Surveys of the Siamese Crocodile
Crocodylus siamensis
in
Savannakhet Province, Lao PDR
6 May – 4 June 2008

Phase 1 Field Trip Report

for

OZ Minerals Ltd. and Wildlife Conservation Society

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WILDLIFE CONSERVATION SOCIETY
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ອົງການ ອະນຸລັກ ສັດປ່າ

Surveys of the Siamese Crocodile *Crocodylus siamensis* **in Savannakhet Province, Lao PDR, 6 May – 4 June 2008**

Cover illustration
by Jack H. Cox, Jr.

Floating mats of water hyacinth and fern,
Kout Mark Peo, Xe Champhone river system,
Champhone District, Savannakhet Province, Lao PDR

and

Juvenile Siamese Crocodile *Crocodylus siamensis*
at Ban Taleo, Champhone District.

Citation

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Table of contents

Figures and Tables

Figure 1. Captured juvenile Siamese Crocodile, Ban Taleo, Champhone District. 13 May 2008.

Executive Summary

The Siamese Crocodile *Crocodylus siamensis* is listed by the International Union for Conservation of Nature (IUCN) as Critically Endangered and is one of the world's most threatened crocodilians. The species has vanished from nearly all of its historical range in Southeast Asia. Highly fragmented, very small populations persist at a few sites in Cambodia (Daltry *et al*. 2003, B. Simpson, *in litt*., 14 June 2008; J. Thorbjarnarson, *in litt*., 11 July 2008) and Lao PDR (Bezuijen *et al*. 2006), and possibly in Vietnam, Thailand and Indonesia.

Lao PDR evidently harbors the largest number of wild Siamese Crocodiles. In 2005 small populations were reported in four southern provinces, of which Savannakhet and Attapeu were assessed as more important. Surveys in Savannakhet Province found two sites inhabited by the Siamese Crocodile: Kout Mark Peo oxbow in Champhone District (Bezuijen *et al*., 2006) and Beung Bon Thong in Xaibouly District (Phothitay and Somphanith 2003).

In response to the urgent need to determine the current status of the species in Savannakhet Province and develop a recovery initiative, OZ Minerals Ltd. provided funding and logistical support through the Wildlife Conservation Society (WCS) program in Lao PDR for population and habitat surveys in the Xe Champhone and Xe Banghiang river systems in May and early June 2008. These Phase 1 activities are part of an envisaged multi-phase program to develop site-specific Management Plans and pilot projects that will enable local communities to lead and substantially benefit from recovery and management of the crocodile resource, and by extension, strengthen the conservation of local wetlands and aquatic biodiversity.

Phase 1 surveys confirmed that the Siamese Crocodile persists in Kout Mark Peo (adult trails, adult and juvenile dung, and an unfinished nest observed), and inhabits at least three other oxbows of the Xe Champhone system: Nong Maehang (adult shined at night), Kout Kaen (locality record for a measured juvenile), and Kout Xelat Kadan (yearling shined at night). Two complete nests were found at a fifth site: Kout Kouang-Kout Koke in Xonbouly District. Each contained infertile eggs. No evidence of hatchlings or small crocodiles was provided by local user groups. Kout Koke is particularly intact and a large trail in dense floating mats indicated the presence of at least one adult crocodile. Existence of a breeding population is advantageous because eggs typically subject to high mortality in the wild can be salvaged, hatched in a controlled environment, and released as reared juveniles to 'head start' recovery of local populations.

A visit to the Lao Zoo on 26 April 2008 found *ca*. 1,000 crocodiles said to originate from Cambodia and many of which showed typical hybrid characters. A group of seven adults were said to have been received in 1993 as young juveniles from Phin District, and are maintained in an isolated enclosure. These crocodiles exhibit non-hybrid morphological characters that are more consistent with the Siamese Crocodile. DNA analyses are needed to confirm the genetic homogeneity of the Phin District crocodiles and incidence of hybridization in other individuals.

Follow-up surveys are needed to adequately assess all five sites and peripheral areas. Beung Bon Thong and proximate wetlands have not yet been surveyed due to

time constraints. Other areas in the Xe Champhone and Xe Xangxoy were identified from satellite imagery as having suitable or recoverable crocodile habitat and therefore also merit assessment. None of the six sites or other areas is within a National Protected Area, underscoring the need for development of a community-oriented approach and community-beneficial management to ensure the long-term maintenance of crocodile populations.

Local communities are heavily and increasingly dependent on most of the five sites in the dry season for fishing and irrigation of second crop paddy fields. Peripheral vegetation is mostly intact, but fields adjoin parts of some sites, adjacent wetlands are being gradually converted to fields, and hunter-gatherer activities also disturb crocodiles and habitat. Local people are generally afraid of crocodiles but tolerate them, and at most sites respect them as spiritual entities. Educating people about the shy and retiring nature of the Siamese Crocodile and lack of any records of attack on humans can dispel the prevailing myth of crocodiles as highly dangerous creatures. This will bolster local support for population and habitat recovery and a sense of pride in this unique animal.

Conservation incentives may also be created by development of a community-based alternative fisheries program as planned by the World Wildlife Fund in Lao PDR (ComFish), an exchange initiative that provides pumping systems so that rivers rather than oxbows are sourced for irrigation water, ecotourism and other promising ventures as locally determined and incorporated into holistic and site-specific Management Plans.

Phase 1 results indicate that design and implementation of a community-based initiative are feasible to safeguard some of the last refuges of the Siamese Crocodile in Lao PDR, eventually replenish and link populations in key areas, and in the process conserve the biodiversity of critical wetlands in Savannakhet Province. Such an initiative takes on global importance and greater urgency considering that Lao PDR apparently possesses the largest remaining metapopulation(s?) of the Siamese Crocodile among all range states.

Introduction

Historically, the Siamese Crocodile *Crocodylus siamensis* was widely distributed in freshwater habitats of Southeast Asia, from Thailand, Laos, Vietnam and Cambodia (Groombridge 1987), to Sumatra, Bangka, Java (Ross, 1986), Borneo (Cox *et al*. 1993, Ross *et al*. 1998), and possibly the Celebes (Ross, 1986). The species apparently persists in very small, highly fragmented populations in Thailand (Platt *et al*., 2002), Vietnam (Platt and Ngo Van Tri 2000), Cambodia (Daltry *et al*. 2003), Laos (Stuart and Platt 2000; Thorbjarnarson 2003; Phothitay and Somphanith 2003; Phothitay and Somphanith 2004; Thorbjarnarson *et al*. 2004; Bezuijen *et al*. 2006), and the Mahakam River in East Kalimantan province, Indonesia (Ross *et al*. 1998; Cox 2004; Kurniati and Widodo 2005). The largest breeding populations in the wild evidently occur in Cambodia (Daltry *et al*. 2003, B. Simpson, *in litt*., 14 June 2008), but are restricted to two isolated sites with an estimated 30 and 40 individuals (J. Thorbjarnarson, *in litt*., 11 July 2008).

In Lao PDR, the Siamese Crocodile has been documented in recent years as occurring in four southern provinces. The largest remnant populations are reported from Savannakhet and Attapeu provinces (Bezuijen *et al*. 2006).

Of the world's 23 crocodilians, the Siamese Crocodile is probably the most threatened with extinction in the wild after the Chinese Alligator *Alligator sinensis* and Philippine Crocodile *C. mindorensis*. Although captive breeding of the latter two species has been successful and safeguards those species from extinction, *ex situ* breeding of the Siamese Crocodile in all range states is fraught with observed and potential hybridization with the Saltwater Crocodile *C. porosus*. In Vietnam and Cambodia, hybridization with the Cuban Crocodile *C. rhombifer* is also a major issue.

Recognizing the dire threats facing the Siamese Crocodile and its habitat in Lao PDR, WCS entered into an agreement in 2008 with OZ Minerals Ltd., co-operators of a large copper and gold mine near Sepon in Savannakhet Province (Figs. 2 and 3), to assess the potential for a multi-phase program that will ensure the long-term survival of the Siamese Crocodile in Lao PDR, and in particular, support the conservation and maintenance of biodiversity in Savannakhet Province (Anon. 2008).

Although the main tributary systems for crocodiles in the province (Xe Champhone and Xe Xangxoy) are relatively distant from the mine site (Figs. 2 and 3) and not impacted by the mine's activities, OZ Minerals is providing crucial and timely funding for an urgently needed conservation initiative, and stands to gain credit and prestige for exemplary demonstration of Corporate Social and Environmental Responsibility (CSER), especially so if a multi-phase program is successful in linking conservation success to improvement of rural livelihoods.

Figure 2. Survey location (red block) in Savannakhet Province, Lao PDR.

All crocodile sites identified in Savannakhet Province are outside National Protected Areas, and most are heavily pressured by local subsistence activities. A community-based and community-beneficial program approach is therefore deemed particularly appropriate. Local people are strategically placed to help reduce exploitation pressure, or if nothing is done further degrade wetlands resources to the detriment of all stakeholders and relict crocodiles. Engaging local communities and government to share knowledge and ideas to help design and implement a mutually beneficial program, and providing local stakeholders with real incentives to do so, will eventually confer management responsibility and ownership of results, and in turn strengthen the long-term sustainability of desired outcomes.

Objectives

- ***Overall***: To identify where wild groups of the Siamese Crocodile persist in Savannakhet Province, and design and implement a community-based conservation program that will eventually link the most promising sites to ensure long-term survival of the species and its habitat.

