PORT HEDLAND PORT AUTHORITY

UTAH POINT BERTH PROJECT

SEA TURTLE ASSESSMENT

Report by

Pendoley Environmental Pty Ltd

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TABLE OF CONTENTS

1 Introduction

Port Hedland Port Authority (PHPA) is constructing a new berthing facility located at Utah Point in Port Hedland Harbour. The first jetty was built in Port Hedland in 1896 while the Port Hedland Harbour was first dredged in 1965 (PHPA 2008). Over 111.8 million tonnes of cargo was handled through the port in 2006/2007 establishing it as the largest port by tonnage in Australia, and one of the largest in the world (PHPA 2008). The new Utah Point berth will cater to junior iron ore miners and will provide additional capacity for existing companies operating in the Harbour (PHPA, 2008).

SKM requested Pendoley Environmental carry out a desk top assessment to address the following objectives.

- Determine the significance of turtle habitat in the vicinity of Finucane Island (particularly West Creek and surrounding mangrove environs);
- Determine the likely turtle species that may utilise habitats in the surrounding area of Finucane Island;
- Determine the potential impacts on turtles due to artificial lighting;
- Determine the potential impacts on turtles due to increased vessel movements;
- Determine the potential impact to known nesting grounds and the significance of these impacts (e.g. cumulative light emissions); and
- Identify mitigation / management measures to minimise the overall light emissions from the development.

The desk top study was carried out by Dr K Pendoley and Ms N Balcazar of Pendoley Environmental Pty Ltd. Section 2 of this report presents background theory on the biology and ecology of sea turtles (section 2.1) light theory and the impact on turtles (section 2.2) and effects of boat strike on turtles (section 2.3). Section 3 is a collation of our current knowledge on sea turtle habitat usage in the Port Hedland region of the Pilbara. Section 4 addresses the study objectives and discusses the significance of turtle habitats and species that are thought to occur in the vicinity of the project area, assesses the potential impacts of the project on the turtles in the area and identified mitigation measures that can be used to reduce the impact of the project on turtles.

2 Background

2.1 Sea turtle life cycle and ecology

Miller (1996) has summarised the life cycle characteristics that are shared by all sea turtle species, i.e. a breeding migration from foraging areas to mating and nesting areas (Figure 2.1). During the breeding period, males and females migrate to mating areas which may or may not be close to the nesting beaches. Following mating the males return to their foraging grounds and the females spend several months at the nesting area laying multiple clutches of eggs. In between nesting, the females move off to nearby internesting grounds while they form the next batch of eggs. After laying the last clutch of eggs, the females return to their foraging area to build up fat reserves until their next reproductive migration. Most females do not nest in consecutive years (Miller 1996). Hatchlings emerge from nests after a 6-13 week (temperature dependant) incubation period. Hatchlings generally emerge onto the beach at night when sand temperature falls (Miller 1996). Hatchlings leaving their natal beaches migrate to deep water, open ocean, nursery habitats where they spend 5-20 years. Juvenile turtles then migrate to shallow near shore feeding grounds until they reach sexual maturity at 30-50 years. The mature adult turtles then migrate to the general vicinity of their natal beaches to begin the reproductive cycle again (Miller 1996).

The flatback turtle life cycle varies slightly from this generalized pattern. Unlike other species, the hatchlings do not migrate offshore to the deep water, open ocean, nursery habitats following hatching, instead juveniles grow to maturity in shallow coastal waters thought to be close to their natal beaches (Musick and Limpus 1996). Recent studies of satellite tracked flatback turtles has confirmed that this species also engages in long distance migrations in coastal waters between feeding grounds and remote nesting beaches (Pendoley unpublished data).

For the purposes of this report the three life stages that are referred to in this document are defined as follows;

- post hatchling, ~ 15 cm curved carapace length,
- juvenile, ~ 30 cm curved carapace length, and
- adult, > 80 cm curved carapace length.

