

Issue

In light of the port design being refined and subsequent improved understanding of the noise emissions from piling, and higher resolution bathymetry data becoming available, the underwater noise modelling previously conducted for the Strategic Assessment Report (SAR) and the Derived Proposal has been re-visited.

The remodelling of the underwater noise generated by piling operations identified two errors related to the modelling results previously reported in the SAR:

- A human error when inputting the source level. As opposed to the specified source level of 205 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$, a source level of 192 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ was actually used.
- A curve fitting algorithm applied to the noise model used in the assessment presented in the SAR was incorrect, causing the model to over predict noise levels in the near field (<100 m) and underestimate levels at greater than 100 m from source.

The modelling errors identified during the review mean that potentially the impacts described in the SAR from the proposed piling activities, are inaccurate.

Impact Assessment – as presented in SAR

Noise and vibration in the underwater environment can result in a range of responses including temporary or permanent loss of hearing sensitivity, other physical injuries, and behavioural changes such as avoidance of the activity area.

Fish

The SAR recognised that there is potential for impacts to fish in proximity to construction related activities that emit intense levels of noise (e.g. piling). McCauley and Salgado Kent (2008) proposed three impact zones for wild fish extending from pile driving:

- Zone 1 (10–20 m away from source): fish within this zone can suffer serious internal injuries.
- Zone 2 (up to 300 m away from source): at 20 m most fish are expected to suffer some form of hearing damage or temporary threshold shifts from continual impact piling. At 300 m some fish, presumably stationary for long periods of time during continuous impact piling, can begin to suffer hearing damage or temporary threshold shifts.
- Zone 3 (out to 500 m away from source): impacts on fish at this zone can include behavioural responses such as avoidance or startle response to increased alertness.

Cetaceans and Dugongs

The SAR (Part 3, Section 2.6.3.1) determined that high intensity impulsive noise emitted during piling overlaps the frequency range of hearing in cetaceans and dugongs and has the potential to cause temporary threshold shift (TTS) or permanent threshold shift (PTS) in the hearing of individuals at close ranges, as well as behavioural disturbance at further distances. Possible behavioural responses include changes in swimming speed, direction and dive profile; localised deviations in migratory patterns; displacement from foraging or resting areas; brief to moderate shift in group distribution; short term cessation or modification of vocal behaviour, and brief separation of females and offspring (McCauley *et al.*, 2000; Southall *et al.*, 2007; Tyack, 2008; and Weilgart, 2007).

Cetaceans are sub-divided into three hearing categories based on their hearing frequency ranges: low frequency (baleen whales such as humpbacks), mid and high-frequency (toothed whales such as dolphins and sperm whales) (Southall *et al.*, 2007).

The assessment presented in the SAR identified thresholds (or criteria for physical injury and behavioural disturbance as a guide for predicting potential impacts to marine mammals from noise related to construction activities associated with the marine infrastructure of the Precinct port facilities. The injury criteria for marine mammals exposed to noise events (i.e. single pulses, multiple pulses and non-pulses) are based on Southall *et al.* (2007) and are presented as received peak pressure level and sound exposure level (SEL). These criteria mark the expected onset of permanent threshold shift (PTS). The Southall *et al.* (2007) physical injury criteria are based on experiments conducted on mid frequency cetaceans (i.e. beluga whales and bottlenose dolphins). Due to the lack of data for low frequency cetaceans (i.e. humpback whales), the criteria for mid frequency mammals is recommended as a conservative threshold by Southall *et al.* (2007) as a surrogate for low frequency cetaceans.

Noise levels for impulsive noise sources (such as pile driving) at which significant behavioural disturbance may occur remain unclear. There is no published literature defining a threshold for potential behavioural disturbance from impulsive noise sources (Southall *et al.*, 2007). For impulsive noise sources, EPBC Policy Statement 2.1 recommends a threshold SEL of 160 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ to minimise the risk of TTS in whales from seismic surveys. In the absence of data specific to marine blasting and piling, an SEL of 160dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ was used in the assessment presented in the SAR for predicting potential TTS.