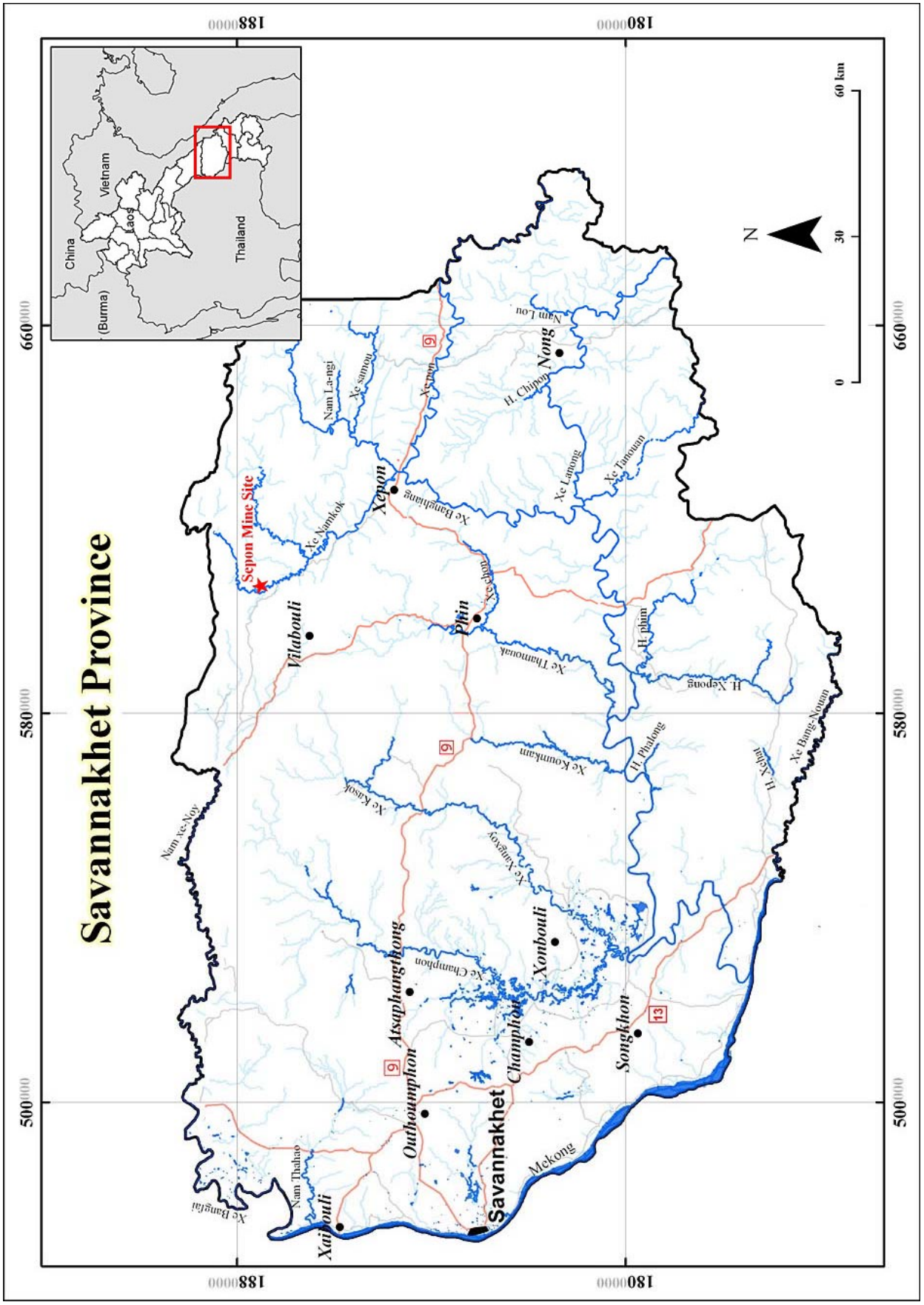

Figure 3. District centers of interest, river systems and main roads in Savannakhet Province.

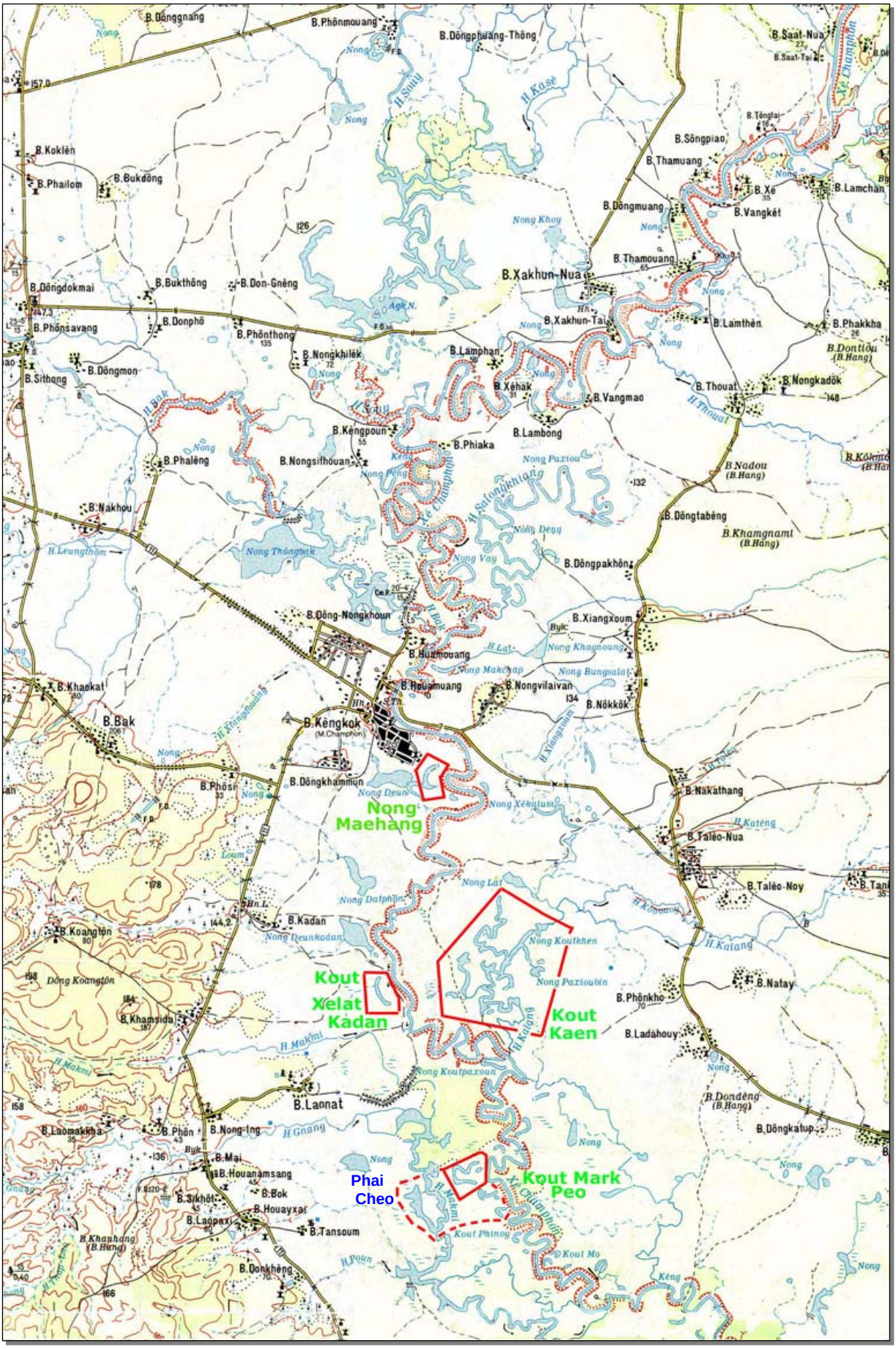

Figure 4. Xe Champhone river system and crocodile sites, Champhone District, Lao PDR.

- ***Objectives Specific to Phase 1:***

  - Confirm occurrence of the Siamese Crocodile at previously reported sites in Savannakhet province.

  - Survey wetlands along the Xe Champhone and lower Xe Banghiang river systems (Figs. 2 and 3) to find additional crocodile sites.

  - Assess human interaction with crocodiles and their wetland habitats.

  - Develop management guidelines for one or more sites that will lead to community-based pilot projects for crocodile population recovery and wetlands conservation.

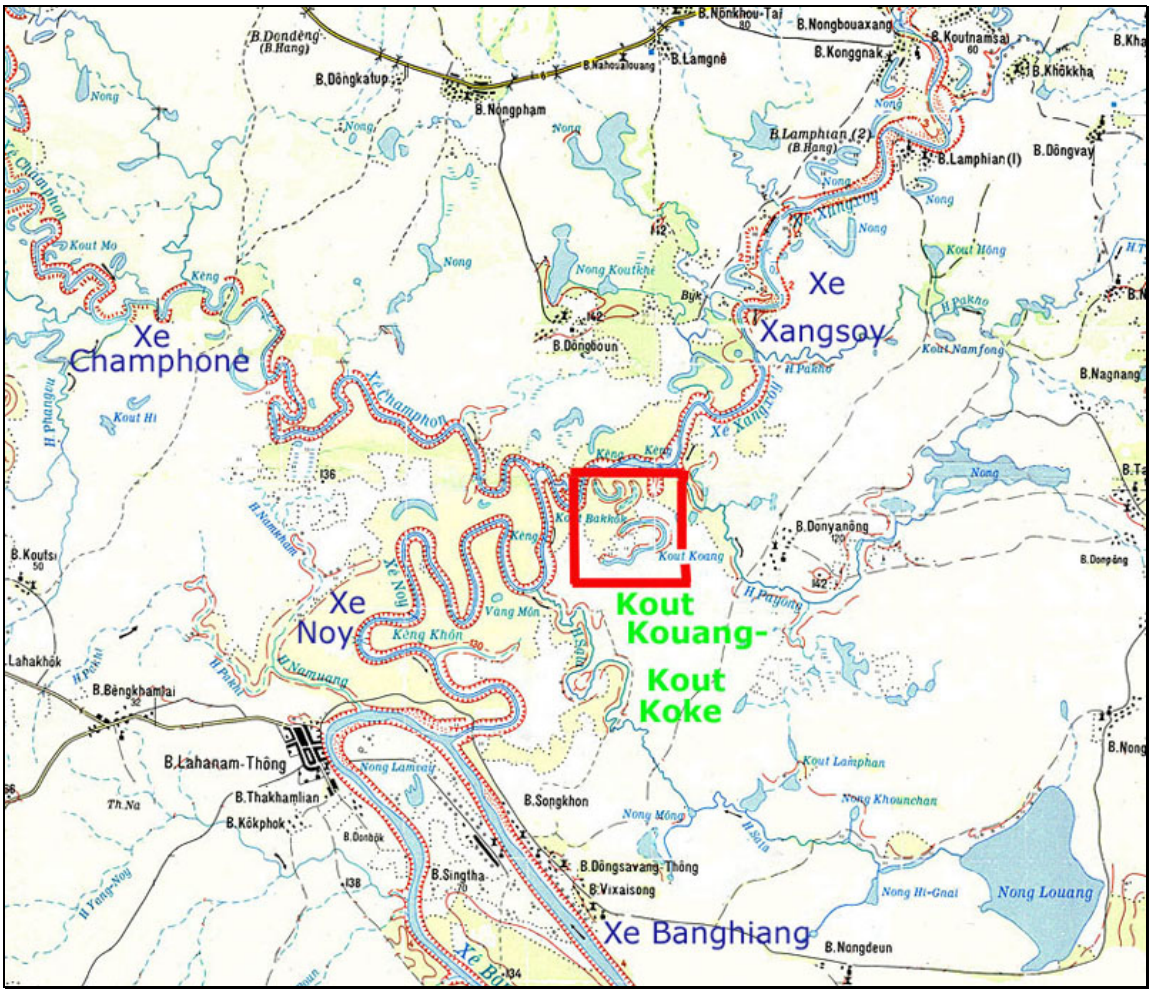

Figure 5. Xe Xangxoy river system and crocodile sites, Xonbouly District, Lao PDR.

Methods

Standard methods to assess and monitor crocodile populations are largely unsuited to habitats in Lao PDR (Bezuijen *et al*. 2006). This is due to the difficulty of observing crocodiles in dense aquatic and littoral vegetation. Night counts of crocodiles using spotlights are feasible at sites with well-defined open water, but most of these

areas are small and lack survey vessels (sampans) (Fig. 6). Systematic nest searches are practicable at most sites, although traversing dense floating mats of vegetation is arduous and tricky (Fig. 7). Aerial surveys using helicopters provide a rapid and easier alternative, although these are comparatively much more expensive and do not directly benefit local communities as 'ground' searches can. Systematic searches for dung in this habitat may indicate the number and approximate size/age class of crocodiles present.

