Appendix Q.

Potential Impacts of Pipeline Installation Activities on Marine Turtles (Pendoley 2017)

CDM Smith

ConocoPhillips Barossa Project – Potential Impacts of Pipeline Installation Activities on Marine Turtles

REV 1

Prepared by

Pendoley Environmental Pty Ltd

For

CDM Smith

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1 INTRODUCTION

ConocoPhillips, as proponent of the Barossa Area Development, is progressing early-stage environmental assessment of a potential field development concept in the Timor Sea, 300 km north of Darwin, Northern Territory (NT). As part of this development concept, a potential gas export pipeline connection is being evaluated to connect the offshore gas field to the existing Bayu-Undan to Darwin gas export pipeline.

On behalf of ConocoPhillips, CDM Smith has requested Pendoley Environmental, as Subject Matter Experts, to provide an independent review and professional opinion on the potential impacts of the Barossa gas export pipeline installation, on local marine turtles, as it passes through waters west of the Tiwi Islands (**Figure 1**).

At this early stage, a broad corridor for the gas export pipeline has been identified, and therefore this assessment conservatively assumes a pipeline alignment at its eastern-most extent that is closest to shore, which may not be the case if future route selection determines a deeper water alignment further to the west. This therefore represents a conservative assessment of the potential interactions with marine turtles in the vicinity.

