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TECHNICAL NOTE

TO:	SKM / Woodside		
ATTENTION:	Andrew Tennyson		
FROM	Dr Barry Shepherd and Dr David Waayers (RPS)		
DATE:	25 June 2012	**OUR REF:**	N1185301
SUBJECT:	**Browse LNG Precinct: James Price Point Turtles, RPS Review of Lindsay et al. (2012).**		

1. Introduction

Woodside Energy Limited (Woodside) has requested RPS Environment and Planning Pty Ltd (RPS) to prepare a technical note that addresses the following:

a) Determine if the existing turtle studies (RPS 2010) were adequate and based on sound rationale.

b) Undertake a review of Lindsay et al. (2012) (the Lindsay report).

c) Determine whether further studies are required given the recent findings of the Lindsay report.

2. Basis of RPS Survey Design

The NatureMap database does not recognise the Dampier Peninsula as a significant nesting area for hawksbill turtles (*Eretmochelys imbricata*). However, it recognises that green (*Chelonia mydas*) and flatback turtles (*Natator depressus*) are likely to use the beaches of the Dampier Peninsula for nesting. A fauna survey conducted at the James Price Point (JPP) coastal area in March 2009 (Biota 2009) reported evidence of nesting activity of flatback turtles at Quondong Beach and south of Coulomb Point, but did not identify turtle activity in the JPP area. The report stated that "the coastline immediately adjacent to the JPP survey area is inundated during high tide and is therefore unsuitable for nesting" (p.30 Biota 2009).

To confirm this information, RPS conducted a reconnaissance survey of all sandy beaches between Quondong Point and Coulomb Point in November 2009, to enable a robust sampling design for the monitoring program during the identified flatback and green turtle primary nesting season (RPS 2010). No prior information existed that suggested hawksbill turtles nested along this coast. Therefore no reason existed to justify conducting a reconnaissance survey in the known peak hawksbill turtle nesting period of September/October. The purpose of the reconnaissance survey was to identify potential nesting sites that were likely to produce typical hatching success based on beach characteristics, potential weather conditions and local knowledge.

The beaches between JPP and the Gully were examined in the reconnaissance survey but were deemed less than optimal for turtle nesting on the following grounds:

a) Compact substrate comprising fine sand/pindan grain size making it difficult for an adult turtle to dig an egg chamber.

b) Dark colouration of the sand would help raise the sand temperature above the optimal Thermal Tolerance Range (TTR) of between 27°C and 33°C (Ackerman 1997 and Hays et al. 2001).

c) Most of the beach area is inundated by tides with <5 m of dry sand/pindan between the high tide mark and the base of the pindan cliff. In some areas, the cliff was eroding due to storm surge and tidal inundation (Plate 1).

As part of the reconnaissance survey, Traditional Owners - Mark Parriman and Terry Hunter - were consulted about turtle nesting areas and they also participated in the survey. Advice from the Traditional Owners suggested that the area between JPP and Flat Rock did not support nesting turtles, but tracks had been reported at Walmadan and Manari Beaches. Although the beach north of Walmadan was not included in the RPS survey area, it was occasionally surveyed visually during the field surveys, however no tracks were observed.

The above predictions about sand temperature were supported during sampling in 2009-10. Sand temperature measurements taken at Walmadan Beach, where the sand colour is lighter than beaches between JPP and the Gully, were found to lie between 28.5 and 35.6°C (mean = 33.5°C) (RPS 2010). This temperature is considered relatively high (Ackermann 1997). Given that sand albedo has a profound implication for nest temperatures (Hays et al. 2001) and that the sand colour is much darker between JPP and the Gully (Plates 1 and 2), it is likely that these beaches would exceed the optimal TTR and thus provide sub-optimal nesting conditions. Furthermore, the low nest success reported by Lindsay et al (2012) provides further evidence that the beaches between JPP and the Gully do not provide favourable turtle nesting habitat as predicted by RPS scientists.

