BHP BILLITON IRON ORE

PROPOSED OUTER HARBOUR DEVELOPMENT

PORT HEDLAND

FLATBACK TURTLE TAGGING PROGRAM AT CEMETERY BEACH 2009/2010

Prepared by

Pendoley Environmental Pty Ltd

For

BHP Billiton Iron Ore

27 May 2010

Pendoley Environmental Pty Ltd

Marine Conservation Biology Consultants

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DOCUMENT CONTROL INFORMATION

TITLE: FLATBACK TURTLE TAGGING PROGRAM AT CEMETERY BEACH 2009/2010

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SUMMARY

BHP Billiton Iron Ore proposes to expand their iron ore operations in the Pilbara by developing a new port. The proposed Outer Harbour Development is located on the coast near Port Hedland in the Pilbara region of Western Australia. The proposed Outer Harbour Development will involve the construction of infrastructure (jetty and wharves) and dredging, to allow ship access to the infrastructure for loading of iron ore. Dredging and disposal activities in this region have been identified as a potential risk to marine turtles. Desktop and field studies have identified flatback turtles nesting on Cemetery Beach, located approximately 6 km to the east of the proposed development, as the most at risk from these dredging and disposal activities. This is considered to be a moderate sized flatback rookery in the North West Shelf genetic management unit (Dutton *et al.*2002) based on historical track count data.

A Draft Marine Turtle Management Plan has been prepared for the proposed Outer Harbour Development which outlines management strategies and monitoring programs that will be adopted to mitigate potential impacts associated with the construction phase of the development. One of the monitoring programs outlined in the Draft Marine Turtle Management Plan is to conduct flipper and Passive Integrated Transponder (PIT) tagging at Cemetery Beach. The objectives of this program were to:

- Provide sufficient data to accurately determine the size of the nesting population of the Cemetery Beach flatback turtle rookery.
- Provide data on individual reproductive behaviour, nesting population size, demographics, survivorship and recruitment.
- Identify and monitor trends and identify potential impacts of the OHD to the nesting population.
- Provide an understanding of the interaction between the different turtle rookeries within the Northwest Shelf genetic management unit (Dutton *et al.* 2002).

The monitoring was conducted over two survey periods; 27 November to 18 December 2009 and 30 December 2009 to 21 January 2010 inclusive. Beach patrols were conducted for 2 to 3 hours on either side of the evening high tide. Nesting turtles encountered were tagged with titanium flipper tags and a PIT tag in accordance with Pendoley Environmental's Marine Turtle Tagging Standard Operating Procedure (Pendoley Environmental 2009). Other data such as the location of the sighting, adult size and clutch size were also recorded.

A total of 188 flatback turtles were tagged over both survey periods. Of these individuals, 182 were 'new' animals and 6 were 'remigrants'. The remigrants included:

- a satellite tagged turtle, which was from the same beach in the previous season,
- a turtle originally tagged at Mundabullangana and
- four other turtles whose tags had been lost.

The number of turtles sighted each night varied from 0 to 48, with a mean of 11.8 ± 1.5 turtles sighted per night. The entire beach was patrolled and sightings were concentrated along the eastern half of the beach. The mean internesting interval, determined by the number of days between observing a turtle laying a clutch and the next sighting, was 12.8 ± 0.3 days, and turtles returned 1 - 5

days following an unsuccessful attempt to nest. Adult females had a mean curved carapace length (CCL) of 88.6 ± 0.2 cm and mean curved carapace width (CCW) of 75.0 ± 0.3 cm. Females laid, on average 45.1 ± 3.9 eggs per clutch.

The tagging program also revealed there was interchange between flatback rookeries (Cemetery Beach and Mundabullangana, located west of Port Hedland) within and between nesting seasons, which has important implications for the management of the regional nesting populations. The peak nesting season for flatback turtles at Cemetery Beach appears to occur earlier (November/December) than more southern populations, such as Barrow Island (December/January). It is therefore recommended that the monitoring program should commence earlier, in November and December. It is also recommended that a nest success program, be incorporated into future nesting season monitoring programs, as it provides an indication of the reproductive output of a population.

The first year of the tagging program has provided an initial estimate of the size of the Cemetery Beach population, allowing it to be compared to other populations in the Pilbara and putting it into a regional context. Tagging programs are intended to be long-term programs which monitor and identify impacts to the population from proposed activities. Given this is the first year of the program, it has provided crucial baseline information on the Cemetery Beach population and continuation of this program will provide any evidence of changes to the population from the proposed Outer Harbour Development activities, such as dredging.

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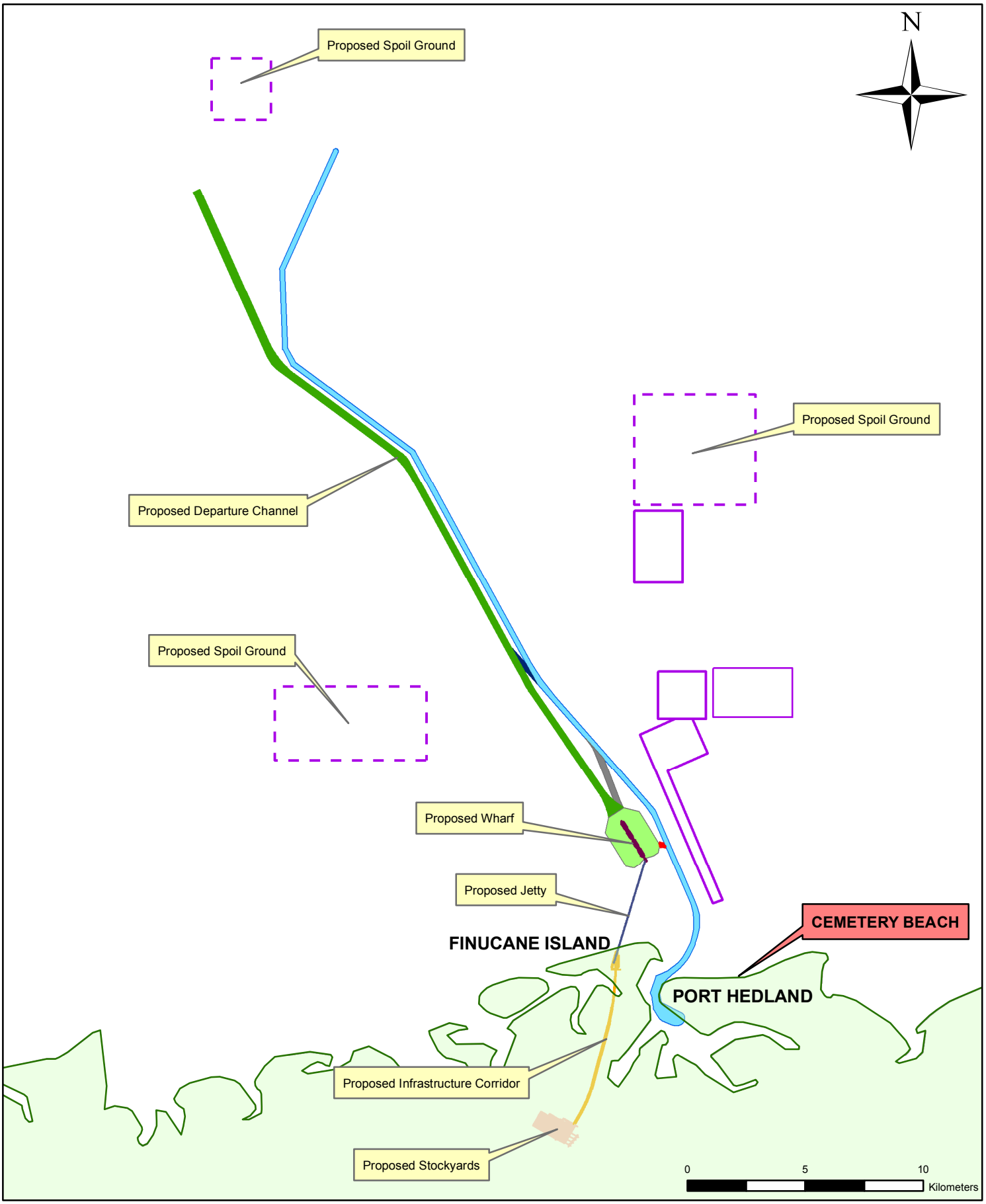
1.1 Nature and Background to the Project

