Annex D

Review of the Mekong Dolphin Population Status and Potential Impacts of the Proposed Don Sahong Hydropower Project
In support of the Prior Consultation process

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This report has been complied based on information and data received from the Lao National Mekong Committee as provided for in Article 5.4.1 of the PNPCA, the experience and expertise of the author(s), and available reports and papers in the public domain.

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1. Introduction to Irrawaddy dolphins in the Mekong River

The Irrawaddy dolphin population that inhabits the lower Mekong River of southern Laos, Cambodia and Viet Nam [hereafter Mekong dolphin population] is listed as Critically Endangered by the IUCN (Smith and Beasley 2004). The Mekong dolphin population historically ranged throughout much of the lower Mekong River south of Khone Falls (including Tonle Sap Great Lake and major tributaries such as the Sekong sub-basin), however, the population is now restricted to a 190km river stretch, between Kratie (Cambodia) north to below Khone Falls on the Laos/Cambodia border (Beasley 2007, Beasley et al. 2012).

Within this river stretch dolphins primarily inhabit eight deep pools ranging in water depth from 10-40m (Baird and Mounsouphom 1994, Baird *et al* 1994, Baird and Mousouphom 1997, Poulsen *et al* 2002: Figure 1). The total Mekong dolphin population size was estimated as 200 individuals in 1997 (Baird and Beasley 2005), 93 individuals as of 2007 (Beasley *et al* 2012), and 85 individuals as of 2011 (Ryan *et al* 2010). The Mekong dolphin population was estimated to be declining (Beasley *et al* 2012), with accidental entanglement in gillnets, low calf survival and daily harassment by dolphin-watching tour vessels at two locations primary causes of population decline (Gilbert and Beasley 2006, Beasley *et al* 2012).

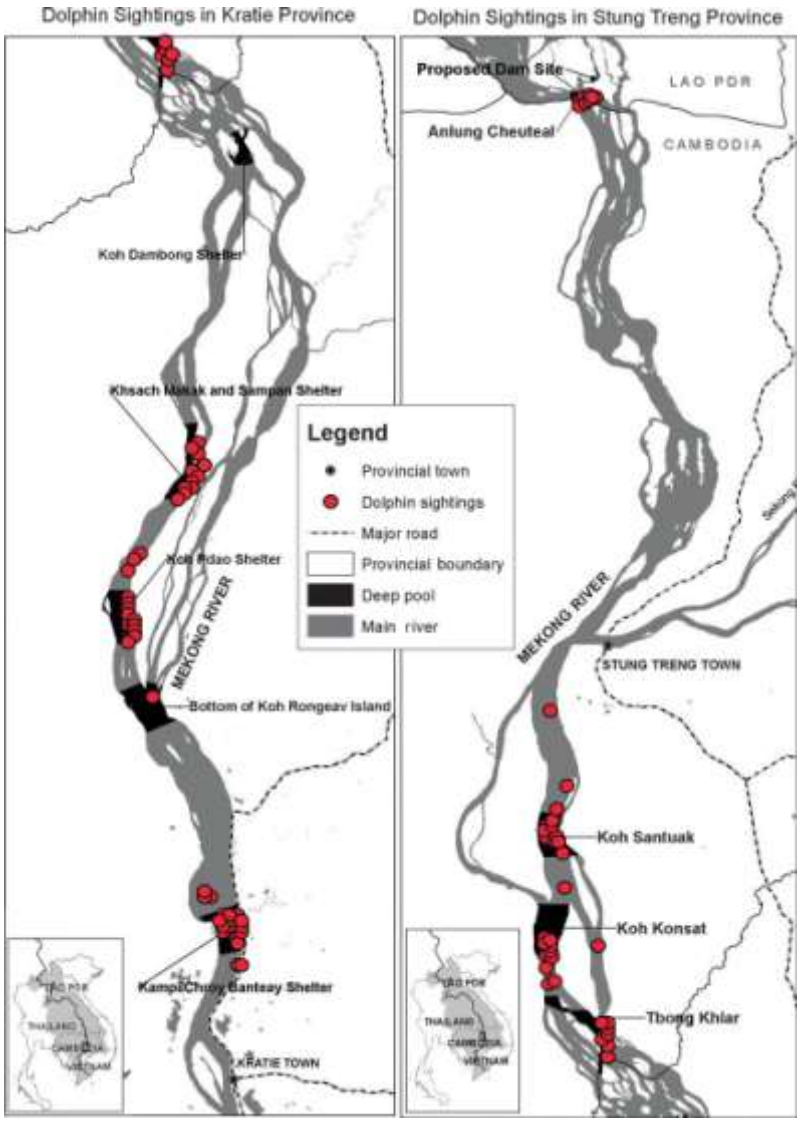

Figure 1. Map of the lower (left) and upper (right) Cambodian Mekong River from Kratie to Khone Falls. Major deep pools are designated by black and the red dots represent dolphin groups that were sighted from 2001-2007. Inset: Lower Mekong Basin.

The sub-population of Irrawaddy dolphins inhabiting the Laos/Cambodian border region of Cheuteal Pool/Vern Nyang deep pool (hereafter transboundary dolphin sub-population) is the only dolphin population in Laos, and has been studied since 1993 (Baird and Mounsoupm 1994, Stacey 1999, Beasley 2007, Beasley *et al* 2012, Ryan *et al* 2012). The transboundary subpopulation has reportedly declined from 20-30 individuals in 1991 to nine individuals in 2005 (Beasley 2007), and 6 individuals as of 2013 (Ryan *et al* 2012).

