Ten-year species action plan for the Cambodian population of River Tern *Sterna aurantia*

2018-2028

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The present action plan represents the output of a workshop entitled 'Consultative Workshop on Species Action Plan for River Tern (*Sterna aurantia*) in Cambodia', held on 24 October 2017 in Phnom Penh, Cambodia. It was compiled by Dr. Andrea Claassen, with technical input from the following organizations: BirdLife International, Birds of Cambodia Education & Conservation, Conservation International, Department of Freshwater Wetland Conservation – Ministry of Environment, Department of Natural Resources Management and Development – Royal University of Phnom Penh, Fisheries Administration, Forestry Administration, NatureLife Cambodia, Wildlife Conservation Society, and World Wide Fund for Nature.

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Suy Senglim, Birds of Cambodia Education & Conservation

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Abbreviations

BLI BirdLife International
CI Conservation International
DFWC Department of Freshwater Wetlands Conservation
DoE Department of Environment
FA Forestry Administration
FiA Fisheries Administration
FFI Fauna & Flora International
IBA Important Bird Area
MAFF Ministry of Agriculture, Forestry and Fisheries
MoE Ministry of Environment
NLC NatureLife Cambodia
PA Protected Area
PF Protected Forest
PUC Paññāsāstra University of Cambodia
RUA Royal University of Agriculture
RUPP Royal University of Phnom Penh
ST Stung Treng
WCS Wildlife Conservation Society
WWF World Wide Fund for Nature

Executive Summary

The River Tern *Sterna aurantia* is a fish-eating waterbird that breeds on riverine sandbars. Although once relatively widespread on large rivers throughout much of Southeast Asia, the River Tern has experienced significant population declines in recent decades. Cambodia contains > 90% of the River Tern population in Indochina. In Cambodia, the River Tern breeds on the Mekong and 3S (Sesan, Sekong, Srepok) Rivers in Stung Treng and Kratie provinces. During the non-breeding season, the River Tern uses the Tonle Sap lake. The Cambodian population has declined from approximately 300 adult individuals in the late 1990s to the estimated current population of 54-62 adult individuals; this is > 80% decrease in the past 20 years, which qualifies the River Tern population as regionally Critically Endangered.

The population decrease has likely been a result of poor breeding success caused by humans harvesting eggs for food, predation by wild and domestic animals (especially rats), trampling of nests by domestic water buffaloes, flooding of nests by upstream hydropower dam releases, and human and animal disturbance at sandbar breeding sites. Another key threat is destruction of sandbar breeding habitat from human encroachment (settlements and agriculture), hydropower dam development, gold and sand mining operations, and vegetative encroachment. Additional threats include loss of fish prey from overfishing and hydropower dams, lack of non-breeding perching habitat, and climate change.

The 10-year aim of this action plan is that by 2028, the River Tern population will increase by at least 50% (to 80-100 individuals). This will be achieved through the following objectives: 1) Improve River Tern survival and breeding success through targeted species interventions, 2) Protect priority habitat of River Tern at all key sites where the species occurs, and 3) Conduct research and monitoring to inform conservation actions. This report details the priority actions required over the next 10 years to ensure the long-term survival of the River Tern population in Cambodia. Top priority actions are to conduct targeted nest protection activities, support effective conservation of breeding sites within and outside of protected areas, enact legislative protections for the species and its breeding habitat, conduct an annual census to monitor population trends, support community co-management and engagement in conservation, implement education, awareness-raising, and capacity-building activities, and establish a River Tern working group to share information on research and conservation measures.

Included in this action plan are suggested guidelines, methodologies, and sample datasheets for conducting River Tern population monitoring, and for monitoring and protecting nests and chicks. Thus, in addition to laying out objectives and actions needed to ensure the survival of the River Terns in Cambodia, this action plan will hopefully be a useful tool for conservation practitioners to implement monitoring and protection activities for the River Tern.

មូលន័យសង្ខេប

សត្វរំពេទន្លេ គឺជាប្រភេទសត្វស្លាបទឹកដែលស៊ីត្រីជាអាហារ និងធ្វើការបន្តពូជនៅឆ្នេរខ្សាច់តាមដងទន្លេនានា។ ទោះបីជាសត្វរំពេទន្លេធ្លាប់មានវត្តមានច្រើនរាយប៉ាយនៅតាមដងទន្លេនៃតំបន់អាស៊ីក៏ដោយ ប៉ុន្តែនាពេលបច្ចុប្បន្នចំនួនសត្វនេះបានមានការធ្លាក់ចុះយ៉ាងខ្លាំង។ ប្រទេសកម្ពុជាមានវត្តមានសត្វរំពេច្រើនជាង ៩០ភាគរយនៃចំនួនសរុបក្នុងតំបន់តណ្ឌចិន។ នៅប្រទេសកម្ពុជា សត្វរំពេទន្លេបន្តពូជនៅតំបន់ទន្លេមេគង្គ និងទន្លេបឹ (ទន្លេសេសាន សេកុង និងទន្លេស្រែពក) ស្ថិតនៅក្នុងខេត្តស្ទឹងត្រែង និងក្រចេះ។ បន្ទាប់ពីរដូវបន្តពូជត្រូវបានបញ្ចប់ គេឃើញមានវត្តមានរបស់សត្វនេះនៅតាមបឹងទន្លេសាបនៃព្រះរាជាណាចក្រកម្ពុជា។ ចំនួនសត្វរំពេទន្លេនៅក្នុងប្រទេសកម្ពុជាមានការធ្លាក់ចុះចាប់ពី ៣០០ ក្បាល នៅចុងឆ្នាំ១៩៩០ មកសល់ត្រឹម ៥៤-៦២ ក្បាល ប៉ុណ្ណោះនាពេលបច្ចុប្បន្ន ដែលការធ្លាក់ចុះនេះមានកម្រិតច្រើនជាង ៨០ ភាគរយ ក្នុងរយៈពេល២០ឆ្នាំចុងក្រោយទើបបណ្តាលឱ្យសត្វរំពេទន្លេត្រូវបានចាត់ទុកជាប្រភេទជិតផុតពូជបំផុត (Critically Endangered) នៅក្នុងតំបន់។

កត្តាដែលធ្វើឱ្យមានការធ្លាក់ចុះនេះ គឺបណ្តាលមកពីអត្រានៃភាពជោគជ័យក្នុងការបន្តពូជមានកម្រិតទាប ដែលមូលហេតុបណ្តាលមកពី មនុស្សប្រមូលយកពង ការស៊ីពងរបស់វាដោយប្រភេទសត្វរំពារព្រៃ ឬស្រុក (ពិសេសសត្វកណ្តុរ) ការជាន់ពងកូនដោយសត្វក្របីស្រុក ការហូរជាត់ ឬលិចសំបុកដោយការបើកបង្ហូរទឹកពីទំនប់វារីអគ្គិសនី និងការរំខានពីសកម្មភាពមនុស្ស ឬសត្វតាមទីជម្រកពងកូនជាដើម។ កត្តាចំបងដែលនាំឲ្យមានការធ្លាក់ចុះខ្លាំងបំផុតនោះគឺ ការបំផ្លាញជម្រកពងកូន តាមរយៈការទន្ទ្រាន់ដីនៅជម្រកពងកូន (សម្រាប់ស្នាក់នៅ ឬជាដីកសិកម្ម) ការសាងសង់ទំនប់វារីអគ្គិសនី ការរុករងរ៉ែ ការបូមខ្សាច់ និងការទន្ទ្រាន់ដោយរុក្ខជាតិផ្សេងៗ។ កត្តាគំរាមកំហែងផ្សេងទៀត មានដូចជាការធ្លាក់ចុះចំនួនត្រីដែលជាប្រភពចំណី ដែលបណ្តាលមកពីការនេសាទហួសកម្រិត និងសាងសង់ទំនប់វារីអគ្គិសនី ការជាត់បង់ទីជម្រកក្នុងរដូវមិនបន្តពូជ និងការប្រែប្រួលអាកាសធាតុជាដើម។

