# Appendix F33

RPS Environment and Planning Pty Ltd 2010c

## Ecology of Marine Turtles of the Dampier Peninsula and the Lacepede Island Group 2009 – 2010

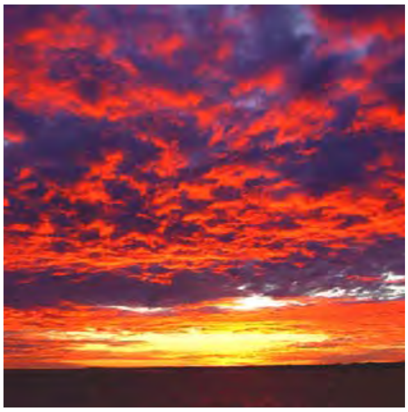
BROWSE FLNG DEVELOPMENT
Draft Environmental Impact Statement

EPBC 2013/7079
November 2014

# WOODSIDE BROWSE TURTLE TECHNICAL REPORT

## Ecology of Marine Turtles of the Dampier Peninsula and the Lacepede Island Group, 2009–2010





# WOODSIDE BROWSE TURTLE TECHNICAL REPORT

## Ecology of Marine Turtles of the Dampier Peninsula and the Lacepede Island Group, 2009–2010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## *Disclaimer*

# EXECUTIVE SUMMARY

Woodside Energy Ltd (Woodside) plans to develop several gas condensate fields in the Browse Basin, with onshore processing facilities proposed to be located at the Browse Liquefied Natural Gas (BLNG) Precinct near James Price Point, on the Dampier Peninsula of Western Australia. This location has been determined by the Department of State Development (DSD) (via the Northern Development Taskforce (NDT)) and state (Western Australian) and commonwealth governments.

A range of environmental investigations have been commissioned by Woodside to characterise the environment in the region of the development, and to inform the environmental impact assessment process. RPS was engaged by Woodside to undertake a series of baseline surveys to support the assessment and management of potential impacts to marine turtles from the proposed LNG development.

The Kimberley region supports a number of threatened species listed under the Western Australian *Wildlife Conservation Act 1950* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), including marine turtles. However, only a few surveys have attempted to quantify the distribution, abundance and habitat use of these fauna. No long-term studies of population status are available to the public.

This technical report presents the results of RPS' field and desktop research into the distribution, abundance and habitat use of marine turtles along the Dampier Peninsula and the Lacepede Island Group during 2009–2010.

The key objectives of the marine turtle studies were:

- to determine the distribution and relative abundance of marine turtles along the west coast of the Dampier Peninsula and at the Lacepede Island Group

- to determine the distribution, density, population characteristics, clutch features and seasonality of the nesting turtle population within and adjacent to the James Price Point area

- to determine the spatial extent of inter-nesting habitat, nesting beach fidelity and post-nesting migrations of flatback and green turtles found within and adjacent to the James Price Point area and the Lacepede Island Group.

The surveys undertaken include:

- aerial surveys (nearshore, regional and offshore)
- vessel surveys
- beach studies (track counts, nearshore surveys and sand temperature analysis)
- satellite tracking (inter-nesting and post-nesting migration).

| Category | Key Findings | Document Reference |
|---|---|---|
| Distribution and relative abundance | The predominant marine turtle species during the breeding period were green turtles with high densities occurring at the Lacepede Island Group. | 5.2.2, 5.3.3.2, 6.1 |
| | A mix of flatback (45%), green (30%) loggerhead (25%) turtles were found along the Dampier Peninsula during the non-breeding period. Hawksbill turtles were also recorded during the dedicated turtle vessel surveys. | 5.2.1 |
| | The majority of turtles in the water were observed within 20 km of the shore and within the 20 m isobath. | 5.1, 5.3 |
| | Turtles were widely distributed throughout all nearshore survey areas with no large aggregations of any species of turtle along the Dampier Peninsula. | 5.1, 5.3 |
| Mating | Low numbers of mating turtles were observed along the Dampier Peninsula whilst relatively high numbers of mating green turtles were sighted in the nearshore areas of the Lacepede Island Group. | 5.2.2, 5.3.3.2 |
| Nesting and hatching | High densities of turtles were recorded in waters around the Lacepede Island Group and north of the James Price Point area late in the 2008–2009 nesting season (March 2009 aerial survey). | 5.1 |
| | Track count data from 2009–2010 indicates that the Lacepede Island Group supports a significant turtle rookery in Western Australia (~431 green turtles/night and ~36 flatback turtles/night) whilst the James Price Point area only supports very low levels of nesting (3 tracks and 1 potential nest over the entire nesting season). | 5.3.2 |
| | At the Lacepede Island Group, 90% of all nesting is attributable to green turtles. Flatback turtles contribute the remaining ten per cent. | 5.3.2 |
| | The sand temperature data indicates that the green and flatback turtle clutches at West Island are likely to be female-biased. | 5.3.4, 0 |
| Potential foraging habitats | Relatively high densities of turtles were recorded in probable foraging habitats off Carnot Bay, Cape Lattreille, Roebuck Bay and Lagrange Bay during the non-breeding period (July–October 2009). | 5.1, 6.2.1 |
| | Low numbers of turtles were recorded at Scott Reef between July–September 2009. | 5.1, 6.1 |
| | Juvenile turtles were sighted within 50 m of the shore at James Price Point Beach and Quondong South Beach during the 2009–2010 nesting season. | 5.3.3.1 |
| Inter-nesting | Satellite tracking indicated that for most of the inter-nesting period, the female green turtles stay within 5 km of nesting beaches at the Lacepede Island Group, but travel up to 18 km. | 5.4.1.1 |
| | Satellite tracking indicated that for most of the inter-nesting period, the female flatback turtles travel up to 50 km from nesting beaches at the Lacepede Island Group. | 5.4.2.1 |
| Post-nesting migration | The northern migratory pathway for green and flatback turtles nesting at the Lacepede Island Group followed a similar pathway demonstrated by turtles tagged at Port Hedland and Barrow Island. | 3.2.1.5, 3.2.2.5 |
| | The majority of green turtles migrated north-east along the Kimberley coast. Data up to 31 March indicated that the maximum migration distance was 1,400 km with one turtle reaching the Gulf of Carpentaria. Two green turtles travelled south passing the James Price Point area en route to 80 Mile Beach and Port Hedland. | 6.1 |
| | The majority of flatback turtles migrated north-east along the Kimberley coast. Data up to 31 March indicated that the maximum migration distance was 1,180 km with most turtles milling around Gale and Penguin Banks. | 5.4.2.2, 6.1 |

The 2009–2010 surveys confirmed that the Lacepede Island Group supports a large green turtle rookery and a smaller flatback rookery. The James Price Point area appears to support foraging and migrating adult and juvenile turtles but little or no successful nesting activity was recorded. Furthermore, it is unlikely that these turtles are restricted to this area and utilise surrounding areas of similar habitat.

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# ACRONYMS AND ABBREVIATIONS

| Acronym | Definition |
|---|---|
| BLNG | Browse Liquefied Natural Gas |
| Bonn Convention | Convention on the Conservation of Migratory Species of Wild Animals |
| CCL | Curved Carapace Length |
| CCW | Curved Carapace Width |
| CITES | Convention on International Trade in Endangered Species |
| CMST | Centre for Marine Science and Technology |
| CWR | Centre for Whale Research |
| DEC | Department for Environment and Conservation |
| DEH | Department of Environment and Heritage |
| DEWHA | Department of the Environment and Water, Heritage and the Arts |
| DSD | Department of State Development |
| DTS | Dedicated Turtle Survey |
| EEZ | Exclusive Economic Zone |
| EPA | Environmental Protection Authority |
| EIS | Environmental Impact Statement |
| EPBC Act | The Environment Protection and Biodiversity Conservation Act 1999 |
| ERMP | Environmental Review and Management Plan |
| GDA | Geocentric Datum of Australia |
| GPS | Global Positioning System |
| IMCRA | The Interim Marine and Coastal Regionalisation of Australia |
| IMF | Integrated Marine Facility |
| IWC | International Whaling Commission |
| IUCN | International Union for the Conservation of Nature and Natural Resources (aka World Conservation Union) |
| LNG | Liquefied Natural Gas |
| LPG | Liquefied Petroleum Gas |
| MOF | Materials Offloading Facility |
| MMFS | Marine Mega Fauna Survey |
| MNES | Matters of National Environmental Significance |
| MTPA | Million Tonnes Per Annum |
| MU | Management Unit |
| NDT | Northern Development Taskforce |
| NES | National Environmental Significance |
| NMB | National Marine Bioregionalisation |
| NT | Northern Territory |
| NWMR | North West Marine Region |
| NWS | North West Shelf |

| Acronym | Definition |
|---|---|
| PIN | Pilbara Nearshore Region |
| PIO | Pilbara Offshore Region |
| SKM | Sinclair Knight Merz |
| STL | Sand Temperature Logger |
| UNEP | United Nations Environment Program |
| TDR | Temperature Depth Recorder |
| TRT | Transitional Range of Temperatures |
| TSD | Temperature-dependent Sex Determination |
| WA | Western Australia |

# DEFINITIONS

***Baseline survey***

A baseline survey provides information on the condition and ecology of an area prior to undertaking any development. Baseline surveys gather information that can be used in subsequent impact assessments and to design monitoring programs.

***Bathymetry***

Bathymetry is the measurement of water depths and the topographic maps of the seafloor resulting from these measurements.

***Benthic***

Benthic relates to the sediment/water interface in an aquatic environment.

***Bombora***

Small, shallow patches of reef or rock, colloquially known as “bommies”.

***Cephalopods***

A class of marine molluscs that includes octopuses, squids and nautilus.

***Continental Shelf***

The continental shelf is an area of the seafloor averaging less than 200 m deep and includes the underwater, extended edge of a continent and associated coastal plain which generally was exposed at times of lower sea level.

***Downwelling***

A downwelling (event) is a wind-driven convergence of surface water with the coastline or another water mass, causing the surfaced water to move downward.

***Ecotype***

A sub-group of a species that have evolved to adapt to a specific or different environment.

***Exclusive Economic Zone***

The EEZ is a sea zone which extends 200 nautical miles from the Australian coast, over which each state has special rights over the exploration and use of marine resources.

***Gas condensate field***

Natural gas condensate is a low-density mixture of hydrocarbon liquids that are present as gaseous components in the raw natural gas produced from many natural gas fields.

***Home range***

An animal’s home range is the area that is normally occupied and used by that animal.

***Indonesian Throughflow***

A warm oceanographic current that transports low salinity water between the Pacific Ocean and the Indian Ocean through the Indonesian Archipelago.

***Inter-nesting***

The period between nesting events within a nesting season.

***Marine megafauna***

Marine megafauna include large fauna that live in the marine environment.

***Matters of National Environmental Significance***

MNES are defined as listed threatened species and communities under the EPBC Act including endangered species, migratory species, Ramsar wetlands, world/national heritage properties, and the Commonwealth marine environment.

***Migratory species***

Migratory species predictably travel from one place to another at regular times of year, often over long distances for example between feeding and breeding grounds.

***Neap tides***

Neap tides have the smallest tidal range which occurs every two weeks during the first and third quarter moons.

***Nearshore***

The nearshore region extends seaward from the shoreline.

***Oceanography***

Oceanography is the study of the ocean with emphasis on the physical and biological aspects of the oceans.

***Offshore***

The offshore region is located at a distance from the shore, extending outward to the edge of the continental shelf.

***Oligotrophic***

Oligotrophic refers to a body of water which is low in nutrients and supports low productivity.

***Pelagic species***

Pelagic species refers to species which inhabit the water column.

***Pipeline corridor***

A pipeline corridor is the area of seabed within which a pipeline, for example, from offshore (upstream) facilities to onshore (downstream) facilities will be constructed.

***Provincial bioregion***

A provincial bioregion (also referred to as bioregion) is an area which has similar types of plants, animals and environments when compared to other areas of a similar size.

***Ramsar wetland***

A Ramsar wetland is an area designated as a wetland of international importance under the Ramsar Convention (especially as waterfowl habitat) because of its importance for preserving biological diversity or because it is a representative, rare and unique wetland type.

***Recapture***

Recapture is to capture/count something for a second or subsequent time.

***Semi-diurnal***

Semi-diurnal refers to events which occur twice a day, for example two tidal changes per day (as opposed to diurnal which occurs once a day).

***Spring tides***

Spring tides have the highest height range in the tidal cycle and occur every two weeks during a full or new moon. Offset with neap tides.

***Strip width sampling***

Strip width sampling is a type of line transect sampling where the assumption is made that all animals from the transect line out to a set distance are detected with equal probability, usually related to the range of visibility. The distance of the detected animal from the line is not measured due to difficulties associated with correctly estimating the distance from the transect line.

***Threatened species***

Threatened species are vulnerable or likely to become endangered or extinct in the near future as defined by the EPBC Act 1999.

***Upwelling***

An upwelling (event) is a wind-driven upward movement of dense, cold, and usually nutrient-rich water from the depths of the ocean towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water and often resulting in highly productive ecosystems.

***Viewing platform***

The platform refers to a location or position of an observer, for example the bridge deck of a vessel or the seats of an aircraft.

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# 1.0 INTRODUCTION

## 1.1 Project Details

Woodside Energy Ltd (Woodside) plans to develop the Torosa, Brecknock and Calliance gas condensate fields in the Browse Basin off the Kimberley coast of Western Australia. Natural gas and condensate hydrocarbons from offshore facilities will be transported to onshore Liquefied Natural Gas (LNG) processing facilities and associated infrastructure in the James Price Point area, located on the Dampier Peninsula, approximately 60 km north of Broome (Figure 1). For the purposes of this report, the James Price Point area is referring to the coastal waters between Quondong Point in the south and Coulomb Point in the north and offshore to approximately 3 nm (Figure 1). The James Price Point Marine Management Area describes an area intended to include the marine infrastructure and dredging footprint of the Browse LNG Precinct. This area was identified for the purposes of the Marine Megafauna surveys to examine fauna occurring within or near the development area and is in no way intended to delineate any future Management Zone (Figure 1).

Woodside's facilities will be part of the Browse Liquefied Natural Gas (BLNG) Precinct. The development will include facilities to load LNG carriers (and potentially Liquefied Petroleum Gas (LPG) carriers) and condensate tankers. An Integrated Marine Facility (IMF) will be constructed to provide all-weather vessel harbouring facilities (for tugs and support vessels) and materials offloading facilities (MOF). Dredging will be required to establish a shipping channel, turning basin and berth pockets for tankers entering and departing the Marine Port Facilities. Dredging will also be required for establishment of the MOF and for trenching designated sections of the pipeline route. A single breakwater will also be constructed to provide shelter for the export jetty and other marine facilities.

The purpose of the BLNG Precinct is to provide a single onshore location for the various oil and gas operators in the Browse Basin. The central location is designed to eliminate the ad hoc development of LNG facilities on the Kimberley coast and islands. The preferred location of the Precinct at the James Price Point area has been determined by the Department of State Development (DSD) (via the Northern Development Taskforce (NDT)) and state (Western Australian) and commonwealth governments.

A range of environmental investigations have been commissioned to characterise the environment in the region of the development and to inform the environmental impact assessment process (also see Humpback Whale and Other Megafauna Technical Appendices). RPS was engaged by Woodside to undertake a series of Marine Megafauna Surveys (MMFS), including the current study of marine turtles to support the assessment and management of the potential impacts to turtles from the proposed BLNG development.

Six species of marine turtle occur in northern Western Australia: green turtles (*Chelonia mydas*); flatback turtles (*Natator depressus*); hawksbill turtles (*Eretmochelys imbricata*); loggerhead turtles (*Caretta caretta*); leatherback turtles (*Dermochelys coriacea*) and olive ridley turtles (*Lepidochelys olivacea*) (DEWHA 2009). Of these six species, only the green and flatback turtle are known to nest in significant numbers in the Kimberley region (DEWHA 2009; Prince 1994). However, there have been very few systematic surveys to quantify the distribution and abundance of turtles in the region, with no known long-term studies of population status, and few dedicated ecological studies of habitat use.

## 1.2 Aim and Objectives

The aim of the turtle studies is to collect baseline data on the distribution and relative abundance of marine turtles along the Dampier Peninsula, including the Lacepede Island Group and specifically within and adjacent to the James Price Point area.

The specific objectives of the studies were:

- to determine the distribution and relative abundance of turtles along the west coast of the Dampier Peninsula and at the Lacepede Island Group
- to determine the distribution, density, population characteristics, clutch characteristics and seasonality of the nesting turtle population within and adjacent to the James Price Point area
- to determine the spatial extent of the inter-nesting habitat, nesting beach fidelity and post-nesting migrations of flatback and green turtles found within and adjacent to the James Price Point area and the Lacepede Island Group
- to determine the incubation temperature of green and flatback turtles at the Lacepede Island Group and the James Price Point area.

## 1.3 This Document

This Technical Report provides an overview of turtle ecology in Western Australia and within the Kimberley region and identifies gaps in the knowledge of turtles in the area of interest. It then presents a series of studies that were used to collect baseline data on the various life stages of turtles along the coastal area of Dampier Peninsula between June 2009 and March 2010. These studies included surveys of foraging turtles during the winter months (June–September) and breeding/nesting turtles during the summer months (November–March). This report also presents a synthesis of information currently available to make a preliminary assessment on the potential interaction of the BLNG development with the regional marine turtle population.

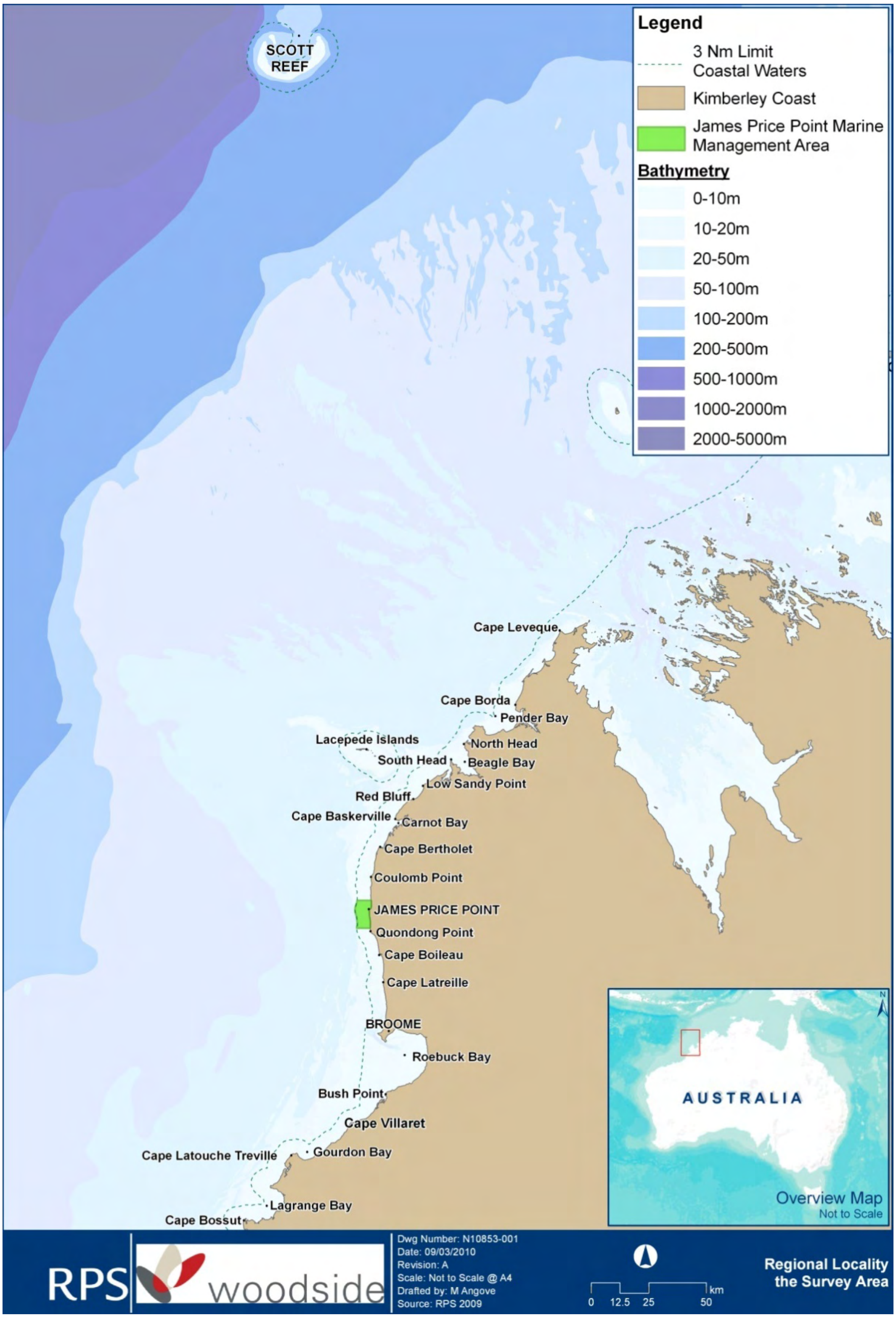


**Figure 1: Location Map of the Dampier Peninsula and Scott Reef**

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# 2.0 BACKGROUND INFORMATION

## 2.1 Regional Geography

The North West Marine Region (NWMR) extends north from Kalbarri, to the Western Australian–Northern Territory border covering an area of more than 1 million km$^2$ (DEWHA 2009). The NWMR has a unique combination of features including a broad continental shelf, high tidal regimes, cyclones, and unique current systems which create warm oligotrophic surface waters. The mosaic of habitat types within the region supports high species richness of turtles and other megafauna (DEWHA 2009).

The latitudinal range of the NWMR is between 22°S and 26°S. The region covers a large area of shallow continental shelf and slope, with more than half the area being shallower than 500 m (Baker et al. 2008). Tides are categorised as semi-diurnal with daily tides ranging between 3 m during neap tides and 10 m during spring tides (DEWHA 2009).

The prevailing currents are the Leeuwin Current and Indonesian Throughflow Current, which are seasonally variable (DEWHA 2009). During the north-west monsoonal season (December–March), both currents weaken as a result of changes in oceanic pressure gradients, onshore winds and high cyclone activity producing intense rainfall and vertical mixing of the water column. This allows localised currents to dominate, resulting in upwelling of colder, nutrient-rich water (DEWHA 2009). In contrast, the south-east monsoonal season (April and September), changes in oceanic pressures generally bring low nutrient and low salinity waters to the surface. The opposing effect of these currents exerts a strong influence on ecological processes by effecting sea surface temperatures and nutrient availability, and has a large influence on seasonal biological productivity and species distribution in the region.

Biological productivity may also be related to other oceanographic features, such as internal tides and associated internal waves, and bathymetry. Canyons in the region are thought to “support rich and dynamic communities” (Brewer et al. 2007). Bathymetric features typical for the NWMR include terraces and steps created by ancient coastlines. These terraces are believed to be important migratory pathways for marine megafauna (DEWHA 2008).

## 2.2 Local Geography and Benthic Habitats

The James Price Point area is a small rocky headland on a west-facing sandy coast with inshore rocky reefs and moderate tidal currents (DSD 2009a). The stretch of shore from Flat Rock to Quondong Point (approximately 10 km to the north and 10 km to the south of James Price Point respectively) was surveyed by Eliot and Eliot in June 2008 and was described as a narrow beach backed by Pindan Plain soils, with exceptions in the vicinity of tidal inlets. Dunes have developed to the north of James Price Point, and to the south as a sequence of overlapping ridges (Eliot and Eliot 2008). The coastal area adjacent to James Price Point is a macrotidal environment (Eliot and Eliot 2008) and is considered unsuitable for marine turtle nesting (DSD 2009b).

The nearshore waters along the Dampier Peninsula are moderately turbid during spring tides (DSD 2009a). The coastal area from Quondong Point to Coulomb Point seaward to the 20 m isobath was surveyed in June 2008 to determine the benthic habitats present (Fry et al. 2008). The coastal area is predominantly sand (55–70% coverage) with extensive areas of subtidal sand waves. The sand flat areas offshore from the James Price Point area have high densities of heart urchins and crinoids. Low relief benthic habitats have sparse to medium densities of sponges, gorgonians, sea whips and soft corals. Seapens are abundant over sand off the James Price Point area.

Occasional corals on rocks and pavements are present in the nearshore area off James Price Point with some isolated corals occurring in deeper areas (DSD 2009c). Seasonally variable seagrass patches of *Halophila* species occur to approximately 10 m water depth. *Sargassum* species and other species of macroalgae grow on inshore reefs in this area (DSD 2009c). There are no mangroves in the James Price Point area.

On the mainland beaches, flatback turtles regularly nest in small numbers around Cape Villaret, Cable Beach in Broome and infrequent observations of turtle tracks along the Dampier Peninsula. Low nesting activity was recorded by Biota Environmental Sciences (2009) at Quondong Point and to the south of James Price Point in March 2009 (Figure 1).

## 2.3 Conservation Status of Marine Turtles

The conservation status of the marine turtles in northern Western Australia is summarised in Table 1. All six species are listed in Schedule 1 (fauna that is rare or likely to become extinct) under the *Western Australian Wildlife Conservation Act 1950* (Wildlife Conservation Act) and are classified as being of National Environmental Significance (NES) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Green, hawksbill, leatherback and flatback turtles are listed as “Vulnerable”, and loggerhead and olive ridley turtles are listed as “Endangered” under the EPBC Act. All species are listed as “Migratory” under the EPBC Act.

Marine turtles are also listed under the Convention for the Conservation of Migratory Species of Wild Animals (CMS/Bonn Convention) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The World Conservation Union (IUCN) has assigned "Critically Endangered" status to hawksbill and leatherback turtles, "Endangered" status to green and loggerhead turtles and "Vulnerable" status to olive ridley turtles. Flatback turtles are listed as "Data Deficient". Loggerhead, green and flatback turtles found at Roebuck Bay are also listed under the RAMSAR Wetland Criterion.

**Table 1: Marine Reptile Conservation Status in Australia**

| Common Name | Species Name | Threatened Species Status | | | | | |
|---|---|---|---|---|---|---|---|
| | | **EPBC Act** | **Wildlife Conservation Act** | **CMS Appendix[a]** | **CITES Appendix[b]** | **IUCN Red List Status** | **Ramsar Wetland (Roebuck Bay)** |
| Green turtle | *Chelonia mydas* | Migratory, Vulnerable | Fauna is rare or is likely to become extinct | I and II | I only | Endangered | Listed |
| Flatback turtle | *Natator depressus* | Migratory, Vulnerable | Fauna is rare or is likely to become extinct | II only | I only | Data Deficient | Listed |
| Hawksbill turtle | *Eretmochelys imbricata* | Migratory, Vulnerable | Fauna is rare or is likely to become extinct | I and II | I only | Critically Endangered | |
| Loggerhead turtle | *Caretta caretta* | Migratory, Endangered | Fauna is rare or is likely to become extinct | I and II | I only | Endangered | Listed |
| Leatherback turtle | *Dermochelys coriacea* | Migratory, Vulnerable | Fauna is rare or is likely to become extinct | I and II | I only | Critically Endangered | |
| Olive ridley turtle | *Lepidochelys olivacea* | Migratory, Endangered | Fauna is rare or likely to become extinct | I and II | I only | Vulnerable | |

[a] CMS/Bonn Appendix I = Endangered migratory species; Appendix II = Migratory species conserved through Agreements
[b]CITES Appendix I = Species threatened with extinction which are or may be affected by trade

# 3.0 MARINE TURTLE OVERVIEW

## 3.1 General Marine Turtle Biology

### 3.1.1 Life Cycle

The basic life cycle of all marine turtle species comprises seven main events; mating, nesting, incubation, hatching, juvenile development, migration and foraging (Figure 2). These distinct and often spatially separated events mean that turtles use a variety of habitats during their life, including mating areas, nesting beaches, inter-nesting habitat and feeding areas. The Recovery Plan for Marine Turtles in Australia (Environment Australia 2003) and the Draft Marine Turtle Recovery Plan for Western Australia 2009–2016 (DEC 2009a) recognise the need to identify and investigate these critical habitats in the northern parts of Australia. Given the broad similarities among species, the biological information below provides a general description of the life history of all marine turtles. Specific information relating to each of the species found in the Kimberley region has been provided in Section 3.2.

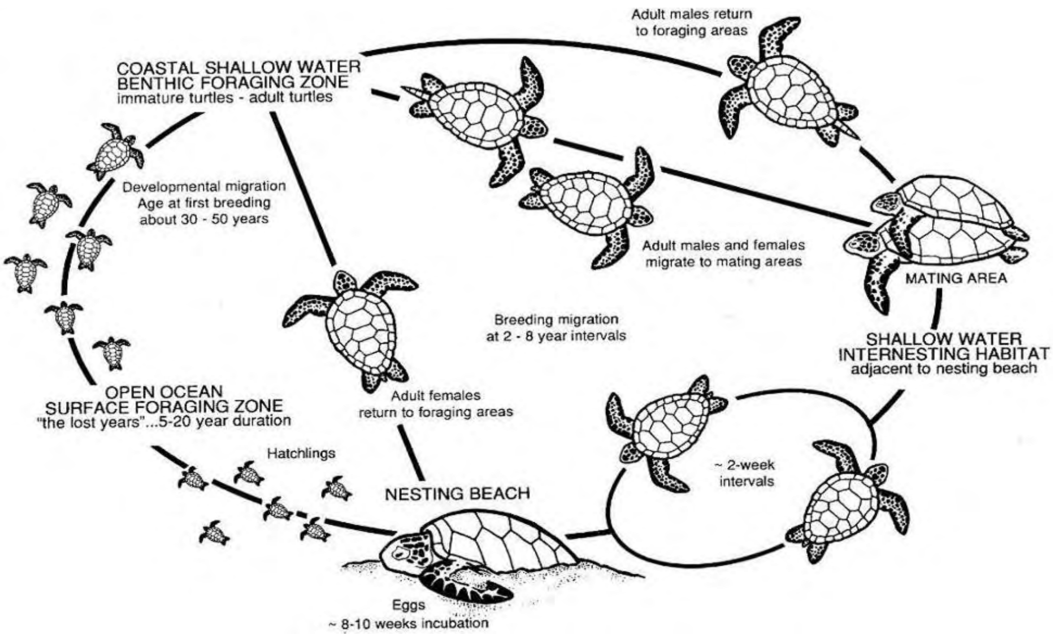



**Figure 2: Basic Life Cycle of Marine Turtles (Lutz and Musick 1997, p. 53)**

Identifying demographically independent breeding populations of marine turtles is becoming increasingly important from a conservation perspective (Dethmers et al. 2006). Independent breeding populations, or management units (MUs), are exposed to different threats and may therefore require different management measures. The majority of the genetic population studies conducted so far have focused on nesting female turtles, because this is the part of the population that is easiest to sample and generally at highest risk of impact from terrestrial and coastal development. However, there is also a need to genetically assess populations of male and juvenile turtles to better understand the range of habitats used by local populations of turtles.

MUs have been proposed for marine turtles on the basis of patterns of genetic exchange among turtles from rookeries in a region (Dutton et al. 2002). Rookeries with evidence of regular gene flow are treated as being part of the same MU.

### 3.1.2 Mating

Marine turtles generally reach sexual maturity between thirty and fifty years of age (Miller 1997). Female and male turtles migrate from their foraging areas to mating areas which are generally in the vicinity of nesting beaches. Female turtles are reproductively receptive for approximately 7–10 days and males are sexually active for about one month (Miller 1997). Male and female turtles may mate with several individuals during the mating period.

### 3.1.3 Nesting

Nesting beach, or rookery, habitat requirements are broadly similar for all species of marine turtle. As defined by Miller (1997), a suitable nesting beach is characterised by:

- clear access from the sea
- adequate elevation to prevent inundation of the eggs by tides or an underlying water-table
- a sandy substrate which facilitates gas diffusion and incubation
- sand that is moist and fine enough to prevent collapse of the egg chamber during construction.

Successful nesting involves six discrete stages; beaching, selecting a nest site, digging an egg chamber, laying, filling in the chamber and returning to the water. Turtles usually nest above the high tide mark on exposed beaches with loose sand. Although most turtles nest at night, some species of turtle, including flatback turtles, also nest during daylight hours (Spotila 2004).

### 3.1.4 Incubation

Turtle eggs incubate in the nest for between fifty and eighty days; the length of incubation is dependent on the species and the temperature of the nest environment (Ackerman 1997). The nest temperature, humidity, salinity and oxygen levels must remain within a narrow range for embryonic development to be successful (Ackerman 1997). The interaction of the physical characteristics of the sand, the structure of the beach and the local climate creates a suitable microclimate for incubation within the egg chamber. Any disturbance of the nest can change the microclimate and hinder embryonic development.

Sand temperature within the nest influences the length of the incubation period and also determines the sex of the hatchlings through a process known as Temperature-dependent Sex Determination (TSD) (Hewavisenthi and Parmenter 2000; Booth and Astill 2001). Warmer nest environments tend to produce females while cooler nest environments produce males. The pivotal temperature for sex determination is around 28 °C to 30 °C for all marine turtles (Wibbels 2003). The range of temperatures in which the sex determination shifts from 100% male to 100% female, known as the Transitional Range of Temperatures (TRT), ranges from <26 °C to >29.25 °C for males and females respectively. Although there are often minor differences in the pivotal temperature and TRT between populations, it is assumed that these temperatures will be similar between nesting beaches within Australia. Based on published data from eastern Australia, the pivotal temperature and TRT for green turtle hatchlings at the James Price Point area and the Lacepede Island Group are likely to be about 29 °C, and between 26 °C to 30 °C, respectively (Booth et al. 2004). The pivotal temperature and TRT for flatback turtle hatchlings at the James Price Point area and the Lacepede Island Group are expected to be around 29.5 °C and 29 °C to 30 °C, respectively (Hewavisenthi and Parmenter 2000). The proportion of females produced is presumed to increase linearly within these ranges (Booth and Astill 2001).

### 3.1.5 Hatching and Hatchling Dispersal

Small groups of hatchlings usually emerge in the early evening over consecutive nights. The emergence of the first hatchlings from the nest initiates a coordinated emergence for the rest of the nest, which can involve the majority of hatchlings emerging from the nest. Once at the beach surface, hatchlings find their way to the sea by crawling towards the brighter, lower oceanic horizon and away from the elevated silhouettes of the vegetation and dunes (Witherington and Martin 2000; Salmon and Witherington 1995; Salmon et al. 1992). Natal beach recognition imprinting is likely to occur as hatchlings emerge from the nest and may be reinforced upon returning to the natal beach as an adult for their first nesting attempt (Lohmann et al. 1997). When hatchlings enter the water, they appear to use wave action as a directional cue to make their way offshore (Lohmann et al. 1997).

### 3.1.6 Juvenile Development

After leaving the beach, the juveniles of some species (e.g. green turtles) are believed to drift in oceanic gyre systems (Lohmann et al. 1997), not reappearing in shallow water habitats for a number of years (Figure 2). Flatback turtles do not appear to have an oceanic phase and are believed to remain in the surface waters of the continental shelf (Walker and Parmenter 1990).

These early developmental years are often termed “the lost years” because very little is known about the juveniles of any species during this time. It is hypothesised that the young juvenile turtles of species with an oceanic stage aggregate at oceanic convergences where they feed on accumulated buoyant biota such as seaweed and small crustaceans (Walker and Parmenter 1990).

### 3.1.7 Migration

Male and female turtles migrate from foraging areas to breeding areas. Migration and reproduction are such energetically expensive processes that turtles do not nest every year (Miller 1997). The remigration interval for female turtles (i.e. the number of years between reproductive migrations) is generally two to three years, but can range from one to nine years. The remigration interval depends on an individual's species and age, as well as environmental factors such as food availability and climate (Miller 1997; Broderick et al. 2001). Female turtles migrate back to the foraging grounds after the nesting season and stay there until their following nesting season; this migration is known as the post-nesting migration.

Male turtles are believed to reproduce every one to two years (Lutz and Musick 1997). After a mating period of approximately one month the male turtles migrate back to their foraging areas.

### 3.1.8 Foraging

The foraging habitats of marine turtles differ among species, life stages, regions and seasons (Bjorndal 1997; Eckert et al. 2006). The distinct diets of the different turtle species are reflected in their foraging habitat preferences. Marine turtles may travel large distances during their post-nesting migration and important foraging areas may attract thousands of individuals annually (Ross 1985). Individuals at a given foraging ground may come from a range of different breeding stocks (Luke et al. 2004) and different nesting beaches.

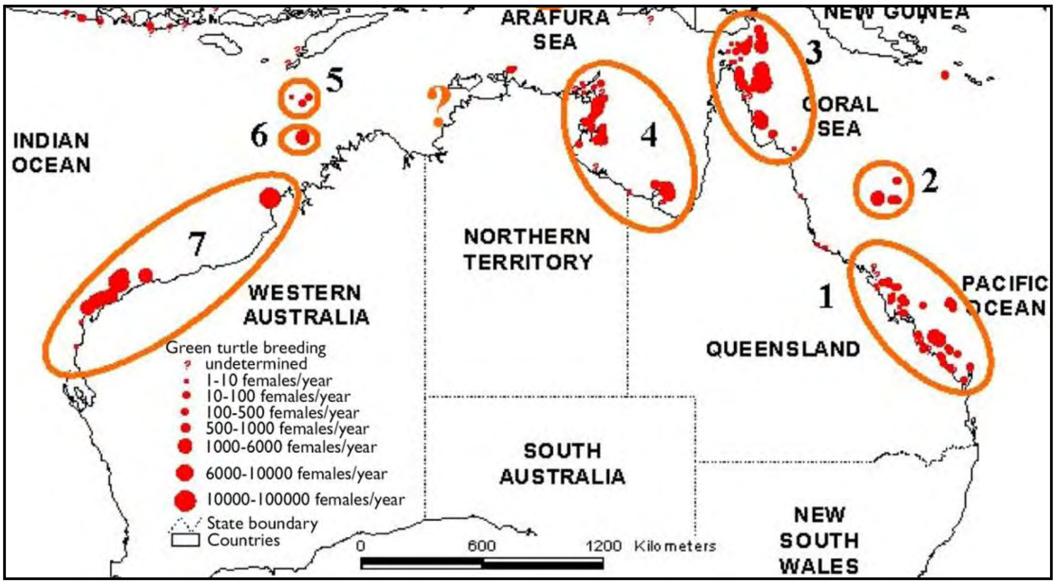
## 3.2 Turtles in the Kimberley region

### 3.2.1 Green Turtles

#### 3.2.1.1 Population Structure

Seven MUs are recognised for green turtles in Australia; (1) South Great Barrier Reef, (2) North Great Barrier Reef, (3) Coral Sea, (4) Gulf of Carpentaria, (5) Ashmore Reef, (6) Scott Reef and (7) the North West Shelf (NWS) (Limpus 2009). The NWS MU includes the rookeries between the North West Cape and the Lacepede Island Group in Western Australia (Figure 3). RPS studies of green turtles nesting on the Maret Islands in the Bonaparte Archipelago have shown that these turtles are also part of the NWS MU (Inpex Browse Limited 2008). Dethmers et al. (2006) estimated the population size of female green turtles in the NWS MU to be approximately 125,300 individuals, which is considered one of the largest green turtle populations remaining in the world (Limpus 2009).

In the past decade genetic markers have been used to investigate structure in nesting green turtle populations in northern Australia and other parts of Australasia and South-east Asia (Moritz et al. 2002; Dethmers et al. 2006). These studies have revealed distinct differences between nesting populations in the NWS MU and the oceanic and more northern populations. Tissue or blood samples from nesting females have been collected in parts of the north-west Kimberley, including the Lacepede Island Group, Scott Reef and Ashmore Reef, however sampling has been opportunistic and much of the region remains un-sampled (Moritz et al. 2002; Dethmers et al. 2006). Male and juvenile green turtle populations have not been genetically assessed in the Kimberley region.




Source: Limpus (2009)

**Figure 3: Distribution of Known Green Turtle (*Chelonia mydas*) MUs in Australia**

### 3.2.1.2 Mating

Male and female green turtles migrate from foraging areas to mating areas prior to the nesting season. Green turtles show high fidelity to particular mating areas over successive migrations (Limpus 1993). These mating areas are often in nearshore areas of <20 m water depth and adjacent to nesting sites (Musick and Limpus 1997; National Research Council 1990; Prince 2001; Balazs 1983). Mating pairs may copulate anywhere in the water column, but are most often observed mating at the surface (Limpus 1993). Mating is also common in lagoonal habitats, close to the shore (~ 5 m) near nesting beaches, which occasionally results in mating pairs being washed ashore (Godley et al. 2002; Broderick and Godley 1997).

Mating generally commences 1–2 months before the first nesting event of the season (Balazs 1983; Musick and Limpus 1997) but continues through the nesting season. Adult male green turtles are thought to spend approximately one month at their mating area each year, during which time they may mate with several females before returning to their foraging areas (Limpus 1993).

Mating areas for green turtles have not been identified in the Kimberley region. It is likely that green turtles mate in the nearshore waters adjacent to their rookeries in the Kimberley region. Based on the timing of the peak nesting season for green turtles in the Kimberley (Prince 1994), they are likely to mate primarily between October and January.

#### 3.2.1.3 Nesting and Hatching

The Lacepede Island Group rookery is the most significant green turtle rookery in Western Australia (DEHWA 2009; Guinea 2009). Over 10,000 green turtles are thought to nest each year at the Lacepede Island Group (Figure 3). The number of green turtles nesting at the Lacepede Island Group was 60–120 turtles per night in 1990–1991 and 1,100–1,600 turtles per night in 1991–1992 (DEC 2009a). The nesting density of green turtles at the Lacepede Island Group does not appear to have been quantified since these surveys.

No data on the nesting characteristics (e.g. number of clutches laid, size of clutches, clutch success, re-nesting interval or nest site fidelity) of green turtles at the Lacepede Island Group are available. In eastern Australia, female green turtles lay up to ten clutches of eggs during the nesting period (Limpus et al. 2001).

Other regionally significant green turtle rookeries include Browse Island, Ashmore Reef and Scott Reef (DEC 2009b; Figure 4). Elsewhere in the Kimberley, green turtle nesting has been observed on the beaches of Cape Leveque, the Maret Islands, East Montalivet Island, Cartier Islet and Cassini Island (D. Oades pers. comm. 2009; Prince 1994; DEC 2009a).

Green turtles in Western Australia primarily nest between November and March (Prince 1994; Pendoley 2005; Guinea 2009; Waayers 2010), however, it has been suggested that green turtles may nest all year round at island rookeries in far northern Western Australia (DEC 2009a) and low-level winter nesting has previously been recorded at Scott Reef (Guinea 2009).

Low numbers of green turtle tracks have been reported on the mainland beaches of the Kimberley region including the coastal area at James Price Point or on the Dampier Peninsula (Biota Environmental Sciences 2009; D. Oades pers. comm. 2009). Prince (1994) suggested that green turtles nest at Eighty Mile Beach however this has not been confirmed.

Adult female green turtles exhibit strong fidelity to nesting beaches between successive nesting seasons (Limpus 2006; Moritz et al. 2002; Dethmers et al. 2006) and often return to nest on beaches within 5 km of their natal beach (Limpus 2006).

In eastern Australia, incubation takes approximately 58 days (Limpus 2009). It is therefore likely that the peak green turtle hatching period in the Kimberley is from January to May.