As stated in Beasley *et al* (2012), based on the carcass recovery program, the current known, and high-risk, threats to the Mekong population are accidental entanglement in gill net fisheries and destructive fishing practices (e.g., dynamite and electric fishing). There are strong indications based on Murphy *et al* (2008) and Dove (2009) that disease, contaminants, and inbreeding depression are potentially high-risk threats, which would have a direct impact on individual survival. Other potential longer-term threats are dolphin-watching boat harassment, causing habitat displacement and increased stress levels (Bejder *et al* 2006, Beasley *et al* 2010), reduced prey availability (causing starvation and reduced foraging success), and large-scale dam and waterway construction (causing loss of habitat and further population fragmentation).

Despite the Mekong dolphin population's precarious situation, recent genetic analysis by Krutzen *et al* (in prep) has found that the transboundary dolphin sub-population is still genetically connected to the remaining Mekong dolphin population in Stung Treng and Kratie Provinces of Cambodia, with haplotype[1] D (the most common) being present in all sub-populations (i.e. Kratie, Stung Treng and Chiteal: Table 1).

Table 1. Haplotype distribution within the Mekong dolphin population, where genetic samples from 55 individuals were analysed. Kratie samples possessed 3 haplotypes (A, C, D), Stung Treng samples possessed 2 haplotypes (B, D) and Chiteal sample was haplotype D (Krutzen *et al* in prep).

Haplotype	Kratie (*n*=42)	Stung Treng (*n*=12)	Chiteal (*n*=1)
A	2 (4.7%)		
B		1 (8.3%)	
C	4 (9.5 %)		
D	36 (85.8%)	11 (91.7%)	1

Krutzen *et al* (in prep) also found that the Mekong dolphin population is genetically distinct from all other known Irrawaddy dolphin populations (Figure 2), with initial indications of sub-species level differences. This new information indicates that there is still genetic exchange between sub-populations throughout the Mekong River (probably during the wet season), with the transboundary sub-population comprising an important genetic component of the Mekong dolphin population.

[1] Haplotype = A sequence of DNA sequences that are likely to be inherited together.

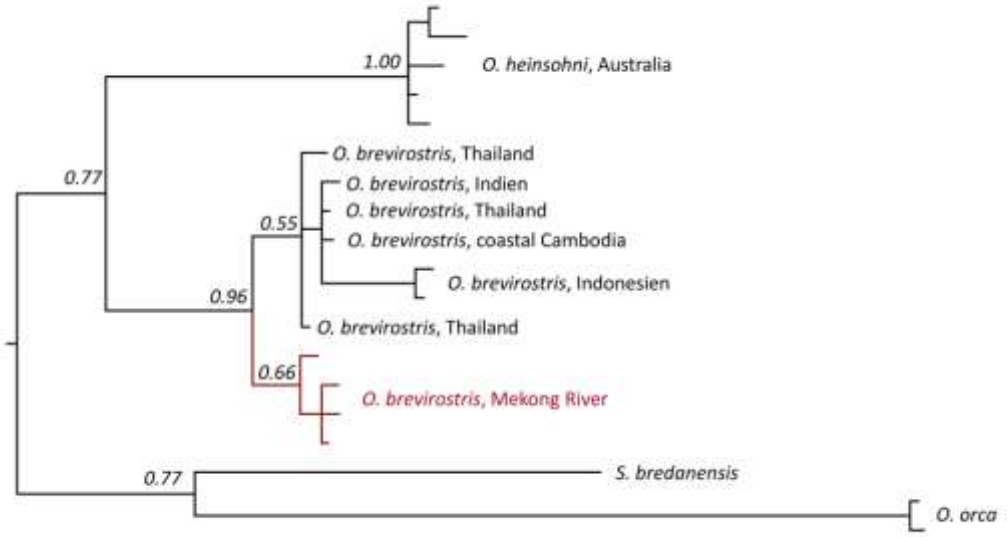

Figure 2 Phylogenetic relationships of the genus *Orcaella* based on 384bp of the hyper-variable region I of mitochondrial DNA. Numbers indicate Bayesian *posterior* probability values for each clade (Krutzen *et al* in prep).

2. Review Process and Information Sources

This review will draw on information from peer-reviewed reports and papers in the public domain, as well as documents provided by LNMC to support the Prior Consultation process. The focus of the review will be upon the potential impacts of the Don Sahong project on the Mekong dolphin population, particularly the small sub-population that inhabits the transboundary deep pool on the Laos/Cambodian border.

Documents received from the LNMC include;

- Final Environmental Impact Assessment 2013, carried out by NCC
- Final Cumulative Impact Assessment 2013 carried out by NCC
- Final Environmental Management and Monitoring Plan 2013 prepared by NCC
- Hydrology, Hydraulics and Sedimentation design studies 2011 carried out by AECOM
- Engineering status report 2011 carried out by AECOM
- Transboundary hydraulics effects study 2013 carried out by SMEC New Zealand

Documents provided by the MRC with reference to the Don Sahong project include:

- Document for the special session of the Joint Committee on the Don Sahong Project, January 2014
- Documents for the PNPCA Joint Committee Working Group on the Don Sahong Project, August 2014

A list of peer-reviewed papers on the Mekong dolphin population and the potential

impact of dam construction and noise on marine mammal populations relevant to this review can be found in the references list.

