Sundarbans Tiger Project Activities and Results 2005-2006

Final report to the USFWS and the Save the Tiger Fund

Adam C. D. Barlow[1], Md, Osman Gani[2], Md. Ishtiaq Uddin Ahmed[12], Sk. Mizanur Rahman[2], Anwar Hossain[12] Abu N. M. Hossain[2] Tariqul Islam[2], Uttam, K. Saha[2] and James L. D. Smith[1]

[1] Department of Fisheries, Wildlife and Conservation Biology, 1980 Folwell Ave. University of Minnesota, St. Paul, MN 55108
[2] Forest Department, BanBaban, Dhaka, Bangladesh

SUNDARBANS TIGER PROJECT

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U.S. FISH & WILDLIFE SERVICE

THE NATIONAL FISH AND WILDLIFE FOUNDATION
SAVE THE TIGER FUND
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Acknowledgements

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Executive summary

The Sundarbans Tiger project is a Forest Department initiative, done in cooperation with the University of Minnesota, that aims to facilitate the effective conservation of wild tigers (*Panthera tigris)* in Bangladesh. Through funding from the United States Fish and Wildlife Service (USFWS) Rhinoceros Tiger Fund, and the National Fish and Wildlife Foundation's Save the Tiger Fund, the project is carrying out research, capacity building and conservation awareness activities. Two female tigers have been radio collared and a pilot study has been conducted on a prey assessment methodology. Twenty Forest Department staff gained experience in various aspects of tiger capture, immobilization and monitoring. A handbook for Forest Department staff has been made to give instruction in animal sign recognition, field equipment use and how to work safely in the jungle. A *Tiger Response Team* has been created to deal with tiger-human conflict. A project web site had been made to raise conservation awareness. Film footage has been collected for two Forest Department programs; one that covers the project activities and another with a more general overview of tiger conservation issues in the Sundarbans.

Logic framework of completed project activities

Activity	Project Output	Post-Project Outcome
I. Telemetry study	**I.** Two female tigers fitted with GPS collars **II.** Information collected on home range size, habitat selection, prey selection and behavior **III.** Training of Forest Department staff in capture, immobilization and monitoring techniques	**I.** Increased understanding of resource requirements and population status for improved management strategies **II.** Forest department staff capable of capturing and monitoring wild tigers
II. Pilot prey survey	**I.** Refinement of prey abundance estimation methodology	**I.** Formulation of a long-term prey monitoring strategy.
III. Field training of Forest Department staff	**I.** Government personnel able to use basic field equipment and recognize common animal sign	**I.** Increased skill base for conducting monitoring programs
IV. Formation of a Tiger Response Team and associated hotline	**I.** Improved capabilities of Forest Department to deal with tiger-human conflict	**I.** Improved relations between Forest Department and local communities **II.** Decrease in unnecessary human suffering **III.** Decrease in animosity towards and retaliatory killings of tigers
V. Development of field skills handbook	**I.** Pocket sized information resource for all Forest Department staff working in the Sundarbans	**I.** Increased understanding of tiger conservation issues **II.** Improved ability to use basic field equipment, recognize tiger sign and work safely in the jungle **III.** Increased motivation for carrying out duty
VI. Filming project activities	**I.** Compilation of film footage for Forest Department programs	**I.** Development of 2 programs that will improve conservation awareness, improve skill base in Forest Department staff and raise profile of the department
VII. Presentations on project activities	**I.** Positive media national and international media coverage of tiger conservation efforts in Bangladesh **II.** Improved awareness of tourists, school groups, diplomats and local communities	**I.** Improved public support for tiger conservation **II.** Additional funding opportunities to aid completion of long-term project goals
VIII. Formation of the Sundarbans Tiger Forum	**I.** Improved communication between stakeholders **II.** Exchange of ideas, skills and resources	**I.** More focused and successful conservation efforts
IX. Development of project web site	**I.** Improved national and international awareness of tiger conservation issues **II.** Transparency of project's objectives, activities and achievements	**I.** Improved public profile of Forest Department **II.** Increased support for tiger conservation in the region

Logic framework for future activities

Activity	Project Output	Post-Project Outcome
I. Fit GPS/satellite collars to 4 female and 2 male tigers	**I.** Improved understanding of home range size, habitat selection, prey selection and behavior **II.** Further training of Forest Department staff in capture, immobilization and monitoring techniques	**I.** Tiger management plan **II.** Publications in peer reviewed journals
I. Survey to estimate relative prey abundance across the sundarbans	**I.** Improved understanding of prey distribution **II.** Formulation of long-term prey monitoring strategy	**I.** Continuous assessment of prey levels to identify potential threats and evaluate management strategies
II. Khal track survey	**I.** Assessment of tiger presence/absence and relative abundance across the Sundarbans	**I.** Long-term monitoring of changes in tiger abundance to aid formulating and assessing conservation initiatives
IV. Training workshop for ground level staff working in Sundarbans	**I.** Capacity building and improved motivation of Forest Department personnel	**I.** Improved capabilities to carry out research programs that help with tiger management
II. Formation of a second Tiger Response Team	**I.** Improved management of wild tigers **II.** Further reduction of human-tiger conflict	**I.** Improved well being for local communities **II.** Good relationship between Forest Department and local villagers
VIII. Conference between Indian and Bangladesh Forest Departments	**I.** Improved relations and communication between departments **II.** Formulation of trans-boundary conservation strategies	**I.** More effective protection and management of entire Sundarbans tiger population
IX. Graduate level study for Forest Department personnel	**I.** High level capacity building of Department staff	**I.** Increased ability of department to manage Sundarbans
XI. Maintenance and further development of web site	**I.** Resource for tiger researchers, students, media and the general public	**I.** Improved support for tiger conservation
XII. Production of secondary level school textbook dealing with conservation issues in the Sundarbans	**I.** Widely available educational material for all schools in Bangladesh	**I.** A foundation for the next generation of tiger conservationists and researchers **II.** Increased public support for tiger conservation

1. Introduction

The tiger (*Panthera tigris*) has emerged as a flagship species for much of the remaining terrestrial ecosystems of south and south-east Asia. As a large carnivore, the tiger requires extensive tracts of land to support a viable population. Protecting the tiger in an area will therefore also help conserve a wide variety of other biota. Furthermore, in many instances, the tiger and its habitat are imbedded into the culture of local communities that still use the forest to some degree for sustenance. The tiger also attracts tourism which, if managed with sensitivity, can help protect the forest and generate money for local people as well as the country as a whole.

