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SCIENCE BRIEF

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THE DON SAHONG DAM AND THE MEKONG DOLPHIN

An updated review of the potential impacts of the Don Sahong Hydropower Project on the Mekong River's Critically Endangered Irrawaddy dolphins *(Orcaella brevirostris)*.

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KEY MESSAGES

- The proposed Don Sahong Hydropower Project is poised to begin construction in 2014, located just one kilometre upstream of the core habitat for Irrawaddy dolphins in the Mekong River.
- A small group of the Mekong's Critically Endangered Irrawaddy dolphins inhabits a transboundary deep-water pool just below the dam site on the Lao PDR–Cambodia border. These are the only dolphins remaining in Lao PDR.
- The Don Sahong Dam will almost certainly cause the disappearance of dolphins in the transboundary pool downstream of the dam site due to excavation activities and increased boat traffic.
- The dam will also increase the extinction risk of the entire Mekong dolphin population due to the probable extirpation of the dolphin group in the transboundary pool, changes in water and sediment flow, and interrupted migration of dolphin prey.
- Not building a dam at Don Sahong will not stop Lao PDR producing electricity, but building it will almost certainly cause the loss of dolphins from Lao PDR and it could precipitate the extinction of the species from the Mekong River.

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EXECUTIVE SUMMARY

The Mekong River is home to a Critically Endangered, declining population of 85 Irrawaddy dolphins. An isolated dolphin group on the border of Lao People's Democratic Republic (Lao PDR) and Cambodia are the only dolphins left in Lao PDR. Plans to construct the Don Sahong hydropower dam in a channel immediately upstream from these dolphins is a major threat to both that group and the whole Mekong population.

Hydropower dams create electricity and can support some development aspirations of the government and people of Lao PDR, however they also pose a significant threat to biodiversity. Freshwater dolphins require hydrologically complex habitat that can be degraded by infrastructure, and dolphins are very sensitive to disturbances such as construction.

This Science Brief examines the potential impacts that the Don Sahong dam may have on dolphins, highlighting areas where knowledge gaps or risks are unrecognized by the proponent's impact assessments. The risks posed by a variety of threats are examined using an internationally standard process for risk assessment.

Major risks to the local dolphin population are through excavation and boat traffic at the site, which are expected to precipitate the loss of dolphins from Lao PDR. The scale of the threat to the whole population is magnified through ecosystem degradation, expected decline in fisheries, as well as the cumulative effects of disturbance and stressors on the dolphins.

The Don Sahong Dam poses a high risk to the Mekong's dolphins. Its effects probably cannot be mitigated, and certainly not given the limited and vague plans outlined in the environmental impact assessment, which address a small fraction of the risks identified here.

Alternatives to Don Sahong exist, such as the Thako Project, which the proponents of Don Sahong agree has much lower risk to biodiversity while still producing significant electricity. Despite the repeated mantra of "no significant impact" on dolphins, the project proponents state that "construction impacts [are] necessary". Not building a dam at Don Sahong is not an irreparable blow to the development aspirations of Lao PDR or its ability to produce electricity, but building it would almost certainly cause the extirpation of Irrawaddy dolphins from Lao PDR and it could very well precipitate the extinction of species from the Mekong River.

There is no doubt that conservation of the Mekong's last dolphins will be difficult, but the attitude implicit in the proponent's impact assessments –that the dolphin population is already vulnerable and therefore should not stand in the way of development– will achieve nothing but to seal their fate.

DOLPHINS OF THE MEKONG

There are about 85 Irrawaddy dolphins *Orcaella brevirostris* left in the Mekong River (Ryan et al. 2011). These dolphins are all that remains of a population that once ranged over about 700 linear km from Khone Falls in the far south of the Lao People's Democratic Republic (Lao PDR) downstream to the delta in Vietnam, and probably >700 linear km far into major tributaries like the Tonle Sap and Sekong Sub-basin. The population can now be found only from Kampi, in Cambodia's northeast, to Khone Falls over a distance of about 190 linear km; an 86% decline in their historic distribution. Deep pools are a key refuge for fish and dolphins during the dry-season in the Mekong River (Poulsen et al. 2002). Immediately below the Khone Falls is a deep-water pool straddling the border between Cambodia and Lao PDR (Baird & Mousouphom 1997). Just six dolphins remain isolated in this transboundary pool, the last remaining dolphins in Lao PDR (Ryan 2012, 2013, figure 1).

The Mekong's dolphins are Critically Endangered in the IUCN Red List (Smith & Beasley 2004), threatened by accidental entanglement in gillnets and low calf survival for reasons that remain uncertain (Gilbert & Beasley 2006, WWF et al. 2012), as well as the construction of hydropower dams especially in the main course of the river. Construction of the Don Sahong Dam may be a crucial factor contributing to their extinction.