3. The Mekong Dolphin Population and the Don Sahong Dam

The proposed Don Sahong Dam is approximately 1.5km upstream of the Laos/Cambodian border, where a group of six Irrawaddy dolphins permanently inhabit the transboundary deep pool. Transboundary Mekong dolphin sightings from 2001-2005 were recorded an average of 1.67km (±0.5km, n=58 sightings) from the proposed dam site during the dry season (range = 0.70km – 4.08km), with the closest sighting location being just 700m from the proposed dam site (Figure 2).

These sightings were primarily obtained during the dry season, and it is likely that dolphins would forage around the Hou Sahong Channel, and potentially into the channel at least during the wet season.

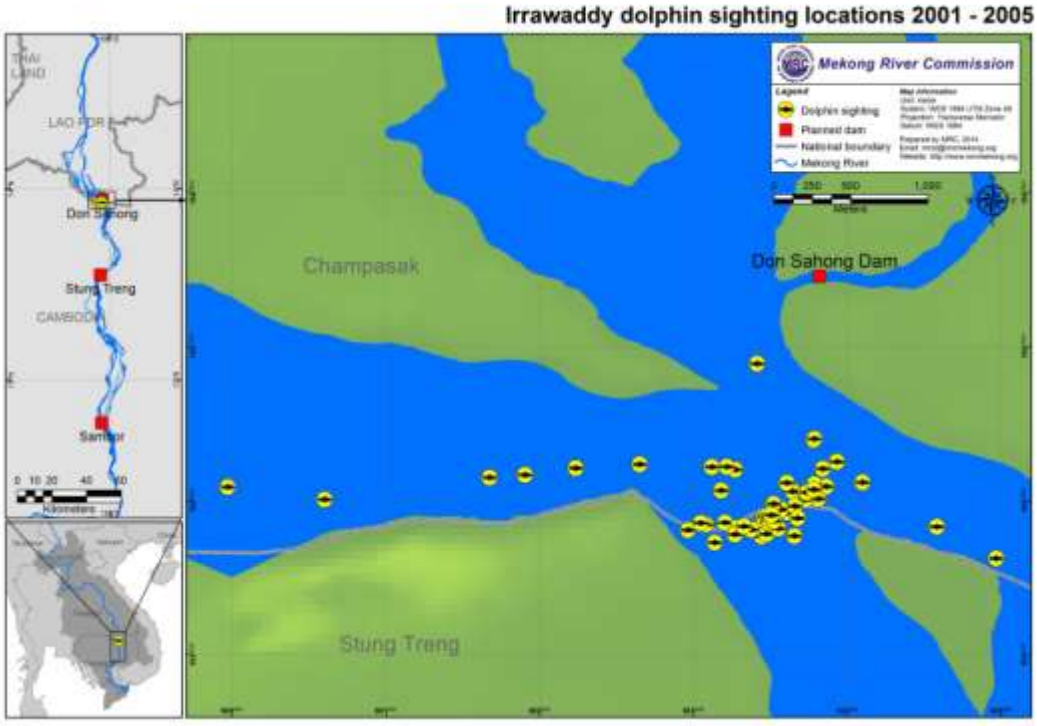

Figure 3. Distribution of Irrawaddy dolphins sighted from 2001-2005 within the transboundary pool, based on data collected by Beasley (2007).

As a result of the close proximity of the transboundary dolphin group to the proposed Don Sahong Hydropower Project (DSHPP), the main activities potentially impacting the sub-population of six dolphins inhabiting the Laos/Cambodian border region are (at least):

- excavation and construction impacts;
- altered water flow regimes and potential changes in sedimentation affecting the pool;
- increased boat traffic as a result of increased human presence in the area;
- reduced prey abundance and diversity through degradation and blocking of fish migration pathways.

The main activities potentially impacting the remaining Mekong dolphin population in Kratie and Stung Treng Provinces of Cambodia are (at least):

- altered water flow regimes and potential changes in sedimentation;
- potentially through reduced prey abundance and diversity through degradation and blocking of fish migration pathways.

While considering the potential impacts of the proposed Don Sahong Dam on the transboundary dolphin subpopulation, it is important to consider that:

- Recent research by Krutzen *et al* (in prep) indicates that the Mekong dolphin population is likely to be a separate subspecies of Irrawaddy dolphin, thus increasing it's conservation importance.
- The Mekong dolphin sup-population is classified as Critically Endangered by the IUCN (Smith and Beasley 2004), which indicates that without adequate protection the sub-population is at high risk of local extinction.
- Irrawaddy dolphins are a sacred species in both Laos and Cambodia, where traditional tales in both countries tell of their human ancestry (Baird and Beasley 2004, Beasley *et al* 2012). The potential loss of this species from Laos would be significant for the local community, the country and particularly for future generations of Laos and Cambodian nationals.
- The transboundary dolphin sub-population is the only dolphin sub-population remaining in Laos, as dolphins are no longer found in the Sekong sub-basin of Laos (Baird and Mounsouphom 1997). The potential demise of this dolphin sub-population would be a significant loss to the mammal megafauna biodiversity of Laos.
- Dolphin-watching tourism in the transboundary pool was initiated in 1994, and has brought direct financial benefit to all local communities of the region (Laos and Cambodian), where visitor numbers have increased from 3,480 visitors in 2008 to 7200 visitors in 2011 (S. Schipani, Asian Development Bank, unpublished data). Over US$15,000 was reportedly generated in local income for the community in 2011, with additional revenue generated from guesthouses and restaurants (S. Schipani, Asian Development Bank, unpublished data). The potential demise of the transboundary dolphin population would cause a significant decline in revenue for local communities that rely on this income, and has not been mentioned in the EIA. Although dolphin-watching tourism has been listed as one of the primary threats to the remaining Mekong dolphin population, well-managed tourism can benefit both the dolphins and local communities.
- The potential loss of the transboundary dolphin sub-population would reduce the extent of occurrence of the Mekong dolphin population by 34% and cause a 7% decline in total population size (Ryan 2014). As noted by Lusseau and Bejder (2007), it has been shown that anthropogenic impacts may alter vital rates (i.e. survival, maturation, reproduction), which can influence the viability of populations (Slooten *et al* 2000). These influences will depend on the resilience of the population's carrying capacity and therefore small, closed populations, such as the Mekong dolphin population, are highly likely to be more prone to extinction when faced with human impacts.