Unfortunately, the tiger is facing ever growing threats from habitat destruction, poaching and depletion of its natural prey. The world tiger population presently numbers somewhere in the region of 5,000 to 7,000 animals. The remaining tigers are spread out among 14 countries, and are often to be found in relatively small and isolated forest patches. The development of the ecosystem management concept has elucidated the need for monitoring and research to help formulate more effective management strategies for an area (Ringold et al 1996; Wikramanayake et al. 1998). Tiger range countries are now incorporating modern scientific methodologies to achieve this aim.

One of the largest tiger forests is the Sundarbans of India and Bangladesh (10,000 km^2). It is the biggest tract of mangrove habitat in the world and represents 6% of the all remaining mangrove forests. The Sundarbans provides a wealth of vital ecological services to the region including oxygen production, soil retention, maintenance of fisheries and protection from powerful cyclones that would otherwise devastate human settlements further inland. These services are not only essential to the well being of the region, but are irreplaceable once lost; the degradation of the Sundarbans could lead to wide scale environmental disasters such as fisheries collapse, flooding, destruction of human settlements by cyclones and an increase in greenhouse gases such as CO_2. As well as the cultural loss of the national animal, the resulting economic stress on Bangladesh and Bengal in India would be huge; millions of people would end up loosing their means of income, vast tracts of agricultural land would be lost and countless communities would be displaced by increased flooding and changes in river courses. In this context, the tiger acts as a flagship species that draws attention and resources for protecting the Sundarbans ecosystem and the countries that depend on it for quality of life, cultural richness and economic revenue.

The Sundarbans (Fig. 1) represents 44% of the Bangladesh's forest cover and contains three designated wildlife sanctuaries with the remainder classified as a reserve forest (Tamang 1993). Strategically placed Forest Department patrol posts at entry points help regulate resource extraction and tourism activities.

With ever increasing threats, it is essential for the future of wild tigers in general to secure the last few substantial populations. The Sundarbans tiger population is probably the largest on the sub-continent and, together with the Amur Valley in Russia, the Western Forest Complex in Thailand, the Terai of Nepal and the Western Ghats of India, one of the largest in the world. These provide the best chance for the species survival because small populations cannot withstand even short periods of poaching or other stresses (Kenny et al. 1995).

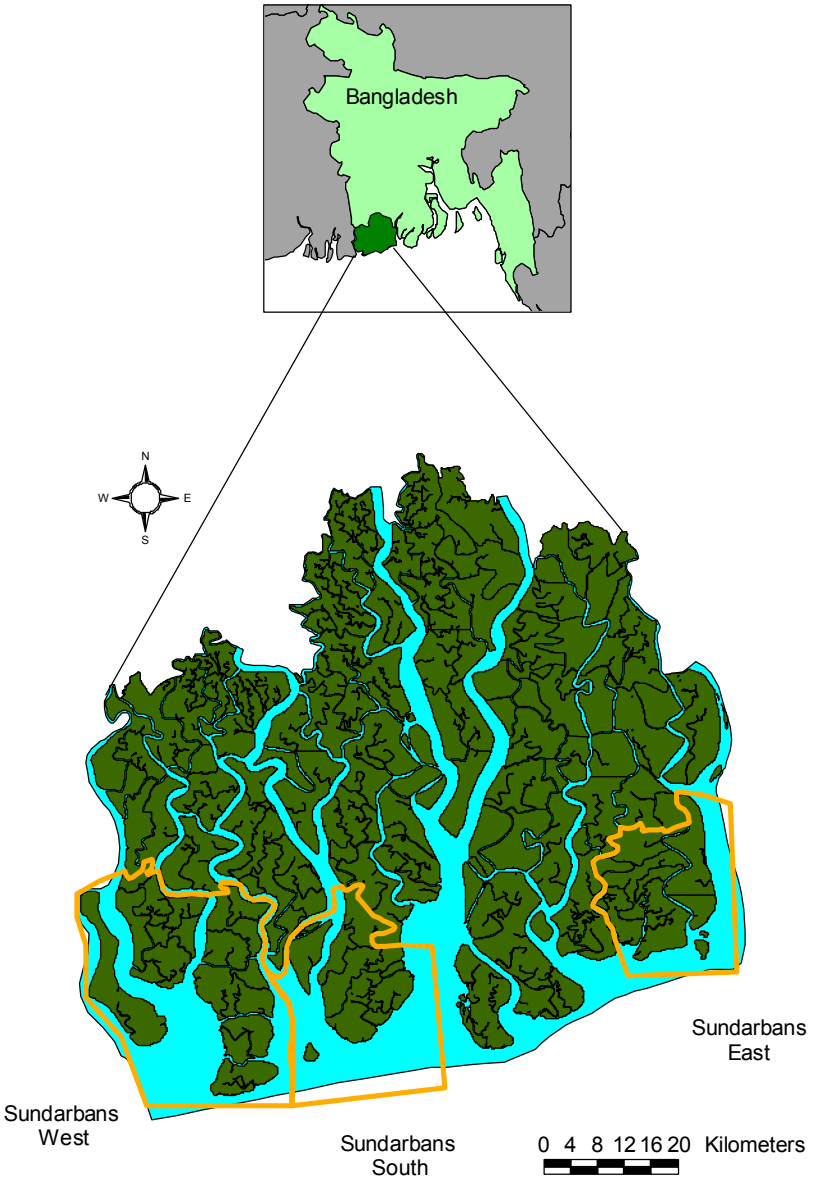

Figure 1. The Bangladesh Sundarbans

The best way to create effective conservation strategies for tigers in Bangladesh is to combine lessons learnt from efforts in other tiger range countries with adaptations to the unique set of conditions presented by the environmental and administrative setting of this large expanse of mangrove forest.

