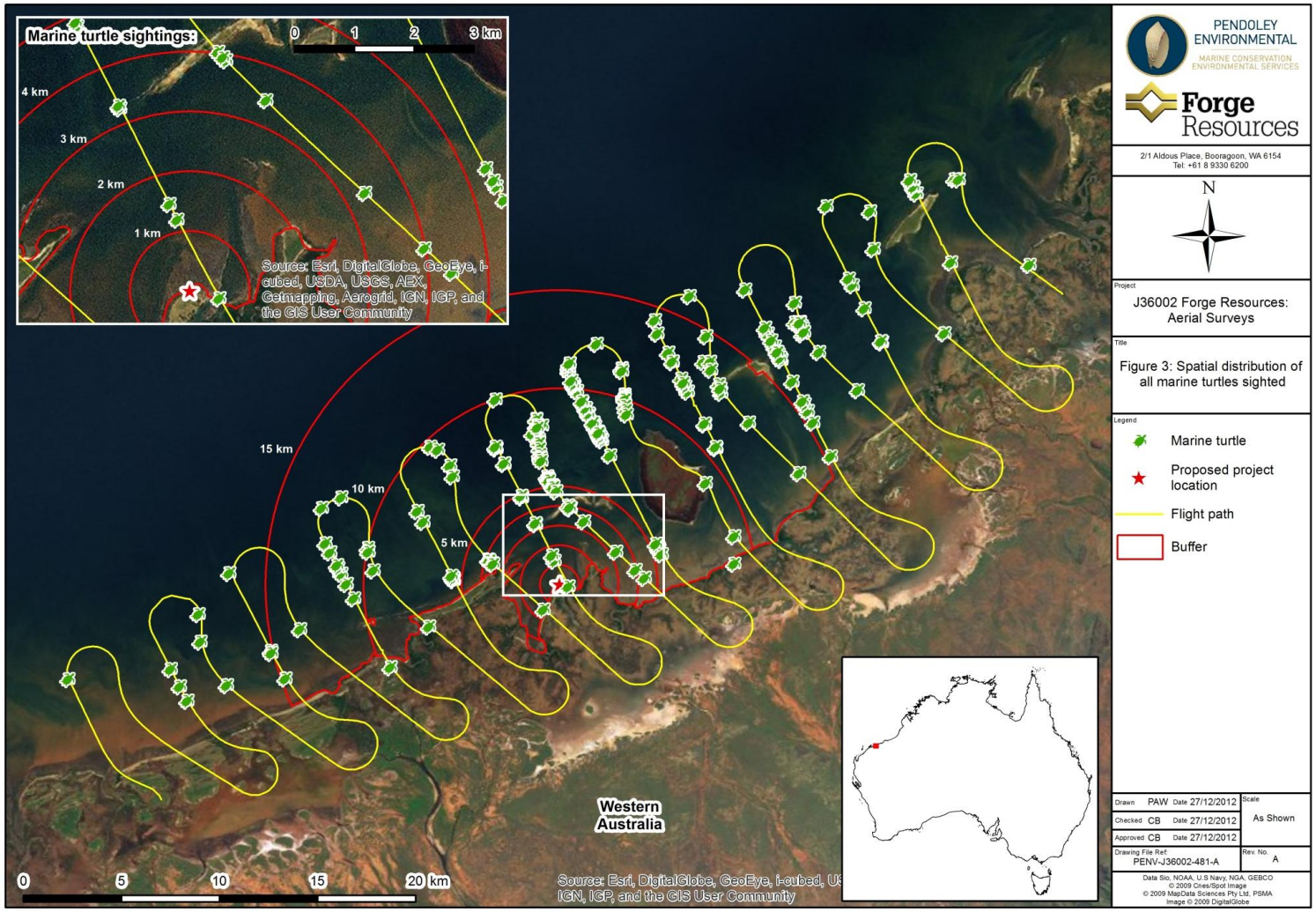
Marine turtle sightings:
0 1 2 3 km
4 km
3 km
2 km
1 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
15 km
10 km
5 km
Western Australia
0 5 10 15 20 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, US
IGN, IGP, and the GIS User Community
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Forge Resources
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Tel: +61 8 9330 6200
N
Project
J36002 Forge Resources: Aerial Surveys
Title
Figure 3: Spatial distribution of all marine turtles sighted
Legend
Marine turtle
Proposed project location
Flight path
Buffer
Drawn PAW Date 27/12/2012
Checked CB Date 27/12/2012
Approved CB Date 27/12/2012
Scale
As Shown
Drawing File Ref.
PENV-J36002-481-A
Rev. No.
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Plate 1: Images of a juvenile turtle observed in coastal creek/mangrove habitat