4. Summary of Impacts Considered and Measures Proposed by the Developer

The main impacts of the Don Sahong Dam on the Mekong dolphin population and mitigation measures proposed by the proponent include:

4.1. Construction

Mitigation and avoidance of impacts on the Irrawaddy Dolphin

- Excavation will not include underwater blasting.
- Fish food supply to be maintained by developing alternative fish passage channels.
- Mekong flows and water quality essentially unchanged in dolphin areas.

4.2. Operations

Impact to Irrawaddy Dolphin

- Fish food supply to be maintained by implementing the FishMAP and operating the alternative passage channels.
- Mekong flows and water quality essentially unchanged in dolphin areas.

4.3. Decommissioning

Blasting and removing dam and concrete infrastructure

- Blasting may affect aquatic animals. Other methods to be used.

Endangered species

- None required.

5. Comments Regarding Impacts Considered and Measures Proposed by the Proponent

The DSHPP Environmental Impact Assessment (EIA) did not report on:

- distribution, abundance and movements of the transboundary dolphins; and
- modelling potential sound emissions and propagation of various construction activities, including dry explosives.

Given that the Mekong dolphin population is listed as Critically Endangered, and that sound emissions are likely to pose the greatest risk to the sub-population, these aspects are further elaborated here. However, as the developer has not undertaken any detailed studies in the area, this assessment is limited to available literature. In particular, studies of the movements and habitat use of the transboundary dolphin sub-population (particularly during the wet season), or potential sound levels and propagation of noise in the project area, particularly from dry excavation and explosives used within the bounds of the cofferdam, would significantly improve the confidence of the evaluation.

5.1. Excavation and Associated Noise

During the EIA process no studies were conducted on dolphin sightings in, and around the Hou Sahong channel, particularly during the wet season. Such studies would assist the

development of potential mitigation strategies. Based on existing data it is known that dolphins have been sighted within 700m from the proposed dam site (Figure 3), so excavation and construction noise will impact the transboundary dolphin sub-population to varying degrees.

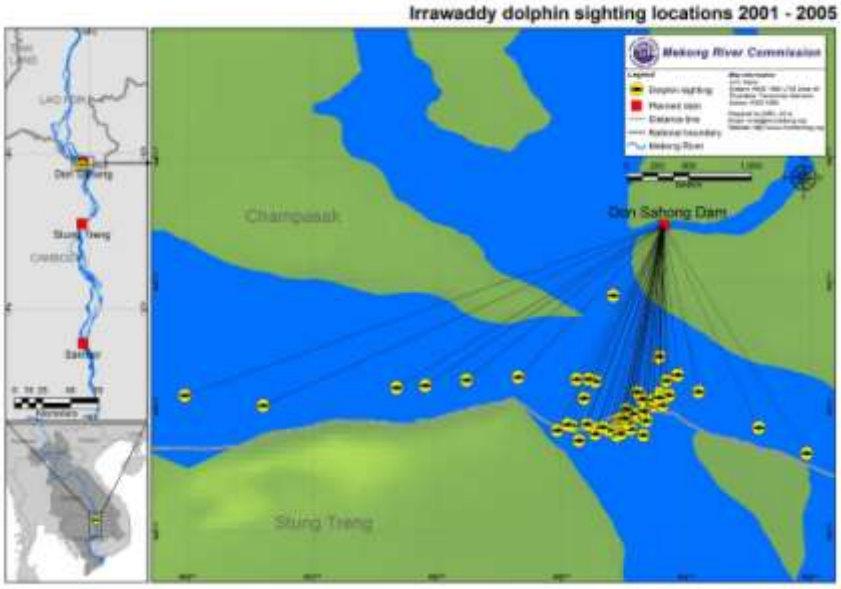

Figure 4. Distribution of Irrawaddy dolphins sighted from 2001-2005 within the transboundary pool, based on data collected by Beasley (2007). The straight lines show how distance was calculated from the proposed Don Sahong Dam site.

The EIA states that '*excavation of a tailrace channel in lower Hou Sahong is required … the main area where the dolphins are usually seen is some 2-3km from the tailrace channel*'. However, dolphins are known to occur within the area to be excavated, just 700m south of the proposed dam site, and are likely to travel at least to the mouth of, if not into, the Hou Sahong channel during high water levels. Figure 5 (extracted from the EIA) shows the extent of tailwater excavation planned. Excavation Options 1-5 would directly impact known areas of dolphin occurrence, particularly Options 4 and 5.