In 2002, the Forest Department initiated a project to study the ecology of tigers living in this mangrove habitat, using funds from the Save the Tiger fund and the United States Fish and Wildlife Service. There have been previous studies in the Sundarbans looking at tiger diet, general abundance or conflict with humans but these have been limited by either short study times or small sample sizes, and have had to rely on secondary sign and anecdotal reports (Hendrichs 1975; Chakrabati 1984; Rahman 1982; Chowdhury 1985; Reza et al. 2001; Khan 2004). Ecological data on tiger population levels, resource use and behavior are needed to integrate tiger management into the overall ecosystem approach to management of the Sundarbans (Ringold & et al. 1996). Resident, breeding females will be the initial focus of the study as this demographic group contributes most to long-term population viability, and their home range size is a good measure of habitat quality (Smith 1987). Following GPS collared female tigers over the long-term will compile knowledge on their habitat requirements, prey selection, behavioral patterns and life history characteristics, such as survival and reproduction rates. The Forest Department aims to use the findings to develop current management strategies that will further improve protection for the tiger and decrease tiger-human conflict. The project will build the capacity of Forest Department staff so that they are able to conduct research, monitor changes in the ecosystem and deal with problem tigers. Furthermore, the Forest Department is looking at new ways to develop an effective conservation awareness program using various media and educational outlets.

This document catalogs the results of the Forest Department's Sundarbans Tiger Project activities between February 2004 and June 2006. A more detailed analysis of the radio-telemetry, GPS and observational data is underway.

2. Methodology

2.1 Tiger capture and immobilization

The methodology for tiger capture was developed with Bart Schlayer, who has caught tigers in Russia, Indonesia, Thailand and Nepal. Live cows were used as bait, set out in rudimentary enclosures made of local materials. Two to 3 entrances were left open, with snares set at these points to catch any tiger attracted by the bait. All cows were checked each morning and evening.

The snares (Fig. 2) were designed especially for trapping tigers by Pornchai Patumrattanathan, an animal capture and handling specialist from the Department of National Parks, Wildlife and Plant Conservation, Thailand. In February, 2004, Pornchai came to the Sundarbans to give instruction on the deployment of this trap.

Figure 2. Uncamoflaged snare

The snares were designed to minimize potential injury to the tiger by not tightening around their wrist as they pull on the snare while attempting to escape.

Snared tigers were immobilized with Telazol (tiletamine hydrochloride and diazapam hydrochloride) using a dosage rate of 4 mg/kg (Smith et al. 1983). Telazol has undergone extensive medical and field trials. It has a very wide margin of safety and has been used in many studies involving other wild felids. It is particularly useful for immobilizing tigers because it has a fast knockdown (2-8 minutes) and slow recovery (normally 2-6 hours, depending on dosage and condition of the animal). The fast knockdown reduces stress to the animal and the slow recovery allows time for researchers to carry out the necessary measurements and collar fitting without concern that the tiger will regain consciousness unexpectedly. The project consulted with Terry Kreeger (author of *The Handbook of Wildlife Chemical Immobilization)* on drug selection and protocol.

Telazol is administered as an intramuscular injection so, when darting the tiger, the dart is aimed to hit either the rump or the shoulder. Like other dissociative anesthetics, Telazol can reduce the normal thermoregulatory capabilities of an immobilized animal, potentially resulting in overheating. However, this can be avoided by constant monitoring of the body temperature. If the tiger's body temperature rises to 102 F or above then water is applied to the animals flank. Fanning of the damp body facilitates evaporation of the liquid and cooling of the animal.

Once the tiger appears to be unconscious, it is approached cautiously from behind and prodded with a long stick. Once confirmed as asleep, a core team of 5-7 people moves the tiger to a shady area where it will have a comfortable recovery.

The tiger is then measured, weighed and fitted with a GPS radio collar. As the tiger starts to show sign of recovery, such as ear, tail and head moving, the capture team moves back to observe from a safe distance. Once the tiger has moved out of site, it is tracked using radio telemetry to monitor its progress.

2.2 Collar specifications

The GPS collars used were designed and made by Advanced Telemetry Systems, Minnesota, USA. GPS collars are programmed to acquire locations at set time intervals, and the radio transmitter component allows monitoring of the tiger's movements on a daily basis.

The battery in the collar allows for a set number of possible GPS locations. The collar's battery life in the field is determined primarily by the time interval between attempts to fix a GPS location. For example, if the collar is set to try for a GPS location every 2 hours, then the collar would have a field life of approximately 8 months. A time interval of less than 2 hours would decrease the filed life of the collar and the opposite would be true for an increase in the time interval setting. Furthermore, battery life varies depending on the ratio of successful and unsuccessful GPS locations; the GPS is on longer for unsuccessful locations.

The collar's VHF signal is programmed to be transmitted for a set period of time each day, normally 8 hours. The GPS collar locations are stored within the collar which has to be retrieved either by recapture, automatic release after the batteries run down, or by remote release using equipment that transmits a signal to activate the collar release system. After the limit of GPS locations had been acquired the collar retains some battery life for radio telemetry and activation of the self release mechanism. Once the collar has fallen off, the still active radio signal should allow researchers to retrieve it.