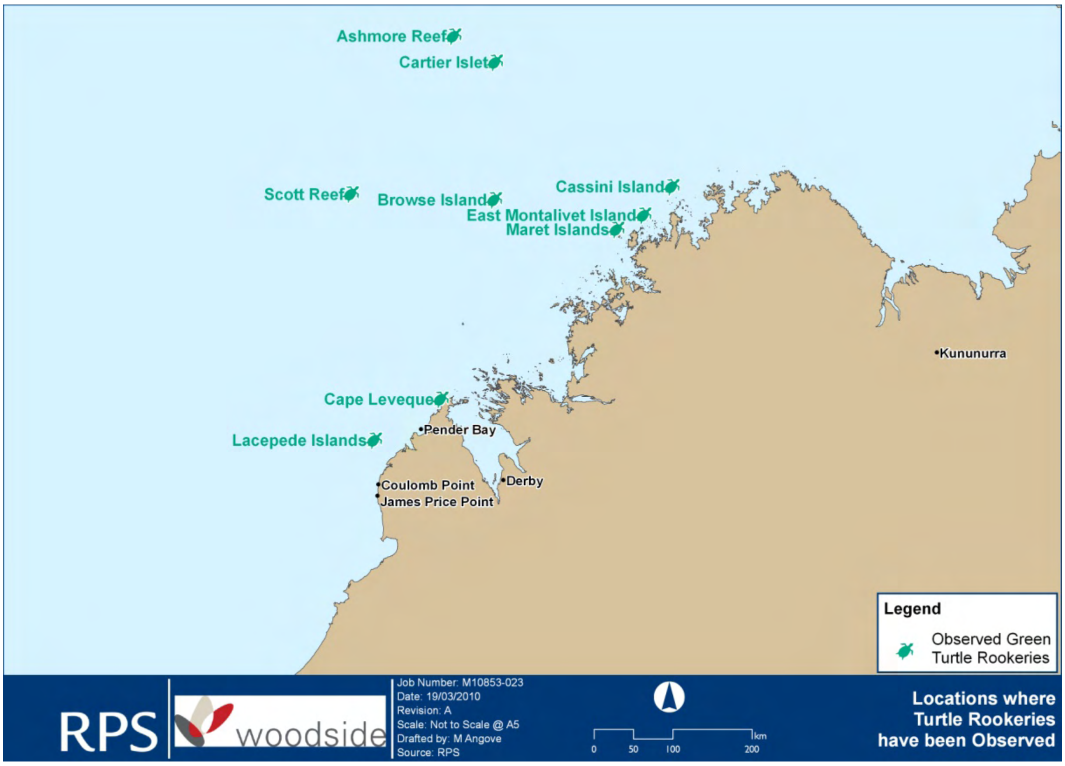



**Figure 4: Green Turtle Rookeries in the Kimberley Region**

### 3.2.1.4 Inter-nesting

In northern Australia, green turtles appear to remain within shallow, inshore waters (<20 m deep) during the inter-nesting period (Pendoley 2005; Hays et al. 2001). Therefore, the nearshore waters adjacent to major green turtle rookeries are considered critical habitat for the nesting populations (Environment Australia 2003).

While the nearshore waters around the Lacepede Island Group have been identified as inter-nesting habitat for green turtles (DEH 2005), the spatial extent of the inter-nesting area remains unknown. However, based on observations of other nesting populations in northern Australia, the turtles at the Lacepede Island Group are likely to remain within the inshore waters throughout the nesting period.

### 3.2.1.5 Migration

Adult green turtles can migrate thousands of kilometres between foraging areas and breeding areas (Miller 1997). Studies of eastern Australian green turtle populations have shown there is considerable variation in their remigration interval with a range of between one and eight years and an average of five years (Limpus et al. 2003).

Adult female green turtles tagged at rookeries in northern Western Australia have been recaptured in the Kimberley, Arnhem Land, Queensland and eastern Indonesia (Prince 1994; Dethmers et al. 2006). Nesting green turtles tagged at Barrow Island migrated 150–1000 km to different potential foraging grounds in north-west Australia (Pendoley 2005). Green turtles nesting at Scott Reef have also been tracked to waters within the Northern Territory (Pendoley 2005).

DEC attached satellite transmitters to three nesting green turtles at the Lacepede Island Group. After the nesting period these turtles migrated to the Coburg Peninsula, the Maret Islands and Adele Island (D. Oades pers. comm. 2009). Nesting turtles tagged at the Lacepede Island Group rookery have been recaptured in King Sound, coastal areas of the Northern Territory and in the Gulf of Carpentaria (Mornington Island and south-west of Groote Island) (Prince 1994). These post-nesting migrations range from approximately 150–2500 km.

The migration patterns of adult male and juvenile green turtles in this region are yet to be assessed.

#### 3.2.1.6 Foraging Habitats and Diets

Juvenile green turtles in the open ocean are omnivorous and often associated with downwelling zones (Bjorndal 1985). When they move into shallow, sub-littoral habitats at roughly ten years of age they change to a largely herbivorous diet, feeding principally on seagrass, macroalgae and mangrove fruits (Whiting and Miller 1998; Read and Limpus 2002). They also augment their diet with jellyfish, bluebottles, dead fish, small crustaceans and other invertebrates (Seminoff et al. 2002).

Adult and juvenile green turtles have been observed foraging over seagrass meadows in Darwin Harbour (Whiting 2001); juveniles have also been observed foraging on algae on the rocky reefs of Fog Bay, approximately 40 km south-west of Darwin (Whiting and Guinea 1998), and Barrow Island (Pendoley 2005). Green turtles also forage on coastal mangroves in the Pilbara region (Pendoley and Fitzpatrick 1999) and in Queensland (Limpus and Limpus 2000).

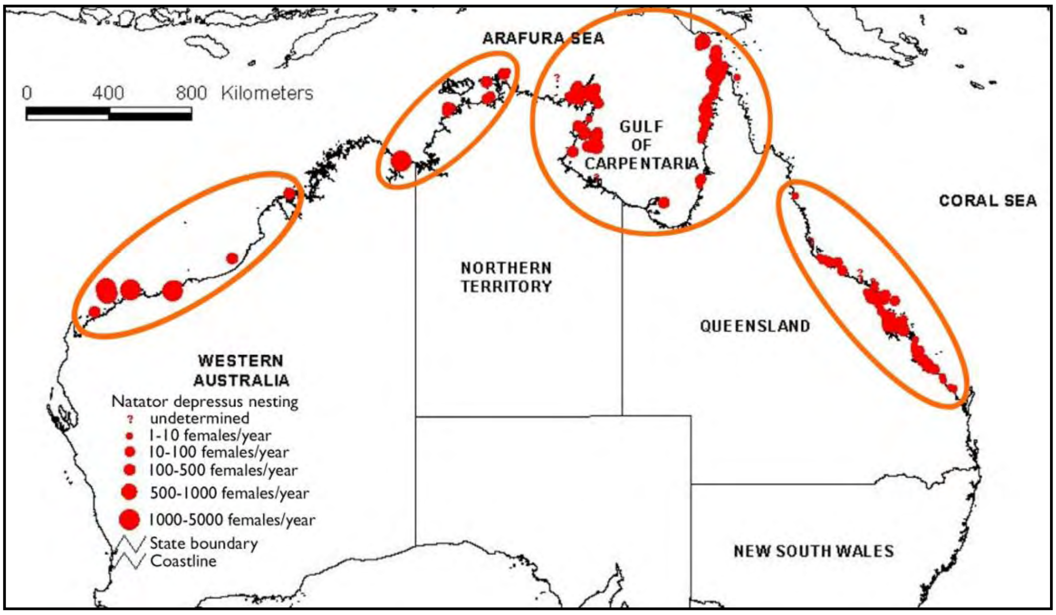
Green turtles from the Lacepede Island rookery appear to forage in other parts of the Kimberley region, including King Sound (Prince 1993, Prince 1994), the Maret Islands and Adele Island (D. Oades pers. comm. 2009). Green turtles have also been observed feeding in Roebuck Bay near Broome (M. Perriman pers. comm., 2010). The intertidal seagrass flats at Ashmore Reef support a large population of foraging immature and adult green turtles (Whiting et al. 2000). It is possible that green turtles forage in the waters off the Dampier Peninsula, including in the vicinity of the proposed development, in seagrass meadows and macroalgal reefs.

### 3.2.2 Flatback Turtles

#### 3.2.2.1 Population Structure

Four MUs are recognised for flatback turtles in Australia; Eastern Australia, the Gulf of Carpentaria, Western Northern Territory and the NWS (Limpus 2009; Dutton et al. 2002) (Figure 5). The geographical boundary of the NWS MU is currently thought to be between Exmouth and the Lacepede Island Group (Dutton et al. 2002) however much of the region has not been sampled. Flatback turtles nesting at the Cape Domett rookery in the Bonaparte Gulf are presumed to belong to the Western Northern

Territory stock (Whiting et al. 2008; Limpus 2009). RPS studies in the Bonaparte Archipelago have shown that flatback populations nesting in the archipelago are genetically distinguishable from other NWS populations, but there is gene flow between the areas (Inpex Browse Limited 2008).




Source: Limpus (2009)

**Figure 5: Distribution of Known Flatback Turtle (*Natator depressus*) MUs in Australia (Note: Data is Incomplete for Western Arnhem Land and Western Australia)**

### 3.2.2.2 Mating

Little is known about the mating activity of flatback turtles. Mating flatback turtles have been observed in the shallow water (approximately 0.7 m deep) adjacent to nesting beaches on Crab Island, off the northern Queensland coast (Limpus et al. 1993). West Arnhem Land flatback turtles have been observed mating on the shores of Bare Sand Island and about 10 to 15 km from Bare Sand Island at Roche Reef (M. Guinea pers. comm. 2007). This suggests that flatback turtles generally mate near their rookeries, but mating is not restricted to the immediate vicinity of the nesting beaches.

Aggregations of mating flatback turtles have not been identified in the Kimberley region. Flatback turtles probably mate in the nearshore areas around the Lacepede Island Group, due to the proximity of the nesting beaches here. Flatback turtles may also mate in coastal areas near mainland nesting beaches in the Kimberley region. Mating may occur all year round but is likely to peak from September to December, leading up to the nesting season in the Kimberley region.

#### 3.2.2.3 Nesting and Hatching

Significant flatback turtle rookeries in the Kimberley region include the Lacepede Island Group and Cape Domett (DEC 2009a, Prince 1994, DEWHA 2009) (Figure 6). Lesser Kimberley rookeries include, North Helpman Island, Lamarck Island, the Maret Islands and East Montalivet Island (DEC 2009a; DEC 2009b). Barrow Island, Eighty Mile Beach (mainly on the Mandora-Wallal section) and Mundabullangana Station in the Pilbara region also represent significant Western Australian flatback turtle rookeries.

Cable Beach and Eco Beach (Roebuck Bay), approximately 55 km south of James Price Point, are not recognised as major flatback turtle rookeries, however surveys conducted by Conservation Volunteers Australia indicate that low numbers of flatback nesting have been recorded (20–53 nests annually) (CVA 2009; McFarlane 2010).

Prior to this study, evidence of very low levels of possible flatback turtle nesting activity (several tracks and body pits in one year) has also been recorded in the James Price Point area at Quondong Beach, south of Quondong Point and south of James Price Point (Biota Environmental Sciences 2009). The density of nesting at these locations has not been quantified, however based on these preliminary findings, the regional significance is considered to be very low.

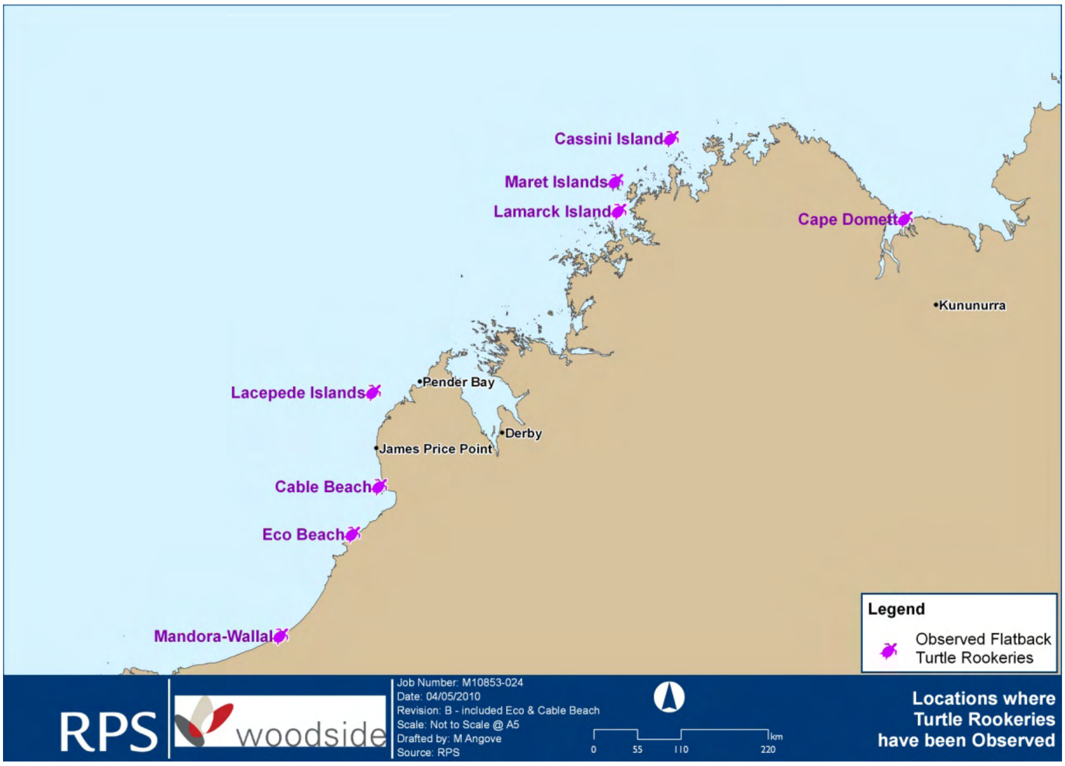



**Figure 6: Flatback Turtle Rookeries in the Kimberley Region**

The peak nesting season for flatback turtles within the NWS, Eastern Australia and Gulf of Carpentaria MUs is from November–February, whilst in the Western Northern Territory MU, flatback turtles nest throughout the year with a June–August peak (DEC 2009a).

Nesting characteristics (e.g. number of clutches laid, size of clutches, clutch success, re-nesting interval or nest site fidelity) are also largely unknown for flatback turtle rookeries in the Kimberley. In the western Northern Territory, the mean incubation period for flatback turtles is approximately 52 days (Limpus 2009). Based on this data, it is likely that most flatback eggs hatch between December and April. However, as nesting may occur year-round, hatching is also likely to occur year-round, but at lower densities outside the peak period.

#### 3.2.2.4 Inter-nesting

Flatback turtles tracked from the Barrow Island rookery migrated approximately 60 km from the nesting beach to the Pilbara mainland nearshore area during the inter-nesting period (Chevron Australia 2008). Publically available data on flatback turtle inter-nesting habitats in Western Australia is limited.

The inter-nesting behaviour of flatback turtles nesting at the Lacepede Island Group or on the mainland Kimberley beaches has not been documented. Given the range of movements of flatback turtles from Barrow Island (Chevron Australia 2008), nesting flatback turtles from the Lacepede Island Group may similarly migrate to nearshore areas during the inter-nesting period.

#### 3.2.2.5 Migration

The post-nesting migration patterns and remigration intervals of adult flatback turtles from the Lacepede Island and Kimberley mainland rookeries have not been determined. The remigration interval of flatback turtles from eastern Australian rookeries is typically between one and five years (Limpus et al. 1984a).

Migration pathways of flatback turtles nesting in southern Western Australian rookeries, such as Port Hedland, generally pass the Dampier Peninsula to probable foraging grounds in the Kimberley region (Care for Hedland Environmental Association 2010).

Satellite tracking of flatback turtles nesting at Barrow Island suggests that these turtles migrate along the northern Western Australian coast from the Pilbara region into the Kimberley region (K. Pendoley pers. comm. 2007). Tagging data indicates that Western Australian flatback turtles may migrate as far as the Northern Territory (Prince 1998).

#### 3.2.2.6 Foraging Habitats and Diets

Flatback turtles are carnivorous; their diet consists mainly of jellyfish and other invertebrates (DEWHA 2009). While high densities of large jellyfish have been observed in the nearshore waters adjacent to James Price Point (D. Waayers pers. obs.), it is not known if they are favoured prey species.

In north-eastern Australia, flatback turtles forage in turbid, shallow, inshore waters in depths of 5–20 m (Bjorndal 1997). They rarely forage in intertidal seagrass meadows or coral reef habitats (Limpus 2009). The foraging habitats of flatback turtles on Western Australia are unknown, however flatback turtles have been observed along an oceanic convergence zone in approximately 30 m water depth off the Dampier Archipelago, where they were possibly foraging (M. Forde pers. comm. 2007).

Flatback turtles have been regularly reported in prawn trawl catches in the Gulf of Carpentaria and the Great Barrier Reef and are recognised as a regular inhabitant of the shallow inshore turbid waters and bays of these areas (Limpus et al. 1983).

The presence and location of flatback turtle foraging habitats in the Kimberley region is not known, and no targeted research has been undertaken. Given the shallow, turbid nature of the inshore waters of the Dampier Peninsula, it is possible that flatback turtles forage along this coast.

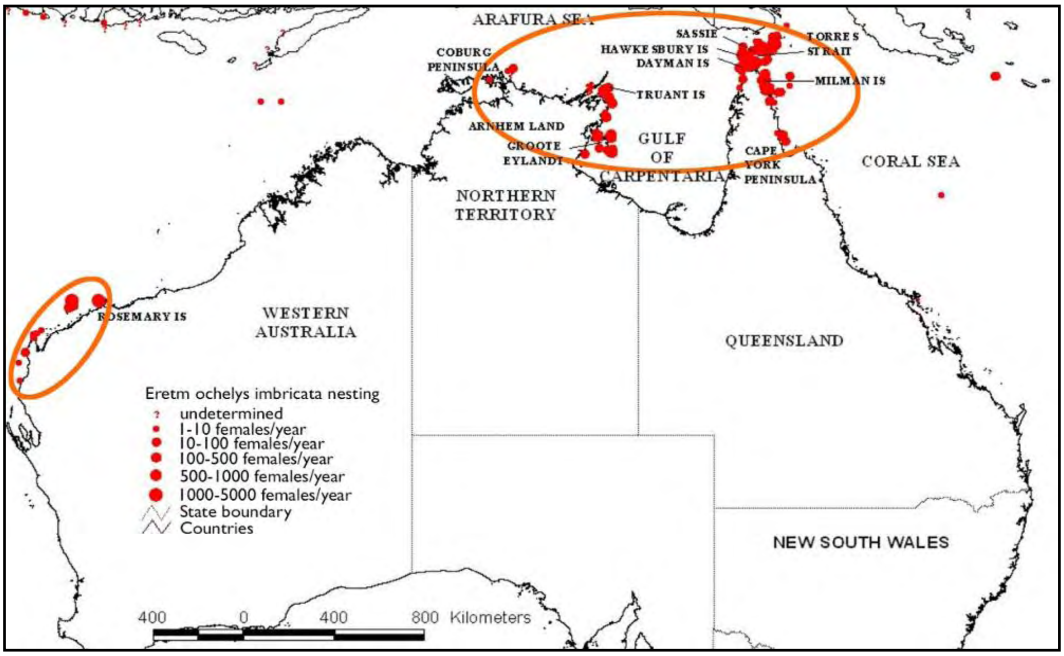
### 3.2.3 Hawksbill Turtles

#### 3.2.3.1 Population Structure

Two hawksbill turtle MUs have been identified in Australia; Torres Strait and the North West Shelf (Moritz et al. 2002, Dutton et al. 2002). The Torres Strait includes the Northern Great Barrier Reef and North-eastern Arnhem Land sub-populations (Figure 7). The Western Australian MU ranges from North West Cape to the Dampier Archipelago. Hawksbill nesting in the Kimberley is sparse however, given the proximity to the Dampier Archipelago; it is likely that the turtles that do nest here belong to the NWS MU. Genetic studies are yet to be carried out for hawksbill turtles in the Kimberley region.

#### 3.2.3.2 Mating

Little is known about the mating activity of hawksbill turtles in Western Australia, however it is expected that mating generally occurs in shallow waters close to their nesting beaches (Plotkin 2003). Mating is likely to occur a month before the first nesting event, as is consistent with other species (Hamann et al. 2003). Given the timing of the peak nesting period for hawksbill turtles in northern Western Australia (October–January; Robinson 1990), the peak mating period is likely to be from September to December. The nesting density of hawksbill turtles in the Kimberley is low (Prince 1994) and it is therefore unlikely that aggregations of mating hawksbill turtles occur in this area.




Source: Limpus (2009)

**Figure 7: Distribution of Known Hawksbill Turtle (*Eretmochelys imbricata*) MUs in Australia (Note: Western Australian and Northern Territory Data is Incomplete)**

### 3.2.3.3 Nesting and Hatching

The major rookeries for hawksbill turtles in Western Australia are the Dampier Archipelago, the Montebello Islands and the Lowendal Islands (Limpus 2009) (Figure 8). Hawksbill turtles nest all year round with a peak nesting period between October and January in Western Australia (Robinson 1990).

There is limited evidence of nesting by hawksbill turtles in the Kimberley region, although few dedicated surveys have been undertaken. The closest known hawksbill turtle rookeries are at Scott Reef, Ashmore Reef (DEC 2009; Guinea 2009) and Cape Leveque (D. Oades pers. comm. 2009). A single hawksbill nest was recorded at the Lacepede Island Group in 1989–1990 (Prince 1994).

Tagging studies in Western Australia have demonstrated that female hawksbill turtles generally display fidelity to their chosen nesting beach (Limpus 1995), however, a small proportion of the nesting population may nest on other nearby beaches (Limpus 2009).

Average incubation periods for hawksbill turtle nests in eastern and northern Australia are between fifty-five and fifty-nine days (Limpus 2009). Therefore, the peak hatching period in Western Australia is expected to be between December and March.

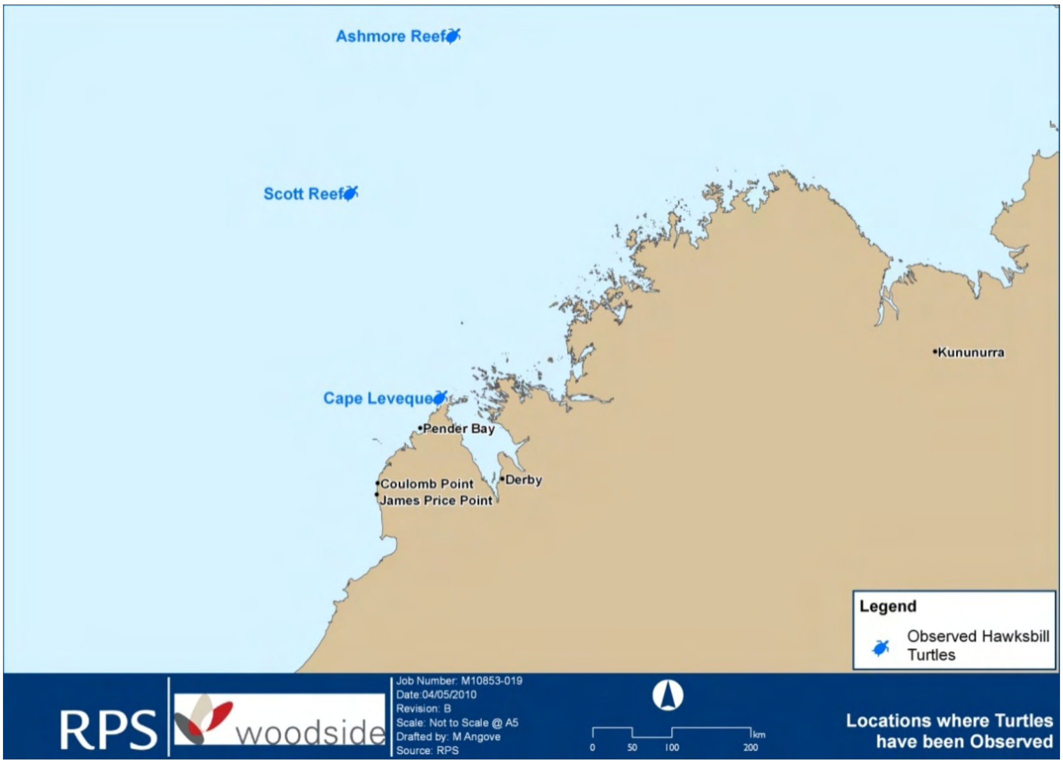



**Figure 8: Hawksbill Turtle Rookeries in the Kimberley Region**

### 3.2.3.4 Inter-nesting

There are no records of the inter-nesting behaviour of hawksbill turtles in the Kimberley. Pendoley (2005) tracked six nesting hawksbill turtles from Varanus Island and three nesting hawksbill turtles from Rosemary Island (in the Pilbara region) and found that the turtles remained within relatively close proximity to their nesting beach during the inter-nesting period (Pendoley 2005). Hawksbill turtles nesting in the Kimberley are therefore also expected to remain relatively close to their nesting beach during the inter-nesting period.

### 3.2.3.5 Migration

Eastern Australian populations of hawksbill turtles are highly migratory (Parmenter 1983). Migrations of up to 2400 km between foraging areas and breeding areas have been recorded (Miller et al. 1998). Nesting hawksbill turtles tracked from Varanus Island and Rosemary Island migrated northwards at the end of the nesting season to foraging grounds near the De Grey River, approximately 380 km away (Pendoley 2005). The mean remigration interval of hawksbill turtles in Western Australia is approximately four years (Limpus 2009).

#### 3.2.3.6 Foraging Habitats and Diets

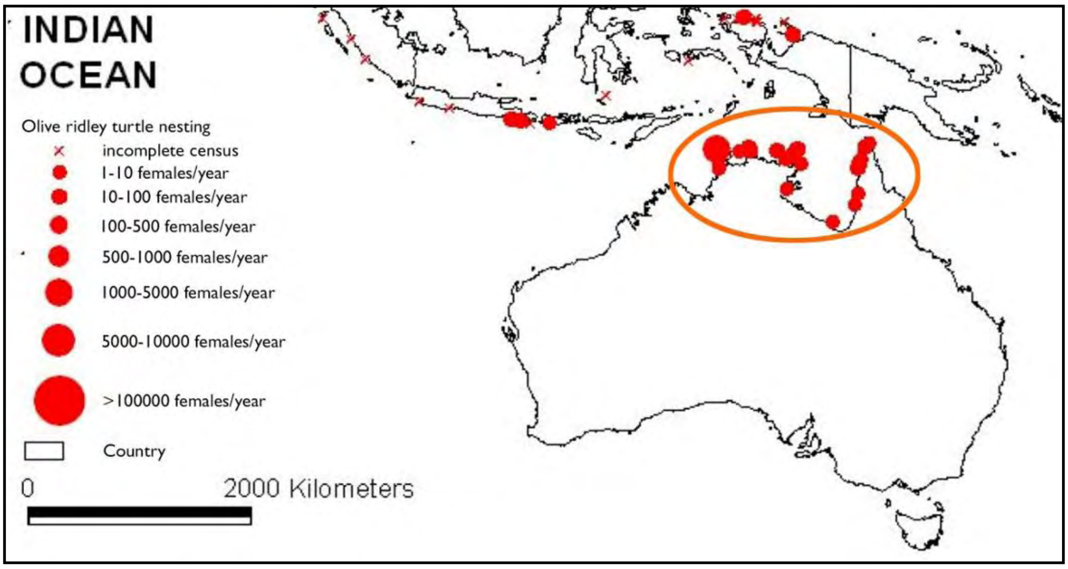
Hawksbill turtles feed on plankton during their pelagic early juvenile phase (Meylan 1984). Older juvenile and adult hawksbill turtles generally forage in benthic habitats such as coral and rocky reefs, where they feed on sponges, molluscs (gastropods, bivalves and cephalopods), cnidarians, seagrass and seaweed (Carr and Stancyk 1975; Limpus 1992, Witzell 1983; Whiting 2000).

Hawksbill turtles have been observed feeding on the reefs adjacent to the mainland Kimberley coast (Prince 1994). However, the feeding habitats of hawksbill turtles in Western Australia are largely unknown.

### 3.2.4 Olive Ridley Turtles

#### 3.2.4.1 Population Structure

There is one MU for olive ridley turtles in Australia (Limpus 2009). This MU includes rookeries from Queensland and the Northern Territory and is genetically distinct from populations in Malaysia, India and the eastern Pacific (Figure 9). There are two records of olive ridley turtle nesting in the Kimberley, at Cape Leveque (D. Oades pers. comm. 2009) and at Darcy Island (in the Heywood Islands Group, to the north of Camden Sound; DEC 2009a). These turtles are presumed to belong to the Australian MU.




Source: Limpus (2009)

**Figure 9: Distribution of Known Olive Ridley Turtle (*Lepidochelys coriacea*) MUs in Australia (Note: Data is Incomplete for Western Australia)**

#### 3.2.4.2 Mating

There are no records of olive ridley turtles mating in Western Australia. The mating behaviour of the two olive ridley turtles recorded nesting in Western Australia individuals is not known (DEC 2009a; D. Oades pers. comm. 2009). Given the very low density of olive ridley nesting in Western Australia, it is unlikely that olive ridley turtles aggregate in the Kimberley region for mating.

#### 3.2.4.3 Nesting and Hatching

Olive ridley turtles have been recorded nesting in Western Australia only twice, both times in the Kimberley region (Figure 10). The first record is from a mainland beach near Cape Leveque in March 2008 (D. Oades pers. comm. 2009) and the second is from Darcy Island in June 2008 (DEC 2009a). Olive ridley turtles may nest elsewhere in the Kimberley in low densities however they have not been recorded nesting at the known rookeries for other species.

The average incubation periods for olive ridley turtles in the Northern Territory ranges from 50–53 days (Limpus 2009).

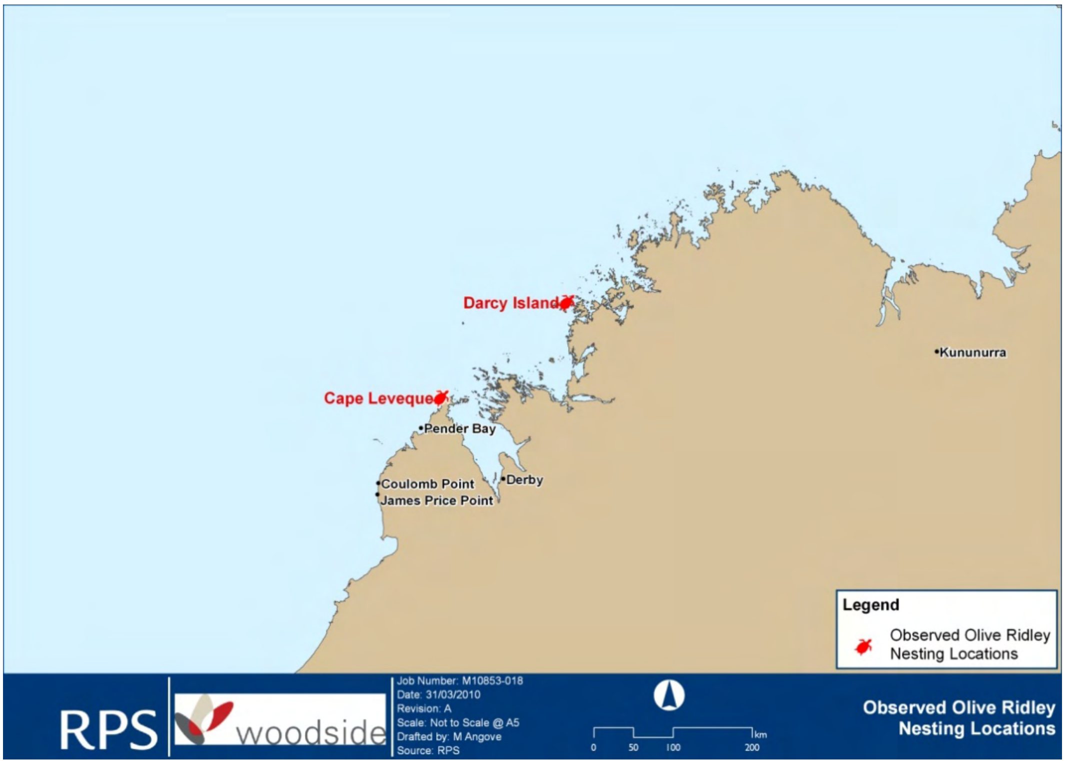



**Figure 10: Observed Olive Ridley Turtle Nesting Locations in the Kimberley Region**

#### 3.2.4.4 Inter-nesting

The inter-nesting behaviours of the two olive ridley turtles recorded nesting in Western Australia were not recorded. Satellite tracking data from olive ridley turtles nesting on Melville Island in the Northern Territory showed that they travelled up to 37 km from their nesting beaches into waters up to 60 m deep during the inter-nesting period, before returning to the inshore habitat in the vicinity of their nesting beaches prior to the next nesting event (Whiting et al. 2005).

It is expected that olive ridley turtles that nest in the Kimberley region display a similar inter-nesting behaviour to those from northern Australia, using both nearshore and offshore habitats, although the Kimberley region is not likely to support significant numbers of inter-nesting olive ridley turtles.

#### 3.2.4.5 Migration

The migrations of olive ridley turtles through the Kimberley region are not known.

Five olive ridley turtles have been tracked from their nesting beach on Melville Island in the Northern Territory. These turtles dispersed to foraging grounds at distances of 230–1050 km from their nesting beaches. All individuals remained within the Australian continental shelf (Whiting et al. 2005).

#### 3.2.4.6 Foraging Habitats and Diets

The olive ridley diet is thought to consist primarily of salps (*Metcalfina*) and fish (Bjorndal 1997). Molluscs, crustaceans, algae, bryozoans and fish eggs are also consumed. However, gut contents sampling from olive ridley turtles stranded at Fog Bay in the Northern Territory identified gastropods as a primary food source for olive ridley turtles in this region (Whiting et al. 2005).

Olive ridley turtles feed in a range of habitats, which includes both deep and relatively shallow benthic habitats, including occasionally near estuaries (Bjorndal 1997). They are commonly encountered over soft bottom habitats but are not often found in coral reef habitats or shallow inshore seagrass flats (Limpus 2009). In northern Australia, olive ridley turtles have been observed foraging in shallow benthic habitats and have been captured by fishing trawlers at depths of 6–60 m in their presumed foraging grounds (Limpus 2009, Whiting et al. 2005).

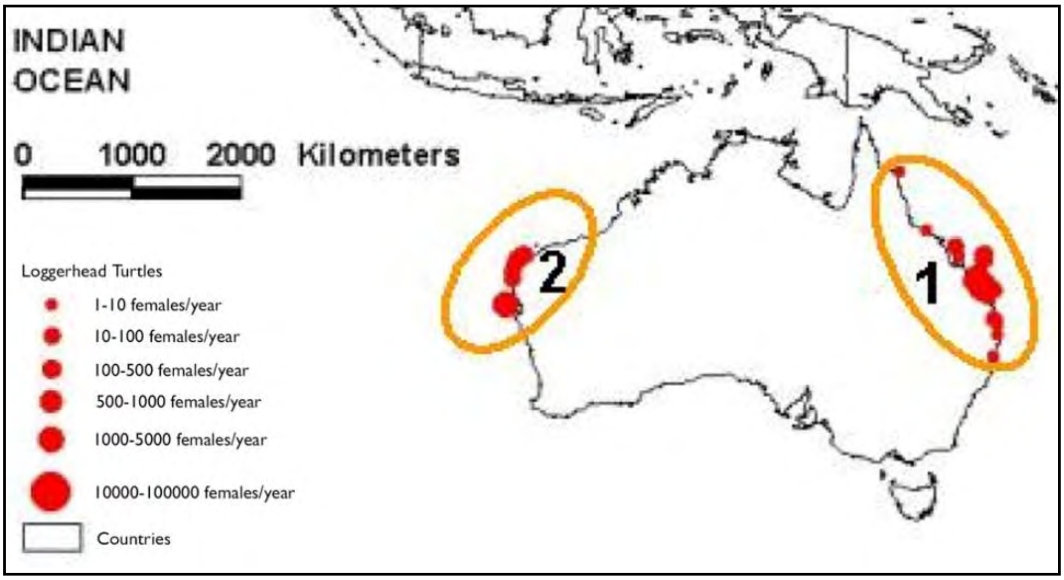
Fog Bay in the Northern Territory is likely to be a major foraging area for olive ridley turtles, as indicated by a major by-catch incident in 1992 where approximately eighty-five olive ridley turtles washed ashore after being captured in shark nets set in Fog Bay over a two week period (Whiting et al. 2005).

There are no records of olive ridley turtles foraging in the Kimberley region.

### 3.2.5 Loggerhead Turtles

3.2.5.1 Population Structure

Two MUs have been identified for loggerhead turtles in eastern Australia and Western Australia (Figure 11) (Dutton et al. 2002). These MUs are based on rookeries in the southern Great Barrier Reef in Queensland and between Shark Bay and Ningaloo in Western Australia.




Source: Limpus (2009)

**Figure 11: Distribution of Known Loggerhead Turtle (*Caretta caretta*) MUs in Australia**

3.2.5.2 Mating

There are no records of loggerhead turtles mating in the Kimberley region.

3.2.5.3 Nesting and Hatching

There are no records of loggerhead turtles nesting in the Kimberley region.

3.2.5.4 Inter-nesting

There are no records of loggerhead turtles nesting in the Kimberley region.

3.2.5.5 Migration

Loggerhead turtles generally migrate up to 1000 km from foraging areas to nesting areas although some individuals migrate up to 2600 km (Limpus 2009). Loggerhead turtles tagged at Western Australian rookeries, including South Muiron Island, have been recaptured between Shark Bay and Arnhem Land and north into the Java Sea (Limpus 2009; Prince 1994). It is likely that loggerhead turtles migrate through the Kimberley region between foraging and breeding areas.

#### 3.2.5.6 Foraging Habitats and Diets

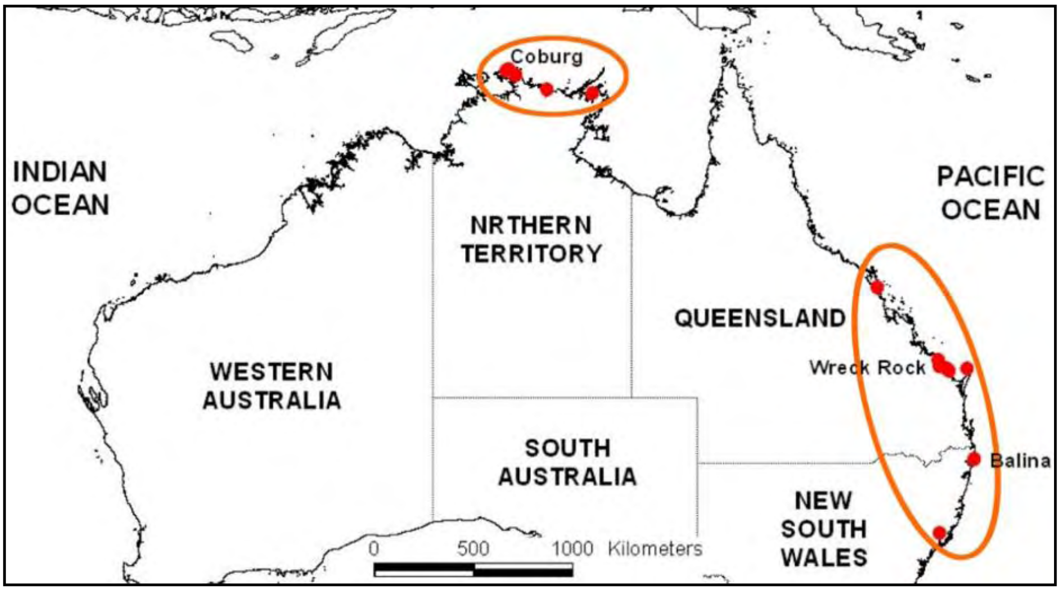
Young juvenile loggerhead turtles forage amongst floating rafts of *Sargassum*, feeding on algae, crustaceans, molluscs, insects, jellyfish, fish and anthropogenic debris (Bjorndal 1997). Large juveniles and adults forage over both hard and soft bottom habitats of the continental shelf. Their diet consists primarily of molluscs (gastropods and bivalves), echinoderms, cnidarians, crustaceans and fish (Limpus et al. 1984b).

There are no available records of loggerhead turtles foraging in the Kimberley, however it is possible that low numbers of loggerhead turtles forage in the waters off the Dampier Peninsula, including in the vicinity of the proposed development, given the availability of suitable foraging habitat.

### 3.2.6 Leatherback Turtles

#### 3.2.6.1 Population Structure

The Australian breeding populations of leatherback turtles have not been genetically assessed. For conservation purposes, it is assumed that the small numbers of leatherback turtles that nest in eastern Australia and north-west Arnhem Land (Figure 12) are from separate MUs (Limpus 2009).




Source: Limpus (2009)

**Figure 12: Distribution of Known Leatherback Turtle (*Dermochelys coriacea*) MUs in Australia**

#### 3.2.6.2 Mating

There are no records of leatherback turtles mating in the Kimberley region.

#### 3.2.6.3 Nesting and Hatching

There are no records of leatherback turtles nesting in the Kimberley region.

#### 3.2.6.4 Inter-nesting

There are no records of leatherback turtles nesting in the Kimberley region.

#### 3.2.6.5 Migration

Leatherback turtles are highly migratory. Post-nesting individuals from Indonesia have been recorded to travel distances of up to 20,558 km from their nesting beaches (Benson et al. 2007). It has been suggested that leatherback turtle migrations may be dependent on the availability of prey (DEWHA 2009). Leatherback turtles are presumed to migrate to Australian waters from nesting populations in Indonesia, Papua New Guinea and the Solomon Islands (Limpus 1997).

Prince (1994) suggests that the number of non-nesting leatherback seen in Australian waters compared to the number of nesting events indicates that these turtles may be migrating to and from foraging areas. There is only one record of a leatherback turtle recapture in Australia, where an individual tagged at an Indonesian rookery was captured and released in King Sound in the Kimberley region, in 1986 (Prince 1994).

#### 3.2.6.6 Foraging Habitats and Diets

Leatherback turtles feed on soft-bodied invertebrates such as pelagic tunicates (e.g. *Pyrosoma* spp.) and jellyfish (e.g. *Catostylus* spp.) (Limpus 2009).

Foraging leatherback turtles have also been observed in inshore waters (approximately 3 m deep) in the south-eastern Gulf of Carpentaria (Limpus 2009) and are regularly recorded foraging in Australian continental shelf waters. The distribution of foraging leatherbacks is dependent on the distribution of their primary prey items (DEWHA 2009), which are believed to occur in greatest densities near convergent zones or water mass boundaries. High densities of foraging leatherback turtles are not likely to occur in the vicinity of the proposed development site.

While all turtle species described in this section could be present within the Kimberley region, green and flatback turtles are the focus of this report as they are the predominant species found within the immediate study area, which is along the west Dampier Peninsula coast and Lacepede Island Group.

# 4.0 METHODS

## 4.1 Survey Overview

A series of marine megafauna and turtle surveys was conducted off the Kimberley coast between July 2009 and March 2010:

- MMFS Aerial Surveys
- MMFS and Dedicated Turtle Surveys (Vessel-based)
- Beach Surveys
- Satellite Tag Surveys

The timing and locations for these surveys are summarised in Table 2.

As part of the Woodside Browse Marine Megafauna Survey (MMFS) program, four aerial surveys and one vessel survey were undertaken off the Kimberley coast (Table 2). The primary purpose of the MMFS surveys was to collect data relating to humpback whales and dugongs however, data on other megafauna, such as marine turtles, was also collected.

The MMFS were conducted between July and October 2009, which coincided with the foraging period for post-nesting turtles in the region. Surveys from this period provide an indication of the distribution of foraging turtles and hence identifies potential foraging habitats.

In addition to the MMFS, a series of Dedicated Turtle Surveys (DTS) was conducted at the James Price Point area and the Lacepede Island Group. The DTS were conducted during the peak marine turtle breeding season (November–March). The DTS included vessel based mating surveys, beach based preliminary habitat assessment, track count, nearshore and sand temperature surveys and inter-nesting and migration satellite telemetry surveys (Table 2).

**Table 2: Survey Program, Name, Type, Location and Timing**

| Survey Program | Survey Name | Survey Type | Location | Timing |
|---|---|---|---|---|
| MMFS | James Price Point Migration Corridor Survey | Aerial (refer to methods in Section 4.2) | Dampier Peninsula (including the James Price Point area and the Lacepede Island Group) and Scott Reef | Jul–Oct 2009 |
| | Reference Site Survey | | | |
| | Scott Reef Offshore Survey | | | |
| | Nearshore Regional Survey | Aerial (refer to methods in Section 4.2 for methods) | Dampier Peninsula (including the James Price Point area and the Lacepede Island Group) | Mar, Jul and Sep 2009 |
| | Marine Megafauna Vessel Survey | Vessel (see Section 4.3.1 for methods) | James Price Point area and Pender Bay | Jul–Sep 2009 |
| DTS | Dedicated Turtle Vessel Survey | Vessel (see Section 4.3.2 for methods) | Dampier Peninsula (including the James Price Point area and the Lacepede Island Group) | Dec 2009 and Feb 2010 |
| | Preliminary Habitat Assessments<br>Track Counts<br>Nearshore Surveys<br>Sand Temperature | Beach (see Section 4.4 for methods) | Dampier Peninsula (including the James Price Point area and Lacepede Island Group) | Nov 2009 – Mar 2010 |
| | Inter-nesting and Migration | Satellite telemetry (see Section 4.5 for methods) | Dampier Peninsula (including the James Price Point area and the Lacepede Island Group) | Dec 2009 and Feb 2010 |

## 4.2 Marine Megafauna Aerial Surveys

### 4.2.1.1 Survey Areas

The James Price Point Migration Corridor Survey targeted the expected humpback whale migration corridor along the Kimberley coast. The survey comprised six east–west transects approximately 90 km in length and 14 km apart. These transects were located north and south of the James Price Point area with the nearest points to shore located approximately at the mean high water level (Figure 13).