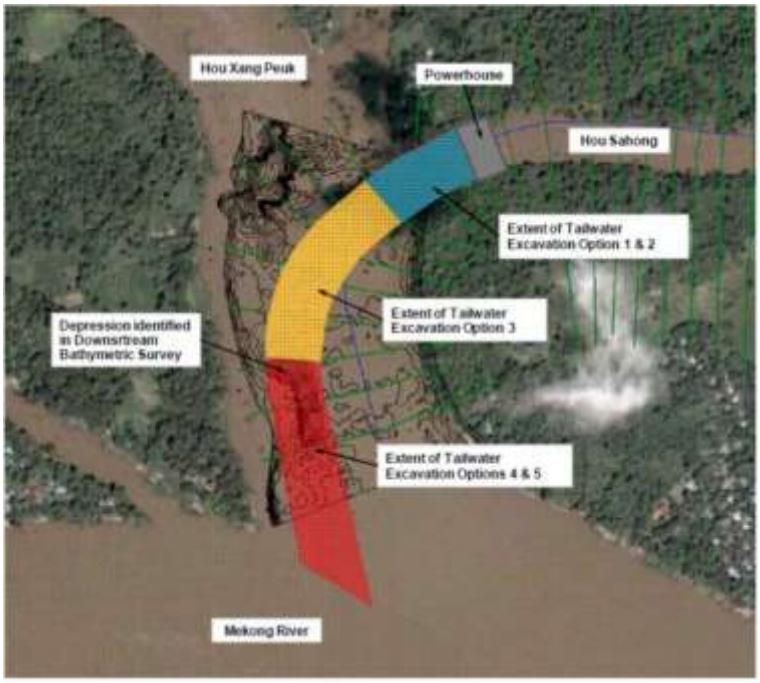

Figure 5. Various options for locations of excavation sites in the Hou Sahong (Figure 2.3 of the EIA)

The major impact on the dolphin sub-population during the construction phase is likely to be excavation and construction of cofferdams, and construction of the dam itself. Within the EIA, proposed measures to minimise the effects of excavation include:

- disposing of excavated materials as part of permanent works;
- all excavation at the downstream end will be carried out in the dry behind a cofferdam;
- no underwater blasting downstream.

Construction and particularly excavation, and blasting even behind the cofferdams will transmit some noise into the area below the coffers through the bedrock and air. The developers, therefore, incorrectly assume that there will be no impact on dolphins by avoiding underwater blasting.

There is very little literature available regarding the potential impact of dry excavations on marine mammals, and no previous studies known for river dolphins. However, it is known that toothed whales (i.e. dolphins) have extremely sensitive hearing, and a complex sonar system used for foraging, navigating and communicating (Au *et al* 2000, Richardson 1995). The impact of human-made sounds may therefore result in physical and/or behavioural changes for these animals. The nature and degree of any acoustic disturbance will vary with the animal's distance from the source, and propagation qualities of the bedrock and water. The received levels and characteristics of sound is a result of a complex interaction of many factors. Some of the known impacts associated with sound are summarised in Finneran *et al* (2002), Lehnhardt (1986), Miller et al 1987), Liberman (1990) and Southall *et al* (2007), and include:

- At very close range to an extremely intense sound source, death and physical damage to body tissue is possible.
- As the noise attenuates with distance from the sound source, the character of its potential impact changes, grading downward through:
    - permanent hearing loss,
    - temporary hearing loss,
    - avoidance of the sound,
    - masking of biologically relevant sounds
    - behavioural changes including interruption of feeding, breeding, nursing.

Keeten (1995) analysed the physical parameters of two underwater detonations of Class A explosives (1200lbs and 10000lbs, 544kg and 4535kg respectively: TNT derivatives with fast rise-time waveforms), for their potential to induce blast injury and acoustic trauma in marine mammals. 100% lethal impact zones for a 1200lb source were between 40-300m, and for a 10000lb source between 70-800m. The level of impact from blasts depends on both an animal's location and, at outer zones, on it's sensitivity to the residual noise. Important factors for trauma from explosive sources are:

- topography,
- proximity of ear to the source,
- anatomy and health of ear,
- charge weight and type,
- acoustic wave rise time,
- overpressure, and
- pressure and duration of positive pressure phase.

A concept widely used in regulation and management of noise impacts is to model likely noise emissions and then establish zones of influence, within which different types of impacts would be expected to occur. If a uniform field of propagation and attenuation is assumed (and ignoring the third dimension of depth), these can be represented as a series of concentric circles around a noise source, whose radii are the ranges at which the level of the sound might be expected to have fallen to a certain threshold level. Four zones suggested by Richardson *et al* (1995) for marine mammals are (from the outermost ring):

1. the zone of audibility (the area within which the sound is both above the animal's hearing threshold and detectable above background noise).
2. the zone of responsiveness (the region within which behavioural reactions in response to the sound occur).
3. the zone of masking (the zone within which the sound may mask biologically significant sounds).
4. the zone of hearing loss, discomfort, or injury (the area within which the sound level is sufficient to cause threshold shifts or hearing damage).

The radius of the circle defining each zone will depend on the characteristics of the sound itself, the susceptibility of the animals being considered, and the acoustic propagation characteristics in the survey area. In devising management guidelines and regulations that are appropriate for a particular development, managers will often use threshold sound levels for certain effects (based perhaps on research in a different area) and calculate the ranges at which the sound level from the particular source being used will fall to this threshold in the area being considered. In these situations, the nature of propagation conditions in the local area becomes critical. Propagation conditions can vary widely from location to location and depend on a variety of factors (Urick, 1983).

Differing propagation conditions have a magnified effect (squared if considering area, cubed if volume) on zones of influence since these represent areas which rapidly increase or decrease with even small changes in radius. For example, the radius of a zone of behavioral influence for an air gun array with a threshold of 140dB could vary by 4000 times between different likely propagation conditions, in which case the area and number of individuals affected would vary by a factor of 16 million. It is therefore important to make empirical measurements of propagation loss, and to apply appropriate models (informed by up-to-date oceanographic/water flow data) when determining appropriate management zones (Madsen *et al* 2006).