Plate 1: **Photograph of beach north of JPP with dark coloured sand, narrow areas of dry sand and eroding pindan cliffs. Photo taken 09:25 hrs, 19 Nov 2009 within 2.5 hrs of the incoming high tide. Tidal range at the time was of a moderate spring tide.**

Plate 2: **Photograph of north JPP containing dark coloured sand and no dune habitat. Photo taken 09:25 hrs, 19 Nov 2009 within 2.5 hrs of the incoming high tide. Tidal range at the time was of a moderate spring tide.**

3. Results of RPS Surveys

One unidentified old false crawl and nest were recorded by RPS turtle biologists at Walmadan beach in January 2010. Two unidentified old false crawls were recorded at Red Cliffs, approximately 100 m north of JPP on dry sand, where there was only 3 m between the high tide mark and the pindan cliff in March 2010 (RPS 2010). Based on the area surveyed by RPS, this equates to a density of 0.46 tracks/km of beach length. Given that hawksbill and flatback turtles lay about three nests per season (Pendoley 1999; Chevron 2009), these activities extrapolate to a potential for one or two turtles attempting to nest in 2009–2010. In contrast, an average of 115.4 green turtle tracks/km and 5.8 flatback turtle tracks/km were recorded on the West Island of the Lacepede Islands, which is approximately 70 km north-west of JPP (RPS 2010). In 2009–2010, the total number of turtles attempting to nest each night for the entire Lacepede Island Group was 467 turtles with 431 green and 36 flatback turtles attempting to nest each night. Based on the best available data[1], these numbers roughly equate to approximately 2,785 female green turtles and 345 female flatback turtles.

It is not possible to gain a clear understanding of temporal variability in turtle nesting without a long-term dataset, especially where sample sizes are relatively small as they were during the RPS, Biota and Lindsay studies. Long-term data (30 years) from eastern Australia of flatback turtle rookeries have shown no obvious trend in the size of the annual nesting population (Limpus et al. 2002). Yet, long-term monitoring of flatback turtles from Mon Repos, Wild Duck Island and Curtis Island located along the central coast of Queensland, indicate that annual nesting populations can fluctuate considerably between years (Limpus et al. 2002). In Western Australia, however, the inter-annual variation of flatback turtles appears to be less. The mean annual nesting population of flatback turtles on Barrow Island for instance, is 1397 ±302 female turtles (n = 4 nesting seasons), however the nesting population doubled in 2006-07 (Chevron 2009). There are no long-term data sets for hawksbill turtle nesting activity in Western Australia. However, nesting data from Milman Island, in the Torres Strait, shows a steady decline in annual nesting activity with relatively little inter-annual variability (Miller et al. 2000).

The inter-annual variability in turtle populations is further complicated by the irregular intervals between which turtles return to their nesting beaches (remigration interval). The average remigration interval for hawksbill turtles at Varanus Island is 3.7 years (range = 1 to 6 years; n = 49) (Robinson 1990; Pendoley 1999), whereas the remigration interval in eastern Australia is 5 years (range = 2 to 9 years; n = 435) (Miller et al. 2000), suggesting that the few turtles nesting at JPP may not be seen again for several years. This is a possible explanation why no evidence was found by RPS of nesting hawksbill turtles during the breeding seasons in 2009–2010 or 2010–2011. It is also likely that the 14 nests recorded by Lindsay et al. (2012) were produced by only three or four turtles, as each female turtle will nest about three times per season (Pendoley 1999; Chevron 2009). The difference between the three or four hawksbill turtles recorded by Lindsay et al. in 2011–2012 compared with the one or two unidentified turtles recorded by RPS in 2010 is likely to be within the expected inter-annual variation of nesting activity along this coast.

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[1] Nesting success (proportion of successful nests): flatback turtles 0.52; green turtles 0.49 (Pendoley 2005, Waayers 2010), the average inter-nesting interval for each species, which was estimated from satellite tagging (green: 10.55 days and flatback: 14.75 days) and 80% of the population nests within a single re-nesting interval (Limpus et al. 2001).

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Although the sampling effort by Lindsay et al. was broader and more frequent in 2011–2012 compared to the RPS sampling effort (RPS 2010), the survey reported about the same number of tracks within the RPS survey area. Based on the track count surveys conducted by RPS in 2009–2010, the retention of tracks is about three to four weeks, depending on weather conditions and cyclonic activity. Therefore, the lower detection of tracks by RPS was not a result of inadequate sampling effort, as suggested in Lindsay's report, but an artifact of less spatial coverage immediately north and south of JPP.