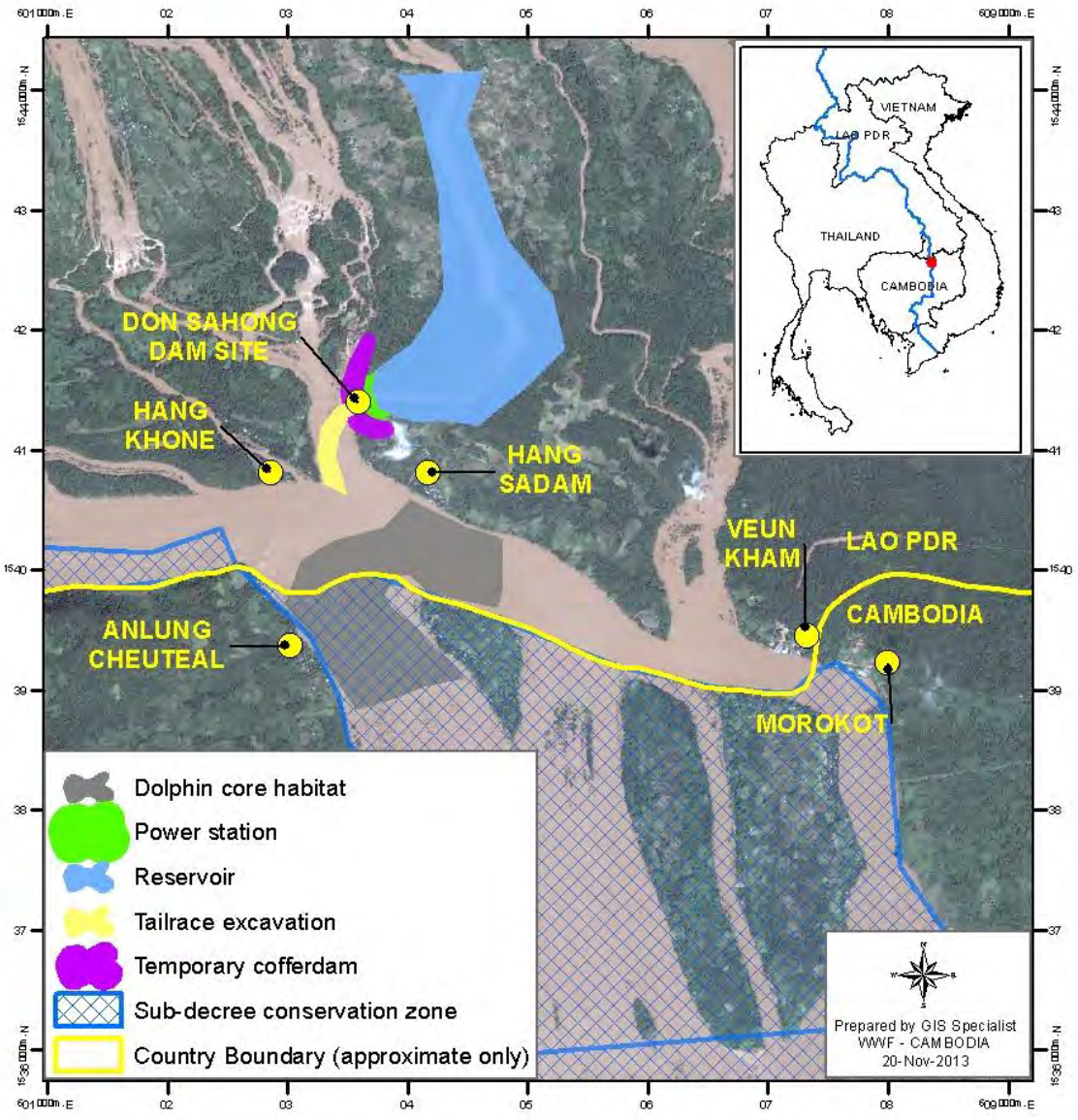
THE DON SAHONG DAM

Development of freshwater resources threatens human water security and freshwater biodiversity worldwide (Vorosmarty et al. 2010). Hydropower development in the Mekong River is one option to meet growing energy demands in mainland Southeast Asia (ADB 2008, Bach et al. 2012). While proponents cite the potentially lower carbon footprint of hydropower as compared with other energy sources (Barros et al. 2011, Chanudet et al. 2011), dams are a significant source of greenhouse emissions (Rudd et al. 1993, McCully 2002, Fearnside 2004, Giles 2006). Hydropower dam construction is fraught with socio-economic risk; dams do not always meet the expected economic benefits and instead may have environmental, social, and health impacts (World Commission on Dams 2000). Several large hydropower dams already exist in the Upper Mekong of China, but the Lower Mekong mainstream remains free-flowing (Grumbine & Xu 2011).