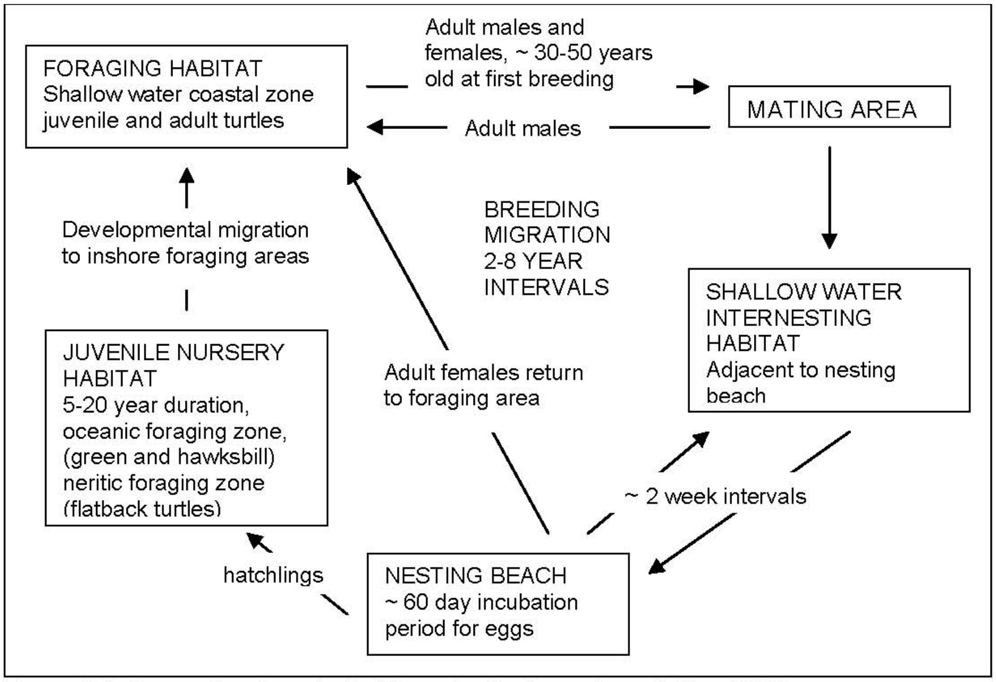

Figure 2.1: Generalized sea turtle life cycle. Redrawn from (Miller 1996)

The three species most commonly found in northern Pilbara waters (green, flatback and hawksbill turtles) share some developmental characteristics. All species are sustained for the first few days after leaving their natal beaches by the egg yolk they reabsorb into their abdomen after pipping from the egg (Lohmann, Witherington et al. 1996; Musick and Limpus 1996). However, the foraging ecology of the three species differs throughout their developmental stages.

Juvenile green turtles in the open ocean nursery habitat are omnivorous and may associate with downwelling zones (Witherington 2002). When they move from the oceanic pelagic habitat to the shallow water neritic habitat (30-40 cm curved carapace length), they shift to a herbivorous diet of seagrass, algae and mangrove fruit (Mortimer 1979; Bjorndal 1996; Musick and Limpus 1996; Pendoley and Fitzpatrick 1999). Juvenile hawksbills may also live in association with sargassum rafts in the open ocean and appear to also be omnivorous. Juvenile hawksbills from the Indo-Pacific region move to benthic foraging habitats over coral reefs and rocky outcrops at a minimum curved carapace length (CCL) of 35 cm, where they feed selectively on sponges (Limpus 1992).

Since flatback turtles do not have an oceanic phase (Walker and Parmenter 1990), the post hatchling, juvenile and adult phases are all spent in the relatively turbid, shallow, inshore waters of northern Australia (as opposed to the open ocean deep water developmental habitat used by loggerhead, hawksbill and green hatchlings) where the juveniles appear to feed on planktonic (snails and siphonophores) and benthic (corals, molluscs and bryozoans) organisms.

Larger juveniles and adults feed on jellyfish, sea pens and soft corals (Limpus, Parmenter et al. 1983; Bjorndal 1996; Musick and Limpus 1996). While little is known on the foraging habitats utilised by juvenile or adult flatback turtles, recent satellite tracking of adult flatback turtles from Barrow Island has shown that they forage in the deeper coastal waters off the Kimberley coast. This is consistent with the findings from Queensland which found both juveniles and adults avoid shallow water, e.g. < 5m deep (Walker 1991). In the Barrier Reef Province, juvenile flatback turtles were most frequently found near offshore islands. Walker found juveniles travelled a mean distance of 21 km from the mainland and 65% stayed within 15km of the coast. The mean distance the juveniles travelled from major nesting islands was 59 km, with 27% within 15km and 85% within 70km. (Walker 1991).