BHP Billiton Iron Ore currently exports iron ore from port facilities in Port Hedland, Western Australia. The current port operations consist of processing, stockpiling and shiploading facilities at Nelson Point and Finucane Island (referred to as the Inner Harbour), located on opposite sides of the Port Hedland Harbour. The port currently receives iron ore from the following BHP Billiton Iron Ore operations located in the Pilbara region of Western Australia – Mt Whaleback, Orebody 29, Yandi, Jimblebar, satellite ore bodies 18, 23/25, Area C and Yarrie/Nimingarra. Two dedicated heavy haulage rail systems, one from the Newman, Area C and Yandi mines and the other from Yarrie/Nimingarra, deliver the ore to the port operations. The operations currently have an approved capacity of 155 million tonnes per annum (Mtpa) within the Port Hedland Inner Harbour. The proposed Outer Harbour Development includes a new port facility linked to Finucane Island to provide an ultimate export capacity of 240 Mtpa (**Figure 1**).

Cemetery Beach is located approximately 6 km to the east of the proposed Outer Harbour Development (**Figure 1**) and is considered a moderate density flatback turtle nesting beach. The flatback turtle (as well as all species of marine turtles) is protected by the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* (Commonwealth), and is also afforded protection under the *Wildlife Conservation Act 1950-1979* (Western Australia).

The flatback turtle, *Natator depressus* is endemic to the Continental Shelf waters of northern Australia extending from the Pilbara region of Western Australia, northwards to around the Northern Territory and into Queensland waters (Limpus *et al.* 1988; Limpus 2009). Four genetic units/stocks are currently recognised; North West (NW) Shelf, Northern Territory, Gulf of Carpentaria and eastern Australia (see **Figure 2**; Dutton *et al*. 2002). Long-term studies on the breeding biology of flatback turtles have largely been confined to the eastern Australia genetic stock (Limpus *et al.* 1981, 1983, 1984; Parmenter and Limpus 1995) and recently the Cape Domett population, considered to be part of the Northern Territory stock (Whiting *et al.* 2008). Some results from tagging programs at Barrow Island and Mundabullangana in north-west Australia as part of the Gorgon Gas Development have recently been made available (Chevron Australia 2009).

Given the lack of published data on flatback turtles from the Northwest Shelf genetic management unit (Dutton *et al.* 2002) and the importance of such data sets for local and regional management of the flatback turtle population, particularly within the Pilbara region that is subject to large scale resource industry development, tagging studies are considered critical to the provision of this information.



Project	J22008 Outer Harbour Development Port Hedland Tagging Program
Title	Figure 1: Project Area and Proposed Outer Harbour Development Infrastructure
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Scale	As shown
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Legend

- Spoil Ground (Existing)
- Spoil Ground (Proposed)
- Proposed Departure Channel
- Proposed Berth Pockets and Swing Basins
- Proposed Link Channel
- Proposed Crossover Channel
- Existing Shipping Channel
- Tug access channel
- Proposed Jetty
- Proposed Wharf
- Proposed Infrastructure Corridor
- Proposed Stockyards

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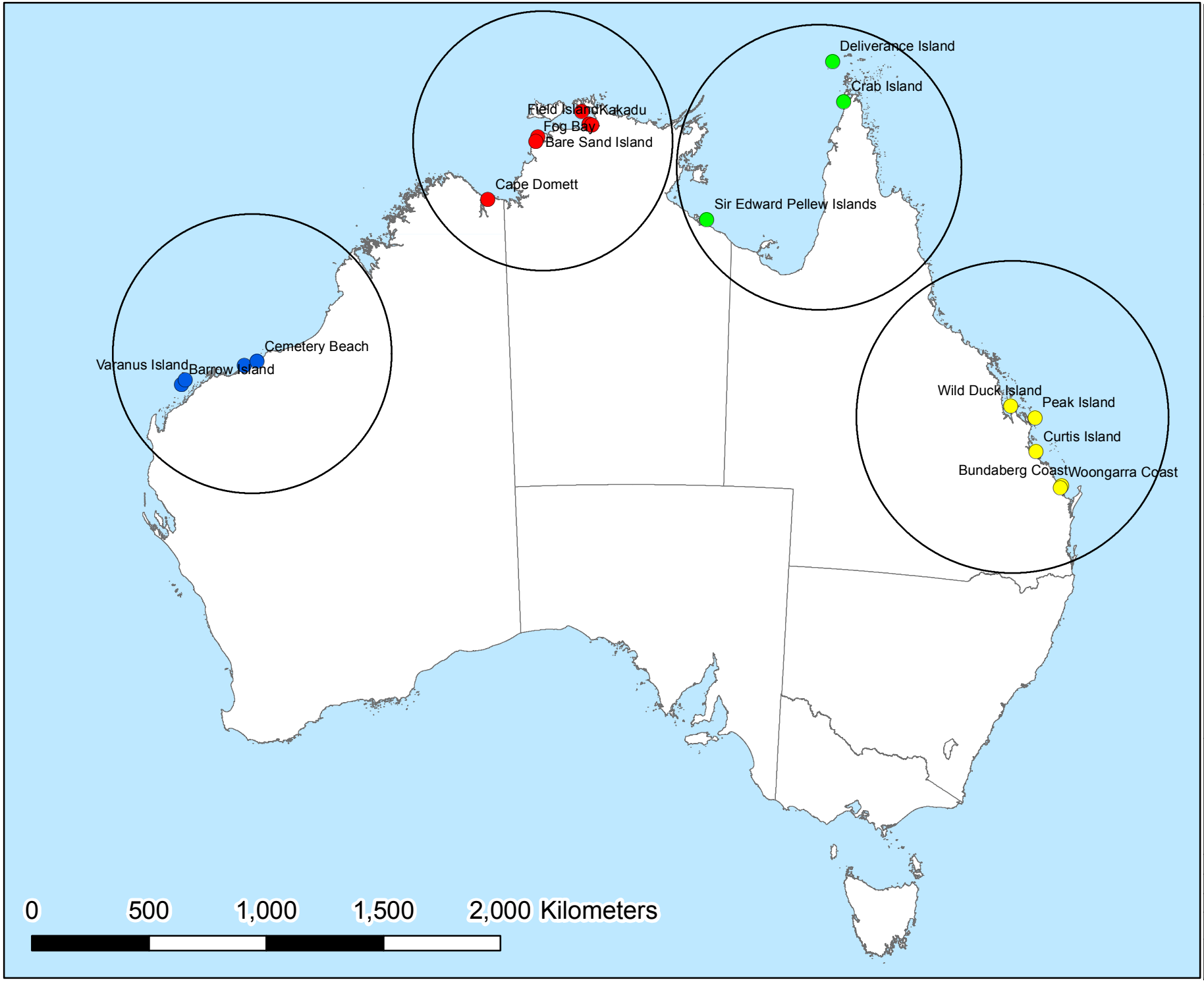

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Figure 2: Flatback genetc management units and rookeries in Australia (only those rookeries discussed in this report are shown on this map)

Legend
- Gulf of Carpentaria
- western Northern Territory
- Northwest Shelf
- eastern Australia

Notes:

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1.2 Scope of Work and Objectives

A Draft Marine Turtle Management Plan (BHP Billiton Iron Ore 2009) has been prepared for the proposed Outer Harbour Development which outlines management strategies and monitoring programs that will be adopted to mitigate potential impacts associated with the construction phase of the development.