The Don Sahong hydropower dam will be located in the Hou Sahong Channel between Don Sahong and Don Sadam Islands, Champassak Province, Lao PDR, in the main course of the Mekong River (figure 1). The Hou Sahong Channel is the major channel in this part of the river and the only one through which late dry-season migratory fishes can pass (Baran & Ratner 2007). The proposed dam site is 1.5 km upstream of the Cambodian border, and one km from where a small group of dolphins permanently inhabits a transboundary, deep pool. The dam wall will be seven km long and up to 22.5 m high with a 260 MW power station, and construction will take around five years (AECOM 2011a, b, NCC 2013a).

The threat that Mekong dams pose for biodiversity, especially riverine fishes, is well discussed in the scientific literature (e.g. Hill & Hill 1994, Grumbine & Zu 2011, Ziv et al. 2012). For example, proposed dams on the Mekong River are expected to reduce fisheries and ecosystem services, and harm those who depend upon this watershed for food and income (Dugan et al. 2010). Many of these discussions also point to the threat hydropower dams pose to a key icon of Mekong River biodiversity: its population of freshwater Irrawaddy dolphins (e.g. Dudgeon 2000, ICEM 2010, Beck et al. 2012). Though the threat is widely acknowledged, the specific mechanisms by which these dams threaten dolphins have rarely been explicitly considered.

Figure 1. **Proposed Don Sahong dam site and core dolphin habitat in the local area. Reservoir, cofferdam, and excavation locations approximate based on project engineering status reports (AECOM 2011a, b) and environmental impact assessment (NCC 2013a). Country boundary is indicative only, and does not represent the view of WWF on its location.**



HYDROPOWER DAMS AND DOLPHINS

Hydropower dams and other water development infrastructure are a feature of many freshwater systems worldwide (World Commission on Dams 2000, Gleik 2003), and constitute a major threat to freshwater cetaceans (Smith & Reeves 2000, Trujillo et al. 2010). Dams can degrade key habitat, fragment populations, and reduce ecosystem function and productivity. River dolphins occur in hydrologically complex habitat (Smith 1993, Gomez-Salazar et al. 2012a, Braulik et al. 2012a), that represents the biological needs of many other riverine denizens, and dolphin populations can indicate ecosystem degradation (Gomez-Salazar et al. 2012b) and trends in other species (Turvey et al. 2012). Infrastructure such as dams reduces the complexity of rivers, and thus degrades or destroys habitat of dolphins and many other species.

Guidelines for the consideration of river dolphins in water development planning include maintaining ecosystem integrity and avoiding habitat loss, siting dams to minimize deleterious effects, ensuring migration and dispersal pathways remain for dolphins and fish, rigorously assessing the impacts of developments on dolphins, biodiversity and the environment including cumulative and synergistic effects of multiple projects, and avoiding unproven interventionist solutions such as translocations (Smith and Reeves 2000). While there is a strong conceptual basis to consider the potential impacts of hydropower dams on dolphins, virtually no studies have considered the topic in detail in relation to a specific development (though see Smith et al. 1998 and Bezuijen et al. 2007).

APPROACH

The approach used in this brief is to gather relevant scientific evidence and make it informative for decision-makers. This brief discusses elements of the Don Sahong dam project that may affect the Mekong's dolphins, highlighting areas where knowledge gaps or risks are unrecognized. Impact categories are detailed and the mechanisms through which they may affect dolphins are discussed and ranked. This brief is not intended to replace the environmental impact assessment processes or alleviate the need to address significant uncertainties regarding dam construction, operation and impacts. It will need to be updated as further information becomes available.

WWF produced a previous brief on this topic: "The Don Sahong Dam and the Irrawaddy Dolphin" (Bezuijen et al. 2007). At that time few technical details of the dam were publicly available, but the brief considered that major threats would result from the loss of habitats due to hydrological changes, the loss of prey due to blocked fish migrations, and disturbance during the construction phase including the blasting of rock.

In this updated brief, the potential impacts are re-assessed based on new information on the technical details of the dam proposal, the dolphin population, and mitigation measures proposed in the latest Environmental Impact Assessment (EIA) submitted by project proponents to the Government of Lao PDR (AECOM 2011a, b, NCC 2013a, b, c, Phonekhampheng 2013, Phonekhampheng et al. 2013).

The risks to dolphins from potential impacts of the Don Sahong Dam are assessed based on international standard methods for risk assessment, where risk is the product of likelihood and consequence (Burgman 2005, table 1). Here consequence is measured as the chance of increasing the risk of extinction of dolphins from the Mekong River, and assessments are made based on table 1.