Prior to the introduction of trawl net 'turtle excluder devices' (TEDs) into the Australian prawn trawl fishery, flatback adults were the most commonly caught species. The records from the pre-TED trawl fishery suggest that 59% of flatback captures took place in water between 5-20m deep (Poiner, Buckworth et al. 1990).

2.2 Interactions between sea turtles and light

Light has been recognized as affecting the orientation of hatchling sea turtle since Hooker (1911) reported a negative reaction in green turtles to red light and a positive reaction to blue light. Since that time, numerous studies have shown that the orientation of sea turtle hatchlings is strongly influenced by light wavelength and intensity (Daniel and Smith 1947; Carr and Ogren 1960; Mrosovsky and Carr 1967; Lohmann, Witherington et al. 1996; Pendoley 2005).

Light has many properties that may influence orientation in hatchlings, e.g. intensity, wavelength, directivity and polarisation (Lohmann and Lohmann 1996a). Studies suggest that hatchlings have a strong tendency to orient towards the brightest direction, with brightness being a function of light intensity, wavelength and hatchling spectral sensitivity (Witherington 1992a). The brightest direction on natural beaches is typically towards the ocean where the horizon is open and unhindered by dune or vegetation shadows.

The brightness of a light to a turtle hatchling is also a function of the spectral characteristics of the light. A light will not be detected if its wavelength is outside the spectrum of light that is visible to the animal. Electroretinography (ERG) studies have shown that green hatchling turtles can see blue (450 nm to 500 nm), green (500 nm to 570 nm), yellow (570 nm to 590 nm) and orange (590 nm to 610 nm) light well (Granda and Dvorak 1977). However, experiments with hatchlings have shown that both green and hawksbill turtles are notably more responsive to shorter wavelengths (*i.e.* near ultraviolet violet to yellow, < 400 nm to 590 nm) than to longer wavelengths of light (*i.e.* orange to red light, 590 nm to >700 nm), even at heightened intensities (Mrosovsky and Shettleworth 1968; Witherington and Bjorndal 1991; Witherington 1992a).

All lights used in domestic and industrial applications are composed of 'visible' wavelengths that range from the blue/green end of the spectrum out to the orange/red range. Lights such as fluorescent, metal halide, mercury vapour, halogens and high pressure sodium vapour lights are made up of varying proportions of these wavelengths. Spectra representative of the four most commonly used lights are shown in Figure 3.1. At high intensity all of these lights are visible to sea turtle hatchlings; however at low intensity the lights containing the greatest proportion of light in the 350 – 550 nm region are more attractive to sea turtles than lights at a similar intensity that contain a greater proportion of light in the 550 – 700 nm region. Consequently, high pressure sodium light is preferred over metal halide, fluorescent or halogen lights when illuminating public or work sites close to sea turtle nesting beaches.