គោលដៅរយៈពេល ១០ ឆ្នាំ នៃផែនការសកម្មភាពនេះ គឺនៅបំណាច់ឆ្នាំ២០២៨ ចំនួនសត្វរំពេទន្លេនៅក្នុងប្រទេសកម្ពុជានឹងកើនឡើង ៥០% (កើនឡើងដល់ ៨០-១០០ ក្បាល) ធៀបនឹងបច្ចុប្បន្ន ។ គោលដៅនេះ នឹងអាចសម្រេចបានតាមរយៈគោលបំណងដូចជា 1) ធ្វើឱ្យប្រសើរឡើងនូវភាពជោគជ័យទាំងអត្រាពងកូន និងរស់រានមានជីវិតរបស់សត្វរំពេទន្លេ 2) ធ្វើការការពារ និងអភិរក្សទីជម្រកបន្តពូជសំខាន់ៗរបស់សត្វរំពេទន្លេ និង 3) ធ្វើការសិក្សាស្រាវជ្រាវ និងតាមដានដើម្បីគាំទ្រដល់សកម្មភាពការងារអភិរក្ស។ រហាយការណ៍នេះនឹងរៀបរាប់លម្អិតអំពីផែនការសកម្មភាពអាទិភាពសម្រាប់រយៈពេល ១០ ឆ្នាំបន្ទាប់ ដើម្បីជានាឱ្យបាននូវនិរន្តរភាពនៃការរស់រានមានជីវិតរបស់សត្វរំពេទន្លេនៅក្នុងប្រទេសកម្ពុជា។ សកម្មភាពចម្បងក្នុងផែនការសកម្មភាពនេះ រួមមានដូចជា ធ្វើការអភិរក្ស និងការពារសំបុកពងកូន ធ្វើការគាំទ្ររាល់សកម្មភាពនៃការអភិរក្សសំបុកពងកូនទាំងក្នុង និងក្រៅតំបន់អភិរក្ស បង្កើតច្បាប់ក្នុងការការពារសំបុក និងជម្រកពងកូន ធ្វើការជំរឿនរបាយប្រចាំឆ្នាំ គាំទ្រ និងលើកទឹកចិត្តដល់សហគមន៍ឱ្យមានការចូលរួមអភិរក្ស លើកកម្ពស់ការយល់ដឹងដល់ប្រជាពលរដ្ឋ និងកសាងសមត្ថភាព និងបង្កើតក្រុមការងារបច្ចេកទេសក្នុងការចែករំលែកព័ត៌មាន និងសកម្មភាពនៃការអភិរក្សសត្វរំពេទន្លេនៅប្រទេសកម្ពុជា។

ផែនការសកម្មភាពនេះគឺរួមបញ្ចូលនូវគោលការណ៍ណែនាំ វិធីសាស្ត្រ និងគំរូឯកសារសម្រាប់ធ្វើការតាមដានអំពីចំនួន ឬរបាយនៃសត្វរំពេទន្លេ និងសម្រាប់តាមដាន និងការពារសំបុកព្រមទាំងកូនរបស់សត្វរំពេទន្លេផងដែរ។ ក្រៅពីគោលបំណង និងផែនការសកម្មភាពសំខាន់ៗសម្រាប់ធានាឲ្យបាននូវនិរន្តរភាពនៃអត្រារស់រានមានជីវិតរបស់សត្វរំពេទន្លេនៅកម្ពុជា ផែនការសកម្មភាពនេះក៏អាចជាឧបករណ៍ដែលមានប្រយោជន៍មួយសម្រាប់ក្រុមអភិរក្ស ដើម្បីយកមកប្រើប្រាស់ក្នុងគោលបំណងតាមដាន និងការពារសត្វរំពេទន្លេនៅកម្ពុជាផងដែរ។

1. Background

1.1 Taxonomy

Phylum: Chordata
Class: Aves
Order: Charadriiformes
Family: Laridae
Genus: *Sterna*
Species: *Sterna aurantia* (Gray, 1831)

1.2 Relevant policies

1.2.1 International conservation and legal status

The River Tern (Figure 1) is considered globally Near-Threatened; although it does not currently qualify for IUCN Red List criteria for being globally Critically Endangered, Endangered, or Vulnerable, the global population trend is declining and it is expected to become globally threatened in the near future (IUCN 2016).

Figure 1. Adult River Tern in flight (photo credit: Jeff Schwilk).

1.2.2 National policies and legislation

River Tern is currently designated by Cambodian law as a 'Common' species (MAFF 2007). Considering the small and threatened population in Cambodia, it is apparent that its legal status in Cambodia should be updated to 'Endangered' to better reflect

the population status and trend of River Terns in Cambodia. The Cambodian River Tern population qualifies as regionally Critically Endangered according to IUCN criteria A2 and C1 (IUCN 2012a, 2012b). Likewise, in a recent annotated checklist for Cambodia (Goes 2013), its national conservation status is regarded as 'Critical'.

Protected areas that encompass portions of the River Tern breeding range in Cambodia include the Mekong Ramsar site which was designated in 1999, and the Western Siem Pang Protected Forest which was designated in 2014. Furthermore, the Mekong Aquatic Biodiversity Conservation Area was designated in 2013 to protect aquatic resources but does not include terrestrial habitat such as sandbars.

Relevant laws in Cambodia include the 2008 Protected Area Law (UN-REDD 2015), as well as a revised and updated Environment and Natural Resource Code (expected to be finalized this year; Baird 2017, NGO Forum 2018).

1.3 Conservation situation

1.3.1 Distribution, population size and trend

The current breeding range of River Tern in Cambodia includes the Mekong River between the Lao border and Kratie (Ramsar site and 'Central Section'), and the Sekong River between the Lao border and the confluence with the Sesan River (Figure 2). Until recently, River Tern also bred on the Sesan River. However, none have been recorded on the Sesan River since 2015. The last records on the Sesan River were of a single individual adult observed on multiple occasions during January-April 2015 (Claassen 2016).

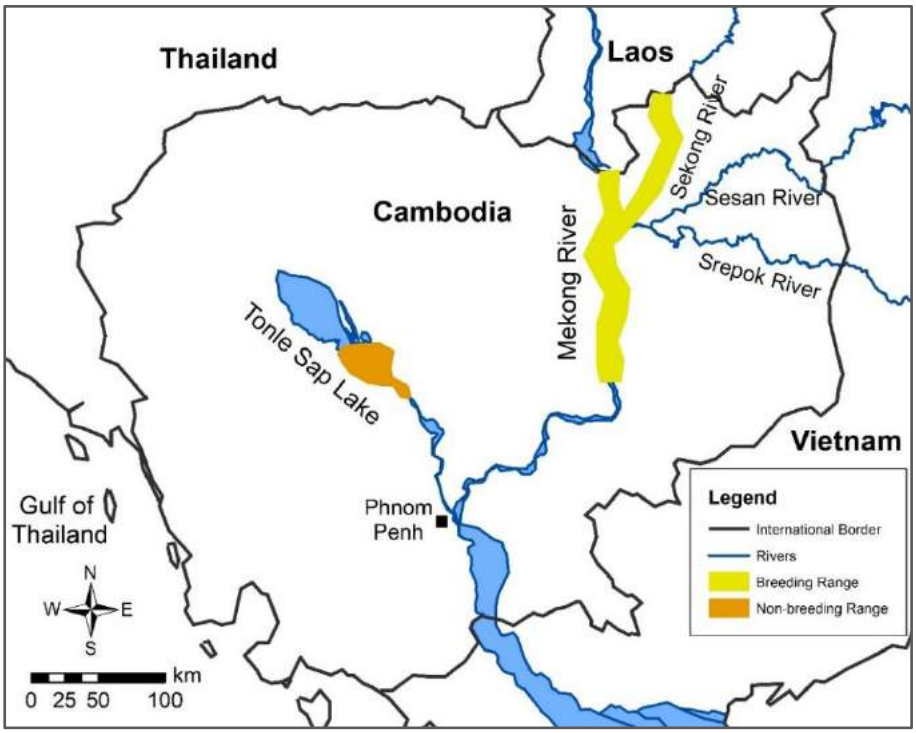

Figure 2. Map of current River Tern breeding season (yellow) and non-breeding season (orange) ranges in Cambodia, as of 2017 (Claassen et al. 2017; RUPP, unpublished data; WWF, unpublished data). Until 2015, River Terns also occurred on the Sesan River (Claassen 2016; RUPP, unpublished data).

The population trend of River Terns in Cambodia is decreasing (Table 1; Figure 3). Historically, River Tern was common along the Mekong River in Cambodia (Thomas and Poole 2003). However, results of numerous surveys conducted since the late-1990s indicate a rapid and significant population decline in Cambodia. In the late-1990s the population was likely around 300 individuals, and by the mid-2000s it was estimated to be around 200 individuals (Timmins 2006, 2008). Based on range-wide surveys in Cambodia that were conducted in 2016 and 2017, the current population in Cambodia is estimated to be 54-62 mature individuals (Table 1; Claassen, in prep.). This is > 60% decrease in the population during the past 10 years, and > 80% decrease during the past 20 years. IUCN (2016) reports that one generation length for River Terns is 10.1 years. Thus, the regional status of River Terns is Critically Endangered (CR) according to IUCN's criteria A2 ($\geq$ 80% population decline over three generations where the cause of reduction may not have ceased or be fully understood) or C1 (estimated population size of less than 250 mature individuals and a population decline of $\geq$ 25% over one generation; IUCN 2012a, 2012b). Only about 18% of River Tern breeding sites are located within protected areas (11% in the Ramsar site and 7% in the Western Siem Pang Protected Forest). The bulk of the River Tern population (approximately 87%) breeds on the Mekong and Sekong Rivers outside of protected areas (Table 1).

Table 1. Breeding distribution and recent population decline of River Terns in Cambodia (Claassen, in prep.).