(Images courtesy of Phoenix Environmental)

Table 4: Cumulative proportion (%) of turtles sighted within each 1 km distance of the project site

Buffer distance (km)	Turtles sighted (cumulative)	cumulative %
1	1	0.7
2	4	2.7
3	4	2.7
4	14	9.6
5	22	15.1
6	36	24.7
7	44	30.1
8	60	41.1
9	76	52.1
10	95	65.1
11	109	74.7
12	124	84.9
13	135	92.5
14	143	97.9
15	146	100

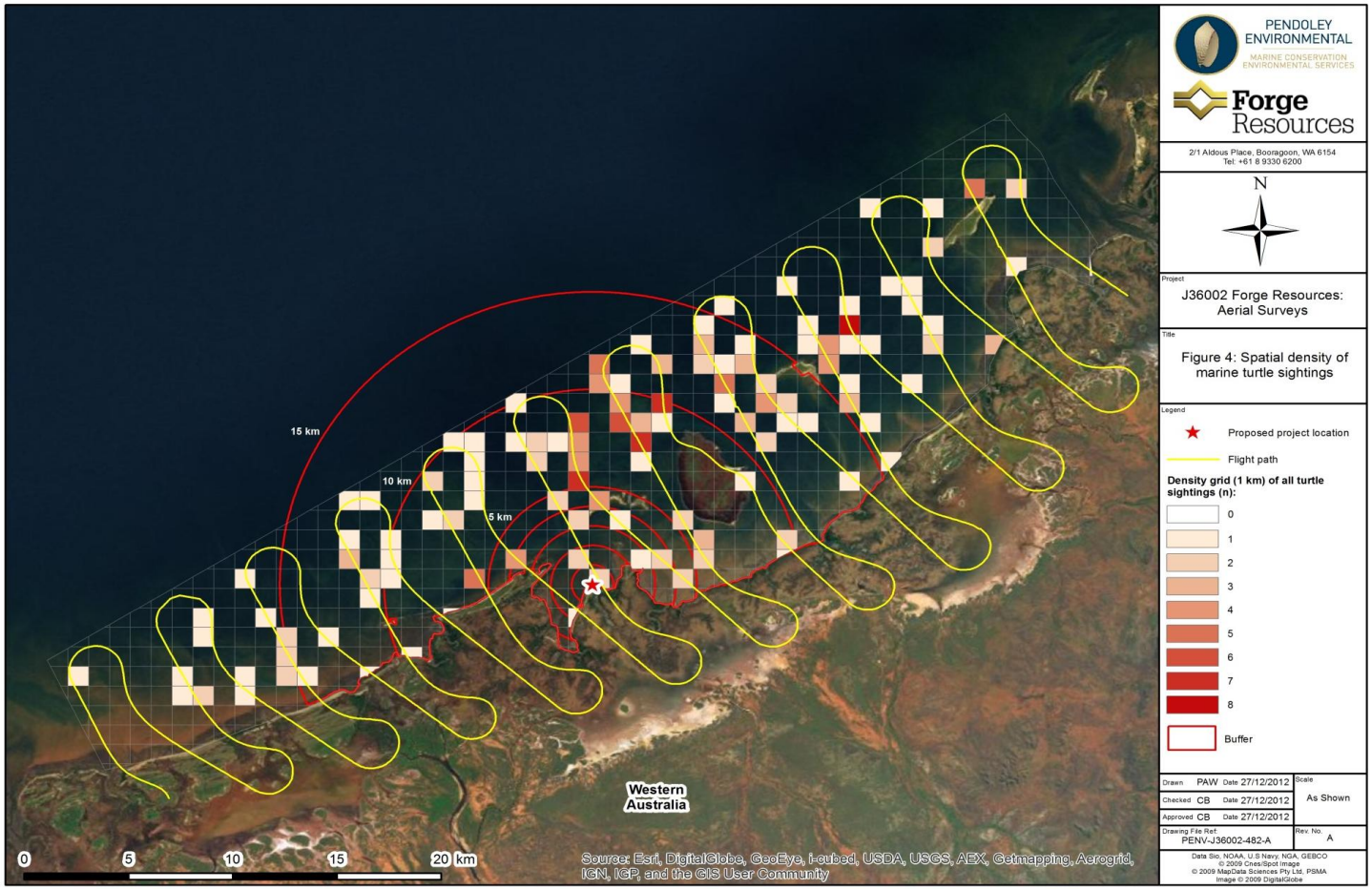
15 km
10 km
5 km
Western Australia
0
5
10
15
20 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
PENDOLEY ENVIRONMENTAL
MARINE CONSERVATION ENVIRONMENTAL SERVICES
Forge Resources
2/1 Aldous Place, Booragoon, WA 6154
Tel: +61 8 9330 6200
N
Project
J36002 Forge Resources: Aerial Surveys
Title
Figure 4: Spatial density of marine turtle sightings
Legend
Proposed project location
Flight path
Density grid (1 km) of all turtle sightings (n):
0
1
2
3
4
5
6
7
8
Buffer
Drawn PAW Date 27/12/2012
Checked CB Date 27/12/2012
Approved CB Date 27/12/2012
Scale
As Shown
Drawing File Ref: PENV-J36002-482-A
Rev. No. A
Data Sio, NOAA, U.S Navy, NGA, GEBCO
© 2009 Cnes/Spot Image
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Image © 2009 DigitalGlobe