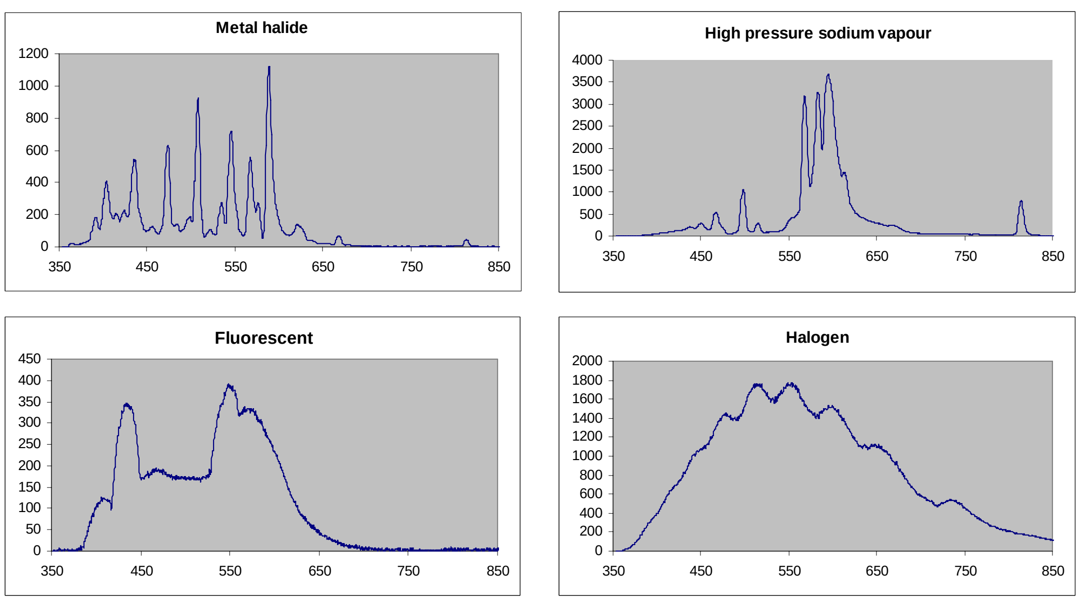

Figure 2.2: Light spectra of common industrial, commercial and urban light sources. The x-axis shows wavelength in nanometers (nm) and the y-axis shows intensity (not to scale).

To date, little research has been carried out on the effects of lighting on nesting adult turtles. Two studies suggest light at nesting beaches may influence the behaviour and nest placement, however, these conclusions are yet to be tested by further studies (Witherington 1992b; Salmon, Reiners et al. 1995). Light may influence nest site selection in some species, with variation in behaviour in individuals.

There is little published information on orientation cues used by juvenile turtles (Avens and Lohmann 2003; Avens and Lohmann 2004; Cain, Boles et al. 2005) and none published studies on the effects of light on foraging juveniles. Nor are there any anecdotal reports, such as trapping of juveniles by light around moored vessels, to suggest light is an important cue for foraging juvenile turtles.

2.3 Boat Strike

Figures show that vessel movements in and out of Port Hedland Harbour have steadily increased since 2002 (Table 1). Vessel collision is a recognised cause of sea turtle mortality (MMS 2007). Turtles are at risk from boat strike when they rise to the surface to breathe or when they surface as a 'startle' response to some situation such as dredging noise, explosions or visual cues (MMS 2007). As vessel traffic increases within sea turtle habitat, the incidence of boat strike is expected to increase (NRC 1990; MMS 2003; MMS 2007).

Table 1: Vessel numbers and cargo tonnage going through Port Hedland Harbour (PHPA, 2007)

Year	Number of Vessels	Cargo (millions of tons)
2006/07	888	111.8
2005/06	925	110.6
2004/05	895	108.5
2003/04	773	89.8
2002/03	693	81.4

Specific impacts from ship movements might include (Limpus, 2007):

- Damage of benthic habitat through anchor and mooring usage,
- Lifting up sediment from continual movement,
- Propeller strikes, and
- Noise.

3 Sea turtle habitat use in Port Hedland area

In order to build a picture of sea turtle habitat usage within the Port Hedland Harbour area, all information collected by Pendoley Environmental both during project work and privately has been routinely collected into a master database called the West Australian Sea Turtle Data Repository (WASTDR). Information in the database has come from opportunistic discussions with scientists and environmental professionals working in the areas as well as local residents. Personnel contributing to the Port Hedland component the WASTDR include Dr R Prince (DEC), Ms K Howlett (Care for Hedland Environmental Association), Mr C Wilson (Port Hedland Port Authority Environmental Manager). Mr P Everson (URS, Marine Scientist), and Mr K Walley (Indigenous Land Management Facilitator, DEH). The WASTDR database continues to grow and is vital to the scientific usage of this information for biological, ecological and conservation purposes.

The Port Hedland rookery size was assessed on a regional basis using a review of relative rookery size estimates for WA flatback rookeries that was carried out in 2006 at the request of the West Australian Environmental Protection Authority (EPA) during the assessment of the Gorgon gas development on Barrow Island (Pendoley 2006). This review attempted to put the Western Australian flatback rookeries into a regional and a national perspective using the best available data (published literature and unpublished nesting data). The results of this review must be viewed as preliminary until further studies have confirmed or corrected the estimates.

The sea turtle habitats that have been identified in the Port Hedland Harbour and adjacent coastal region, are listed below.

- Nesting habitat for female flatback turtles has been confirmed at Cemetery Beach, Pretty Pool and Cooks Point (Prince 1994). There is no sandy nesting habitat within the Harbour area. Any suitable sandy nesting beach within the wider Port Hedland/Finucane Island region may support flatback turtle nesting, however there is no published information to confirm this.
- Foraging habitat for juvenile green turtles and flatback turtles within the mangrove lined creeks of the Port Hedland Harbour.