Figure 6. Kout Kaen oxbow, Champhone District. **Figure 7.** Nong Panghien, Champhone District.

Daytime reconnaissance of habitats was conducted on foot along wetland margins and in sampans at open water sites where crocodiles were said to occur perennially (Fig. 6), and to a lesser extent at sites of seasonal occurrence. Selection of sites was based on recent capture of juveniles or observation of crocodiles by local people and the results of previous research (mainly Bezuijen *et al*. 2006).

Site selection, assessment and travel logistics were facilitated by perusal of 1:100,000 topographic maps (Lao PDR State Geographic Service sheets E-48-127 B.KENGKOK 1987 edition and E-48-139 B.LAHANAM-THÔNG 1986 edition). High resolution satellite imagery taken in January 2008 but confined to most of the Xe Xangxoy tributary system was downloaded from Google Earth© and photo-edited. Resulting images provide *ca*. 5 m resolution, detailed views of site topography, vegetation types (including dense vs. thin floating mats) and peripheral land use.

Participatory Rapid Appraisal (PRA) techniques were used to obtain information on crocodile occurrence, habitat and human interaction. These techniques consisted of informal village meetings and interviews (Fig. 8) with persons familiar with crocodiles, and discussions held during reconnaissance of crocodile sites and on population night counts. Open-ended questions were emphasized to obtain local knowledge and perceptions of crocodiles, wetlands and local livelihoods. Ideas were elicited on how local biodiversity can be conserved and replenished while substantially benefiting local people.

Figure 8. Village discussion at Ban Pathumwam, Xonbouly District, 1 June 2008.

In addition to the authors, the survey team consisted of District Agricultural and Forestry Office (DAFO) staff in each district visited, crocodile informant-guides field assistants and at times included village leaders. The survey itinerary and summary of activities is appended as Annex 4. Fieldwork expenditure is summarized by category in Annex 2.

Results

Crocodiles and habitat. The initial one month survey produced a basic understanding of current crocodile distribution, status and habitat in the Xe Champhone river system of Champhone District. Four sites, each an old oxbow of the Champhone, were found to support crocodiles and suitable habitat: Kout Mark Peo, Kout Xelat Kadan, Kout Kaen and Nong Maehang. Recent, evidently successful nesting was recorded at Kout Xelat Kadan and a current nesting attempt was observed at Kout Mark Peo (Fig. 22; Table 1).

A fairly good understanding of crocodiles and habitat was gained in the Xe Xangxoy tributary system, Xonbouly District. Kout Kouang oxbow contains particularly intact nesting and foraging habitat (Fig. 9). Two new nests, each with an infertile clutch, were inspected. Secluded Kout Koke (Figs. 11 and 12), a nearly adjoining oxbow, is negligibly disturbed and contains similar good crocodile habitat

Figure 9. Kout Koung Nyai, Xonbouly District.

Figure 10. Kout Mark Peo, Champhone District**.**

Direct observations infer that a minimum of 10 crocodiles (6 nesting adults + 2 adults + 2 yearlings) inhabit the six sites in the Xe Champhone and Xe Xangxoy (Table 1). On the basis of recent observations by local people acknowledged as the most familiar with crocodile occurrence at these sites, a minimum of 75 crocodiles was estimated. Most (*ca*. 50) of these are small juveniles from Kout Mark Peo. Seven adults (≥5 breeding) were inferred from the current survey results, with no more than a pair indicated from each site.

All five sites merit inclusion in a community-based initiative to better gauge the status and distribution of resident crocodiles, habitat characteristics and socio-economic conditions. This will enable identification of site-specific requirements to secure local crocodile populations, actions to improve habitat that will promote maintenance of viable populations, and development of a Management Plan. A short ecological profile and survey results of each of the five sites are provided in order of conservation priority.

Table 1. Crocodile observations, signs and local estimates of population in the Xe Champhone and Xe Xangxoy river systems. Only from sites where observations and local information indicate crocodiles persist. A=adult; J=juvenile; Y=yearling. *=recorded on night counts (Table 3). See Annex 3 for GPS coordinates.

Site	Crocodiles observed*	Nests	Adult trails (w/out nests)	Dung	Local estimate of population (min)
Kout Kouang-		2 new (infertile)			2 A
(Kout Koke)			1		1 A
Kout Mark Peo		1 unfinished		1 J ≥1 A	*ca*. 50 (J + A)
Kout Xelat Kadan	1 Y	1 old hatch			12 J + 2 A
Kout Kaen	1 Y*				2 J + 1 A
Nong Maehang	1 A				1 A + 4 J
TOTALS	3	4	1	2	*ca*. **75**

1. Kout Kouang-Kout Koke oxbow complex (Xonbouly District).

Nearly connected old oxbows of Xe Xangxoy tributary, extensively covered with mats of dense floating vegetation and bordered by tall thorny thickets of bamboo, mimosa, and shrubs (Figs. 11 and 12). The most remote and intact of all sites.

Figure 11. Dense bamboo and watery littoral, Kout Koke, Xonbouly District.

Figure 12. Floating mats of grass, sedge and broadleaf saplings, Kout Koke. (photo by Tia).

Kout Kouang is a serpentine oxbow lake, split by a central forest corridor into Kout Kouang Nyai and Kout Kouang Noy. The two sections are *ca*. 30% covered by patches of open water. Local people from Ban Dongnyanong in Xonbouly district, and Ban Songkhone and Ban Donsavang in Songkhone District said they fish there occasionally. Ban Dongnyanong residents assert that the Kout Kouang-Kout Koke complex lies within Xonbouly District. Ban Donsavang residents were equally assertive that the complex lies within Songkhone District. The Xonbouly DAFO chief informed us that the border between the two districts is demarcated by the Houay Sala (Fig. 5), which places the complex within Xonbouly District. Ban Donsavang residents said the district border was the Houay Payong (Fig. 5), which would put Kout Kouang and Kout Koke in Songkhone District.

Some water is pumped out of Kout Kouang for irrigation of peripheral paddy fields in late spring (end of the dry season), mainly by residents of Ban Dongnyanong (Fig. 11). Water level appeared little affected. Much of the littoral is undisturbed, but fringing vegetation has been cleared and paddy fields excavated at one end of the oxbow (Fig. 12). With the help of our guide Mr. Tia, trails of at least two large crocodiles were observed in Kout Kouang Nyai and traced to nest sites on an Incomplete search of floating mats.

Figure 13. Irrigating a paddy field, edge of Kout Kouang Nyai, Xonbouly District.

Figure 14. Fallow and cut fields, northern end of Kout Kouang Noy oxbow, Xonbouly District.

Each nest contained infertile eggs (Figs. 15, 16, 19 and 20). These were measured (Annex 5) and returned to respective clutch cavities. The authors requested local people to protect the eggs for future inspection by the survey team.

Figure 15. Second infertile nest (XNX 002), Kout Kouang Nyai, Xonbouly District. 28 May 2008.

Figure 16. First infertile nest (XNX 001), Kout Kouang Nyai, Xonbouly District. 27 May 2008.

Kout Koke is particularly secluded, little used and negligibly disturbed by human activities. Occasional eel trapping and fishing takes place. Crocodiles are regarded as spiritual entities, not disturbed and poorly known by local people. Floating mats cover about 60% of the water surface. Most mats are herbaceous and rather thin, but dense patches with floating saplings also occur (Figs. 12 and 18). A forest patch with unusually tall trees occurs inside the inner meander of Kout Koke and said to be protected from most cutting because of forest spirits.

Figure 17. Kout Kouang Nyai and nests XNX001 and XNX002, Xe Xongxoy, Xonbouly District.

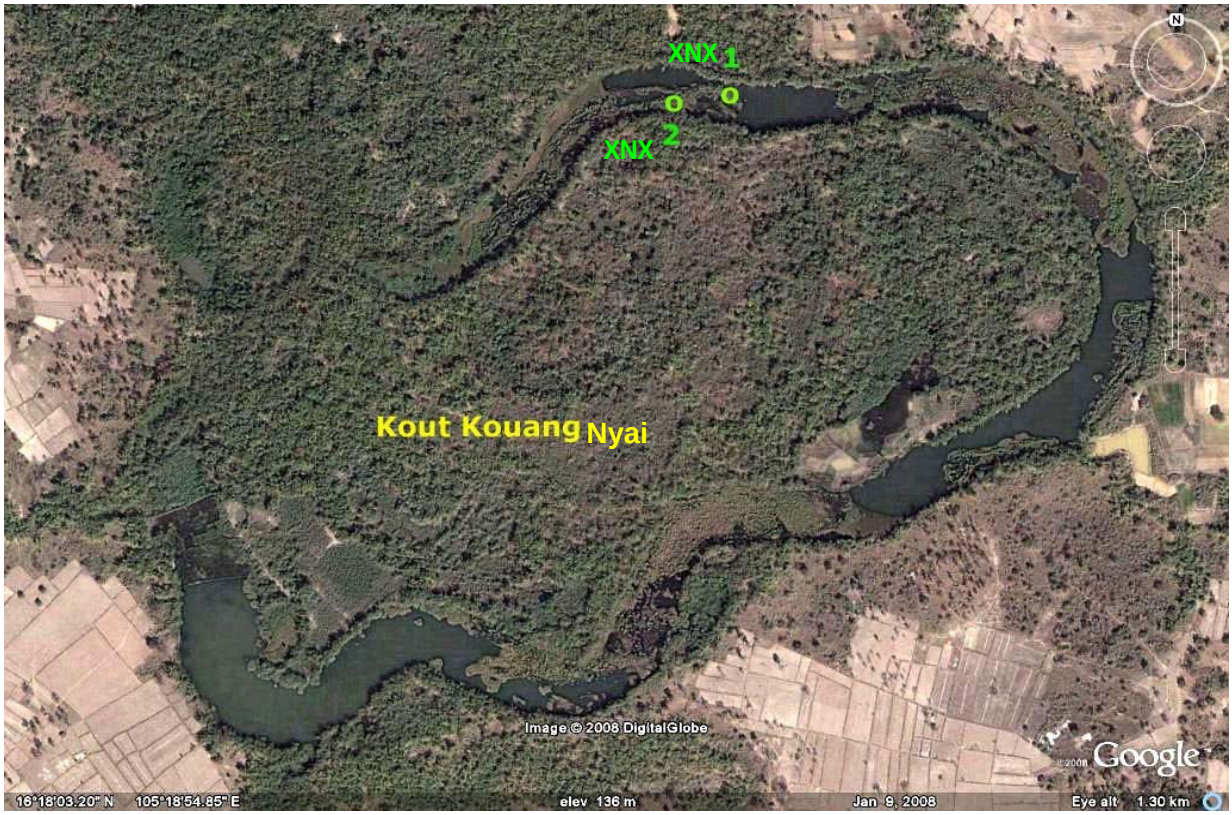

Figure 18. Kout Koke and Kout Kouang Noy, Xe Xangxoy, Xonbouly District. January 2008.

Figure 19. Weighing eggs at nest XNX 002, Kout Kouang Nyai, Xe Xangxoy. 29 May 2008.