It is likely that the noise from excavation and construction will be heard into the area where the dolphin are known to forage, and probably as far as the deep pool in Cambodia. This noise is likely to affect the dolphin in some way. However, recognizing the inherent difficulty of empirically determining the propagation properties of sound from excavation, piling and blasting through the bedrock and water in the Khone Falls area without affecting the dolphin sub-population, other international procedures could be adopted. The standard procedures adopted internationally for seismic and other sound-based construction activities (such as piling), provide for precautionary zones, where construction work will not commence if a marine mammal is sighted within the zone. As an example, for seismic surveys in Australia, standard precaution zones are (Australian Government 2008):

- Observation zones – 3+km radius from the sound source
- Low power zone – 2km radius from the sound source
- Shut-down zone – 500m radius from the sound source

It is often assumed that temporary displacement from important areas may occur as a result of increased sound in the environment, where precaution zones provide an opportunity for animals to move out of the area. Temporary displacement is often unlikely to result in any real biological cost to the animals unless the interaction occurs during critical behaviours (eg. breeding, feeding and resting), or in important areas such a narrow migratory corridors and/or areas that animals cannot move away from. In these biologically important habitats, where the displacement of marine mammals may have a more significant or biologically relevant effect, the developer is encouraged to conduct surveys at a different time of year, or not proceed if mitigation cannot be guaranteed (Australian Government 2008).

Pre-construction studies of the transboundary dolphin sub-population (minimum one year) to investigate dolphin movements and habitat use and peer reviewed sound modelling studies are required to adequately assess the potential impacts of excavation and construction activities on the transboundary dolphin sub-population and determine whether mitigation is possible.

5.2. Operational Noise from Turbines

The hydropower turbines will contribute to additional noise in the area up to and possibly into Cambodia. Although not as significant as the construction noise, continual noise such as from turbines can cause behavioural changes, mask biologically relevant sounds, and cause avoidance of the sound (Richardson *et al* 1995). Few studies have been conducted on the effects of marine mammals and turbines. One study examined the reactions of harbour porpoises and harbour seals to a 2MW turbine, where responses occurred within a 60 to 200m perimeter around the sound source, suggesting that that the impact zone for 2MW turbine noise is potentially small for marine mammals (Koschinski *et al* 2003).

No studies could be found on the noise levels and impacts on marine mammals emitted from 4x65MW turbines (such as will be installed in the DSHPP). As with construction activities, peer reviewed sound modelling studies are required from existing hydropower turbines of similar size (i.e. 4x65MW) to adequately assess the potential impact of noise from the dam turbines on the transboundary dolphin sub-population and determine whether mitigation is possible, or required.

5.3. Reduced Prey Abundance and Diversity

Reduced prey availability is a primary concern for the transboundary sub-population of Mekong dolphins, as well as the remaining Mekong dolphin population inhabiting Kratie and Stung Treng Provinces of Cambodia. The Hou Sahong Channel has been reported as a major route for fish passage, and the only passage available for important fish species throughout the year. It is reported as the only channel passable for late-dry season migrating fish species such as some large cyprids, which are known dolphin prey (Baird and Mounsouphom 1994). The proposed DSHPP may therefore affect dolphin prey abundance.

The Fisheries Expert Group will address the impacts of the proposed hydropower plant in greater detail. However, it is noted for the purposes of this report that while the EIA indicates that; '*the depletion of fish stocks is not anticipated because of the mitigation measures proposed in the FishMAP programme*', the veracity of this statement depends on the extent to which the lost fish passage can be mitigated. Any reduction in prey would have a significant negative impact on the remaining Mekong dolphin population.

5.4. Increased Sediment, Altered Water Flow and Altered River Morphology

Increased sediment, altered water flow patterns in the Cambodian/Lao border area are considerations regarding the proposed DSHPP's impact on the transboundary dolphin sub-population.

The developer proposes the following measures to control sediment increases during construction:

- disposing of excavated materials as part of permanent works;
- all excavation at the downstream end will be carried out in the dry behind a cofferdam; and

- no underwater blasting downstream of the coffer dam.

The developer also notes that there will be no discernable change in sediment concentrations during scheme operation as the project will operate as run-of-river plant, with a small headpond, which will reach equilibrium within 3-4 years. The veracity of this has yet to be tested by the Sediment Expert Group. However, it is important to note that, declines in water flows and changes to the flood-pulse systems of rivers are a major concern for river dolphins throughout Asia, and may have significantly contributed to population declines elsewhere (Smith and Reeves 2000, Smith *et al* 2009, Braulik 2006).

Similarly, should scouring of accumulated sediment be required, and if this is done at low flows into the river, then sedimentation of deep pool habitats, particularly the transboundary deep pool), and changes in water flow or river morphology in the shallow island area may affect prey distribution and diversity, and thus might affect the transboundary dolphin sub-population, and potentially the remaining Mekong dolphin population in Kratie and Stung Treng Provinces of Cambodia

5.5. Increased Boat Traffic

The EIA (page 27) suggests that boat traffic will be reduced in the transboundary pool as a result of a road connection between Sahong and Sadam Islands.

There is however the potential for boat traffic to remain at the same level, or increase, with more people living and working in the area. Any increase in boat traffic, particularly the very fast boats that transverse the river from Cambodia to Laos, would have a major impact on the transboundary dolphin population through increased noise, reduced time for important behaviours such as resting, feeding and socialising, and the potential for direct deaths due to collision.