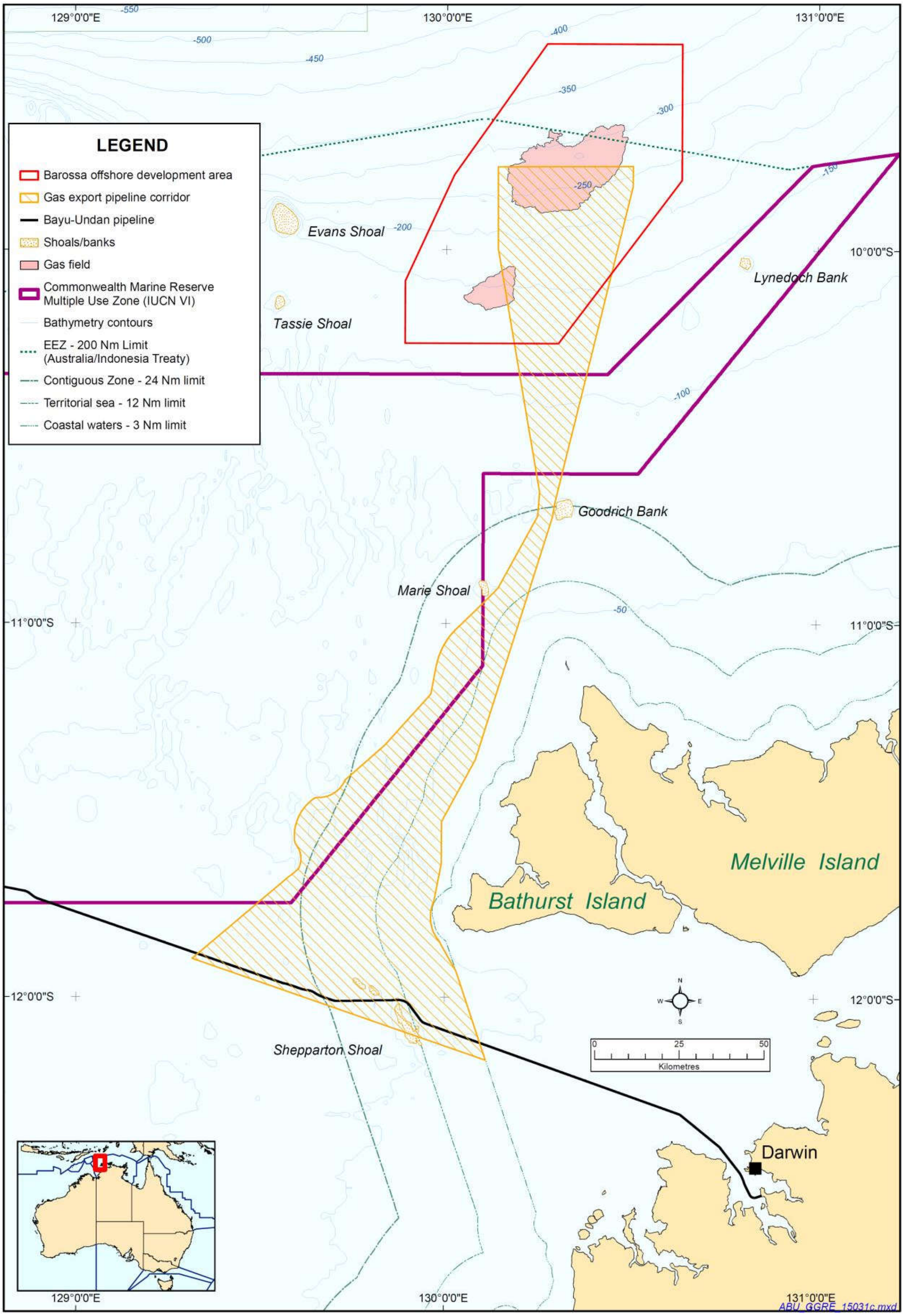


Figure 1: Barossa Project pipeline corridor location relative to Tiwi Islands.

2 OBJECTIVES

The objective of this study is to review published and grey literature with a focus on the impacts of artificial light on marine turtles as a priority, and to include a review of the impact of the physical presence of vessels and noise on marine turtles.

The project scope is as follows:

1. Review of the current Biologically Important Areas (BIA) boundaries using recent publications on flatback turtle internesting behaviour by Whittock et al. (2014, 2016), to more precisely define the likely internesting zone to the north and west of Tiwi Islands (primarily Bathurst and Melville Island).

2. Development of a project specific impact assessment, within the context of the site specific factors (e.g. local turtle species and their habitat usage, seabed bathymetry, benthic habitats, distance of the project footprint offshore, temporary nature of the light source, currents, tidal influences, existing anthropogenic light sources). The assessment will:

    a. Target the highest conservation value receptors (i.e. internesting flatback and olive ridley females turtles and dispersing hatchlings);

    b. Integrate the site specific factors to define a notional area extent at which potential impacts may be anticipated; and

    c. Form a conclusion on whether the proposed activities represent a significant risk to flatback and olive ridley turtles at a population level, as per Department of the Environment and Energy's 'Significant Impact Guidelines 1.1 – Matters of National Environmental Significance'.

3 ASSESSMENT SCOPE

3.1 Local Species Status and Nesting Seasonality

The species that are the focus of this assessment, flatback and olive ridley turtles, are listed as vulnerable and endangered, respectively, under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Marine turtles are long lived, migratory animals who are slow to reach sexual maturity; they nest every 1 – 9 years, producing 1-3 clutches and show no paternal care following egg nesting (Bjorndal *et al,* 2013; Miller, 1997; Hirth, 1980).

Population estimates for Tiwi Island regional nesting populations of marine turtles have been reported using a mix of aerial track census and ground based surveys by Chatto & Baker (2008). The west coast beaches of Bathurst Island and the north coast beaches of Melville Island are dominated by flatback turtle nesting followed by dispersed olive ridley nesting Whiting et al 2007a). Flatback turtles are endemic to Australia, their nesting range extending from the Pilbara region of Western Australia (WA), across the NT into Queensland (Limpus et al. 1988, Chatto & Baker 2008, Pendoley et al. 2014, Pendoley et al. 2016). Extrapolation of tagging data from the Pilbara, together with track census results from Cape Domett and the Tiwi Islands suggests that flatback turtles nest in the tens of thousands throughout this range (Pendoley et al. 2014, Whiting et al. 2008). Studies undertaken by Chatto & Baker (2008) along sections of coastline in the NT, including the Tiwi Islands, observed that estimates suggest high numbers of flatback turtles nest in five segments (Segments 3.5 to 3.9; **Figure 2**) of the Tiwi Islands coastline, producing in the order of thousands of nests annually.

In comparison, olive ridley turtle nesting is geographically constrained, restricted to nesting sites in the NT and western Cape York in Queensland (Chatto & Baker, 2008). The Species Nesting Map for olive ridley turtles provided in the Commonwealth Recovery Plan for Marine Turtles in Australia (Department of the Environment and Energy (DoEE) 2017), together with Chatto & Baker (2008), identify the Tiwi Island rookeries as matters of national environmental significance supporting high levels of annual nesting (thousands of nests/year), compared to the wider geographical region which reports approximately 1000 nests/year (Indonesia), 100's nests/year (Myamar and Brunei) and <50 nests/year (Papua New Guinea, Malaysia, Thailand and Vietnam) (see Jensen et al. 2013 and references therein). The greatest concentration of olive ridley turtles has been recorded around Cape Van Diemen and on Seagull Island (Segment 3.8 and 3.9, respectively; **Figure 2**) (Whiting et al., 2007a).