Figure 20. Clutch of nest XNX001, Kout Kouang Nyai, Xe Xangxoy. 27 May 2008.

2. Kout Mark Peo (Champhone District).

An old, nearly totally overgrown oxbow of the Champhone River northeast of Ban Tansoum and Phai Cheo reservoir (Figs. 4 and 10). Identified in 2003 as harboring a nesting population of Siamese Crocodile (Thorbjarnarson *et al*. 2003). Successful nesting in 2004 inferred. Night counts on foot along flooded littoral of bamboo and mimosa scrub 13-15 March 2005 concluded that ≥5 hatchlings/ yearlings, one larger juvenile and two adults were present (Bezuijen *et al*. 2006). Approximately ten crocodiles were reportedly observed by University of Lao PDR researchers in the water and on floating vegetation during daytime assessment of Kout Mark Peo on 7 March 2008 (C. Somvonpha, pers. comm.). Consensus among Ban Thamsoun villagers was that about 50 crocodiles inhabit this oxbow and at least a pair of adults continues to breed.

Water levels were too low to conduct night counts when the site was visited 9-10 May and 17 May 2008; daytime reconnaissance of habitat on 9 May showed numerous trails of ≥1 adult (Fig. 10). Dung of an adult and small juvenile was collected from a floating hummock (Table 2) (Fig 21). On 17 May an unfinished nest was documented on particularly dense floating vegetation at the northern end of the oxbow (Fig. 22).

Table 2. Crocodile dung collected from Kout Mark Peo oxbow, 9 and 19 May 2008.

Date	Habitat sub-type	Max. diameter (cm)	Color & texture
9 May 2008	Floating mat hummock	0.95	white/gray, hard
9 May 2008	Floating mat hummock	0.80	white/gray, hard
19 May 2008	Decaying floating mat	3.52	mostly white, hard

Figure 21. Juvenile dung, Kout Mark Peo.

Extensive floating mats impede access and use of Kout Mark Peo by local communities. Only a small amount of water is pumped in the dry season for irrigation of nearby paddy fields, which are few. Mr. Sone is adept at traversing floating mats to set eel traps and gather snails, and was said to have captured a small juvenile crocodile o/a 2 June 2008. Due to imposed time constraints the team could not return to examine the crocodile.

Figure 22. Unfinished nest, Kout Mark Peo. (photo by Kamphane).

3. Kout Xelat Kadan (Champhone District).

An old oxbow of the Xe Champhone SE of Ban Kadan. Heavily covered in aquatic vegetation (Fig. 23). Some dense herbaceous mats and floating thickets are present, but mostly overgrown with water hyacinth and scattered sapling clumps.

One hatchling/yearling was observed and nearly caught on a night count conducted 18 May 2008. Almost no open water was accessible. A section overgrown with water hyacinth was about knee deep in the center. Our guide Mr. Noy said that when the water level is higher but not over the banks 10-12 or perhaps as many as 20 small juveniles could be shined in one night. Crocodiles here are regarded as spiritual creatures and not to be disturbed. Mr. Noy attempted to call up crocs by chanting softly while he spotlighted open areas of the oxbow from the banks at night.

Extensive pumping of water for paddy field irrigation takes place in the late dry season. Kout Xelat Kadan was almost dry (*ca*. 1m deep) in the more open, water hyacinth covered end on 18 May, which would normally have more patches of water, but the draining has increasingly reduced the open water area (Fig. 23). The shallowness is a significant source of stress for crocodiles, especially adults, and makes foraging difficult for smaller crocs.

Figure 23. Kout Xelat Kadan, Xe Champhone, Champhone District.

Figure 24. Old nest, Kout Xelat Kadan, Xe Champhone, Champhone District.

An old nest said to have hatched in October 2007 was examined on 18 May 2008 in the deeper end of the oxbow (Fig. 24). The condition of nest material, eggshell fragments and site vegetation are consistent with this information. The deduced nesting period is several months later than that for Siamese crocodiles in Cambodia, (B. Simpson, *in litt*., 14 June 2008), and for nests observed this year in Kout Koung. A hatched nest was said to have been found on the banks of Kout Xelat Kadan several years ago (2004?).

4. Kout Kaen (Champhone District).

An extensive meandering oxbow and old channel system, ≥3.0 km in length, SW of Ban Taleo, comprised by open turbid water and patches of water hyacinth (some extensive) (Figs. 4 and 25). The hyacinth shifts around with changing winds to reconfigure areas of open water. Dense mats of floating vegetation were not encountered on daytime reconnaissance or known to exist according to local informants. Open water is moderately to heavily fished by villagers from Ban Taleo and Ban Phônkho. Kout Kaen is perennially watered (minimum 1.5 - 2.0 m in dry season?) and functions as a seasonal and probably perennial refuge for crocodiles, but apparently not as a breeding site.

Figure 25. Section of Kout Kaen oxbow system covered with water hyacinth *Eichhornia crassipes* and salvinia *Salvinia* sp., Xe Champhone, Champhone District.

A captive 47 cm TL (total length) juvenile was inspected at Ban Taleo on 13 May 2008 (Fig. 26). The holder Mr. Bounthong is rearing the crocodile as a pet and subsequently guided the survey team to the spot where he incidentally captured the crocodile o/a 7 May 2008 in a cast net along the littoral of Kout Kaen oxbow. Mr. Ang, a fisherman from Ban Phônkho stated that he saw two large crocs (an adult and large juvenile) traversing water and nearly flooded banks in 2006.

Figure 26. Young juvenile Siamese Crocodile from Kout Kaen, Xe Champhone.

5. Nong Maehang (Champhone District).

An isolated old oxbow of the Xe Champhone at the edge of Champhone town, mostly overgrown with floating mats of grass and sedge, water hyacinth and a few saplings (Fig. 27). A small patch of open water occurs at the northern end. At the request of local user groups the oxbow has been declared by the district government as a conservation area for fish brood stock to supply area wetlands, in particular the adjacent lake Nong Deun. A peripheral forest patch is said to harbor nature spirits.

Figure 27. Nong Maehang oxbow, Champhone District.

No fishing or disturbance of aquatic vegetation is allowed, but frogs are said to be hunted at night by spotlight, usually after a heavy rain. One adult crocodile was shined at night on 14 May 2008, and is seen frequently in the northern end of the oxbow, which is the only patch of open water in the oxbow (Fig 28). Mr. Sounthone's family is housed near the banks there. Based on eyeshine width of other crocodiles spotted at night, Mr. Sounthone estimates ≤5 crocodiles, mostly small individuals, inhabit Nong Maehang. Some of the floating mats in the southern end appear secluded and strong enough to support nests.

Figure 28. Open water and crocodile site, Nong Maehang.

Inspection of nearby Nong Panghien on 15 May 2008 revealed a small old oxbow lake mostly overgrown with dense floating mats and thickets, and inhabited by giant leeches (Fig. 29). Local people were said to not exploit the area.

Additional sites were identified that contained suitable perennial habitat for crocodiles but said to lack them for the past 20-30 years (*i*. e. Angsouay Reservoir (Fig. 30), Nong Taiheua in the Xe Banghiang river system (Fig. 31), Songkhone District; and Nong Kanh in Champhone District; oxbow lakes S and SE of Ban Dongboun in Xonbouly District). Other sites in Champhone District were reconnoitered which appear to provide suitable habitat for

Figure 29. Floating vegetation, Nong Panghien, Champhone District.

crocodiles in the wet season. These sites occur as shallow lakes and ponds, flooded scrub and fallow/abandoned rice fields. All of them apparently lack crocodile nesting habitat (*i. e.*, dense floating mats) but can be used as seasonal foraging habitat.

Figure 30. Angsouay Reservoir floating mats, Champhone District.

Figure 31. Sedges of Nong Taiheua oxbow, Songkhone District.

Kout Xehack, an oxbow of the Xe Xangxoy in Xonbouly District was assessed during the day on 1 June 2008. Residents of nearby Ban Konpathoumvan (= Ban Konggnak) informed us that as recently as 2004 ≥1 large crocodile inhabited the oxbow, but in that year floating vegetation was cleared, the open water began to be used intensively for fishing, and the littoral for grazing, expansion of paddy fields and hut construction (Fig. 32). No crocodiles have been observed since 2004. Kout Xehack habitat was currently assessed as too disturbed to support crocodiles.

Figure 32. Heavily disturbed Kout Xehack, Xe Xangxoy river system, Xonbouly District.

Night counts of crocodiles were conducted at seven sites over the course of the surveys (Table 3). These sites were known by daytime assessment to either contain crocodiles (Kout Kouang Nyai), purported to by local people (Kout Xelat Kadan), considered likely to by incidental capture of juveniles (Kout Kaen), said to occur in the recent past (Kout Xehack), or provide suitable habitat (Phai Cheo Reservoir). Counts confirmed the presence of crocodiles at Kout Xelat Kadan and Nong Maehang. Conditions were generally good, but in non-flood stage at medium water levels the littoral of many sites is obscured by overhanging thickets.

Table 3. Crocodile night counts in the Xe Champhone and Xe Xangxoy river systems, Savannakhet Province 11 May to 1 July 2008. A=adult, J=older juvenile, Y=yearling, H=hatchling; EO=eyes only; E=encounter rate; H_20=water level, M=medium, Hi=high, L=low; We=weather, dr=drizzle; cr=clear, cl=cloudy; Mn=moon, no=no moon; gb=gibbous; fl=full moon; **=calculated from GPS start-end coordinates and 1:200,000 topographic maps. See Annex 3 for start and end of survey GPS coordinates.

Site	Date	Crocodile Age Class					Distance (km)**	E rate (/km)	Conditions		
		A	J	Y	H	EO			H_20	We	Mn
Phai Cheo (outer)	11 May						1.42	0	M	cr	fl
Nong Maehang	14 May	**1**					0.66	1.52	L-M	cl	gb
Phai Cheo (inner)	17 May						0.84	0	M	cl	gb
Kout Xelat Kadan	18 May			**1**			0.18	5.56	L	dr	no
Kout Kaen	24 May						≈3.5	0	M	cl	no
Kout Kouang Nyai	27 May						0.15	0	L-M	cr	no
Kout Xehack	1 June						0.84	0	L	cl	gb
TOTALS		**1**	**0**	**1**	**0**	**0**	**7.59**	**0.26 crocodiles/km**			

Captive crocodiles at Lao Zoo. The Lao Zoo at Ban Kuen north of Vientiane was visited on 26 April 2008. A detailed account is given in Annex 7. Approximately 1,000 Siamese crocodiles are reared in a variety of pens, comprising some 300 obtained from Cambodia the 1990s and their subsequent offspring (Mr. Bounchan, Lao Zoo Manager, pers. comm.). Many of these crocodiles show scalation suggestive of hybridization with the Saltwater Crocodile (*i.e.*, reduced sharpness of dorsal armor, reduced size of large post-occipital scutes, less rounded snout) (Fig. 33), which commonly takes place on farms in Thailand and Indonesia (pers. obs.).

Figure 33. Hybrid(?) Siamese crocodiles at Lao Zoo.