River	Location	Number of Mature Individuals (1998 Estimates)	Number of Mature Individuals (2017 Estimates)
Mekong	Lao border to Stung Treng town *	50-77	6-8
Mekong	Stung Treng town to Sambor **	104-139	34-38
Sekong	Lao border to Siem Pang ***	28-36	4
Sekong	Siem Pang to Stung Treng town	42-46	10-12
Sesan	Entire Cambodian stretch	46-50	0
Total		**270-348**	**54-62**

* Stung Treng Ramsar site
** Mekong Aquatic Biodiversity Conservation Area
*** Western Siem Pang Protected Forest

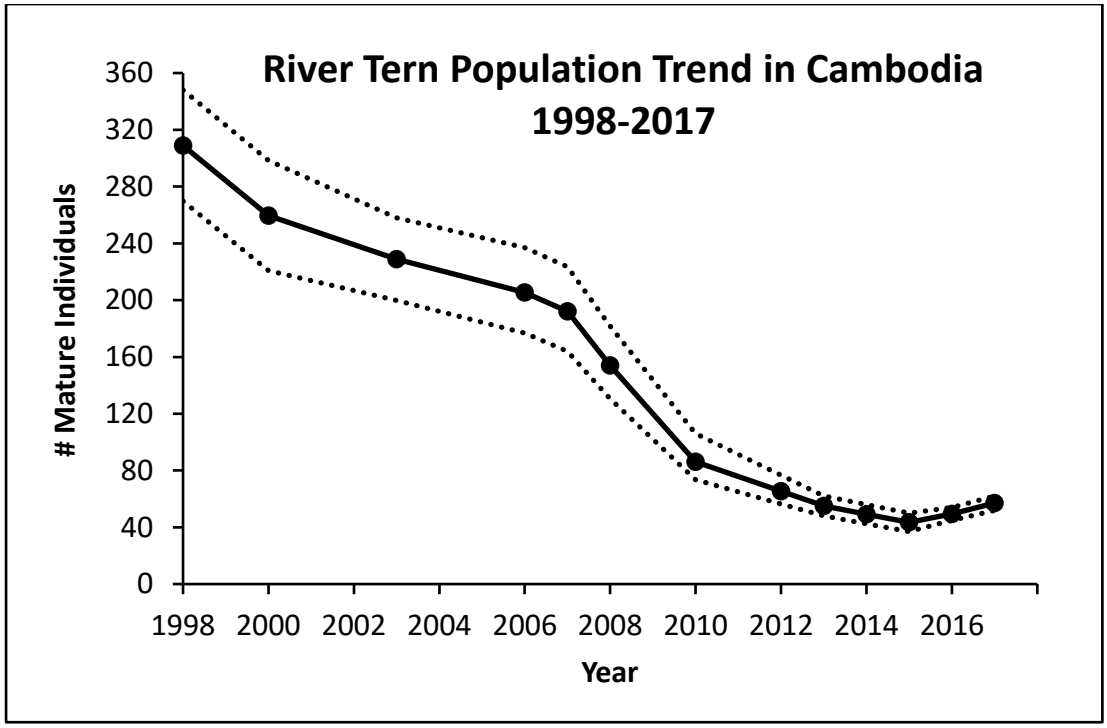

Figure 3. River Tern population trend in Cambodia from 1998-2017. Population estimates are based on data from Timmins and Men 1998, Duckworth et al. 2000 (unpublished data), Claassen 2004, Timmins 2006, 2008, Schwilk 2012, Claassen 2016, Claassen 2007-2017 (unpublished data). Black dots represent point estimates. Dotted lines represent level of error associated with estimates.

If current population declines are not halted, the River Tern is predicted to disappear from Cambodia within the next 5-10 years (Smith and Chan 2016). As such, the River Tern is the next species predicted to become extinct in Cambodia. Notably, the last two birds to become extinct from Cambodia and the Mekong basin, Indian Skimmer *Rynchops albicollis* and Black-bellied Tern *Sterna acuticauda*, were also riverine nesting species (Goes et al. 2010, Goes 2013). The River Tern is a flagship riverine species and conservation action for River Terns will also protect a suite of other riverine bird species, including Great Thick-knee *Esacus recurvirostris* and River Lapwing *Vanellus duvaucelii*, that face similar threats (Timmins 2008, Goes 2013, Claassen et al. 2017).

Extirpation of the River Tern from Cambodia signifies extirpation from the entire Mekong River basin. Although the same population of River Terns that occurs in Cambodia extends into the Siphandone area of southern Laos, probably only a few individuals persist in Laos (Timmins 2008, IUCN 2016). River Tern is probably already extinct as a breeder in Thailand and Vietnam (Timmins 2008). The closest population to Cambodia is in Myanmar, where River Terns likely number 80-100 individuals (Claassen 2017, Naing Lin, WCS, pers. comm.). India presumably still has a relatively large population of River Terns and is the last global stronghold of the population (IUCN 2016). However, no systematic surveys have been conducted in India, making it difficult to accurately assess population size and trends. Globally, Cambodia contains the easternmost population, and losing the Cambodian population

would significantly shrink the species' global range. Therefore, the Cambodian population is significant at national, regional, and global levels.

As the River Tern population has decreased, there has been a corresponding decrease in the number of breeding sites occupied each year (Claassen, in prep.). High breeding site fidelity suggests that disappearance of River Terns from breeding areas may be due to adult mortality rather than emigration to locations outside Cambodia (Claassen, unpublished data). Hunting does not seem to be a significant threat to adult River Terns (Claassen, unpublished data). Lack of fish prey could be a possible factor affecting adult survival (I.G. Baird, personal comment). However, the reasons behind adult mortality are largely unknown.

Recent records from July-August indicate that River Terns migrate to the Tonle Sap Lake during the rainy (non-breeding) season (Figure 2). In July 2010, a loose group of approximately 50 individuals was recorded near Acol on the southern side of the Tonle Sap Lake (P. Everingham, personal comment). Approximately 37 individuals in July-August 2014, and approximately 22 individuals in July 2015 were recorded in scattered small groups in the south-eastern portion of the Tonle Sap Lake (Claassen, in prep.). River Terns also occasionally use other smaller lakes and wetlands during the non-breeding season. In July-September 1999 and July 2003, 1-3 birds were recorded at Basset Marsh north of Phnom Penh (Goes 2013, C. Poole personal comment). After the breeding season ends (around June), River Terns likely travel downstream along the Mekong River, then upstream along the Tonle Sap River to find non-breeding foraging habitat. In July 2007, several birds were recorded on the Mekong River between Kratie and Kampong Cham, which is a considerable distance downstream of their breeding sites (Timmins, 2008). Historically, River Terns probably bred along the Mekong River downstream of Kratie, as well as along the Tonle Sap River. Records from the late 1950s and early 1960s describe River Tern as being "fairly common" along the Mekong and Tonle Sap Rivers in Kandal, Kampong Cham, and Phnom Penh provinces (Thomas and Poole, 2003), although it is unknown during which season those records were from.

1.3.2 Breeding Ecology

The breeding season of River Terns in Cambodia occurs from January – May, during the latter part of the dry season (Claassen 2004, Claassen et al. 2017). Clutch size is 2-3 eggs. Previously, River Terns were semi-colonial breeders (Timmins and Men 1998, Claassen 2004, Timmins 2008). However, most River Terns now breed as scattered pairs, and only rarely do they nest near other River Terns (Claassen personal observation, RUPP unpublished data, WWF unpublished data), likely because the population is now very small. The average incubation period (day the first egg is laid until the day the first egg hatches) is 23.5 $\pm$ 2.6 days (Claassen et al. 2017). The average chick period (day the first chick hatches until the day the first chick fledges) is 22.0 $\pm$ 1.3 days (Claassen et al. 2017). Young birds begin breeding when they are in their second or third year (Mundkur 1992). Generation length (average age of breeding adults in a cohort) is estimated to be 10.1 years (IUCN 2016).

1.3.3 Habitat requirements

During the breeding season, River Terns use seasonally emergent sand and gravel

(shingle) bars within the river channel. The average breeding territory is 122 ± 80 ha (Claassen et al., in press.). They select breeding territories with large areas of exposed ground (sand, gravel, rock) and not much vegetation (Claassen et al., in press; Figure 4). River Terns nest on the ground (Figure 5). Claassen et al. (in press) found that nesting success and chick survival were lower in areas with lots of woody vegetation (native shrubs or alien *Mimosa pigra*), likely because tall, dense shrub thickets provided habitat for rodents and other predators.