Both flatback and olive ridley turtles nest at low numbers year round in the NT, however there are recognised windows of peak breeding activities during the Austral winter, as shown in **Table 1** (M Guinea pers comm.; DoEE 2017).

Table 1: Annual activity calendar for olive ridley and flatback turtles in the Tiwi Islands. Light grey: year round low level, dispersed activity; dark grey: peak months for each activity.

Species/Life Stage	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flatback (Arafura stock, Tiwi Islands)												
Nesting												
Internesting												
Hatchlings												
Olive Ridley (NT stock, Tiwi Islands)												
Nesting												
Internesting												
Hatchlings												

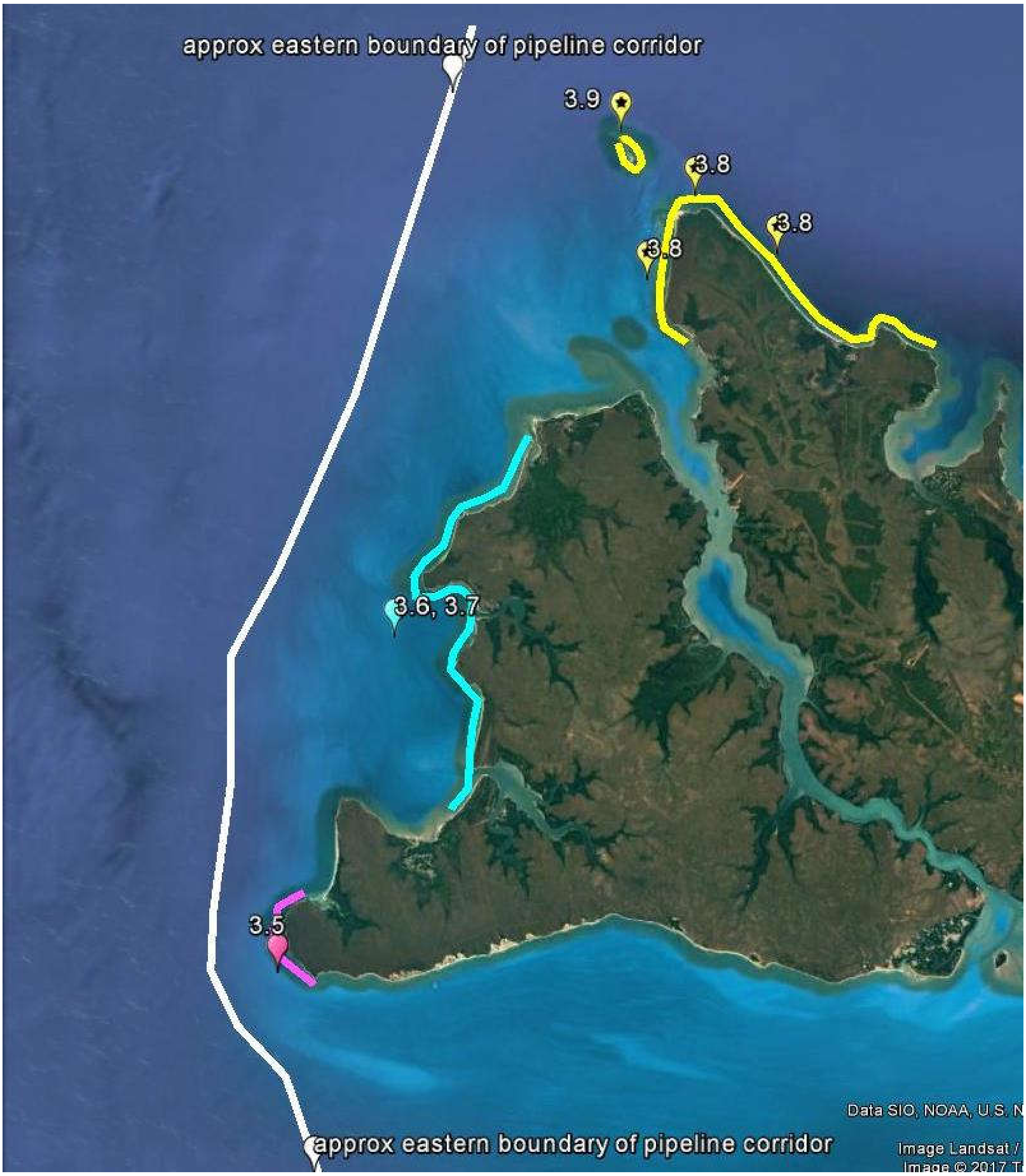


Figure 2: Location of nearshore pipe lay corridor boundary relative to Tiwi Islands marine turtle nesting beaches. Survey segment codes 3.5 – 3.9 from Chatto & Baker (2008).