A group of seven adult Siamese Crocodiles are reared separately and said to have been received from an unknown location in Phine District in 1993 (Mr. Bounchan, Lao Zoo Manager, pers. comm.). Four of these were observed to lack hybrid characters. The three other crocodiles were mostly hidden in the water. Sexes are unknown. At least one crocodile is known to have nested in 2007. Comparative mitochondrial DNA analysis is needed to confirm genetic purity.

Socio-economic results. Quantitative assessment of resource importance to local communities and development priorities was not conducted. A month prior to the survey two researchers from the University of Lao PDR conducted an independent investigation of crocodiles at most of the same sites in Champhone and Songkhone districts. The fieldwork and results partially satisfy the researchers' requirements for a Bachelors of Science degree (Somvonpha and Xayphone, in prep).

JC attended a well-prepared and informative presentation by Ms. Chanhvilay Somvonpha at the WWF-Lao PDR office on 20 June 2008. The study emphasized a socio-ecological assessment of threats to crocodiles. Local people near each site scored threats to crocodiles. Ranked results vary among sites but four common threats were cited in approximate order of severity: human population increase, fishing, irrigation and collection of non-timber forest products. No additional studies in the area are planned by the researchers.

Village discussions during Phase 1 helped prepare local people for Phase 2 by asking them to think of ways that crocodiles and wetlands can better benefit local communities, while protecting and increasing the numbers of crocodiles and keeping local wetlands wet and wild with existing fauna and flora.

Phase 1 results were discussed with Oxiana Environment Department managers and consultants at the mine site in Sepon during a visit by JC from 25 June to 2 July 2008. A PowerPoint presentation was delivered to the Sepon site General Manager and Assistant General Manager on 1 July 2008, and to additional personnel later that evening. A subsequent presentation to Oxiana directors and consultants in Vientiane was made on 4 July 2008. Positive reactions were received, indicating approval of Phase 1 outputs and endorsement of Phase 2 plans.

Strong points:

- Four of the five main sites are within a fairly close area, easily approached by road, then by short walk (0.3 – 2.5 km), mostly on good paths or tracks.

- Local people do not disturb crocodiles at any site. At 3 of 5 sites crocodiles are respected as spiritual entities that do not benefit local people, but if disturbed can harm them (*e*. *g*. cause individual/family illness or death).

- Dialogues with local people indicate they support basic conservation of crocodiles, especially where wetlands resources (water and biotic) are mostly intact or can be replenished/recovered for sustainable utilization.

- Good support was provided by DAFO officers in all three districts locating crocodile sites and local people with knowledge of crocodiles. In the field, DAFO officers performed satisfactorily when accompanying the survey team.

Figure 34. Champhone DAFO counterpart Mr. Bounsuang at Phai Cheo Reservoir.

Weak points and possible resolutions:

- Most local people fear crocodiles, and in the vicinity of crocodile habitat are wary of or oppose trying to increase crocodile populations. Crocodiles in some areas are regarded as competitors for scarce fish resources. These perceptions can likely be changed by a conservation awareness campaign that elucidates the non-aggressive character and bio-ecology of the Siamese Crocodile, and is linked to generation of tangible economic benefits (*e*. *g*., payment for active protection and basic monitoring, ecotourism, provision of alternative means of irrigation, integrated fisheries development, non-detrimental development initiatives, land lease arrangements).

- Unfortunately, the principal investigator does not yet speak Lao. A counterpart fluent in English is needed to enable accurate translation in the field.

- Pressing need exists to identify and recruit counterparts/field assistants (preferably local) who are not afraid of crocodiles, rain, mosquitoes, mud or leeches; who are interested in biodiversity conservation, sympathetic to helping improve local livelihoods, have a good understanding of science, are technically competent at scientific measurements, willing to learn, have good organizational and communication skills, able to work effectively as part of a team, dedicated to helping the rural poor, and not taking advantage of local people in any way.

- A car-type vehicle is unnecessary. Costly to place, hire and operate, and gives the impression to local people that the project has lots of money. Better to hire

local vehicles, where smaller public transport such as *songthaew*s, motorcycle taxis and *tock tock*s are readily available and drivers knowledgeable about local roads and conditions. In this way project funds go directly to local people instead of distant, more economically advantaged urban people.

- *Per diem* rates paid to village assistants (US$2) and DAFO staff (US$4.5) who accompany the team to field sites are too low to obtain adequate support. These were increased by the consultant to US$3.45 and 5.75 respectively.

Discussion

The Phase 1 survey identified four sites with remnant crocodile populations and habitat (including nesting habitat at three sites) in Champhone District. These sites represent core areas for protection of crocodiles and wetlands biodiversity, and the basis of a community-based program to conserve and replenish crocodiles and critical wetlands in the Xe Champhone system.

Kout Kouang and Kout Koke oxbows in the Xe Xangxoy system represent a fifth site with equal or greater conservation potential than those in the Xe Champhone. Although on a smaller scale and more remote, these nearly adjoining oxbows are less utilized by local communities and habitat is more intact. Breeding/nesting habitat was assessed as in the best condition of all sites reconnoitered in the Xe Champhone and Xe Xangxoy. High resolution satellite imagery of oxbows across the Xe Xangxoy W and NW of the Kout Kouang-Kout Koke complex shows several sites of good crocodile habitat suitable for a local landscape approach to conservation (Fig. 33).

Figure 35. Oxbows north of Kout Kouang-Kout Koke, Xe Xangxoy, Songkhone District.

Taken together, the five sites represent two distinct project areas where local communities have voiced support for a conservation initiative, preferably one that will benefit them tangibly and in the near-term. The modalities are unclear and underscore the need to have input on project design from local communities, and their active participation at every stage of planning, decision-making and implementation. Incorporating local knowledge, ideas and skills will likely be a key to program success. PRA techniques are indicated as an important part of an appropriate and effective approach.

Figure 36. Dip net catch, Ban Tansoum, Champhone District.

Zoning and enforcement of wetlands use and the designation of at least one minimally utilized core area for crocodile conservation may be an effective program component but needs to be vetted at the local level. Development of ecotourism appears to have potential at several sites. Nong Maehang is easily reached and could be important for international as well as domestic tourism. Remote sites such as Kout Kouang may offer a unique attraction for adventure tourism, but design and promotion will need guarantees that substantial benefits accrue to local communities.

Irrigation is an increasingly serious threat at key sites for crocodiles such as Kout Xelat Kadan, and to a lesser extent, Kout Kouang. Following removal of subsidies for diesel in recent years, local framers have turned to smaller pump sets and more proximate deep water oxbows to irrigate second crop paddy fields. Large floating pump sets (Fig. 35) provided by the government formerly drew water from rivers for distant and larger scale irrigation, but few villages can afford the current extremely high price of fuel to operate these pumps.

Pilot projects should be seen as an iterative process, requiring flexibility in timing and activities, and encouraging and enabling local communities to manage as much of the effort as they can with a minimal amount of external inputs. Each of the five principal sites is socio-ecologically distinct, which emphasizes the need to include local knowledge, locally determined socio-economic needs, and adequate conservation incentives in the design of site specific management plans.

Figure 37. Irrigation pump, Ban Kadan, Champhone District.

The appropriateness of a community-oriented projects is reflected by the observed trend of the remotest sites (*e*. *g*. Kout Kouang-Kout Koke) being superior for crocodiles and habitat yet surrounded by the most impoverished of local communities. And within

these communities the most knowledgeable and proximal people for crocodile conservation tend to be the most marginalized economically (*i*. *e*. the poorest of the poor). Poverty reduction can be an additional locally important output of the projects.

Follow-up projects and development of a community-participatory and community-beneficial program should result in a remarkable turnaround for the Siamese Crocodile in Savannakhet Province, one that all partners can take enormous pride in. Oxiana will gain an outstanding example of CSER by enabling the rescue of some (most?) of the remaining individuals in Lao PDR of a crocodilian (= species of charismatic megafauna) that has survived virtually unchanged for 60,000,000 years but is approaching national and perhaps global extinction in the wild. An eventual outcome of establishing viable populations protected by and benefiting local communities would be a major global conservation success story.

Potential for even greater success exists with eventual linking up of 'specks-in-a-landscape' of habitat to strengthen population viability and lead to sustainable conservation of critical wetlands and associated biodiversity. This is likely to be a rather long-term process, but not necessarily expensive.

Seasonal wetlands near identified crocodile sites (Fig. 36) need further assessment and represent important landscape sites to allow dispersal and interaction of crocodiles, especially breeding adults. Physically linking such sites will enhance local gene pools and promote maintenance of a robust crocodile population.

Figure 38. Fallow and harvested paddy fields, edge of Kout Kaen, Champhone District**.**

The breeding group of seven adult Siamese Crocodiles originally obtained as juveniles from Phin District in Savannakhet Province in 1993 and maintained at Laos Zoo at Ban Kuen (50 km north of Vientiane) are a potentially invaluable source of offspring to help replenish wild populations. However, comparative analyses of

mitochondrial DNA with specimens from the wild are needed to confirm the genetic 'purity' of the Ban Kuen adults (Fig. 37). Genetically pure offspring from Lao Zoo can be used to 'head start' recovery of crocodiles where non-breeding populations persist or where local extinctions have occurred but suitable habitat and community support exist.

Figure 39. Hybrid (?) Siamese Crocodile laying eggs, Lao Zoo, Ban Kuen. 26 April 2008.

A survey of Phin District government offices and villages along the Xe tributary may identify the origin of the seven Lao Zoo crocodiles, and additional sites for crocodile conservation closer to the OZ Minerals/LXML Sepon mine site. This can be done as a trip by boat from near Sepong to Meuang Phin and the Xe Thamouak during Phase 2.

Recommendations

1. Implement Phase 2 of the project along the lines of the project proposal, and include additional time and resources to re-survey Kout Mark Peo (nest re-visit; night count), Kout Xelat Kadan (daytime thorough reconnaissance; night count), Kout Kouang (re-inspect nests; search for others), Kout Koke (systematic nest search) and the Xe Thamouak in Phin District (search for the origin of the seven Lao Zoo crocodiles). Survey Beung Bon Thong (tame adult crocodile still present?) and proximate wetlands (Xaibouly District), only 2.5 km off Highway 13. Some unspent funds are available from Phase 1. Multi-tasking with Phase 2 activities requires little additional funding or time.

2. Conduct village meetings at times and venues convenient for local communities. Ensure that adequate English language translation is included. Circulate the framework of a Management Plan in Lao language, and encourage local people to suggest practicable, site-specific modalities. Themes to be discussed include: development of conservation incentives, zoning of wetlands to control exploitation and promote sustainable use of aquatic resources, crocodile management options, community-participatory roles, and expected outcomes.

3. Collaborate with the WWF-Lao PDR Community Fisheries program (ComFish) in Savannakhet Province, and seek to involve University of Laos researchers, and scientists from institutions in Savannakhet (if available), in future project phases to enhance the scientific capacity of fieldwork personnel and assist implementation of pilot projects.

4. Acquire equipment and supplies to obtain DNA samples (tissue and blood), conduct sampling on captive juveniles in the field, captive adults at Lao Zoo said to be obtained as juveniles from Phin District, and as materials and processing allows, a representative series of apparent hybrid crocodiles at Lao Zoo. Have material analyzed and interpreted to determine if hybridization is present.