One of the monitoring programs outlined in the Draft Marine Turtle Management Plan is to conduct flipper and Passive Integrated Transponder (PIT) tagging at Cemetery Beach, which is addressed by the scope of this study. This program will provide the basic biological data needed to determine the size of the nesting population and will provide solid evidence of any trends in turtle nesting over time and whether or not the turtle population is being impacted. The objectives of the tagging monitoring program are to:

- Provide sufficient data to accurately determine the size of the nesting population of the Cemetery Beach flatback turtle rookery.
- Provide data on individual reproductive behaviour, nesting population size, demographics, survivorship and recruitment.
- Identify and monitor trends and identify potential impacts of the OHD to the nesting population.
- Provide an understanding of the interaction between the different turtle rookeries within the Northwest Shelf genetic management unit (Dutton *et al.* 2002).

2 METHODOLOGY

2.1 Location and Site Description

Cemetery Beach is a 1 km long sandy beach situated along the northern coastal boundary of the town of Port Hedland in Western Australia (**Plate 1**). The location of the nesting beach is -20.30761°, 118.60685° and -20.30571°, 118.61581° and is approximately 6 km to the east of the proposed Outer Harbour Development (**Figure 1**). The north facing beach is known to host a flatback turtle rookery.

Plate 1: Cemetery Beach, flatback turtle nesting beach.

2.2 Tagging Program Method

The tagging program was conducted at Cemetery Beach during the peak nesting season for flatback turtles in December 2009 and January 2010. The monitoring was conducted over two survey periods: 27 November to 18 December 2009 and 30 December 2009 to 21 January 2010, inclusive.

Beach patrols were conducted for 2 to 3 hours on either side of the evening high tide. Nesting turtles encountered were tagged with titanium flipper tags (Stockbrands, Perth, Western Australia) through the axial scale of the front left flipper and implanted with a Passive Integrated Transponder (PIT) tag (Stockbrands, Perth, Western Australia) in the left shoulder. PIT tags were used to overcome problems caused by high rates of flipper tag loss that is experienced in flatback turtles (Limpus 1992; Parmenter 1993; Balazs 1999). Turtles were systematically examined for flipper tag loss scars. Turtles were tagged after they had completed nesting or were returning to the water, in accordance with Pendoley Environmental's Marine Turtle Tagging Standard Operating Procedure (Pendoley Environmental 2009).

Plate 2: Titanium flipper tag inserted in the front left flipper of a flatback turtle.

2.2.1 Nesting Abundance and Distribution

The number of turtles encountered each night of the survey was recorded and a mean was calculated. The number of down tracks only (tracks left by a turtle when they leave the beach) was also counted at the beginning and end of each shift on the beach so the number of turtles missed could be determined. The distribution of nests laid on the beach was recorded using a GPS and mapped using ArcGis software.

2.2.2 Remigration and Internesting Intervals

The remigration interval is the number of years between successive breeding seasons for individual females (Schauble *et al.* 2006). Remigration intervals could not be calculated as this was the first year that tagging had been conducted at Cemetery Beach.

The internesting interval is the number of days from completion of laying a clutch of eggs to the next sighting of the turtle on the beach, irrespective of whether nesting was successful (Whiting *et al.* 2008). The internesting period is the number of days between two successful nesting attempts. A successful nest is recorded only if the tagger observes the turtle laying its clutch of eggs. Individual turtles may have multiple internesting periods in a nesting season. Since turtles are physiologically unable to produce fertile eggs in less than 6 days (Miller 1997), 7 days was the minimum number of days to qualify as an internesting interval. Based on the distribution of internesting intervals recorded over the entire season, 22 days or longer represented a secondary nesting event and was used as the maximum range for calculating internesting intervals.

2.2.3 Adult Morphology and Clutch Size

The midline curved carapace lengths (CCL) and curved carapace widths (CCW) of all turtles encountered were measured using a flexible tape, as outlined in Pendoley Environmental's Marine Turtle Tagging Standard Operating Procedure (Pendoley Environmental 2009). The mean CCL and CCW measurements were calculated and used in the analyses.

Clutch sizes were opportunistically recorded when a turtle was observed from the beginning to the end of the egg laying process.

2.3 Data Analysis

All tagging data are maintained in the Western Australian Department of Environment and Conservation 'Database for WA Marine Turtle Conservation' V1.1.12.

Statistical analyses were undertaken using XLStat 2010. All data were tested for Normality using the Jarque-Bera and Shapiro-Wilk tests. If the data conformed to a Normal distribution then an Analysis of Variance (ANOVA) was performed. If the data did not conform to a Normal distribution a Kruskal-Wallis non-parametric test was performed. Data are presented as mean ± standard error (*n*, range).

3 RESULTS

3.1 Nesting Abundance and Distribution

A total of 188 individual flatback turtles were recorded at Cemetery Beach during the two tagging periods. Of these, 182 were 'new' turtles and 6 were considered 'remigrant' turtles (**Table 1**). One of the remigrant turtles was identified as a remigrant to Cemetery Beach as it still carried a satellite tag that was applied the previous year (2008/2009) at Cemetery Beach. Another remigrant turtle had a previous flipper tag indicating it was originally tagged at the Mundabullangana rookery. It is unknown if this was the first time it had nested at Cemetery Beach. Four remigrant turtles were identified based on the presence of tag scars (scars indicating flipper tags were once attached). The original rookery that these turtles were tagged at is unknown. Potential nesting sites include Mundabullangana or Bells Beach at Cape Lambert, as these are the closest nesting sites with recently active flipper tagging programs (refer to **Figure 6**).

Table 1: Number of new and remigrant turtles recorded at Cemetery Beach in 2009/10.

Turtles		Number of turtles	%
New Turtles	No tags or tag scars	182	96.8
Remigrant Turtles	Tag scars, from which population unknown	4	2.1
	Previous tag, from Mundabullangana population	1	0.5
	Satellite tag, from Cemetery Beach	1	0.5
	Total remigrants	6	3.1
Total		**188**	**100**

The total track count for the period indicated a maximum of 671 records, which included estimates all direct observations of turtles (531) and missed turtles (140). The number of turtles sighted each night varied from 0 to 48 turtles, with a mean of 11.8 ± 1.5 turtles per night (**Figure 3**). The number of turtles recorded during the second monitoring period (January 2010) was less than that recorded during the first monitoring period (December 2009). During the last week of monitoring, only one turtle was recorded on each of the nights, with no turtles on the last night.

Sightings of turtles were recorded over the entire length of the beach, however, nesting activity was concentrated more in the eastern half of the beach. The majority of successful nests were observed on the eastern half of the beach (**Figure 4**).