Table 1. Risk assessment matrix used to rank impacts the proposed Don Sahong dam in the Mekong's dolphins based on Burgman (2005, p. 150)

		Consequence				
Likelihood		**Very high** 75–100%	**High** 50-74%	**Moderate** 25-49%	**Low** 1–24%	**Very low** 0–1 %
Highly likely	>85%	Very high	Very high	High	Moderate	Moderate
Likely	50–85%	Very high	Very high	High	Moderate	Moderate
Fairly likely	21–49%	Very high	High	High	Moderate	Low
Unlikely	1–20%	Very high	High	Moderate	Moderate	Low
Very unlikely	<1%	Very high	High	Moderate	Low	Low
Extremely unlikely	<0.01%	Very high	High	Moderate	Low	Low

POTENTIAL IMPACTS OF DON SAHONG DAM ON DOLPHINS

1. Construction Phase

Excavation

To increase the power output of the Don Sahong dam, the developers propose to draw additional water through the Hou Sahong Channel by removing around 2.5 million cubic metres of hard rock from the entrance, body, and exit of the channel (AECOM 2011a, NCC 2013a). Most of this excavation will be done using explosives creating strong percussive forces (i.e., very strong sound waves) that could potentially kill the dolphins (see Richardson & Wursig 1997, Ketten 1995). Like other toothed cetaceans, Irrawaddy dolphins depend on a complex sonar system and have highly sensitive hearing structures sensitive to these forces (Au et al. 2000). If nearby explosions do not kill dolphins outright, injury could severely compromise the animals' ability to find food, navigate, or communicate; indirectly causing their death. To reduce this risk the developers have proposed to separate the animals from explosions by a coffer dam and blast in the dry channel. This may reduce some risk to the dolphins but, since the dam site is very close to their core habitat, it is unclear if this separation will sufficiently reduce percussive forces to prevent death or serious injury, and this has not been rigorously assessed.

Excavation of the dam's tailrace below the coffer dam will extend to within hundreds of metres of core dolphin habitat in the Lao PDR/Cambodian deep pool (Figure 1; NCC 2013a, p. 2–5). The developer proposes to avoid using explosives to excavate the dam tailrace below the proposed coffer dam (NCC 2013a, p. 2–5). Although methods are not specified, it is likely that a combination of drilling, jackhammering, and hydraulic excavation will be used. These activities also threaten to injure or extirpate dolphins in the area due to protracted high-energy noise disturbance and direct contact with the machinery or rock debris. Excavation during construction will also greatly increase sedimentation in the transboundary deep pool which will degrade and potentially cause the loss of dolphin habitat.

The risk of extirpation of the dolphin group remaining in the Lao PDR/Cambodia transboundary pool is very high. Direct risk to dolphins occurring farther downstream is relatively low. However, the removal of six animals represents a major loss of demographic potential in a dolphin population already considered as critically endangered due to low numbers.

Boat traffic

Irrawaddy dolphins are sensitive to boat traffic, especially large, motorized vessels. Boat traffic can cause dolphins to change their behaviour in the short-term (Nowacek et al. 2001), which can result in long-term impacts on their nutrition (Williams et al. 2006) and habitat use (Lusseau 2005). Dolphins can also be injured or killed when hit by boats (Van Waerebeek et al. 2007), which has occurred at this site (Ryan 2012). Boat traffic, including speedboats, large barges and dredges, will dramatically increase around the dam project site. These concerns certainly apply to the trans-boundary pool due to its small size (around one square kilometre), which limits avoidance options.

Toxic substance spill

The near presence of heavy industrial activity at the site poses the threat of spillage of toxic substances such as oil. Toxic spills can cause acute and high levels of mortality in cetaceans (e.g., Williams et al. 2011), as well as ecotoxicological effects (Geraci 1990) that can continue for long after the event (Matkin et al. 2008). The environmental management plan does make provisions to reduce risk of spillage into the river (NCC 2013b), but it is reasonable to expect that over five years of industrial activity at the site, some spillage of toxic substances in to the river is likely – which is tacitly acknowledged in provisions of the environmental management plan.

Seismic mapping

It is unclear from available documents what seismic or sonar activities will be used in the construction phase, though some seismic testing has been conducted in the planning phase with no consideration of the risk to dolphins (AECOM 2011a, NCC 2013a). Dolphins make extensive use of biosonar and their hearing system is sensitive to high-energy noise (Ketten 1992, Stone & Tasker 2003). At near range the risk of death or injury from some seismic and sonar activities are high. The proposed use of seismic tools in the decommissioning phase is also of concern (NCC 2013a).