4 IMPACT ASSESSMENT OF BAROSSA PIPELINE INSTALLATION

4.1 Project Description

The vessels required for the installation of a pipeline typically comprises a slow moving pipe lay vessel and an attendant supply vessel that may or may not be permanently stationed in the vicinity of the pipe lay vessel. The entire gas export pipeline will be installed over an approximately 6 – 12 month period, potentially across the peak of the flatback and olive ridley turtle internesting/nesting seasons. The pipeline corridor traverses the floor of the Timor Sea, including a portion to the west of the Tiwi Islands, approaching to within approximately 6-7 km at its closest point near Cape Fourcroy in the southwest, approximately 12 km off Rocky Point on the mid-west coast and approximately 18 km off Seagull Island to the northwest (**Figure 3**). Water depths along the eastern edge of the pipeline corridor range from approximately 20 m deep northwest of Rocky Point to 50 m deep as the corridor rounds Cape Fourcroy, to the west of Bathurst Island.

The existing predominant source of light, boat strike and underwater noise in the pipeline corridor has been identified as commercial shipping. However, the most heavily used shipping routes are located to the south of the Tiwi Islands

4.2 Internesting Females

4.2.1 Literature review

An exhaustive analysis of a large dataset of 47 internesting flatback turtles satellite-tracked from five different mainland and island rookeries and providing 5402 internesting positions over 1289 tracking days showed flatback females remained in water depths of <44 m, favouring a mean depth of <10 m (Whittock et al. 2016). These results were consistent with those of Sperling et al. (2010) who observed flatback turtles off Bare Sand Island in the NT in a maximum depth of 44 m.

Whittock et al. (2016) defined suitable internesting habitat as water 0 – 16 m deep and within 5 – 10 km of the coastline while unsuitable internesting habitat was defined as water >25 m deep and >27 km from the coastline (Whittock et al. 2016). Flatback turtles generally demonstrate internesting displacement distances of 3.4 – 62 km from the nesting beach, typically confined to longshore movements in nearshore coastal waters or traveling coastal waters between island rookeries and the adjacent mainland (Whittock et al. 2014). There is no evidence to date to indicate flatback turtles swim out into deep offshore waters during the internesting period.

The literature on internesting olive ridley turtles is less complete than flatback turtles. Eight internesting olive ridley turtles, satellite tracked post-nesting from Cape Van Diemen on the Tiwi Islands, were initially recorded travelling ‘slowly’ through waters 45 – 55 m deep at distances 17 – 37 km from the nesting beach before moving into shallower water, waiting offshore from the nesting beach in the days prior to renesting (Whiting et al. 2007, Whiting et al. 2005). The internesting habitat was located to the north and west of Cape Van Diemen. The selection of this internesting habitat appears to be deliberate given that two olive ridleys tracked from Groote Eylandt (approximately 700 km east of Cape Van Diemen) travelled long distances of 125 and 200 km during extended internesting periods, and it is understood that this behaviour may be linked to a relatively low metabolic rate in this species (Hamel et al. 2008, McMahan et al. 2007).