4.4.4 Other marine fauna & flora

4.4.4.1 Dugong

After turtles, dugong were the most abundant (*n* = 17) of all mega-fauna observed; 17 individuals were seen on four of five survey days equalling 3.4 ± 1.9 sightings.day^{-1} (0 – 5, n = 5) (**Table 5** and **Figure 5**).

4.4.4.2 Sharks

Two shark *spp*. were sighted; one on day one and the second on day two of the survey equalling 0.4 ± 0.8 sightings.day^{-1} (0 – 2, n = 5) (**Table 5** and **Figure5**).

4.4.4.3 Rays

Stingray *spp*. (*n* = 4) and manta ray spp. (*n* = 2) sightings were observed, mean sightings.day^{-1} were 0.6 ± 0.5 (0 – 1, *n* = 5) and 0.4 ± 1.2 (0 – 3, *n* = 5) respectively (**Table 5** and **Figure 5**). Additional rays (*n* = > 20) were seen aggregating in the shallows of West Moore Island during assessment of coastal nesting habitat, but not during offshore transects and are therefore not included in the table below.

4.4.4.4 Dolphins

Cetacean *spp.* (*n* = 15) were seen on two of five survey days equalling a daily mean (sightings.day^{-1}) of 3.0 ± 3.7 (0 – 8, *n* = 5) (**Table 5** and **Figure 5**).