Table 1 presents the furthest distances from the piling activity at which the received noise levels (as predicted from the underwater noise modelling) are equal to the threshold levels used to predict potential physical injury and behavioural disturbance. There is a lack of scientific data specific to sirenians (i.e. dugongs) for determining injury and behavioural disturbance as a result of underwater noise, therefore the SAR also applied criteria for mid-frequency cetaceans to dugongs.

Predicted Zone of potential physical injury (m)	Zone of potential behavioural disturbance (m)
198 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ (SEL for a single pile strike)	160 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ (SEL for 10 sec period)
60	250

Table 1 Radial extent of zones of potential physical injury and possible behavioural disturbance based on the modelling as presented in the SAR.

Impact Assessment – actual assessment

The remodelling (with correct source level and amended curve fitting algorithm) of underwater noise levels generated by piling operations, indicates higher underwater noise levels (beyond 100 m from the piling source) than presented in the SAR, for a comparable piling scenario. The higher noise levels subsequently affect the extent of the zones of potential behavioural disturbance.

Table 2 compares the furthest distances from the piling activity at which the received noise levels (as predicted from the underwater noise modelling as presented in the SAR and with the error corrected) are equal to the threshold levels used to predict potential physical injury and behavioural disturbance.

Scenario	Zone of potential physical injury (m)	Zone of potential behavioural disturbance (m)
	198 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ (SEL for a single pile strike)	160 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ (SEL for 10 sec period)
As presented in the SAR	60	250
With modelling errors removed	12	4500

Table 2 Radial extent of zones of potential physical injury and possible behavioural disturbance based on the modelling as presented in the SAR and as corrected.

The zone of potential behavioural disturbance indicated by the corrected modelling is comparable with zones of potential behavioural disturbance identified for other recent developments within North-Western Australia. For example the recently approved Port Hedland Outer Harbour Development (Ministerial Statement No. 890) identified that potential behavioural disturbance can occur at ranges up to tens of kilometres, based on the results of a literature survey (BHP Billiton 2011).

Implications on Predicted Impacts

The SAR concluded that underwater noise and vibration generated during piling has the potential to cause physiological injuries or a behavioural response (e.g. avoidance) in marine fauna.

Fish

The SAR concluded that for pile driving activities, fish are unlikely to be in close proximity to the noise source other than at start-up. Piles require multiple hammer drives at short intervals of minutes or hours within each of many consecutive days. Such activity will scare fish away prior to commencement of more intense activities.

Given that the SAR's conclusions with respect to the impact of noise generated by pile driving activities was not determined from the underwater noise modelling, the errors in the modelling will not have influenced the conclusion and therefore the impacts described in the SAR from the proposed piling activities are accurate.

Reptiles

As there have been no studies to date which have determined physiological injury or behavioural noise threshold levels for marine reptiles, including turtles, the SAR concluded that it is uncertain what effects piling activities would have on nearby individuals. Samuel et al. (2005) demonstrated that anthropogenic noise may increase surface time of turtles, as they may rise to the surface as a 'startle' response to noise stimuli.

The SAR determined that altered behaviour due to construction noise would be temporary and restricted to the construction phase of the BLNG Precinct. The primary impact on marine reptiles from piling activities would be focused nearshore with sound exposure levels for a given time period of exposure decreasing with distance from the source. Therefore, the SAR concluded that it is unlikely that noise emissions would affect turtles transiting through and/or foraging within the wider James Price Point coastal area. It was determined that post-construction, displaced individuals would resume use of the area.

The remodelling (with correct source level and amended curve fitting algorithm) of underwater noise levels generated by piling operations, indicates lower received underwater noise levels less than 100 m from the piling source and higher underwater noise levels beyond 100 m from the piling source when compared to those presented in the SAR, for a comparable piling scenario. It is reasonable to assume that the higher noise levels beyond 100 m will result in an increase in the area in which reptiles will potentially exhibit behavioural disturbance. However, as with dugongs, the BLNG Precinct Port area is not considered regionally significant for reptiles, and although the area in which behavioural change may occur has increased, the significance of the impact on the reptile population on a local and regional level is unlikely to change and therefore the impacts described in the SAR from the proposed piling activities, are accurate.