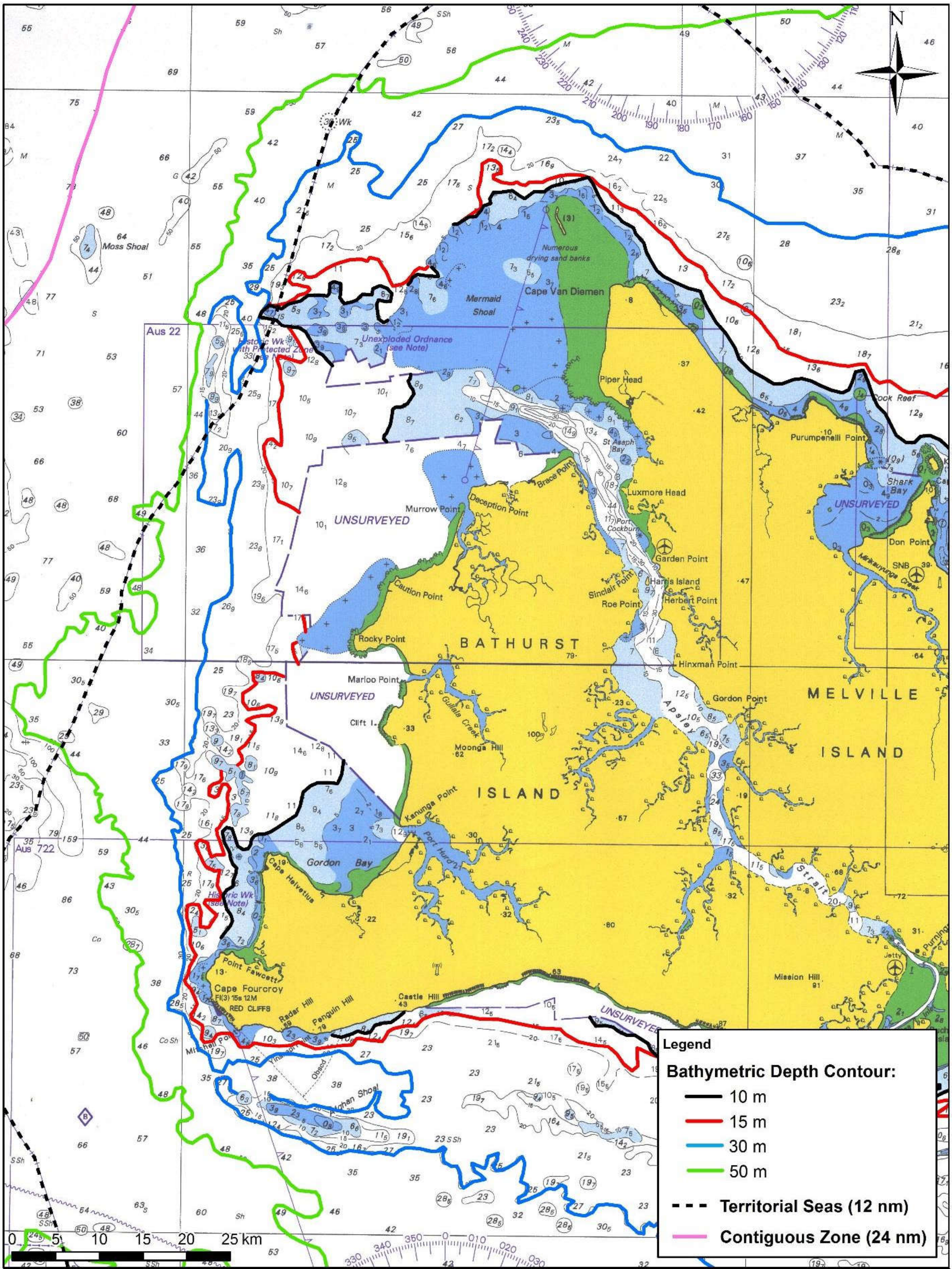
Similar internesting behaviour was observed in olive ridleys tracked in the Atlantic Ocean. The internesting habitat described for four of five olive ridleys nesting in the mouth of the Congo River in Angola travelled over 50 km from the nesting beach along the coast, remaining within waters 6 – 20 m deep. A fifth animal selected internesting habitat <6 m deep and within 4 km of the nesting beach (Pikesley et al. 2013, K Pendoley *pers obs* 2009).

Vessel collision with adult turtles is recognised as a cause of sea turtle mortality when they bask on the surface, rise to the surface to breathe or surface as a 'startle' response to a sudden sound (dredging noise, explosions) or visual cues (MMS 2007). The collision risk between vessels and sea turtles is linked to vessel speed; specifically, turtles are struck by boats travelling at 11 km h^{-1} more often than by boats travelling at 4 km h^{-1} (Hazel et al. 2007). In the US, 9 % – 18 % of stranded turtles displayed boat strike injuries (Lutcavage et al. 1996) while in Queensland, 56 % of 139 stranded turtle records showed injuries consistent with boat strike (Haines & Limpus 2000). Species impacted included green, loggerhead, hawksbill and olive ridley turtles.

While sound induced stress in marine turtles has been documented (Samuel et al. 2005) turtles have also been observed rapidly acclimating to regular, continuous noise (O'Hara & Wilcox 1990, Dickerson et al. 2004, Geraci & Aubin 1980, Whittock et al. 2017), with the response dependent on the distance from the sound source (Bartol et al. 1999).