Literature Cited

Anon. (2008). Proposal for Crocodile Survey and Assessment of Recovery Potential. Wildlife Conservation Society and Oxiana Mining Ltd. Vientiane.

Bezuijen, M. R., C. Phothitay, M. Hedemark and S. Chanrya (2006). Preliminary status review of the Siamese Crocodile (*Crocodylus siamensis* Schneider, 1801) (Reptilia: Crocodylia) in the Lao people's Democratic Republic. Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme, Vientiane, Lao PDR, 114 pp.

Cox, J.H., R. Frazier and R. Maturbongs (1993). Freshwater crocodilians of Kalimantan (Indonesian Borneo). *Copeia* **2**: 564-566.

Cox, J. H., (2004) Status and Conservation of the Siamese Crocodile *Crocodylus siamensis* in Kalimantan (Indonesian Borneo). Pp. 150-154 in Crocodiles. Proceedings of the 17th Working Meeting of IUCN-SSC Crocodile Specialist Group. Darwin. IUCN: Gland.

Daltry, J. C., C. Dany, E. Phal, P. Mora, S. Han, S. Pisith, T. Thara and B. Simpson (2003). *Status of the Siamese Crocodile in the Central and Southern Cardamom Mountains, Cambodia. Findings of Recent 'Kropeu Phnom' Surveys*. Fauna & Flora International-Cambodia Programme and Department of Forestry and Wildlife, Phnom Penh.

Groombridge, B. (1987). The distribution and status of world crocodilians. Pp. 9-21. In: G. J. W. Webb, S. C. Manolis, and P. J. Whitehead (eds.). Wildlife Management: Crocodiles and Alligators. Surrey Beatty and Sons: Sydney.

Kurniati, H. and T. Widodo (2005). Surveys of the Siamese Crocodile *Crocodylus siamensis* Habitat in the Mahakam River, East Kalimantan, Indonesia. Indonesian Insitute of Sciences (LIPI), Research Center for Biology, Cibinong, West Java.

Phothitay, C. and Somphanith (2003). *Crocodile Survey Report of Wetland areas in Savannakhet and Attapeu Provinces*. Living Aquatic Resources Research Center (LARReC), National Agriculture and Forestry Research Institute, Ministry of Agriculture and Forestry, Vientiane.

Phothitay, C. and Somphanith (2004). *Saravan Crocodile Survey 6-12 June 2004*. Living Aquatic Resources Research Center (LARReC), National Agriculture and Forestry Research Institute, Ministry of Agriculture and Forestry, Vientiane.

Platt, S. G., A. J. Lynam, Y. Temsiripong and M. Kampanakgarn (2002). Occurrence of the Siamese crocodile (*Crocodylus siamensis*) in Kaeng Krachan National Park, Thailand. *Nat. Hist. Bull. Siam Soc*. **50**(1): 7-14.

Platt, S. G. and Ngo Van Tri (2000). Status of the Siamese Crocodile in Vietnam. Oryx **34** (3): 217-221.

Ratanakorn, P., B. Amget and B. Otley (1994). Preliminary surveys of crocodiles in Thailand. Pp. 35-49 in Crocodiles. Proceedings of the 12th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Pattaya, Thailand. IUCN: Gland.

Ross, C. A. (1986). Comments on Indopacific crocodile distributions. Pp. 349-354 in Crocodiles. Proceedings of the 7th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Caracas. IUCN: Gland.

Ross, C. A., J.H. Cox, H. Kurniati, and S. Frazier (1998). Preliminary surveys of palustrine crocodiles in Kalimantan. Pp. 46-79 in Crocodiles. Proceedings of the 14th Working Meeting of IUCN-SSC Crocodile Specialist Group. Singapore. IUCN: Gland.

Stuart, B. L., and S. G. Platt (2000). Status of the Siamese Crocodile *Crocodylus siamensis* in Laos. Pp. 523-530 in Crocodiles. Proceedings of the 15th Working Meeting of the IUCN-SSC Crocodile Specialist Group. Varadero, Cuba. IUCN: Gland.

Somvonpha, C. and Xayphone, T. (in prep.) The study on habitat of fresh water crocodile (*Crocodylus siamensis*) in Songkhone and Champhone Districts, Savanakhet province. Thesis for Bachelors of Science degree. University of Lao PDR.

Thorbjarnarson, J. B., C. Photithay and M. Hedemark (2004). Conservation of the Critically Endangered Siamese Crocodile in Lao PDR. Pp. 1-10 in: Crocodiles. Proceedings of the 17th Working Meeting of IUCN-SSC Crocodile Specialist Group. Darwin. IUCN: Gland.

Thorbjarnarson, J. B. (2003). Conservation of Siamese Crocodiles in Lao PDR. Report of a trip to review the situation concerning the Critically Endangered Siamese crocodile and recommendations. Wildlife Conservation Society, Gainesville.

Figure 40. Rice fields near Ban Taleo, Champhone District.

Appendices

Annex 1. Acknowledgements

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University of Lao PDR researchers Chanhvilay Somvonpha and Toulavanh Xayphone are recognized for their important contribution to the knowledge of Siamese Crocodile in Savannakhet Province and their interest to collaborate on future fieldwork.

Annex 2. Fieldwork expenditure summary

ITEM	Amount in Kip
Foodstuffs & meals for consultant, counterpart & driver	3,300,000
Supplemental foodstuffs, batteries, spotlights, etc.	1,496,451
Guest house accommodation for team members	2,866,000
Vehicle hire (30 days at US$ 40/day @ Kip 8,700/$)	10,440,000
Fuel for vehicle and incidental local hire	4,761,000
Per diem to village guides, DAFO & LARReC counterparts	3,853,400
Supplies and materials	1,256,150
Jack Cox's recruitment travel from Bangkok & visa	1,005,752
Photocopies and internet use	203,920
Phone cards for team members	365,000
Medicine and medical tests for Chantone Phothitay	174,000
Total =	**29,721,623**

Figure 41. Recently converted wetland near Kout Kaen, Champhone District.

Annex 3. GPS coordinates

Crocodile Survey GPS Coordinates, Savannakhet Province, Lao PDR			
Code	**Date**	**Coordinates**	**Remarks**
1	09-May-08	16° 21.301' N 105° 13.001' E	start of Kout Mark Peo day transect of floating mats
2	"	16° 21.355' N 105° 12.963' E	end of Kout Mark Peo day transect
3	11-May-08	16° 21.442' N 105° 12.139' E	bamboo clump end pt. of Phai Cheo recce and night count
4	"	16° 21.082' N 105° 11.822' E	start of night count at Phai Cheo, 11 May 19h25
5	"	16° 20.986' N 105° 12.130' E	channel to lake dogleg, Phai Cheo
7	"	16° 26.016' N 105° 12.377' E	dense end of Nong Maehang
8	14-May-08	16° 26.247' N 105° 12.293' E	starting pt. of 14 May 2008 night count
9	"	16° 26.028' N 105° 12.241' E	wooden bridge on 14 May night count
10	15-May-08	16° 25.891' N 105° 12.476' E	north bank of Nong Panghien
11	"	16° 25.882' N 105° 12.427' E	start of walk along north bank of Nong Panghien
12	17-May-08	16° 21.046' N 105° 11.978' E	start of Phai Cheo inner lake day time traverse; 09h35
13	"	16° 21.386' N 105° 12.266' E	entrance to main Phai Cheow from inner lake, 22h10, night count
14	"	16° 21.214' N 105° 12.535' E	endpt. night count, 10h35, sampan dock a side of channel
15	"	16° 21.327' N 105° 12.867' E	Xe Hack hut near Kout Mark Peo; waiting pt for nest search
16	"	16° 21.215' N 105° 12.520' E	start pt. 17 May 2008 night count, 20h30 inner Phai Cheo
17	"	16° 21.629' N 105° 12.334' E	end pt. 17 May 2008 night count, 21h10, inner Phai Cheo
18	18-May-08	16° 24.465' N 105° 10.440' E	Ban Kadan; starting point for walk to Kout Xe Lat Kadane
19	"	16° 24.537' N 105° 12.296' E	Tong Leung Khouay Ha hut, edge of Kout Xe Lat Kadane
20	"	16° 24.546' N 105° 12.250' E	start of 18 May night count along banks of Kout Xelat Kadan
21	"	16° 24.456' N 105° 12.289' E	end pt.18 May night count along banks of Kout Xelat Kadan
BNTANG		16° 24.984' N 105° 15.151' E	Mr. Bountang's home, Ban Taleo
CP 1	8-May-08	16° 21.440' N 105° 13.067' E	Xe Champhone banks near Kout Mak Peo
CROC 1		16° 23.656' N 105° 13.037' E	Kout Kaen croc catch site
NEST 1		16° 21.306' N 105° 12.963' E	Kout Mark Peo new unfinished nest, 17 May 2008
NEST 2	18-May-08	16° 24.376' N 105° 12.239' E	Oct. 07 hatched nest, Kout Xelat Kadan
SONE	10-May-08	16° 21.237' N 105° 13.132' E	Sone's hut opposite Kout Mark Pheo
22	24-May-08	16° 24.589' N 105° 14.482' E	Ban Taleo - Kout Kaen route point of interest
23	24-May-08	16° 24.457' N 105° 13.902' E	edge of khets and scrub approaching Kout Kaen
24	24-May-08	16° 24.159' N 105° 13.524' E	trailside hut, Ban Taleo to Kout Kaen
25	24-May-08	16° 24.137' N 105° 13.437' E	sampan 'dock' at Nong Houay Peuay
26	24-May-08	16° 23.577' N 105° 12.977' E	Wang Naxaeng hut in second paddy fields
27	24-May-08	16° 23.589' N 105° 12.987' E	start of night count survey, Kout Kaen
28	24-May-08	16° 23.732' N 105° 12.926' E	break pt in survey route, night of 24 May