Humpback Whales

The SAR acknowledged that humpback whales would be present off the Dampier Peninsula during the northerly and southerly migration periods, and the data available at the time (i.e. 1 year worth of aerial surveys) indicated the mean distance offshore during the migration for adults and calves was 27 km and 24 km, respectively. In addition, the SAR noted (RPS, 2010a, Appendix C-8) that demonstrably fewer humpback whales were seen to travel along the coastal migration corridor on the southbound migration when the more vulnerable cow-calf groups would be present (RPS, 2010a; Appendix C-8).

It was determined from the surveys that the majority of animals (95%) were migrating at a distance of at least 8 km off the coast. At this distance, noise emitted from piling activities would be significantly less than that considered to cause any physiological impacts. Additionally, avoidance behaviour initiated as a result of the noise generated from these activities and the other lower intensity activities would minimise the potential risk of any individuals actually moving close enough for any potential physiological impacts. Consequently, the SAR concluded that piling associated with the construction activities were unlikely to have a significant impact on the broader humpback whale population.

Based on the amended underwater noise modelling, the zone of potential behavioural disturbance is likely to extend to 4500 m, compared to 250 m stated in the SAR. Although this is a significant increase in distance, it is unlikely to result in a different impact to humpback whales to that predicted in the SAR. The vast majority of animals (95%) will be migrating sufficiently distant from the construction activities so as not to experience noise levels which are predicted to generate change in behaviour.

In summary, although the error in the underwater noise modelling has resulted in a significant increase in the zone of potential behavioural disturbance, the intersection of this zone with the migratory pathways, based on the criteria presented in Table 2, is such that it is not expected to result in an increase in the number of humpback whales potentially exposed to noise levels sufficient to change behaviour. Consequently, the error in the underwater noise modelling does not change the significance of the impact on humpback whales from that described in the SAR, and the impacts described in the SAR from the proposed piling activities, are accurate.

Dugongs

The SAR determined that in general, hearing capabilities of dugongs are poorly understood and there is a lack of scientific data specific to dugongs for determining injury and behavioural disturbance as a result of underwater noise. Therefore to determine injury and behavioural disturbance as a result of underwater noise, the SAR applied criteria for mid-frequency cetaceans (Southall *et al.*, 2007) as a surrogate for dugongs.

The SAR stated that for piling activities at close ranges (60 m) there is a potential for individuals to be exposed to levels that could result in physical injury (based on thresholds developed for cetaceans (Southall *et al.*, (2007))). However, high intensity impulsive noise activities during construction are likely to result in the localised avoidance of individuals from the BLNG Precinct Port area, thus minimising the risk of exposure. The SAR concluded that the BLNG Precinct Port area is not considered regionally significant for dugongs and the wider Dampier Peninsula supports established populations. Therefore, it is likely that any dugongs displaced from the BLNG Precinct Port area would find suitable habitats within the wider Kimberley region during the construction period, and that this displacement would not have a significant impact on the dugong population on a local and regional level.

Based on the amended underwater noise modelling, the zone of potential physical injury (based on thresholds developed for cetaceans (Southall *et al.*, (2007))) has been reduced from that presented in the SAR. This reduction will decrease the risk of physical injury to dugongs resulting from piling activities below that assessed in the SAR. The amended modelling indicated that the zone of potential behavioural disturbance is likely to extend to 4500 m, compared to 250 m stated in the SAR (based on thresholds developed for cetaceans (Southall *et al.*, (2007))). Given the avoidance behaviour of dugongs and that the BLNG Precinct Port area is not considered regionally significant for dugongs and the wider Dampier Peninsula supports established populations, any displacement of dugongs would not have a significant impact on the dugong population on a local and regional level and therefore the impacts described in the SAR from the proposed piling activities, are accurate.