The bulk of the large and apparently stable nesting population of flatback turtles using the west and north coast beaches of the Tiwi Islands for nesting are expected to use the shallow nearshore waters adjacent to the Bathurst Island and Melville Island coast for internesting; in <16 m deep and within 10 km of the coastline (Whittock et al. 2016) with individuals occasionally moving into waters up to 44 m deep (within 5 – 15 km of the coastline). While most of the nesting females in the area are not expected to inter-nest within the pipeline corridor it is possible some individuals will use waters extending into the corridor up to 50 m deep (**Figure 3**). The seabed characteristics off Cape Fourcroy (i.e. narrow continental shelf, steep seabed slope and relatively high current speeds) are not typical of the internesting habitat used by flatback turtles and consequently they are unlikely to inter-nest in the pipeline corridor waters in this area. Further to the north where the continental shelf is wider and slopes more gently offshore, the 10 m deep internesting grounds are located approximately 10 – 20 km inshore of the pipeline corridor.

While the literature is less complete regarding Australian olive ridley internesting behaviour, the females nesting on Cape Van Diemen and Seagull Island beaches are expected to move through the waters <55 m deep and < 37 km from the coast during the average 1.5 internesting periods (Marquez 1990). In the days prior to nesting, the olive ridley turtles, like flatback turtles, are likely to rest on the seabed in the shallow waters off their nesting beaches (Whiting et al. 2005), approximately 10 – 20 km away from the pipeline corridor. While the majority of the nesting olive ridley females are not expected to inter-nest within the pipeline corridor it is possible some individuals will use waters extending into the corridor up to 55 m deep.



J54001 CDM Smith

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PENDOLEY ENVIRONMENTAL
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Figure 3: Bathymetry and territorial sea boundaries.
NOT TO SCALE

4.2.2 Impact Assessment

The number of internesting females potentially exposed to the pipelay operations over the approximate 6 – 12 month period the pipeline installation will take to complete will be generally low due to the presence of low level nesting effort throughout the year, and will increase during the April to September peak in nesting of both species.

The threats to the few individual internesting females that may occur in the pipeline corridor include; light, boat strike and underwater noise, in addition to the current levels of risk posed by the existing shipping in the area.

There is no evidence, published or anecdotal to suggest internesting turtles are impacted by light from offshore vessels, and nothing in their biology would indicate this is a plausible threat. The physical presence and risk of boat strike the pipelay vessel anchored or moving slowly through the ocean is also not expected to impact internesting females. Fast moving supply vessels are a greater risk of boat strike (Hazel et al. 2007), however Whittock et al. (2017) found no evidence of vessels associated with a full dredge spread causing an increase in boat strike in shallow waters <5 km offshore from a major flatback rookery on Barrow Island. This lack of impact is likely due to the internesting turtles resting on the seabed, physically removing them from the surface activity of the vessels.

Noise from the project will be confined to engines on the pipe lay vessel and supply vessels. This low level constant noise will be audible over a long distance and will not cause a startle response in turtles. It is likely animals in the vicinity will become rapidly habituated to the sound.

4.3 Dispersing Hatchlings

4.3.1 Literature Review

Following an incubation period of between 37 – 85 days (flatback) and 42 – 63 days (olive ridley) (Hirth 1980, Miller 1985, Whiting et al. 2008, Pendoley et al. 2014) hatchlings emerge from the sand, crawl to the ocean and swim offshore, under the influence of tides and currents, into deeper, less predator rich, waters. Hatchlings rely on their internal egg yolk reserves to sustain the offshore migration for the first 3 – 6 days at sea until they intercept food, typically associated with seaweed rich convergent zones (Trullas et al. 2006). This offshore migration occurs in the top 30 cm of the ocean in both species and this swimming behaviour is regularly interrupted by rest periods when hatchlings float on or near seaweed at the sea surface (Duran & Dunbar 2015, K Pendoley pers obs).

Coastal tides and surface currents in excess of approximately 0.5 knots will carry hatchlings offshore. While larger than all other hatchlings, flatback turtles typically swim at <0.4 ms (0.8 knots) which is consistent with other marine turtle species (Wyneken 1997, K Pendoley pers obs). Unlike the olive ridley, flatback turtles do not have an oceanic (pelagic) phase instead residing exclusively in neritic (i.e. shallow) waters on the Australian continental shelf (Walker & Parmenter 1990). The coastal dispersal of flatback hatchlings is facilitated by the inshore location of nesting beaches, local water circulation and directional swimming as the hatchling grows (Wildermann et al. 2017).