The Reference Site Survey comprised six transects arranged broadly along the western Kimberley coast from Gourdon Bay in the south to Pender Bay in the north near Cape Leveque (Figure 13). The whole flight covered 841 km of transects.

The Scott Reef Offshore Survey covered 848 km of transect and comprised nine transects out to Scott Reef from the northern ends of transects T4 and T6 of the Reference Site Survey (Figure 13).

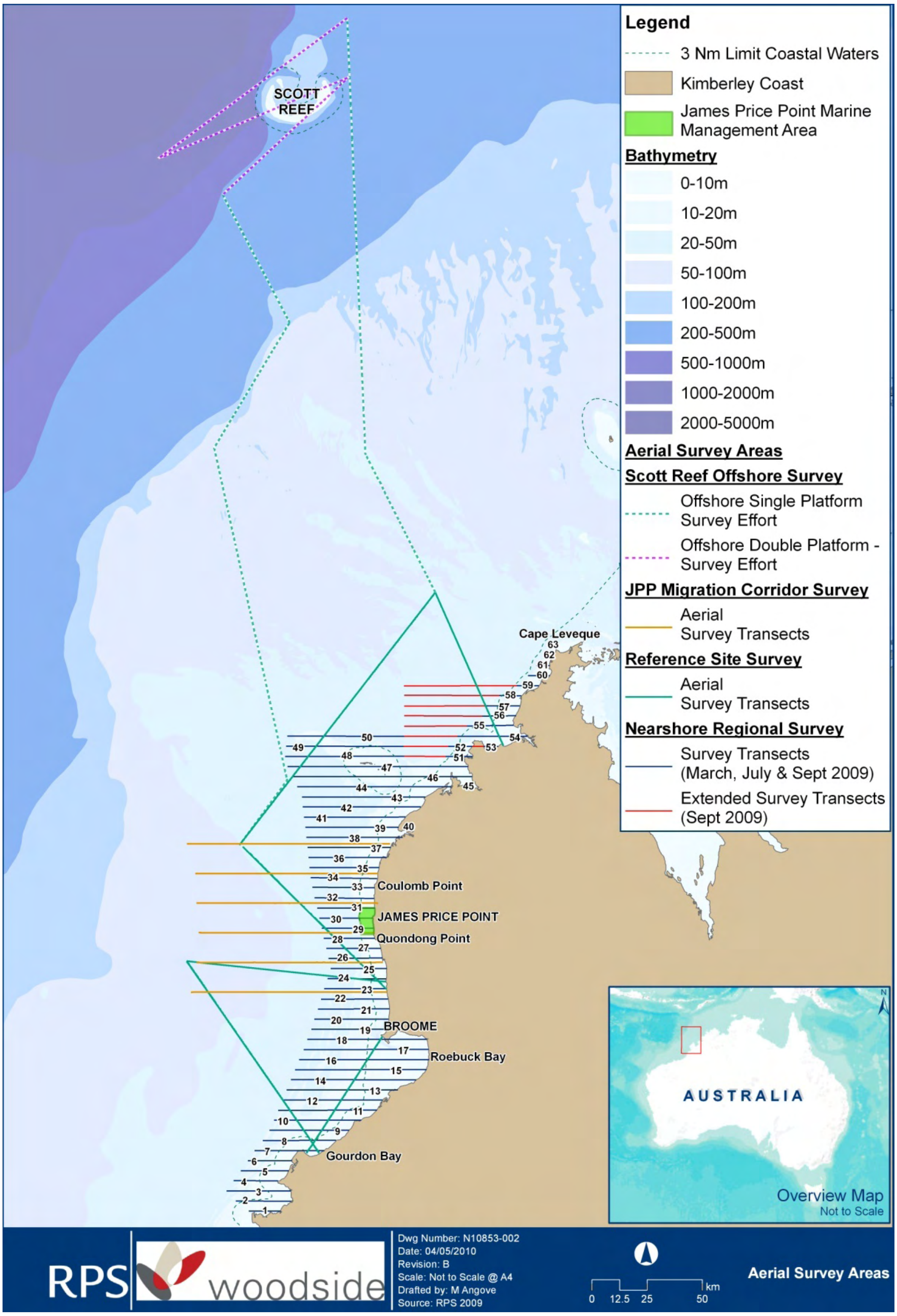



**Figure 13: Geographic Extent of Aerial Surveys Undertaken as Part of the MMFS**

#### 4.2.1.2 Survey Schedules

The James Price Point Migration Corridor Surveys were conducted eight times through the period 1 July to 10 October 2009 (Table 3). All six transects were flown on the same day except during Flight N2 where the survey was abandoned due to deteriorating weather conditions. It was completed as soon as conditions permitted thereafter on 3 August 2009.

**Table 3: Schedule for the James Price Point Migration Corridor Surveys**

| Flight No. | Date | Start Time | End Time | Transects Surveyed | Sea State |
|---|---|---|---|---|---|
| N1 | 1 July | 09:48 | 12:40 | T6–T1 | 2–3 |
| N2 | 31 July | 13:01 | 15:52 | T5–T1 | 2–5 |
| | 3 Aug | 13:59 | 16:26 | T6 | 1-2 |
| N3 | 18 Aug | 13:36 | 16:26 | T6–T1 | 1–3 |
| N4 | 30 Aug* | 13:11 | 16:06 | T6–T1 | 2–4 |
| N5 | 10 Sept | 07:46 | 10.39 | T6–T1 | 2–4 |
| N6 | 22 Sept | 07:52 | 16:18 | T1–T6 | 3–5 |
| N7 | 28 Sept | 08:26 | 10:57 | T1–T6 | 2–4 |
| N8 | 10 Oct | 07:14 | 10:45 | T1–T6 | 2 |

Note *=Neap Tide

The Reference Site Surveys were conducted seven times through the period 1 July to 12 October 2009 (Table 4). Transect T2 was also flown before or after the James Price Point Migration Corridor Survey and Transects T4 and T6 were also flown at the beginning or end of the offshore survey. This amounted to transect T2 being sampled 11 times and T4 and T6 being sampled 13 times each.

**Table 4: Schedule for the Reference Site Surveys**

| Flight No. | Date | Start Time | End Time | Transects Surveyed | Sea State |
|---|---|---|---|---|---|
| R1 | 1 July | 12:52 | 13:23 | T2 | 2 |
| | 2 July | 13:10 | 16:03 | T6–T1 | 1–4 |
| | 3 July* | 08:57 | 09:15 | T6 | 4 |
| | | 13:53 | 14:21 | T4 | 3 |
| R2 | 1 Aug* | 13:30 | 16:29 | T1–T6 | 2 |
| | 3 Aug | 14:33 | 15:49 | T2,T4 | 1–4 |
| | 4 Aug | 15:13 | 15:33 | T6 | 2–4 |
| R3 | 21 Aug | 08:46 | 11:55 | T6–T1 | 1–4 |
| | 22 Aug | 08:28 | 08:48 | T6 | 2 |
| | | 13:14 | 13:41 | T4 | 2 |
| R4 | 30 Aug* | 16:12 | 16:42 | T2 | 1–3 |
| | 31 Aug* | 07:48 | 10:27 | T6–T1 | 1–3 |
| | 1 Sept | 07:27 | 07:47 | T6 | 2 |
| | | 12:08 | 12:33 | T4 | 2 |
| R5 | 18 Sept | 06:37 | 09:35 | T1–T6 | 3 |
| | 19 Sept | 06:39 | 07:04 | T4 | 4 |
| | | 11:12 | 11:33 | T6 | 2 |
| | 22 Sept | 07:19 | 07:46 | T2 | 1–3 |
| R6 | 28 Sept | 07:50 | 08:20 | T2 | 2 |
| | | 14:33 | 16:30 | T4–T6 | 2 |
| R7 | 11 Oct* | 07:26 | 10:29 | T1–T6 | 2–4 |
| | 12 Oct* | 06:34 | 07:01 | T4 | 3 |
| | | 08:57 | 09:18 | T6 | 2 |

Note *=Neap Tide

The Scott Reef Offshore Surveys were conducted six times through the periods 1 July to 12 October 2009 (Table 5). Flight O6 had to be abandoned due to deteriorating conditions.

**Table 5: Schedule for the Scott Reef Offshore Surveys**

| Flight No. | Date | Start Time | End Time | Transects Surveyed | Sea State |
|---|---|---|---|---|---|
| O1 | 3 July* | 09:25 | 13:38 | T11–T3 | 2–6 |
| O2 | 4 Aug | 10:56 | 15:12 | T3–T11 | 2–4 |
| O3 | 22 Aug | 08:48 | 13:11 | T11–T3 | 1–3 |
| O4 | 1 Sept | 07:47 | 12:05 | T11–T3 | 1–3 |
| O5 | 19 Sept | 07:08 | 11:12 | T3–T11 | 2–5 |
| O6 | 12 Oct* | 07:05 | 08:57 | T3–T5,T11 | 2–5 |

Note *=Neap Tide

The Nearshore Regional Survey was conducted twice through the period 1 July to 10 October 2009 (Table 6). The third Nearshore Regional Survey, conducted by SKM between 19 and 26 March 2009 (SKM 2009), also documented the distribution of turtles and will be referred to in this report.

**Table 6: Schedule for the Regional Nearshore Survey**

| Flight No. | Date | Start Time | End Time | Transects Surveyed | Sea State |
|---|---|---|---|---|---|
| D1 | 16 July | 14:24 | 16:18 | T63–T54,T50–T49 | 2–4 |
| | 17 July | 13:25 | 16:04 | T53–T51,T48–T42 | 1–3 |
| | 18 July* | 08:42 | 10:59 | T41–T30 | 1–3 |
| | | 13:39 | 16:13 | T29–T17 | |
| | 19 July* | 08:28 | 14:21 | T16–T1 | 2–5 |
| D2 | 11 Sept | 08:35 | 13:11 | T71–T46 | 2–5 |
| | 12 Sept | 07:36 | 11:07 | T45–T31 | 2–3 |
| | 13 Sept* | 07:19 | 10:17 | T18–T9 | 2–3 |
| | 17 Sept | 07:02 | 10:30 | T1–T8, T19–T30 | 1–2 |

Note *=Neap Tide

#### 4.2.1.3 Survey Design

The Strip Width Sampling technique, routinely used for dugongs and humpback whales in Australia (Marsh and Sinclair 1989; Pollock et al 2006) was used to survey marine turtles. A transect strip width of 400 m was surveyed on each side of the aircraft (800 m in total).

The flight altitude for the James Price Point Migration Corridor Survey, Reference Site Survey and Scott Reef Offshore Survey was 1000 feet whilst the Nearshore Regional surveys were 900 feet. This flight altitude is appropriate for large animals such as humpback whales but may lead to underestimates of the abundance of smaller marine megafauna, such as marine turtles (Marsh and Sinclair 1989; Hodgson 2007; SKM 2009). Identification to species level is also not achievable for marine turtles at 1000 ft (SKM 2009).

White water (sea spray and white horses) and, to a lesser extent, choppy surfaces on the ocean can reduce sightability of small marine fauna, such as turtles. Significant levels of white water start to occur in Beaufort Sea State (BSS) 4 and occasionally BSS 3, depending on other environmental conditions (Reid et al. 2003). Tidal races can also cause white water and surface chop whereby it becomes increasingly difficult to detect and identify fauna (Reid et al. 2003).

To maximise sightability of marine megafauna, where possible, all surveys were conducted as close to neap tides as possible when water turbidity was at its lowest, in good weather (BSS <4), and minimal glare (i.e. avoiding midday glare) (Marsh and Sinclair 1989; Lanyon 2003).

While the surveys provide a preliminary indication of the relative density of turtle populations in the region, they are based on less than a single year's data. The variability in turtle distribution between seasons, years and sites in life history parameters, especially for green turtles (Broderick et al. 2001), necessitates caution when interpreting this data.

#### 4.2.1.4 Survey Protocol

All MMFS were conducted using two pilots, a team leader, four scientists (observers) and occasionally two Traditional Owners (TOs). The pilots ensured the aircraft maintained its flight path and altitude and recorded the aircraft's altitude, flight path (compass bearing) and associated angle of drift for correction of sighting positions in post processing. The team leader (scientist) communicated with the pilots, coordinated the survey and monitored survey progress via computer output. Four observers surveyed for, and recorded sightings of marine megafauna animals: two on each side (port and starboard), and one behind each other (front and rear). The primary purpose for using two observers on each side of the aircraft was to acquire double count (recaptures) data for humpback whales, which enabled estimation of the proportion of animals that were missed by the front surveyors. For the purpose of analysing turtle data, records from a single platform (front observers only) were used in the analysis as recaptures were impossible. The TOs collected records from sightings to help establish group size for turtles. This data has not been used to adjust any of the survey data but used to enhance the qualitative data collected throughout the survey period.

Environmental parameters collected by the team leader included wind speed (knots) and direction (degrees), cloud cover (oktas), Beaufort Sea State (BSS) (1–12), turbidity (1–4), visibility (1–9), other weather conditions (e.g. rain), transect start and finish time, and sighting data with associated viewing zone. While the above environmental parameters were collected, no Availability Correction Factors (ACFs) were established due to the lack of information relating to the proportion of time turtles spend at the surface and dive duration.

All observers undertook a pre-survey training workshop where they were given detailed information about the survey method and conducted a series of trial runs in the classroom prior to one, three hour training flight out of Broome.

Observers searched the area to the side of the aircraft, scanning in a zigzag fashion in and out from the aircraft. Observer teams on each side of the aircraft independently recorded their observations to an audio recording system via aviation headsets for subsequent transcription to the database and spatial referencing. Post-survey analysis within ArcGIS estimated the geographic coordinates for each of the groups sighted using position of the aircraft, and zone in which they were recorded.

Flight track coordinates were acquired every second from a Garmin GPSMAP 60CSx with an external antenna located in the cockpit of the aircraft. The coordinates were downloaded to a laptop. A backup GPS was also placed in the cockpit, and set to record fixes every second to internal memory. Real-time output to the laptop enabled the team leader to monitor survey progress.

#### 4.2.1.5 Data Analysis

The distribution, abundance and densities of turtles recorded in the water were analysed and presented spatially using ArcGIS. The number of turtles recorded during the aerial surveys was presented in ranges based on the relative abundance of turtles in a particular area. For example, the ranges for the Nearshore Regional Survey were 1, 2–4, 5–8, 9–15, 16–30 and 31–46.

As part of the Nearshore Regional Survey analysis, densities (sightings/km² within the 800 m strip-width transects) were also displayed in four categories (<0.6; 0.6–1.5; 1.6–2.4; and 2.5+) to identify "hot spots", or areas of high density in the survey area. The total number of turtles and densities of turtles sighted at the surface within the 800 m strip-width transect were then tabulated for each category.

Population estimates were not calculated due to the uncertainty of perception bias and ACFs for turtles.

## 4.3 Vessel Surveys

Two types of vessel surveys were undertaken along the Dampier Peninsula: marine megafauna surveys (July–October 2009) and dedicated turtle surveys (December 2009 and February 2010). While these surveys cover different areas, the survey protocol is similar.

### 4.3.1 Marine Megafauna Vessel Surveys

#### 4.3.1.1 Survey Area

Two 20 x 20 nautical mile (Nm) survey "boxes" were located offshore from James Price Point and at Pender Bay (Figure 14). The boxes were 20 Nm wide to allow a survey vessel to cross the entire box two or possibly three times per day at approximately 6–8 knots.

The James Price Point survey box was centred offshore from the proposed development area at James Price Point and avoided very shallow water. Survey work was conducted around pearl farm structures. The Pender Bay reference site was located to allow safe passage of vessels at inshore locations and easy access to appropriate anchorage sites.

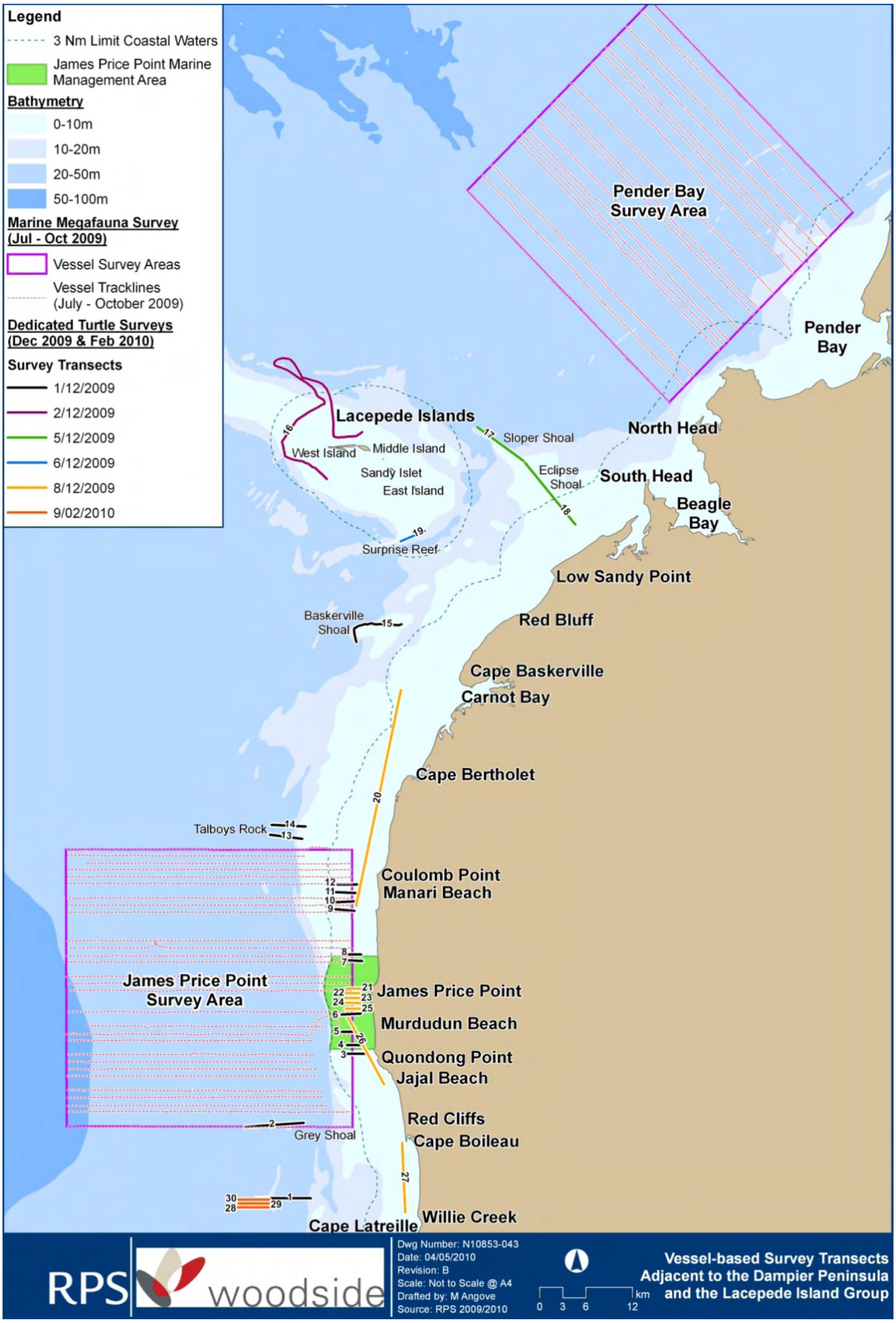



**Figure 14: Vessel Surveys (July 2009 to February 2010) at James Price Point, the Lacepede Island Group and Pender Bay**

#### 4.3.1.2 Survey Schedule

The vessel surveys were conducted over three separate periods between July and October 2009 to identify species of megafauna, including turtles, sighted from the aerial surveys (Table 7). This period incidentally coincided with the non-breeding period for turtles in Western Australia. Weather conditions were selected to be Beaufort Sea State (BSS) of 3 or less where possible to ensure adequate visibility.

**Table 7: Vessel Survey Schedule for James Price Point and Pender Bay**

| Survey No. | Survey Area | Date | Transects | Distance Surveyed (km) |
|---|---|---|---|---|
| 1 | James Price Point | 25 July | 1,27 | 78.18 |
| | | 26 July | 16 | 37.68 |
| | | 29 July | 37 | 34.21 |
| | | 30 July | 3 | 34.28 |
| | | 5 Aug | 33, 17 | 69.49 |
| | | 9 Aug | 10, 30 | 69.60 |
| | Pender Bay | 6 Aug | 3, 21 | 76.12 |
| | | 7 Aug | 6, 28, 8 | 114.18 |
| | | 8 Aug | 38 | 38.07 |
| 2 | James Price Point | 24 Aug | 28, 9 | 69.02 |
| | | 25 Aug | 38 | 37.31 |
| | | 27 Aug | 15, 24, 35 | 109.26 |
| | | 28 Aug | 14, 21, 31 | 105.88 |
| | | 7 Sept | 6 | 37.15 |
| | Pender Bay | 4 Sept | 11, 33, 13 | 114.26 |
| | | 5 Sept | 24, 10 | 76.09 |
| | | 6 Sept | 27, 17 | 76.13 |
| 3 | James Price Point | 29 Sept | 26, 8 | 67.96 |
| | | 2 Oct | 2 | 30.95 |
| | | 5 Oct | 19, 32 | 69.86 |
| | | 6 Oct | 40, 20, 5 | 111.32 |
| | | 8 Oct | 4 | 37.10 |
| | | 9 Oct | 36 | 33.31 |
| | Pender Bay | 7 Oct | 1, 26, 20 | 114.11 |
| | | 8 Oct | 35 | 38.08 |

#### 4.3.1.3 Survey Design

A total of 40 transects were placed across the 20 x 20 Nm survey boxes at 0.5 Nm spacing. They were orientated across local bathymetric contours at both sites: east to west at James Price Point and in a north-westerly direction at Pender Bay. Transects were numbered and selected randomly for each day of surveying. It was not intended to sample across all transects.

The Browse Express was used for the vessel survey and provided an observation eye height of approximately 5.3 m above water level. The bridge deck had adequate observation area for the four scientific staff, TOs and crew.

#### 4.3.1.4 Survey Protocol

The survey team was comprised of two dedicated whale observers (one port, one starboard), one dedicated marine fauna observer and one data recorder. The data recorder logged transect, sighting and environmental data onto a laptop computer using a customised Access database.

Each dedicated whale observer scanned ahead and to approximately 90° abeam of the vessel (one port, one starboard). The marine fauna observer scanned the full 180° abeam of the vessel. Observation was conducted using the naked eye and hand-held binoculars. When a sighting cue was detected, observers provided the sighting information to the data recorder. Information recorded included species of turtle, time, bearing (magnetic compass), distance (range estimate or reticle), reliability index (certain, probable, guess), number in group, age class (adult, sub-adult, juvenile), direction of travel and turbidity. In addition to the whale and marine fauna observers, TOs were asked to help spot turtles and other megafauna during the survey. The objective was to spot and identify all species in the survey area, rather than apply a systematic and constant effort.

Environmental data (e.g. BSS, wind speed and direction, cloud cover, swell direction and height, glare, turbidity and oceanographic features) were also collected by the recorder. Continuous geographic fixes were downloaded from a Garmin GPSMAP 60CSx into a laptop.

The position of each encounter was calculated from the GPS position at the time of the sighting (marked by the dedicated recorder), and an estimated distance and magnetic compass bearing (from handheld, binocular or vessel compass) provided by the observer.

### 4.3.2 Dedicated Turtle Vessel Surveys

The vessel surveys conducted in December and February were targeted at capturing the expected mating activity of adult male and female turtles. Resident juveniles and foraging turtles were also recorded during the survey based on the results from the Nearshore Regional Aerial Surveys.

#### 4.3.2.1 Survey Area

A total of 30 transects was surveyed along the Dampier Peninsula coast between Broome and the Lacepede Island Group in December 2009 and February 2010. The following areas were surveyed (Figure 14):

***December 2009***

- The James Price Point area coastline: Quondong Point, Coulomb Point, Murdudun Beach, Manari Beach and Red Cliffs.
- Shoals offshore the James Price Point coast: Grey Shoal, Talboys Rock and the reef site west of Willie Creek.
- Islands and shoals surrounding the Lacepede Island Group: Sandy Islet, Baskerville Shoal, Sloper Shoal, Eclipse Shoal and Surprise Reef.

***February 2010***

- Waters approximately 20 km west of Willie Creek

#### 4.3.2.2 Survey Schedule

The targeted vessel surveys were conducted in early December 2009 and February 2010 (Table 8). The survey was integrated into the scope of work as part of the satellite tagging program and to capture the mating period for green and flatback turtles in December. The survey conducted in February was specifically designed to cover potential foraging habitat west of Willie Creek. Weather conditions were selected to be Beaufort Sea State (BSS) of 3 or less where possible.

**Table 8: Schedule of Surveys 1–8 December 2009 and 9 February 2010**

| Survey No. | Survey Area | Date | Transects | Distance Surveyed (km) |
|---|---|---|---|---|
| 1 | James Price Point | 1 Dec | 1–15 | 53.3 |
| | | 8 Dec | 20–27 | 56 |
| | Lacepede Island Group | 2 Dec | 16 | 40 |
| | | 5 Dec | 17, 18 | 17.7 |
| | | 6 Dec | 19 | 3.5 |
| 2 | James Price Point | 9 Feb | 28-30 | 12 |

#### 4.3.2.3 Survey Design

Vessel surveys in December 2009 targeted areas that were previously identified as potential "hot spots" for turtles by aerial surveys conducted in 2009 (Section 4.2) and/or considered potential foraging habitat for turtles.

A total of 30 strip width transects (100 m wide) at varying lengths were conducted over areas of interest to provide more detailed information about turtle species and their behaviour (Figure 14). Most of the transect lines adjacent to the James Price Point area were between 1 and 3 km from the coast, while other transects covered areas of interest further offshore based on the results of the aerial surveys. Not all transects were linear due to sudden changes in depth and the risk of colliding with bombora during the surveying period (Transects 15 and 16). Transects were mostly restricted to depth of >10 m to also avoid grounding the vessel on bombora, which are randomly scattered along the nearshore coastal areas adjacent to the James Price Point area and the Lacepede Island Group.

#### 4.3.2.4 Survey protocol

The survey protocol used for conducting the targeted vessel survey in December 2009 was based on the MMFS vessel surveys (Section 4.3.1.4). However, rather than streaming the GPS locations onto a laptop, locations and times were marked using a handheld GPS unit and corresponded with descriptions of turtles recorded on a audio recorder.

## 4.4 Beach Studies

Beach studies were conducted at the James Price Point area in November 2009, January 2010 and February 2010 to cover the entire breeding season for green and flatback turtles. At the Lacepede Island Group, surveys were conducted in December 2009 and February 2010, during the peak of the breeding season.

Beach studies included several different survey types: preliminary habitat assessments, track counts, nearshore surveys, sand temperature measurement and inter-nesting and satellite tracking of tags on nesting female turtles. Each of these survey types is detailed below.

The purpose of the preliminary habitat assessment was to identify monitoring beaches for conducting the other surveys. Track counts were conducted to establish the species of turtle nesting in the study area and determine their spatial distribution and abundance at various rookeries. The primary focus of the nearshore surveys was to identify possible mating aggregations adjacent to monitoring beaches. Sand temperature was measured to gauge the potential for gender bias due to temperature dependent sex determination. Satellite tags were attached to green and flatback turtles at West Island (Lacepede Island Group) to determine the size of inter-nesting ranges and post-nesting migratory routes to probable foraging grounds.

### 4.4.1 Preliminary Habitat Assessment

#### 4.4.1.1 Survey Areas

All accessible sandy beaches within the James Price Point area (between Quondong Point and Coulomb Point) and in the Lacepede Island Group (Figure 15) were visited to identify potential turtle rookeries and nearshore foraging sites.

#### 4.4.1.2 Survey Schedule

The preliminary habitat assessment was conducted in November 2009 at the James Price Point area and in December 2009 at the Lacepede Island Group.

#### 4.4.1.3 Survey Design

Potential nesting beaches were identified from signs of turtle nesting activity (e.g. fresh tracks, body pits and egg shells) and a visual assessment of the dune topography and beach slope (i.e. evidence of erosion and dune stability), evidence of tidal inundation during spring high tides and barriers to beach approach (e.g. intertidal rocky formations).

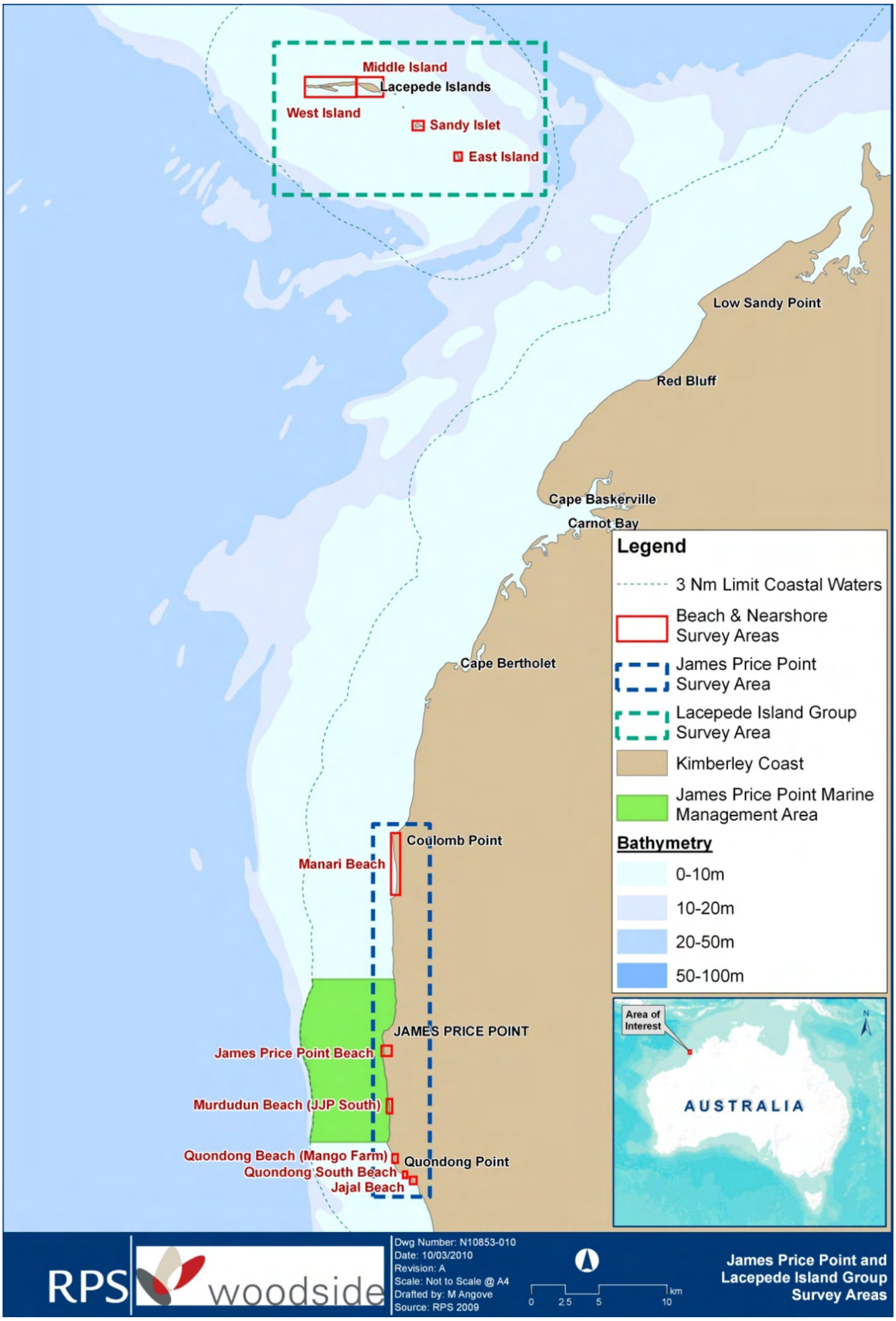



**Figure 15: Location of Track Counts and Nearshore Surveys at the James Price Point Area and the Lacepede Island Group**

### 4.4.2 Track Counts

#### 4.4.2.1 Survey Area

Six survey sites were selected at the James Price Point area, including Jajal Beach, Quondong South Beach, Quondong Beach (Mango Farm), Murdudun Beach (James Price Point South), James Price Point Beach (Main) and Manari Beach (between Flat Rock and Coulomb Point) (Figure 15). A total of 128.70 km of beach was surveyed during the track count surveys (Table 9).

Four survey sites were selected at the Lacepede Island Group, including 1 km sections of beach on West Island, Middle Island, and all of Sandy Islet (1 km) and East Island (0.3 km) (Figure 15). A total of 14.90 km was surveyed at the islands (Table 9).

**Table 9: Location and Distance of Beach Survey Sites and Sand Temperature Loggers**

| Location | Beach Name | No. of Sand Temperature Loggers Installed | Length of Beach Surveyed (km) | Number of Days Surveyed | Total Distance Surveyed (km) |
|---|---|---|---|---|---|
| James Price Point Area | Jajal Beach | 0 | 0.64 | 17 | 10.88 |
| | Quondong South Beach | 2 | 0.59 | 17 | 10.03 |
| | Quondong Beach (Mango Farm) | 0 | 1.05 | 12 | 12.60 |
| | Murdudun Beach (JJP South) | 0 | 0.90 | 13 | 11.70 |
| | James Price Point Beach | 2 | 0.72 | 17 | 12.24 |
| | Manari Beach | 2 | 4.75 | 15 | 71.25 |
| | **Total** | **6** | **8.65** | **91** | **128.70** |
| Lacepede Island Group | West Island | 3 | 1.00 | 8 | 8.00 |
| | Middle Island | 0 | 1.00 | 3 | 3.00 |
| | East Island | 0 | 0.30 | 3 | 0.90 |
| | Sandy Islet | 0 | 1.00 | 3 | 3.00 |
| | **Total** | **3** | **3.3** | **17** | **14.90** |

#### 4.4.2.2 Survey Schedule

Four Beach Studies were conducted at the James Price Point area and two Beach Studies were conducted at the Lacepede Island Group between November 2009 and March 2010. A summary of the survey effort is presented in Table 10.

All beaches were walked on the first day of the survey to document historical turtle nesting activity and the presence of turtles in the nearshore habitats. Thereafter, all beaches were walked daily apart from Jajal, Quondong South and Quondong Beaches, which were scanned daily for fresh turtle tracks using binoculars from a vantage point.

Track Count and Nearshore Surveys were conducted in the morning between 0530 and 1200 hours to take advantage of the shadows in the sand, which assists in track identification.

#### 4.4.2.3 Survey Methods

Tracks were counted in the early morning based on methods described in Schroeder and Murphy (1999), Pendoley (2005) and Waayers (2010). Surveys were conducted on foot and the survey team recorded fresh tracks left by the turtles that had attempted to nest during the previous night. To avoid duplication of records, each track was marked with a line in the sand or the entire beach above the high tide was marked, and marked tracks were not counted the following day.

On the first day of the survey, when tracks and beaches were unmarked, return tracks were counted below the high tide mark. However this technique underestimates the total number of turtles on the beach because it does not consider turtles which emerged and returned to the water before the high tide. Consequently, only surveys that used the line-marking technique to indicate old tracks were used to calculate the proportion of turtles between islands within the Lacepede Island Group.

The species of turtles was identified by observing the characteristics of the track such as track width, gait symmetry, plastron drag, tail drag and/or track depth were used. A single turtle attempting to nest leaves an emerging and returning track. To avoid double counts, only tracks returning to the water were recorded. The number of nests at the Lacepede Island Group was not determined due to the high density of tracks however, this was done at the mainland at the James Price Point area.

### 4.4.3 Nearshore Surveys

Two different sampling techniques were used to identify turtles in nearshore waters at the James Price Point area; scanning surveys and point surveys. Scanning surveys were conducted in conjunction with track counts (Section 4.4.2), and involved one observer who recorded turtles in the nearshore waters along the whole section of the beach. Point surveys of intertidal reef areas were conducted from fixed vantage points on James Price Point Beach and Quondong South Beach, based on aggregations of turtles observed at these locations during scanning surveys.

Only scanning surveys were conducted at the Lacepede Island Group because of the high number and relatively even distribution of turtles in nearshore areas.

**Table 10: Survey Schedule for Beach Surveys at the James Price Point Area and at the Lacepede Island Group**

| Survey No. | Survey Area | Beach | Dates |
|---|---|---|---|
| 1 | James Price Point | Jajal | 16 Nov, 17–22 Nov |
| | | Quondong South | 16 Nov, 17–22 Nov |
| | | Quondong (Mango Farm) | 21–22 Nov |
| | | Murdudun | 16 Nov, 21 Nov |
| | | James Price Point | 16 Nov, 17–22 Nov |
| | | Manari | 17–22 Nov |
| 2 | Lacepede Island Group | West Island | 2–7 Dec |
| | | Middle Island | 6–7 Dec |
| | | East Island | 6–7 Dec |
| | | Sandy Islet | 6–7 Dec |
| 3 | James Price Point | Cancelled due to tropical cyclone Laurence | |
| 4 | James Price Point | Jajal | 18–21 Jan |
| | | Quondong South | 18–21 Jan |
| | | Quondong (Mango Farm) | 18–21 Jan |
| | | Murdudun | 18–21 Jan |
| | | James Price Point | 18–21 Jan |
| | | Manari | 18 Jan* |
| 5 | James Price Point | Jajal | 13–19 Feb |
| | | Quondong South | 13–19 Feb |
| | | Quondong (Mango Farm) | 13–19 Feb |
| | | Murdudun | 13–19 Feb |
| | | James Price Point | 13–19 Feb |
| | | Manari | 13–19 Feb |
| | Lacepede Island Group | West Island | 10–11 Feb |
| | | Middle Island | 11 Feb |
| | | East Island | 11 Feb |
| | | Sandy Islet | 11 Feb |
| 6 | James Price Point | Jajal | 16 Mar |
| | | Quondong South | 16 Mar |
| | | Quondong (Mango Farm) | 16 Mar |
| | | Murdudun | 16 Mar |
| | | James Price Point | 16 Mar |
| | | Manari | 16 Mar |

#### 4.4.3.1 Survey Area

***Scanning Surveys***

Turtles within approximately 50 m of the shore were recorded as the teams walked the beaches during the track count surveys.

***Point Surveys***

Short-term temporal observations (10 minute sampling period) of nearshore turtle activity were also recorded in quadrats 50 m offshore and 100 m wide from vantage points at James Price Point Beach and Quondong South Beach.

#### 4.4.3.2 Survey Schedule

Scanning and Point surveys were conducted on the same days as track counts. Surveys were conducted in the morning to avoid sun glare and sea breezes over six consecutive days from 14–19 February 2009 and on 16 March 2010.

#### 4.4.3.3 Survey Methods

***Scanning Surveys***

Scanning surveys were conducted concurrently with the track counts with one person dedicated to observing turtles in the nearshore water. Nearshore waters approximately 50 m from shore were scanned by eye and with binoculars whilst walking along beaches during the morning track counts.

***Point Surveys***

Short-term temporal observations of nearshore turtle activity were also recorded for 50 x 100 m quadrats from vantage points at James Price Point Beach and Quondong South Beach over a 10 minute period. These quadrats delineated intertidal reef areas where high turtle numbers were observed during scanning surveys.

The following parameters were recorded for each turtle sighting:

- species
- age class (adult or juvenile) based on carapace size and/or head size
- behavioural category (e.g. swimming, resting, feeding)
- time of observation
- GPS coordinate (GDA 96) of the closest point on the beach.

Sightings were recorded using a Garmin GPSmap 60CSx unit and were later transferred to an Excel database and mapped using ArcGIS 9.3.

### 4.4.4 Sand Temperature

#### 4.4.4.1 Survey Area

Submersible iB-Cod 22L Sand Temperature Loggers (STLs) with 8 kB data memory (Thermodata Pty Ltd, South Yarra, Victoria) were buried in the primary dune at the West Island of the Lacepede Island Group and at three beach on the mainland including Quondong South, James Price Point and Manari beaches. On the mainland, two STLs were buried at each beach, while three STLs were installed 500 m apart on West Island. The STLs were attached to a metal stake with fishing line and buried at a depth of 50 cm. This depth is consistent with average nest depths found at other Australian rookeries (Hewavisenthi and Parmenter 2002). The GPS location of the location of the STLs was recorded. Rocks were also placed adjacent to the locations to provide a visual indicator for retrieving the STLs later in the year.

#### 4.4.4.2 Survey Schedule

The STLs were buried at the James Price Point area on 20 November 2009 and retrieved on 16 March 2010 to measure the sand temperature during the critical incubation period. The Lacepede Island Group STLS were buried on 2 December and retrieved on 11 February 2010. The loggers sampled sand temperature every two hours.

#### 4.4.4.3 Data Analysis

The data was downloaded using a iBClamp logger connecting clamp (Alpha Mach inc., Mont St Hilaire, Canada) and processed using Thermodata Temperature Logging and Reporting Software Version 3.0. The data was exported and graphed in Microsoft Excel.

The analysis involved determining the mean incubation temperature ranges at the James Price Point area and at the Lacepede Island Group and determining temporal changes in the temperature during the nesting season. The number of days the mean incubation temperatures dropped below and within TRTs for green and flatback turtles was calculated based on published data in eastern Australia and as described in Table 11.

**Table 11: Pivotal Temperatures and TRT Ranges for Green and Flatback Turtles**

| Turtle Species | Pivotal Temperature (°C) | 100% Male TRT (°C) | 100% Female TRT (°C) |
|---|---|---|---|
| Green | 28.8 | 26 | 30 |
| Flatback | 29.5 | 29 | 30 |

## 4.5 Satellite Telemetry

### 4.5.1 Survey Area

Due to no nesting turtles emerging during surveys at the James Price Point area, satellite tags were only deployed from West Island in the Lacepede Island Group (Figure 15).

### 4.5.2 Survey Schedule

All tags were deployed from West Island (Lacepede Island Group) in December 2009 and February 2010 as shown in Table 12.

### 4.5.3 Survey Methods

Twenty FastLoc™ (Sirtrack Pty Ltd, New Zealand) and 2 Mk10-AF (Wildlife Computers Inc.) satellite tags were deployed at West Island (Lacepede Island Group) to collect data relating to inter-nesting, migration and foraging migrations. Both types of tag transmit locations via Argos satellites and transfer data when the turtle is at the surface of the water. The Mk10-AF transmitters also record time and depth.

Twelve FastLoc tags were attached to six green and six flatback turtles on West Lacepede Island Group between 2 and 4 December 2009. An additional eight FastLoc tags were attached to four green and four flatback turtles between 9 and 10 February 2010. Two Mk10-AF tags were also attached to one flatback turtle and one green turtle in February 2010.

Turtles were also measured and had flipper tags attached, which will allow them to be identified if they are recaptured after the satellite tags stop transmitting.

For each turtle, the following parameters were recorded:

- date/time transmitter was attached
- satellite transmitter ID
- turtle species
- turtle flipper tag ID
- DNA sample – (samples will be analysed at a later date)
- curved carapace length (CCL) and curved carapace width (CCW)
- nesting activity (e.g. successful nest, false crawl).