2.3 Radio tracking

Although the collar is taking GPS locations, it is vital to track the tiger every day using radio-telemetry. The GPS locations by themselves do not divulge information regarding what the tiger was doing when it was at each location. By radio-tracking, it is sometimes possible to determine tiger behavior, for example, when the tiger had made a kill or if it is associating with other tigers.

Three bearings are taken to determine the tiger's location, which is then plotted on a map. The research team remains nearby to record data on the tiger's activity, movement and general behavior. Radio telemetry is carried out on a daily basis by a team of wildlife technicians and forest guards. Tracking was done on foot or using a diesel engine trawler as transport.

Additional data were collected on tiger sign including tracks, sprays, scrapes, scats and scratch marks. Notes were taken on the type of kills made and the characteristics of feeding and killing sites.

2.4 Data analysis

Locations are determined from the radio-telemetry data using Location Of A Signal (LOAS) software (Ecological Software Solutions). LOAS estimates the tiger's location, together with location error, based on the bearings and locations recorded in the field. These can be combined with the GPS data recorded by the collar to get an overall picture of the tiger's home range, movement and habitat preference.

For this report, home range sizes (95% minimum convex polygons) were estimated using an animal movement extension for Arcview (Hooge & Eichenlaub 1997). The number of points needed to calculate 95% MCP home ranges was deduced using location-area graphs produced with a home range analysis function in BIOTAS software.

Figure 3. Plotting radio telemetry derived locations on a map

2.5 Prey abundance pilot study

Before initiating a wide scale prey survey it is first necessary to design a methodology that is practical for the local conditions and that will produce results of the necessary resolution required for assessment.

The main tiger prey in terms of abundance and selection are chital *Axis axis* and wild boar *Sus scrofa* (Khan 2004). Pellet count surveys are the only option in the Sundarbans to determine abundance of deer because other methods, such as distance sampling, are not practical due to visibility and safety considerations.

A pilot study was carried out to aid transect design and assess variance in pellet occurrence. Two plot designs were tested; a square plot of 100 m^2 and a circular plot 20 m^2. The circular 20 m^2 plots were set up ~ 15 m apart along straight line transects of 15 plots. A pole marked the center of the plot, the location of which was recorded using a GPS. All old pellets are then cleared within a 2.52 m radius of the plot center. After 10-15 days, each plot was checked to count the number of new pellet group. A pellet group was defined as a minimum of 5 pellets of similar age (determined by coloration and surface texture) and size, distributed in a way consistent with how they would fall from an individual deer (either as a circular group or linear string of pellets.

2.6 Capacity Building

Capacity building was split up into (1) intense field level training for a core group of selected Forest Department staff and (2) improving ecological knowledge and motivation throughout all the staff working in the Sundarbans (Fig. 4).

For field level training, Forest Department Staff received instruction in:

1. GPS use
2. Compass use
3. Map work
4. Prey abundance estimation methodology
5. Tiger secondary sign recognition
6. Capture site selection
7. Snare setting
8. Snare monitoring
9. Tiger immobilization
10. Radio telemetry
11. Working safely in the jungle

Skills were acquired in the field though set exercises or during the work itself. Verbal and practical tests were carried out to assess individual knowledge and competence with equipment.

Figure 4. Forest Department staff recording tiger sign

We also recognized that there is a need for a "package" of information that every forest guard can carry with him wherever he goes; a constant reference point of instructions on how to carry out his job effectively and his motivation for doing so. To fulfill this need, *The Forest Department's Sundarbans Handbook* was compiled to improve the general ecological understanding, increase data collection skills, and motivate the Forest Department staff working in the Sundarbans.

Film footage was collected for two Forest Department videos aimed at people both working or visiting the Sundarbans. These will highlight issues regarding tiger conservation and engage the viewer by explaining various aspects of tiger biology and behavior. The program will be presented in Bengali. We are exploring opportunities to broadcast them on Bangladesh national television.

2.7 Increasing awareness and improving efficiency of tiger conservation efforts.

A project web site was used to publicize the projects ongoing activities, provide educational material free for downloading, and link to all relevant groups and organizations. Content was provided directly by the researchers in the field. Local and national media were provided details of the project through regular press conferences. In addition, the researchers gave numerous talks to visiting tourist vessels, members of the media, the diplomatic community in Dhaka, and schools.

To improve communication, collaboration and efficiency of tiger conservation in the country, we established the Sundarbans Tiger Forum; a group of interested parties including people from the Forest Department, media, public, universities, and eco-tourism ventures. This will improve communication between stakeholders and facilitate joint conservation initiatives.

2.8 Tiger-human conflict mitigation

In April, 2006 a *Tiger Response Team* was established to deal with man-eating, cattle killing and tigers straying into villages. The team was made up of the research team members and a hotline was established for people to make contact. A sticker, advertising the hotline, was produced and distributed to patrol posts and local villages (Fig. 5). The research team was stationed in Katka, where mobile reception is intermittent. To improve chances of receiving incoming calls, one member of the team stayed on duty for most of the day on the Katka jetty where there was better network coverage available.