4.5 Creek and Mangrove Habitat

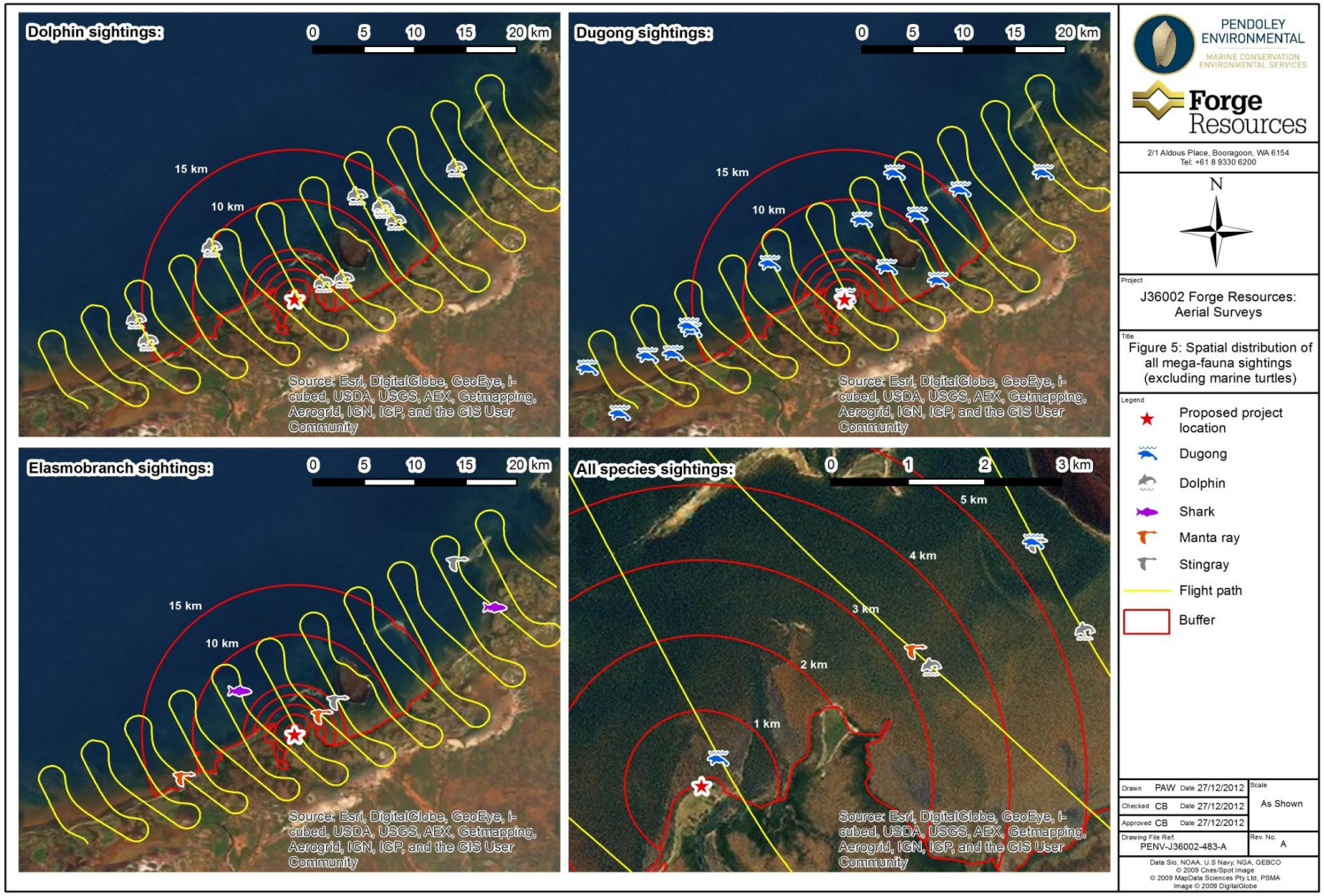
No turtles or other fauna were observed in creek or mangrove habitat.

Table 5: Daily observations of marine mega-fauna.

	Survey Day					
Species	**1**	**2**	**3**	**4**	**5**	**Total**
Dugong	5	5	0	4	3	17
Dolphin	0	0	0	8	7	15
Manta ray	2	0	0	0	0	2
Shark	1	1	0	0	0	2
Stingray	0	0	0	3	0	3
Total	**8**	**6**	**0**	**15**	**10**	**39**
Turtles	36	13	18	105	34	206

4.6 Survey Conditions

There was a strong positive correlation between the number of turtles and other mega-fauna observed in each survey day. There was no correlation between the number of observations of turtles and tidal state (mins before high tide) (r^2 = 0.00), wind speed (knots) (r^2 = 0.06), wind direction (°) (r^2 = 0.34) or cloud cover (%) (r^2 = 0.05). Similarly there was no correlation between the number of observations of all fauna and tidal state (mins before high tide) (r^2 = 0.00), wind speed (knots) (r^2 = 0.05), wind direction (°) (r^2 = 0.37) or cloud cover (%) (r^2 = 0.00).


Dolphin sightings:
0 5 10 15 20 km
15 km
10 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
Dugong sightings:
0 5 10 15 20 km
15 km
10 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
Elasmobranch sightings:
0 5 10 15 20 km
15 km
10 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
All species sightings:
0 1 2 3 km
5 km
4 km
3 km
2 km
1 km
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
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MARINE CONSERVATION ENVIRONMENTAL SERVICES
Forge Resources
2/1 Aldous Place, Booragoon, WA 6154
Tel: +61 8 9330 6200
N
Project
J36002 Forge Resources: Aerial Surveys
Title
Figure 5: Spatial distribution of all mega-fauna sightings (excluding marine turtles)
Legend
Proposed project location
Dugong
Dolphin
Shark
Manta ray
Stingray
Flight path
Buffer
Drawn PAW Date 27/12/2012
Checked CB Date 27/12/2012
Approved CB Date 27/12/2012
Scale
As Shown
Drawing File Ref: PENV-J36002-483-A
Rev. No. A
Data Sio, NOAA, U.S Navy, NGA, GEBCO
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Image © 2009 DigitalGlobe