**Table 12: Details of Satellite Tags Released from West Island, December 2009 and February 2010**

| Satellite Tag ID (Name) | Release Details | | | | Species | Flipper Tag ID | | Carapace Measurements | |
|---|---|---|---|---|---|---|---|---|---|
| | Date | Time | Latitude | Longitude | | Right | Left | CCL (cm) | CCW (cm) |
| 47671 (Arnica) | 2/12/2009 | 20:30 | 16.85266 | 122.12434 | FB | WA70301 | WA70302 | 88.0 | 70.5 |
| 47676 (Sam) | 2/12/2009 | 21:10 | 16.85263 | 122.12482 | GR | WA70307 | WA70308 | 103.0 | 93.5 |
| 47674 (Kai Laini) | 2/12/2009 | 21:25 | 16.85261 | 122.12492 | GR | WA70305 | WA70306 | 101.1 | 89.6 |
| 47670 (Jeanie) | 2/12/2009 | 23:27 | 16.85274 | 122.12347 | FB | WA70303 | WA70304 | 86.4 | 73.0 |
| 47686 (Laia) | 3/12/2009 | 20:30 | 16.85260 | 122.12479 | GR | WA70310 | Existing tag - WA23003 | 106.7 | 99.0 |
| 47684 (Patty) | 3/12/2009 | 20:30 | 16.85265 | 122.12495 | GR | WA70312 | WA70314 | 91.5 | 82.2 |
| 47681 (Charlotte) | 3/12/2009 | 22:48 | 16.85274 | 122.12368 | FB | Existing tag - WA11535 | Existing tag - WA11536 | 87.0 | 69.8 |
| 47682 (Tiane) | 4/12/2009 | 0:18 | 16.85258 | 122.12484 | FB | WA70315 | WA70316 | 89.0 | 73.3 |
| 47673 (Alba) | 4/12/2009 | 20:58 | 16.85259 | 122.12500 | GR | WA70322 | WA70323 | 102.4 | 89.5 |
| 47687 (Anya) | 4/12/2009 | 21:22 | 16.85281 | 122.12499 | GR | Existing tag - WA35585 | Existing tag - WA35586 | 98.5 | 95.5 |
| 47689 (Adie) | 4/12/2009 | 22:13 | 16.85266 | 122.12486 | FB | WA70318 | WA70319 | 87.0 | 72.5 |
| 47688 (Courtney) | 4/12/2009 | 23:16 | 16.85288 | 122.12652 | FB | WA70320 | WA70321 | 93.2 | 73.4 |
| 53238 (Hannah) | 9/02/2010 | | 16.85258 | 122.12450 | FB | WA70326 | WA70327 | 92.0 | 77.7 |
| 53244 (Shirley) | 9/02/2010 | 20:41 | 16.85260 | 122.12556 | GR | WA70329 | WA70328 | 101.3 | 91.0 |
| 47675 (Meg) | 9/02/2010 | 20:57 | 16.85259 | 122.12563 | GR | WA70334 | WA70332 | 92.5 | 86.4 |
| 47685 (Chrissy) | 10/02/2010 | 20:02 | 16.85257 | 122.12525 | GR | WA70341 | WA70342 | 93.5 | 91.5 |
| 47679 (Toni) | 10/02/2010 | 21:47 | 16.85269 | 122.12309 | FB | WA70338 | WA70337 | 85.9 | 71.2 |
| 47677 (Amanda) | 10/02/2010 | 22:12 | 16.85269 | 122.12311 | FB | WA70340 | WA70339 | 85.5 | 74.0 |
| 47678 (Flossy) | 10/02/2010 | 22:38 | 16.85265 | 122.12413 | FB | WA70330 | WA70333 | 88.5 | 76.5 |
| 47683 (Danni) | 10/02/2010 | | 16.85257 | 122.12525 | GR | WA70343 | WA70344 | 96.0 | 87.4 |
| 47672 (Petrina) | 10/02/2010 | 23:23 | 16.85257 | 122.12525 | GR | Nil | WA70349 | 91.0 | 83.4 |
| 47680 (Becky) | 10/02/2010 | 23:53 | 16.85249 | 122.12538 | FB | WA70345 | WA70346 | 87.0 | 77.0 |

#### 4.5.3.1 Green Turtles

Selected female green turtles found returning to the water were guided into a plywood pen approximately 1.5 m x 1.5 m x 0.75 m. Once contained in the pen, the turtle's second central scute and surrounding carapace was cleaned using a scraper and steel wool and then with a fine grade sand paper to remove any algae, barnacles and other fouling organisms and cleaned with sterile swabs. The scute and bottom of the satellite tag were roughened with the sharp edge of a paint scraper in a grid pattern, to provide additional friction for affixing the tag.

A thick layer of PFPRO™ (a high strength and rapid setting epoxy resin) was spread on the bottom of the satellite tag. The tag was then placed on the central scute of the turtle. Following placement, additional epoxy cement was applied around the edge of the tracker to create a ridge. The cement was left for up to 90 minutes to dry, and then a second coat was applied and left to dry for an additional 90 minutes. Once the second coat of the epoxy cement had hardened, a layer of antifouling paint was applied to the satellite tag the turtle was released from the pen 15–30 minutes following anti-fouling.

#### 4.5.3.2 Flatback Turtles

Selected female flatback turtles found returning to the ocean were guided by two experienced handlers to a nally bin over which a harness was draped. The turtle was lifted onto the nally bin and stabilised. The satellite tag was then placed over the top of the second central scute and harness lines were threaded through the tag base plate, tightened, then fixed into place by the velcro strips. To ensure the velcro strips remain fixed, 2.5 mm heavy duty wire was crimped over the harness lines and tightened with pliers. Following crimping, any excess strips of harness were trimmed with scissors and the satellite transmitter was magnetically activated. The turtle was then lowered onto the ground by the two handlers and allowed to return to the water.

Satellite tags were attached to flatback turtles using harnesses as their carapaces are more sensitive to epoxy resin. Each harness comprised a moulded polypropylene base-plate, straps made from 22 mm wide seatbelt webbing with velcro ends and a centralised plastron ring with raised nodules to reduce the potential for snagging. Satellite tags were fixed to the base-plate using a fast curing marine adhesive/sealant and stainless steel screws. They were also coated with antifouling paint.

### 4.5.4 Data Analysis

Data for the Sirtrack tags were processed through Sirtrack FastLoc Admin Tool v1.1.5.8 and data for the Wildlife Computers tags were processed in the Data Analysis Program software version 2.0. Text files received from Argos were processed using this software to produce csv files.

Only GPS locations obtained from four or more satellite fixes were used in the analyses and any remaining erroneous location points (i.e. any data points that were well inland or would have required the turtle to swim >5 km/h) were removed (C.F. Luschi et al. 1998).

Nesting events were defined by GPS positions that were either recorded on land or within 150 m of land. The re-nesting interval of nesting turtles was determined by calculating the number of days between nesting events. The final position recorded on land before the turtle moved out of the area was considered to be the nesting event and the earlier positions were considered to be false crawls.

The commencement of post-nesting migrations was measured from the turtle's final nesting event for the season. A turtle was considered to have commenced its post-nesting migration after leaving the inter-nesting area, swimming constantly in a set direction without returning the inter-nesting area. A turtle was considered to have completed her post-nesting migration when it stops swimming in a constant direction and remains within a ~50 $km^2$ area for more than two weeks.

The direction, distance travelled, straight-line distance, latest recording and the latest destinations and behaviours were determined using filtered Argos data from STAT (Satellite Tracking and Analysis Tool) (Coyne & Godley 2005). GPS location data were plotted in ArcGIS to produce maps showing areas of high, medium and low density during the inter-nesting period. The movements of the turtles were also plotted using GPS data to show the post-nesting migration routes and potential foraging ground locations up until 31 March 2010. Whilst tags will continue to collect data throughout 2010, only data before 31 March was available for inclusion in this report.

# 5.0 RESULTS

## 5.1 Marine Megafauna Aerial Surveys

The results of the MMFS were consolidated to provide a holistic representation of the distribution of turtles along the Dampier Peninsula and out to Scott Reef.

Of the aerial surveys conducted between March and October 2009, the Nearshore Regional Survey covered the greatest area and provided a good spatial representation of the turtle distribution between Cape Bossut to Cape Leveque. In total, 1,875 turtles were sighted at the surface within the 800 m strip-width transects during the Nearshore Regional Survey. There were twice as many turtles recorded during the March 2009 survey (975 turtles) compared to the July 2009 (428 turtles) and September 2009 surveys (472 turtles). While turtles were recorded throughout the survey area, the majority of turtles were recorded within 18 km of the coast in 0–20 m water depth (Figure 16).

During the Nearshore Regional Survey (March 2009), a total of 305 turtles (2.9 sightings/km$^2$) were recorded within the 800 m strip-width transects around the Lacepede Island Group (SKM 2009) (Table 13; Figure 16). This large aggregation makes up 30% of turtles sighted during this period. The nearshore areas between Coulomb Point and Quondong Point (164 sightings; 2.4 sightings/km$^2$) and 20 km offshore from Willie Creek (76 sightings; 3.2 sightings/km$^2$) were also identified as having relatively high densities of turtle sightings (Table 13; Figure 16).

**Table 13: Number and Densities of Turtle Sightings within "Hot Spot" Areas**

| Locations | March 2009 | | July 2009 | | September 2009 | |
|---|---|---|---|---|---|---|
| | No. | Density | No. | Density | No. | Density |
| Lacepede Island Group (106.4 km$^2$) | 305 | 2.9 | 40 | 0.4 | 37 | 0.3 |
| West of Carnot Bay (44.6 km$^2$) | 36 | 0.8 | 53 | 1.2 | 44 | 1.0 |
| Coulomb Point – Quondong Point (67.8 km$^2$) | 164 | 2.4 | 20 | 0.3 | 44 | 0.6 |
| West of Willie Creek (23.4 km$^2$) | 76 | 3.2 | 47 | 2.0 | 15 | 0.6 |
| Gourdon Bay – Lagrange Bay (92 km$^2$) | 83 | 0.9 | 41 | 0.4 | 51 | 0.6 |

Density: Turtle sightings/km$^2$

In contrast, low densities of turtles were recorded at the Lacepede Island Group during the non-nesting period in July (0.4 sightings/km$^2$) and September 2009 (0.3 sightings/km$^2$) (Table 13). However, the relative density of turtles sighted was consistently higher throughout the year in particular areas including west of Carnot Bay, 15–20 km offshore from Willie Creek and between Gourdon Bay and Lagrange Bay (Table 13; Figure 16). The James Price Point Migration Corridor and Reference Site surveys conducted between July and September 2009 also found relatively high turtle sightings in the offshore areas (<20 km) adjacent to Carnot Bay (Figure 17), Coulomb Point (Figure 17), Willie Creek (Figure 18) and the transect across Roebuck Bay (between Broome and Gourdon Bay) (Figure 18).

Low densities of turtles were recorded up to 118 km offshore during the Scott Reef Offshore Surveys between July and October 2009 (Figure 19). These turtles were generally lone individuals intermittently spaced. Very few turtles were recorded beyond 118 km offshore until the plane reached Scott Reef (approximately 270 km offshore) (Figure 19). While most surveys were conducted each day in similar weather conditions, the variability in turtles observed was largely a function of changes in environmental conditions such as sea state, turbidity and glare.

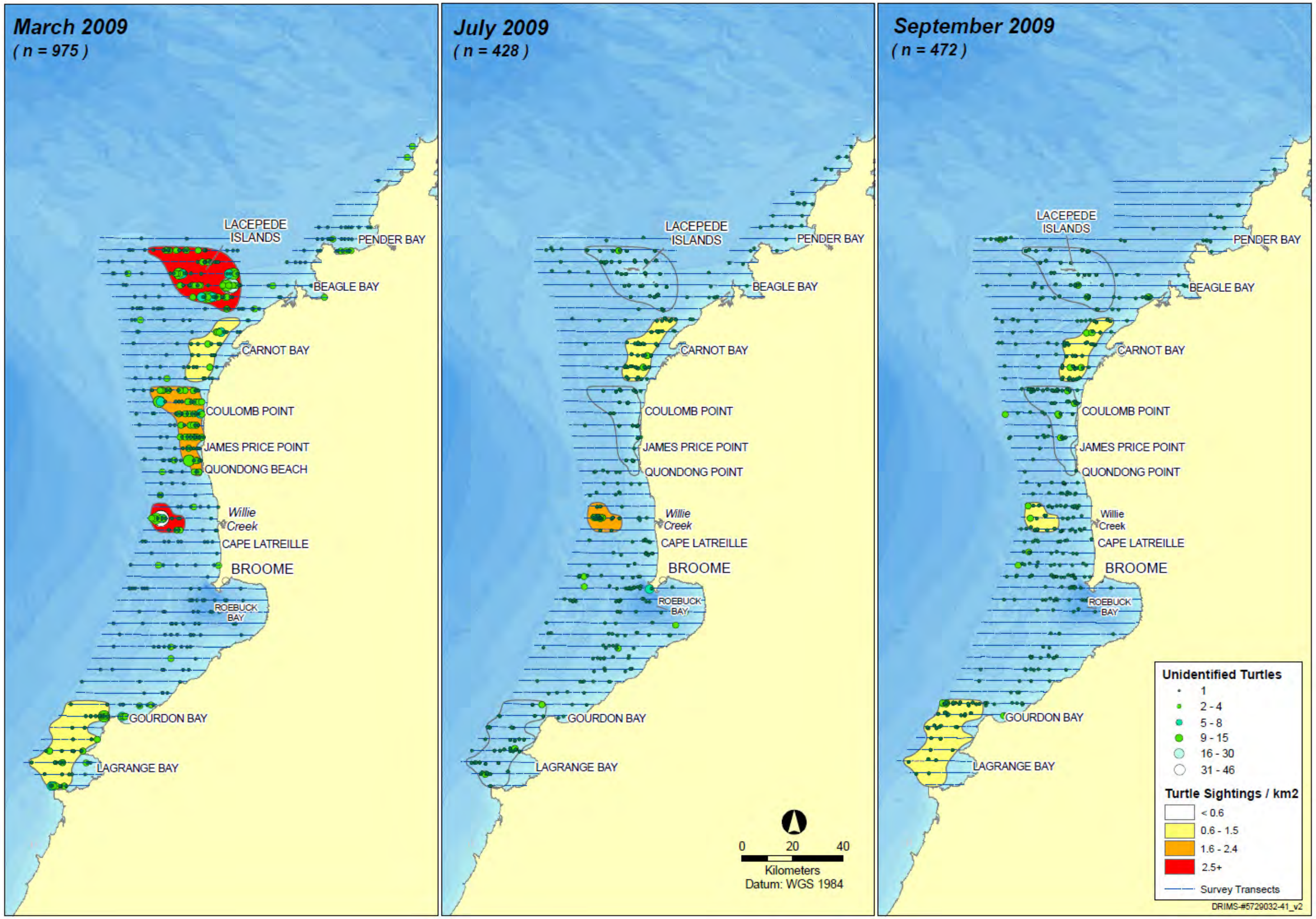



**Figure 16: Distribution, Abundance and Density of Turtles during the Nearshore Regional Survey in March, July and September 2009**

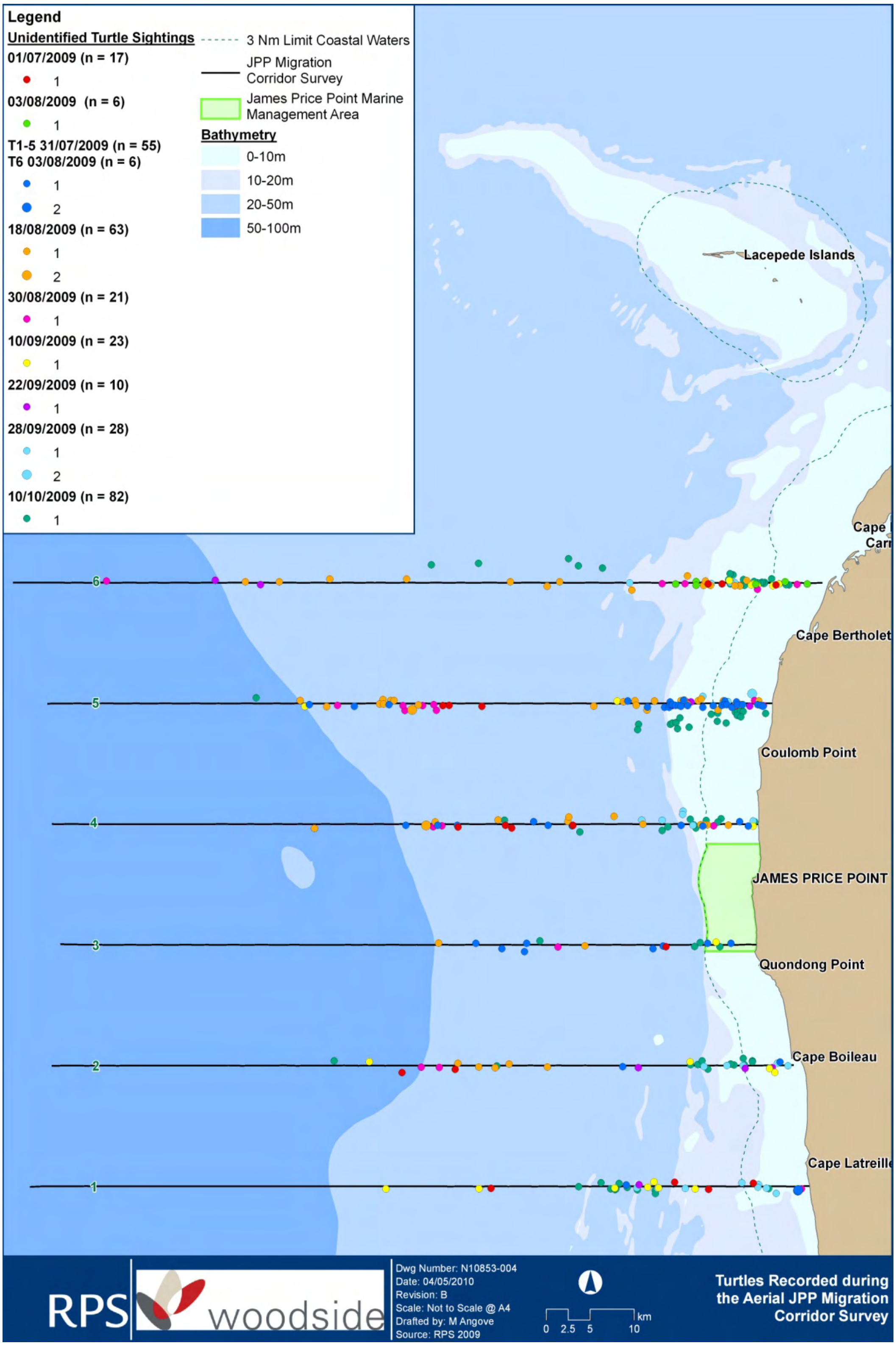



**Figure 17: Distribution of Turtles along James Price Point Migration Corridor Survey Transects, July–October 2009**

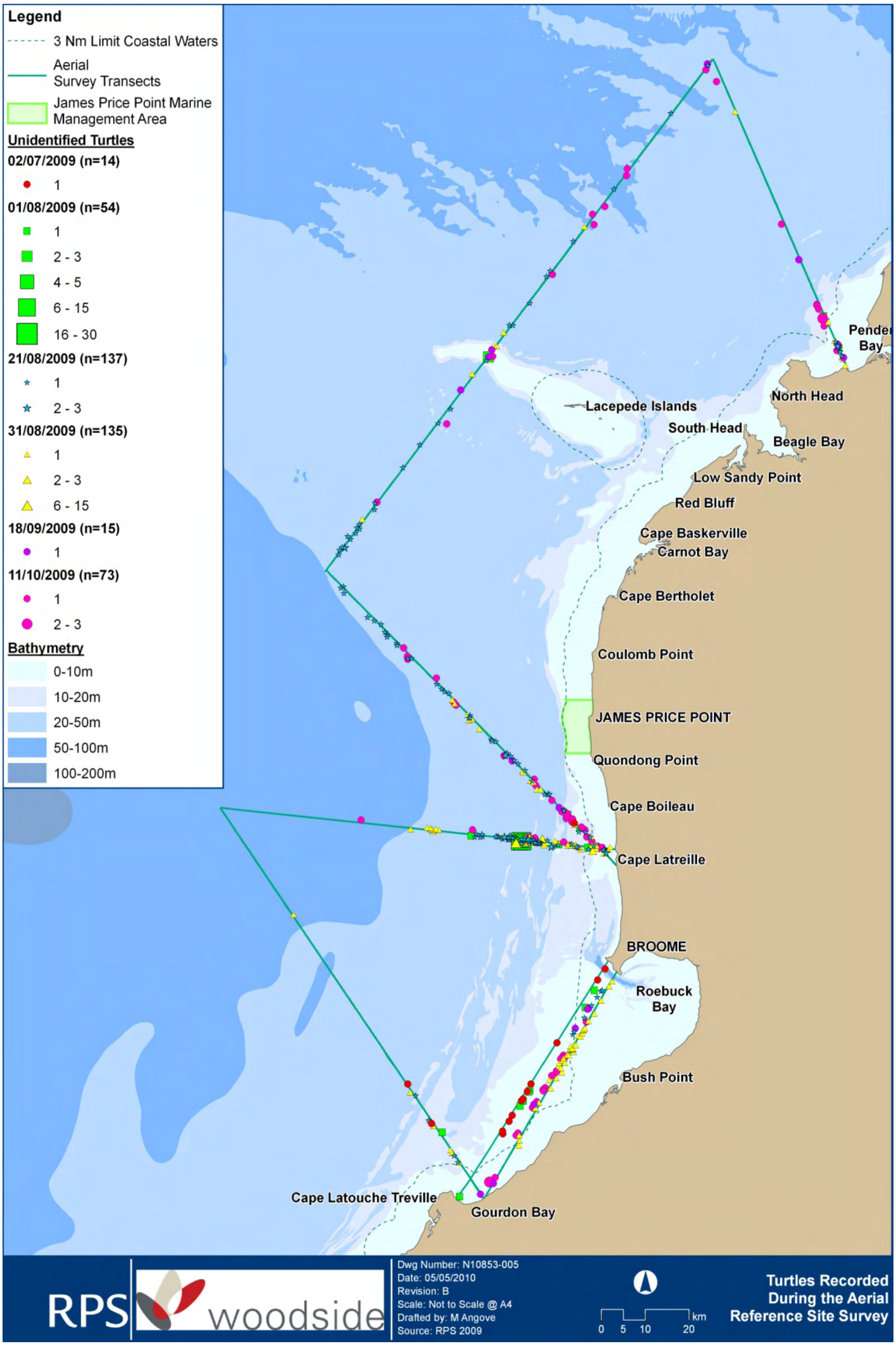



**Figure 18: Distribution of Turtles along Reference Site Survey Transects, July–October 2009**

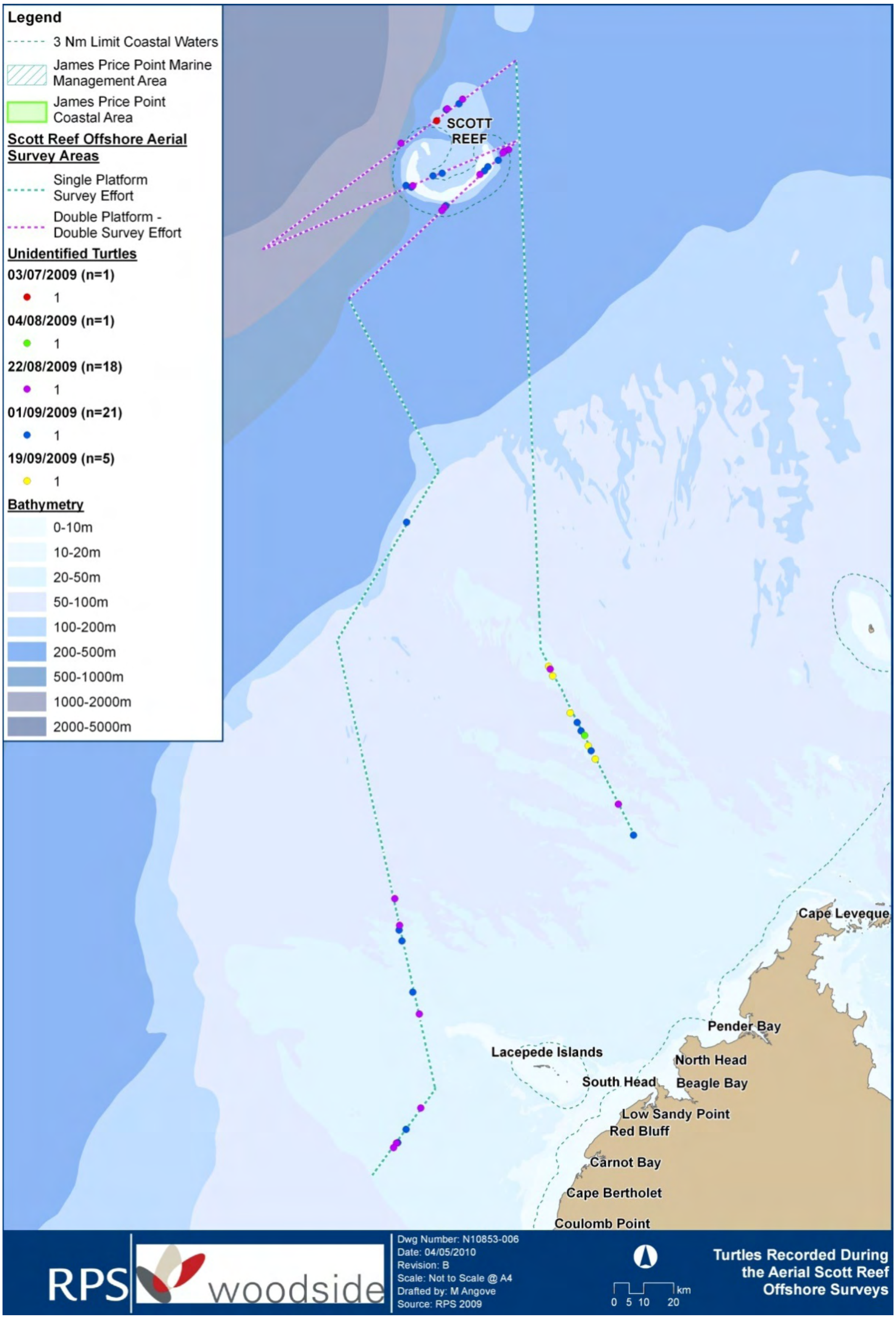



**Figure 19: Distribution of Turtles along Scott Reef Offshore Survey Transects, July–October 2009**

## 5.2 Vessel Surveys

### 5.2.1 Marine Megafauna Surveys

Seventy turtles were recorded during the vessel surveys between July and October 2009. Of these, 66 were sighted along transects adjacent to the James Price Point area, whilst only four turtles recorded at Pender Bay. Three species of marine turtle were identified in the water adjacent to the James Price Point area; green, flatback and loggerhead turtles.

Adjacent to the James Price Point area, 40 (57%) of the recorded turtles were identified to species level. Flatback turtles made up the largest proportion of the turtle sightings identified to species level (45%), while green turtles made up 30% and loggerhead turtles comprised the smallest portion of the turtle community (25%). Although no hawksbill turtles were identified during these surveys, hawksbill turtles were observed during the Dedicated Turtle Vessel Surveys (see Section 5.2.2). Green and flatback turtles were evenly distributed adjacent to the James Price Point area however loggerhead turtles were attitudinally distributed about 15–25 km offshore in 20 m of water (Figure 20).

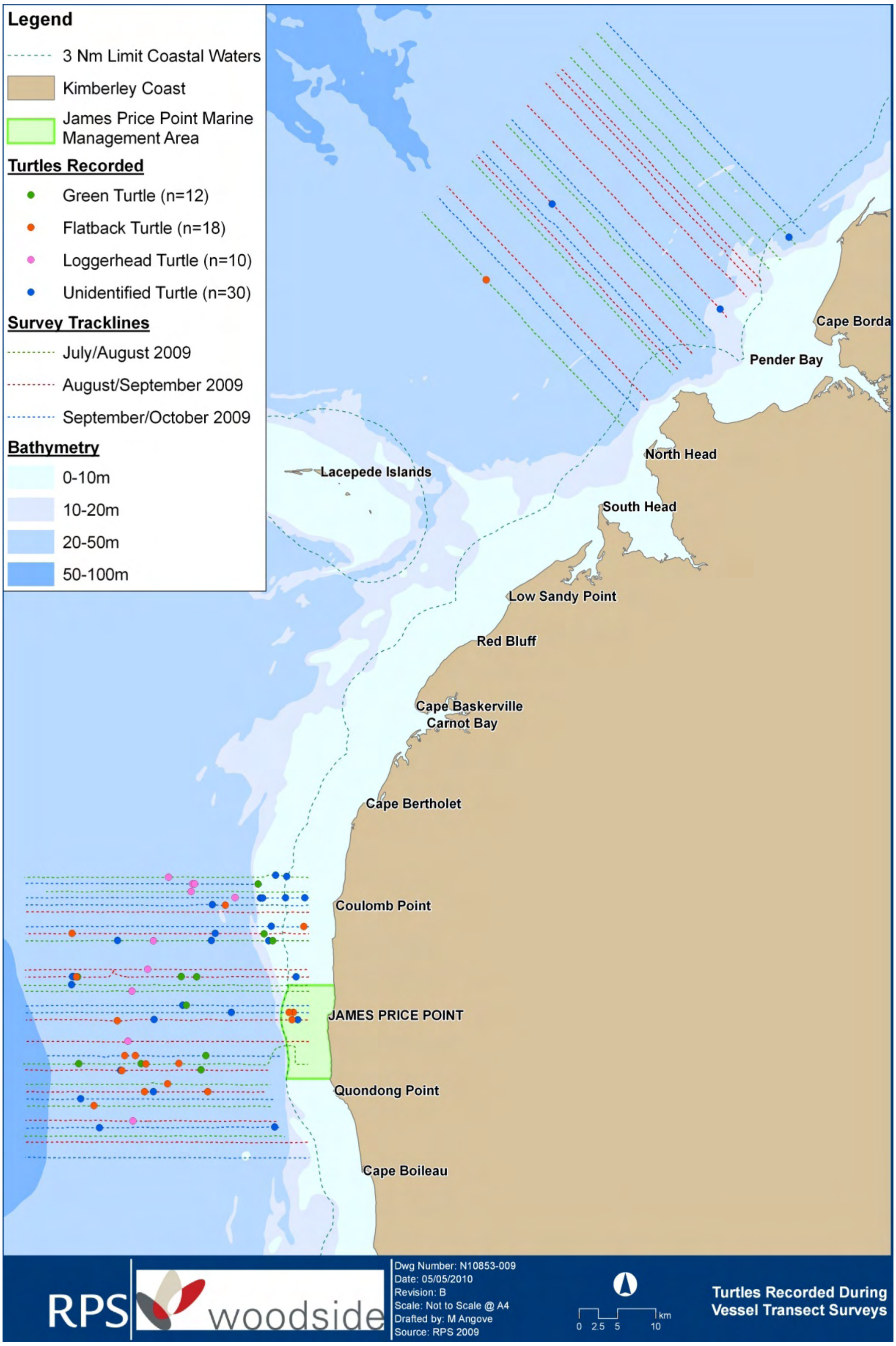



**Figure 20: Distribution and Species Composition of Turtles observed during Vessel Surveys at the James Price Point Area and Pender Bay, July–October 2009**

### 5.2.2 Dedicated Turtle Surveys

The vessel surveys conducted in December 2009 and February 2010 focused on areas that showed high densities of turtles from previous aerial surveys (Section 5.1). The results of the vessel surveys indicated that the Lacepede Island Group supported high densities of green turtles with lower densities of flatback turtles. A total of 43 turtles were sighted during surveys adjacent to the Lacepede Island Group (Table 14). Of these, there were 32 green turtles, five flatback turtles and six unidentified turtles. Five green and one unidentified turtle mating pairs were observed during these surveys.

**Table 14: Turtles Sighted during the Vessel Survey at the Lacepede Island Group – December 2009**

| Species | No. of Adults | | No. of Juveniles | Total |
|---|---|---|---|---|
| | Swimming | Mating | | |
| Green | 15 | 10 | 7 | **32** |
| Flatback | 5 | 0 | 0 | **5** |
| Hawksbill | 0 | 0 | 0 | **0** |
| Unidentified | 4 | 2 | 0 | **6** |
| **Total** | **24** | **12** | **7** | **43** |

A total of 20 turtles were sighted during the vessel surveys adjacent to the Dampier Peninsula (Table 15) comprising 12 green turtles, four hawksbills, two flatback and two that could not be identified. The adult hawksbill turtles were sighted west of Cape Latreille and Quondong point (Figure 21). One mating pair of green turtles was recorded adjacent to Coulomb Point.

**Table 15: Turtles Sighted during the Vessel Survey at the Dampier Peninsula – December and February 2010**

| Species | No. of Adults | | No. of Juveniles | Total |
|---|---|---|---|---|
| | Swimming | Mating | | |
| Green | 8 | 2 | 2 | **12** |
| Flatback | 2 | 0 | 0 | **2** |
| Hawksbill | 4 | 0 | 0 | **4** |
| Unidentified | 2 | 0 | 0 | **2** |
| **Total** | **16** | **2** | **2** | **20** |

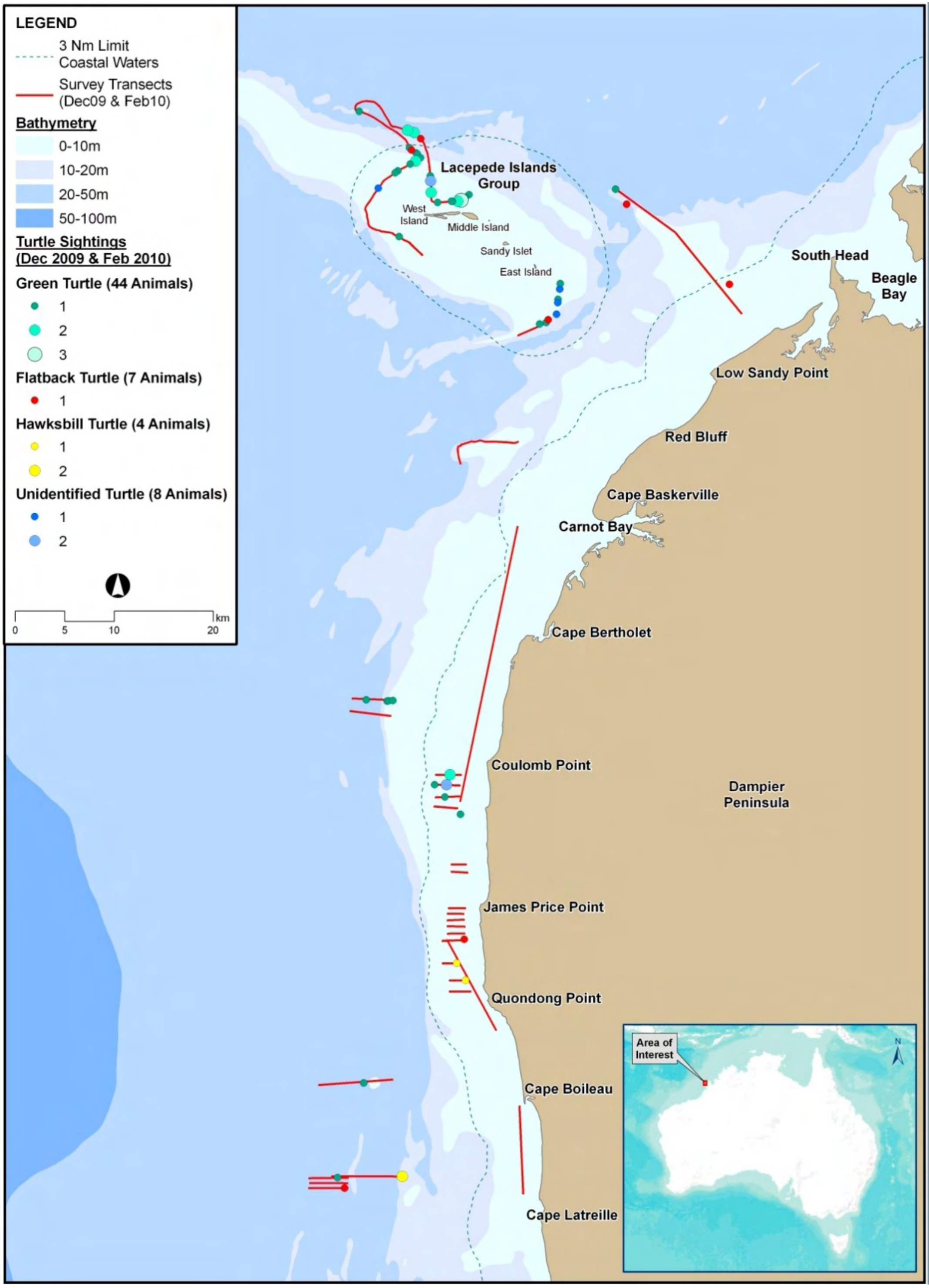



**Figure 21: Distribution of Turtle Species during Vessel Surveys at the Dampier Peninsula and Lacepede Island Group, December 2009 and February 2010**

## 5.3 Beach Studies

### 5.3.1 Preliminary Habitat Assessments

#### 5.3.1.1 James Price Point Beaches

The habitat assessment identified six potential nesting beaches along the James Price Point coastal area, including Jajal Beach, Quondong South Beach, Quondong Beach (Mango Farm), Murdudun Beach (James Price Point South), James Price Point Beach (Main) and Manari Beach (between Flat Rock and Coulomb Point) (Figure 15). These beaches consist of Holocene sands with occasional outcrops of sandstone and indurated sand and beach rock. Beaches are backed by vegetated Holocene dune systems and/or red earth pindan cliffs. The intertidal area generally comprises loose sands with exposed hard substrate and is interspersed by rock/reef systems of varying sizes. A habitat assessments and aerial photography of each beach surveyed in the James Price Point area are provided below. Additional detailed field notes, transect start and end points, temperature logger locations and points of interest locations are provided in Appendix 1 for each beach.

***Jajal Beach***

The area surveyed on Jajal Beach is 640 m long (Figure 22). A rocky outcrop divides this beach into northern and southern subsections. The primary dune systems on both sections of beach are suitable for marine turtle nesting. The northern section experiences greater tidal inundation than the southern section however, the primary dune does not get inundated on either section of beach. The sandy intertidal area in the centre of the beach provides a suitable approach for nesting turtles.


**Figure 22: Jajal Beach – Survey Area and Points of Interest Observed during Beach Studies in November 2009 and January 2010 to March 2010**

***Quondong South Beach***

Quondong South beach is 590 m long (Figure 23). It has a large primary dune and extensive sandy areas, which make it a suitable nesting beach. The sheltered offshore approach to the beach is typical of turtle nesting beaches. The primary dune is not inundated by the tide. Approximately half way along the beach, a series of rocky reefs support foraging juvenile and adult turtles. Point surveys were conducted at this location.

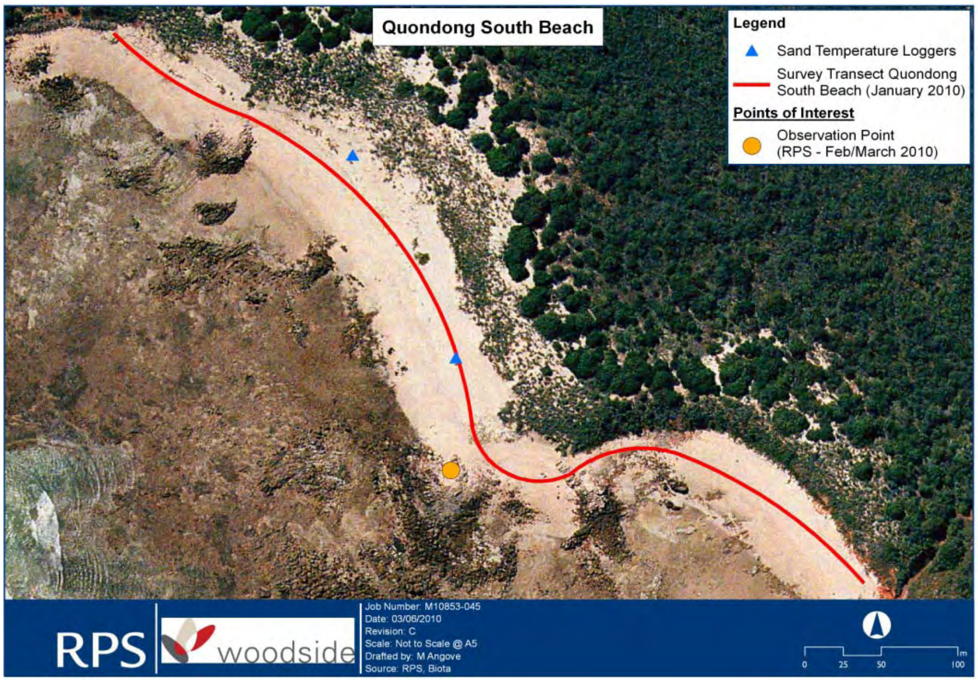



**Figure 23: Quondong South Beach – Survey Area and Points of Interest Observed during Beach Studies in November 2009 and January 2010 to March 2010**

***Quondong Beach (Mango Farm)***

Quondong Beach (Mango Farm) is 1,050 m long (Figure 24). It comprises a distinct foredune with extensive sandy areas from the shore to the primary dune (approximately 260 m from the high tide line). There are rocky outcrops at the northern and southern extents with a wide sandy approach to the centre of the beach. The spring high tide line is several metres from the foredune, indicating a low risk of nest inundation in the foredune nesting habitat, except perhaps in cyclones.

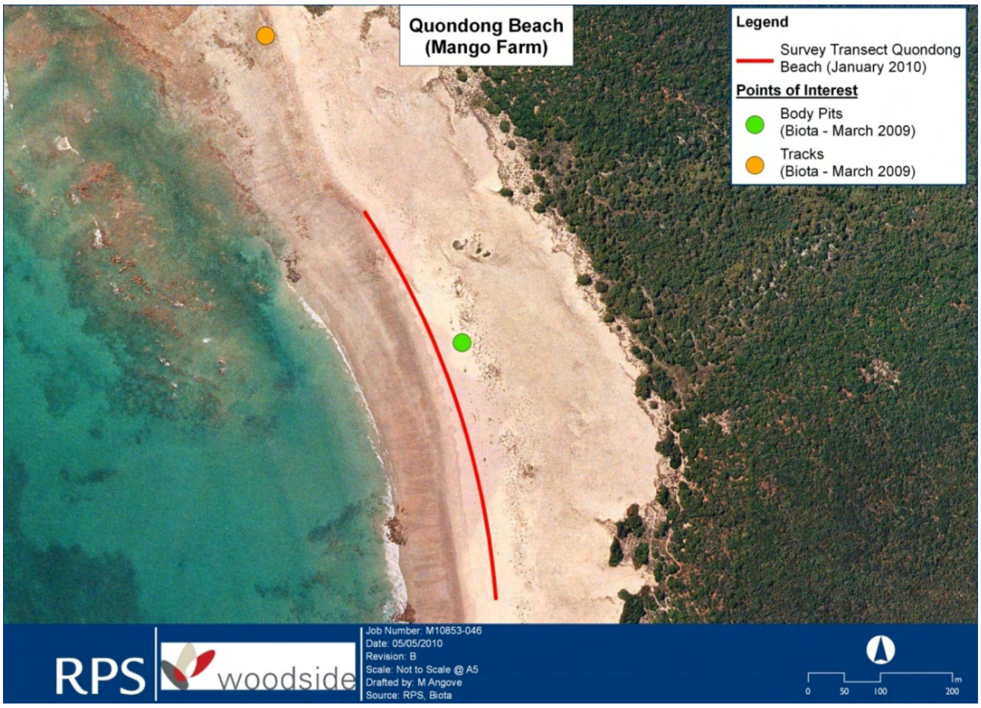



**Figure 24: Quondong Beach (Mango Farm) – Survey Area and Points of Interest Observed during Beach Studies in November 2009 and January 2010 to March 2010**

***Murdudun Beach***

Murdudun Beach is approximately 900 m long (Figure 25). This beach has well vegetated foredunes which gradually slope to the primary dune, and appear suitable for turtle nesting.

During surveys in November 2009, two turtle carapace bones and a lower jaw bone (mandible) were found on the dune above the high tide line.