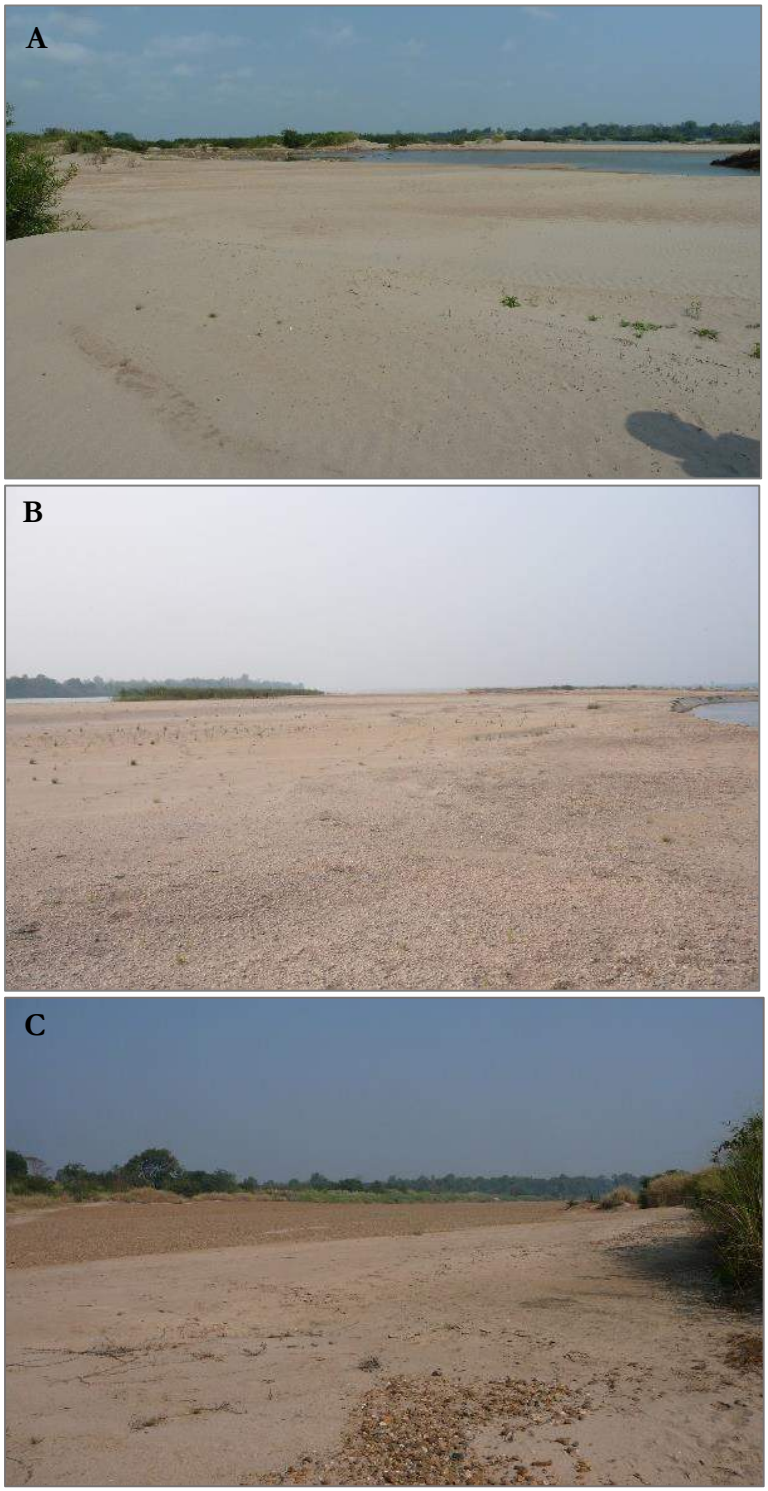

Figure 4. Typical River Tern habitat on the Mekong (A and B) and Sekong (C) Rivers in Cambodia (photo credits: Andrea Claassen).

Figure 5. River Tern nest (photo credit: Andrea Claassen).

During the non-breeding season, River Terns primarily use the Tonle Sap Lake (Claassen, in prep.), but also occasionally use other smaller lakes and wetlands within the Mekong and Tonle Sap River floodplains (Goes 2013). Recent records of River Terns on the Tonle Sap Lake are from the southeast portion of the lake near the mouth of the Tonle Sap River (Claassen, in prep.). During the non-breeding season, River Terns require suitable perches (Figure 6). However, perching habitat structures appear to be a limited resource for River Terns on Tonle Sap. We speculate that historically, there may have been more dead trees around the edge of Tonle Sap Lake that would have been suitable perches for River Terns, but which have since been cleared by humans. Because few natural perches now occur on Tonle Sap, River Terns predominantly use human-installed fishing posts as perching habitat (Claassen, in prep.). However, elimination of the fishing lot system on Tonle Sap Lake in 2012 together with enforcement of illegal fishing gear have reduced the number of suitable perches on Tonle Sap Lake (Dong Tangkor, CI, personal comment). There appears to have been a shift away from larger, semi-permanent posts to smaller, temporary posts. River Terns require relatively flat perches that are at least 3cm in diameter (Claassen, in prep.). However, most of the fishing posts on Tonle Sap Lake are too narrow and pointed to be used as perches by River Terns. There appears to be a high level of competition for perches among River Terns, as well as between River Terns and other bird species (Claassen, personal observation).

River Terns are piscivorous, preying on small fish that use near-surface and shallow water areas. River Terns appear to adapt their foraging behaviour seasonally as a result of aquatic conditions (and perhaps fish behaviour). During the breeding (dry) season, River Terns primarily plunge dive, but in the non-breeding (rainy) season they primarily forage by skimming the surface and occasionally make shallow dives (Claassen, personal observation).

Figure 6. River Terns at Tonle Sap Lake using fishing posts as perches during the non-breeding season (photograph credit: Paul Everingham).

1.4 Priority Issues

1.4.1 General overview

Low reproductive success is thought to be the single most important factor behind the decline in the Cambodian population of River Terns. Habitat alteration also threatens the population.

1.4.2 Important threats

Threats to River Terns in Cambodia are summarized in Table 2. The significance of each threat was determined by considering the severity and scope of the threat to the River Tern population if the threat is not eliminated or reduced. Further details about threats are provided in the text below. Throughout this section, "Current threat level" refers to the level of threat now and during the next ten years.

Table 2. Threats to River Terns in Cambodia.

Threat	Significance	Priority
Egg collection by humans	Very High	Very High
Nest predation by animals	Very High	Very High
Hydropower dams	Very High	Very High
Disturbance	High	High
Trampling by livestock	Moderate	Medium
Flooding of nests	Moderate	Medium
Vegetation encroachment	Moderate	Medium

Sandbar agriculture	Moderate	Medium
Mining	Moderate	Medium
Lack of food resources (fish)	Moderate?	Medium?
Lack of non-breeding perches	Moderate?	Medium?
Climate change	Moderate?	Medium?
Pollution	Unknown	Low?
Hunting	Low	Low

Poor reproductive success

Egg collection by humans

Prior to nest protection schemes implemented in the Mekong 'Central Section' and the Sekong, and Sesan Rivers, opportunistic egg collection by people was perhaps the single highest threat to the species. Egg collection by humans has been implicated in declines of both the Cambodian (Claassen 2004, Claassen et al. 2017) and Lao populations (Thewlis et al., 1998). In a study that monitored the fates of 9 nests on the Sesan River in Cambodia, all 9 nests failed, 6 due to humans harvesting the eggs (Claassen 2004). In a 5-year (2010-2014) study of 79 nests on the Mekong River, human egg harvest was the leading cause of nest failure during the first two years of the study; egg harvest rates declined during the last 3 years of the study due to a direct payment (conservation incentives) program that recruited local community members to protect nests (Claassen et. al, 2017). Prevention of egg harvest by people hinges on continued implementation of nest protection measures. Collection of chicks by people is infrequent (documented once on the Mekong River; Claassen, unpublished data), because the semi-precocial chicks usually leave the nest within 1-2 days after hatching and are thereafter difficult to find.

Current threat level: Very High

Nest predation by animals

Asian House Rat *Rattus tanezumi* and Southern Jungle Crow *Corvus macrorhynchos* are the primary nest predators of River Terns on the Mekong River in Cambodia (Claassen et al., 2017). Rats and crows are opportunistic predators that benefit from human activities. Other nest predators documented on the Mekong River and tributaries in Cambodia, include Domestic Dog, Little Heron *Butoroides striata*, snakes, and Small Asian Mongoose *Herpestes javanicus* (Claassen et al., 2017; RUPP, unpublished data). In a 2010-2014 study in the Mekong 'Central Section' between Kratie and Stung Treng, 20 of 79 nests were predated by animals (Claassen et al. 2017). Since implementing nest protection programs on the Mekong River in 2010, and on the Sekong and Sesan Rivers in 2013, nest predation by animals has overtaken human nest predation as the leading cause of nest failure of River Terns. However, the use of nest exclosures (i.e., anti-predator fences) effectively protects River Tern nests and chicks from predation by animals such at rats (Figure 7; Claassen et al. 2017).