5 DISCUSSION

Surveys were conducted during the peak reproductive season for flatback and green turtles in the region (Pendoley 2005, Pendoley Environmental 2012) and turtles observed could therefore have been migratory adult nesting females or males of any species. Proximity to Cowrie beach, Mundabullangana, where a total of 3,386 nesting female flatback turtles have been individually identified since 2005 (Pendoley Environmental 2012), would imply potential for presence of inter-nesting adult females of this species in the area. Flatback turtles tracked from Cowrie beach travelled a total distance of 38.0 ± 7.8 km (range = 32.1 – 46.8, *n* = 3) and had a maximum displacement distance away from the nesting beach of only 11.0 ± 4.2 km (6.5 – 14.8, *n* = 3) (Whittock et al 2012) and it is therefore unlikely that these animals use the embayment during the sensitive inter-nesting period.

This, combined with the very low-level of nesting observed with the survey area, indicates it is more likely that this area comprises residential juvenile or sub-adult developmental habitat for marine turtles and that it is this life-stage we were observing. Surveys require repetition during winter months to confidently eliminate potential for inclusion of transitory migratory adults present for reproduction.

Abundance of turtles within the embayment cannot be accurately determined from data derived during aerial survey; only abundance of animals seen at the sea surface is known. Despite other studies having been able to derive a conversion factor based upon known species and life-stage specific dive duration and information describing time spent at the surface, it was not possible to confidently identify either species or life stage using this survey method. Despite discussion regarding the likelihood of these animals being juvenile turtles, no data are available describing these behaviours in juvenile green, hawksbill or flatback turtles in the region, and so a reliable conversion factor could not be estimated. It is worthy of note therefore that abundance estimates provided within are conservative, and present only the 'minimum' number of animals present in the survey area during the survey duration.

Juvenile green turtles tracked over 100 days at an offshore coral reef in Eastern Australia used home range areas ≤1 km^2 (Hazel et al. 2012). Ranges reported from studies at other sites have been 3.5 km^2 over 22 – 51 days (Mendonca 1983; values for 'summer' periods of study), 3.2 km^2 over 4 – 26 days (Whiting & Miller 1998), 16.6 km^2 over 34 – 96 days (Seminoff et al. 2002) and 2.4 km^2 over 55 – 66 days (Makowski et al. 2006) and 4.6 km^2 over 4.5 days (Hazel 2009). All ranges fall inside that defined by the embayment at Balla Balla and thus we deduce that turtles identified during the aerial survey are likely resident within the embayment area. Further survey during winter months, and using alternate fine-scale tracking methods would confirm or refute this.

Juvenile turtles were observed by Phoenix Environmental in the creeks and mangrove habitat of the embayment and are known to utilise these areas for foraging purposes (Pendoley & Fitzpatrick 1999). Despite none being seen during our aerial surveys (see Limitations; **Section 3.6**), it is likely that they are present. These areas are of significance as juvenile foraging habitat for green, hawksbill and potentially flatback turtles.

No data were available regarding benthic habitat at the survey site; however suitable forage for green and hawksbill turtles (algae, seagrass and mangrove; pers. obs.) is available either within the

embayment and associated creeks and inlets nearby. It is likely that only scant forage exists in deeper waters around the embayment as seagrass is restricted by low light penetration in turbid water (Abal & Dennison 1996). It is suggested therefore that there exists a spatial concentration of available forage and shelter resources (protected from winds and swell) within the embayment as it is the only habitat of its type along this coastline and is considered 'highly productive' (Phoenix Environmental pers. comm. 2013)

Green turtles in Queensland waters are understood to maintain long-term associations with particular foraging areas, based on recaptures of marked individuals (Limpus et al. 1992; Limpus & Chaloupka 1997). The combination of long-term fidelity to foraging sites (shown by mark–recapture studies) and continuity of occupation (Hazel et al. 2012) indicates that individual turtles could suffer long-term exposure to anthropogenic risks at a particular site, if such risks exist.