Crocodile Survey GPS Coordinates, Savannakhet Province, Lao PDR			
Code	Date	Coordinate	Remarks
29	24-May-08	16° 23.738' N 105° 13.038' E	re-start pt of survey, night of 24 May 2008
30	25-May-08	16° 24.503' N 105° 13.773' E	end pt 24 May 2008 survey, actually 25 May 00h15
31	25-May-08	16° 24.430' N 105° 13.710' E	sampan dock 2 after end of survey
32	24-May-08	16° 24.506' N 105° 14.198' E	waypt in walking route, hut Deun Palor to Kout Kaen
33	24-May-08	16° 24.200' N 105° 13.354' E	confluence of Nong Peuay and Kout Kaen
34	(unintentionally skipped)		
35	27-May-08	16° 18.243' N 105° 19.456' E	Nong Payongdouane littoral
36	27-May-08	16° 18.257' N 105° 19.024' E	Kout Kouang banks, sampan docking point
37	27-May-08	16° 18.233' N 105° 18.984' E	one end of open water, Kout Kouang
38	27-May-08	16° 18.233' N 105° 19.046' E	other end of open water, Kout Kouang
39	27-May-08	16° 18.291' N 105° 19.156' E	hut Thong Kout Kouang
40	27-May-08	16° 18.233' N 105° 19.071' E	end pt of survey, Kout Kouang
41	28-May-08	16° 18.186' N 105° 19.354' E	Nong Aw seasonal oxbow (dry in late dry season)
42	28-May-08	16° 18.555' N 105° 18.967' E	Kout Kouang Noi
43	28-May-08	16° 18.459' N 105° 18.672' E	Kout Koke banks
44	28-May-08	16° 18.432' N 105° 18.635' E	Kout Koke side stream confluence
45	28-May-08	16° 18.409' N 105° 18.729' E	Kout Koke nest search edge
46	28-May-08	16° 18.270' N 105° 18.929' E	Kout Kouang Nyai sampan pick up
47	1-Jun-08	16° 21.408' N 105° 20.459' E	Kout Xehack
48	1-Jun-08	16° 21.317' N 105° 20.723' E	end of open water in one arm, Kout Xehack
49	1-Jun-08	16° 21.243' N 105° 20.560' E	start of night count in Kout Xehack, 19h55
50	1-Jun-08	16° 21.317' N 105° 20.714' E	end of night count in Kout Xehack, 20h15
51	3-Jun-08	16° 17.524' N 105° 15.914' E	Nong Tiaheuay, sampan dock
52	3-Jun-08	16° 17.642' N 105° 16.118' E	one end of open water, Nong Tiaheuay
53	3-Jun-08	16° 17.397' N 105° 15.839' E	other end open water, Nong Tiaheuay
54	3-Jun-08	16° 15.192' N 105° 18.326' E	Ban Dongsavang, village headman's house
55	3-Jun-08	16° 16.156' N 105° 16.140' E	dock at Lahanam, Xe Banghiang, Songkhone district
BNXANG	27-May-08	16° 23.206' N 105° 22.979' E	Ban Bungxang, car meeting point outside village
DONGNG	26-May-08	16° 17.990' N 105° 20.228' E	Ban Dongnyanong, headman's house
HOUAY	29-May-08	16° 18.066' N 105° 23.322' E	Ban Houay, on tock tock trip from Ban Dongnyanong
KONGPW	1-Jun-08	16° 22.221' N 105° 21.205' E	Ban Kongpathumwan
NAA	29-May-08	16° 22.818' N 105° 24.293' E	Ban Naa, tock tock trip from Ban Dongnyanong
NAYANG	29-May-08	16° 19.037' N 105° 23.363' E	Ban Ngangyang, tock tock trip from Ban Dongnyanong
XNX 001	27-May-08	16° 18.245' N 105° 19.072' E	Kout Kouang complete nest (first of two there)

Crocodile Survey GPS Coordinates, Savannakhet Province, Lao PDR			
Code	Date	Coordinate	Remarks
XNX 002	28-May-08	16° 18.236' N 105° 18.932' E	Kout Kouang Nyai complete nest (second of two there)
NNGPEU	29-May-08	16° 20.246' N 105° 23.417' E	Ban Nong Peu, tock tock trip from Ban Dongnyanong
NONGTI	29-May-08	16° 21.370' N 105° 24.321' E	Ban Nongti, tock tock trip from Ban Dongnyanong
SAAT	29-May-08	16° 20.751' N 105° 24.611' E	Ban Saat, tock tock trip from Ban Dongnyanong
TANONE	29-May-08	16° 18.355' N 105° 23.467' E	Ban Tanone, tock tock trip from Ban Dongnyanong
TANSUM	9-May-08	16° 20.911' N 105° 10.897' E	Ban Tansoum, Chaphone district, headman's house
WAT	29-May-08	16° 22.296' N 105° 24.255' E	Wat Pugnam, tock tock trip from Ban Dongnyanong

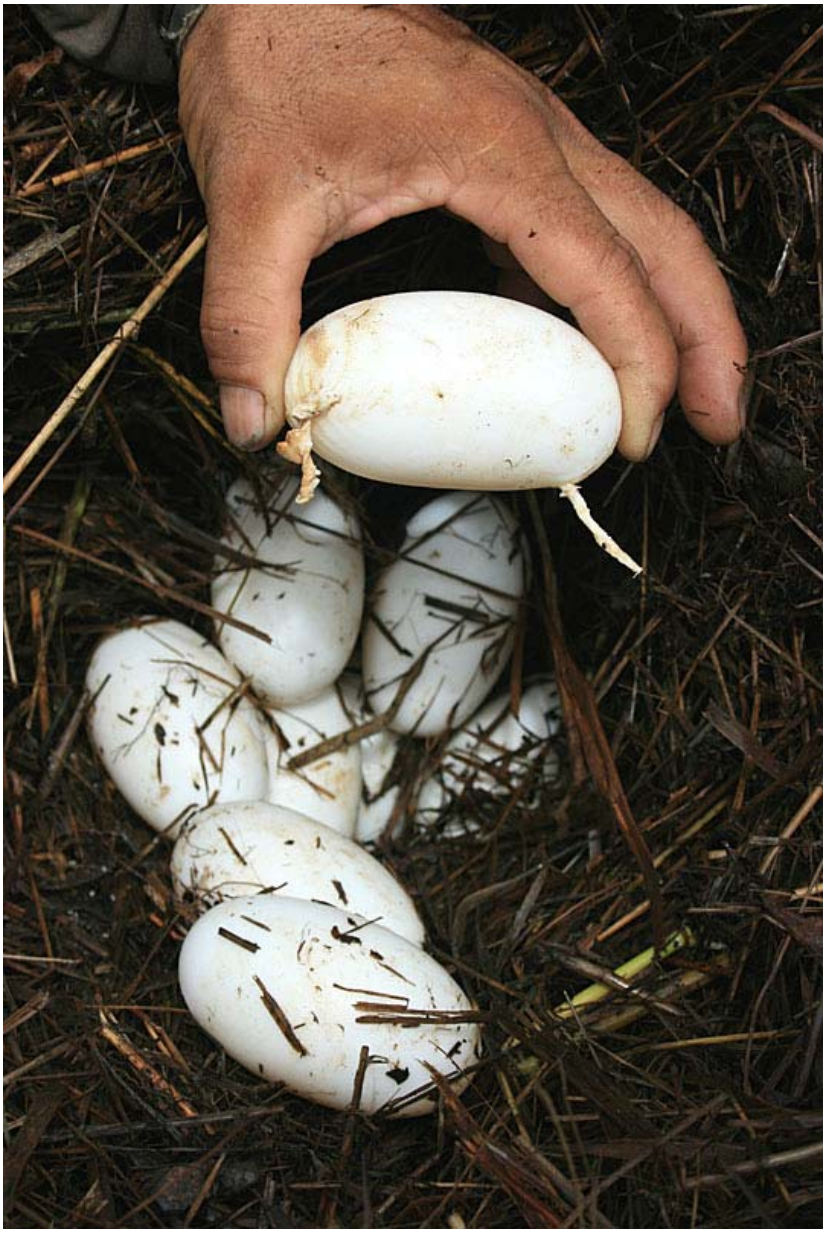

Figure 42. Malformed egg, nest XNX 002, Kout Kouang, Xonbouly District.

Annex 4. Survey itinerary and summarized activities

Date	Travel Details	Activities and Remarks
6 May 2008	By hired car from Vientiane to Savannakhet	Found Provincial Agriculture & Forestry Office; overnight at Soulinsouk Guest House (good value, quiet, near bus station)
7 May 2008	Savannakhet	Meeting and discussion at Savannakhet PAFO office with Director Mr. Laty and staff Mr. Somchan, to brief them on project objectives and survey plans. Received information on crocodile locations in province, and in afternoon PAFO letter of introduction.
8 May 2008	Savannakhet - Champhone town, (Champhone District center); afternoon to Ban Tansoumkham (= Ban Tansoum)	Visited DAFO office in Champhone, discussed survey objectives in Champhone district with Mr. Bounsuang; traveled with him to Ban Tansoum for meeting with village head and crocodile informants.
9 May 2008	Ban Tansoum - Kout Mark Peo campsite by hired tock tock	Daytime habitat assessment, Kout Mark Peo. Found dung of adult and juvenile crocodiles. Heavy rain from evening into night.
10 May 2008	Kout Mark Peo - Ban. Tansoum	Continuous rain until 3 PM from remnant typhoon; decided to return to Ban Tansoum. Further informal discussions.
11 May 2008	Ban Tansoum	Crocodile night count at Phai Cheo Reservoir by sampan. No crocodiles observed.
12 May 2008	Ban Tansoum - Champhone - Ban Sakheun Neua - Champhone	Assessment of Angsouay Reservoir from road; interview at nearby Ban. Sakheun Neua with store owner about crocodiles and development needs; overnight at Champhone 1 Guest House.
13 May 2008	Champhone - Ban Taleo - Champhone	Survey discussion with the village head and others. Interviewed Mr. Bounthong who caught juvenile crocodile at Kout Kean in cast nest about one week earlier. Measured and photographed crocodile.
14 May 2008	Champhone – Ban Kaengkokdong - Champhone	Afternoon excursion to Nong Kanh (roadside at Ban Kaengkokdong, edge of Champhone town), then to Nong Maehang (oxbow further east, but still at periphery of Ban Kaengkokdong). Interviewed Mr. Sounthone, who regularly sees crocodiles in end of Nong Maehang. Conducted night count. Overnight at Champhone 1 Guest House.
15 May 2008	Champhone – east of Ban Kaengkokdong - Champhone	Habitat assessment of Nong Paphou (hyacinth covered, disturbed oxbow) and Nong Panghien (undisturbed oxbow with dense floating mats). Overnight at Champhone 1 Guest House.
16 May 2008	Champhone – Ban Kadan – Ban Tansoum	Held an initial discussion at Ban Kadan with the village head and others knowledgeable about crocodiles; interviewed villager who showed hatched nest to two students at Xelat Kadan in April. Continued to Ban Tansoum, held discussions and made arrangements for return trip next day to Kout Mark Peo.
17 May 2008	Ban Tansoum – Kout Mark Peo – Ban Tansoum	Used sampans to cross Phai Cheow reservoir; walked to hut at Xe Hack near Kout Mark Peo, waited while guides searched for nests and dung. Inspected an unfinished nest at Kout Mark Peo in the afternoon. Overnight at Ban Tansoum.