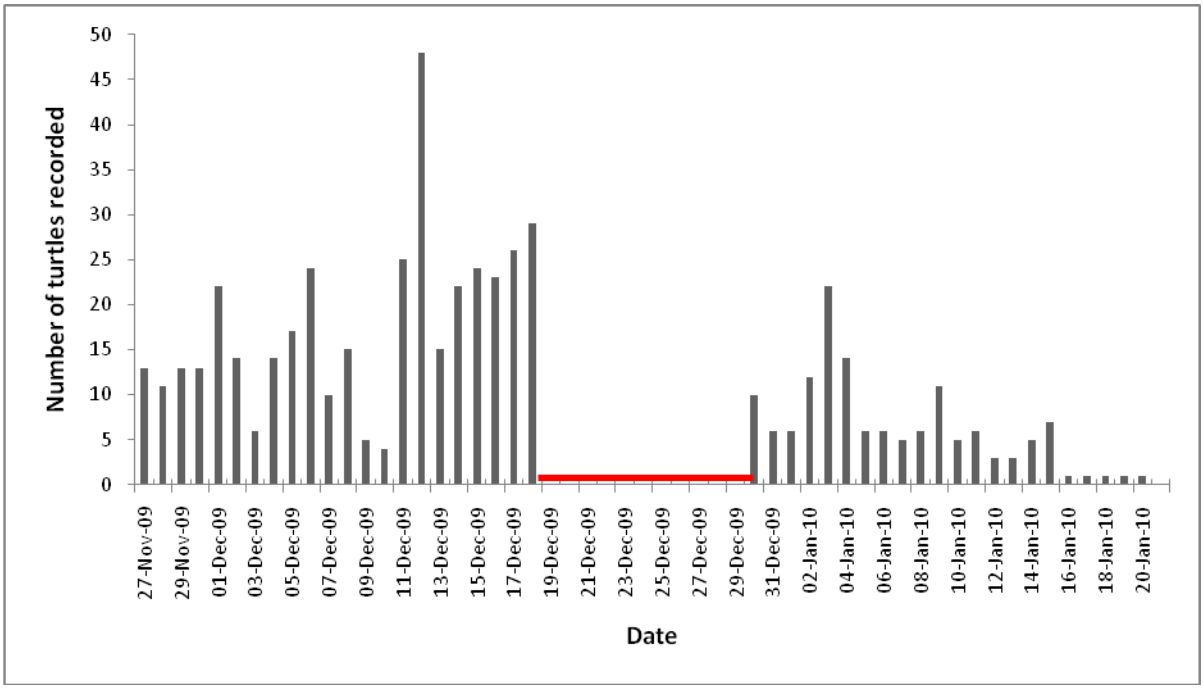

Figure 3: Number of turtles recorded on each night during the monitoring period.
The red line indicates when the beach was not monitored by Pendoley Environmental.

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Figure 4: Distribution of turtle records at Cemetery Beach

Legend

Recorded Observations

- Unsuccessful nesting attempt
- Successful Nest
- Unknown whether nested successfully

Scale:

0 25 50 100 Meters

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3.2 Fidelity to Nesting Sites

During the tagging monitoring program, five turtles were recorded nesting in the current season at both Cemetery Beach and Mundabullangana, where a concurrent flipper tagging program was underway. Mundabullangana is a significant mainland rookery approximately 50 km west of Cemetery Beach and approximately 45 km from the proposed Outer Harbour Development. **Table 2** shows the recorded observations for these turtles. One of these turtles (WA48007) was originally tagged at Mundabullangana in 2002. This turtle was then recorded on three occasions at Cemetery Beach (30 November 2009 and twice on 12 December 2009). A satellite tag was attached to this turtle on 12 December 2009 as part of BHP Billiton Iron Ore's satellite tracking marine turtle research program at Cemetery Beach. The satellite data showed that the turtle returned to Mundabullangana to nest during the current season.

Table 2: Turtles recorded nesting at Cemetery Beach and Mundabullangana beaches within the nesting season.

Turtle ID	Observation 1		Observation 2		Observation 3		Observation 4	
	Location	Date	Location	Date	Location	Date	Location	Date
WA48007	Cemetery Beach	30/11/09	Cemetery Beach	12/12/09	Munda	27/12/09		
WA80480	Munda	30/11/09	Cemetery Beach	13/12/09	Cemetery Beach	14/12/09	Cemetery Beach	15/12/09
WA80434	Cemetery Beach	03/01/10	Cemetery Beach	05/01/10	Munda	22/01/10		
WA80458	Cemetery Beach	12/01/10	Munda	25/01/10				
WA80243	Cemetery Beach	01/12/09	Munda	11/12/09				

One turtle was observed with a satellite tag (Cecilia, #89759) that had been applied in 2008/09 at Cemetery Beach in the first year of a satellite tracking program. This turtle provides evidence of fidelity to a nesting site and an annual nesting migration. The evidence of an annual migration is important to consider, as a short remigration interval means that the whole nesting population is will be exposed to the potential impacts of the proposed development during the construction phase.

3.3 Internesting Interval

The mean internesting interval, the time between observing a successful nest to next time the turtle is sighted regardless of whether it nests successfully or not, for flatback turtles at Cemetery Beach was 12.8 ± 0.3 days (n = 125, range = 7-22; **Figure 5**). The mean internesting period, which is the time between two successful nests, was half a day longer, with a mean of 13.3 ± 0.8 days (n = 15, range = 11-24). A maximum of four clutches were laid within the season by two turtles.

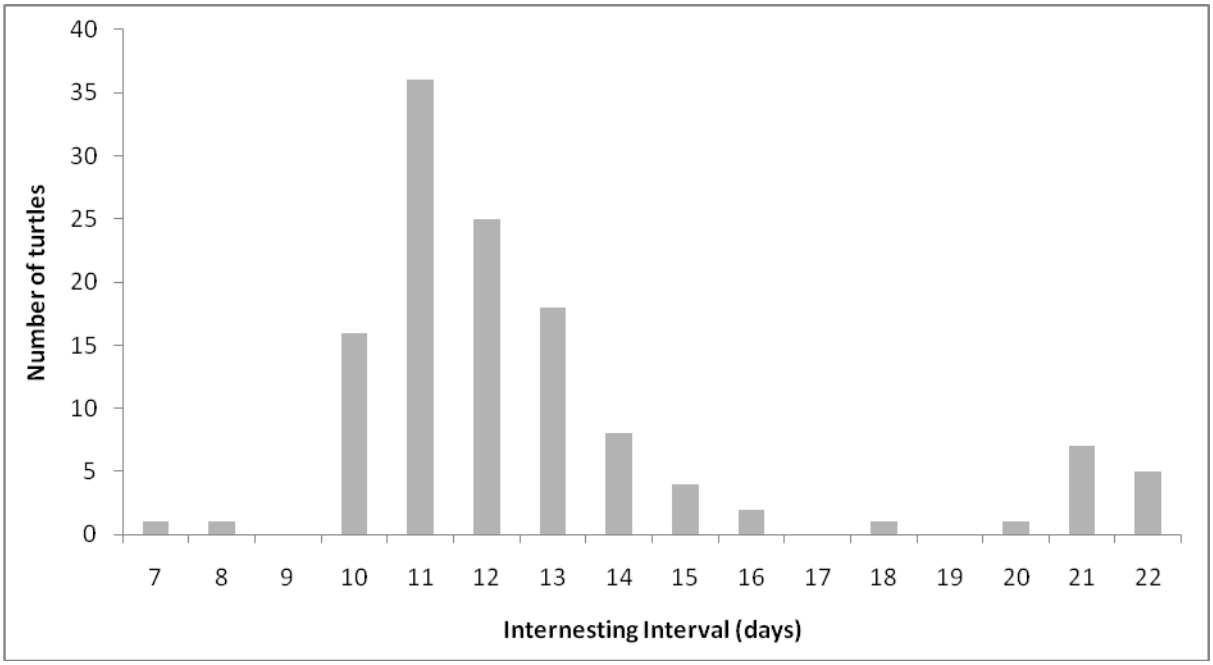

Figure 5: Internesting intervals (days) for flatback turtles at Cemetery Beach in 2009/10.

3.4 Nesting Success

Of the 531 nesting observations a total of 175 successful nests were observed, 213 were confirmed as nesting attempts (no successful nest) and 143 were of unknown success. This resulted in a nesting success rate of approximately 45% and a ratio of 2.27 tracks per clutch laid. This ratio is useful when only using track counts to estimate nesting effort, as not every track is a successful nest; approximately two tracks equates to one successful nest. For the recorded returns following an unsuccessful nesting attempt, the female returned 1 – 5 days later and a mean of 1.3 ± 0.1 days (*n* = 111).

Turtles were observed on many occasions digging egg chambers that continuously collapsed. Turtles would often make up to three attempts to dig an egg chamber before returning to the water without successfully having deposited a clutch. This was also observed at other beaches that were also monitored during the 2009/10 season (J. Oates, pers. obs).