Hatchlings emerging from the sand locate the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon and away from elevated silhouettes of dunes and/or vegetation bordering the beach on the landward side (Limpus 1971, Salmon et al. 1992, Limpus & Kamrowski 2013, Pendoley & Kamrowski 2017). Hatchling behaviour is impacted by both direct, point source lighting (e.g. unshielded lights) and indirect 'sky glow' an accumulation of light from multiple sources (Salmon et al. 1995, Salmon 2006, Kamrowski et al. 2014). Hatchling orientation has been shown to be disrupted by light produced at distances of up to 18 km from the nesting beach (Hodge et al. 2007, Kamrowski et al. 2014). The relative brightness, and therefore potentially disorienting impact of artificial lighting, fluctuates as a function of moon phase (Salmon & Witherington 1995, Pendoley 2005), and the amplification effects of cloud cover (Kyba et al. 2011).

A substantial body of research exists which demonstrates most species of turtle hatchlings, including olive ridley and flatbacks, show a preference for (and are therefore more influenced by) shorter wavelength, high intensity light (Witherington & Bjorndal 1991a, Witherington & Bjorndal 1991b, Witherington 1992, Pendoley 2005, Pendoley & Kamrowksi 2016, Karnard et al. 2009). Light rich in short wavelength emissions are the most disruptive to hatchling sea-finding behaviour in all species of marine turtles (Pendoley & Kamrowski 2016).

Once hatchlings enter the ocean, an internal compass set while crawling down the beach, together with wave cues, are used to reliably guide them offshore (Lohmann & Lohmann 1992, Stapput & Wiltschko 2005). In the absence of wave cues however, swimming hatchlings have been shown to orient towards light cues (Lorne & Salmon 2007, Harewood & Horrocks 2008). Research quantifying swimming hatchling response to artificial lights is lacking but hatchlings have been documented 'pooling' in areas of artificial light offshore (Limpus 1991).

The paucity of data describing the impact of offshore light on hatchling behaviour during their initial offshore migration is due to the highly variable environmental conditions and logistical complications implicit in these studies. Acoustic tracking methods have, however, shown that over short distances of up to 150 m, flatback hatchlings are more influenced by light than wave cues (i.e. the light cue overrode the wave cue). Hatchlings were not trapped indefinitely in light pools and eventually continued the migration offshore (Thums et al. 2013; 2016). Hatchlings may be exposed to an increased risk of predation when trapped in light spill from vessels.

There is no published or anecdotal information on the impacts of underwater noise on hatchlings. It is possible they will be sensitive to sound in the same way as adults, though this will depend on the development on the internal ear structure.

4.3.2 Impact Assessment

Both species of hatchlings leaving the Tiwi Islands nesting beaches will swim offshore under the influence of tides and currents dispersing over large geographical areas of the ocean. Limited observations on hatchling behaviour as they leave the beach suggests that they will search out and use floating weed to rest on after several hours of swimming (Trullas et al. 2006, K Pendoley pers obs). This, together with the overriding influence of tides and currents (stronger than 0.5 knot) on swimming speeds, will carry the hatchlings to some common convergent zones where they will use floating rafts of seaweed for shelter and foraging (Musick & Limpus 1997). The primary threat hatchlings face from the pipe lay operations is the attraction to vessel lights and predation within the light spill zone.

Overnight observations of flatback turtle hatchlings trapped by the light spill from a pipelay barge moored approximately 10 km off the east coast of Barrow Island found hatchlings remained within the light spill in the lee of the barge all night until dawn when they swam away from the barge and were carried away by currents (K Pendoley pers obs 2003). None of the monitored hatchlings were predated. These observations, together with experimental results that demonstrated the attraction of hatchlings to light at sea over 150 m (Thums et al. 2016), suggests that hatchlings carried by currents into the vicinity (estimated 500 – 1000 m) of a pipe lay barge can become trapped by light. The 2010 study by Thums et al. found this light trapping was very temporary (minutes) possibly due to the small size of the vessel which did not provide the same shelter from tides as a pipe lay vessel (K Pendoley pers obs). The risk of trapping and possible predation is greatest in the southern end of the pipeline corridor where it passes at its closest point to Bathurst Island off Cape Fourcroy.

The risk of this occurring is considered relatively low when taking into account: the limited time the pipe lay vessel and associated support vessel will be present on any one location off the west coast of the Tiwi Islands, the temporally restricted four month peak hatchling season (June – September), the low risk of hatchlings intersecting a small zone (approximately 500 m – 1000 m) around the pipe lay vessel over which they might be influenced to orient towards the vessel lights, the low likelihood the hatchlings will be in slow moving water (< 0.5 knots) that will allow them to swim against a current towards, and the short (overnight) time frame the hatchlings could be trapped. Any hatchlings that do become trapped in the light spill from a vessel may be at risk from an increased risk of predation however the risk of this is likely reduced due to the distance offshore from predator rich inshore waters. The risk to the olive ridley and flatback turtle populations from the proposed project is therefore considered to be low and undetectable against normal population fluctuations.