Current threat level: Very High

Disturbance from humans and domestic animals

During the breeding season, River Terns are threatened by disturbance from humans and domestic animals. Fishing and sandbar agriculture (e.g., watermelons and vegetable crops) are the primary human activities on sandbars. Human settlements

threaten breeding birds, especially from fishermen and farmers who frequently establish temporary or semi-permanent seasonal encampments on or near sandbars. Additionally, gold-mining and sand-dredging activities have increased human disturbance in some areas of the Mekong, Sekong, and Sesan Rivers (Claassen, personal observation). Free-ranging domestic livestock, especially water buffalo, trample nests and cause disturbance to breeding birds.
Current threat level: High

Trampling of nests by domestic livestock
Trampling of nests by free-ranging domestic water buffalo has occurred on the Mekong and 3S Rivers (Claassen 2004; Claassen et al., 2017; RUPP, unpublished data). Although trampling by livestock such as water buffalo has generally been infrequent, some nesting sites are more heavily used by livestock and thus much more vulnerable to potentially being trampled. Nest exclosures (i.e., wire mesh fencing) and/or wood or bamboo fences have effectively protected several nests at sites with high risk of trampling by livestock. However, in one instance at Koh Santouk on the Mekong River, water buffalo apparently knocked over a wire mesh exclosure and trampled the nest (A. Claassen, personal observation).
Current threat level: Moderate

Flooding of nests due to hydropower dam releases
In 2003, 1 of 9 River Tern nests on the Sesan River were destroyed by flooding that was attributed to water releases from the upstream Yali Falls hydropower dam (Claassen, 2004). On the Mekong River, 4 of 96 River Tern nests were destroyed by flooding from 2010-2017 (Claassen et al. 2017); these flood events may have resulted from combined effects of rainfall and Chinese mainstem dams (G. Congdon, personal comment). In general, River Terns tend to select nest areas farther from the river channel, thus making their nests less vulnerable to flooding (Claassen et al., in press).
Current threat level: Moderate

Habitat Alteration
Hydrological Changes from Dams
Dams trap sediment, which means that fewer new sandbars are created downstream. Also, the low sediment load of water released downstream induces a “hungry water” effect and leads to increased erosion of existing downstream sandbars. Moreover, dams are predicted to weaken the natural flood-pulse of the Mekong River system, which will result in higher water levels in the dry (breeding) season and lower water levels in the rainy (non-breeding) season (Ligon et al. 1995, Lauri et al. 2012, Piman et al. 2012). In effect, hydropower developments on the Mekong River and tributaries will result in fewer and smaller sandbars that will be available to breeding River Terns during the dry season. Also, lower rainy season water levels will lead to encroachment of vegetation on sandbars. On the Mekong River, the hydropower project that would likely have the highest impact to River Terns is the proposed Sambor dam; if this hydropower project is constructed, it will inundate suitable breeding habitat between Stung Treng and Sambor that supports approximately 62% of the current population of River Terns in Cambodia (Table 1). On the 3S Rivers, construction of the Lower Sesan 2 dam corresponds to the recent disappearance of the River Tern from the Sesan River (RUPP, unpublished data).
Current threat level: Moderate (if the Sambor dam is not built); Very High (if plans for the Sambor dam move ahead)

Vegetation Encroachment
River Terns require open, unvegetated sandbar areas for breeding. Encroachment of vegetation, especially native shrubs, non-native invasive *Mimosa pigra*, and tall grasses on sandbars reduces suitability of habitat for breeding River Terns (Claassen et al., in press). Sites with more vegetation are less likely to be chosen by River Terns for nesting and are likely to harbour more nest predators such as rodents. River Tern chicks have low survival rates in areas with more woody vegetation, likely because they have a high chance of being predated by rats (Claassen et al, in press). High flows during the rainy (non-breeding) season are important for maintaining breeding habitat because they scour vegetation from sandbars. However, hydropower dams are predicted to decrease water levels during the rainy season (Piman et al. 2012), which means that high flows may not be sufficient to scour vegetation from the sandbars (Claassen et al., in press).
Current threat level: Moderate

Sandbar agriculture
River Terns tend to select breeding areas with lots of bare ground and little vegetation (Claassen et al., in press). On the Mekong River, watermelon farming at the south end of Koh Lakrou displaced River Terns and caused them to move to the central and northern portions of the island (A. Claassen, personal observation); it is unclear if the displacement was due to increased vegetative cover from watermelon crops or increased disturbance caused by farming activities, or both. However, watermelon farmers at Koh Lakrou are also community nest protectors, and their presence has led to an overall increase in reproductive success of River Terns in the area (Claassen et al., 2017). Nevertheless, agricultural activities and expansion on sandbars remain threats to River Terns, especially on the Mekong River where agricultural activities such as watermelon farming appear to have increased over the past decade (A. Claassen, personal observation; R.J. Timmins, personal comment).
Current Threat Level: Moderate

Mining
Gold-mining and sand-dredging activities have destroyed sandbar breeding habitat and increased human disturbance at sandbars. Gold mining mainly affects gravel bars, where large pits are created as gravel is removed for gold processing. The pits fill with water and may be contaminated with mercury or other toxic chemicals used in gold processing. On the Mekong River, most gold mining activity observed in recent years has not been near River Tern breeding sites, but has occurred farther downstream towards Sambor (Claassen, unpublished data). On the Sekong and Sesan Rivers, large-scale gold mining operations constructed pipelines and removed gravel from sites that were used by breeding River Terns; however, RUPP's conservation project in conjunction with local communities and local authorities have succeeded in stopping gold mining activities for the time being (Claassen, 2016). Additionally, sand-dredging operations on the Sekong and Sesan Rivers have constructed pipelines, removed sediment, and created disturbance on sandbars. It is unknown to what level sand dredging impacts sandbar size, creation, or erosion patterns.
Current Threat Level: Moderate

Reduction in Food Resources
Fish are the main food source of River Terns. Fish populations in the Mekong River basin are threatened by over-fishing, including through the use of illegal fishing

methods. Furthermore, hydropower dams negatively impact fish populations by blocking fish migrations (the vast majority of Mekong basin fish are migratory; Ligon et al. 1995, Piman et al. 2012). The weakening of the flood pulse of the Mekong River, tributaries, and Tonle Sap River and Lake will further impact fish populations and reduce food resources of River Terns.
Current threat level: Moderate (?)

Lack of perching structures during the non-breeding season
River Terns use the Tonle Sap Lake during the non-breeding (rainy) season (Claassen et al., in prep.). Suitable perching structures for River Terns at this time of year appear to be limited, causing River Terns to compete for perches with other River Terns, as well as with other bird species (Claassen et al., in prep.). Historically, River Terns may have used dead snags and logs around the perimeter of Tonle Sap Lake, which have since been cleared by humans. Currently, fishing posts provide the only perching structures suitable for use by River Terns on Tonle Sap Lake. The 2012 closure of the fishing lot system together with enforcement of illegal fishing gear likely resulted in a significant reduction of suitable perching posts on Tonle Sap Lake (Claassen et al., in prep.; Dong Tangkor, CI, personal comment).
Current threat level: Moderate (?)

Climate Change
Climate change is predicted to result in hotter temperatures and increased precipitation and river flows in northeastern Cambodia (Trang et al. 2017). Climate change will alter river flows, although the magnitude of the impacts is expected to be less than from hydropower dams (Lauri et al. 2012, Piman et al. 2012). The primary immediate threat to River Terns from climate change is likely to be hotter surface temperatures. River Tern chicks have occasionally died during periods of extreme heat (Claassen, pers. obs.). Furthermore, behavioural observations indicate that incubating adults experience considerable heat stress (Claassen, pers. obs.). Increasing surface temperatures from climate change will likely exacerbate overheating problems for eggs, chicks, and incubating adult River Terns, and will likely lead to lower breeding success.
Current threat level: Moderate (?)

Hunting
Hunting of River Terns using guns, slingshots, nets, traps, snares, poisoned bait, or other methods seems to be rare. On one occasion in 2009, a snare was found at a River Tern nest on the Mekong River (Claassen, pers. obs.). Interviews with local people indicate that River Terns are not generally targeted for hunting because they are quick and difficult to hunt (Claassen, unpublished data). However, one interviewee said that in the past (during the war), River Terns had been hunted using poison-laced fish as bait.
Current threat level: Low

Pollution
Studies of contaminants in the Mekong, 3S Rivers, and Tonle Sap indicate high levels of agricultural pesticides such as DDT and other organochlorines (Monirith et al., 1999, 2003; Tran et al., 2014), and high levels of mercury from gold mining and processing (Murphy et al., 2006, 2013). Organochlorines and mercury are known to bioaccumulate in the food chain and cause reproductive failure in birds (Ohlendorf et

al. 1988). At high concentrations, these toxins cause bird eggs to become too thin to support the weight of incubating adults, which results in eggs breaking and embryos dying. On the Mekong River, from 2010-2014, 3 of 79 River Tern nests failed because the eggs broke (Claassen et al. 2017). It is not known what levels of toxins were present in the eggs or if the eggs cracked due to eggshell thinning.
Current threat level: Unknown

2. Ongoing conservation strategies

With support from international NGOs, national government agencies are managing protected areas within the River Tern range in Cambodia. On the Mekong River, WWF is providing support to MoE to protect the Stung Treng Ramsar site, and to FiA and FA to protect the Mekong 'Central Section'. On the Sekong River, BirdLife International is providing support to MoE to protect the Western Siem Pang Protected Forest. Additionally, RUPP is providing support to provincial Fisheries and Forestry Cantonments to protect important River Tern breeding sites in the Sekong and Sesan River IBAs.

Conservation interventions aimed at improving nesting success have been ongoing for River Terns since 2010. Nest protection utilizing direct payments to individuals was first implemented by University of Minnesota on the Mekong River in 2010, and the program has been implemented by WWF since 2011 (Sok et al. 2012, Claassen et al. 2017). River Tern nest protection on the Sekong and Sesan Rivers has been implemented by RUPP since 2013 (Claassen, 2016).

WWF and RUPP are supporting protection of specific River Tern breeding sites, both within and outside of protected areas, through individual and community conservation agreements as part of a Payment for Ecosystem Services (PES) nest protection scheme. The nest protection programs implemented by WWF and RUPP provide direct payments (financial incentives) to individual community nest guards to protect nests, and also contribute to community funds. Individual community nest protectors are paid daily salaries of $4-5 (USD) to guard nesting sites (Sok et al. 2012, Claassen et al. 2017, Phat et al., in review).