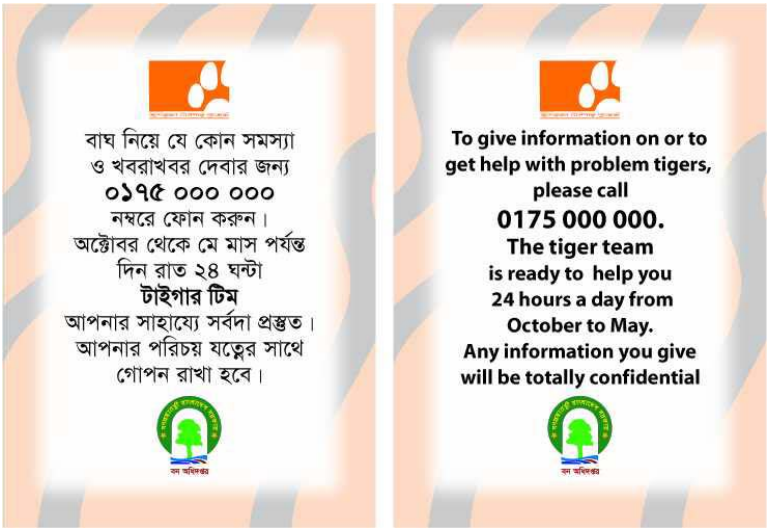

Figure 5. Tiger Response Team Stickers

The goals of the response team were to (1) decrease unnecessary human suffering and loss of life due to man-eating and (2) improve relations between local communities and the Forest Department to encourage support for tiger conservation initiatives. The response team is a vehicle for increased local participation in conservation (Fig. 6).

Figure 6. Tiger response team working with villagers at Chaprakhali village

Each tiger-human conflict situation will be unique. On receiving a call for assistance, the first priority is to gain information to make a rapid assessment of the situation, and issue immediate instruction over the phone on how the caller should proceed to minimize further danger. The response team will then go to the area and if the tier is in a village or near human habitation action will be taken. The team will first try to keep tiger and humans separate, gather information on the tiger's condition and previous behavior, and liaise with the community leaders.

The next course of action will depend on many factors including, the tiger's actions, the estimated level of threat to human life, and instructions from the administration. Options would include;

1. Monitoring the tiger from a safe distance until it returns to the jungle
2. Scaring the tiger back to the jungle using beat cloth and blank round fire
3. Immobilization and collaring of the tiger, followed by release back into the jungle
4. Immobilization followed by transport to a zoo
5. Extermination (in the case of a man-eater in bad physical condition, as a last resort on advice from the Chief Conservator of Forests).

3. Results

3.1 Immobilization

Two tigers were successfully captured and fitted with GPS-radio collars. The first tiger snared (named Jamtola Rani or JR) was female, and captured at the Jamtola area on the 22nd of April 2005. It was darted at 6:58 p.m. with 600mg of Zolatil (Fig. 7).

Figure 7. Jamtola Rani waking up after immobilization

All its upper incisors were either worn down to stumps or totally broken off. Two lower incisors and the right lower canine were also missing. Although thin, the rest of the body seemed to be in relatively good condition. All claws were intact and, apart from three small kinks in the tail, the tiger showed no signs of previous injuries.

The tiger weighed approximately 75 kg and measured 234 cm from nose to tail along the curves. Hair and tissue samples were taken for genetic analysis and photos were taken of the tiger's stripe pattern for future identification. A GPS collar was attached and the tiger's temperature was continually monitored as it slowly recovered from the effects of the drug. It was difficult to give accurate estimates of a tiger's age from an examination of its teeth. However, compared to other tigers of known age examined by the investigator, a conservative estimate for the captured tiger would be around 14 years or older. She recovered slowly but steadily through the night. The first "head up" was recorded at about 1:30 p.m. She then went through intermittent bouts of sleep until she walked away from the capture site at 10:00 a.m.

A second female tiger (Chaprakhali Rani or CR) was captured on the night of the 2nd of March, 2006. Judging by teeth wear it was between 10-12 years old.

She weighed an estimated 110-125 kg, and measured 228 cm from nose to tail tip along the curves. Her body was in good condition; all claws were intact and the only sign of previous injury was an old 15 cm long scar on her right shoulder, and a missing upper canines. The tiger recovered well from the immobilization, leaving the capture site at 8:30 a.m.

3.2 Home range utilization

JR: JR's territory was defined using the 648 GPS locations recorded in the collar. Her estimated home range was 17.38 km^2 (95% MCP estimator). JR's territory encompassed some grass meadows that stretched from Jamtola to Kochikali, together with a mixture of keora (*Sonneratia apetala*), gewa-goran (*Excoecaria agallocha - Ceriops decandra*), and sunduri (*Heritiera fomes*) (Figs 8 & 9).