2. Operation phase

Hydrology and sediment transport

Hydrological processes underpin the ecological and physical complexity of rivers that support biodiversity (Ligon et al. 1995, Trush et al. 2000). Sediment transport is an integral part of water flow in alluvial rivers such as the Mekong (Milliman & Meade 1983, Bridge 1993), and dams trap large volumes of sediment and can dramatically change the geomorphology of the river downstream (Ligon et al. 1995). The long-term effects of dam operation are generally to starve an alluvial river of sediments thereby reducing geomorphic complexity needed to sustain dolphins and high-levels of biological productivity. There are already signs that hydropower dams are affecting the flow of sediments and hydrological processes of the Mekong (Kummu & Varis 2007, Bravard et al. 2013). Hydrology also directly influences the behaviours of riverine fish (Baran 2006). Declines in water flow and changes to the flood-pulse systems are a major concern for river dolphins throughout Asia and may have significantly contributed to population declines elsewhere (Smith & Reeves 2000, Smith et al. 2009, GT Braulik *in litt*. 2013).

The Don Sahong Dam will pass most suspended sediments due to its run-of-the-river design. It will block many larger non-suspended particles however, though only a portion of the whole river's sediment given the siting on a channel (AECOM 2011a). It is uncertain if additional inputs from the smaller channels below the dam site will provide sufficient sediment to mitigate potential changes to the geomorphology further downstream.

During operation the proposed dam would also periodically flush sediment trapped in the reservoir, creating large bursts of sediment-heavy water (AECOM 2011a). Flushing is necessary for dam operations because sediments deposited in the reservoir behind the dam can damage turbines and reduce power output. This practice can have immediate consequences for downstream biodiversity (Corsa et al. 2010, Espa et al. 2013).

The run-of-the-river design and channel siting suggests that the dam will not affect all river flow, but some impact is expected. Guaranteed minimum flows in some channels are only slightly above extreme-dry season low-flow (NCC 2013a, p. 3-5), so it is hard to expect this will not impact the local ecosystem.

Blocked fish migrations

More than 100 species of Mekong fishes migrate long distances, including most commercially fished species and a large portion of the total biomass (Baran 2006, Ziv et al. 2012). The potential effects on fisheries of dams in the Mekong river basin are beyond the scope of this report, but have been reviewed in detail (e.g.: Hill & Hill 1994, Baran et al. 2007, Dugan et al. 2010, Ziv et al. 2012), including those potentially caused by construction of the Don Sahong Dam (Baran & Ratner 2007, ICEM 2010, Baird 2011). A dam built across the Hou Sahong channel would create a major barrier to fish migrations in both upstream and downstream directions (Baran & Ratner 2007). The Hou Sahong channel is one of several at the Khone falls, but given its width and unique morphology, it is the only channel passable for late-dry season migrating species such as some large cyprinids –known dolphin prey (Baird & Mounsouphom 1994, WWF unpublished data)– and a major pathway for other species for much of the year. The ecosystem effects of expected declines in migratory fish populations are uncertain but they will certainly reduce the availability of dolphin prey in the immediate vicinity of the dam and farther downstream (see Baird & Mounsouphom 1997, Baran 2006, Baird 2011).

The proposed mitigation measures for upstream migration – removal of traps and modification of nearby channels (Phonekhampheng 2013, Phonekhampheng et al. 2013) – have only been tested at a very small scale and are not proven to work for the volume and variety of fish necessary. The management plan is based on the hope that fish migrations can be accommodated, rather than the evidence that they can.

Hydroelectric turbines also kill many fish migrating downstream (Cramer & Oligher 1964, Schilt 2007). While the proponents suggest that the design should allow for the passage of 95% of fish (NCC 2013a, p. 5-21) many rates reported elsewhere are much higher (Coutant & Whitney 2000, Schilt 2007). Although a fish screen is proposed if passage targets are not met, clearly additional fish mortality is inevitable.

3. Cumulative and interactive effects

Environmental impacts do not occur in isolation and factors may interact to magnify respective effects in unknown ways. Cumulative and interactive effects among stressors must therefore be rigorously incorporated into the decision-making

process associated with the construction of the Don Sahong Dam (Smith et al. 1998, Smith & Reeves 2000). These kinds of interactions were not considered in the proposal's Cumulative Impact Assessment (NCC 2013c). In the construction phase these stressors include excavation at a massive scale causing noise disturbance and excessive sedimentation; and dramatically increased boat traffic with a greater risk of fatal strikes and stress from avoidance behaviour and noise. In the operation phase, these stressors include altered hydrology and sedimentation leading to potential habitat loss and degradation; blocked fish migration leading to declines in prey; and possibly turbine operation causing excessive noise and fish kills. Cumulatively and interactively these stressors, along with the already existing threats summarized above, may cause a further reduced availability of prey; loss of range and demographic potential in the dolphin population; and disturbance and stress leading to decrease fitness – a powerful recipe for extinction. A compelling example, with clear parallels to the current situation in the Mekong, is the recent almost certain extinction of the baiji or Yangtze River dolphin (Turvey et al. 2007). After 20 million years this species succumbed to the stresses of human impacts including mortality from entanglement in fishing gear and the construction of dams.