Figure 7. Nest guards protecting River Tern breeding sites (photo credits: Andrea Claassen).

The nest protection programs have effectively improved breeding success of River Terns (Claassen et al. 2017). A key component of nest protection has been the use of predator exclosures (i.e., predator exclusion fences; Figure 7). In a 2010-2014 study of the Mekong River, nest success (the likelihood of at least one egg hatching) was 60% for nests protected by exclosures (and guarding), compared to 29% for nests that were guarded only, and only 5% for unprotected nests (Figure 8A; Claassen et al. 2017). Nest exclosures (fences) also effectively protected chicks from predators; brood success (likelihood of at least one chick surviving until fledging) was 82% when chicks were protected by exclosures (and community nest guards), compared to 42% when chicks were protected by guarding only, and only 2% for unprotected chicks (Figure 8B; Claassen et al. 2017). A detailed description of methods for installing and monitoring exclosures (fences) is provided in Appendix 1 of this Action Plan.

Figure 8. Anti-predator exclosure (fence) used to protect River Tern nests and chicks from rats and other mammalian predators (photograph credit: Andrea Claassen).

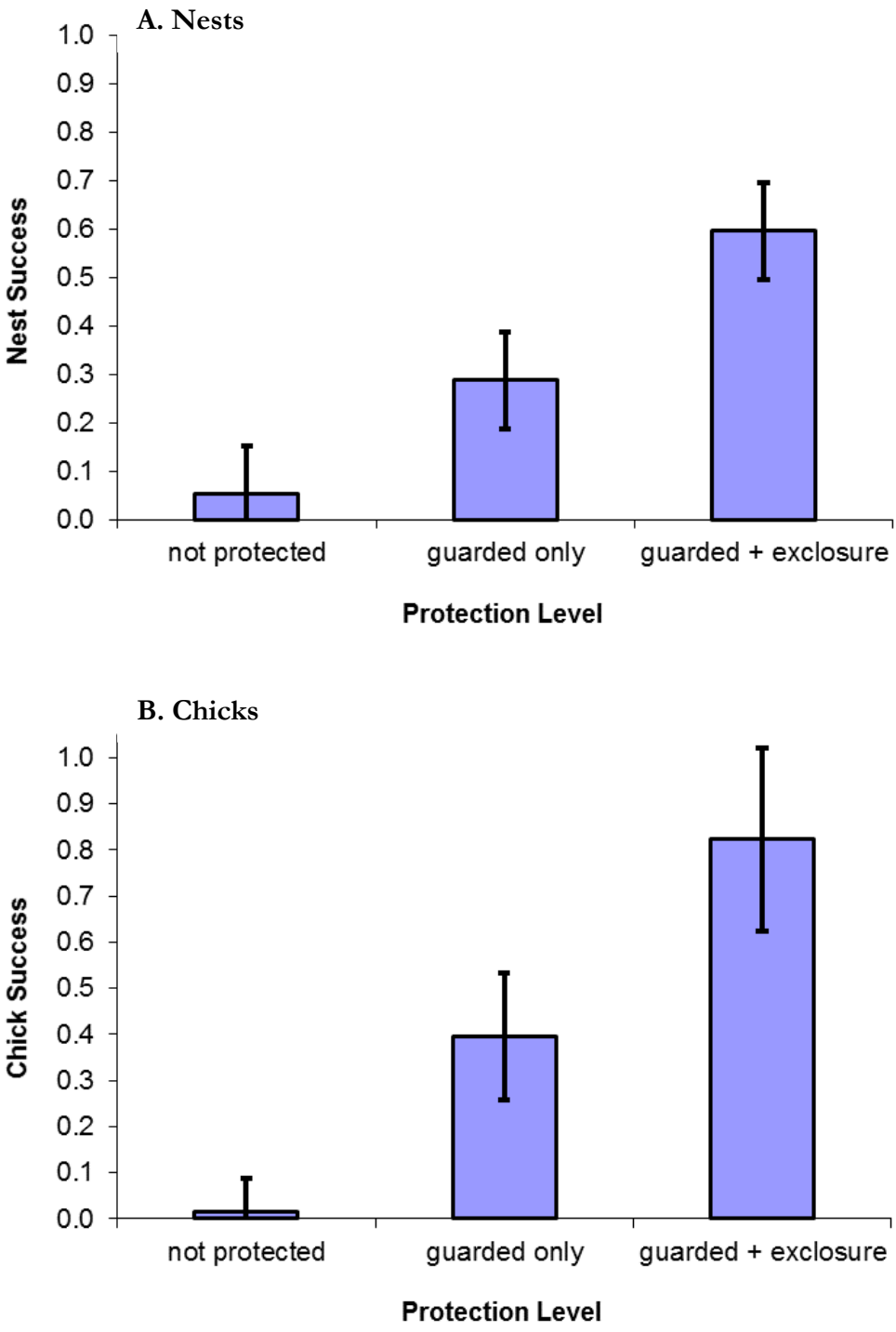

Figure 9. Estimates of hatching success of nests (A) and fledging success of chicks (B) that are not protected, guarded only, and guarded plus protected using anti-predator exclosure fences (Claassen et al., 2017).

3. Framework for action

3.1 Scope of planning

This action plan represents the output of a workshop entitled 'River Tern Conservation' conducted in Phnom Penh, Cambodia, on 24 October 2017. A list of attendees is contained in Appendix 5.

3.2 Matrix

Aim

By 2028, the River Tern population will increase by at least 50% (to 80-100 individuals)[1].

Objectives

1. Improve River Tern survival and breeding success through targeted species interventions.
2. Protect priority habitat of River Terns at all key sites where the species occurs.
3. Conduct research and monitoring to inform conservation actions.

Outcomes

1. Targeted species interventions result in improved breeding success and survival.
2. All priority sites within the range of River Terns are managed to maximize species survival and reproduction.
3. Conservation research and monitoring is used to inform species management.

[1] This aim is based on an approximate 4% population increase per year, which should be achievable if conservation activities can effectively maintain the level of population increase that occurred during 2015-2017 (See Figure 2).

Actions and Indicative Budget
All costs in USD. Indicative budget does not account for rate of inflation.

Objective 1. Improve survival and breeding success through targeted species interventions.						
Action	**Priority**	**Timescale**	**Organizations**	**Annual Cost**	**Years**	**Total**
1.1 Locate River Tern nests within and outside of Protected Areas and provide targeted nest protection – e.g., nest guardians/nest exclosures (fences)/targeted monitoring and patrols.	Very High	Ongoing	WWF, RUPP, PA Managers, FA, FiA, Local Authorities.	80,000	10	800,000
1.2 Update national status of River Tern as endangered.	High	2018	MAFF, MoE.	2,000	1	2,000
1.3 Incorporate River Tern as a priority species, setting conservation targets and activities within site level management plans for Protected Areas (Central Section, Stung Treng Ramsar site, Western Siem Pang PF, Stung Sen).	High	2018	MoE, PA Managers, FA, FiA, WWF, BLI, CI, Local Government.	20,000	1	20,000
1.4 Conduct education and awareness raising program in villages surrounding key River Tern sites[1].	High	Ongoing	MoE, PA Managers, FA, FiA WWF, BLI, RUPP, CI, Dept. of Education.	5,000	10	50,000
1.5 Build capacity (of rangers, local authorities, communities) to protect River Tern nesting sites.	High	Ongoing	MoE, PA Managers, FA, FiA, Local Authorities, WWF, RUPP, BLI, CI, NLC.	5,000	10	50,000

1.6 Pilot removal of predators (e.g., rodents and crows) at key breeding sites.	Medium	2019, 2022, 2025	FA, WWF, BLI.	5,000	3	15,000
Total Cost						**937,000**

[1] The folk tale about the River Tern and the dolphin (Keo and Soriya 2002, Beasley et al. 2009) could be used to foster cultural values regarding River Terns during education and awareness-raising campaigns.