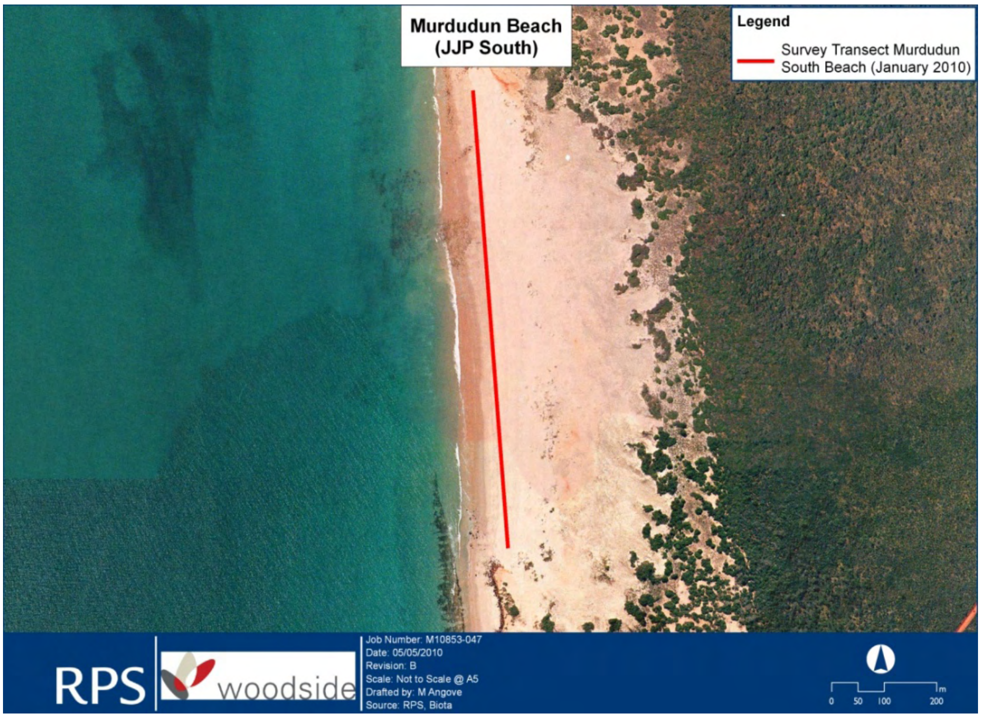



**Figure 25: Murdudun Beach – Survey Area and Points of Interest Observed during Beach Studies in November 2009 and January 2010 to March 2010**

***James Price Point Beach***

James Price Point Beach starts at the end of the rocky shoreline approximately 200 m south of the James Price Point and is 720 m long (Figure 26). It comprises an extensive sandy beach area with a well developed vegetated foredune. The foredune is set back and gradually slopes to a primary dune. There are rocky outcrops on the shore line at the northern and southern extent of the beach. The northern beach area above the high tide comprises a rocky platform covered by approximately 20 cm of sand. This section of beach is therefore unlikely to be suitable for nesting.

The beaches to the immediate north and south of James Price Point Beach are considered unsuitable for nesting. These beaches are subject to tidal inundation and have rocky shore lines. There are minimal suitable dune structures with most beaches being backed by Pindan cliffs.

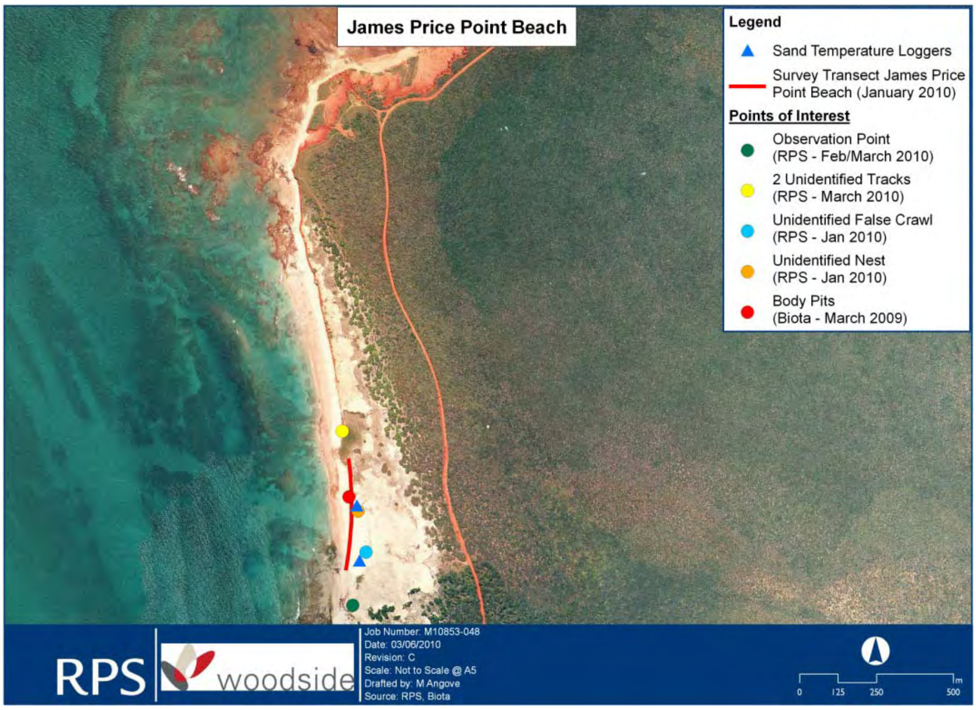



**Figure 26: James Price Point Beach – Survey Area and Points of Interest Observed during Beach Studies in November 2009 and January 2010 to March 2010**

***Manari Beach***

Manari Beach is approximately 4750 m long (Figure 27). The section of beach immediately north of Flat Rock comprises Pindan cliffs that are inundated by the spring high tide. This section of beach is not considered suitable turtle nesting habitat.

The remainder of Manari Beach, however, does comprise suitable nesting habitat. The mid-section of the beach is mainly flat with sandy areas supporting sparse vegetation. There are patches of darker red sand in the mid-section that are likely to be unsuitable for nesting. At the northern end of Manari Beach, adjacent to Coulomb Point, the primary dune system is very flat with sparse foredune vegetation. An extensive reef area is exposed at low tide at Coulomb Point.

A small hawksbill turtle (~40 cm CCL) was found dead above the high tide mark approximately 500 m south of Coulomb Point. Damage to the turtle's neck suggested a possible shark attack.


**Figure 27: Manari Beach – Survey Area and Points of Interest Observed during Beach Studies in November 2009 and January 2010 to March 2010**

### 5.3.1.2 Lacepede Islands Group

Four potential nesting beaches were identified in the habitat assessment. These beaches are located on small platform reef islands overlaid by coarse sand and coral deposits. One kilometre transects were surveyed on West Island, Middle Island and Sandy Islet. A 300 m transect was surveyed on East Island, which is also the circumference of the island. The total amount of potential nesting habitat available on beaches within the Lacepede Island Group was 6.66 km. Detailed habitat assessments for each island in the Lacepede Island Group are provided below.

***West Island***

West Island is approximately 3.86 km long, 0.62 km wide and covers an area of approximately 0.84 km² (Figure 28).

The northern side of the island is dominated by extensive sandy beaches interspersed by occasional rocky outcrops. These outcrops are mostly inundated by the high tide and are not likely to restrict nesting marine turtles emerging on the beach. There is a large, well developed vegetated dune system fringing the beach. This dune system gradually decreases in height and vegetation cover to the west. Beach substrate comprises coarse sand and coral rubble near the water's edge, decreasing to medium-fine grained sand at the base of the dune. There is approximately 50 m between the high tide and dune vegetation providing good habitat for nesting turtles. The approach toward the beach from the water is largely unhindered from the open ocean. The 1 km survey transect was placed on the eastern side of the northern beach, where evidence of nesting activity suggested high densities.

A fine sand/mudflat area occurs in a tidally inundated inlet on the south side of the island. To the east of the inlet there are sections of beach enclosed by extensive rocky outcrops which could potentially be barriers to nesting marine turtles. To the west of the inlet is a long beach separated by sections of rocky outcrops and fringed by a large vegetated dune. Such characteristics are favourable habitat for nesting marine turtles.

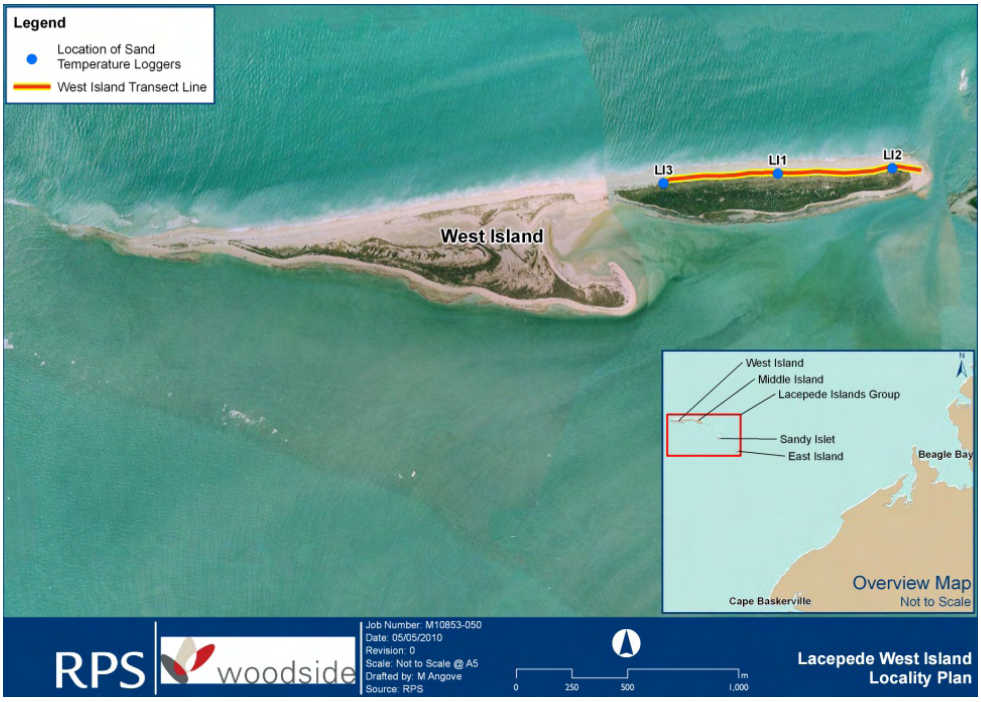



**Figure 28: West Island Survey Area (1 km) and STL Locations**

***Middle Island***

Middle Island is approximately 1.81 km long, 0.60 km wide and covers an area of approximately 0.61 km$^2$ (Figure 29).

Middle Island comprises coarse sand and coral rubble on a low-lying vegetated dune system. Much of the southern coastal area of the island comprises large rocky outcrops which are unsuitable for turtle nesting, whilst the northern coastal area comprises sandy beaches with sparsely distributed rocky outcrops that restrict access to a small proportion of the beach.

The dune on the northern beach is low-lying, but well vegetated. The beach immediately adjacent consists of coarse-medium grained sands which are not inundated by the high tide. The inshore waters adjacent to the beach comprise a sandy bottom interspersed by patchy reef. The 1 km survey transect was used on the western side of the beach to determine the abundance of turtles attempting to nest (Figure 29, Appendix 1).

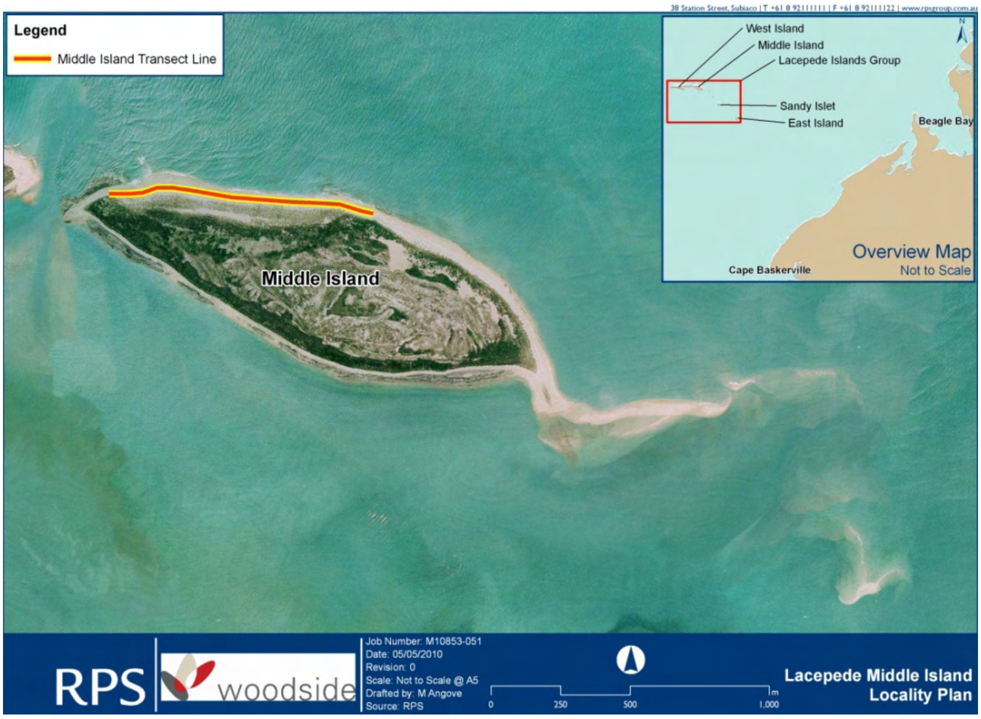



**Figure 29: Middle Island Survey Area (1 km)**

***Sandy Islet***

Sandy Islet is situated south-east of Middle and West islands. The perimeter of sandy Islet is 1.45 km and covers an area of 0.11 km² (Figure 30, Appendix 1). The island is covered in a well vegetated dune system. Rocky outcrops are present on the beach in the southern, north-eastern and north-western quadrants of the island, however these are covered at high tide and do not restrict beach access for nesting turtles. The south-western portion of the island is mostly covered by rocky substrate with some sandy areas. This area is likely to act as a barrier to nesting marine turtles. The dune is generally steeper on the north side of the island and more gradual on the south. Shallow sand bars dominate the intertidal area.

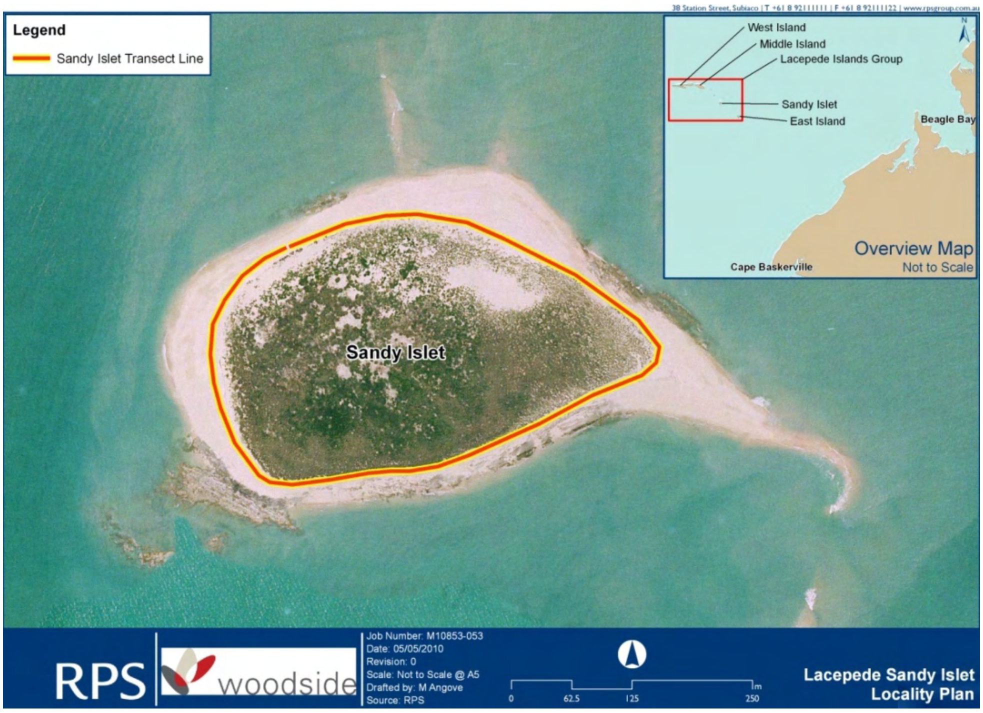



**Figure 30: Sandy Islet Survey Area (1.45 km)**

***East Island***

East Island is located south-east of Sandy Islet. East Island is smallest Island in the Lacepede Island Group with a perimeter of 0.90 km and covers an area of 0.04 km$^2$ (Figure 31, Appendix 1). A well vegetated dune covers the island and a lighthouse is situated in the centre. A rocky reef fringes much of the island, creating a potential barrier to nesting turtles but provides potential foraging habitat for juvenile green turtles. A gap in the reef and a small sandbar occurs on the north-west side of the island. Nesting activity is restricted to the beach immediately adjacent to this gap. Beyond the fringing reef, the island is surrounded by shallow sandy benthos which is often exposed at low tide.

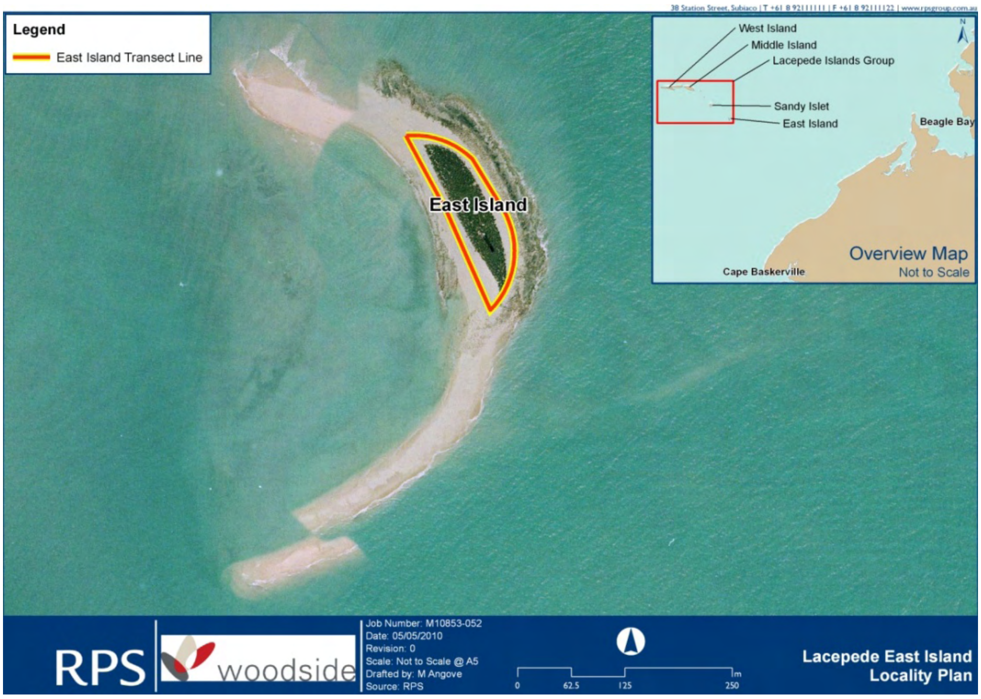



**Figure 31: East Island Survey Area (0.9 km)**

## 5.3.2 Track Counts

No fresh tracks or nests were recorded during any of the surveys in the James Price Point area between November 2009 and March 2010. One old false crawl and one old nest were recorded on James Price Point Beach in January 2010 (Figure 26). Two old false crawls were also sighted at Red Cliffs, 100 m north of James Price Point Beach, on dry sand where there was approximately 3 m between the high tide and the cliff face in March 2010 (Figure 26).

Old tracks and nests are difficult to age beyond a few days given the variability in local weather conditions (e.g. wind, rain and storms/cyclones). The false crawl and nest recorded at James Price Point Beach in January 2010 were not observed during the terrestrial survey in November (eight weeks prior). It is likely that these tracks were less than four weeks old given Cyclone Lawrence, which passed on 20 December, would have cleaned the beach of any sand indentations. The tracks at Red Cliffs in March 2010 were difficult to age because they could be up to three months old, based on the passage of Cyclone Lawrence in December 2009.

A total of 881 tracks were recorded at the Lacepede Island Group in December 2009 (four days) and February 2010 (two days) (Table 16). Green turtles tracks were most common within the Lacepede Island Group, making up 90% of records. However, the majority of tracks (78%) recorded at East Island were from flatback turtles. The majority of tracks in the Lacepede Island Group were recorded at West Island (60%), followed by Middle Island (36%), Sandy Islet (3%) and East Island (1%).

**Table 16: Number of Old and Fresh Tracks at the Lacepede Island Group**

| Location | December 2009 | | | | | February 2010 | | Total |
|---|---|---|---|---|---|---|---|---|
| | Species | 4.12.09 | 5.12.09 | 6.12.09 | 7.12.09 | 10.02.10 | 11.02.10 | |
| West Lacepede Island | Green | 60[1] | 93 | 117 | 126 | 124 | 117 | **637** |
| | Flatback | 6[1] | 2 | 4 | 4 | 7 | 12 | **35** |
| Middle Lacepede Island | Green | NS | NS | 29[1] | 42 | NS | 96 | **167** |
| | Flatback | NS | NS | 2[1] | 7 | NS | 12 | **21** |
| East Lacepede Island | Green | NS | NS | HA | 0 | NS | 3 | **3** |
| | Flatback | NS | NS | HA | 6 | NS | 1 | **7** |
| Sandy Islet | Green | NS | NS | HA | 7 | NS | 2 | **9** |
| | Flatback | NS | NS | HA | 0 | NS | 2 | **2** |

[1] Only return tracks after high tide were recorded
HA – Habitat Assessment
NS – Not Surveyed

The days where only return tracks were counted are not included in the density calculations (i.e. turtles/km/night) as they only represent a proportion of the total number of turtles attempting to nest per night. The average daily number of fresh tracks in the 1 km transect on West Island was 115.4/km (SE = 5.89; range = 93-126; n = 5) for green turtles and 5.8/km (SE = 1.74; range = 2-12; n = 5) for flatback turtles. The number of fresh green turtle tracks at West Island was similar in December 2009 and February 2010. However, more flatback turtles were recorded in February 2010 than in December 2009 (Table 16).

The number of turtles attempting to nest on the Lacepede Island Group per night was calculated by extrapolating from the number tracks/night/km at each island. This extrapolation assumes the density of turtles is consistent across all beaches with suitable nesting habitat.

Based on the track count data collected in December 2009 and February 2010, an estimated 431 green turtles and 36 flatback turtles attempted to nest each night on the beaches of the Lacepede Island Group (Table 17).

**Table 17: Track Density Estimates for Green and Flatback Turtles on the Lacepede Island Group, 2009–2010**

| Location | Potential Nesting Habitat (km) | Density (Average Tracks/km) | | Estimated Tracks per Night (all Beaches) | |
|---|---|---|---|---|---|
| | | Green | Flatback | Green | Flatback |
| West Island | 3.00 | 115 | 6 | 345 | 18 |
| Middle Island | 1.81 | 43 | 7 | 78 | 13 |
| Sandy Islet | 1.45 | 5 | 2 | 7 | 3 |
| East Island | 0.40 | 3 | 4 | 1 | 2 |
| Total | 6.66 | 166 | 19 | 431 | 36 |

### 5.3.3 Nearshore Surveys

#### 5.3.3.1 James Price Point

***Scanning Surveys***

Ten turtles were recorded during nearshore scanning surveys in November 2009 (Table 16). No other turtles were sighted at any other beaches in the James Price Point area between November 2009 and March 2010. The average number of turtles sighted per day during scanning surveys was 0.19 (SE = 0.13; range = 7; n = 58) for all beaches within the James Price Point area.

It was not possible to confidently identify these turtles to species level due to the distance of observations (up to 100 m from the vantage point) and inshore conditions (i.e. waves, swell and wind).

***Point Surveys***

A total of 46 turtles were recorded off James Price Point Beach and 27 turtles were recorded off Quondong South Beach during point surveys in February and March 2010. The average number of turtles sighted per day during these surveys was 6.6 (SE = 1.85; range = 0–13; n = 7) at James Price Point Beach and 3.9 (SE = 0.82; range = 1–7; n = 7) at Quondong South Beach. As with the scanning surveys, it was not possible to confidently identify these turtles to species level due to the distance of observations.

**Table 18: Number of Turtles Observed in Nearshore Waters adjacent to James Price Point Beach**

| Location | Age Class | Scanning Surveys | | Point Surveys | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2009 | | 2010 | | | | | | |
| | | 16/11 | 19/11 | 14/2 | 15/2 | 16/2 | 17/2 | 18/2 | 19/2 | 16/3 |
| James Price Point Beach | Adult | 0 | 1 | 3 | 1 | 5 | 1 | 0 | 0 | 2 |
| | Juvenile | 3 | 6 | 10 | 9 | 5 | 2 | 2 | 0 | 6 |
| Quondong South Beach | Adult | 1 | 0 | 0 | 4 | 3 | 1 | 1 | 1 | 0 |
| | Juvenile | 0 | 0 | 5 | 2 | 4 | 2 | 2 | 0 | 2 |

#### 5.3.3.2 Lacepede Island Group

A total of 107 green turtles were recorded during nearshore scanning surveys at West, Middle and East Island and Sandy Islet in December 2009 and February 2010 (Table 19). No flatback turtles were sighted during these survey periods. The average number of turtles sighted per day during surveys at the Lacepede Island Group was 11.0 (SE = 3.92; range = 0–27; n = 7).

The majority of the green turtle were observed during surveys in December 2009, when they were likely to be inter-nesting/mating females or mating males. Most of the turtles were sighted at West Island. There was a relatively even distribution of green turtles along the nearshore area, with slightly higher concentrations on the eastern extent of West Island Beach. Of these turtle sightings, 25 were swimming adults, 52 were mating adults.

**Table 19: Number of Green Turtles Observed in Nearshore Waters at the Lacepede Island Group**

| Date | Age Class | Swimming | Resting | Mating |
|---|---|---|---|---|
| 2-Dec-09 | Adult | 0 | 0 | 8 |
| | Juvenile | 0 | 0 | 0 |
| 3-Dec-09 | Adult | 0 | 0 | 7 |
| | Juvenile | 0 | 0 | 0 |
| 4-Dec-09 | Adult | 4 | 0 | 19 |
| | Juvenile | 0 | 0 | 0 |
| 5-Dec-09 | Adult | 7 | 0 | 4 |
| | Juvenile | 0 | 0 | 0 |
| 6-Dec-09 | Adult | 6 | 0 | 14 |
| | Juvenile | 10 | 2 | 0 |
| 7-Dec-09 | Adult | 8 | 0 | 10 |
| | Juvenile | 7 | 0 | 0 |
| 10-Feb-10 | Adult | 0 | 0 | 0 |
| | Juvenile | 0 | 0 | 0 |
| 11-Feb-10 | Adult | 0 | 0 | 0 |
| | Juvenile | 1 | 0 | 0 |

### 5.3.4 Sand Temperature

Sand temperatures ranged from 27.2 °C to 36.2 °C in the southern Kimberley region (Table 20). Mean sand temperatures were highest at mainland beaches in the James Price Point area, ranging from 33.5 °C at James Price Point Beach to 34.1 °C at Manari Beach with the lowest sand temperature (31.2 °C) recorded at West Island.

**Table 20: Summary of Sand Temperature Data from West Island and the James Price Point Area**

| Location | Av. Min Temp °C | Av. Max Temp °C | Mean Temp °C (SE) |
|---|---|---|---|
| West Island, Lacepede Island Group | 27.2 | 33.1 | 31.2 (0.02) |
| James Price Point Beach | 28.5 | 35.6 | 33.5 (0.03) |
| Quondong South Beach | 27.8 | 36.1 | 33.6 (0.03) |
| Manari Beach | 29 | 36.2 | 34.1 (0.03) |

All sites showed a similar pattern of increasing beach sand temperature over the survey period (2 December 2009 – 1 February 2010) (Figure 32; Figure 33). There were gradual temperature increases during early–mid December followed by dramatic decreases in temperature (6–7 °C) on 17 December 2009 and 24 January 2010. These declines in temperature were associated with heavy rainfall and tropical cyclone activity in the region.

#### 5.3.4.1 Green Turtles

Eggs laid on West Island were exposed to temperatures above the TRT (100% female) for 88.3% of the critical incubation time, whilst on the mainland temperatures were above the TRT (100% female) between 92.3–93.4% of the critical incubation time. No temperatures fell below the TRT (100% male) at any of the monitored beaches (Table 19).

**Table 21: Proportion of Days Green Turtle Eggs were exposed to above, below and within the TRT during the Peak Incubation Period (Dec–Feb) at West Island and the James Price Point Area**

| Location | Above the TRT (30 °C or Above) | | Below the TRT (26 °C or Below) | | Within the TRT (26–30 °C) | |
|---|---|---|---|---|---|---|
| | Days | % | Days | % | Days | % |
| West Island | 54.8 | 88.3 | 0 | 0 | 7.2 | 11.7 |
| James Price Point Beach | 57.9 | 93.4 | 0 | 0 | 4.1 | 6.6 |
| Quondong South Beach | 57.2 | 92.3 | 0 | 0 | 4.8 | 7.7 |
| Manari Beach | 57.6 | 92.9 | 0 | 0 | 4.4 | 7.1 |

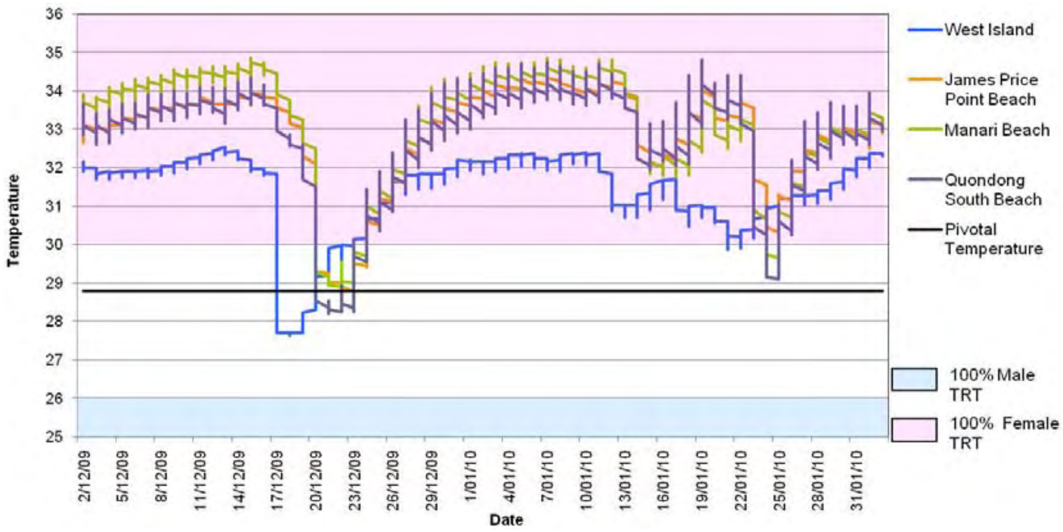



**Figure 32: Sand Temperatures from December 2009 and January 2010 and Pivotal Temperatures for Green Turtles at West Island and the James Price Point Area**

### 5.3.4.2 Flatback Turtles

Sand temperatures fell below the flatback turtle TRT (100% male) at West Island for 5.4% of the critical incubation time and were within the TRT (50% female; 50% male) for 6.3% of the critical incubation time (Table 22). On the mainland beaches, these percentages dropped to 1.1–4.6% of the TRT (100% male) and 3.1–6.0% within the TRT (50% female; 50% male).

**Table 22: Proportion of Days Flatback Turtle Eggs were Exposed to Above, Below and Within the TRT during the Peak Incubation Period (Dec–Feb) at West Island and James Price Point Area**

| Location | Above the TRT (30 °C or above) | | Below the TRT (29 °C or below) | | Within the TRT (29–30 °C) | |
|---|---|---|---|---|---|---|
| | No. of days | Per Cent (%) | No. of days | Per Cent (%) | No. of days | Per Cent (%) |
| West Island, Lacepede Island Group | 54.8 | 88.3 | 3.3 | 5.4 | 3.9 | 6.3 |
| James Price Point Beach | 57.9 | 93.4 | 1.0 | 1.6 | 3.1 | 5.0 |
| Quondong South Beach | 57.3 | 92.3 | 2.8 | 4.6 | 1.9 | 3.1 |
| Manari Beach | 57.6 | 92.9 | 0.7 | 1.1 | 3.7 | 6.0 |

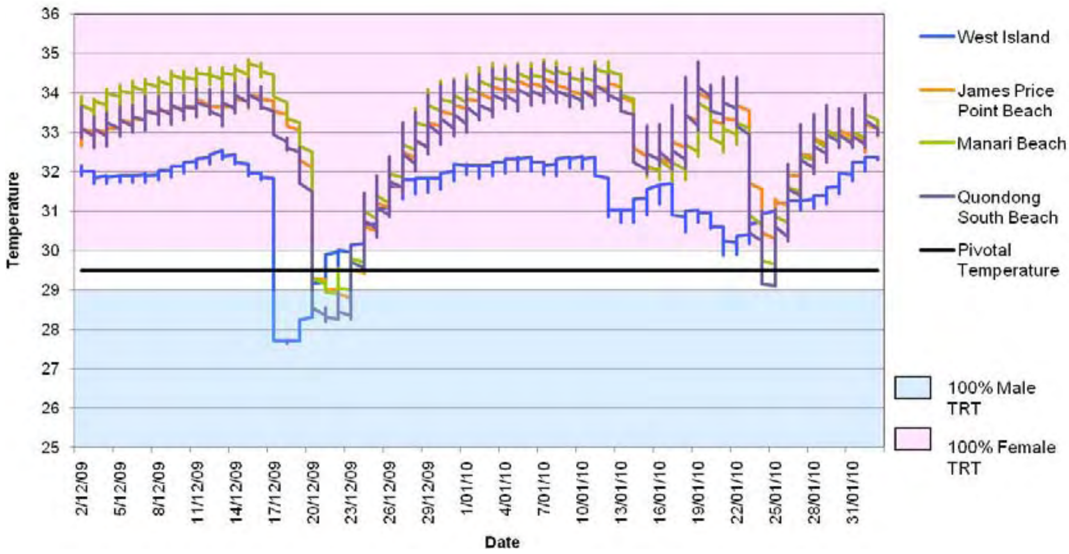



**Figure 33: Range of Sand Temperatures and Pivotal Temperatures for Flatback Turtles at West Island and the James Price Point Area**

## 5.4 Satellite Telemetry

### 5.4.1 Green Turtles

#### 5.4.1.1 Inter-nesting

Eight of the eleven satellite tags attached to green turtles at the Lacepede Island Group provided data relating to inter-nesting movements (Table 23). The three remaining turtles (Sam, Petrina and Shirley) left the Lacepede Island Group within several days of the satellite tag being attached and did not provide inter-nesting data.

Green turtles remained within 20 km of the Lacepede Island Group during the inter-nesting period and spent the majority of the inter-nesting period within 5 km of the Lacepede Island Group (Figure 34). The mean re-nesting interval for green turtles was 10.55 days (SE = 0.19; range = 8 – 13; n = 29 re-nesting events).

Green turtles exhibited high nest site fidelity, with no green turtles moving between islands within the Lacepede Island Group during the inter-nesting period.

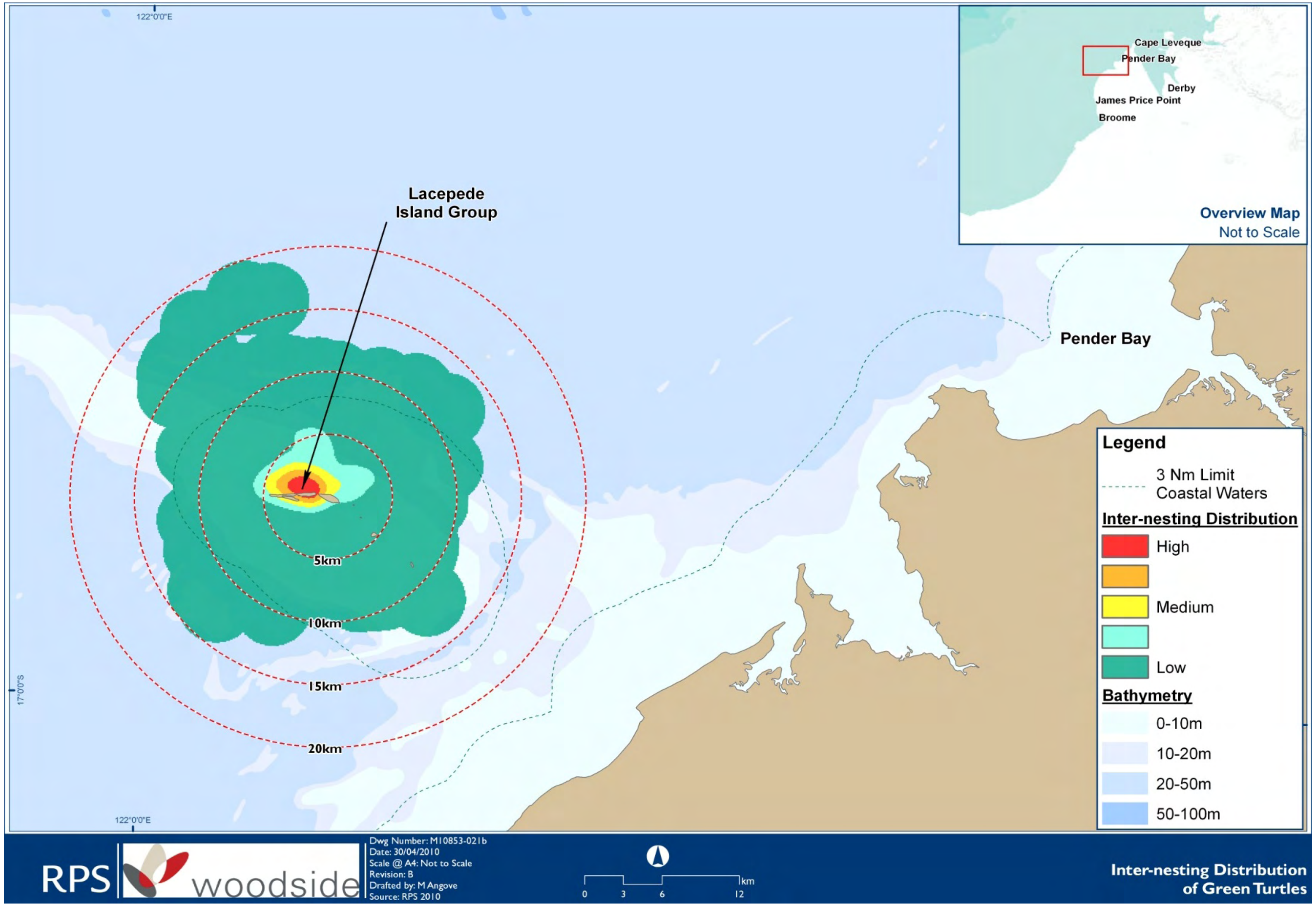



**Figure 34: Inter-nesting Distribution of Green Turtles Nesting on the Lacepede Island Group**

**Table 23: Summary of Green Turtle Inter-nesting Behaviour**

| Satellite Tag ID | Turtle Name | Deployment Date | No. of Re-nesting Events | Mean Inter-nesting Period (# of Days) | Maximum Straight-line Distance Travelled from the Lacepede Island Group during Inter-nesting Period (km) |
|---|---|---|---|---|---|
| 47676 | Sam | 02-Dec-09 | 0 | - | - |
| 47674 | Kai Laini | 02-Dec-09 | 4 | 10.5 | 5 |
| 47686 | Laia | 03-Dec-09 | 3 | 11.3 | 8 |
| 47684 | Patty | 03-Dec-09 | 3 | 11 | 5 |
| 47673 | Alba | 04-Dec-09 | 7 | 10.1 | 10 |
| 47687 | Anya | 04-Dec-09 | 7 | 10.2 | 10 |
| 53244 | Shirley | 09-Feb-10 | **0** | **-** | **-** |
| 47675 | Meg | 09-Feb-10 | 1 | 12 | 20 |
| 47685 | Chrissy | 10-Feb-10 | 2 | 11 | 12 |
| 47683 | Danni | 10-Feb-10 | 2 | 10 | 10 |
| 47672 | Petrina | 10-Feb-10 | 0 | - | - |

#### 5.4.1.2 Post-nesting

All green turtles tagged at the Lacepede Island Group had commenced their post-nesting migration by the end of February. Eight of the eleven tagged turtles migrated in a north-easterly direction, while the other three (Patty, Anya and Chrissy) travelled in a south-western direction (Table 24; Figure 35). Data up to 31 March shows that four turtles (Kai Liani, Patty, Anya and Petrina) appear to have reached a foraging area, having remained within a small area (<50 km$^2$) over a two week period. The post-migration locations for those turtles include Bathurst Island, Northern Territory (Kai Liani), Eighty Mile Beach (Patty), Rowley Shoals (Anya) and King Island (Petrina) (Table 24).

Five turtles (Alba, Meg, Sam, Chrissy and Shirley) appear to still be migrating as at 31 March (Table 24). Alba in the Northern Territory (Gunyangara), Meg is at Cape Bougainville, Chrissy is at the Bedford Islands about 100 km north-east of the Lacepede Island Group and Shirley has headed west of the Maret Islands (Figure 35). Individual maps for each turtle are provided in Appendix 2.

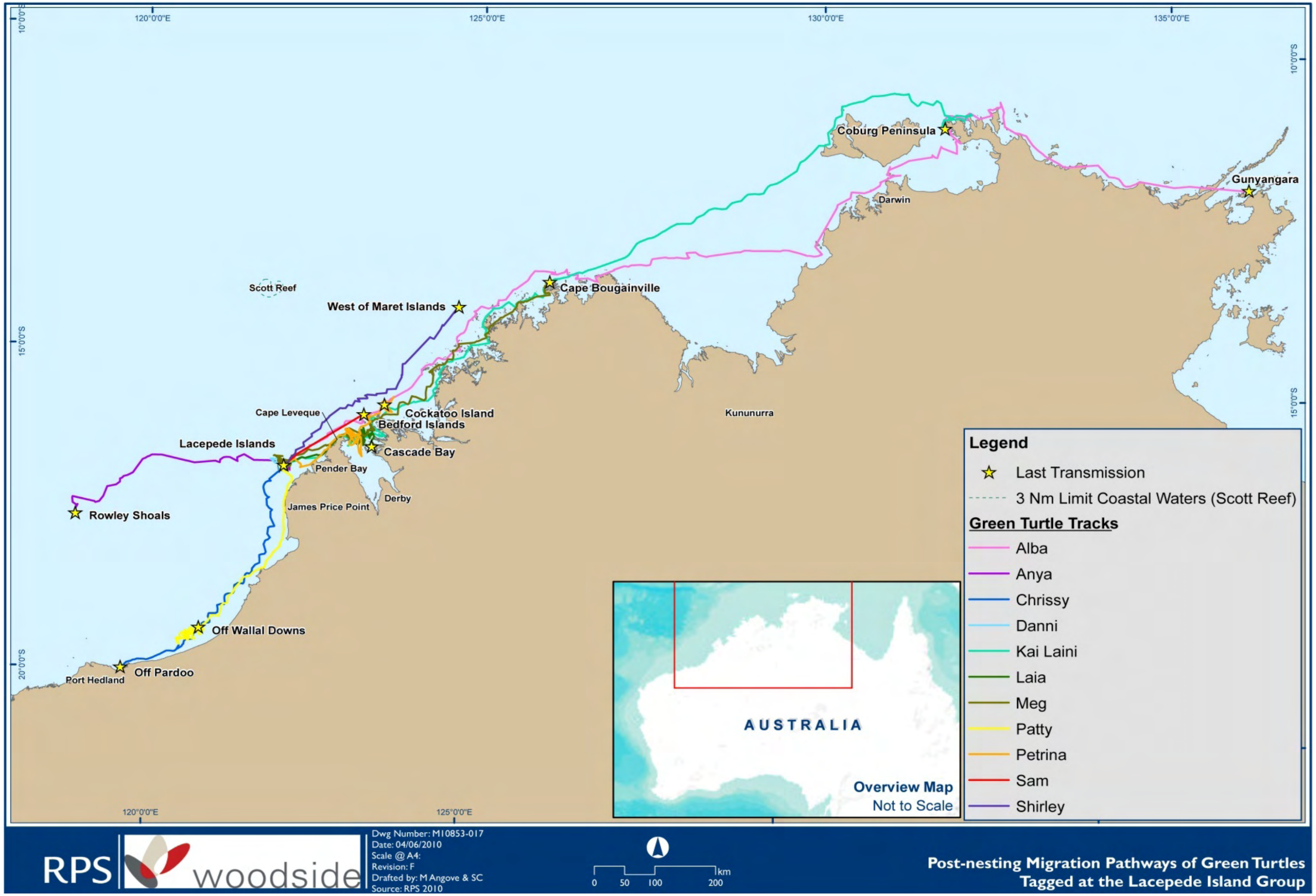



**Figure 35: Post-nesting Migration Pathways of Green Turtles Tagged at the Lacepede Island Group (Note: this Map only includes Data up to 31 March 2010)**

**Table 24: Summary of Green Turtle Post-nesting Migration (GPS Locations up to 31 March 2010)**

| Satellite Tag ID | Turtle Name | Date of Last Nesting Event | Post-nesting Migration | | | Most Recent Transmission | | |
|---|---|---|---|---|---|---|---|---|
| | | | Direction Travelled | Total Distance Travelled (km) | Straight-line Distance Travelled (km) | Date | Location | Activity at Last Transmission |
| 47672 | Petrina | 10-Feb-10 | NE | 281 | 72 | 31-Mar-10 | Cockatoo Island, WA | Milling |
| 47673 | Alba | N/A | NE | 1366 | 1157 | 31-Mar-10 | Gunyangara (East Arnhem), NT | Travelling |
| 47674 | Kai Liani | 17-Jan-10 | NE | 1411 | 1260 | 31-Mar-10 | Coburg Peninsula, NT | Milling |
| 47675 | Meg | 26-Feb-10 | NE | 534 | 255 | 31-Mar-10 | Cape Bougainville, WA | Travelling |
| 47676 | Sam | N/A | NE | 1273 | 1142 | 16-Jan-10 | Bedford Islands, Western Australia ** | Travelling |
| 47683 | Danni | 02-Mar-10 | N | 11 | 0 | 31-Mar-10 | Lacepede Island Group, WA | Milling |
| 47684 | Patty | 07-Jan-10 | SSW | 427 | 312 | 31-Mar-10 | Off Wallal Downs (Eighty Mile Beach), WA | Milling |
| 47685 | Chrissy | 04-Mar-10 | SW | 75 | 3 | 31-Mar-10 | Off Pardoo (near Port Hedland), WA | Travelling |
| 47686 | Laia | 10-Jan-10 | NE | 195 | 148 | 31-Mar-10 | Cascade Bay ( King Sound), WA | Milling |
| 47687 | Anya | 3-Mar-10 | WSW | 442 | 353 | 03-Mar-10* | Rowley Shoals, WA | Milling |
| 53244 | Shirley | N/A | NE | 436 | 141 | 25-Feb-10* | 36 km NW of Maret Islands, WA | Travelling |

[#]Transmitter malfunctioned after this date
** Argos data available after this data
N/A – not known to have nested when tagged.