Nearly half of all turtle sightings were made between West Moore and Ronsard Islands with another 30 % observed east of this point, equalling a total of 75 % of all sightings made within this 'zone'. Data regarding benthic habitat, tidal flow, current, water depth and other associated ecological parameters would add value to further interpretation of these findings, regarding why turtles are observed most frequently in this area, but were not available at the time of writing.

The Balla Balla Transhipment Facility project does not propose dredging nor any other long-term or permanent modification of the seabed or coastal processes and is not therefore considered to threaten these, presumed resident, populations of turtles.

Given the information regarding home-range fidelity, it is more likely that the high variability in turtle sightings per day was a function of observation conditions and did reflect not presence/absence of animals within the survey area, as it appears they are unlikely to move very far. There was a strong positive correlation between the number of turtles and other mega-fauna observed in each survey day, however despite increased cloud cover and associated reduction in glare from the sea surface increasing visibility, no correlation with increased observations during these days was detected during analysis. On clear days with good observation characteristics, larger numbers of turtles and other mega-fauna were visible and it is therefore likely that these numbers more accurately represent abundance in the survey area.

6 RECOMMENDATIONS

- Winter aerial surveys conducted using the same methodology to more clearly describe abundance and distribution of resident turtles of all life stages within the embayment;
- Boat surveys of creeks are planned for April and it is recommended that these are carried out to more formally assess abundance of juvenile and sub-adult species of marine turtles, particularly in light of observations provided by Phoenix Environmental in combination with those of this survey;
- Dugong were present and further surveys would assist in definition of abundance in resident animals or alternately of the temporal patterns in distribution and migratory pathways in this species;
- Passive acoustic tracking (Hazel et al. 2012) by fixed array of receivers of juvenile green turtles detect dive behaviour and provide indication of accurate conversion of number of animals sighted at sea-surface to total over whole survey area; and
- Benthic habitat mapping would greatly assist in remotely identifying potential abundance and distribution of all mega-fauna within the area and in providing additional context for findings described within.

7 REFERENCES

ABAL E.G. & DENNISON W.C. (1996) Seagrass depth range and water quality in Southern Moreton Bay, Queensland, Australia. *Marine Freshwater Research,* **47**, 763–771.

BUCKLAND, S.T., ANDERSON, D.R., BURNHAM, K.P., LAAKE, J. L., BORCHERS, D. L., & L. THOMAS, L. (2001) Introduction to distance sampling: Estimating abundance of biological populations. Oxford University Press.

HAZEL, J., HAMANN, M., & LAWLER, I.R (2012) Home range of immature green turtles tracked at an offshore tropical reef using automated passive acoustic technology. *Marine Biology*

HAZEL, J. (2009) Evaluation of fast-acquisition GPS in stationary tests and fine-scale tracking of green turtles. *Journal of Experimental Marine Biology Ecology*, **374**, 58–68.

LIMPUS, C. & CHALOUPKA, M. (1997) Nonparametric regression modelling of green sea turtle growth rates (southern Great Barrier Reef). *Marine Ecology Progress Series*, **149 (1–3)**, 23–34.

LIMPUS, C.J., MILLER, J.D., PARMENTER, C.J., REIMER, D., MCLACHLAN, N. & WEBB, R. (1992) Migration of green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles to and from eastern Australian rookeries. *Wildlife Research*, **19**, 347–358.

MAKOWSKI, C., SEMINOFF, J.A. & SALMON, M. (2006) Home range and habitat use of juvenile Atlantic green turtles (*Chelonia mydas* L.) on shallow reef habitats in Palm Beach, Florida, USA. *Marine Biology*, **148**, 1167–1179.

MENDONCA, M.T. (1983) Movements and feeding ecology of immature green turtles (*Chelonia mydas*) in a Florida lagoon. *Copeia*, **4**, 1013–1023.

MINTREX (2013) Balla Balla Barge Loading Facility Project Preliminary information for Environmental Assessment Submission Project number 1332-FRG

PENDOLEY, K. (2005) Sea Turtles and Industrial Activity on the North West Shelf, Western Australia. PhD thesis, Murdoch University, Perth.

PENDOLEY, K. & FITZPATRICK, J. (1999) Browsing of mangroves by green turtles in Western Australia. *Marine Turtle Newsletter,* **84**, 10.