Objective 2. Protect priority habitat of River Tern at all key sites where the species occurs.						
Action	**Priority**	**Timescale**	**Organizations**	**Annual cost**	**Years**	**Total**
2.1 Enact and strengthen legislation to protect key sites – e.g., establish new PA to cover sandbar islands in Central Section, possibly as a Biodiversity Conservation Corridor.	High	2018-2019	MoE, FA, FiA, DoE, Local Government Agencies.	25,000	2	50,000
2.2 Implement and support effective protected area management, including law enforcement and targeted patrolling of key River Tern habitat, and conducting management zoning for Stung Treng Ramsar site.	High	Ongoing	MoE, PA Managers, FA, FiA, DoE, WWF, BLI, RUPP, WCS, Local Authorities.	100,000	10	1,000,000
2.3 Implement and support conservation of River Tern breeding sites outside of protected areas, including law enforcement and patrolling of key River Tern habitat, and establishing conservation agreements with local authorities at provincial and commune levels.	High	Ongoing	FA, FiA, WWF, BLI, RUPP, Local Authorities (Provincial and Commune levels).	100,000	10	1,000,000

2.4 Improve coordination among relevant stakeholders to conduct River Tern conservation and monitoring, and to conduct law enforcement.	High	2018-2028	MoE, PA Managers, FA, FiA, Local Authorities, WWF, RUPP, BLI, CI, NLC.	1,000	10	10,000
2.5 Support environmental impact assessment processes for planned development initiatives to consider and minimize impacts on key River Tern habitat – e.g., minimize impacts of planned dam development projects on River Tern habitat.	High	2018-2028	MoE, FA, FiA, WWF, BLI, WCS.	20,000	10	200,000
2.6 Support efforts to engage the private sector to reduce or mitigate impacts of existing development projects – e.g., mitigate impacts of Sesan river hydropower dams by implementing environmental flows.	High	2018-2028	MoE, FA, FiA, WWF, BLI, WCS.	20,000	10	200,000
2.7 Support community co-management of priority habitats (riverine sandbars) and advocacy to reduce community disturbance and harvesting of eggs and chicks.	High	Ongoing	MoE, FA, FiA, WWF, BLI, WCS, RUPP.	30,000	10	300,000
2.8 Investigate and implement ways to broaden community support and community benefits of River Tern conservation activities.	Medium	Ongoing	WWF, WCS, RUPP.	10,000	10	100,000

2.9 Pilot habitat management techniques such as removal and burning of woody vegetation	Medium	2019, 2022, 2025	MoE, PA Managers, FA, WWF, BLI.	5,000	3	15,000
2.10 Pilot installation of non-breeding perching habitat (bamboo or wood posts) at Tonle Sap.	Medium	2019, 2022, 2025	FiA, CI, NLC.	2,500	3	7,500
Total Cost						**2,882,500**

Objective 3. Conduct research and monitoring to inform conservation actions.						
Action	**Priority**	**Timescale**	**Organizations**	**Annual Cost**	**Years**	**Total**
3.1 Establish River Tern Working Group to share information on River Tern research, conservation, and monitoring.	High	2018-2028	MoE, FA, FiA, WWF, BLI, WCS, RUPP, CI, NLC.	2,000	10	20,000
3.2 Conduct annual breeding census of the entire River Tern population in Cambodia (to be conducted each year in March).	High	2018-2028	MoE, FA, WWF, BLI, RUPP.	$4,000	10	$40,000
3.3 Conduct regular monitoring of all nesting sites.	High	2018-2028	MoE, FA, WWF, BLI, RUPP.	$20,000	10	$200,000
3.4 Conduct regular monitoring of non-breeding areas (Tonle Sap).	Medium	2018-2028	MoE, FiA, CI, NLC.	5,000	10	50,000

3.5 Research impacts to River Tern breeding and non-breeding habitat resulting from hydrological changes due to dams and climate change.	Medium	2018-2028	MoE, FA, FiA, WWF, BLI, WCS, CI, RUPP.	20,000	1	20,000
3.6 Support other research on River Terns, including by master's and PhD students – e.g., research on survival rates and causes of mortality of adults and juveniles, taxonomy (genetic differences between populations in Cambodia, Myanmar, India), pilot artificial habitat such as floating platforms.	Medium	2018-2028	MoE, FA, FiA, WWF, BLI, WCS, FFI, CI, RUPP, RUA, PUC.	10,000	10	100,000
3.7 Assess effectiveness of conservation actions to reaching goals of action plan – e.g., assess population trends, breeding success etc.	Medium	2018, 2023, 2028	MoE, FA, FiA, WWF, BLI, RUPP, CI.	$5,000	3	$15,000
Total cost						**445,000**

3.3 Budget Summary

All costs in USD. Indicative budget does not account for rate of inflation.

Actions	Mean annual cost	Years	Total
Objective 1. Improve survival and breeding success through targeted species interventions.	93,700	10	937,000
Objective 2. Protect priority habitat of River Tern at all key sites where the species occurs.	288,250	10	2,882,500
Objective 3. Conduct research and monitoring to inform conservation actions.	45,500	10	455,000
Total	**427,450**	**10**	**4,274,500**

4. Monitoring and Evaluation

Impact of River Tern conservation measures should be evaluated through the direct monitoring of breeding populations and breeding success (nests and chicks) following the methods described below.

4.1 Population Monitoring

A census of the population should be conducted annually. This census should take place during the breeding season (January-May) and should cover the entire breeding range (Figure 2). See Appendix 2 at the end of this action plan for a sample data recording form for the River Tern census. One or two censuses should be conducted each breeding season, depending on time and funding available. If only one survey is conducted each year, it should be conducted in March during the midpoint of the breeding season. If two surveys are conducted, the first survey should occur during the early part of the breeding season (mid-January to mid-February) and the second survey should occur during the late part of the breeding season (mid-April to mid-May).

On the Sekong River, which is a simple, mostly single channel tributary of the Mekong River, suitable habitat is easily identified, and all suitable sites should be visited during the census; small habitat patches can be visited briefly, while larger habitat patches should be walked, with surveyors spending at least 20 minutes at each larger site. On the Mekong River, which is a large, braided channel consisting of hundreds of seasonally emergent sandbars, the River Tern census should focus on relevant habitat patches (survey locations) previously identified by Claassen and WWF based on previous survey records (Timmins 2006, 2008, Claassen et al. 2017) and inspection of satellite imagery. There are approximately 40 survey locations in the Ramsar site and 25 survey locations in the Mekong Central section that should be visited during the annual River Tern census. Small, isolated habitat patches can be visited briefly, while larger habitat patches should be walked if possible to ensure adequate coverage of the site. Surveyors should spend at least 20 minutes (or preferably longer) at sites that are large, where visibility is low, or where accessibility of the entire site is difficult such as when survey sites are located within a mosaic of habitat patches. When conducting the census, care should be taken to avoid double counting individuals.

During the census, adults, juveniles, and chicks (Figure 9) should be counted separately. For many wildlife species, estimates of the adult breeding population have the most power to detect true population changes across years (Barlow et al. 2009, Tella et al. 2013). Therefore, to assess River Tern population trends, only the adult breeding population should be assessed. This is because adults have much higher survival rates than young birds and thus population estimates of adults during the breeding season are less susceptible to short-term fluctuations than estimates of total abundance of all individuals (adults, juveniles, and chicks). However, if two surveys are conducted in the same breeding season, comparing numbers of juveniles from the first and second survey can be a useful indicator of breeding success. Also, the ratio of juveniles to adults can be used to estimate productivity per breeding pair. As such, numbers of adults and juveniles should be listed separately on the data recording form

(Appendix 2), and the numbers of adults and juveniles should not be combined together to assess population size or trends.

Figure 9. River Tern adult (A; photo credit: Pranjal Saikia), juvenile (B; photo credit: Sunil Singhal), and chicks (C; photo credit: Andrea Claassen).

4.2 Nest and Chick Monitoring

Nest Monitoring

Nests should be located and monitored regularly to determine threats and to assess reproductive success. The average nest (egg) period for River Terns is 24 days from the day the first egg is laid until the first egg hatches (Claassen et al. 2017). Ideally, nests should be monitored once every 1-3 days. An area around the nest of approximately 1m radius should be kept clear of tracks and human footprints; nest monitors should use their hand or a branch from a shrub to gently and carefully sweep the sand to clear any tracks around the nest. Then, if the nest fails, it will be easier to identify the cause of nest failure (e.g. recent human or dog tracks next to the nest). It is important to only check the nest in the morning or evening when it is cool. Do not cause prolonged disturbance to nests when it is hot. Also, do not monitor the nest if crows are nearby; crows are very observant and intelligent and may predate the nest after the nest visit. An example nest monitoring data form is provided in Appendix 3; this is a detailed data form to be completed by conservation staff.

All River Tern nests should be protected by community nest guards and should have anti-predator exclosures (fences) installed around them. Nest guards should check the nest once per day in the morning or evening, and they should fill out a nest monitoring data form. A simpler data form than the one provided in Appendix 3 may need to be created that is more appropriate for community nest guards to complete. After installation, exclosures need to be carefully monitored to ensure acceptance by

adult River Terns. Appendix 1 contains detailed instructions for installing and monitoring exclosures. Information about nest protection activities such as use of exclosures should be recorded on the nest monitoring data form.

Chick Monitoring

All River Tern chicks should be protected by anti-predator exclosures (fences), as well as by community nest guards. Chicks inside exclosures should be monitored every 1-3 days until they fledge. The average chick period is 22 days from the day the first chick hatches until the first chick fledges (Claassen et al. 2017). Chicks remain in the nest for 1-3 days after hatching. After that, they become more mobile and start walking around, although during the heat of day they usually hide under cover of vegetation. After chicks hatch, cut leafy branches or other vegetation to provide shade and cover for the chicks inside the exclosure. Also, provide water for the chicks, but make sure the water dish is shallow enough that chicks can get out if they fall in.

Chicks that are not inside exclosures should also be monitored, although unfenced chicks are more difficult to monitor because they may move dozens of meters from the nest, and they are cryptic, being well camouflaged and tending to hide under vegetation and debris. Chicks that are not inside exclosures should be monitored ideally 1-2 times per week until they fledge. However, because they are difficult to observe, it is often necessary to infer their survival based on adult behaviour. If the chicks are still alive, the adults are usually fairly aggressive. Also, adults can often be observed carrying fish for the chicks. After chicks fledge, the adults and chicks usually remain in the vicinity of the nesting sandbar for 2-4 weeks. During the post-fledging period, juveniles can be observed following their parents and trying to beg for fish from their parents. A chick monitoring data form is provided in Appendix 4.