## 5.4.2 Flatback Turtles

### 5.4.2.1 Inter-nesting

Six of the 11 satellite tags attached to flatback turtles at the Lacepede Island Group provided data relating to inter-nesting behaviour (Table 25). Four turtles (Hannah, Flossy, Amanda and Toni) left the Lacepede Island Group immediately after the satellite tag was attached and the transmitter malfunctioned for one turtle (Arnica).

Flatback turtles remained within 50 km of the Lacepede Island Group during the inter-nesting period, with recorded positions evenly distributed around the Lacepede Island Group (Table 25; Figure 36). The mean re-nesting interval for flatback turtles was 14.75 days (SE = 1.31; range = 12–17; n = 4 re-nesting events).

**Table 25: Summary of Flatback Turtle Inter-nesting Behaviour**

| Satellite Tag ID | Turtle Name | Deployment Date | No. of Re-nesting Events | Mean Inter-nesting Period (# of Days) | Maximum Straight-line Distance Travelled from the Lacepede Island Group during the Inter-nesting Period (km) |
|---|---|---|---|---|---|
| 47671 | Arnica | 02-Dec-09 | Argos data to be analysed. | | |
| 47670 | Jeanie | 02-Dec-09 | 1 | 17 | 50 |
| 47681 | Charlotte | 03-Dec-09 | 0 | - | 25 |
| 47682 | Tiane | 03-Dec-09 | 2 | 12.5 | 40 |
| 47689 | Adie | 04-Dec-09 | 1 | 17 | 45 |
| 47688 | Courtney | 04-Dec-09 | 0 | - | 30 |
| 53238 | Hannah | 09-Feb-10 | **0** | - | - |
| 47679 | Toni | 10-Feb-10 | 0 | - | - |
| 47677 | Amanda | 10-Feb-10 | 0 | - | - |
| 47678 | Flossy | 10-Feb-10 | 0 | - | - |
| 47680 | Becky | 10-Feb-10 | 0 | - | - |

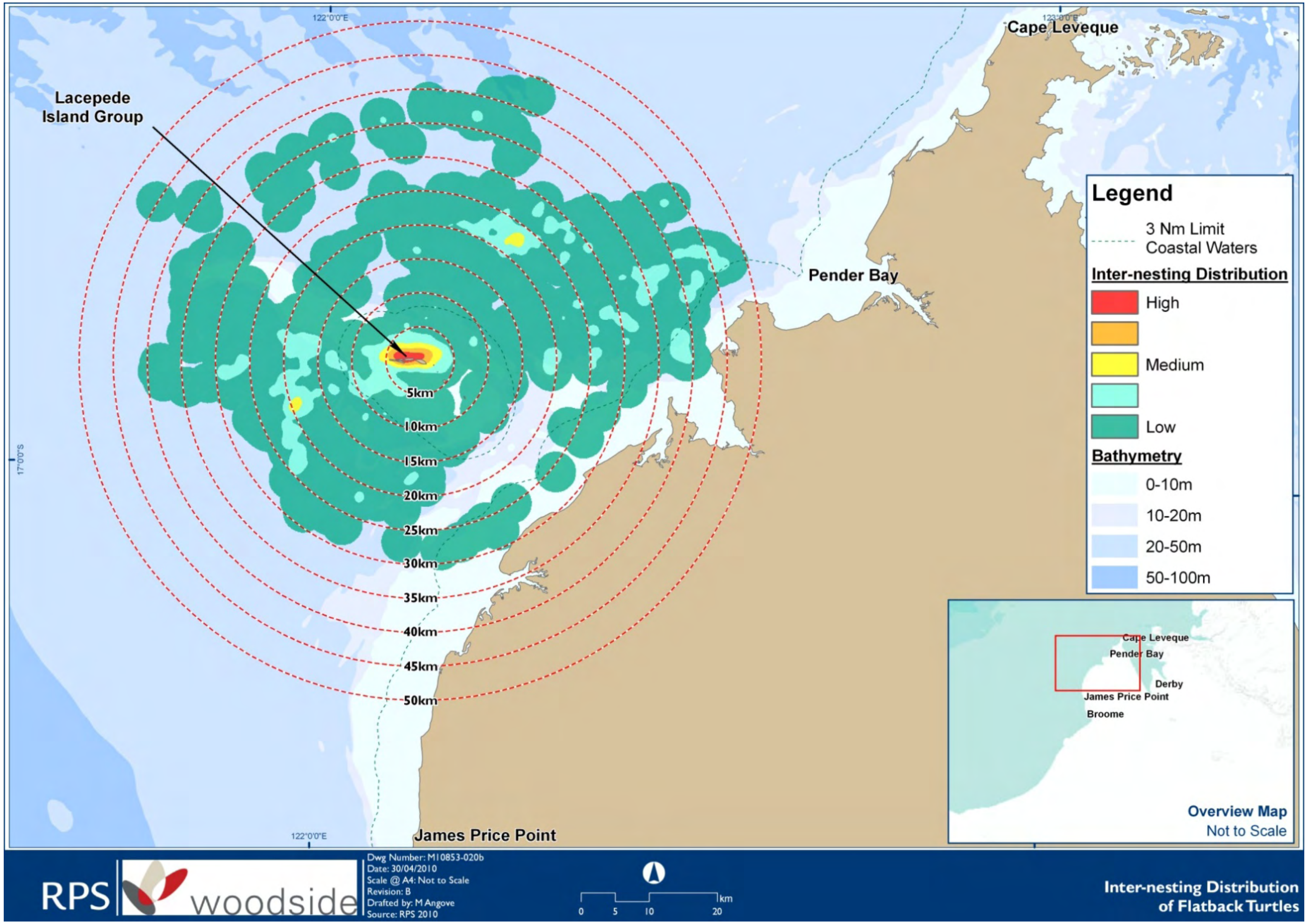



**Figure 36: Inter-nesting Distribution of Flatback Turtles Tagged at the Lacepede Island Group**

#### 5.4.2.2 Post-nesting

All of the 11 flatback turtles tagged at the Lacepede Island Group commenced their post-nesting migration by the end of February (Table 25). Nine of the migrating turtles travelled in a north-eastern direction (Table 25, Figure 37). Two turtles (Arnica and Toni) remain within 17 km of the Lacepede Island Group as at 31 March. Both turtles have not nested for greater than two weeks and are probably in a post-nesting phase. One satellite tag (Adie) malfunctioned and stopped transmitting data 20 km north-east of the Lacepede Island Group.

Eight of the 11 turtles tagged appear to have completed their migration and are exhibiting post-migration behaviour. As at 31 March, four turtles (Jeanie, Courtney, Charlotte and Amanda) had travelled as far as Gale Banks in the northern Kimberley region (Figure 37). Three of these turtles (Jeanie, Courtney and Charlotte) travelled to Gale Banks and then changed their orientation by 180° to be travelling in a southern eastern direction. Individual maps for each turtle are provided as Appendix 2.

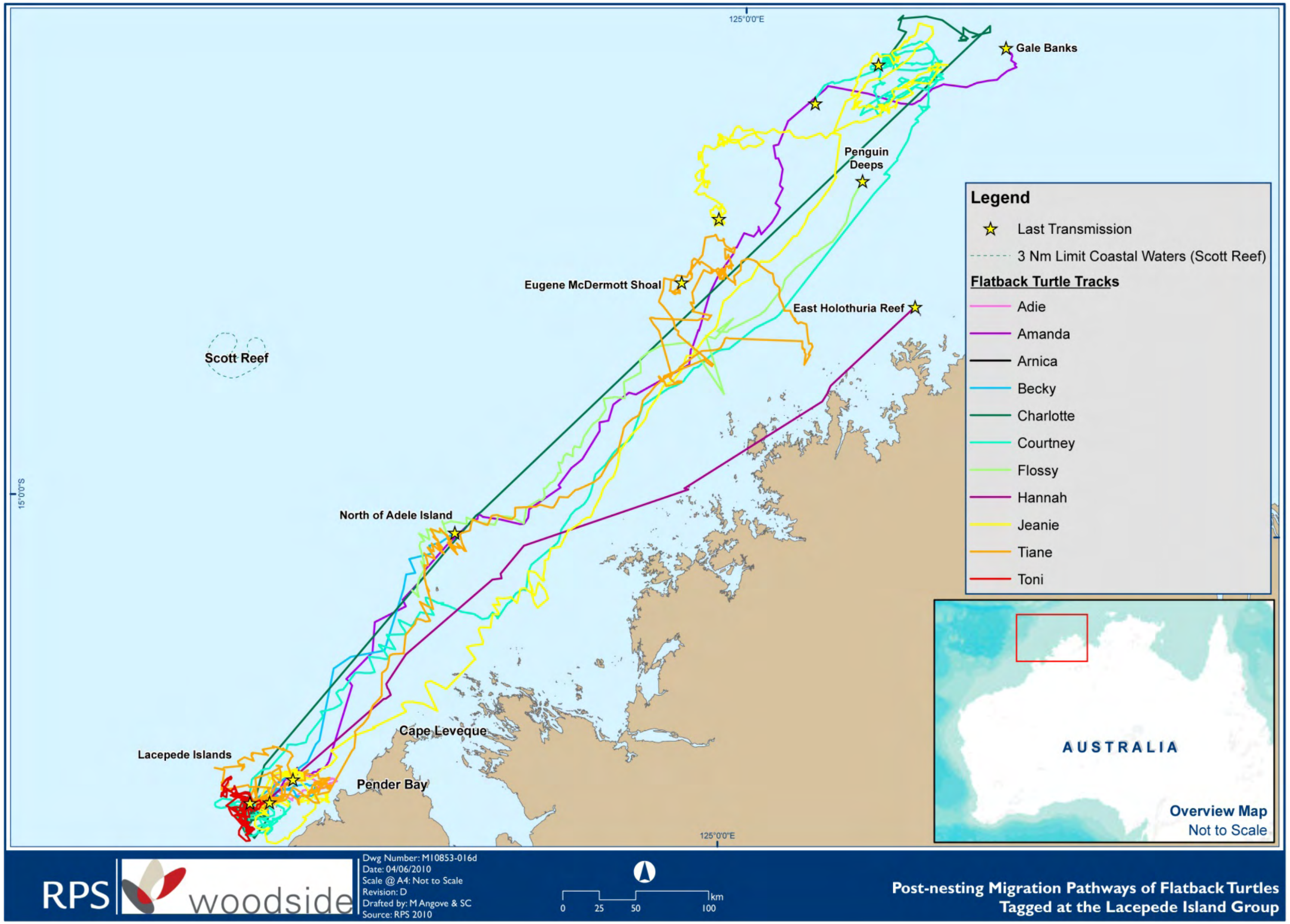



**Figure 37: Post-nesting Migration Pathways of Flatback Turtles from the Lacepede Island Group (Note: this Map only includes Data up to 31 March 2010)**

**Table 26: Summary of Flatback Turtle Post-nesting Migration Behaviour (GPS Locations up to 31 March 2010)**

| Satellite Tag ID | Turtle Name | Date of Last Nesting Event | Post-nesting Migration | | | Most Recent Transmission | | |
|---|---|---|---|---|---|---|---|---|
| | | | Direction Travelled | Total Distance Travelled (km)* | Straight-line Distance Travelled (km) | Date | Location | Activity |
| 47670 | Jeanie | 18-Dec-09 | NE | 1251 | 565 | 31-Mar-10 | Eugene McDermott Shoal, Kimberley, WA | Milling |
| *47671 | Arnica | N/A | SW | 513 | 5 | 04-Apr-10* | West of Lacepede Island Group, WA | Milling |
| 47677 | Amanda | N/A | NE | 569 | 421 | 14-Mar-10* | East Holothuria Reef (Kimberley), WA | Milling |
| 47678 | Flossy | 22-Feb-10 | NE | 504 | 262 | 31-Mar-10 | Penguin Deeps (Kimberley), WA | Travelling |
| 47679 | Toni | N/A | W | 182 | 6 | 31-Mar-10 | Lacepede Island Group, WA | Milling |
| 47680 | Becky | 21-Feb-10 | NE | 98 | 26 | 31-Mar-10 | North of Adele Island (Kimberley), WA | Milling |
| 47681 | Charlotte | N/A | NE | 1123 | 697 | 31-Mar-10 | Gale Banks, Timor Sea | Milling |
| 47682 | Tiane | 01-Jan-10 | NE | 1180 | 435 | 31-Mar-10 | Eugene McDermott Shoal (Kimberley), WA | Milling |
| 47688 | Courtney | N/A | NE | 1139 | 623 | 31-Mar-10 | Gale Banks (Kimberley), WA | Milling |
| 47689 | Adie | N/A | NE | 160 | 21 | 26-Dec-09* | North of Lacepede Island Group, WA | N/A |
| 53238 | Hannah | N/A | NE | 16 | 5 | 31-Mar-10 | Gale Banks (Kimberley), WA | Travelling |

* Transmitter malfunctioned after this date
** Argos data available after this data
N/A – not known to have nested when tagged.

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# 6.0 DISCUSSION

The baseline studies reported herein represent the current state of knowledge of marine turtle distribution, biology and abundance in the southern Kimberley region and specifically in the areas in close proximity to the proposed development at James Price Point. Existing literature has been reviewed and interpreted in terms of the relative importance of the proposed development site at James Price Point, and additional field survey work conducted as part of this study has increased our understanding of the importance of the area to marine turtles.

Limited targeted marine turtle research has previously been conducted in the study area and the research presented herein represents findings of the baseline surveys conducted to underpin the assessment of potential impacts associated with the proposed BLNG project.

Marine turtle populations are intrinsically variable in space and time. Population parameters such as age at maturity, remigration intervals, clutch success rates, proportion of the population nesting in a given year, and day to day variation in nesting densities are highly variable (Limpus and Nicholls 1988; Broderick et al. 2001; Limpus et al. 2003). This intrinsic variability means that a single year's data only provides a preliminary insight into the population dynamics of the marine turtles in this area.

## 6.1 Southern Kimberley Region

Baseline studies conducted at a regional level employed a combination of aerial, vessel and ground-based (beach) survey techniques. Synergies with other Woodside survey programs in the region, such as the MMFS, were taken advantage of to increase the level of spatial and temporal coverage in the survey program. Surveys extended over most of the Dampier Peninsular coast, out to the oceanic Scott Reef system and encompassed the regionally significant turtle rookery at the Lacepede Island Group.

Mainland beaches between Jajal Beach and Coulomb Point appear to support low levels of flatback turtle nesting, compared to other nearby mainland rookeries. The surveys conducted in the James Price Point area showed that turtle nesting densities were very low (one possible nest) in 2009–2010 nesting season and are not considered regionally significant. Surveys conducted by Conservation Volunteers Australia (CVA) at Cable Beach in Broome recorded an average of approximately 37 nests per nesting season during 2006–2009, all of which were identified as flatback nests (CVA 2008). Surveys conducted by CVA in southern Roebuck Bay (between 9 November – 19 December 2009) also found an average of 53 flatback nests in 2008–2009 and 91 flatback nesting in 2009–2010 (McFarlane 2010).

While there is extensive linear nesting beach habitat on the west coast of the Dampier Peninsula, these beaches probably only contribute a very small proportion of the annual flatback (and possibly green) turtle productivity within the NWS Management Units for these species. Turtle nests on mainland beaches are vulnerable to predation from humans and native and feral animals, whereas turtle rookeries on offshore and nearshore islands tend to suffer less predation. In the longer term, predation pressure may have led to the decline of nesting densities on mainland beaches. This further increases the conservation significance of island rookeries such as the Lacepede Island Group rookery.

The Lacepede Island rookery is globally significant because it the largest green turtle rookery in the NWS MU. The regional importance of the Lacepede Island Group rookery was confirmed through the studies conducted in the 2009–2010 season. The current study estimated that 431 green turtles and 39 flatback turtles attempt to nest each night on the beaches of the Lacepede Island Group. However, these numbers are considered low compared to previous seasons where up to 1,600 turtles per night have been recorded (DEC 2009a; Pendoley 2005). In contrast, nesting activity (as evident from tracks and body pits) along the west Dampier Peninsular was limited to individual turtles.

No new regionally significant rookeries were identified, despite the current studies extending the regional coverage of targeted turtle surveys in the southern Kimberley Region. Aggregations of turtles at varying densities were seen around offshore reefs (5–20 km) west of Carnot Bay (0.8–1.2 sightings/km$^2$), Willie Creek (0.6–3.2 sightings/km$^2$) and Lagrange Bay (0.4–0.9 sightings/km$^2$) during the non-breeding period (July and September), suggesting these are favoured foraging areas, but little is known of the characteristics of these reefs and if they are spatially limited in the region. The majority of turtles recorded during surveys in the non-breeding season at Scott Reef in July, August and September 2009 tended to be on the outer reef areas, which are thought to be suitable foraging habitat for green and hawksbill turtles (Jenner and Jenner 2009).

The current studies support the idea that green turtles from the NWS MU commonly undertake large-scale, post-nesting migrations along the Kimberley. The satellite telemetry data shows green turtles travelling up to 1,400 km to the Gulf of Carpentaria and nearshore waters around Melville/Bathurst Island in the Northern Territory.

The post-nesting migration routes for green and flatback turtles from the NWS MU are becoming evident from satellite telemetry studies of female turtles from the Pilbara and now, also Kimberley rookeries. While only relatively few nesting turtles have been tracked, the northward migration from rookeries to foraging areas appears broadly representative of the turtle movements between nesting and foraging areas, although it is expected that there will be some annual variation amongst individuals.

The satellite telemetry data from the current studies shows green turtles migrate to parts of northern Australia, outside the NWS MU, and can potentially reach foraging areas within the range of other Management Units, such as the Gulf of Carpentaria (Prince 1994). The potential for occasional inter-breeding among these adjacent MUs is consistent with Dethmers et al. (2006) hypothesis that the rookeries in the Gulf of Carpentaria were colonised by individuals from the NWS after sea levels rose around 10,000 years ago.

Flatback turtles also migrate over large distances within the Kimberley region. Satellite telemetry data from the current study shows that flatback turtles generally migrate north along the Kimberley coast to possible foraging locations within Penguin Deeps in the Timor Sea and Eugene McDermott Shoal in the Kimberley region. Other satellite tracking studies on flatback turtles from Roebuck Bay (Eco Beach 2009; McFarlane 2010), Port Hedland (Care for Hedland Community Monitoring Group 2009) and Barrow Island (Chevron Australia 2009), show similar migration pathways and potential foraging areas in the Kimberley region.

Given the low nesting activity of turtles on the mainland beaches of the Dampier Peninsula, observations of inter-nesting turtles in the nearshore waters are unlikely during the nesting season (October–March). Therefore, the relatively high densities of turtles recorded in the nearshore waters between Quondong Point and Coulomb Point during the Nearshore Regional Survey in March 2009 (Figure 16) are likely to be post-nesting turtles from southern rookeries passing the area as they swim to foraging areas in the Kimberley region. It is possible that these turtles are using the area to navigate within the northern migratory pathway and bypass Roebuck Bay from 80 Mile Beach.

## 6.2 James Price Point Area

### 6.2.1 Turtle In-water Distribution

While nesting densities appear to be consistently low along the southern Kimberley coast relatively high densities of turtles observed adjacent to Carnot Bay, Cape Latreille, Roebuck Bay and Lagrange Bay during aerial surveys from July 2009 to October 2009 indicates that these may be important foraging areas. Relatively high densities of turtles were observed in the vicinity of the James Price Point area during March 2009. However, during aerial surveys in July 2009, and targeted vessel surveys in December 2009 and February 2010, the turtle densities were much lower off the James Price Point area than in March 2009. This indicates that the James Price Point area does not consistently support high densities of turtles and it is likely the densities observed in March 2009 represent a short-term habitat use by inter-nesting turtles from nearby rookeries or post-nesting turtles migrating to foraging areas in the north.

The unidentified turtles sighted in surveys off the James Price Point area may have included hawksbill, leatherback or olive ridley turtles, as these species are known to occur in the general area (DEC 2009a). However, the absence of these species during the vessel surveys suggests that they are not present in significant numbers in the vicinity of the James Price Point area, or Pender Bay, during the non-breeding period. These species are not known to nest in this area.

While the current study indicated that the nearshore areas adjacent to James Price Point and Quondong South beaches potentially support relatively high numbers of juvenile turtles and low numbers of adult turtles, nearby areas outside the study area could also support similar activity in the same habitat types. The number of turtles recorded in the nearshore waters appears to be associated with tidal movements. Higher numbers of turtles were observed when the high tide covered the rocky outcrops within the intertidal area.

### 6.2.2 Inter-nesting Habitats

The nearshore surveys and satellite tracking data from the Lacepede Islands confirmed the findings of previous satellite telemetry studies that green turtles remain within shallow (<20 m) nearshore habitats adjacent to their nesting beaches during the inter-nesting period (Pendoley 2005; Hays et al. 2001). Such habitats are considered critical for nesting green turtle populations in Australia (Environment Australia 2003).

In contrast, the inter-nesting distribution of flatback turtles nesting at the Lacepede Island Group ranged from 30–50 km from the island, with the majority of turtles travelling to the mainland coastal areas between Cape Baskerville and North Head. The aerial surveys conducted in March 2009 also showed the highest densities of turtles around the Lacepede Island Group were approximately 30 km from the islands, with a distribution skewed towards the mainland.

### 6.2.3 Nesting Areas

No significant green or flatback turtle nesting areas were recorded on the mainland coast in the James Price Point area in the 2009–2010 nesting season. The tracks recorded at James Price Point Beach are likely to be from a flatback turtle since they are the dominant species found on mainland beaches in the southern Kimberley area (CVA 2009; McFarlane 2010), with no records of green turtles within the Pilbara region. Furthermore, no eggs were found after excavating the presumed nest that was recorded at James Price Point in January 2010, suggesting the mainland beaches adjacent to James Price Point are not productive rookeries for turtles.

### 6.2.4 Sand Temperature

The sand temperature study provided a preliminary investigation into the probable gender bias of hatchlings produced in the James Price Point area and the Lacepede Island Group based on TRTs and pivotal temperatures from other studies in Queensland (Hewavisenthi and Parmenter 2000; Booth and Astill 2001). In the absence of sufficient samples from James Price Point for determining the sex of hatchlings due to the very low nesting activity, it was assumed that the sand temperature ranges elsewhere in Australia would provide an estimate of gender-bias for the southern Kimberley region (see Wibbels 2003).

Mean sand temperature data from the Lacepede Island Group and James Price Point were greater than 30 °C at a 50 cm depth, indicating that incubation temperatures were female-biased for both green and flatback turtles. The mean sand temperatures at the James Price Point Coastal area were consistently 2–3 °C higher than those at the Lacepede Island Group, but still within the incubation thresholds (25-36 °C) for green and flatback turtles, suggesting the low number of adult turtles nesting at James Price Point is not a result of unsuitable incubation temperature.

The regular occurrence of tropical cyclones in the Kimberley region during the nesting and hatching seasons may affect the gender bias of nests laid in the Kimberley region. Tropical cyclones can lower the ambient sand temperatures as a result of increased cloud cover and rainfall and if they occur during the critical incubation period, can potentially change the gender of a small proportion of clutches. The sand temperature data from the current study showed that the sand temperature fell within the 100% male temperature range (below 29 °C) for flatback turtles for approximately three days at the Lacepede Island Group and Quondong South Beach and approximately one day on the remaining mainland beaches as a result of Cyclone Lawrence.

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# 7.0 CONCLUSION

The following section concludes the report by summarising the major findings for each species within their geographic regions. It also relates these findings to the different life stages of turtles in a table (e.g. mating, nesting and hatching, foraging, inter-nesting and migration).

Green turtles found in the study area are part of the NWS MU (Green turtles), which is the largest genetically distinct population in the world. The Lacepede Island Group supports a high proportion of the breeding green turtle population within the NWS MU, which also utilise foraging habitats across northern Australia during the non-breeding period. While no green turtles attempted to nest or were observed mating within the James Price Point area, high densities of nesting turtles (430 green turtles/night) and frequent mating activity were recorded at the Lacepede Island Group during the 2009–2010 nesting season.

Flatback turtles sighted in the study area are likely to be part of the NWS MU (Flatback turtles) however the actual extent of their genetic affiliations within the Kimberley region remains unknown. The low numbers of tracks found along the James Price Point coast are indicative of nesting activity along the mainland coast within the southern Kimberley region. The old tracks found on James Price Point Beach and Red Cliff were presumed to be flatback turtles as they are the dominate species nesting on the mainland beaches. Adult flatback turtles were also spotted in the intertidal areas on a high tide at James Price Point Beach and Quondong South Beach during the 2009–2010 nesting season, however no mating was observed. In contrast, the Lacepede Island Group supports a medium sized rookery of flatback turtles (40 turtles/night).

Although no genetic study has been conducted in the Kimberley region targeting hawksbill turtles, the turtles sighted off the Dampier Peninsula are likely to be part of the NWS MU (Hawksbill turtles), which is thought to extend to Dampier Archipelago. Hawksbill turtles have been observed feeding on the reefs adjacent to the mainland Kimberley coast. The hawksbill turtles sighted during the dedicated turtle vessel survey and the dead hawksbill turtle found on Manari Beach during the track counts confirm that this species may utilises the nearshore areas within the James Price Point area.

No genetic studies have been undertaken on loggerhead turtles in the Kimberley region. However, the loggerhead turtles sighted in the current study are likely to be part of the Western Australia MU since loggerhead turtles migrate past the Dampier Peninsula from southern rookeries such as the Ningaloo Marine Park. Loggerhead turtles were sighted about 20 km offshore from the James Price Point coast during the non-breeding period (July–October).

No olive ridley or leatherback turtles were recorded during the study period. Although olive ridley turtles have been recorded in Western Australia, their numbers are reported to be very low compared to other rookeries in Northern Territory. No leatherback turtles were sighted during the survey area and based on very limited records, are known to infrequently swim passed the Kimberley region.

The key findings obtained from the survey data are presented in Table 27.

**Table 27: Key Findings Obtained from the Survey Data**

| Category | Key Findings | Document Reference |
|---|---|---|
| Distribution and relative abundance | The predominant marine turtle species during the breeding period were green turtles with high densities occurring at the Lacepede Island Group. | 5.2.2, 5.3.3.2, 6.1 |
| | A mix of flatback (45%), green (30%) loggerhead (25%) turtles were found along the Dampier Peninsula during the non-breeding period. Hawksbill turtles were also recorded during the dedicated turtle vessel surveys. | 5.2.1 |
| | The majority of turtles in the water were observed within 20 km of the shore and within the 20 m isobath. | 5.1, 5.3 |
| | Turtles were widely distributed throughout all nearshore survey areas with no large aggregations of any species of turtle along the Dampier Peninsula. | 5.1, 5.3 |
| Mating | Low numbers of mating turtles were observed along the Dampier Peninsula whilst relatively high numbers of mating green turtles were sighted in the nearshore areas of the Lacepede Island Group. | 5.2.2, 5.3.3.2 |
| Nesting and hatching | High densities of turtles were recorded in waters around the Lacepede Island Group and north of the James Price Point area late in the 2008–2009 nesting season (March 2009 aerial survey). | 5.1 |
| | Track count data from 2009–2010 indicates that the Lacepede Island Group supports a significant turtle rookery in Western Australia (~431 green turtles/night and ~36 flatback turtles/night) whilst the James Price Point area only supports very low levels of nesting (3 tracks and 1 potential nest over the entire nesting season). | 5.3.2 |
| | At the Lacepede Island Group, 90% of all nesting is attributable to green turtles. Flatback turtles contribute the remaining ten per cent. | 5.3.2 |
| | The sand temperature data indicates that the green and flatback turtle clutches at West Island are likely to be female-biased. | 5.3.4, 0 |
| Potential foraging habitats | Relatively high densities of turtles were recorded in probable foraging habitats off Carnot Bay, Cape Lattreille, Roebuck Bay and Lagrange Bay during the non-breeding period (July–October 2009). | 5.1, 6.2.1 |
| | Low numbers of turtles were recorded at Scott Reef between July–September 2009. | 5.1, 6.1 |
| | Juvenile turtles were sighted within 50 m of the shore at James Price Point Beach and Quondong South Beach during the 2009–2010 nesting season. | 5.3.3.1 |

| Category | Key Findings | Document Reference |
|---|---|---|
| Inter-nesting | Satellite tracking indicated that for most of the inter-nesting period, the female green turtles stay within 5 km of nesting beaches at the Lacepede Island Group, but travel up to 18 km. | 5.4.1.1 |
| | Satellite tracking indicated that for most of the inter-nesting period, the female flatback turtles travel up to 50 km from nesting beaches at the Lacepede Island Group. | 5.4.2.1 |
| Post-nesting migration | The northern migratory pathway for green and flatback turtles nesting at the Lacepede Island Group followed a similar pathway demonstrated by turtles tagged at Port Hedland and Barrow Island. | 3.2.1.5, 3.2.2.5 |
| | The majority of green turtles migrated north-east along the Kimberley coast. Data up to 31 March indicated that the maximum migration distance was 1,400 km with one turtle reaching the Gulf of Carpentaria. Two green turtles travelled south passing the James Price Point area en route to 80 Mile Beach and Port Hedland. | 6.1 |
| | The majority of flatback turtles migrated north-east along the Kimberley coast. Data up to 31 March indicated that the maximum migration distance was 1,180 km with most turtles milling around Gale and Penguin Banks. | 5.4.2.2, 6.1 |

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# APPENDIX 1

## Field Notes: Terrestrial Field Survey (James Price Point)

# APPENDIX 1: Field Notes: Terrestrial Field Survey (James Price Point)

## 1.0 JAJAL BEACH

The area surveyed on Jajal Beach is 640 m in length. A rocky outcrop divides this beach into northern and southern subsections. The primary dune systems on both sections of beach are suitable for marine turtle nesting. The northern section experiences greater tidal inundation than the southern section however, the primary dune does not get inundated on either section of beach. The sandy intertidal area in the centre of the beach, with no rocky features obstructing the shore line, provides a suitable approach for nesting turtles.

### 1.1 Field Observations

A possible turtle track was observed at the crest of the primary dune during surveys in November 2009 however, it was too weathered for a conclusive identification. No other turtle tracks were observed on Jajal Beach during surveys in January–March 2010.

### 1.2 Anecdotal Evidence

Green turtles were reported to be observed nesting on Jajal Beach and mating in the near-shore water off Jajal beach in December 2008 (Mark Parriman pers. comm.). Flatback turtles have been observed in this area however, they are not as common as green turtles (Mark Parriman pers. comm.). Overall, Jajal Beach only experiences very low marine turtle activity (Terry Hunter pers. comm.).

# 2.0 QUONDONG SOUTH

Quondong South beach is 590 m in length. It has a large primary dune and extensive sandy areas, which make it a suitable nesting beach. The sheltered offshore approach to the beach is typical of turtle nesting beaches. The primary dune is not inundated by the tide. Approximately half way along the beach, a series of rocky reefs support foraging juvenile and adult turtles.

## 2.1 Field Observations

A possible, highly eroded, green turtle track with a small body pit indent was recorded on the primary dune. One adult green turtle was seen in the nearshore waters adjacent to the beach during November 2009 (Table 2). No other turtle tracks were recorded on Quondong South beach in surveys during January–March 2010.

Point surveys were conducted adjacent to rocky reefs located in the middle of the beach (Table 2). These surveys indicate that these reefs support juvenile and adult green and flatback turtles.

## 2.2 Anecdotal Evidence

Flatback tracks were observed on this beach in December 2008 and juvenile green turtles are common in the nearshore waters off this beach, especially in rocky areas (Mark Parriman pers. comm.).

# 3.0 QUONDONG BEACH (MANGO FARM)

Quondong Beach (Mango Farm) is 1,050 m long. It comprises a distinct foredune with extensive sandy areas from the shore to the primary dune (approximately 260 m from the high tide line). There are rocky outcrops at the northern and southern extents with a wide sandy approach to the centre of the beach. The spring-high stops several metres from the foredune, indicating a low risk of nest inundation in the foredune nesting habitat.

## 3.1 Field Observations

No turtle activity was observed at this beach during any surveys during 2009–2010.

## 3.2 Anecdotal Evidence

No anecdotal turtle evidence was recorded for this beach.

# 4.0 MURDUDUN BEACH (JPP SOUTH)

Murdudun Beach is approximately 900 m in length. This beach has well vegetated foredunes which gradually slopes to the primary dune, which is conducive to turtle nesting.

## 4.1 Field Observations

During surveys in November 2009, two turtle carapace bones and a lower jaw bone (mandible) were found on the dune above the high tide line. The location of the bones indicated that the turtle was likely to be an adult female stranded on the beach possibly during a nesting attempt.

No turtle activity was observed at this beach during any surveys during 2009–2010.

## 4.2 Anecdotal Evidence

No anecdotal turtle evidence was recorded for this beach.

# 5.0 JAMES PRICE POINT BEACH

James Price Point Beach is 720 m in length. The beach comprises one potential nesting area that is approximately 900 m to the south of James Price Point. This area is a extensive sandy beach area with a well developed vegetated foredune with vegetation. The foredune is set back and gradually slopes to a primary dune. There are rocky outcrops at the shore line at the northern and southern extent of the beach. The northern beach area above the high tide comprises a rocky platform covered by approximately 20 cm of sand. This section of beach is therefore unlikely to be suitable for nesting.

The beaches to the immediate north and south of James Price Point Beach are considered poorly suitable for nesting. These beaches experience almost complete tidal inundation and have very rocky shore lines. There are minimal suitable dune structures with most beaches being backed by Pindan cliffs.

## 5.1 Field Observations

One old false crawl and one old potential nest were recorded on James Price Point Beach during surveys in January 2010 (Table 2). Old tracks and nests are difficult to age beyond a few days given the variability in local weather conditions (e.g. wind, rain and storms/cyclones), however these tracks were approximated to being up to four weeks old, based on passage of Cyclone Lawrence, which occurred four weeks prior to surveys, and would have cleaned the beach of any sand indentations.

Turtles often make several attempts to nest on the same night or over consecutive nights until they eventually lay eggs. The tracks (false crawl and potential nest) found at James Price Point Beach are likely to be from the same turtle over a few nights given the tracks were weathered to a similar extent. Turtles usually return to the same beach about every two weeks to nest, but there was no evidence of this particular turtle returning to this section of James Price Point Beach.

To ascertain the species of turtle which dug the potential nest on James Price Point Beach, the site was excavated in March 2010, well after the hatchlings would have emerged. No egg chamber, egg fragments or dead hatchlings were found in the excavated area, indicating that the nest was outside of the area excavated, or the track was a false crawl.

Although the species could not be determined using track morphological techniques or the excavation of the nest, the size of the nest and secondary body pit and its position on the beach suggests it was a flatback turtle. Historical observations of flatback turtles nesting in the area by TOs also gives evidence to the nest being from a flatback turtle.

Despite the unsuitable nesting conditions observed on the beach directly north of James Price Point Beach, two possible turtle tracks were found on a sparsely vegetated pocket of sand during surveys in March 2010 (Table 2). These tracks were too weathered for a conclusive identification.

Point surveys were conducted adjacent to the rocky reefs on the southern section of James Price Point Beach. These surveys indicate that these reefs support juvenile, sub-adult and adult green and flatback turtles.

Two temperature loggers were installed on northern and southern sections of the beach respectively (Table 1).

The carapace of a green adult turtle was found next to an information shelter just off the access road to James Price Point Beach. The carapace had evidence of spear wounds. It is unknown where this carapace originated from.

# 6.0 MANARI BEACH

Manari Beach is approximately 4750 m in length. The section of beach immediately north of Flat Rock comprised Pindan cliffs that are inundated by the spring high tide. This section of beach is not considered suitable turtle nesting habitat.

The remainder of Manari Beach, however, does comprise suitable nesting habitat. The mid-section of the beach is mainly flat with sandy areas comprising sparse vegetation. There are patches of darker red sand in the mid-section that are likely to be unsuitable for nesting. Just south of Coulomb Point the primary dune system is very flat with sparse foredune vegetation. An extensive reef area is exposed at low tide at Coulomb Point.

## 6.1 Field Observations

Two temperature loggers were installed on northern and southern sections of the beach respectively (Table 1).

No turtle tracks were observed on Manari Beach during 2009–2010 surveys.

A freshly dead female hawksbill turtle (~40 cm Curved Carapace Length) was washed up about 500 m south of Coulomb Point (Table 2). A large portion of the turtle's neck was missing, suggesting a shark attack.

## 6.2 Anecdotal Evidence

Turtles of all sizes have been observed in the nearshore waters off Manari Beach (Mark Parriman pers. comm.). Turtle faeces were found along the high tide line at a few locations between the mid and southern end of the beach (Mark Parriman pers. comm.). The faeces contained undigested sea grass, which is the primarily food source for green turtles.

Turtle tracks have been seen about 5 km north of Coulomb Point near Yellow Creek throughout the year (Mark Parriman pers. comm.).