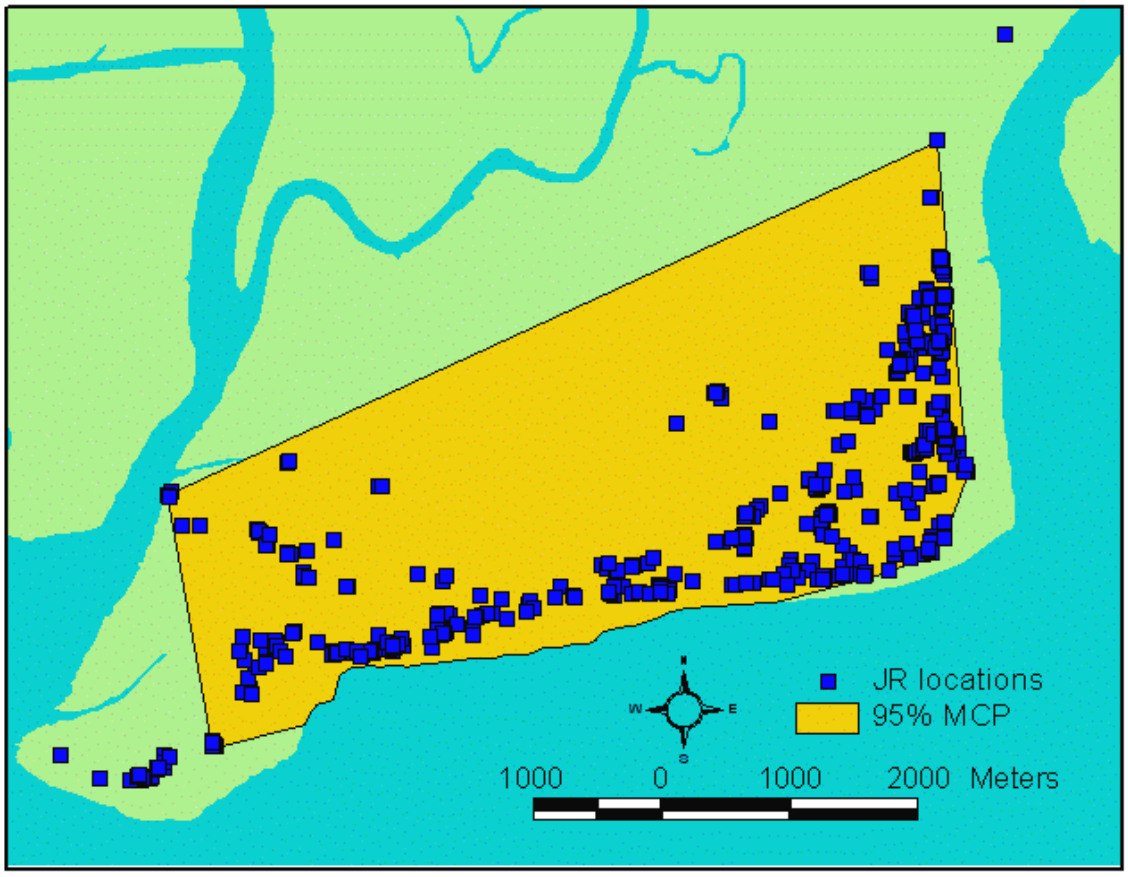

Figure 8. 95% MCP home range of JR

JR stayed in what can be considered its normal home range from April 22nd to September 29th (5 months), apart from a brief exploratory foray between the 23rd-25th of August, (Fig. 9). On the 29th of September it made a sudden shift to the east, where it stayed until its death (Fig 10). The last location recorded for the tiger when it was still alive was on 15th of October.

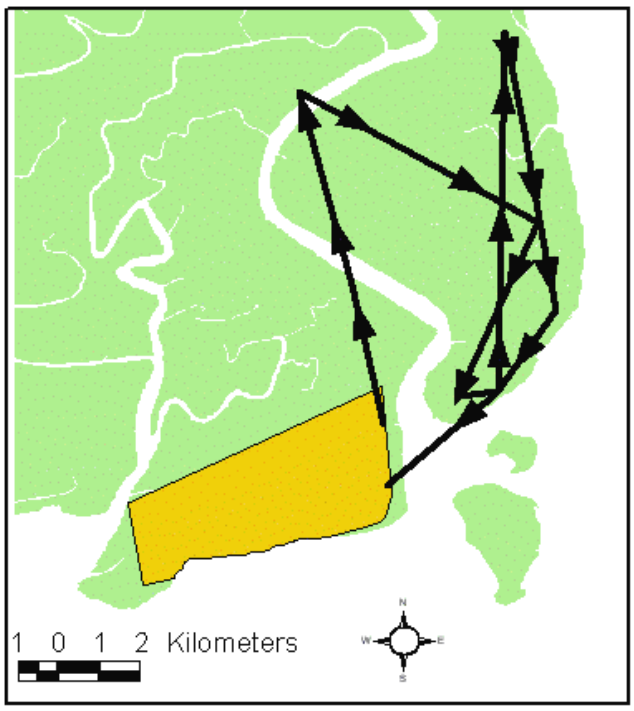

Figure 9. JR's exploratory trip (August 25ht-28th, 2005)

Her remains were discovered on the 28th of October, just north of Chandeshwar patrol post and approximately 8 km from her former home range (Fig 10).

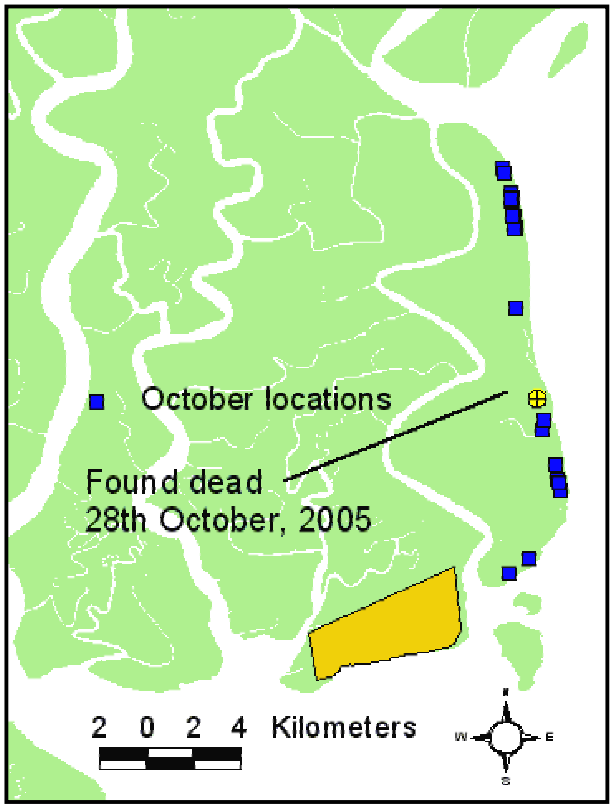

Figure 10. JR's October locations

The age of the tiger, indicated by teeth condition (Figs 11a, 11b & 11c), its movement patterns, and the recorded presence of a new tigress in her territory, all strongly suggest that the study tiger was displaced by a younger, stronger female.