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Appendix 1. Exclosure (Fence) Instructions

Using Exclosures (Fences) to Protect River Tern Nests and Chicks

Exclosures (i.e., fences) can be used to protect River Tern nests and chicks from rats and other animal predators. It is very important to carefully monitor the nest after exclosure set up to make sure adult River Terns go back to their nest.

Materials:

- Roll of fencing that is 1m x 30m. Size of holes in fencing need to be small to keep out rats (about 2cm diameter or smaller). Do not use "chicken wire", because it is not strong enough—it is more time consuming to install, requires many more sticks, and will move around too much in the wind.
- Wire cutters/shears to cut fencing.
- Wood or bamboo sticks (about 15-20 sticks that are approximately 0.5m tall and 3-4cm wide, with one end cut at an angle).
- Wire to tie fence to sticks (about 40-50 pieces that are approximately 15cm long).

Construction:

1) Only construct exclosures around nests when it is a cool time of day. Do not put up exclosures when it is very hot, because the activity will disturb the adult birds and the eggs might overheat and die.
2) First, before going to the nest site, unroll the fencing and cut lengthwise to make 2 or 3 long strips. Make 3 (33cm wide and 30m long) pieces if rats are the main problem. A short (33cm tall) fence will keep out rats, but water buffalo will likely require using a taller fence. It is usually necessary to use two 30m long strips of fencing (60m total) for each nest exclosure. Roll up the fencing and take to nest, along with pre-cut sticks and wire pieces for tying.
3) 2-3 people should put up the exclosure. Work carefully and quickly to limit disturbance to adult birds, but be careful not to step on or drop the fencing on eggs.
4) Use wood or bamboo sticks to hold up the fence (about 15-20 sticks). Only use enough sticks necessary to hold up the fence. Too many sticks can scare the adult River Terns. Sticks should only be as tall as the fence. If sticks are taller than the fence, Crows (*Kha-ait*) or other avian predators might perch on the sticks.
5) Push sticks into the ground in a circle around nest (it takes a bit of practice to place the circle of sticks at the proper radius). Tie one end of the fence to a stick and unroll the fence in a circle around the sticks. Place a stick at the end of the fence (if there is not one already in place) and tie fence to the stick. Then tie one end of the second roll of fence to the stick and unroll. Adjust stick placement if necessary. Tie fence to each stick using short pieces of wire.
6) Bury or cover bottom of fence with sand to keep out rats.
7) When finished, remember to look around the area and collect any extra tools or materials.
8) Go find a place to hide and monitor the nest where you will not disturb the birds.

Note: It is often necessary to do steps 5 and 6 in multiple sessions to ensure acceptance of exclosures by adults (i.e., to avoid birds abandoning their nests due to disturbance caused by exclosure installation). For example, you might need to place the sticks during the evening, return the following morning to unroll the fencing and tie the ends to sticks, then make a third visit that evening to tie the rest of the fence to the sticks and bury the bottom of the fence with sand. After each stage of installation, it is important to monitor the birds and ensure that they resume incubation. This method of installing exclosures over multiple sessions is especially useful for pairs that seem especially wary or pairs that do not show strong defensive behavior around their nests (very aggressive birds are much less inclined to abandon their nests than birds that do not exhibit strong nest defense behavior).

Monitoring the Exclosure (Fence):

- After constructing the exclosure (or after each session of exclosure installation), hide and watch the nest.
- Make sure adult River Terns go back to their nest and resume incubation of the eggs. Monitor the nest for up to 1-2 hours to make sure the adults go back. The adults should sit on the nest for awhile (at least 10 minutes). If the bird only sits on the nest for a few seconds and flies away again, that is not acceptable, and you must continue to watch until it sits for a longer period of time (at least 10 minutes) on the nest.
- If River Terns do not go back to their nest within two hours after you finish setting up the exclosure, then you should remove the exclosure (Note: Remove the exclosure sooner than two hours if it is already getting hot out. Remember, you do not want to keep the birds away from their nest for too long in the heat). After removing the exclosure, go hide again and watch the River Terns for up to two more hours. Make sure they go sit on the nest for at least 10 minutes.
- If the exclosure installation was not successful (i.e., birds did not return to the nest and you decided to remove the exclosure), then wait 3-4 days before re-attemping to install the exclosure. If possible, increase the size of the exclosure by using additional pieces of fencing.
- If the exclosure was successful and the River Tern goes back to the nest, you should leave the exclosure in place until the chicks fledge (i.e., they can fly).
- After the chicks hatch, provide shade and water inside the exclosure for the chicks. Put lots of leafy branches or other vegetation inside to provide shade and cover for the chicks. Make sure the water dish is shallow so chicks can easily get out if they fall in the water.
- Nest protectors need to guard the nest and chicks at all times. This is especially important when exclosures are used, because people and crows can easily observe the exclosure and might take the eggs or chicks.

Figure A1.1. Cutting fence for exclosure (photo: A. Claassen, 2017). Notice that the 1m-wide roll of fence is being cut to make three 33cm-wide strips.

Figure A1.2. Installing a nest exclosure at a River Tern nest on Koh Preah, Mekong River (photo: Trong Kam, 2012). Note: This exclosure used a single 10m-long strip of fence to construct a circular 2.3m-radius exclosure, which is much too small. The recommended size is to use two 30m-long strips of fence (60m total) to construct a 14.0m-radius exclosure, which vastly improves the chance that adults will accept the exclosure and not abandon their nest.

Figure A1.3. Anti-predator exclosure (fence) used to protect River Tern nests and chicks from rats and other mammalian predators (photo: A. Claassen, 2017).

Figure A1.4. Anti-predator exclosure (fence) used to protect River Tern nests and chicks from rats and other mammalian predators (photo: A. Claassen, 2017).

Figure A1.5. An exclosure at a River Tern nest on Koh Lak Krou, Mekong River (photo: A. Claassen, 2013). Notice the clump of dead branches; shrub branches were placed in the exclosure shortly after the chicks hatched to provide them with shade. Note: This exclosure used a single 10m stip of fence, which is much too small. The recommended size is to use two 30m strips of fence (60m total), which vastly improves the chance that adults will accept the exclosure and not abandon their nest.

Figure A1.6. River Tern chick inside exclosure (fence; photo: A. Claassen, 2017). Chicks have a much higher chance of survival if they are kept inside exclosures until they fledge. Notice the 2cm-diameter hole size of the wire mesh fencing used to construct the exclosure; this hole size effectively prevents access by rats, the primary predator of River Tern nests and chicks.

Appendix 2. Sample River Tern census data form.

A census should be conducted in March of each year. Spend at least 20 minutes at each survey point.

Point	Date	Location Name	GPS Coordinates		Time		Number of Individuals			Notes:
			Easting	Northing	Start	Finish	Adults	Juveniles	Chicks	
1										
2										
3										
4										
5										
6										
7										
8										
9										
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Appendix 3. Sample nest monitoring data form. Page 1.

Nest ID:	Species:	River:	GPS coordinates (UTM):
Location Name:		Description (e.g. next to stick, under short grass)	
Date Found:	# eggs when found:	# chicks when found:	Protected by (names):
Nest protection (circle one): None / Guarded only / Exclosure (and Guarded)	Exclosure details (date and time put up, etc.):		

Visit #	Date	# Eggs	# Chicks	Comments (adult behavior, threats, exclosure info, etc.):
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Fate (circle one): Success / Fail / Not Sure	Date Hatched:	Date Failed:
Failure cause (e.g. rat predation, trampled by cattle, etc.):	Justification (e.g. saw chicks, adult behavior, rat tracks to nest, incubation too short):	

Appendix 3 (continued). Sample nest monitoring data form. Page 2 (for additional nest visits).

Visit #	Date	# Eggs	# Chicks	Comments (adult behavior, threats, exclosure info, etc.):
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Appendix 4. Sample chick monitoring data form.

Nest ID:	Species:	River:	GPS Coordinates (UTM):
Location Name:		Protected by (names):	

Nest protection (circle one): None / Guarded only / Exclosure (and Guarded)	Exclosure details (date and time put up, etc.):

Visit #	Date	# Eggs	# Chicks	# Juvs	Comments (adult behavior, threats, exclosure info, etc.):
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Fate (circle one): Success / Fail / Not Sure	Date Fledged (Successful):	Date Died (Failed):
Failure cause (e.g., rat predation, trampled by cattle, etc.):	Justification (e.g., saw fledged juveniles, adult behavior, chick period too short, etc.):	

Appendix 5. List of species action plan workshop participants.

បញ្ជីវត្តមានសិក្ខាកាមចូលរួមសិក្ខាសាលាផ្សព្វផ្សាយ និងរៀបចំ
ផែនការអភិរក្សត្រចៀកពេនទន្លេនៅកម្ពុជា

Consultative Workshop onRiver Tern (Sterna aurantia) Species Action Plan in Cambodia

ORCHIDEE Paster, Phnom Penh, 24-Oct- 2017

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