## Table 1 Beach Surveys – Transect Start and End Points, Temperature Logger Locations

| Beach | Transect Start | | Transect End | | Temperature Logger Location | | |
|---|---|---|---|---|---|---|---|
| | Northing | Easting | Northing | Easting | ID# | Northing | Easting |
| Jajal | -17.58697 | 122.16555 | -17.58237 | 122.16212 | - | - | - |
| Quondong South | -17.58254 | 122.16018 | -17.57916 | 122.15557 | 6 | -17.58115 | 122.15767 |
| | | | | | 9 | -17.57991 | 122.15704 |
| Quondong Beach (Mango Farm) | -17.57176 | 122.15188 | -17.56689 | 122.15018 | - | - | - |
| Murdudun Beach (JPP South) | -17.53922 | 122.14783 | -17.53148 | 122.14724 | - | - | - |
| James Price Point Beach | -17.50060 | 122.14439 | -17.49734 | 122.14449 | 8 | -17.50031 | 122.14481 |
| | | | | | 10 | -17.49871 | 122.14474 |
| Manari Beach | -17.39796 | 122.15028 | -17.35376 | 122.15346 | 5 | -17.39239 | 122.15287 |
| | | | | | 2 | -17.35712 | 122.15057 |
| West Island | -16.85265 | 122.12583 | -16.85306 | 122.11557 | 4 | -16.85265 | 122.12583 |
| | | | | | 3 | -16.85224 | 122.12038 |
| | | | | | 1 | -16.85306 | 122.11557 |
| Middle Island | -16.85329 | 122.12917 | -16.85396 | 122.13808 | - | - | - |
| Sandy Islet | -16.88115 | 122.17225 | -16.88115 | 122.17225 | - | - | - |
| East Island | -16.90195 | 122.19732 | -16.90195 | 122.19732 | - | - | - |

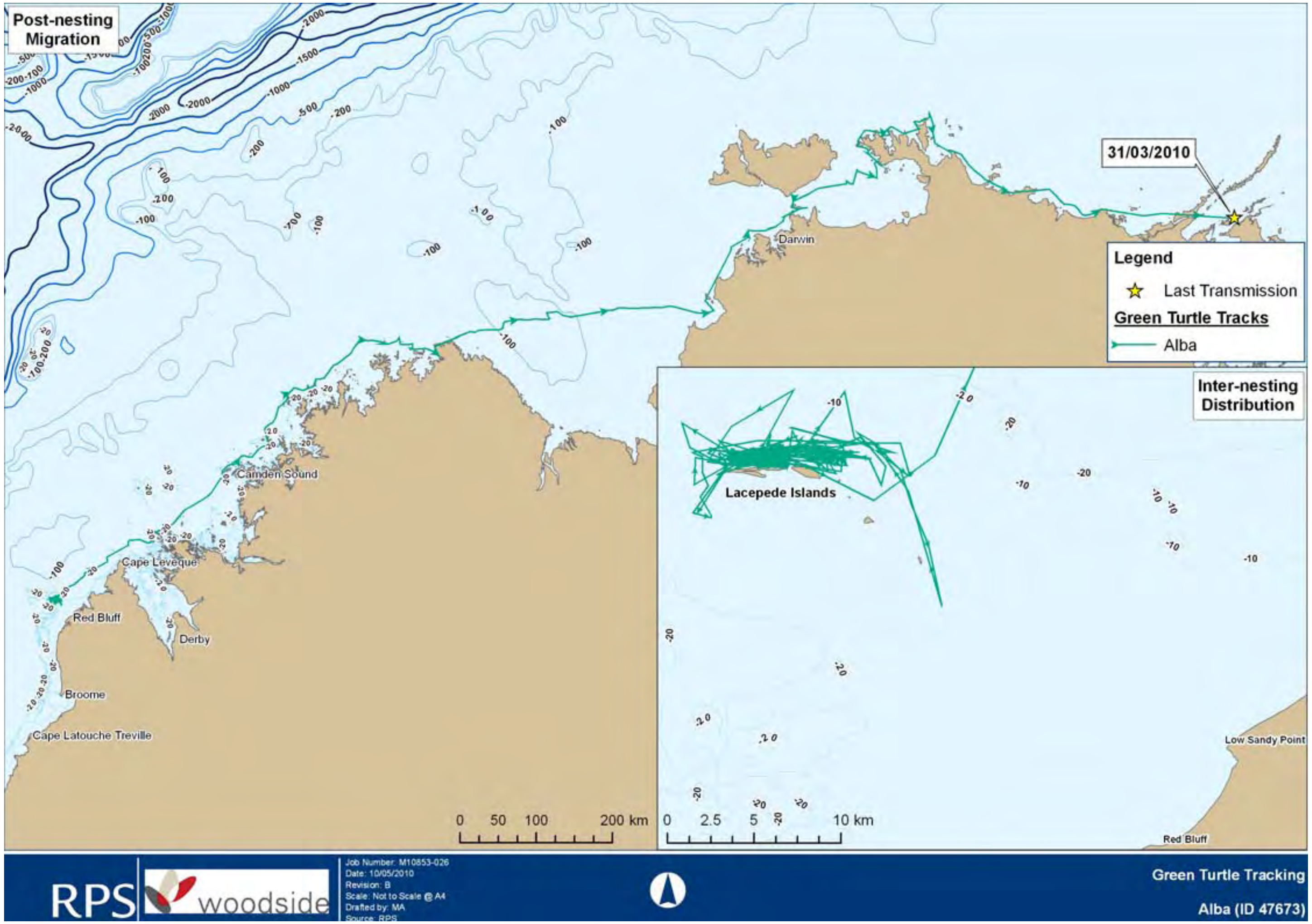
### Table 2 Beach Surveys – Significant Observations

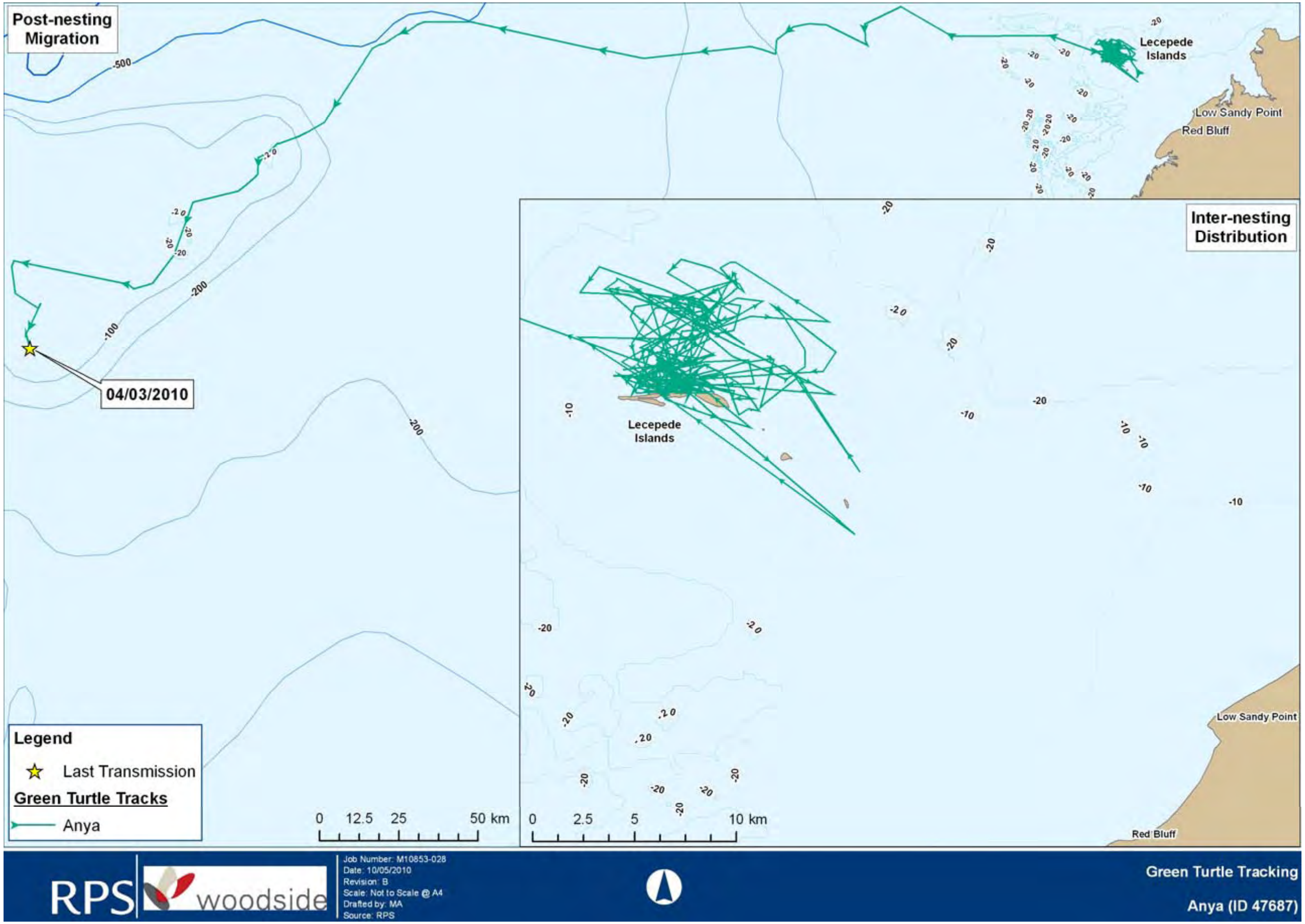
| Beach | Significant Observation Location | | Location |
|---|---|---|---|
| | Northing | Easting | |
| Jajal | - | - | - |
| Quondong South | -17.57945 | 122.15592 | Adult green turtle in nearshore waters (RPS Nov 2009) |
| | -17.58184 | 122.15764 | Observation point (RPS Feb/Mar 2010) |
| Quondong Beach (Mango Farm) | -17.56461 | 122.14890 | Tracks (Biota March 2009) |
| | -17.56854 | 122.15145 | Body pits (Biota March 2009) |
| Murdudun Beach (JPP South) | - | - | - |
| James Price Point Beach | -17.57945 | 122.15592 | 1 green turtle adult (RPS Nov 2009) |
| | -17.49827 | 122.14420 | 3 green turtle juveniles (RPS Nov 2009) |
| | -17.50007 | 122.14502 | False crawl (RPS Jan 2010) |
| | -17.49887 | 122.14478 | Nest (RPS Jan 2010) |
| | -17.50161 | 122.14460 | Observation point (RPS Feb/Mar 2010) |
| | -17.49654 | 122.14431 | 2 tracks (RPS March 2010) |
| | -17.49846 | 122.14450 | Body pits (Biota Mar 2009) |
| Manari Beach | -17.36106 | 122.15106 | 1 Dead juvenile hawksbill turtle (RPS Nov 2009) |
| West Island | - | - | - |
| Middle Island | - | - | - |
| Sandy Islet | - | - | - |
| East Island | - | - | - |

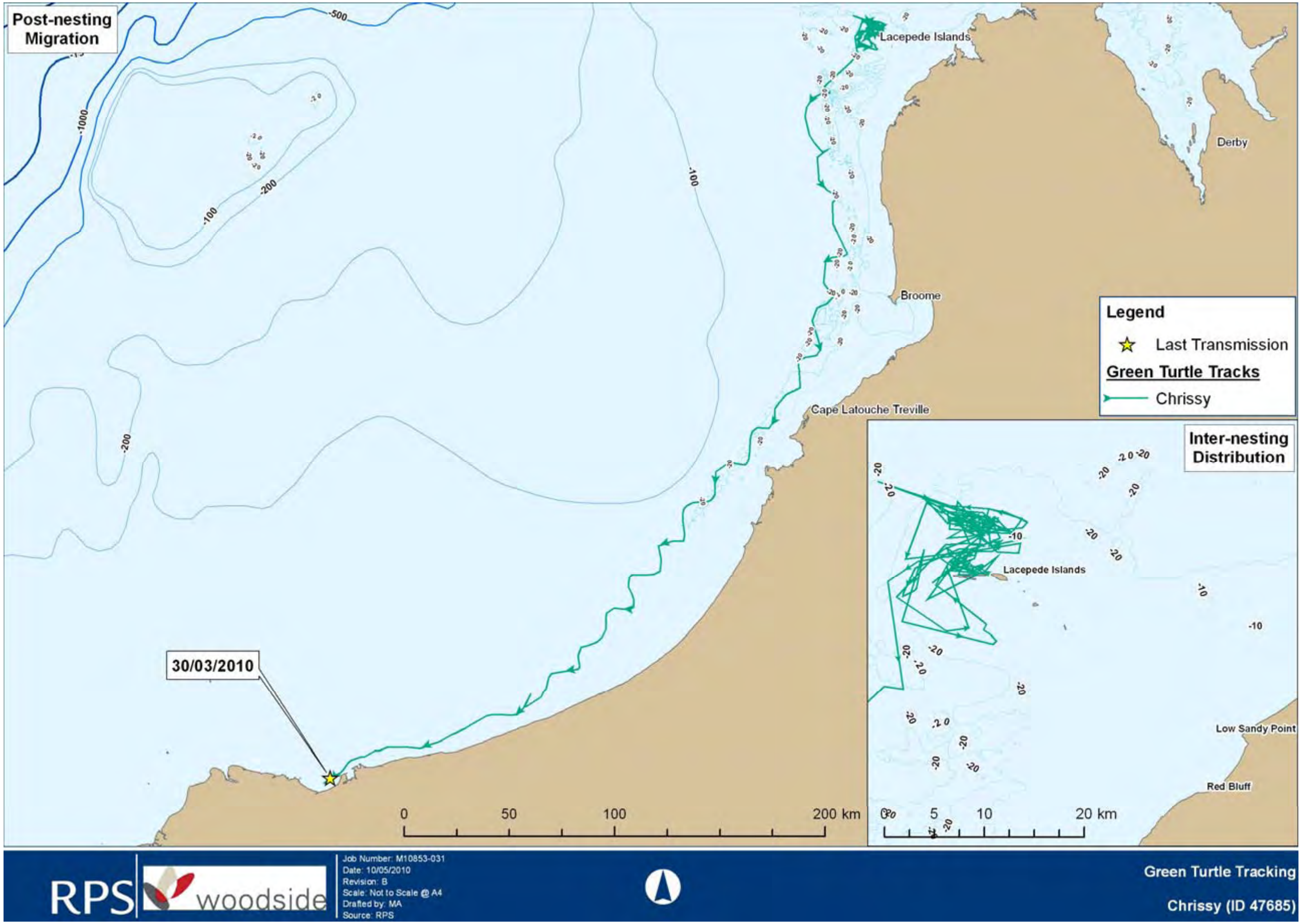
# APPENDIX 2

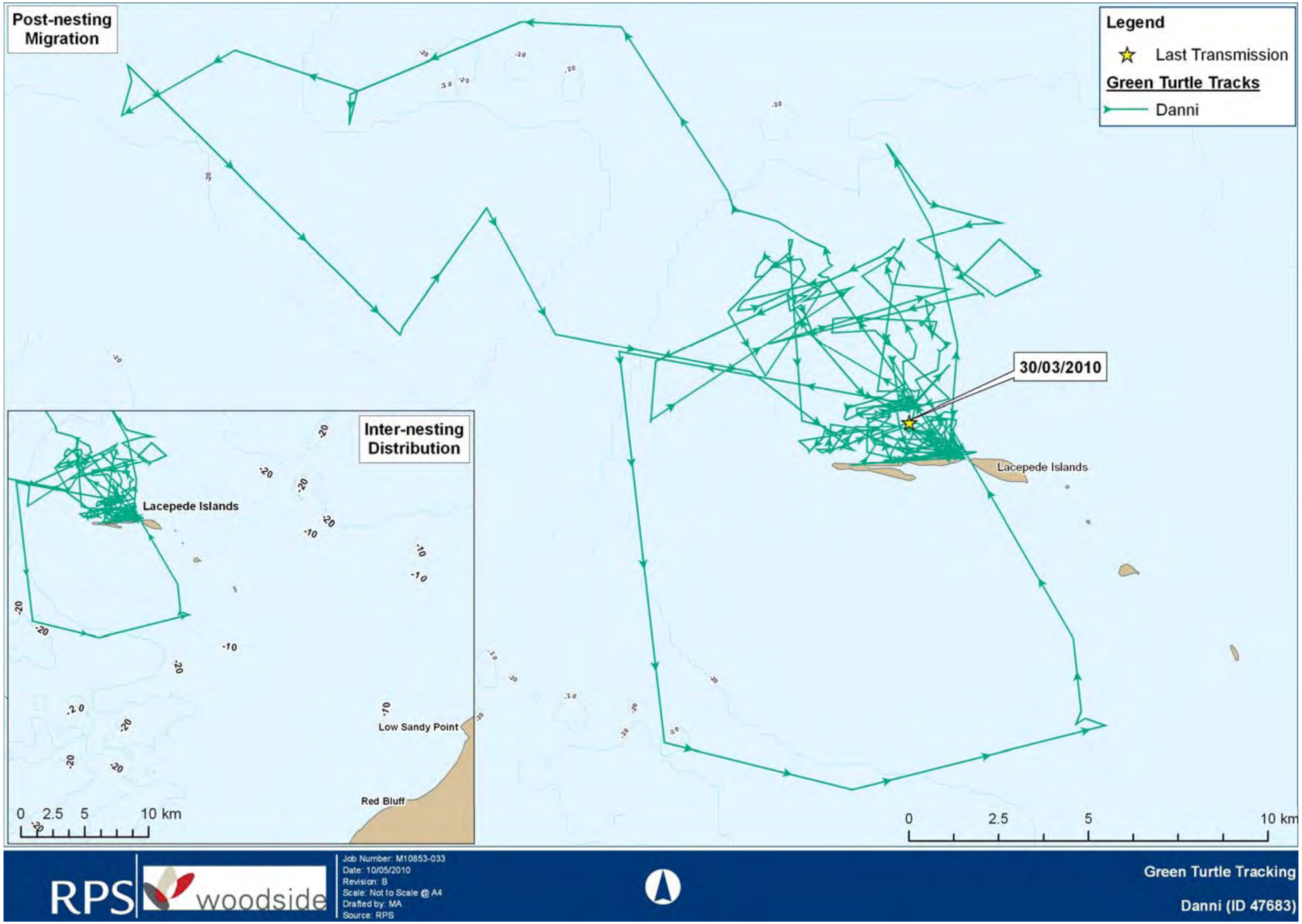
## Inter-nesting and Post-nesting Movements of Green and Flatback Turtles Nesting on West Island, the Lacepede Island Group

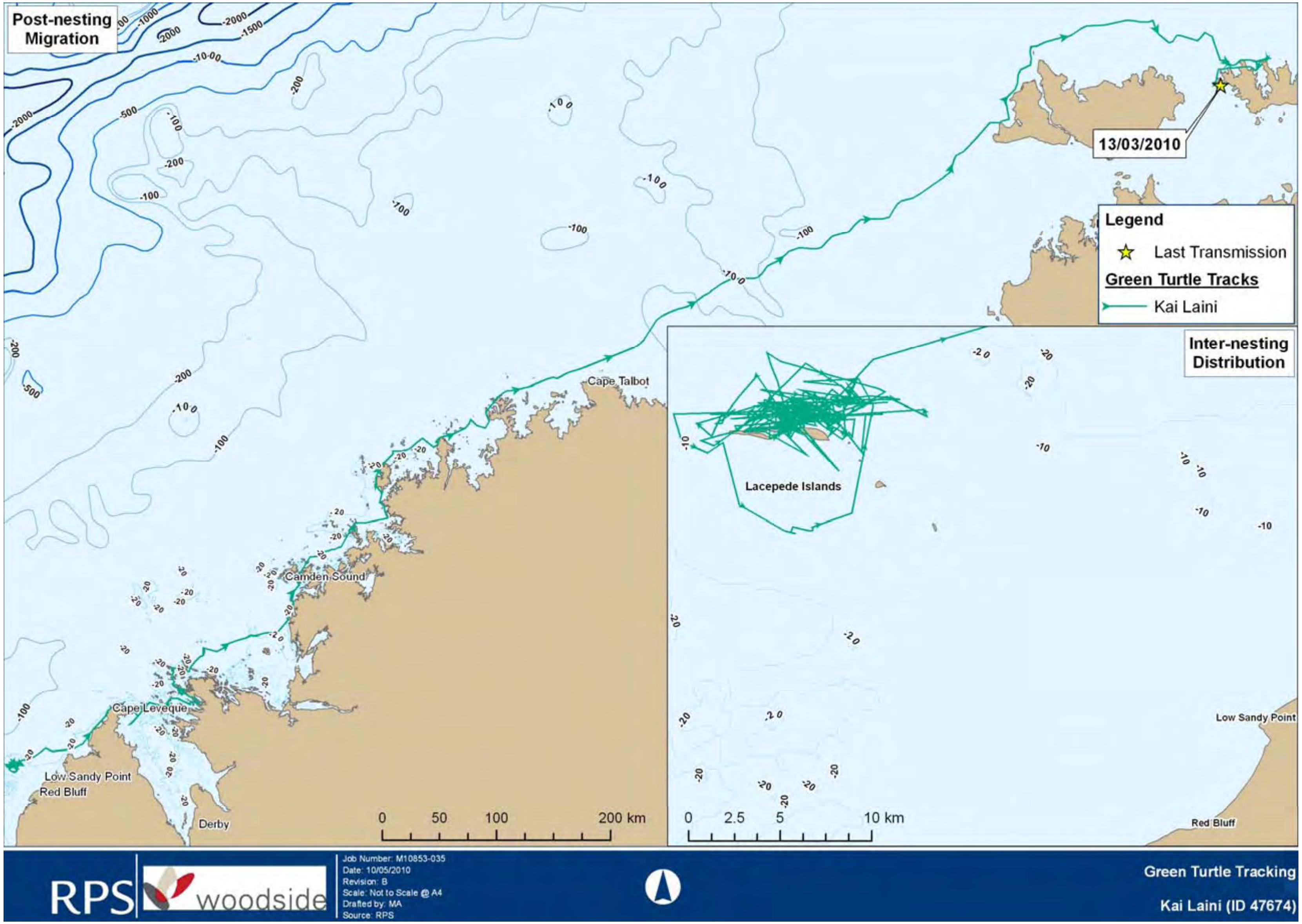
# APPENDIX 2: Inter-nesting and Post-nesting Movements of Green and Flatback Turtles Nesting on West Island, the Lacepede Island Group (Note: Maps include Lastloc GPS Transmissions up until 31 March 2010)




Post-nesting Migration
Inter-nesting Distribution
Lecepede Islands
Low Sandy Point
Red Bluff
04/03/2010
Legend
Last Transmission
Green Turtle Tracks
Anya
0 12.5 25 50 km
0 2.5 5 10 km
Job Number: M10853-028
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Anya (ID 47687)


Post-nesting Migration
Lacepede Islands
Derby
Broome
Cape Latouche Treville
30/03/2010
Legend
Last Transmission
Green Turtle Tracks
Chrissy
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0
50
100
200 km
5
10
20 km
Job Number: M10853-031
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Chrissy (ID 47685)


Post-nesting Migration
Legend
Last Transmission
Green Turtle Tracks
Danni
30/03/2010
Lacepede Islands
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 2.5 5 10 km
0 2.5 5 10 km
RPS
woodside
Job Number: M10853-033
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Danni (ID 47683)


Post-nesting Migration
13/03/2010
Legend
Last Transmission
Green Turtle Tracks
Kai Laini
Inter-nesting Distribution
Lacepede Islands
Cape Talbot
Camden Sound
Cape Leveque
Low Sandy Point
Red Bluff
Derby
0 50 100 200 km
0 2.5 5 10 km
Job Number: M10853-035
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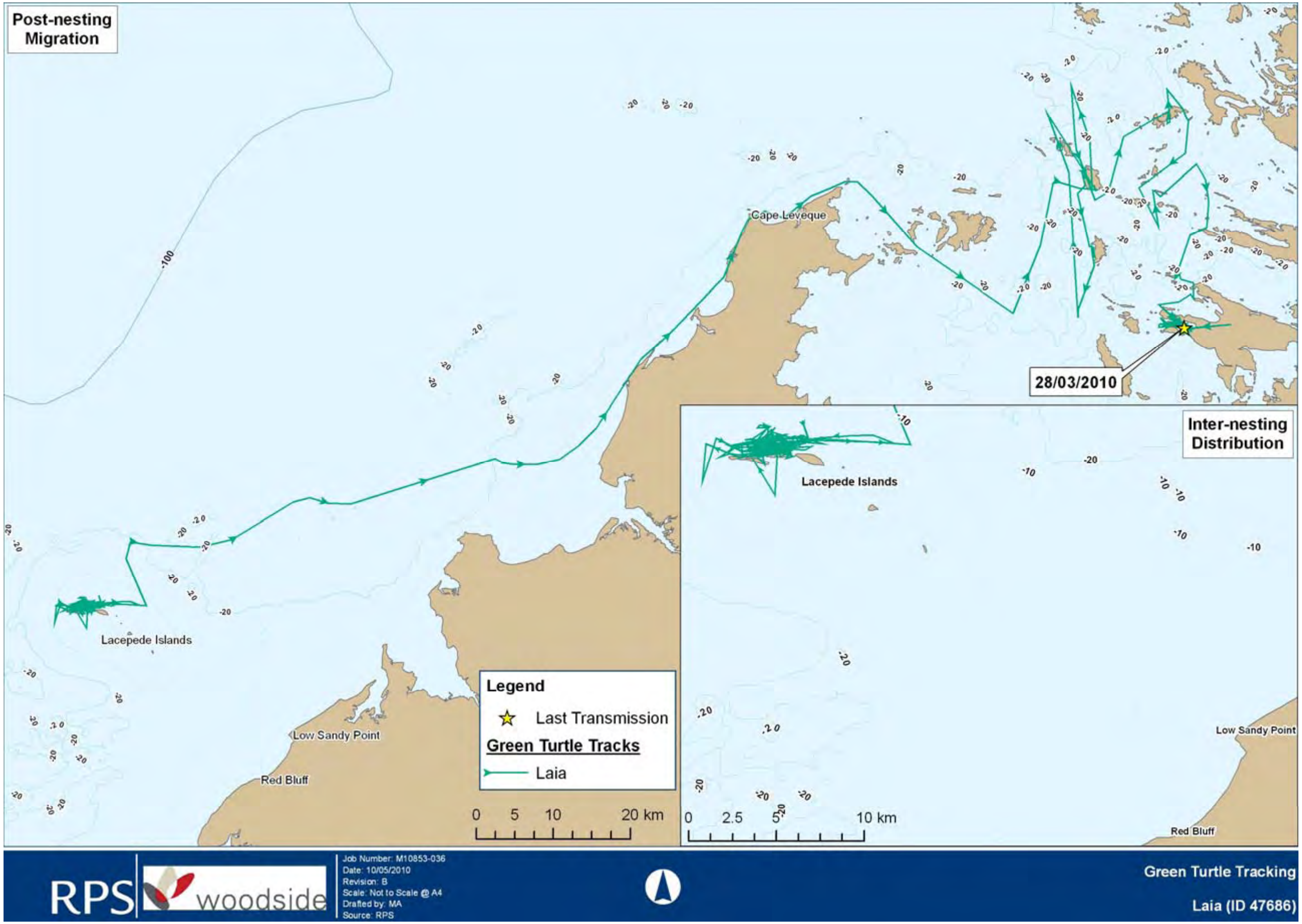
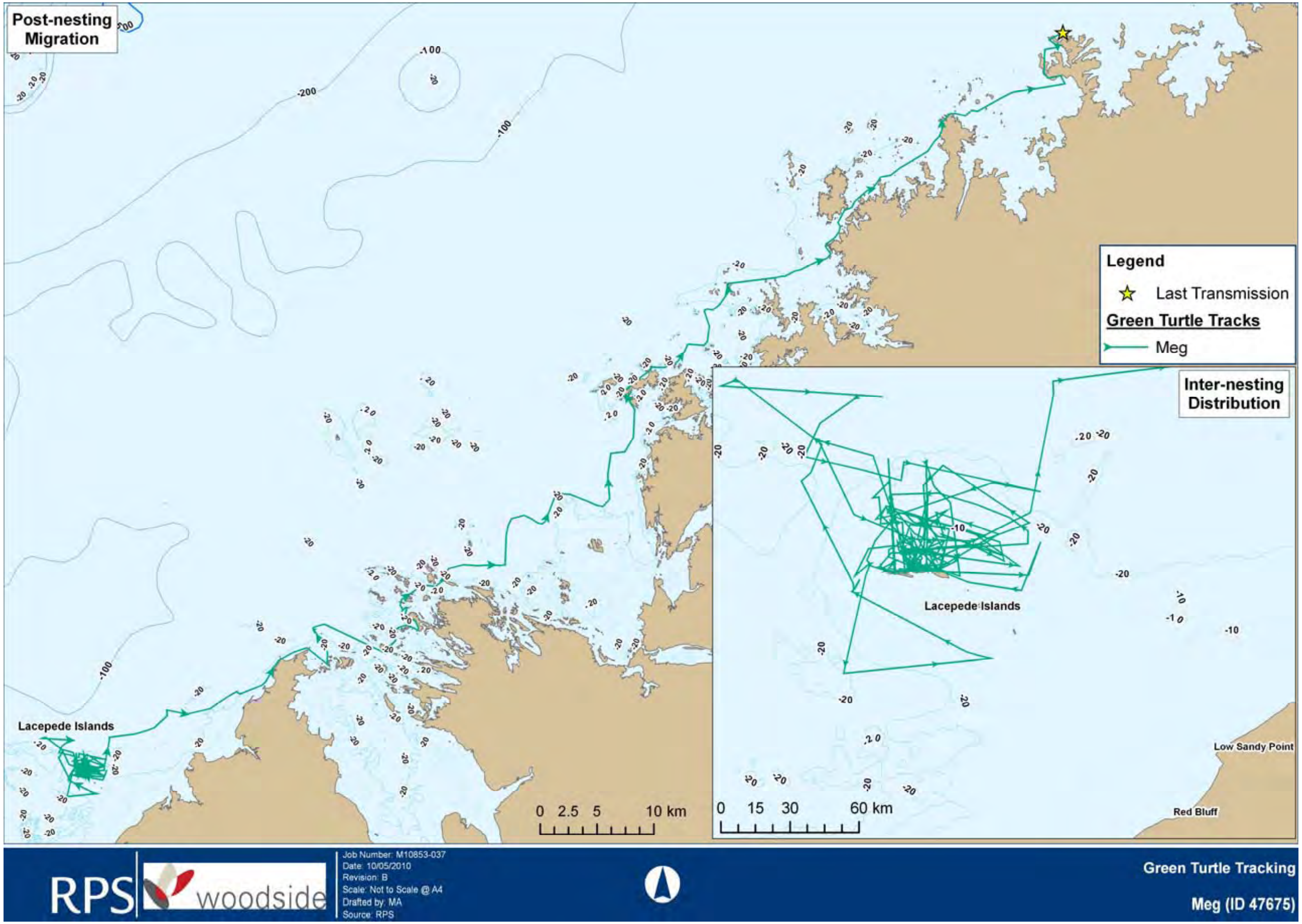
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Kai Laini (ID 47674)


Post-nesting Migration
Cape Leveque
28/03/2010
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
Legend
Last Transmission
Green Turtle Tracks
Laia
0 5 10 20 km
0 2.5 5 10 km
Job Number: M10853-036
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Laia (ID 47686)


Post-nesting Migration
Lacepede Islands
0 2.5 5 10 km
Legend
Last Transmission
Green Turtle Tracks
Meg
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 15 30 60 km
RPS
woodside
Job Number: M10853-037
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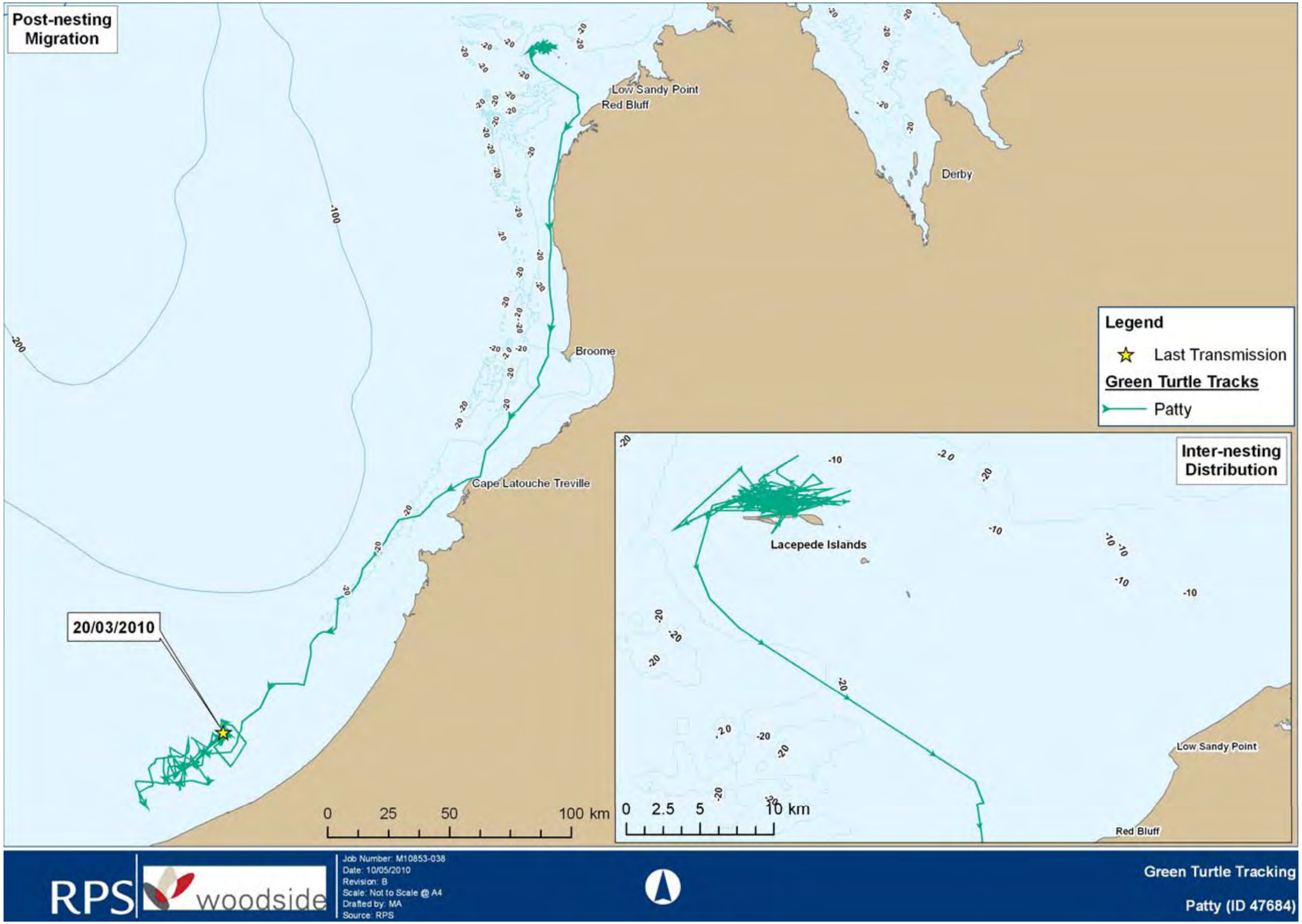
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Meg (ID 47675)


Post-nesting Migration
Low Sandy Point
Red Bluff
Derby
Broome
Cape Latouche Treville
20/03/2010
0 25 50 100 km
Legend
Last Transmission
Green Turtle Tracks
Patty
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 2.5 5 10 km
Job Number: M10853-038
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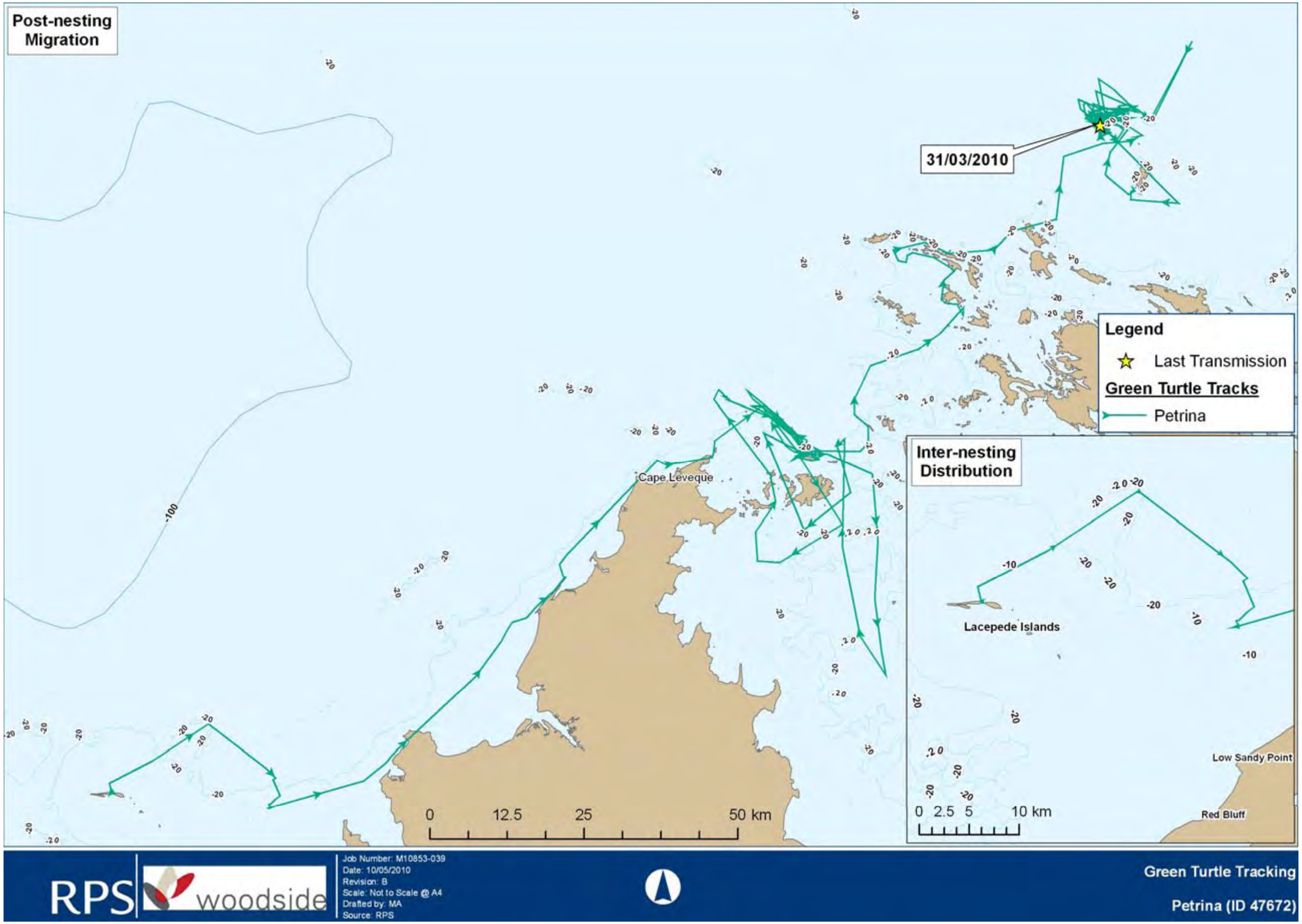
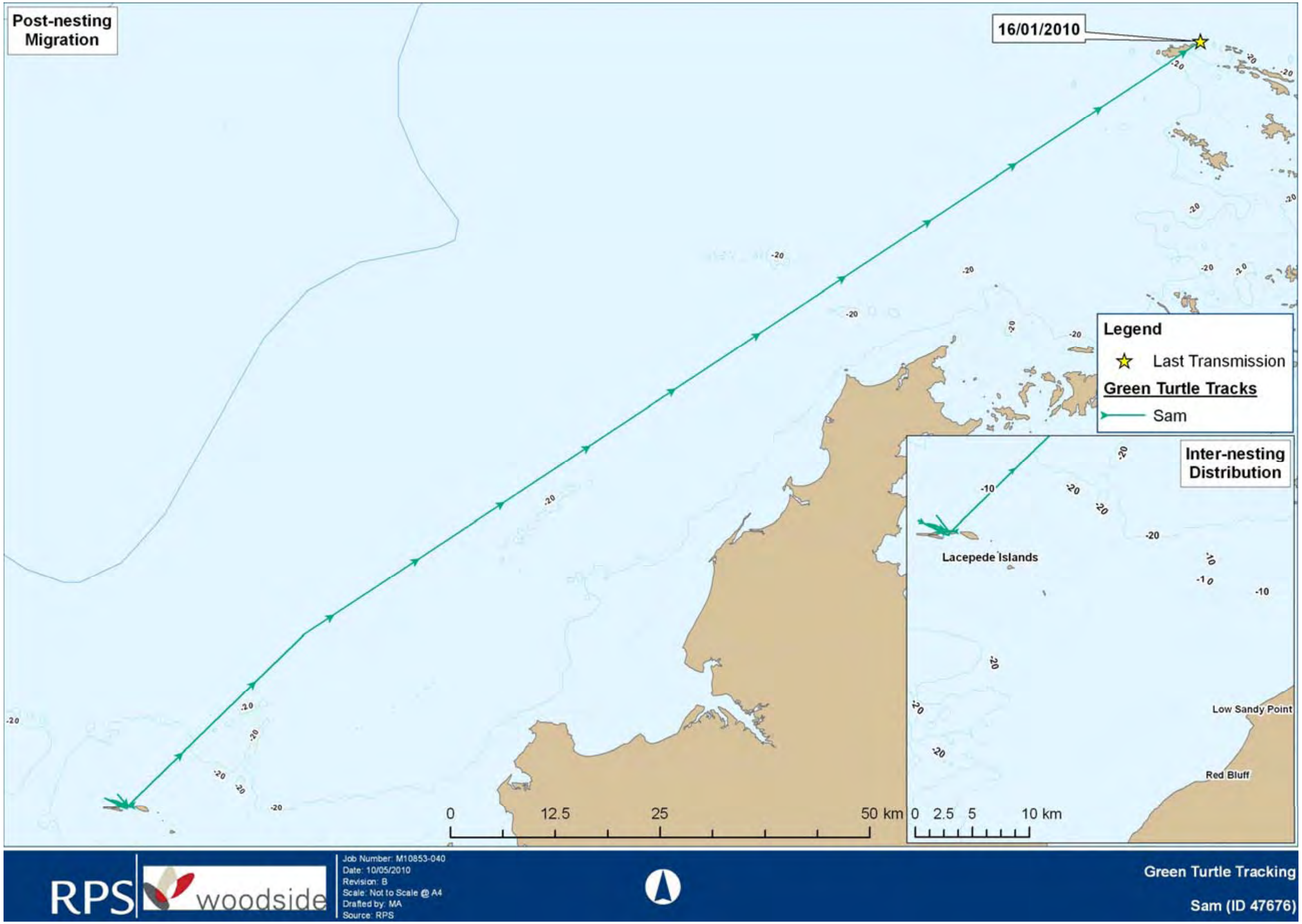
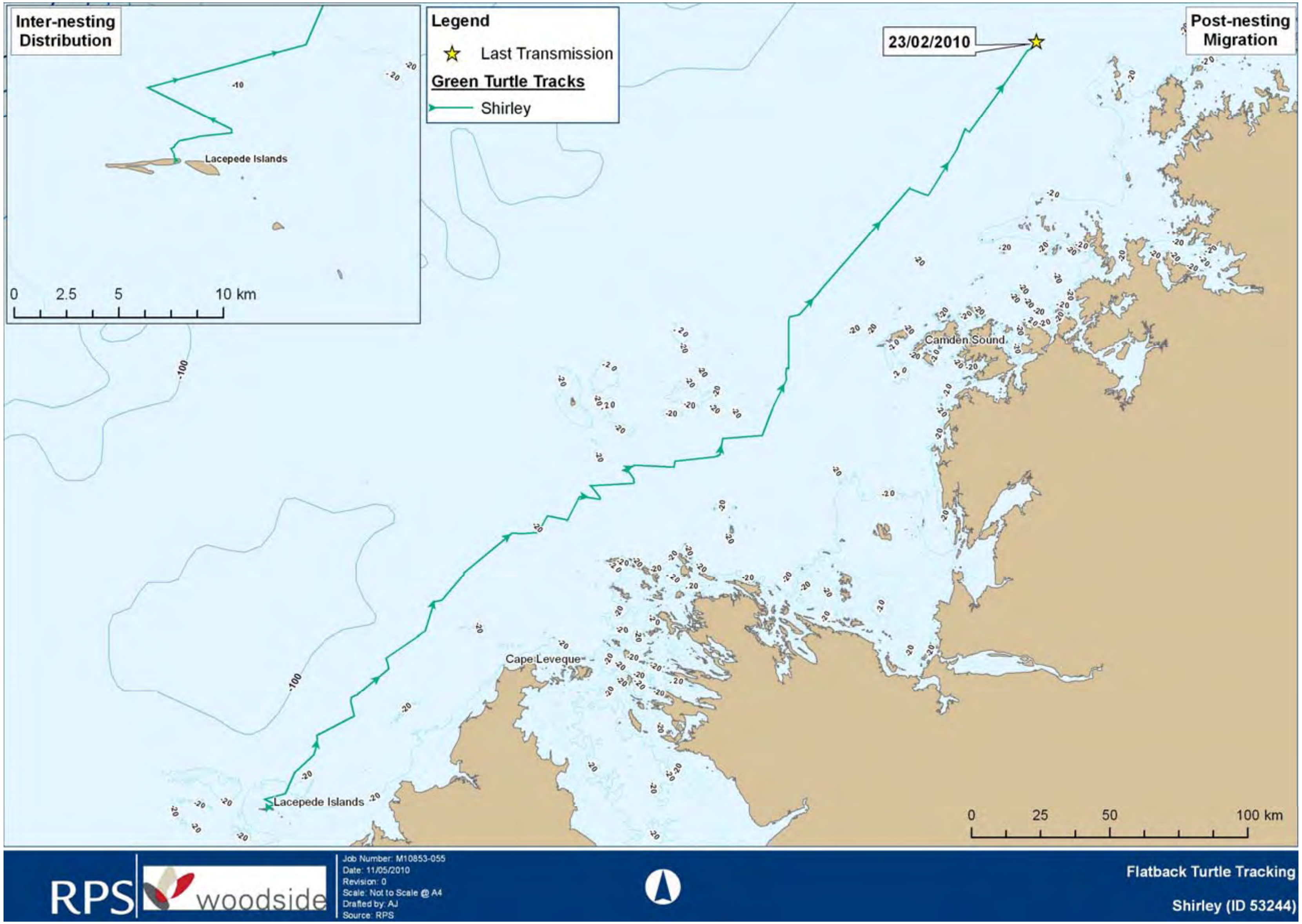
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Patty (ID 47684)


Post-nesting Migration
31/03/2010
Cape Leveque
Legend
Last Transmission
Green Turtle Tracks
Petrina
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 2.5 5 10 km
0 12.5 25 50 km
Job Number: M10853-039
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Petrina (ID 47672)


Post-nesting Migration
16/01/2010
Legend
Last Transmission
Green Turtle Tracks
Sam
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 12.5 25 50 km
0 2.5 5 10 km
RPS woodside
Job Number: M10853-040
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Green Turtle Tracking
Sam (ID 47676)