- Foraging habitat for mature green and flatback turtles has not been found in the Port Hedland Harbour. This habitat may occur offshore but is yet to be confirmed.
- Nearshore wave zone traversed by hatchlings migrating offshore from Cemetery Beach and Pretty Pool rookeries.
- Hawksbill habitat has not been identified in the Harbour or adjacent coastal region, to date.

The available anecdotal and grey literature information on sea turtle habitat use in the Port Hedland area is summarised below.

3.1 Nesting/internesting adults

The Pendoley (2006) report on relative, rookery size estimates for flatback turtles suggests that Port Hedland (including Cemetery Beach and Pretty Pool) is a small rookery (maximum 6% of the North West Shelf breeding unit) relative to rookeries at 80 Mile Beach, Mundabullangana Station, Barrow Island, Dampier Archipelago and the Montebello Islands, each of which may comprise ~ 15% (75% total) of the breeding unit. This finding is consistent with the estimates made by Prince (1994). Both of the main Port Hedland rookeries are separated from Utah Point by the Port Hedland port and industrial area and urban areas (Figure 3.1).

Flatback turtles spend the time between laying successive clutches of eggs on internesting grounds. The preliminary results from satellite tracking of flatback turtles at Barrow Island suggest that these internesting grounds are close to their mainland rookeries (Pendoley unpublished data 2008, http://www.seaturtle.org/tracking listed under Barrow Island and Mundabullangana). To date, none of the internesting flatback turtles studied has been documented using creeks or rivers as internesting habitat (Pendoley unpublished data 2008). Therefore, internesting flatback turtles are not expected to occur in the Port Hedland Harbor, however, targeted studies of flatback turtle movements from Cemetery Beach are required to confirm this.

Figure 3.1: View of Port Hedland showing the major sources of industrial, commercial and urban lighting (yellow shading, as at January 2007) and the recognised flatback turtle nesting beaches.

3.2 Foraging juveniles

Investigations carried out by Dr Pendoley as part of an earlier review of sea turtle habitat usage in Port Hedland Harbour included discussions with personnel familiar with the Harbour area. P Everson (pers. comm. 2007) spent over 40 days surveying the waters within the Port Hedland Harbour and associated creeks during 2006 and 2007. He reported that juvenile turtles are common throughout the area, however, he was unable to identify the species. While the species of the turtles have not been confirmed by a qualified sea turtle biologist, the descriptions of the animals and their behaviour suggest these are primarily juvenile greens (pers. comm. C Wilson, Jan 2007, K Howlett, Jan 2007) and possibly juvenile flatback turtles (pers. comm. C Wilson, Jan 2007). The discovery of a juvenile green turtle drowned in a fish trap up a creek line within Port Hedland harbour provides further evidence to support this assumption (pers. com. L Wheat, 2007).

Juvenile flatback turtles also use the shallow nearshore waters of the Pilbara. This has been confirmed from reports and West Australian Museum records of post hatchling and juvenile material that was collected from Pilbara waters (Pendoley unpublished data 2007) and islands (Pendoley and Ford 2000; Pendoley and Vitenbergs 2003). Juvenile green turtles are commonly sighted in shallow water adjacent to beaches and mangrove root systems

(Pendoley pers. obs.). They utilise the seaward fringes of the mangrove habitat, remaining on the periphery of the root system, presumably to avoid the risk of entanglement and drowning in the densely tangled roots found deeper inside. They have never been observed (Pendoley pers. obs.), nor have they been documented, swimming or crawling inside the mangrove root system.

Over the past 20 years, opportunistic surveys of mangrove habitat have been carried out by WA sea turtle biologists Dr RIT Prince and Dr K Pendoley. Few of these surveys have targeted juvenile sea turtles specifically, however neither Dr Prince nor Dr Pendoley have confirmed juvenile flatback turtle occurrence in a river or creek habitat. Nor have they observed juvenile flatback turtles in the water on the seaward fringes of mangroves (where juvenile greens are often found). Further systematic and focused studies are necessary to confirm the presence or absence of flatback juveniles in this fringing mangrove habitat.