PENDOLEY ENVIRONMENTAL (2012) Marine turtle distribution in the Balla Balla and Wider Pilbara Region of Western Australia. *Unpublished report for Forge Resources Ltd.*

SCHROEDER, B.A. & MURPHY, S.R. (1999) Population Surveys (Ground and Aerial) on Nesting Beaches. IN: K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois & M. Donnelly. *Research and Management Techniques for the Conservation of Sea Turtles*. IUCN/Marine Turtle Specialist Group Publication No. 4, 45-55.

SEMINOFF, J.A., RESENDIZ, A., NICHOLS, W.J. (2002) Home range of green turtles *Chelonia mydas* at a coastal foraging area in the Gulf of California, Mexico. *Marine Ecology Progress Series*, **242**, 253–265.

WHITING, S.D. & MILLER, J.D. (1998) Short term foraging ranges of adult green turtles (*Chelonia mydas*). *Journal of Herpetolology*, **32(3)**, 330–337.

WHITTOCK, P, HAMMAN, M & PENDOLEY K (In press) Inter-nesting distribution of flatback turtles (*Natator Depressus*) in Western Australia. First Western Australian Sea Turtle Symposium

Appendix A: Location and length of surveyed beach habitat

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		Location (start)		Location (end)		
	Name	**Latitude**	**Longitude**	**Latitude**	**Longitude**	**Length (km)**
Mainland	Beach 1	-20.615020	117.845417	-20.624960	117.827482	2.2
	Beach 2	-20.666712	117628447	-20.679807	117.592639	4.0
	Beach 3	-20.697602	117.575534	-20.699482	117.585638	1.1
	Beach 4	-20.709700	117.544113	-20.718161	117.508651	4.0
	Beach 5	-20.723837	117.481764	-20.732429	117.439289	4.6
Depuch Island	Beach 1	-20.628123	117.741434	-20.626378	117.752658	0.3
	Beach 2	-20.636234	117.740447	-20.658823	117.741392	1.0
	Beach 3	-20.617503	117.730826	-20.617355	117.729881	0.1
Ronsard Island	Beach 1	-20.516995	117.874350	-20.516995	117.874350	8.1
Sable Island	Beach 1	-20.587679	117.780539	-20.587864	117.760969	4.0
	Beach 2	-20.588016	117.780148	-20.548472	117.76952	1.2
	Beach 3	Sand spit only; length variable and tide dependant				
West Moore Island	Beach 1	-20.637598	117.671608	-20.640892	117.667044	0.5
	Beach 2	-20.634809	117.681172	-20.635697	117.681547	0.1
	Beach 3	-20.635211	117.679302	-20.635651	117.681397	0.2
	Beach 4	-20.633208	117.684511	-20.633287	117.684586	0.5
	Beach 5	-20.636376	117.674056	-20.637591	117.693667	1.7
Total (km)						33.6

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Appendix B: Flight line length (km)

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Flight Line No.	Flight Line Length (km)
1	9.9
2	13.0
3	13.6
4	14.6
5	15.2
6	15.7
7	16.0
8	17.1
9	17.7
10	18.3
11	18.5
12	19.1
13	19.6
14	20.3
15	19.9
16	20.5
17	20.6
18	18.7
19	19.0
20	17.1
21	17.8
22	11.5

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Appendix C: Angle of observation and calculated survey area

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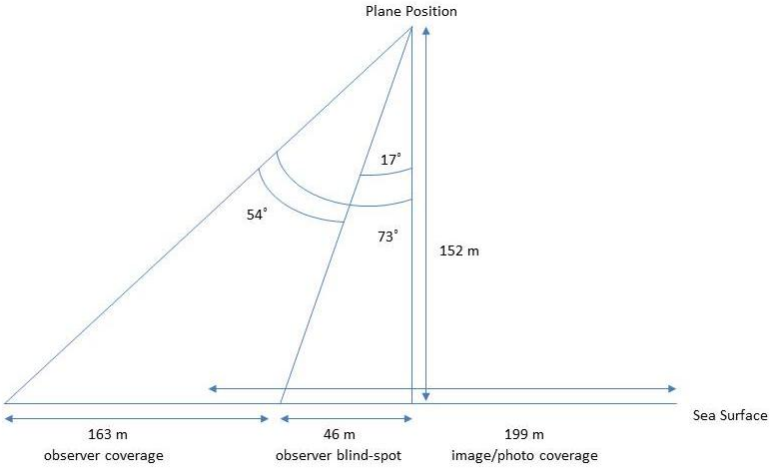

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