Loss of range and demographic potential

The loss of dolphins from the Lao PDR/Cambodia transboundary pool would amount to a 34% decline in the extent of occurrence of the species in the Mekong River and a 7% decline in their overall population size. Such a large reduction in range and numbers in a Critically Endangered population greatly increases its vulnerability to catastrophic events (natural or human caused), demographic *stochasticity* and reduced genetic fitness (see Caughley 1994). Based on the risks discussed above, the loss of dolphins from the transboundary pool would seriously affect the conservation potential of the entire Mekong population.

Disturbance and stress

Stress due to disturbance can cause physiological problems in mammals (e.g. Gamble 1982, Morgan & Tromborg 2007, Knight & Swaddle 2011). In cetaceans, the effects of disturbance, especially loud or ongoing acoustic disturbance can include avoidance behaviours, increased stress hormone levels, disruption of communications and foraging, and physical and physiological damage resulting in temporary or permanent hearing loss (Nowacek et al. 2007, Weilgart 2007).

In the Mekong River, dolphins are restricted to specific deep pool areas during the dry season and exhibit strong site fidelity (Poulsen et al. 2000, Beasley 2007). Dolphins inhabiting the transboundary pool rarely leave it (Baird & Mounsouphom 1994, Ryan 2012), and one animal seen recently was first recorded there 20 years ago (Stacey 1996, WWF unpublished data). Construction at the dam site will be ongoing for around five years (AECOM 2011a) with intense industrial activity, causing major disturbance for the animals at the site. Meanwhile, the dolphins cannot escape without dispersing far downstream to the next area of habitat at Koh Santuak. It is unlikely the dolphins have the capacity to disperse and occupy downstream deep pools that are already inhabited by other dolphin groups. Together this disturbance from dam construction will almost certainly create conditions where communication and foraging becomes severely compromised. Dolphins are likely to become physiologically stressed which can indirectly lead to their death or reduced reproductive capacity.

Prey decline

The blockage of fish migrations, the killing of fish through turbines, and the long-term degradation of habitats will likely synergise to reduce fish populations further than any of these impacts individually. Synergies may be through effects of food-webs (Brett & Goldman 1996) or interacting ecological effects of changes to the environment (Ligon et al. 1995)

4. Overall Risk

The Don Sahong Dam will affect dolphins directly through its construction and operation and indirectly though cumulative impacts on the species, and the broader environment. The major expected effects on dolphins from dam construction and operation are from the excavation of millions of tonnes of bedrock, sedimentation in the dolphin pool area, increased boat traffic, and disturbance during construction. The river-system effects of greatest significance for dolphins include declines in fisheries and alterations in water and sediment flow. The loss of habitat in the trans-boundary pool below Khone Falls would equate to ~34% decline in the extent of dolphin occurrence in the Mekong River thus placing the entire Mekong population at significantly greater risk of extinction in the near future.

Considering the already Critically Endangered status of the dolphin population, the extinction risk posed by the Don Sahong dam to the transboundary dolphins –the last in Lao PDR– is very high and risk to the Mekong population, high (table 2a, b).

Table 2. Risk from impacts of the Don Sahong hydropower project on Irrawaddy dolphins, assessed both for the trans-boundary sub-population (2a), and the Mekong River population as a whole (2b).

2a. Transboundary sub-population.

		Consequence				
Likelihood		**Very high** 75–100%	**High** 50-74%	**Moderate** 25-49%	**Low** 1–24%	**Very low** 0–1 %
Highly likely	>85%	Excavation, cumulative and interactive effects, (loss of range and demographic potential), disturbance and stress, **Overall risk**	Boat traffic	Hydrology and sediment transport, blocked fish migrations, prey decline		
Likely	50–85%		Toxic spill			
Fairly likely	21–49%					
Unlikely	1–20%					
Very unlikely	<1%					
Extremely unlikely	<0.01%					

2b. Mekong River population.

		Consequence				
Likelihood		**Very high** 75–100%	**High** 50-74%	**Moderate** 25-49%	**Low** 1–24%	**Very low** 0–1 %
Highly likely	>85%	Loss of range and demographic potential	Cumulative and interactive effects, **Overall risk**	Excavation, blocked fish migrations, prey decline	Boat traffic	
Likely	50–85%			Toxic spill	Hydrology and sediment transport	
Fairly likely	21–49%		Disturbance and stress			
Unlikely	1–20%					
Very unlikely	<1%					
Extremely unlikely	<0.01%					

POTENTIAL MITIGATION

Following the initial environmental impact assessment (MFCB 2007), the proponents propose two measures to reduce risks to dolphins (NCC 2013a, p.5-4, b, c):

- Explosive excavation behind a coffer dam to reduce risk of acute blast injury or death with excavation of the tailrace area by unspecified non-explosive means, and
- Removal of snags and deepening of Hou Xang Pheuak Channel to provide a potential alternative dry-season fish passage and offset the barrier effect of the dam.