Figure 11a and 11b. Side view of JR skull showing discolored and worn teeth

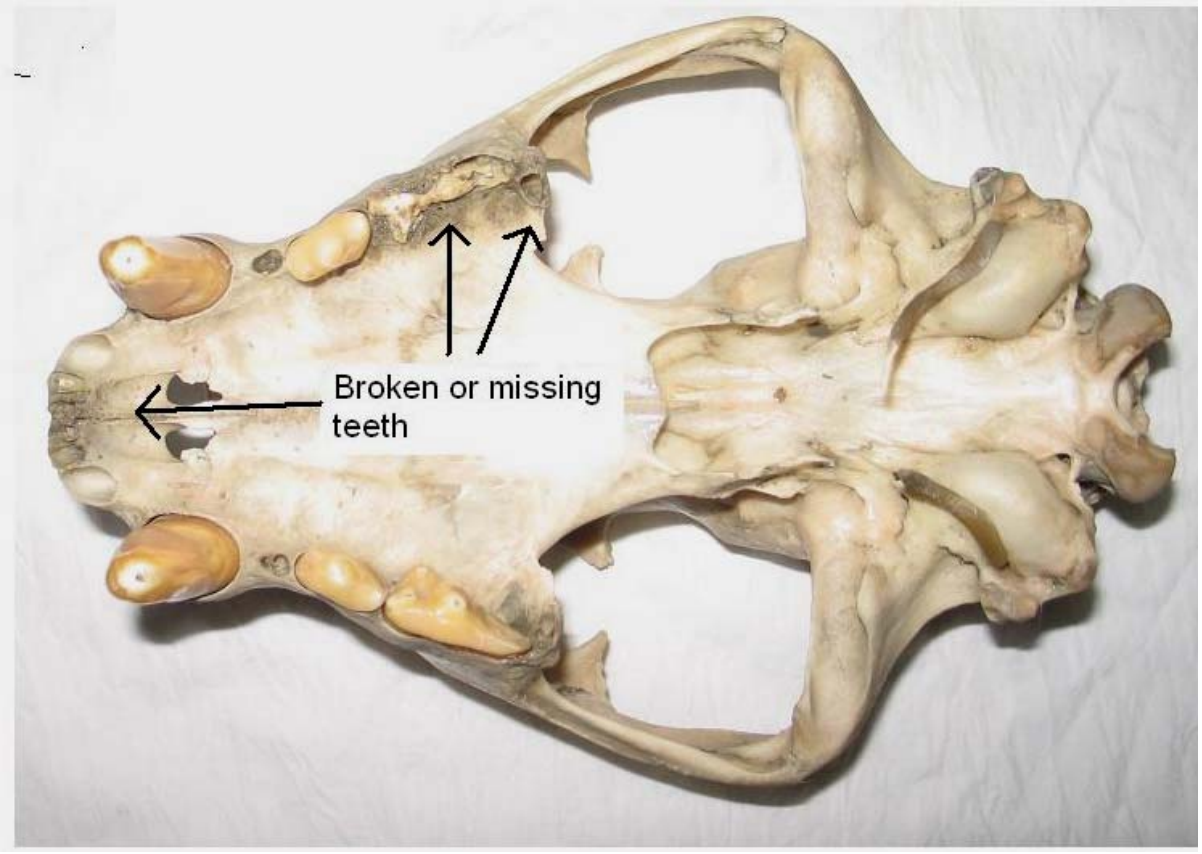

Figure 11c. Ventral view of JR skull showing missing incisors and broken carnassial pair

CR: A total of 62 days of radio tracking were conducted between the 3rd of March and the 16th of May, 2006. During that period, the tiger was located on 57 days (91% success rate). CR's home range extended east and west of Chaprakhali village and totaled 12.1 km^2 (95% MCP estimator) (Fig. 12).