Furthermore, the turtles recorded at the JPP coastal area may not be utilising the area as their primary nesting site. Hawksbill and flatback turtles generally have strong philopatry and nest site fidelity (Miller 1997). However, hawksbill turtles have been reported nesting 80 km from the primary nest site within a nesting season (Garduño-Andrade et al. 1999), which is a possibility for turtles nesting at the Lacepede Islands. The low number of turtles recorded by Lindsay (2012), RPS (2010) and Biota (2009) suggest that the Dampier Peninsula is not a major rookery and that the turtles attempting to nest along the coast are likely to be opportunistic events or a display of poor inter-nesting fidelity. However, the lack of conclusive evidence of this, in this instance, suggests further investigation may be required.

4. Results of Lindsay et al. Survey

Lindsay et al. reported 14 nests and 38 false crawls along the beaches from Quondong Point to Flat Rock between 7 October 2011 and 11 January 2012. Of the 14 nests, eight were excavated to determine clutch sizes and hatching success. The results indicate relatively inconsistent hatching success compared with other rookeries in Western Australia (RPS 2007; Chevron 2009; Limpus 2009). The Lindsay et al. report indicated that the hatching success of nests north of JPP were very low (31.83%). These nests (NN11, NN5 and NN12) were recorded within the narrow band of dry sand along the pindan cliffs between JPP and the Gully. No eggs hatched from nest NN13, which was located at the base of the pindan cliff on the southern side of the point, and is vulnerable to storm surge and inundation. In contrast, the hatching success was considerably higher at average 96.3% between Walmadan and JPP, where the beach width is broader and the colour of the sand is lighter. This area provided similar beaches to those identified in the RPS reconnaissance survey in 2009.

Assuming Lindsay et al. used the correct methods for measuring the width of tracks; NN4 appears to be too narrow (690 mm) for a flatback turtle and is likely to be from a hawksbill turtle. The average width of a flatback turtle track is 1.02 m (range 0.78 – 1.25 m), whilst the average width of a hawksbill turtle tracks is 0.795 m (range 0.60 – 0.94 m) (Pendoley 2005; Waayers 2010).

Lindsay's reference to turtle behavior coinciding with "spring-neap tidal oscillations" is also unfounded and not supported by appropriate references. Marine turtles generally emerge from the water to nest on any day of the month during the season depending on their re-nesting interval (Miller 1997).

5. Discussion

Given that flatback and hawksbill turtles return to the same beach about three times in a season (Limpus et al. 2001; Miller et al. 2000), the 14 nests reported by Lindsay et al. (2012) are likely to be associated with one flatback turtle and two or three hawksbill turtles. The nests not excavated (Table 1 of Lindsay et al.) were possible false crawls, since eggs were not found and the dates did not match typical re-nesting intervals for each species.

The four productive clutches (>70% hatching success) that were identified at JPP does not suggest that this is a major marine turtle rookery (e.g. Lacepede Islands would have produced up to 150 clutches per night in 2009-10 based on track count data). In comparison to nearby nesting areas, such as the Lacepede Islands, Cable Beach and Ecobeach, JPP supports a small proportion of nesting flatback turtles (<1%) in the southern Kimberley region (RPS 2010; CVA 2009; CVA 2011).

As stated in the Strategic Assessment Report (SAR), hawksbill turtles are not commonly known to nest along the Dampier Peninsula. The SAR and RPS Technical Report did not discount that hawksbill turtles may nest in the area, which is consistent with the findings of the Lindsay report. The major hawksbill turtle rookeries are known to be located at the Dampier Archipelago, Montebello and Lowendall Group, Barrow Island, Northwest Cape and Ashmore Reef (Guinea 1995; Chevron 2009; Pendoley 1999; Limpus 2009, Waayers 2010). Based on available data from these major rookeries, JPP supports a small proportion of hawksbill turtles (<0.2%) in Western Australia.

The ability to detect change or trends over time with small sample sizes is very difficult given the large variation inherent in the nesting frequencies apparent along the coast near JPP. This is further complicated by the irregular intervals between which turtles return to their nesting beaches.

As discussed earlier, the 14 nests reported by Lindsay et al are likely to be from three or four individual turtles that have re-nested about three times during the season. The narrow band of dark dry sand available north of JPP is less than optimal for nesting, producing low hatching success and a small proportion of the regional population. However, the beach south of JPP around Walmadan has produced hawksbill hatchlings and shows signs of being a suitable nesting area. Nevertheless, this stretch of coast represents an area of low preference for turtles, but requires monitoring to understand future nesting activity.