The 2013 EIA also gives some vague suggestions about how the project will support conservation research and management of dolphins at the site, as well as fisheries management, however nothing binding or specific is mentioned.

These proposed measures address just a fraction of the risks discussed above. The measures regarding explosive use will reduce risk to the animals but it remains unclear if they will prevent deaths or serious injury. It is extremely doubtful the fishery mitigation measures will be successful. The remaining risks from this large infrastructure project remain unaddressed.

While the environmental impact assessment suggests that monitoring of dolphins and support to dolphin conservation would be part of the proposal (NCC 2013a, p. 5-25), the environmental management plan does not include actions or budget to do so (NCC 2013b).

KNOWLEDGE GAPS

This brief covers many potential impacts the Don Sahong dam may have on dolphins, most of which were not considered by project proponents. This is simply an early step in examining available evidence. A truly rigorous approach would require a great deal more time and resources involving such things as quantitative assessments of sound transmission in the deep pool below the dam site, broader fisheries studies, and hydrological and sediment transport modelling. By recognizing the limits of current knowledge the brief aims to open up opportunities to fill in gaps with a recommendation for science-based decision making.

The limited understanding of potential impacts on dolphins is compounded in the environmental impact assessment by errors of fact (*such as that dolphins are generally 2–3 km from the proposed tailrace excavations,* NCC 2013c, p.31, *or that flow from the Hou Sahong channel will not pass through dolphin habitat*, NCC 2013a, p.5-24), and the use of outdated data (*referring to dolphin research based on no data more recent than* 2005, NCC 2013a, p. 3-19, *except where it served to show the population is already at risk, despite explicit knowledge of ongoing research in the area* NCC 2013a, p. 3-19), and a failure to consider all concerns raised at the time of the initial environmental impact assessment (e.g., Bezuijen et al. 2007). It is clear that significant uncertainty remains around the impacts to dolphins and well-informed decisions cannot yet be made.

CONCLUSIONS

Given the Critically Endangered status of the Mekong River's Irrawaddy dolphins (Smith & Beasley 2004) and their very small and declining population size (Ryan et al. 2011, Beasley et al. 2012), only the lowest risk activities are compatible with the survival of dolphins in Lao PDR and the Mekong River. The Don Sahong Dam poses a high risk to the Mekong's dolphins; its effects probably cannot be mitigated, and certainly not given the limited and vague plans outlined in the impact assessment documents (NCC 2013a, b, c).

Alternatives to Don Sahong exist, such as the Thako Project, which the proponents of Don Sahong agree has much lower risk to biodiversity while still producing significant electricity (NCC 2013a, p. 4-13). Despite the repeated mantra of "no significant impact" on dolphins (NCC 2013a, p. 5-4), the project proponents state that "construction impacts [are] necessary" (NCC 2013a, p. 4-12). A decision is to be made. It is clear that not building a dam at Don Sahong is not an irreparable blow to the development aspirations of the Lao PDR or its ability to produce electricity, but building it would almost certainly cause the extirpation of Irrawaddy dolphins from Lao PDR and it could precipitate the extinction of the species from the Mekong River.

In the long-term, with many proposed infrastructure developments likely to be constructed on the Mekong River, and with the dolphin population already imperilled it may be difficult to easily attribute cause if the population goes extinct. There is no doubt that conservation of the Mekong's last dolphins will be difficult, but the attitude implicit in the environmental impact assessment –that the dolphin population is already vulnerable and therefore should not stand in the way of development (e.g. NCC 2013a p. 4-12) – will achieve nothing but to seal their fate.