5.6. Other Project Initiatives to Aid Dolphin Conservation

As stated in the EIA (pg. 5.25) '*Given the sensitivity and importance of the local dolphin population, DSHPP will facilitate the monitoring and management of the dolphins in the Mekong River by supporting:*

- *Monitoring the dolphin population in the immediate area downstream of the Project*
- *Research into the serious ongoing problem of mortality of new born calves which threatens the entire river dolphin population of the Mekong River, and*
- *The management of illegal destructive fishing activities and restrictions on the use of gillnets in sensitive areas including dolphin habitat in and around the Project area'.*

While this initiative is laudable, the following main concerns are raised in this respect:

1. There are no obvious budget items in the Environmental Management and Monitoring Plan (EMMP) to implement any of these initiatives.
2. Research into the newborn mortality will be very time-consuming and expensive. The proponent needs to explain how this research will be conducted for it to be considered as an effective aid to dolphin conservation.
3. The management of gillnets within a subsistence fishery and management of illegal fishing practices is a very complex issue, time-consuming and expensive. The developer needs to explain how this management will be conducted and how the process differs from previous, mostly unsuccessful, attempts to manage gillnet fisheries throughout the lower Mekong River.

6. Assessing the adequacy of the Environmental Management and Monitoring Plan (EMMP) with regard to protection of dolphins compared with accepted international good practice

6.1. Construction

The EMMP is deficient in designating the '*Impact Significance*' and also describing '*Required Mitigation/Management Measures*' for construction impacts affecting the Mekong dolphin population, particularly the transboundary sub-population.

Although there will be no underwater blasting, the excavation and construction that is required for this project will result in increased noise levels in the areas frequented by the dolphin. Given that; 1. there is extensive published literature on the effects of noise on marine mammals; 2. the lack of sound modeling studies relevant to this particular context; and 3. the small known home range of the transboundary dolphin sub-population, it is likely that the construction of the DSHPP will have significant impact on the resident dolphin population. It will not be possible to avoid these impacts entirely, although the impacts of noise could be reduced by adopting international standards in this regard. However, there is no way of assessing whether these measures would be sufficient.

6.2. Operational

The EMMP does not consider the effect of continual noise from the turbines on the dolphins in the area, and no sound modeling has been provided in the EIA. Since dolphins are known to occur within a few hundred meters of the proposed dam site, it is possible that dolphins may be excluded from the area if the noise is sufficiently different from background noise so as to affect feeding or temporary or permanent threshold shifts in hearing. The effects of noise are particularly acute for newborn calves, which are essential for the Mekong dolphin population to survive in the long-term.

6.3. Decomissioning

The EMMP states that '*blasting may affect aquatic animals. Other methods to be used*'. Although the Environmental Management and Monitoring Plan states that alternatives to blasting will be used, there are no other options for decommissioning are discussed.

The developer needs to state how such a large structure will be decommissioned if blasting does not occur, assess the risks to the transboundary dolphin population, and develop appropriate mitigation strategies.

7. More Information Required

The following items, included in the EIA, require more explanation and detail, particularly concerning potential impacts on the transboundary dolphin sub-population.

7.1. Development of Alternative Livelihoods

The EIA states (pg. 5-24) that '*An important aim of the Project's fisheries management program is … development of alternative livelihoods for the local population … to reduce the dependency of the local communities on fishing. The Project hopes these efforts will also reduce the risk to the dolphin population'*.

Although this is a stated aim of the project, there is no detail in the EIA or associated documents regarding:

- how the alternative livelihood program will be developed,
- which agency will implement the alternative livelihoods program,
- what alternative livelihoods are being considered,
- is the community supportive of alternative livelihoods,
- how will the alternative livelihoods program be evaluated.

This detail is required to adequately assess the program's potential effectiveness. A dedicated alternative livelihood program to reduce gill-net use in the Cambodian Mekong River has been operating for nearly 10 years, at a cost of hundreds of thousands of dollars, with potentially limited success at removing gillnets/illegal fishing practices from the river (Beasley *et al* 2012).

7.2. Bridge Construction

While it is noted that the bridge construction across the islands of Don Sadam and Don Sahong is being undertaken by the Lao authorities, and is not part of the DSHPP *per se*, there is potential for the transboundary dolphin population to be disturbed by these activities. More information is needed about the construction detail and type of bridge being considered, to evaluate the potential effects on the dolphin population. If piling is to occur, then additional mitigation measures will be required following international protocols (i.e. trained marine mammal observers on-watch, soft-starts, exclusion zones), to ensure dolphins are not in the immediate vicinity of the pile-driver when active (Australian Government 2008).

7.3. Dredging

Dredging is mentioned on pg. 5.26 of the EIA (i.e. '*…and possibly Veun kham, would be directly affected by the downstream dredging of their traditional fishing grounds'*, but no mention of dredging is listed in the EIA Project activities. It is believed that this dredging will be undertaken upstream of the Hou Sahong inlet to ensure adequate flows through the power plant. However, it is noted that any dredging downstream of the Khone Falls and project area could affect the dolphin population, so this requires further elaboration.

8. Other mitigation options to avoid, minimize or mitigate the impacts on dolphins

The Mekong dolphin population is listed as Critically Endangered by the IUCN, with an estimated population size of 85 individuals, as of 2011. The transboundary dolphin sub-population is now at a critical stage, where effective conservation actions are required immediately for the estimated six individuals to survive in the long-term.