3.3 Foraging adults

The review found a single record of an adult green turtle stranded in the Harbour area in 2006 when the PHPA environmental engineer documented an adult green turtle that had been cut in half and was found floating in the Harbour. While mangrove plants are not considered a primary food source for adult green turtles, they are probably used as a supplemental or opportunistic food source by Pilbara green turtles (Pendoley and Fitzpatrick 1999). The lack of documented seagrass and algae beds within the Harbour area is likely to preclude large numbers of adult green turtles from using these waters for foraging. Furthermore the harbor waters are unlikely to support the sea pen, hard and soft coral habitat (typically found in clear oceanic waters) favoured by flatback and hawksbill turtles for foraging (Pendoley unpublished satellite data, 2008).

3.4 Hatchlings

Little is known about the behaviour of flatback hatchlings after they leave their natal beaches other than they appear to exhibit the same frenzied offshore swimming as green and hawksbill hatchlings which presumably takes them away from shallow water containing numerous predators to the relative safety of deeper water offshore. It is reasonable to assume flatback hatchlings use the wave direction to orient in an offshore direction, in the same manner as green hatchlings (Lohmann and Lohmann 1993). If this is the case, it is unlikely that flatback hatchlings will swim along the prevailing swell direction (northwest), around the dredge spoil sand bar and into the mouth of Port Hedland Harbour. It is possible that hatchlings may be drawn into the Harbour area by strong tidal flows and once inside become attracted to the port and shipping lights, which could trap them until daylight.

It is well accepted by the scientific community that green hatchlings use offshore pelagic habitat as a nursery and hence would not be found in Port Hedland Harbour or in the mangrove habitat. There are no published or anecdotal reports to suggest that flatback turtle hatchlings use the Port Hedland Harbour or creek area. While our scientific knowledge of flatback turtles is very limited, there is nothing in the literature to suggest that flatback hatchlings use mangrove roots as a nursery habitat. It is reasonable to expect that the alternating inundation and exposure of this habitat over the diurnal tidal cycle would preclude its use as a primary habitat.

4 Outcomes of the desktop study objectives

The specific desktop study objectives are discussed individually below.

4.1 Determine the significance of turtle habitat in the vicinity of Finucane Island (particularly West Creek and surrounding mangrove environs);

The mangroves lining the creeks and Harbor area are the primary turtle habitat in the vicinity of Finucane Island. This habitat is alternately inundated and exposed during the daily tidal cycle. The seaward fringe of the mangroves provides habitat for juvenile and adult green turtles on a high tide when the mangroves are inundated and the turtles can swim along the seaward edge of the root system. There is no evidence to suggest turtles ever deliberately penetrate the mangrove root system and they are never reported nor observed using the salt flats behind the mangroves band. The loss of the landward edge of the mangrove and the salt flat habitat will therefore not have any detectable effect on sea turtles.

4.2 Determine the likely turtle species that may utilise habitats in the surrounding area of Finucane Island

Two important habitats for green turtles have been identified in the area surrounding Finucane Island. Developmental habitat used as shelter and possibly foraging by juvenile green turtles and the low hanging leaves along the seaward edge of the mangroves provides secondary foraging habitat for adult green turtles. Limited anecdotal reports suggest there is no evidence to indicate flatback turtles use this habitat, however, this needs to be confirmed by systematic in-water surveys of the area. Hawksbill turtles are not expected to occur in this habitat at all since the juvenile and adult life stages typically use coral reef habitat which does not occur in the Finucane Island area.

4.3 Determine the potential impacts on turtles due to artificial lighting

The life stage that is at greatest risk from exposure to operational lighting are foraging juveniles (green and possibly flatback) within the port and mangrove creek area. While hatchlings are known to use light to assist in sea finding following emergence from the nest, there is currently nothing in the literature, or in anecdotal reports, to suggest juvenile turtles are impacted by light.

Neither hatchlings nor adult turtles appear to routinely enter the Port Hedland Harbour area. Given the existing level of lighting and industrial activity within the port area, it is reasonable to assume these life stages would have been observed before now. Therefore, further discussion is not warranted at this time.

Nesting flatback turtles and emerging hatchlings at Cemetery Beach are currently exposed to the existing urban and industrial lighting. In the absence of any baseline data, it is difficult to determine if this lighting has had an impact on nesting effort of the adults. According to the findings of Salmon *et al.* (1995) and Witherington (1992b), one might expect to see a long-term shift in nesting effort from light exposed beaches to naturally dark beaches. Measuring this shift requires regional, long-term, scientifically sound monitoring programs that are able to identify individuals (e.g. flipper tagging program). In addition there is currently no formal monitoring program in place to assess the impact of light on hatchling orientation at Cemetery Beach. However, anecdotal reports by informal monitoring of nesting turtles on Cemetery Beach suggest that some hatchlings are currently being misoriented by light, i.e., delaying seafinding upon emergence from the nest.