3.5 Adult Size

Flatback turtles at Cemetery Beach had a mean CCL of 88.6 ± 0.2 cm (*n* = 163, range = 81.5-95.0) and mean CCW of 75.0 ± 0.3 cm (*n* = 98, range = 68.0-89.5).

3.6 Clutch Size

The clutch sizes recorded varied considerably among turtles (range = 8-57; *n*- = 15), with an overall mean clutch size of 45.1 ± 3.9 eggs.

3.7 Health of Turtles

Most turtles appeared in good health and few turtles had substantial (but healed) damage to their carapace (1 %) or front flippers (1.5 %). More turtles had minor (but healed) damage to their

carapace (11.2 %) or front flippers (0.5 %). Fibropapilloma tumours were not observed in any turtles.

3.8 Hatchlings

3.8.1 Clutch and Hatchling Predation

On two occasions, Indigenous peoples were observed searching for, and excavating clutches of eggs on Cemetery Beach. It is not known if they were successful or how many clutches (if any) were removed from the beach.

Tracks around nests suggested clutches were being dug by varanid lizards; however, this seemed to be confined to nests with dead hatchlings just below the sand surface. Although numerous tracks were observed, there were no observations of direct predation by varanids on emerging hatchlings.

Other tracks (either dog or cat) were observed and although there were no direct observations of these animals preying on hatchlings, dogs were observed on the beach during night monitoring. There was no evidence of fox predation on clutches and/or hatchlings at Cemetery Beach during the monitoring period.

3.8.2 Hatchling Disorientation by Light

It was noted that hatchling tracks at the ends of Cemetery Beach had a high propensity to travel in a direction parallel to, or towards the dunes. These locations are impacted by lighting from the council building surrounds at the eastern end and the carpark/play area at the western end.

Two high wattage floodlights positioned on the council building are directed towards the beach and cast light over approximately 228m or 30 % of the beach. These lights were on 16 of the 23 nights monitored in the second monitoring period. Observations made during these nights, recorded disorientated hatchlings at the base of the dune and in the vegetation at the back of the dune. One hatchling track was traced 160 m into the dune base at the front of the council building.

4 DISCUSSION

Based on historical data collected, Cemetery Beach was considered to support a moderate-sized flatback turtle nesting population relative to other rookeries in the region. **Table 3** compares Cemetery Beach with other flatback rookeries in the Pilbara region for which tagging data were publically available. These rookeries are part of the same genetic management unit and interchange between the rookeries has been documented (this report and Biota 2009), we can therefore directly compare these rookeries, regardless of whether they are mainland or island rookeries. However, caution must be used in the comparison of population sizes at this stage as the seasons for which the data are available are different, some have small sample sizes (i.e. low number of years monitored) and data have been collected differently.

The size of the flatback turtle population at Cemetery Beach (188 turtles recorded in 2009/10 season) appears to be smaller than the flatback rookeries on the offshore islands of Delambre and Legendre in the Dampier Archipelago (south west of Port Hedland), but larger than the mainland rookery at Bells Beach (estimated at 90-100 turtles), which is being monitored as part of the Cape Lambert development (Biota 2009). The regionally significant rookeries at Barrow Island, estimated at 1396 annual nesting females (Chevron Australia 2009) and Mundabullangana, estimated at 1692 annual nesting females (Pendoley *et al*. in press) are larger by nearly an order of magnitude in comparison to the Cemetery Beach rookery (**Figure 6**).

Table 3: Comparison of flatback turtle rookeries in the Pilbara region for which tagging data are publicly available.

Rookery	Seasons monitored (n)	Number of nights monitored per season	Number of individual turtles	Number of turtles per night
Cemetery Beach (This report)	2009/10 (1)	44	188	0 - 48
Delambre Island (Biota 2009)	2008/09 (1)	21	341	9 - 44
Legendre Island (Biota 2009)	2008/09 (1)	22	303	5 - 39
Bells Beach (Biota 2009)	2008/09 (1)	26	40	0 - 10
Barrow Island (Chevron Australia 2009)	2005/09 – 2008/09 (4)	~54	1396 (mean) Range = 894 - 1658	-
Mundabullangana (Pendoley *et al.* in press)	1998/99 – 2008/09 (10)	~14	1692 (mean) Range = 1197 – 2171	-

The tagging monitoring program at Cemetery Beach was conducted in December and January to target the peak nesting season for flatback turtles in north-west Australia. These data for the peak of the nesting season are based primarily on information from the Barrow Island, Montebello, Lowendal region (Pendoley 2005; Chevron Australia 2009). However, the results of the tagging monitoring program indicate that the peak nesting season occurs earlier in the summer at Cemetery Beach, which is located further north than Barrow Island. The numbers of turtles recorded decreased in January and track count data from the Care for Hedland Association suggest that number of turtles is high in early November (Kelly Howlett, unpublished data).