The minimum viable population (MVP) size (i.e., the smallest size required for a population of a species to have a predetermined probability of persistence for a given length of time (Shaffer 1981), is not known for small cetaceans, or any other species, although many have attempted to answer this question (Franklin 1980, Lande and Barrowclough 1987, Reed *et al* 2003). Importantly, a MVP is not one that can simply maintain itself under average conditions but one that is of sufficient size to endure the calamities of various perturbations (natural or man-made) and do so within its particular biogeographic context (Shaffer 1981, Thomas 1990).

Reed *et al* (2003) used population viability analysis to estimate MVPs (99% probability of persistence for 40 generations) for 102 vertebrate species and concluded that to ensure long-term persistence, at least 7000 breeding age adults were required (with sufficient habitat). However, genetic studies conducted on the New Zealand Chatham Island black robin (*Petroica traversi*), where the entire current population of ~200 individuals is derived from a single breeding pair, suggests that the population is viable under existing conditions, thus illustrating that significant levels of genetic variation are not a necessary prerequisite for endangered species survival (Ardern and Lambert 1997). As Caughley and Gunn (1996) state, '*common-sense tells us that there is no single number that tips a species into the small, or minimum viable population categories'*. There are various examples of small populations, such as the black footed ferret (*Mustela nigripes*) (May 1986, Seal *et al* 1989, Russell *et al* 1994), Californian condor (*Gymnogyps californianus*) (Sarrazin and Barbault 1996) and northern elephant seal (*Mirounga angustirostris*) (Hoelzel *et al* 2002, Weber *et al* 2004), that have been brought back successfully from the brink of extinction. Irrespective of population size, when populations become small the survival of each individual is critical.

Although there are only an estimated six Irrawaddy dolphins inhabiting the transboundary pool, it appears through recent research by Krutzen *et al* (in prep) that the transboundary sub-population remains genetically connected to the remainder of the population in Kratie and Stung Treng Provinces (probably through wet season movements), and therefore is an important sub-population where increased conservation efforts must be directed. Given the published evidence of small populations returning from low numbers, the Mekong dolphin population remains viable, particularly as calves are still being born (although calf mortality remains high).

Given the current population size, continual births, and significant local community support (in Laos and Cambodia) for conservation efforts, it is too early to assume that the Mekong dolphin population has reached its MVP. Effective conservation initiatives are now needed that are radically different from previous unsuccessful efforts to ensure the populations' long-term survival. Recent collaborations between the IUCN Cetacean Specialist Group, WWF-Cambodia and the Commission for Conservation and Development of the Mekong River Dolphin EcoTourism Zone have been a positive step forward, with new conservation initiatives being proposed at a recent Kratie workshop.

Although a number of mitigation measures are proposed within the EIA for the proposed DSHPP, the impact of construction and associated cumulative effects from the development is likely to be significant for the transboundary dolphin population. Pre-construction surveys and modelling to assess impacts have not been conducted as part of the EIA process, and

as a result the potential impacts have not been adequately considered, or mitigated for, within the EIA. With the information currently at hand, it seems unlikely that impacts on the dolphin can be completely avoided, and is consequently at odds with dolphin conservation efforts.

Nonetheless, it is recognized that some actions could be taken to further mitigate or minimize impacts, and to reduce the uncertainty around the assessment of the extent of the impacts of the construction and operating of the DSHPP on the resident dolphin population. Recommendations to this effect are provided below

9. Conclusions and Recommendations

The following conclusions and recommendations have been drawn from this review.

More detail on methods and timing is required on the development of alternative livelihoods, and dredging, particularly in relation to the potential effects on the transboundary dolphin sub-population.

It is concerning that seismic surveys were conducted at the proposed dam site without any mention of mitigation to avoid the potential effects on the transboundary dolphin subpopulation (pg. 3.3 of EIA). It is recommended that any future seismic surveys conducted as part of the design phase of the DSHPP should implement internationally accepted guidelines for reducing the impact of seismic surveys on marine mammals (e.g. Australian Government 2008). A monitoring plan would be required prior to seismic surveys being undertaken, to state precaution zones and precautions taken to mitigate impacts to the transboundary dolphin sub-population.

Studies on the frequency, duration, sound pressure levels and propagation of sound from 1. seismic activities, 2. blasting within the cofferdam, 3. planned construction activities, and 4. operation of the turbines, requires detailed analysis and sound audit, to appropriately determine the potential impacts to dolphins, and develop appropriate exclusion/precaution zones (e.g. Australian Government 2008). These studies would contribute towards an understanding of whether dolphins are likely to be impacted by excavation and construction activities. It is highly recommended that these studies are independently peer-reviewed by a relevant technical expert to assess accuracy of methods and results.

There is no budget item in the EMP for monitoring the transboundary sub-population of Mekong dolphin. Given the likely impact that the proposed dam construction, operation and decommissioning will have on the transboundary dolphin sub-population, long-term monitoring of the transboundary sub-population and remaining Mekong dolphin population should be a high priority. These studies should include detailed yearly boat-based capture-recapture studies from Kratie north to Khone Falls, to determine distribution, abundance and habitat use, and monitor trends over time. It is recommended that a monitoring strategy is developed by independent experts, and peer reviewed to assess the accuracy of study design and planned analysis. Monitoring should begin at least a year prior to construction, and include wet season surveys around the project site, particularly near the Hou Sahong Channel outlet.

It is recommended that the developer elaborates on how the dam structure will be decommissioned if blasting does not occur, assess the risks to the transboundary dolphin population, and develop appropriate mitigation strategies based on sound science, particularly in relation to noise levels and blast impacts (if any).

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