4.4 Determine the potential impacts on turtles due to increased vessel movements

An increase in vessel movements in and out of the Harbour will increase the risk of boat strike on turtles sharing the waterway. This can be managed by enforcing vessel speed limits within the Harbour area. A systematic program for reporting stranding observations to the DEC Strandings Database should be implemented for Port Hedland Harbour so that this risk can be quantified.

4.5 Determine the potential impact to known nesting grounds and the significance of these impacts (e.g. cumulative light emissions).

Differentiating the effects of the PHPA project from the existing industrial and urban infrastructure is not possible, particularly in the absence of any long-term, rigorous monitoring data on sea turtles. Sea turtles exhibit cyclic behaviour in nesting which results in day-to-day, week-to-week and year-to-year variations in nesting attempts. Individuals have also been documented moving between nesting beaches within the same season (unpublished data K Pendoley). It is no longer possible to establish the natural (pre human activity) baseline for nesting effort at Port Hedland, nor does a current baseline exist (e.g. nesting effort under the influence of current lighting regimes) with which to compare the effects of a new development. Without any baseline data, it would be difficult to prove conclusively that a new development has caused an impact over both the normal cyclic variation in nesting behaviour.

The same logic applies to hatching behaviour. Hatchling orientation on dark beaches is affected by beach topography and moon cycles (Pendoley 2000) and is often specific to an individual beach. Hatchlings may already be misoriented by light on Cemetery Beach and attempting to distinguish the effects of the current light regime from any additional light emissions from the Utah Point site could not be done with any confidence.

4.6 Identify mitigation / management measures to minimise the overall light emissions from the development.

The primary objective for managing lights near turtle nesting beaches is to minimise the amount of light directed into the sky. The direct glow from lights is exacerbated further when it is reflected off clouds, so it is important to minimise the upward direction of lights. Measures that can be implemented to minimise light spill include:

- Avoid high wattage, high intensity white lights (e.g. fluorescent, metal halide, halogen, mercury vapour) where possible
- Use orange/yellow bulbs where possible (e.g. low pressure sodium, high pressure sodium)
- Use low wattage light sources to minimize the intensity of light
- Keep lights low to the ground, avoid placing them high over equipment
- Direct all lights downwards or straight onto work areas, minimize overspill of light from work areas
- Shield lights to prevent any upward glow
- Consider putting lights on motion sensors or timers, turn them off when an area is not being accessed by personnel
- Consider using low profile and low intensity bollard lighting
- Consider embedded road lighting or cats eyes on roadways
- Consider using reflective material in place of lights
- Consider using matte paint to reduce reflection of light
- Consider using personal light sources in areas requiring high intensity white light to read instruments
- Maintaining or restoring the dark horizon on nesting beaches

Construction activity typically requires a large amount of intense white light. Flatback hatching peaks during January – March while lesser hatchlings may occur during the shoulder months (December and April).

The effects of lights on turtles within the Harbour area is difficult to quantify in the absence of sound scientific data on the effects of light on turtles in the water and on the number, species and age range of turtles using the Harbour area. The results of this review suggest juvenile green turtles are most commonly found in the Harbour area, while few adults of either species have been reported and no hatchlings. While the literature suggests that no experimental studies have been carried out on the effects of bright lights on juvenile or adult sea turtles in the water there have been no reports (scientific or otherwise) to suggest that adult or juvenile turtles are attracted to lights over the water.

Given the amount of lighting currently present in the Harbour area, it would be reasonable to assume that some evidence of this would be apparent if it was a major risk factor. Consequently it is expected that any impacts associated with construction and operational lighting on turtles that use the Harbour are minor and possibly limited to temporary night-blindness, such as occurs in humans following exposure to a bright light. Implementation of light management strategies aimed at minimising light spill and sky glow is recommended as good management practice, for PHPA and every other operator using the Harbour area.