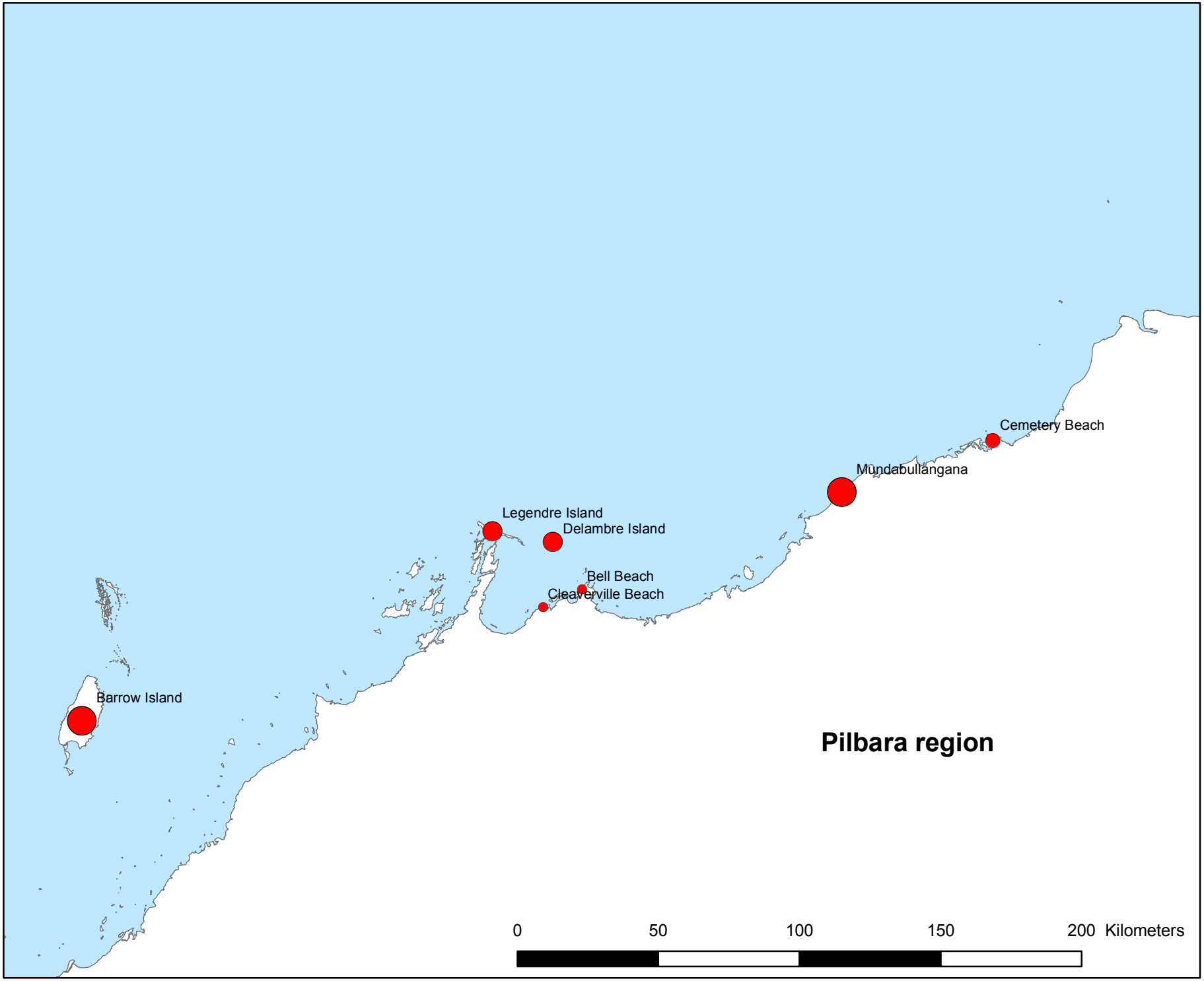

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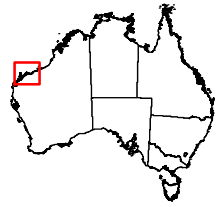
Figure 6: Flatback rookeries in the Pilbara region (only those discussed in this report are shown)

Legend
Size of rookery

- **<100**
- **100-200**
- **200-1000**
- **1000+**



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One turtle was observed with a satellite tag that had been applied in 2008/09 at Cemetery Beach in the first year of the BHP Billiton Iron Ore satellite tracking program, providing evidence of fidelity to a nesting site and an annual nesting migration. Other results from the tagging program at Cemetery Beach revealed that there is also interchange between flatback rookeries (Cemetery Beach and Mundabullangana), both within and between nesting seasons. The two rookeries are located over 50 km apart on the mainland coast. There were two incidences of turtles nesting at different beaches within the nesting season and at least one incidence of a turtle nesting at different beaches between nesting seasons. It is likely there were four other incidences of between-season changes in nesting beaches, based on tag scars recorded on these turtles. It is unknown which rookery they were originally recorded, although it is likely to also be Mundabullangana or Bells Beach at Cape Lambert. Biota (2009) also reported movement of female flatback turtles between Pilbara rookeries (including Delambre, Mundabullangana, Bells beach and Cleaverville beach) within and between seasons (see **Figure 6** for locations).. Although the majority of turtles still appear to exhibit nesting site fidelity, this does indicate that turtles are capable of moving between beaches and may simply move to another beach if disturbed.

Studies on other marine turtle species have also shown that turtles are capable of moving large distances between intra-seasonal nesting movements (e.g. loggerhead turtles; Bjorndal *et al.* 1983). As the number of tagging programs being undertaken in north-west Australia increase, we may find more instances of these inter- and intra-seasonal nesting movements by female flatback turtles. These findings have important implications for management of these rookeries, including the issue of sharing data between companies and the role of the DEC in managing the data within the Pilbara region.

The mean internesting interval is also shown in **Table 4** for other flatback populations in Australia. The mean internesting intervals differed significantly with respect to location (**Figure 7**; $F = 34.13$, d.f. = 8, 271, $p < 0.001$). The mean internesting interval of the Cemetery Beach flatback turtle population was similar to that recorded for Varanus, Wild Duck and Curtis Islands but significantly different from all other populations including Mundabullangana and Barrow Island (**Figure 2**).

Table 4: Mean internesting intervals of flatback rookeries in Australia.

Internesting Intervals (days)	Mean	SD	n	Peak internesting days
Cemetery Beach, Port Hedland (NW Shelf) This report	12.8	3.3	125	10-13
Barrow Island (NW Shelf) Chevron Australia 2009	14.3	2.4	2164	7-22 (entire range)
Mundabullangana (NW Shelf) Chevron Australia 2009	11.9	2.1	179	7-22 (entire range)
Varanus Island (NW Shelf) Pendoley 1999; DEC tagging database 2008	-	-	16	12-16
Bundaberg coast, (eastern Australia) Limpus *et al.* 1984	16.0	1.89	115	14-17
Woongarra Coast (eastern Australia) Limpus *et al*. 2006	13.75	0.87	12	12-15
Curtis Island (eastern Australia) Limpus *et al.* 2006	12.7	0.82 (SE)	6	12-14
Wild Duck Island (eastern Australia) Limpus 2009	13.0	1.28	83	10-15 (entire range)
Greenhill Island (western NT) Hope & Smit 1998	14.8	2.2	11	9-17 (entire range)

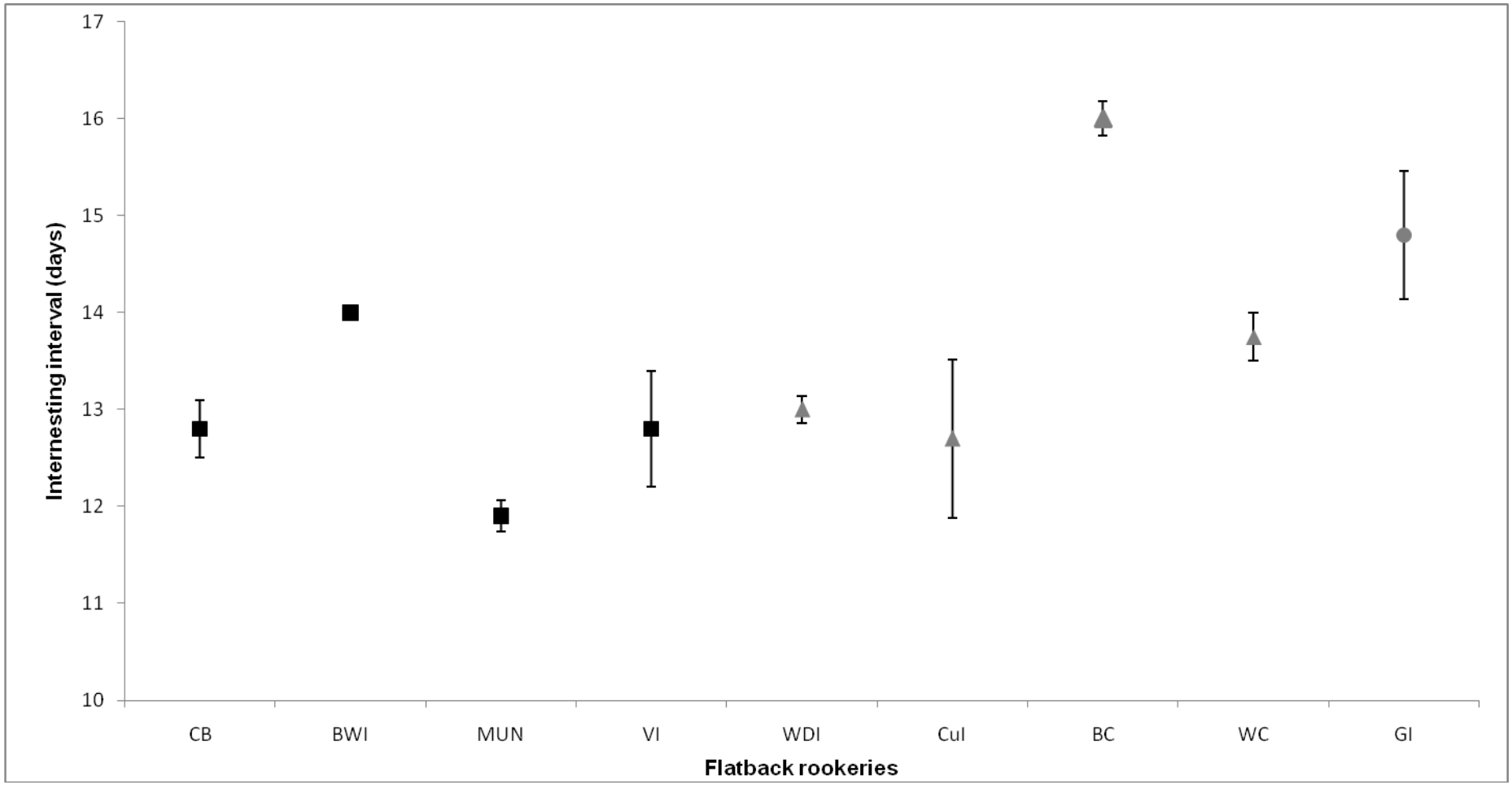

Figure 7: Comparison of mean (± SE) internesting intervals for flatback rookeries in Australia.
Black squares denotes rookeries within the NW Shelf genetic unit, grey triangles denotes rookeries within the eastern Australia genetic unit, black crosses denotes rookeries within the Gulf of Carpentaria genetic unit and grey circles denotes rookeries within the western Northern Territory genetic unit.
CB – Cemetery Beach, BWI Barrow Island, MUN – Mundabullangana, VI – Varanus Island, WDI – Wild Duck Island, CuI – Curtis Island, BC – Bundaberg Coast, WC – Woongarra Coast, GI – Greenhill Island.