4.4 BIA Assessment

Currently the Biological Important Area (BIA) as defined by the Recovery Plan and the Commonwealth EPBC site (National Conservation Values Atlas) ranges from 60 – 80 km for flatback turtles. These boundaries are intended to provide additional protection for internesting turtles nesting on the Tiwi Islands. Recently published literature describing the range of flatback turtle internesting habitat can now be used to better refine these boundaries for more effective protection this species during this life-stage.

The following boundary limit is presented here for consideration. The existing 24 nm (44.5 km) Contiguous Zone boundary, as shown in **Figure 3**, would comfortably encompass the olive ridley and flatback internesting habitat (including Seagull Island) and is beyond the 50 m depth contour to the north and west of the Tiwi Islands.

5 CONCLUSIONS

The installation of the Barossa gas export pipeline is not expected to form a significant risk to flatback and olive ridley turtles at a population level, as per DoEE's Significant Impact Guidelines 1.1 – Matters of National Environmental Significance. This conclusion is based on the following points:

1. There is a spatial separation (approximately 10 – 20 km) between the favoured coastal internesting habitat for flatback and olive ridley turtles, and the offshore pipeline corridor.

2. The relatively short 6 – 12 month time frame of the pipeline installation is insignificant within the context of the long breeding period of marine turtles and so the time frame the breeding females are potentially exposed to the project is low.
3. Pipelay vessels are mobile and will not be on any one location for extended periods of time. Any exposure of internesting females or dispersing hatchlings to project related risk will be temporary.
4. The seasonally dispersed nesting behaviour reduces the risk of exposure to the entire breeding population.
5. While migrating offshore, hatchlings will be dispersed by currents across large areas of ocean, under the influence of tides and currents which will reduce the opportunity for individuals to intercept or pool around a vessel.
6. Hatchlings are unable to swim against fast moving tides and currents and a few individuals might be trapped by light spill from a vessel if they are carried directly to the vessel location by tides or currents.
7. Hatchlings will only be able to engage in directional swimming (i.e. to actively swim directly towards a vessel light) during the few hours a day when water speeds are very slow or at slack water and will be swept away as the tide gains strength. The number of individuals potentially impacted are expected to be low.
8. The current large (60 – 80 km) BIA boundary to the north and west of Tiwi Islands can be re-assessed based on recent publications that indicate internesting habitat for flatback and olive ridley turtles is in shallow water closer to shore and can be comfortably encompassed by the Contiguous Zone Boundary (24 nm, 44.5 km).

An assessment against the significance impact criteria in the Significant Impact Guidelines 1.1 – Matters of National Environmental Significance is provided in Table 2. Note, the assessment has been undertaken against the endangered species criteria, as this represents a more conservative approach.

Table 2: Assessment against the significant impact criteria

Significant Impact Criteria	**Assessment of Significance**
Lead to a long-term decrease in the size of a population	No significant impact at a population level Due to the short time frame of the activity, the spatially restricted area of impact, the lack of identified risk and the limited number of individuals that might be exposed to the activities.
Reduce the area of occupancy of the species	No significant impact on area of occupancy of the species. Due to the limited degree of overlap between the pipeline corridor and the defined internesting habitat and the limited impact of vessel lighting on hatchling dispersal.
Fragment an existing population into two or more populations	No significant impact. The project will not fragment the population.
Adversely affect habitat critical to the survival of a species	No significant impact. Due to the spatially and temporally limited duration of the activities, footprint of the pipe lay spread, overlap between the project area and the internesting habitat, the speed of tides and currents sweeping hatchlings along and the small number of

Significant Impact Criteria	**Assessment of Significance**
	individuals animals that might be present, both in the internesting habitat and in the surface waters used by dispersing hatchlings
Disrupt the breeding cycle of a population	No significant impact at a population level Due to the short time frame of the activity, the spatially restricted area of impact, the lack of identified risk and the limited number of individuals that might be exposed to the activities.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No significant impact to population. The small amount of habitat potentially removed by the installation of a pipeline will be balanced by the creation of artificial reef habitat once the pipeline is installed.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	No significant impact at population level. No invasive species risks have been identified by this assessment.
Introduce disease that may cause the species to decline	No significant impact at population level. Assuming all AQIS guidelines for vessels are followed there are no identified risks of introduced disease.
Interfere with the recovery of the species	No significant impact at population level. No threats to the recovery of the species were identified during this assessment.

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