The clutch sizes were generally within the expected ranges for both species, with the exception of NN5, which is likely to be from a hawksbill turtle since it produced 112 eggs. Flatback turtles produce on average 50 eggs and no more than 80 eggs per clutch (Limpus 2009, Pendoley 1999). Whereas, hawksbill turtles on Varanus Island average 112 eggs (n = 54) (Pendoley 1999).

The average hatching success of hawksbill turtles on Varanus Island is 0.708 (n = 73) (Robinson 1990). In the Lindsay report, the results from the hawksbill turtle nest excavations indicate poor hatching success north of JPP (31.83%), whereas the beaches south of JPP produced 96.3% hatching success (excluding NN13).

While the Lindsay report speculates that NN11 is a possible hawksbill/olive ridley (*Lepidochelys olivacea*) hydrid, further discussions with Dr Bob Prince suggests that it remains unclear whether NN11 is a hawksbill turtle or a hybrid hawksbill turtle mixed with a olive ridley or loggerhead turtle (Bob Prince pers. comm. 2012). While it is uncertain if NN11 is the first reported hawksbill hybrid turtle in Australia, hybridisation of marine turtles, in general, has occurred among all species of the Family Cheloniidae throughout the world. However, the extent to which natural hybridization in turtles occurs has not been determined (James et al. 2004; Lara-Ruiz et al. 2006). As genetic techniques are increasingly applied, hybridization may prove to be more common than previously thought. Molecular genetics conducted elsewhere have confirmed hybridization between the hawksbill and olive ridley turtles (Lara-Ruiz et al. 2006), loggerhead (*Caretta caretta*) and Kemp's ridley turtle (*Lepidochelys kempii*) (Karl et al. 1995; Barber et al. 2003), loggerhead and hawksbill turtles (Karl et al. 1995; Witzell & Schmid 2003), and green and hawksbill turtles (Wood et al. 1983; Karl et al. 1995).

Studies have reported sterility or low fitness in hybrids (Allendorf et al. 2001). Nevertheless, hybrids can sometimes be reproductively viable (Karl 1996; Lara-Ruiz et al. 2006), where the hybridization might be accompanied by introgression, a process that involves the backcross of the hybrids with one or both parental taxa. The introgression process may be related to the population decline of both species in the recent past, or it can also be evidence of an ancient process, as suggested by Karl et al. (1995), given the long generation times of turtles and the long evolutionary history of these species.

Given the likelihood of sterility in NN11 (e.g. 1.4% hatching success), it is postulated that the particular turtle that Lindsay et al. identified as a possible hybrid would have poor reproductive capacity and therefore unlikely to contribute significantly to the already low nesting population at JPP.

6. Conclusions

In light of the above discussions, RPS concludes that the sampling design and results provided in RPS 2010 are defensible given the following factors:

- The design was based on the best available information at the time (e.g. NatureMap, Biota 2009, RPS reconnaissance survey in early November 2009 and local indigenous knowledge).
- RPS found no evidence from 2009-2011 that hawksbill turtles were nesting along this stretch of coast. If evidence was discovered, the sampling strategy would have been modified to account for nesting hawksbill turtles, such as monitoring the area during October.
- Due to the broad re-migration intervals of nesting hawksbill and flatback turtles, it is possible that no turtles will nest along this section of coast on any given year.

By considering the combined results of RPS (2010) and Lindsay et al. (2012), the turtle nests along this section of coast do not represent a significant number for hawksbill or flatback turtles in terms of their wider population. Information on hawksbill turtles nesting along this stretch of coast is sparse, and therefore it is unlikely that these four turtles found attempting to nest in sub-optimal habitat play a significant role in the wider Western Australian population and possibly represent isolated nesting events.

These findings have implications for the design and content of the environmental management plan related to turtles for the Browse LNG Precinct. The SAR (Part 3) only considered the potential of nesting green and flatback turtles in the JPP coastal area and concluded that hawksbills do not regularly use the JPP area for nesting. However, the SAR accepted that Hawksbill turtles may on occasion use the area. On this basis, no detailed impact assessment was conducted specific to hawksbill turtles as part of the SAR.

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