Comparison of CCL measurements indicate that the Cemetery Beach population is similar in size to the populations from the Gulf of Carpentaria genetic unit, significantly larger than populations from the western Northern Territory unit (except for the Fog Bay rookery) and significantly smaller than populations from the eastern Australia unit (**Figure 8**; F = 164.45, d.f. = 14, 6030, p < 0.0001). Although significant, it should be noted that the populations vary in size by only 3 - 4 cm (**Table 5**).

Table 5: Mean CCL measurements (cm) of flatback rookeries in Australia.

CCL (cm)	Mean	SD	Range	n
Cemetery Beach, Port Hedland (NW Shelf) This report	88.6	2.3	81.5–95.0	163
Bundaberg coast (eastern Australia) Limpus 1971	93.2	-	88.0–96.0	14
Peak Island (eastern Australia) Limpus *et al.* 1981	94.0	2.6	85.5–100.0	212
Wild Duck Island (eastern Australia) Limpus 2009	94.0	2.7	85.5–100.0	185
Curtis Island (eastern Australia) Limpus *et al.* 2006	94.6	2.4	90.3–99.3	48
Crab Island (Gulf of Carpentaria) Limpus *et al.* 1993	89.3	2.7	80.5–97.0	326
Crab Island (Gulf of Carpentaria) Sutherland & Sutherland 2003	88.2	3.1	-	69
Deliverance Island (Gulf of Carpentaria) Limpus *et al.* 1989	88.8	3.0	81.5–94.0	18
Sir Edward Pellew Islands (Gulf of Carpentaria) Hamann *et al.* 2006	88.7	2.7	81.5-94.8	42
Cape Domett (western NT) Whiting *et al.* 2008	86.2	3.0	79.5–94.5	135
Greenhill Island (western NT) Hope & Smit 1998	86.3	3.6	75.0-95.0	181
Fog Bay (western NT) Blamires *et al.* 2003	89.3	2.1	-	13
Bare Sand Island (western NT) Whiting & Guinea 2006	86.4	2.7	67.0-96.9	-
Field Island (western NT) Schauble *et al.* 2006	86.3	3.5	81.5–94.0	215
Kakadu (western NT) Vanderlely 1993	85.5	4.9	73.5–91.2	10

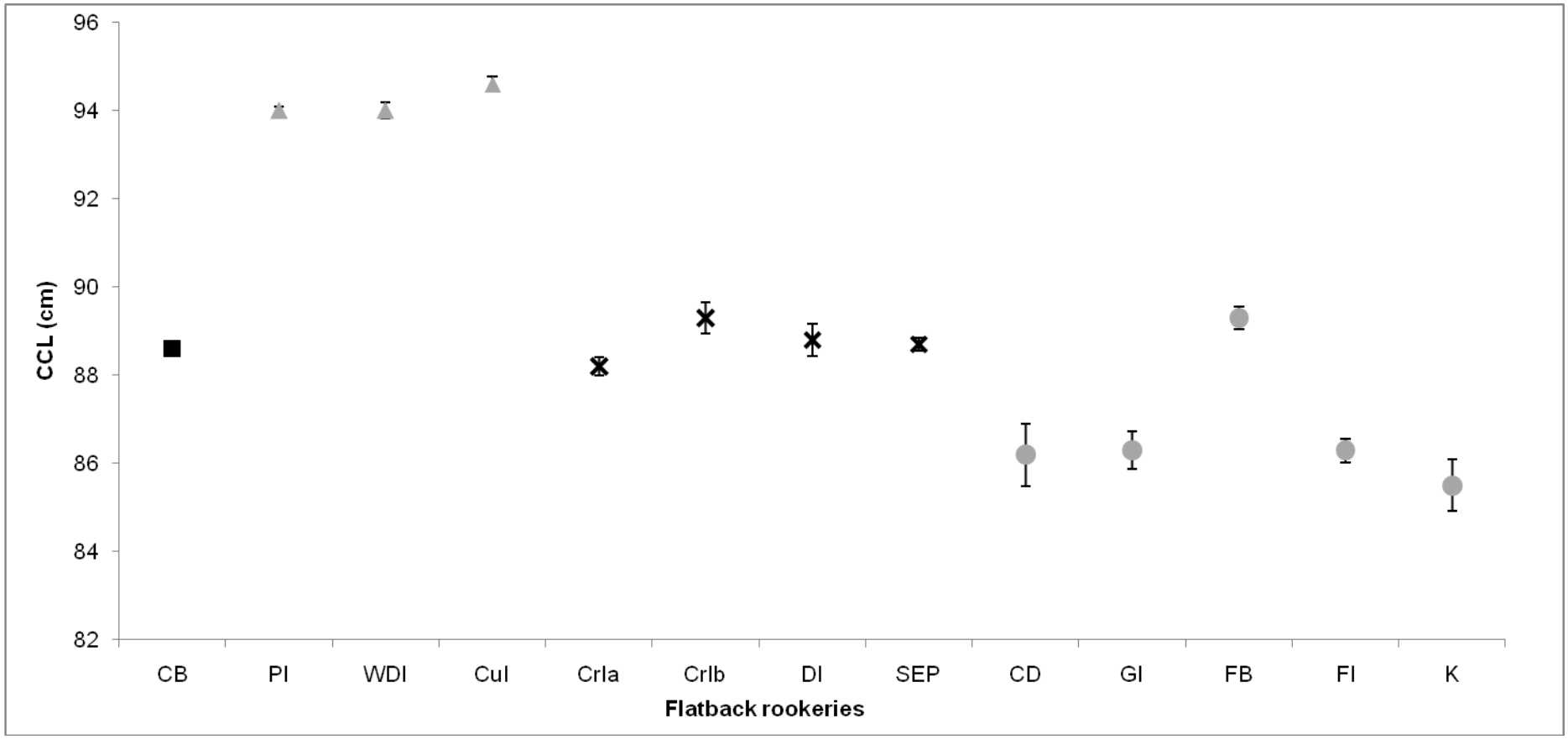

Figure 8: Comparison of mean (± SE) CCL measurements for flatback rookeries in Australia.
Black squares denote rookeries within the NW Shelf genetic unit, grey triangles denote rookeries within the eastern Australia genetic unit, black crosses denote rookeries within the Gulf of Carpentaria genetic unit and grey circles denote rookeries within the western Northern Territory genetic unit.
CB – Cemetery Beach, PI – Peak Island, WDI – Wild Duck Island, CuI – Curtis Island, CRIa/b – Crab Island, DI – Deliverance Island, SEP – Sir Edward Pellew Islands, CD – Cape Domett, GI – Greenhill Island, FB – Fog Bay, FI – Field Island, K – Kakadu.