Inter-nesting Distribution
Lacepede Islands
0 2.5 5 10 km
Legend
Last Transmission
Green Turtle Tracks
Shirley
23/02/2010
Post-nesting Migration
Camden Sound
Cape Leveque
Lacepede Islands
0 25 50 100 km
RPS woodside
Job Number: M10853-055
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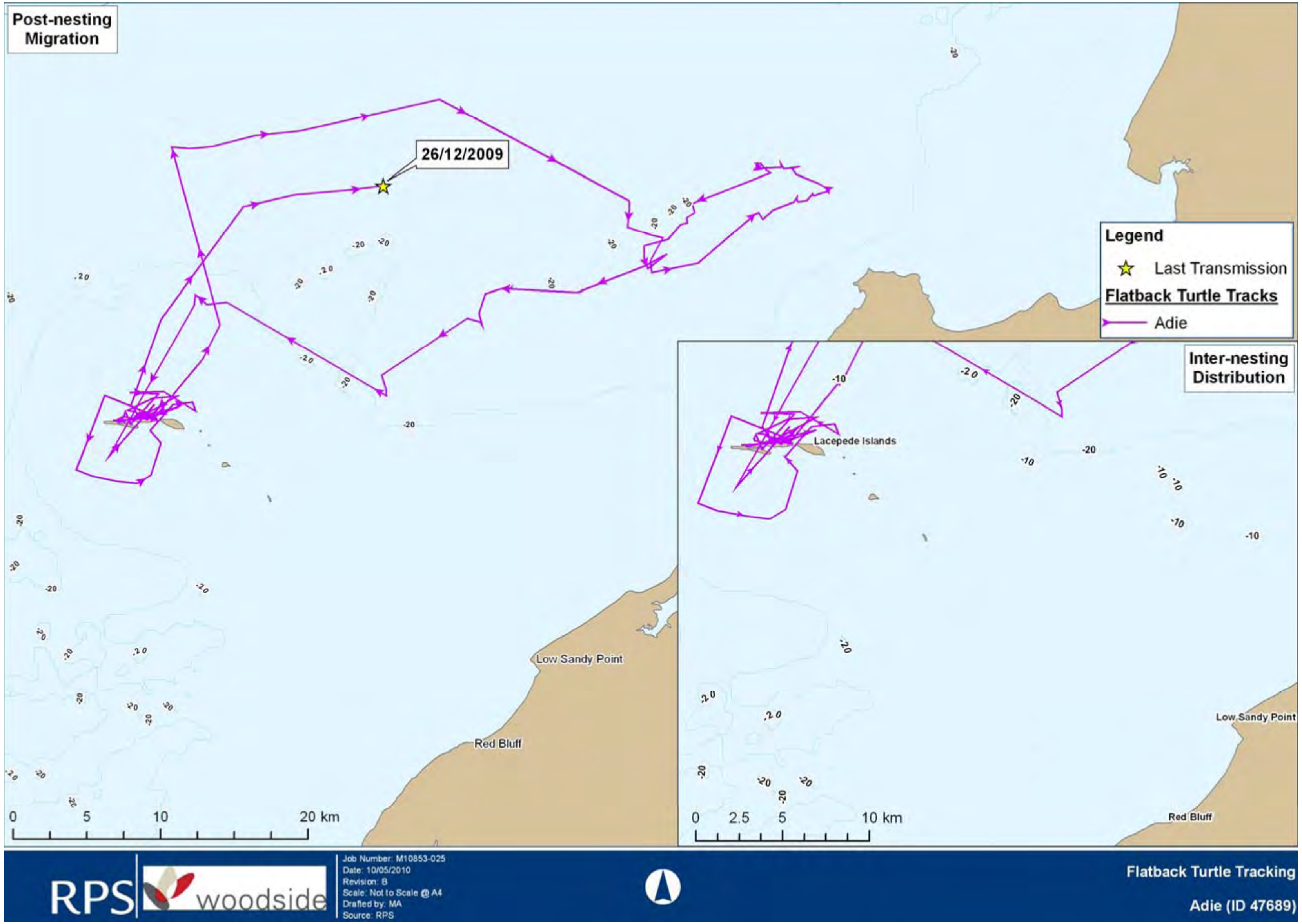
Revision: 0
Scale: Not to Scale @ A4
Drafted by: AJ
Source: RPS
Flatback Turtle Tracking
Shirley (ID 53244)


Post-nesting Migration
26/12/2009
Legend
Last Transmission
Flatback Turtle Tracks
Adie
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 5 10 20 km
0 2.5 5 10 km
Job Number: M10853-025
Date: 10/05/2010
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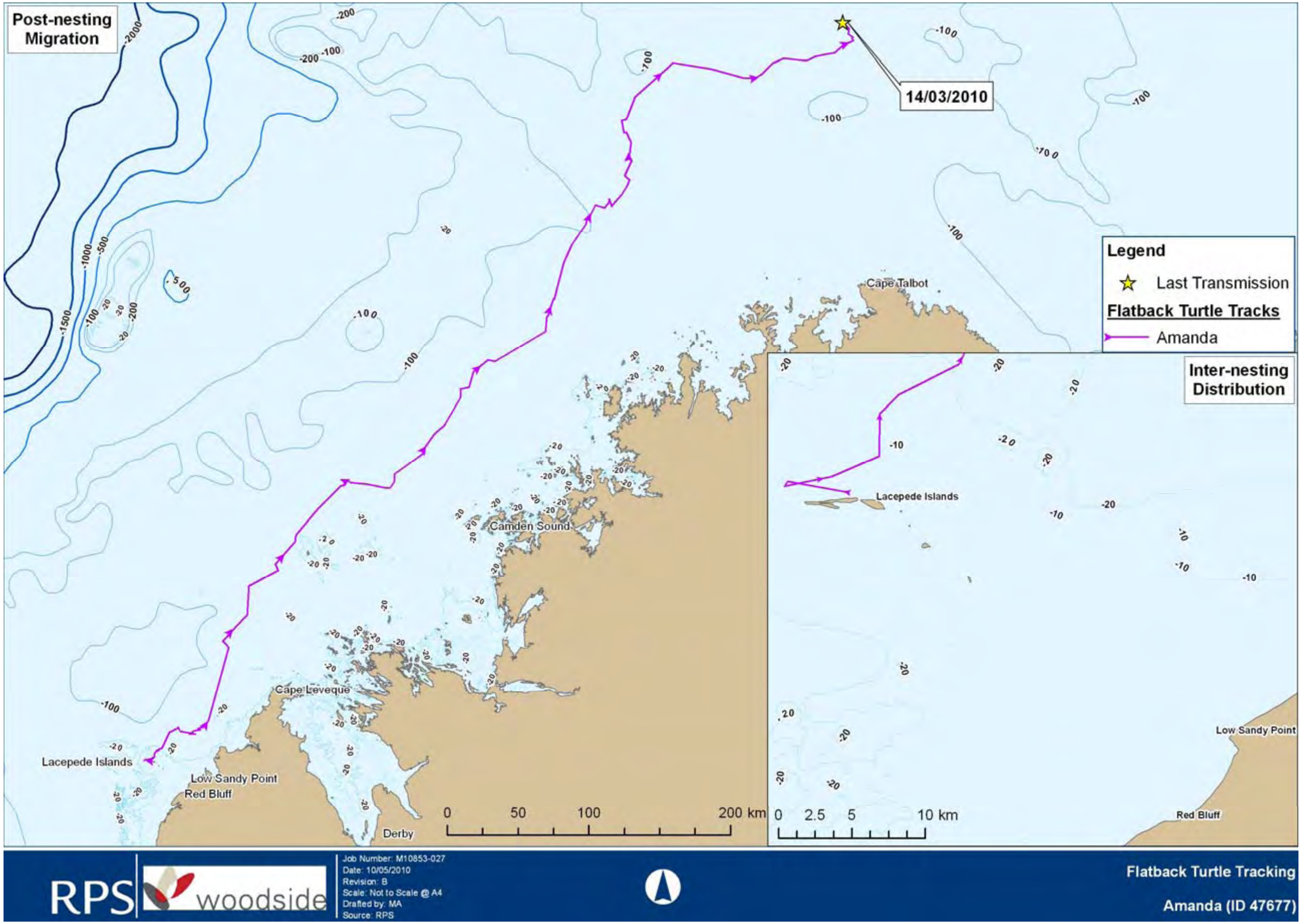
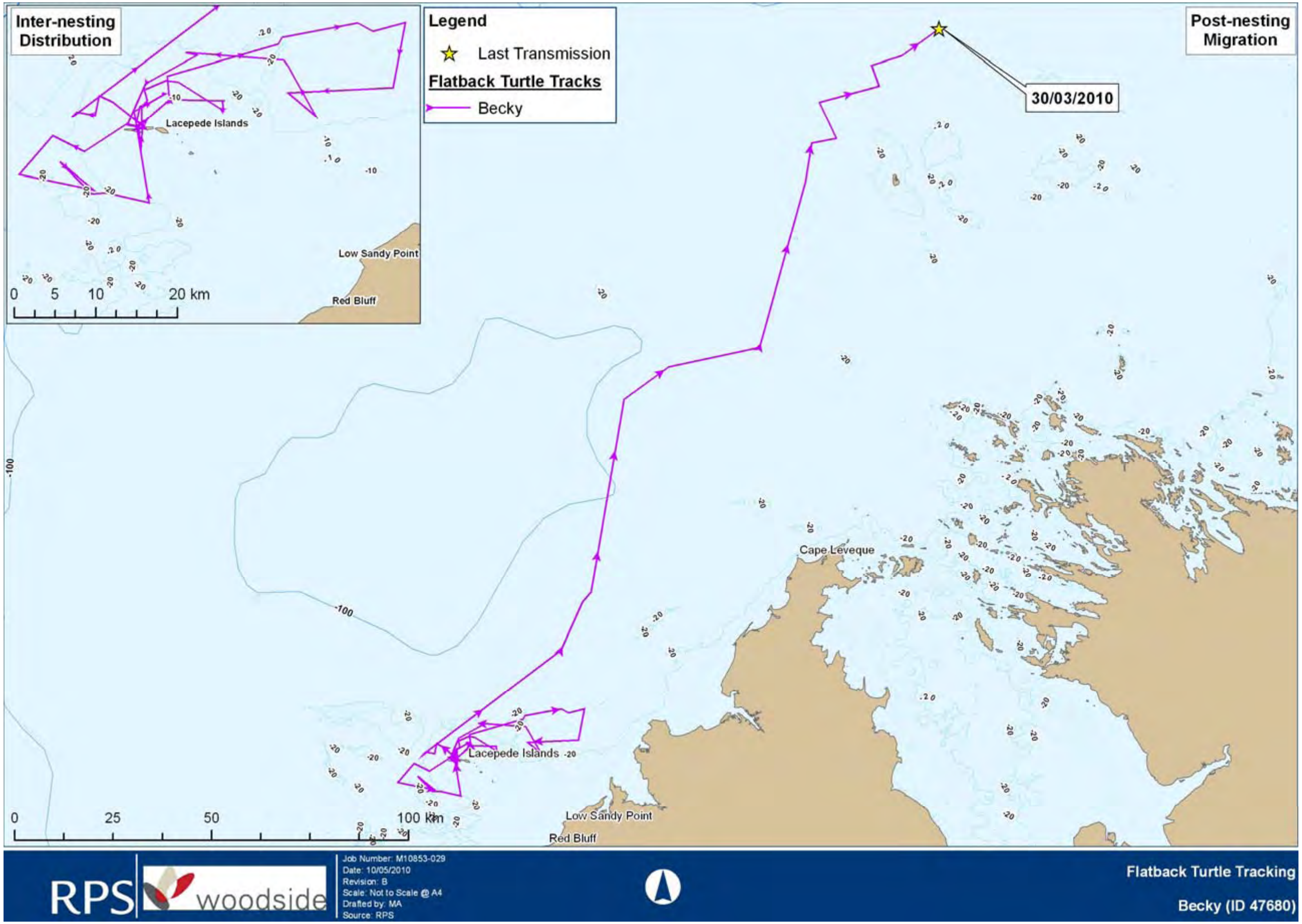
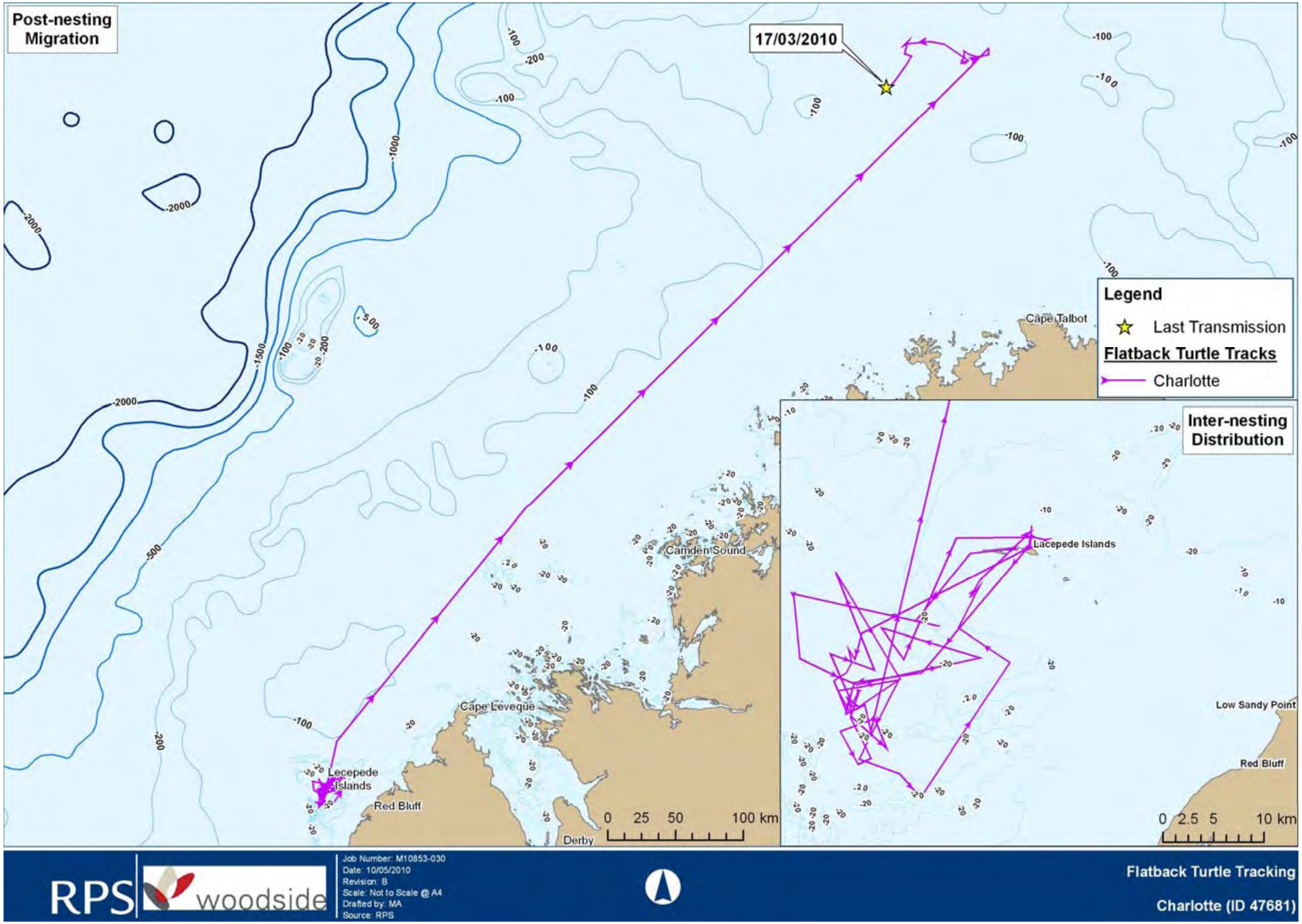
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Adie (ID 47689)


Post-nesting Migration
14/03/2010
Cape Talbot
Camden Sound
Cape Leveque
Lacepede Islands
Low Sandy Point
Red Bluff
Derby
0 50 100 200 km
Legend
Last Transmission
Flatback Turtle Tracks
Amanda
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 2.5 5 10 km
RPS woodside
Job Number: M10853-027
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Amanda (ID 47677)


Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 5 10 20 km
Legend
Last Transmission
Flatback Turtle Tracks
Becky
Post-nesting Migration
30/03/2010
Cape Leveque
Lacepede Islands
Low Sandy Point
Red Bluff
0 25 50 100 km
RPS woodside
Job Number: M10853-029
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Becky (ID 47680)


Post-nesting Migration
17/03/2010
Legend
Last Transmission
Flatback Turtle Tracks
Charlotte
Inter-nesting Distribution
Cape Talbot
Camden Sound
Cape Leveque
Lecepede Islands
Red Bluff
Derby
Lacepede Islands
Low Sandy Point
0 25 50 100 km
0 2.5 5 10 km
Job Number: M10853-030
Date: 10/05/2010
Revision: B
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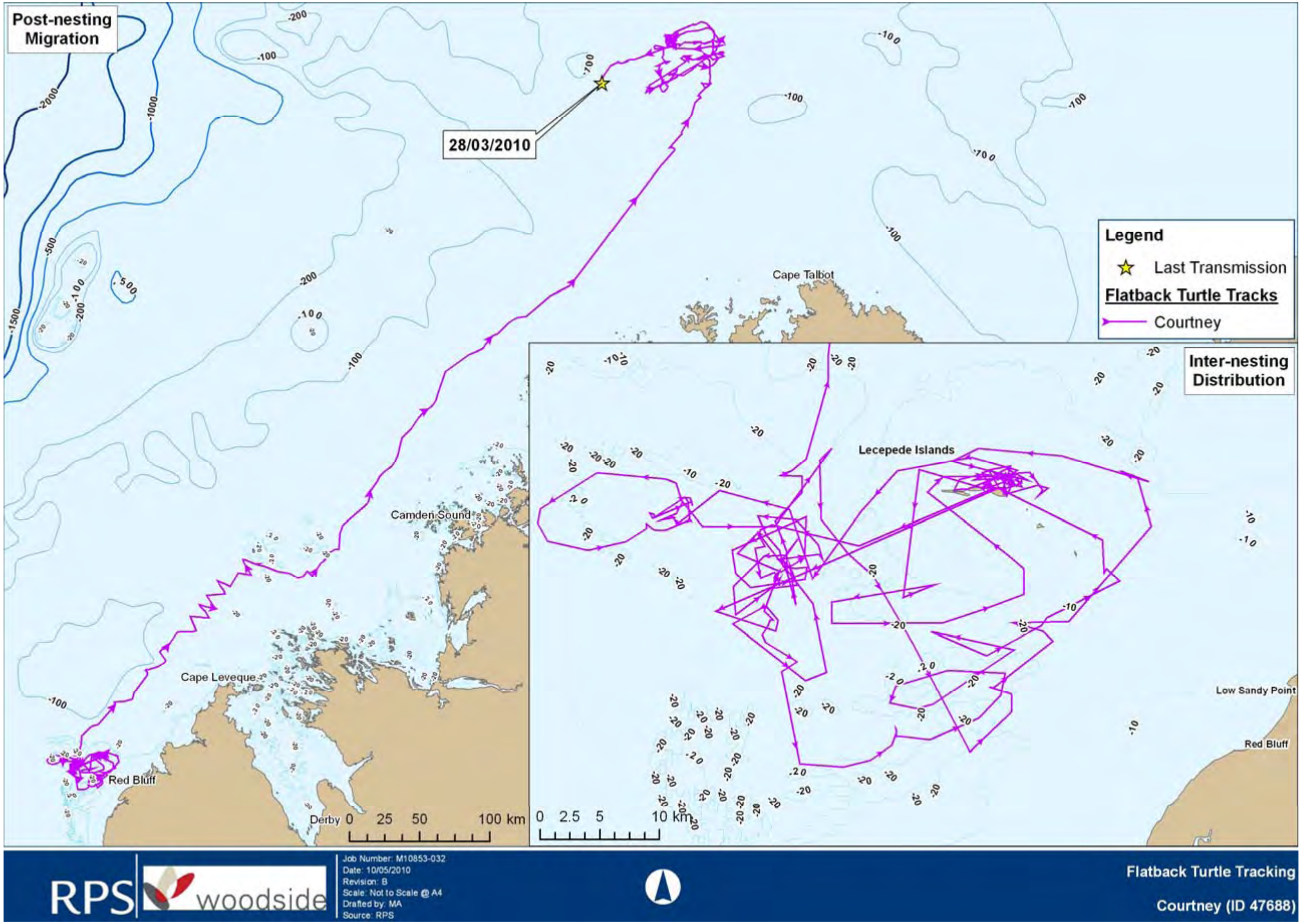
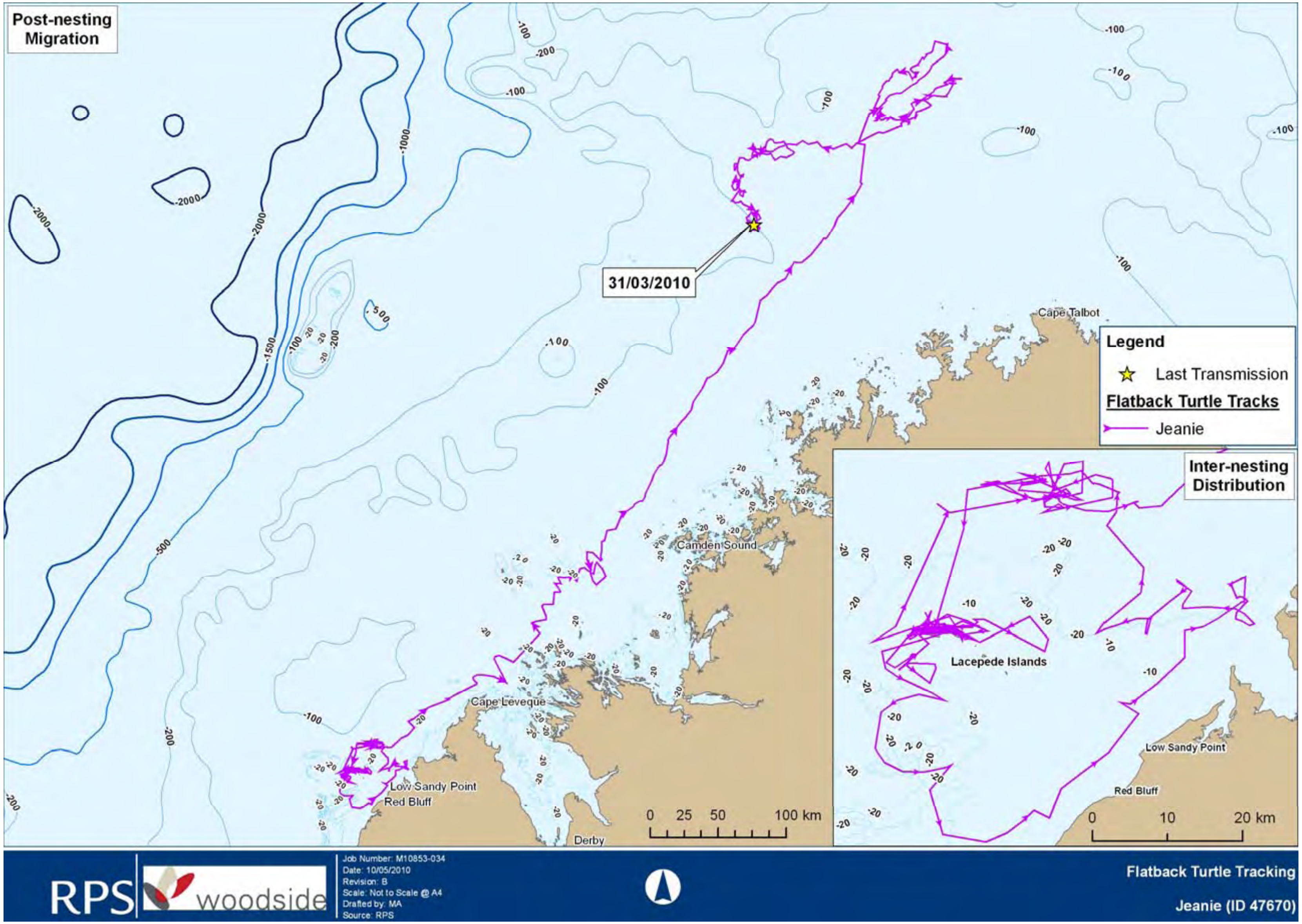
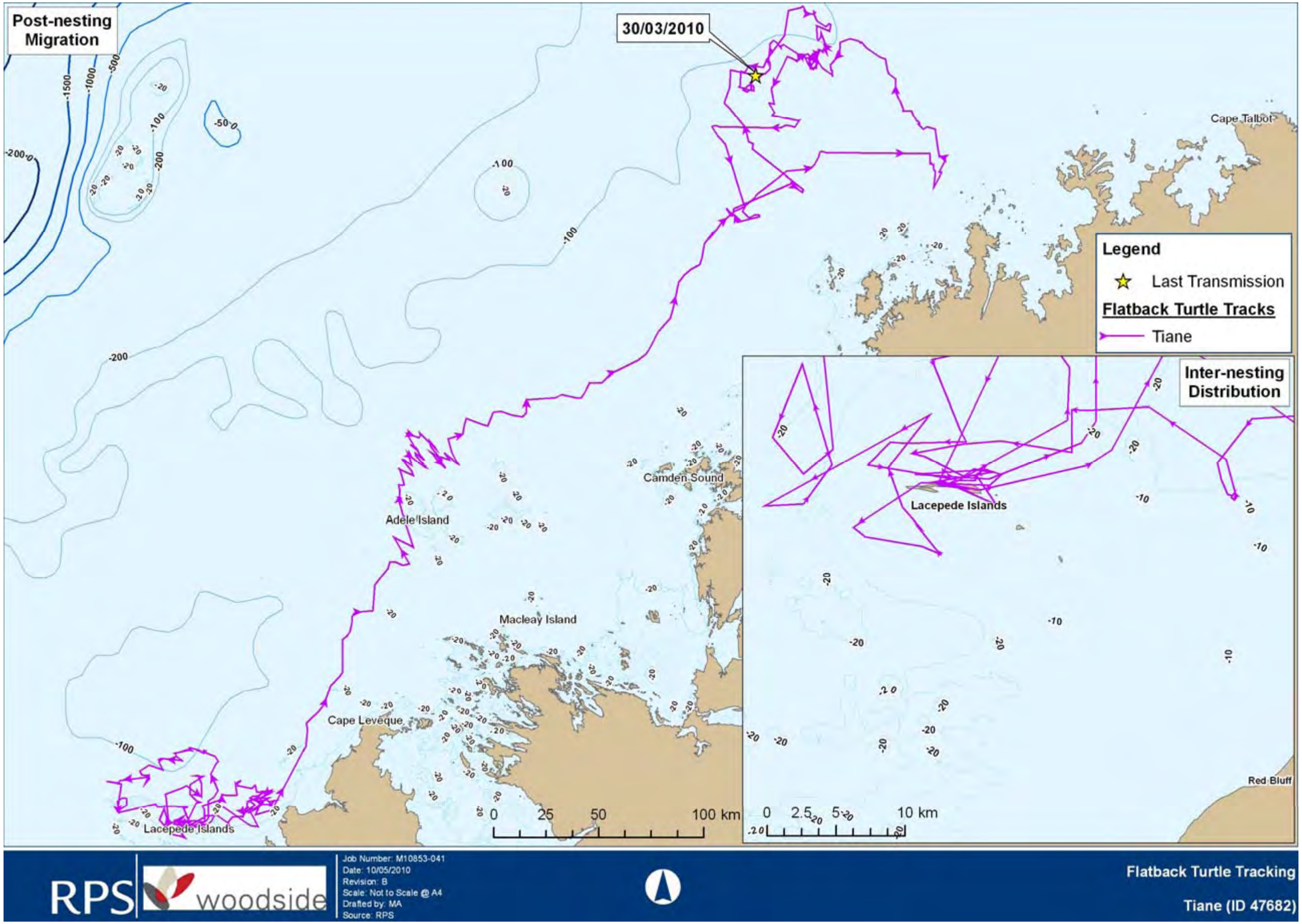
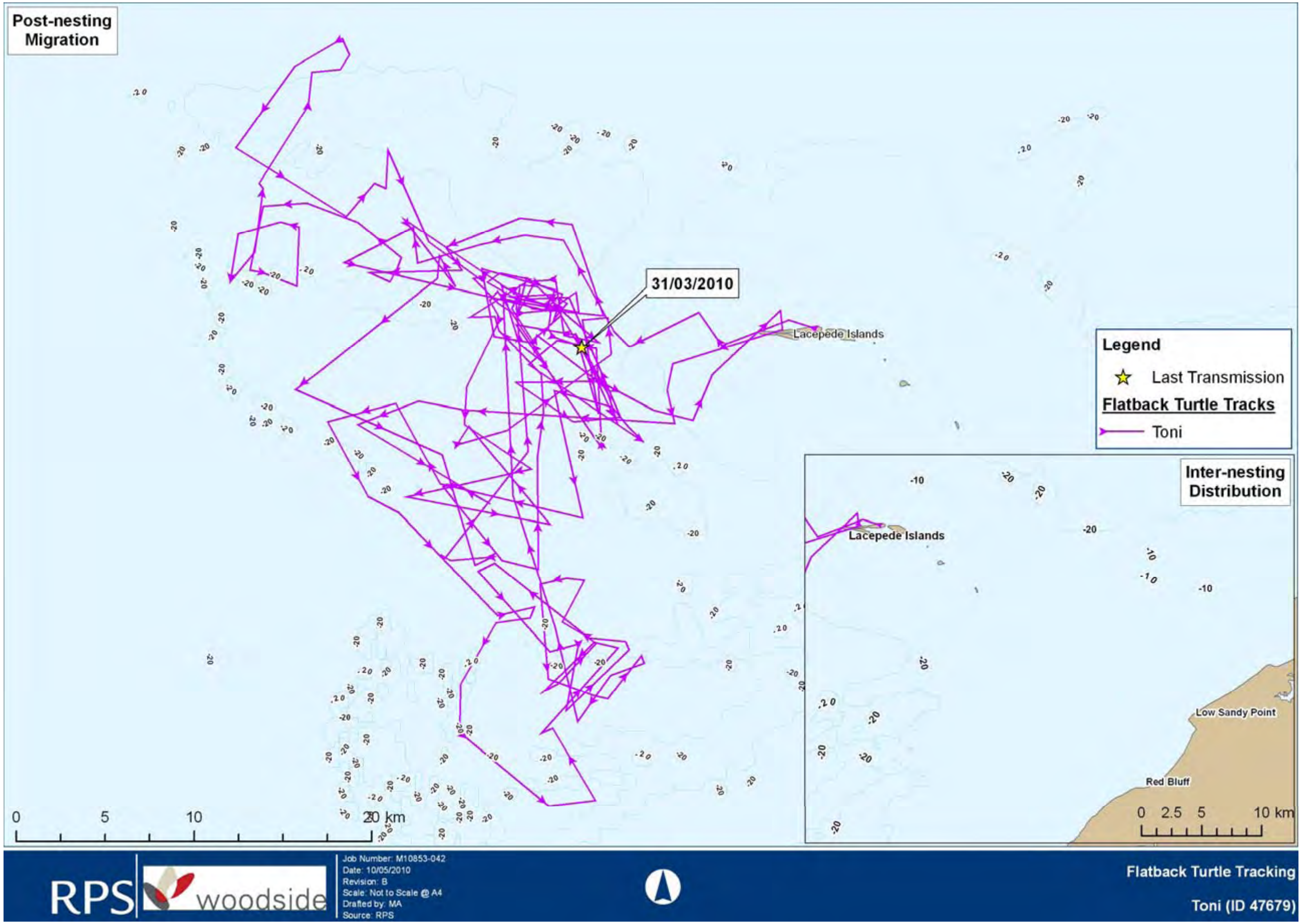
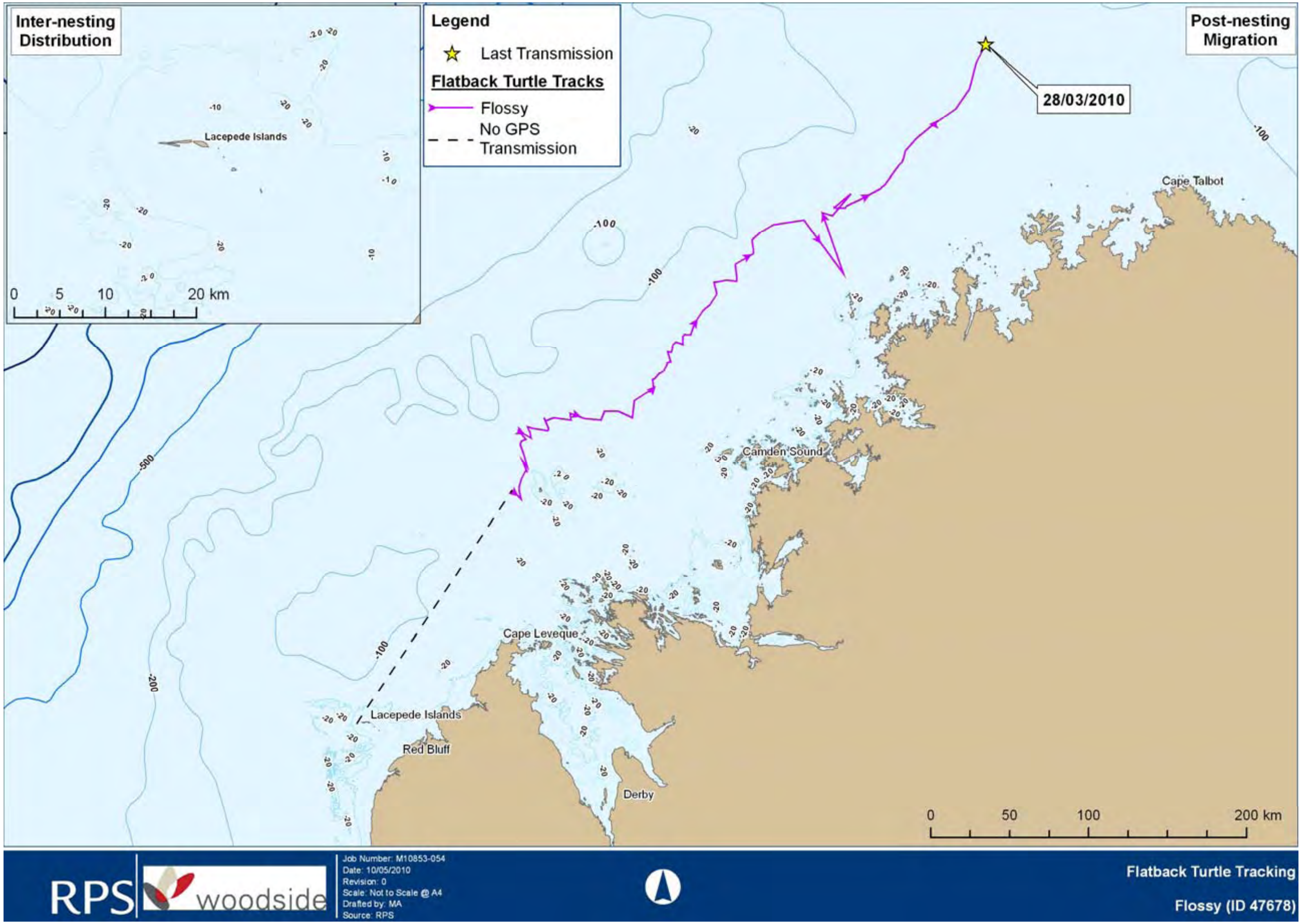
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Charlotte (ID 47681)


Post-nesting Migration
28/03/2010
Cape Talbot
Camden Sound
Cape Leveque
Red Bluff
Derby
0 25 50 100 km
Legend
Last Transmission
Flatback Turtle Tracks
Courtney
Inter-nesting Distribution
Lecepede Islands
Low Sandy Point
Red Bluff
0 2.5 5 10 km
RPS woodside
Job Number: M10853-032
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Courtney (ID 47688)


Post-nesting Migration
31/03/2010
Cape Talbot
Camden Sound
Cape Leveque
Low Sandy Point
Red Bluff
Derby
Legend
Last Transmission
Flatback Turtle Tracks
Jeanie
Inter-nesting Distribution
Lacepede Islands
0 25 50 100 km
0 10 20 km
Job Number: M10853-034
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Jeanie (ID 47670)


Post-nesting Migration
30/03/2010
Cape Talbot
Legend
Last Transmission
Flatback Turtle Tracks
Tiane
Inter-nesting Distribution
Camden Sound
Adele Island
Macleay Island
Cape Leveque
Lacepede Islands
Red Bluff
0 25 50 100 km
0 2.5 5 10 km
Job Number: M10853-041
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Tiane (ID 47682)


Post-nesting Migration
31/03/2010
Lacepede Islands
Legend
Last Transmission
Flatback Turtle Tracks
Toni
Inter-nesting Distribution
Lacepede Islands
Low Sandy Point
Red Bluff
0 2.5 5 10 km
0 5 10 20 km
Job Number: M10853-042
Date: 10/05/2010
Revision: B
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Toni (ID 47679)


Inter-nesting Distribution
Lacepede Islands
0 5 10 20 km
Legend
Last Transmission
Flatback Turtle Tracks
Flossy
No GPS Transmission
Post-nesting Migration
28/03/2010
Cape Talbot
Camden Sound
Cape Leveque
Lacepede Islands
Red Bluff
Derby
0 50 100 200 km
RPS woodside
Job Number: M10853-054
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Drafted by: MA
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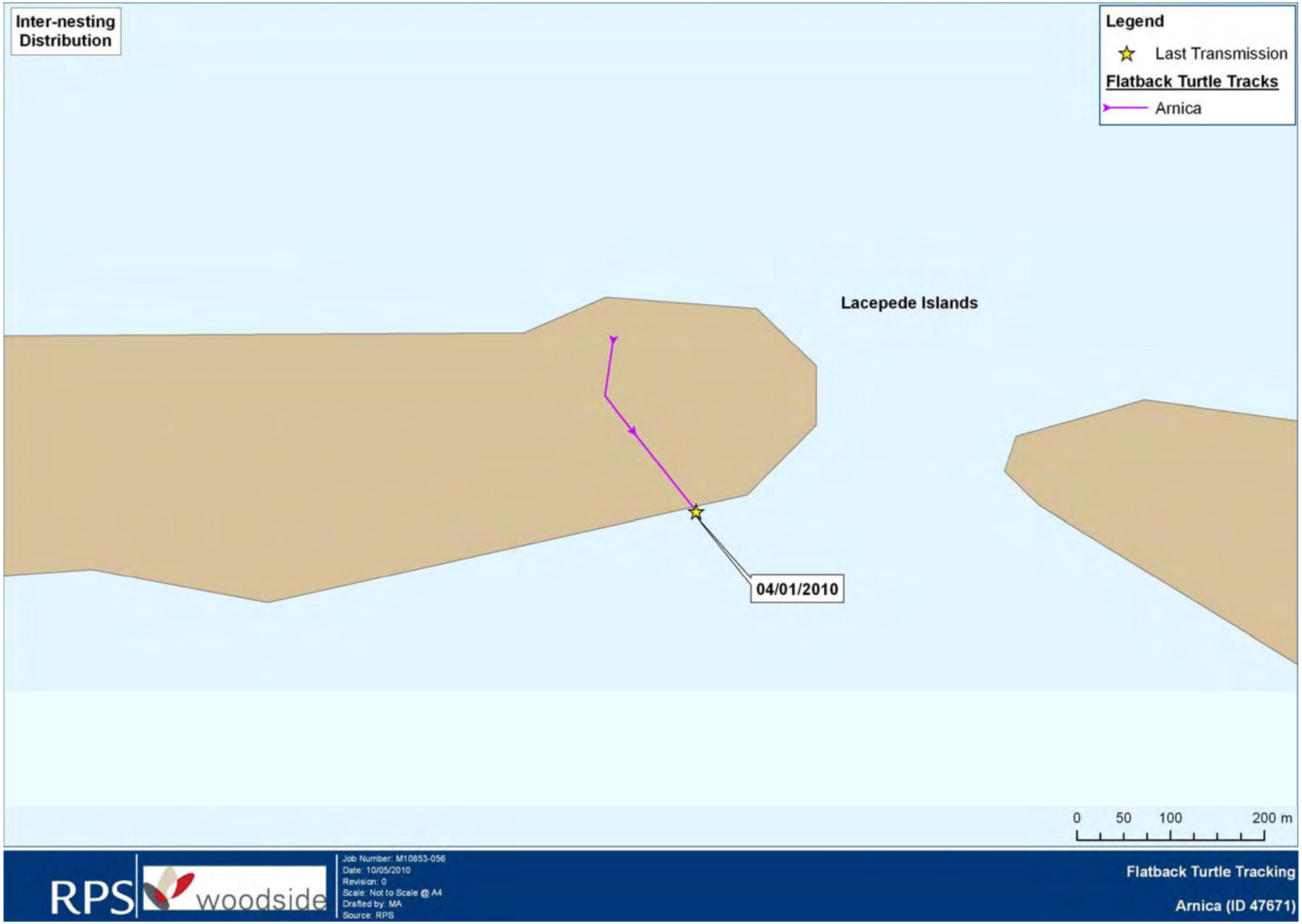
Flatback Turtle Tracking
Flossy (ID 47678)


Inter-nesting Distribution
Legend
Last Transmission
Flatback Turtle Tracks
Arnica
Lacepede Islands
04/01/2010
0
50
100
200 m
RPS
woodside
Job Number: M10853-056
Date: 10/05/2010
Revision: 0
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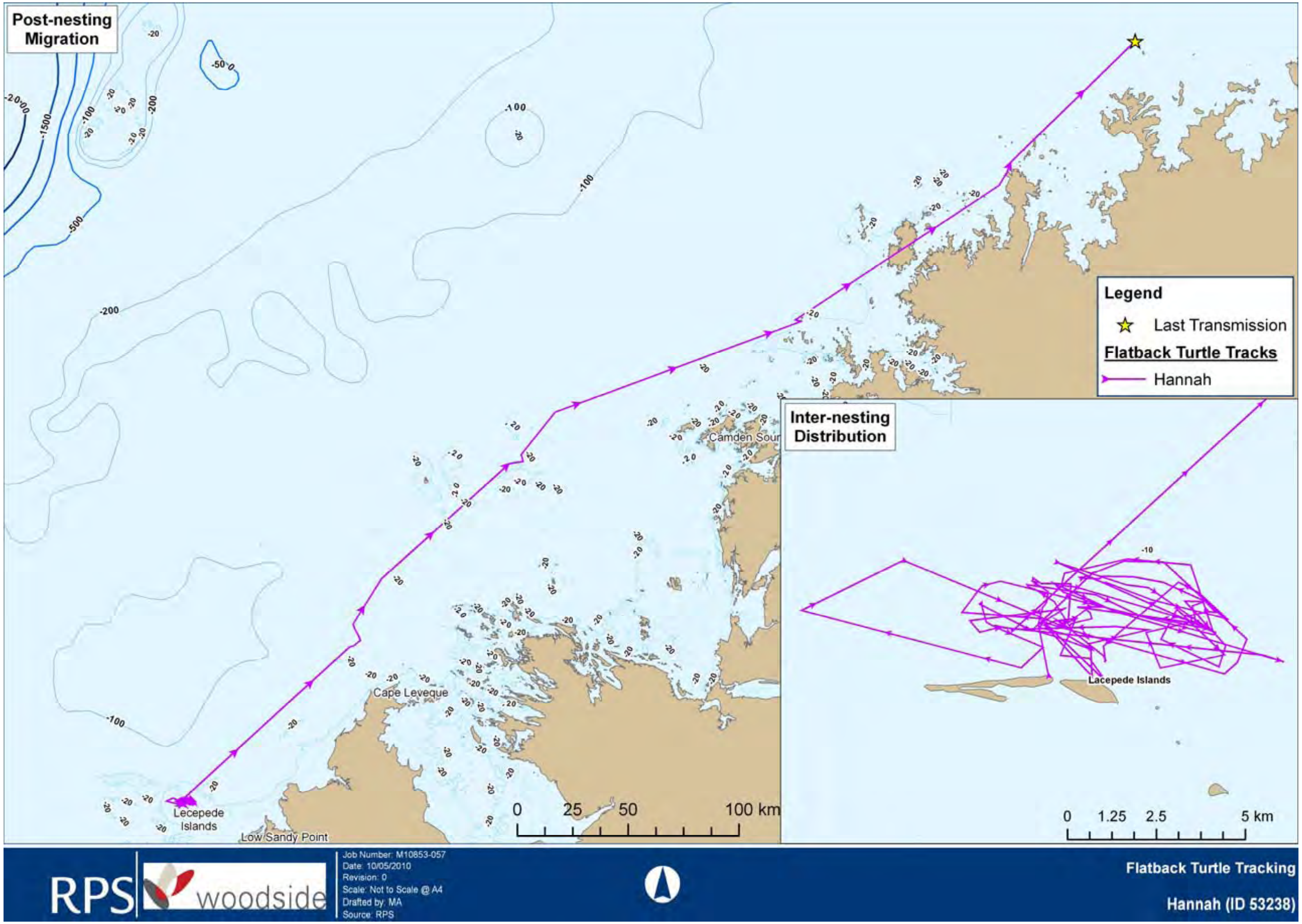
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Arnica (ID 47671)


Post-nesting Migration
Inter-nesting Distribution
Legend
Last Transmission
Flatback Turtle Tracks
Hannah
Camden Sound
Cape Leveque
Lecepede Islands
Low Sandy Point
Lacepede Islands
0 25 50 100 km
0 1.25 2.5 5 km
Job Number: M10853-057
Date: 10/05/2010
Revision: 0
Scale: Not to Scale @ A4
Drafted by: MA
Source: RPS
Flatback Turtle Tracking
Hannah (ID 53238)