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APPENDIX: RISK ASSESSMENTS

Impact	***Trans-boundary sub-population***			***Mekong population***		
	Likelihood	***Consequence***	***Risk***	***Likelihood***	***Consequence***	***Risk***
Construction phase						
Excavation	**Highly likely:** core construction activity	**Very high**: excavation will likely cause extirpation of dolphins from Lao PDR	**Very high**	**Highly likely:** core construction activity	**Moderate:** excavation will increase the potential extinction of the Mekong population due to demographic and genetics risks of a smaller population.	**High**
Boat traffic	**Highly likely:** key part of construction activity	**High:** heavy boat traffic at the site would increase the likelihood of boat strikes and cause major stress for dolphins.	**Very high**	**Highly likely:** key part of construction activity	**Low:** unlikely to be a direct threat to the Mekong population but will have an indirect demographic impacts by contributing to the extirpation of the group in the Lao PDR/Cambodia transboundary pool.	**Moderate**
Toxic spill	**Likely:** considerable construction activity over years	**High:** depending on nature of spill, could be acutely disastrous	**Very high**	**Likely:** considerably construction activity over years	**Moderate:** depending on the nature of the spill could be very high, or very low over the whole Mekong	**High**
Operation phase						
Hydrology and sediment transport	**Highly likely:** although it appears that the dam is unlikely to have a major impact on the flow of water the impacts on sediment transport are uncertain	**Moderate:** it is not clear what effect this will have on dolphins locally.	**High**	**Likely:** sediment will be disturbed during construction, and flushed during operation.	**Low:** effects due to sediment flushing are not expected to be large	**Moderate**
Blocked fish migrations	**Highly likely:** major effect on some migratory fishes	**Moderate:** moderate effect on the availability fish prey at certain times of the year at the trans-boundary pool	**High**	**Highly likely:** strong evidence of major effect on some migratory fishes	**Moderate:** Irrawaddy dolphins are catholic feeders so can switch to other species assuming that downstream habitat loss (see above) does not also reduce the availability of these species to levels that cannot sustain both the dolphins and local fisheries	**High**
Cumulative and interactive effects	**Highly likely:** clear pathways for cumulative and interactive effects	**Very high:** interactions will almost surely cause the extirpation of dolphins from the transboundary pool if a single stressor does not kill them outright	**Very high**	**Highly likely:** clear pathways for cumulative and interactive effects	**High:** a good chance interactions will cause the extinction of the Mekong dolphin population	**Very high**
Loss of range and demographic potential	**Highly likely:** many very high risks to dolphins in the proposal	**Very high:** no more dolphins in Lao PDR	**Very high**	**Highly likely:** many very high risks to dolphins in the proposal	**Very high:** significant increase in extinction risk in the Mekong	**Very high**
Disturbance and stress	**Highly likely:** core construction activities will create major disturbance	**Very high:** almost certain deleterious consequences for local dolphin population	**Very high**	**Fairly likely**: core construction activities will create major disturbance	**Moderate:** downstream effects likely to be minimal but will likely increase extinction risk	**High**
Prey decline	**Highly likely:** major effect on some migratory fishes and possible interactive effects on others	**Moderate:** moderate effect on the availability fish prey	**High**	**Highly likely:** strong evidence of major effect on some migratory fishes and likely cascading effects on other species	**Moderate:** Irrawaddy dolphins are catholic feeders so can switch to other species assuming that downstream habitat loss (see above) does not also reduce the availability of these species to levels that cannot sustain both the dolphins and local fisheries	**High**
Overall risk	**Highly likely**	**Very high**	**Very high**	**Highly likely**	**High**	**High**

The Mekong River and its dolphins

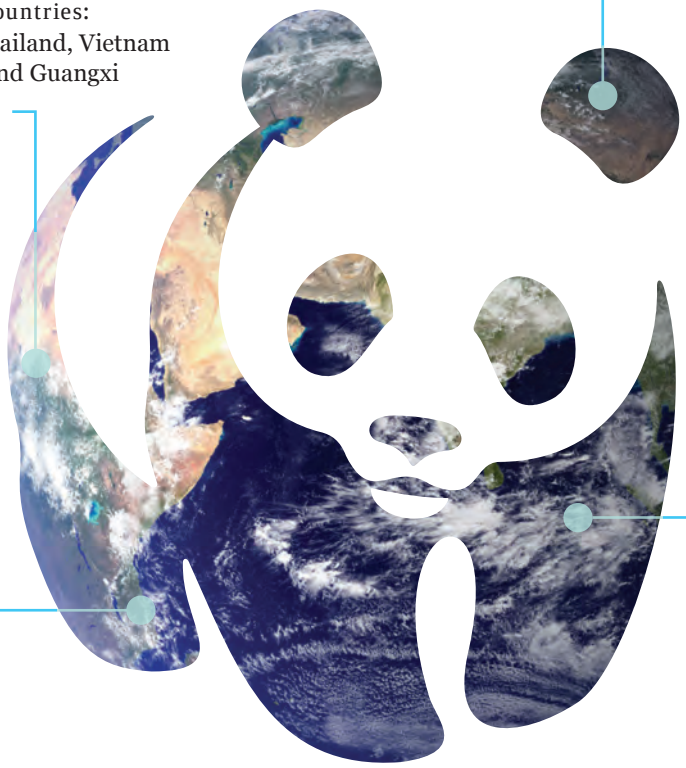
100% RECYCLED

85

An estimated 85 dolphins are found in the Mekong River.

6

The Greater Mekong spans 6 countries: Cambodia, Laos, Myanmar, Thailand, Vietnam and China (Yunnan province and Guangxi Zhuang Autonomous Region).



10

Along with the Mekong River Commission, WWF is calling for a 10-year moratorium on dam development on the Lower Mekong mainstream so the potential impacts can be properly studied and understood.

11

11 dams are proposed on the mainstream of the Mekong River.

WWF

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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