The mean clutch size recorded for Cemetery Beach flatback turtles in this study were similar to the other North West Shelf populations (Varanus and Barrow Islands) but significantly smaller from all populations in other genetic units (**Figure 9**; F = 9.91, d.f. = 15, 1533, p < 0.0001) which have generally reported a mean clutch size of over 50 eggs (**Table 6**; Limpus *et al.* 1993; Parmenter & Limpus 1995; Whiting *et al.* 2008).

Table 6: Mean clutch sizes of flatback rookeries in Australia.

Clutch Size (number of eggs)	Mean	SD	Range	n
Cemetery Beach, Port Hedland (NW Shelf) This report	45.1	15.0	8–57	15
Barrow Island (NW Shelf) Chevron Australia 2009	45.96	11.66	3-66	127
Varanus Island (NW Shelf) Pendoley 1999	49.3	9.2	-	31
Bundaberg coast (eastern Australia) Limpus 1971	50.2	10.7	7-73	87
Peak Island (eastern Australia) Parmenter & Limpus 1995	53.35	0.48 (SE)	18-80	409
Wild Duck Island (eastern Australia) Limpus 2009	53.8	9	15-68	50
Crab Island (Gulf of Carpentaria) Limpus *et al.* 1993	55.9	9.6	34-74	32
Crab Island (Gulf of Carpentaria) Sutherland & Sutherland 2003	57.0	7.31	-	54
Deliverance Island (Gulf of Carpentaria) Limpus *et al.* 1989	52.0	14	36-87	12
Sir Edward Pellew Islands (Gulf of Carpentaria) Hamann *et al.* 2006	51	7	-	22
Cape Domett (western NT) Whiting *et al.* 2008	54.0	8.6	40-72	31
Fog Bay (western NT) Blamires & Guinea 2000	51.5	8.6	-	85
Greenhill Island (western NT) Hope & Smit,1998	52.2	10.7	-	137
Field Island (western NT) Schauble *et al.* 2006	52.4	8.6	-	127
Kakadu (western NT) Vanderlely 1996	53.2	7.1	41-75	25

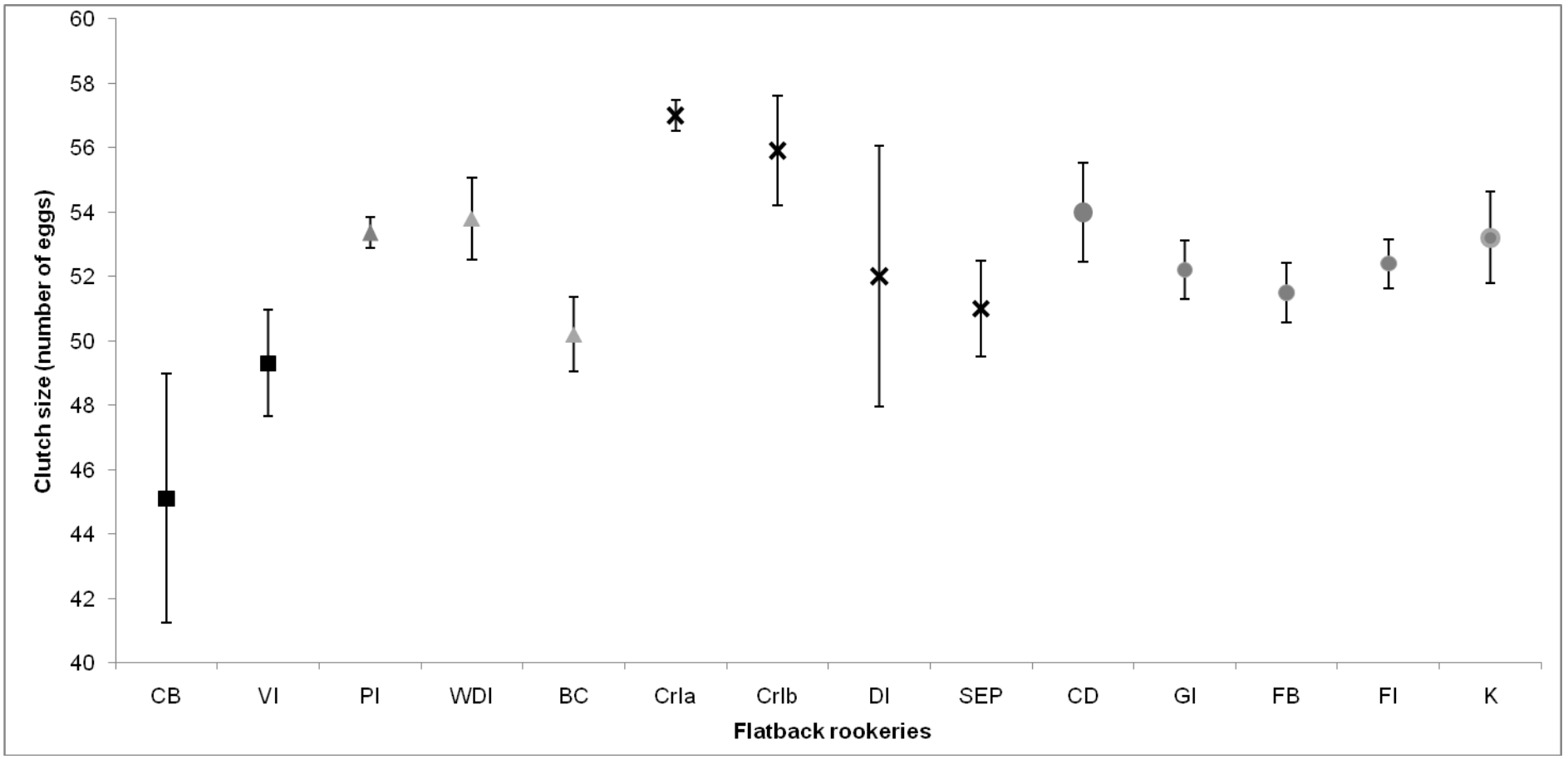

Figure 9: Comparison of mean (± SE) clutch sizes for flatback rookeries in Australia.
Black squares denote rookeries within the NW Shelf genetic unit, grey triangles denote rookeries within the eastern Australia genetic unit, black crosses denote rookeries within the Gulf of Carpentaria genetic unit and grey circles denote rookeries within the western Northern Territory genetic unit.
CB – Cemetery Beach, PI – Peak Island, WDI – Wild Duck Island, CuI – Curtis Island, CRIa/b – Crab Island, DI – Deliverance Island, SEP – Sir Edward Pellew Islands, CD – Cape Domett, GI – Greenhill Island, FB – Fog Bay, FI – Field Island, K – Kakadu.

The tagging program has provided crucial baseline information on the population size and basic biological parameters for the Cemetery Beach nesting flatback turtle population. The movement of several female flatbacks between the Cemetery Beach and Mundabullangana rookeries, particularly within the same nesting season, is the first evidence to document regular interchange between two flatback populations along mainland Western Australia and is an important finding for future management of the flatback turtle species within the Pilbara region. Based on the findings of this study, the following recommendations are provided:

- The tagging monitoring program be continued at Cemetery Beach to provide further baseline data and a more robust population estimate (the population can only be accurately modelled with a minimum of five years of data), as well as providing additional information on biological parameters such as remigration intervals and recruitment rates for the population.

- The tagging program continues to be conducted over two months, but to commence the program earlier in November to capture more of the peak nesting season.

- A nest success program, measuring hatch and emergence success of the nests, be incorporated into the program. These data are important in addition to the information collected on the breeding females, as they provide an indication of the reproductive output of a population. Although the number of females breeding within a population may be high, the number of eggs that are successfully hatching and emerging may be low, which may reduce the overall reproductive success of the population.

Quantification and monitoring of these biological parameters are critical to the successful monitoring and management of development activities in the vicinity of the Cemetery Beach rookery.

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