5 Conclusions

The following conclusions can be drawn from this review:

- The flatback nesting population at Port Hedland is small relative to the major rookeries within the Pilbara breeding unit (e.g. Barrow Island, Montebello Islands, Dampier Archipelago, Mundabullangana and 80 Mile Beach).
- Juvenile green turtles routinely use the waters of Port Hedland Harbour and mangrove creeks. Juvenile flatback turtles may use these waters but anecdotal reports are yet to be confirmed by qualified scientists.
- Hawksbill turtles are not expected to occur in the vicinity of Finucane Island or Port Hedland Harbour due to the lack of the coral reef habitat they are typically found in.
- Hatchling green or flatback turtles do not actively swim into the Harbour.
- Hatchlings do not use mangroves as nursery habitat.

- Juvenile green turtles may use the edges of the mangroves on high tide, they do not penetrate the mangrove system and do not use the landward edge of the mangroves or the salt flat habitat.
- Mature adult turtles do not appear to *routinely* use the Harbour waters.
- There is no nesting habitat within the Port Hedland Harbour area; flatback turtles nest on coastal beaches over 3km away.
- There is not publicly available information on turtle nesting of Finucane Island beaches.
- Based on the current literature and anecdotal reports, juvenile green turtles are not known to be adversely affected by light.
- Flatback turtles nesting at Cemetery Beach are currently exposed to industrial and urban lighting.

Within the constraints of human safety requirements, lighting design at the proposed Utah Point Berth development site should aim to reduce lights as follows so as to minimize adding additional light to the existing sky glow over Port Hedland Harbour. The design should:

- Use long wavelength light instead of short wavelength light (i.e. sodium vapour light is preferred over metal halide, fluorescent and halogen light).
- Reduce light spillage outside of work areas and into sky (shield, direct and lower the height of light fixtures).
- Reduce light intensity by using low wattage bulbs.

The cumulative impact of well-managed lighting from the proposed Utah Point Berth development is unlikely to be detectable at Cemetery Beach, given the 3 km distance.

6 Recommendations

Any monitoring program attempting to isolate the effects of the Utah Point Berth development are likely to be unreliable due to the confounding impacts of the un-quantified industrial and urban lighting that currently exists within the Port Hedland area. A range of monitoring options is recommended. Most of these are aimed at establishing a reliable baseline data set on the species that use the waters of the Port Hedland Harbour and regional nesting beaches.

- Confirm the number and species of juvenile turtles that use the mangrove creeks of the Port Hedland Harbour and Finucane Island area.

Any information on habitat use by juvenile flatback turtles in WA waters would add to the very limited knowledge currently available on flatback turtle (hatchling, adult or juvenile) habitat use.

- Survey the regional beaches east and west of Port Hedland for nesting effort and species use to put the local beaches into a regional perspective.

Significant regional nesting sites for flatback turtles occur at 80 Mile Beach and Mundabullangana Station. No information is available on flatback turtle nesting on the coastline between Port Hedland and these regionally important rookeries. Identification of other rookeries near to Port Hedland would not only put the size of the town's rookeries into perspective, but would also identify any potential reference sites for monitoring programs at Cemetery Beach and Pretty Pool

- Collect local knowledge of sea turtle sightings. This information can then be used to target specific areas for further surveys that may support important habitat for sea turtles (e.g. foraging, internesting or mating habitat).

Currently there are no habitat maps available for sea turtles in WA. Any information will form a basis for targeting further habitat use surveys.

- Initiate a hatchling orientation monitoring program at Cemetery Beach.

This program will establish the current baseline hatchling emergence behaviour at Cemetery Beach and will indicate which direction hatchlings are currently moving towards when they emerge from nests on Cemetery Beach. Long term monitoring could be used to measure the effects of changes in lighting on hatchling behaviour.

- Monitor the behaviour of turtles in the water off Utah Point during construction and operations.

A program designed along the lines of those used by Mammal Observers on seismic vessels could be implemented to monitor sea turtle behaviour off Utah Point during construction and operation of the port facility.

- Initiate a flatback turtle tagging program on Cemetery Beach, Pretty Pool and a reference beach (no artificial lighting) near to Port Hedland.

Flipper tagging is recognised as the most appropriate and reliable way to identify individual sea turtles for long-term monitoring programs. The type of information that can be extracted from flipper tagging programs include nesting population size, renesting migration intervals, internesting intervals, growth rates, movements between nesting beaches and can be used to carry out computer based population modeling.

- Conduct further field trials to develop and refine instruments for quantifying low light levels.

The current commercially available equipment used to measure lighting is inadequate for sea turtle research and requires additional refinement to better target and quantify light sources.

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