Date	Travel Details	Activities and Remarks
18 May 2008	Ban Tansoum – Champhone – Ban Kadan - Champhone	Walked from Ban Kadan over shorter route to Kout Xelat Kadan Conducted night count after late evening torrential storm. Spotted 1 juvenile in hyacinth and low water. Returned by muddy walk mostly in rain to Ban Kadan, then drove back to Champhone.
19 May 2008	Champhone – Ban Phunkor - Champhone	Plans for night count excursion to Kout Kaen cancelled by heavy rain. Better weather in late afternoon allowed visit to Ban Phunkor by car. Conducted interview with village head and others including a fisherman (Mr. Ang) who reports seeing crocodiles during the day in recent years in Kout Kaen.
20 May 2008	Champhone	Rest day. Rain during much of the day in Champhone.
21 May 2008	Champhone - Savannakhet (-Mukdahan) - Savannakhet	Returned to Savannakhet. Jack Cox continued on to Thai border and Mukdahan for visa renewal.
22 May 2008	(Mukdahan-) Savannakhet	Contacted resource persons and prepared logistics for Xonbouly district. Planned a night count at Xelat Kadan, but rain in the late afternoon and evening forced postponement.
23 May 2008	Savannakhet - Champhon	Drove from Savannakhet to Champhone in the morning.
24 May 2008	Champhon – Ban Taleo - Champhone	Drove to Ban Taleo, then walked to Kout Kaen via a shorter staging point than initial visit for a night count. No crocodiles recorded.
25 May 2008	Champhone – Ban Taleo – Champhone	Returned to Ban Taleo in the afternoon and retraced previous route to assess and photograph habitat. Additional discussions with guides while walking and in sampans.
26 May 2008	Champhone – Xongbouly – Ban Dongboun – Xe Xangxoy – Ban Dongnyanong	Met Mr. Phoudong the Head of Xongbouly DAFO and Irrigation Officer Mr. Korlakan who informed the team that Kout Kouang and Kout Koke near Ban Dongyanong and Kout Xehack near Ban Kong Pathoumvan were the only sites for crocodiles in the district. Proceeded to Ban Dongnyanong via car to Ban Dongboun, then by tock tock to Xe Xangxoy, crossed to opposite bank in leaky sampan, and to Ban Dongnyanong by another tock tock.
27 May 2008	Ban Dongnyanong – Kout Kuang Nyai– Ban Dongnyanong	Walked to Kout Kouang Nyai in the morning, reconnoitered habitat including some floating mats. Found crocodile nest with 26 infertile eggs. Recorded nest, egg and temperature measurements. Conducted night count of open water patch, then returned to village.
28 May 2008	Ban Dongnyanong – Kout Kouang Nyai – Kout Kouang Noy – Kout Koke – Ban Dongnyanong	Reconnoitered Kout Koke and Kout Kouang Noy. Revisited Kout Kouang Nyai to search for hatched nest from May 2007. No longer there, but found second active nest 250 m from nest of previous day. Inspection and measurements postponed due to rain and lateness.
29 May 2008	Ban Dongnyanong – Kout Kouang Nyai – Ban Dongnyanong – Ban Bungxang - Champhone	Inspected, photographed and measured second nest at Kout Kouang Nyai. (GPS coordinates taken the previous day). Traveled by tock tock over a circuitous muddy route from Ban Dongnyanong to Ban Bungxang, then by car to Champhone.

Date	Travel Details	Activities and Remarks
30 May 2008	Champhone – Ban Kongpathoumvan (= Ban Konggnak) - Champhone	Interview at Ban. Kongpathoumvan (formely Ban Konngnak) about previous occurrence of crocodiles at Kout Xehack and Kout Xelat. Returned to Champhone in late afternoon.
31 May 2008	Champhone	Prepared for crocodile night count at Ban Kongpathoumvan. Postponed due to late afternoon and evening rain.
1 June 2008	Champhone – Ban Kongpathoumvan – Kout Xehack – Ban Kongpathoumvan - Champhone	Returned to Ban Konpathoumvan by car. Walked to Kout Xehack for late afternoon habitat assessment and night count. Returned to Ban Kongpathoumvan and Champhone.
2 June 2008	Champhone – Paxong (Songbouly district)	Visited Xongkhone DAFO for discussion with Head Mr. Kiengsack Head. Received information on crocodile occurrence in recent past at some district villages. Irrigation Officer Mr. Khonsavan knows these locations but he is only available from next day.
3 June 2008	Paxong – Ban Lahanamthong – Nong Thaiheua – Ban Lahanamthong – Ban Songkhone – Ban Dansavang – Ban Songkhone – Ban Lahanamthong - Paxong	Met Mr. Khonsavan at DAFO, drove to Ban Lahanamthong for discussion with village head and residents familiar with crocodile locations. Mr. None, Head of farmer's cooperative, used to see crocodiles at Nong Taiheua oxbow lake when he was a child. Accompanied us by car and short walk to Nong Thaiheua for assessment by sampan. Hired 'speed boat' sampan to go 3 km up Xe Banghiang to Ban Xongkhone village. Walked to headman Mr. Bounkham's house at Ban Donsavang for discussion on crocodiles and village use of Kout Kuang-Kout Koke. Large lake Nong Luang to east may still have crocodiles. No time to visit. Retraced route in afternoon to Ban Xongkhone, Ban Lahanamthong and Paxong.
4 June 2008	Champhone - Vientiane	Returned by hired car to Vientiane (7 hours via Savannakhet).

Figure 43. Track from Ban Dongnyanong to Ban Bungxang, Xonbouly District.

Annex 5. Nest and clutch measurements from Kout Kouang Nyai, Xonbouly District, Savannakhet Province.

Nest XNX 001:

GPS coordinates: 16° 18.245' N 105° 19.072' E Date: 27 May 2008

Nest dimensions: 110 - 130 cm diameter, 28-32 cm height, 10 cm wide and 5 cm deep furrow (tail groove) on top of nest

Cleared area around nest: mostly 1.9 – 2.0 m wide, 0.9 m in back near water; 0.7 m to sapling base on one side

Clutch: size = 26; top of nest to top of eggs = 24 cm; cavity 39 x 29 cm; depth = 7-11 cm; temperature at 15h55 = 33.8°C.

Site vegetation: dense stable mat of *Imperata cylindrica* grass, short fern and spindly saplings ('khainoun' = typical floating mat species); some *Nepenthes* sp. (pitcher plants) and other lianas. Nest not overhung.

Nest material: fairly moist, well-compacted brown and yellowish grass and small brown fern fronds; some fern still green (about 4-7 days old?).

Egg Number	Length (mm)	Width (mm)	Weight (g)	Remarks
1	74.1	47.3	101	unbanded
2	77.7	46.6	103	"
3	79.6	48.1	104	"
4	76.8	48.1	102	"
5	75.5	46.3	100	"
6	77.5	46.6	104	"
7	75.1	47.0	103	"
8	77.3	45.5	103	"
9	73.9	44.5	97	"
10	74.1	44.3	93	"
11	77.0	45.4	92	"
12	75.1	47.2	102	"
13	75.7	46.6	103	"
14	76.8	45.4	102	"
15	81.0	44.3	98	""
16	76.0	47.2	100	"
17	77.9	46.8	104	"
18	74.1	47.0	106	"
19	75.0	46.9	100	""
20	76.1	46.2	98	"
21	75.9	45.3	102	"
22	74.9	46.5	99	"
23	81.9	47.6	111	"
24	75.3	46.6	105	"
25	75.2	47.0	102	"
26	75.5	45.1	98	"
means (n=26)	76.35	46.36	101.2	all eggs appear infertile

Nest XNX 002:

GPS coordinates: 16° 18.236' N 105° 18.932' E Date: 29 May 2008
Nest dimensions: 130-140 cm diameter, 38 cm height
Cleared area around nest: mostly 1.9 – 2.0 m wide, 0.9 m near water; 0.7 m to sapling base on one side
Clutch: size = 11; top of nest to top of eggs = 26 cm; cavity 19 x 16 cm; depth = 12-15 cm; temperature at 10h25 = 33.5°C.
Site vegetation: dense floating mat, mainly reeds *Phragmites* sp., thin grass, broadleaf saplings; nest slightly obscured by overhanging vegetation.
Nest material: mainly reed stems and leaves, some thin grass and short fern, all shades of brown; well compacted; (about 7-10 days old?).

Egg Number	Length (mm)	Width (mm)	Weight (g)	Remarks
1	83.1	48.1	118	unbanded
2	81.7	47.8	111	"
3	86.1	47.9	121	"
4	82.4	46.7	114	"
5	80.3	48.3	113	"
6	81.7	48.1	116	"
7	80.2	46.5	106	"
8	83.5	47.6	115	"
9	82.5	47.3	117	unbanded; with 'pigtails'
10	≈ 89	47.5*	n/a	unbanded; open-ended
11	≈ 95	46.6*	n/a	"
means (n=9)	82.39	47.59	114.56	all eggs appear infertile

Figure 44. Open-ended egg, nest XNX 002, Kout Kouang Nyai.

Annex 6. Visit to Lao Zoo at Ban Kuen, 26 April 2008.

The authors traveled with Mr. Bounthavy (WCS driver) to the Lao Zoo at Ban Kuen, about 60 km NE of Vientiane on Highway 10. Left at 9:10 AM and returned to Vientiane about 1:30 PM.

Lao Zoo is impressively neat, clean and well-attended. We began the visit by talking with Manager Mr. Bounchan. The facility was established in 1991. In 1993 nine Siamese crocodiles were received from Phin District of Savannakhet Province. Since then two of them have died. These crocodiles were said to have originated from the wild and kept by local people. Since being acquired the crocodiles have been kept in separate pens.

About 300 crocodiles were received in the 1990s from Cambodia. Where these crocodiles originated is unknown, which calls into question the genetic purity of the stock, as farmed individuals of the Siamese crocodile *Crocodylus siamensis* and the Saltwater Crocodile *C. porosus* in Thailand commonly hybridize. Offspring are said to exhibit hybrid vigor in their growth (Uthen Youngprapakorn, pers. comm.). Many of the crocodiles are large juveniles or adults, and the (older?) adults regularly breed. Current stock is estimated at about 1,000 animals. These are maintained by size in various clean and well-designed pens. Observation of several hundred of these showed frequent scalation suggestive of hybrid *siamensis* and *porosus*.

We later toured the facility and took representative digital photos. The origin-Lao Siamese Crocodiles are kept in one fairly spacious and shady pen, which can accommodate nesting at the base of a planted bamboo clump. Four of the seven crocodiles were observed on the land part of the pen. Three of these showed cranial morphology and body armor typical of *C. siamensis*. This could not be determined for the fourth individual. One adult (female?) was guarding a small nest. Mound material appeared insufficient and too dry. Animals looked to be in good condition, some rather thin. None of the four crocodiles showed signs of hybridization with *C. porosus*, but further study of photos and the three others is needed and DNA testing required to verify this.

We later visited the hatchery. Eggs are kept in styrofoam coolers packed about two-thirds full with moist hardwood sawdust which was cool to the touch. Temperatures were said to be monitored regularly, although how often was unclear, and maintained at 28 - 29°C. Staff are informed that <30°C produces females. JC mentioned that >32°C would produce all males (at least in *C. porosus*). Staff seemed surprised by this. They said the aim of the zoo was to breed more crocodiles so they preferred to have females. The eventual goal is to sell excess production in-country or as exports. It was pointed out that better growth may be achieved by rearing males.

The seven *C. siamensis* from Lao PDR represent an invaluable founder population if the species became extinct in the wild, or no longer able to reproduce. Mr. Bounchan was unsure of which area(s) in Phin District these crocodiles came from but he asserted they were definitely from the wild as no ranching or farming of crocodiles is permitted in Lao PDR. Comparative mitochondrial DNA analysis is needed to confirm genetic purity and incidence of hybridization.