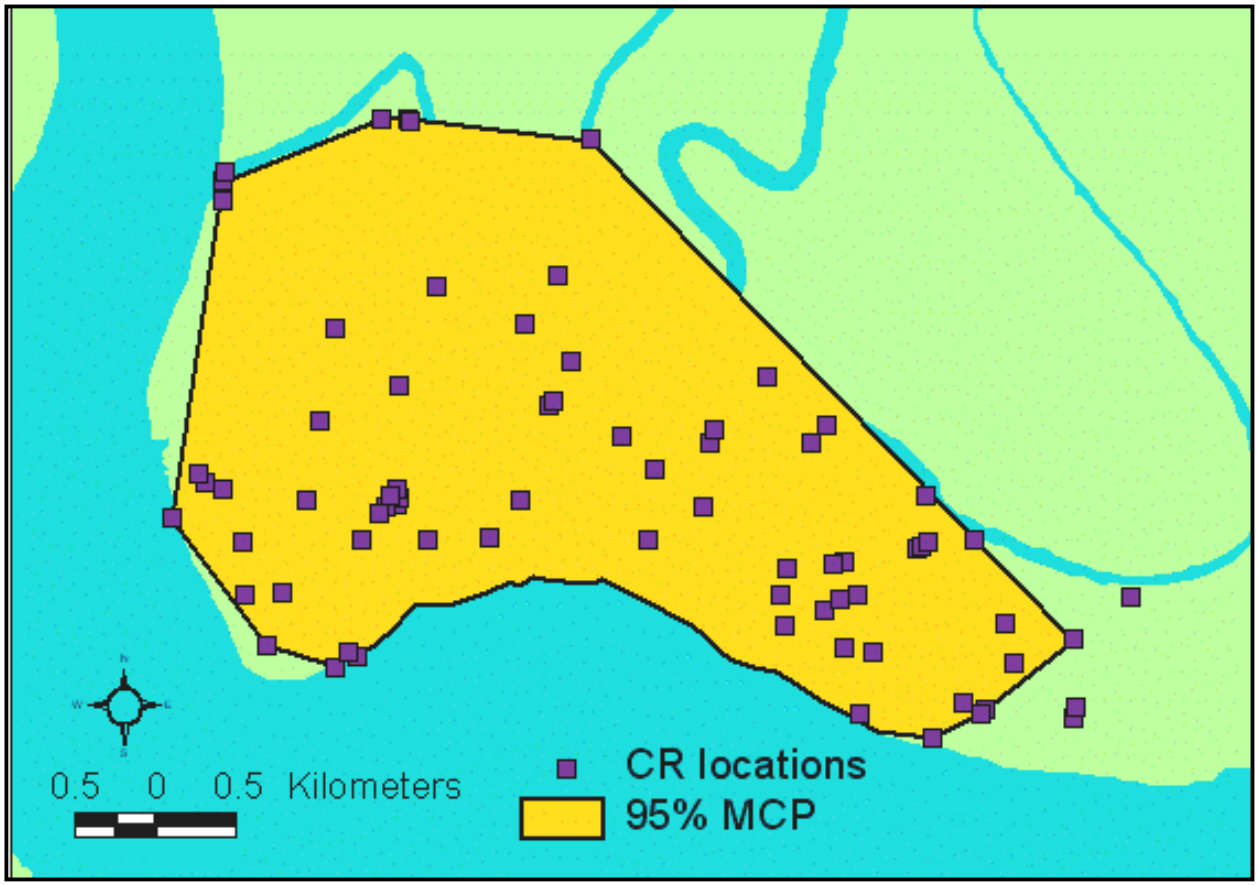

Figure 12. Home ranges of Jamtola Rani and Chaprakhali Rani

Her territory had large stands of gewa-goran, sundri and keora but no substantial patches of grassland. Her boundaries were well defined and at no time during the radio telemetry period (March 2nd- May 16th) was there any sign of another female tiger being inside CR's home range. A male tiger was detected (differentiated by the larger track size), but infrequently. Both CR and the male tiger both visited the fresh water hole maintained by the villagers at Chaprakhali.

3.3 Tiger Kills

JR: The difficult weather conditions of the monsoon and the damage of a receiver prevented kills being identified during the course of the radio telemetry. Kills were instead inferred by the movement patterns recorded by the GPS collar. The tiger was considered to have made a kill if it either spent more than 12 hours in a 100 m radius during the day or more than 8 hours during the night. Using this criteria, a total of 39 hypothetical kills were recorded, ranging from 2-9/month (Table 1).

Table 1. Number of hypothetical kills made by tiger JR.

Month	*Hypothetical kills*
May	6
June	9
July	9
August	2
September	9
October	4
Total	39

Note; kills are based on time spent within a 100 m radius of a location. October data is for 15 days only.

CR: Tracking CR every day using radio telemetry enabled the discovery and identification of some of her kills. If she stayed in an area for more than a day it was nearly always indicative of her having made a kill. An attempt was made to find all of her kills but undoubtedly some went undiscovered. Nine carcasses were recovered and 2 other kills were confirmed by kill sites and drags, giving a total of 11 confirmed kills. All kills were of chital, and of the 9 animals whose remains were found 4 were large stags, 3 were adult females, 1 was a small fawn and one was a medium sized animal of unknown sex. Once killed, CR typically dragged the carcass into thick goran (*Ceriops decandra*) to continue feeding.

3.4 Pilot study of prey assessment methodology

A total of six 100 m^2 plots and two transects of fifteen 20 m^2 circular plots were set out. Counts were carried out 10-20 days after the plots were initially cleared of pellets. Pellets from chital, wild boar (*Sus scrofa*) and monitor lizard were detected. Four of the circular plot transects were washed out by either high tides or storms (Table 2). This preliminary investigation gave an idea of the effort and man-power required to clear plots. Extensive additional testing is needed to determine variance in pellet group number between plots in the same transect and between separate transects within the same vegetative type.

Table 2. Results of pellet count pilot study

						Days before count	
Plot number	**Area (m2)**	**No. Plots**	**Habitat type**	**Date cleared**	**Prey species**	**10**	**20**
1	100	1	Gewa/Goran	7-Mar-05	Chital	1	4
					Wild boar	1	1
					Other	0	0
2	100	1	Gewa/Goran/Keora	7-Mar-05	Chital	3	9
					Wild boar	0	0
					Other	0	0
3	100	1	Gewa/Goran / Keora/Sundari	7-Mar-05	Chital	5	10
					Wild boar	0	0
					Other	0	0
4	100	1	Keora	7-Mar-05	Chital	10	-
					Wild boar	1	-
					Other	0	-
5	100	1	Keora	7-Mar-05	Chital	6	-
					Wild boar	0	-
					Other	0	-
6	100	1	Keora	7-Mar-05	Chital	9	-
					Wild boar	0	-
					Other	0	-
7	255	13	Gewa/Goran/Keora	26-Mar-05	Chital	2	-
					Wild boar	0	-
					Other	0	-
8	236	12	Gewa/Goran	27-Mar-05	Chital	41	-
					Wild boar	0	-
					Other	1	-

3.5 Capacity Building

Our goal is to train a minimum of two teams that are able to capture, immobilize and monitor tigers. The two teams will work as both researchers and as *Tiger Response Teams*. This will be a lengthy process and require some staff will need to attend future immobilization workshops. One of the most useful skills for this type of work is to be able to work safely around tigers. This means being able to interpret alarm calls, read sign and have some idea of tiger behavior. Radio tracking a tiger helps with this by increasing the number of times tiger can be observed. To date, we have begun training the first *Tiger Response Team*. In addition, 20 staff have been trained in various aspects of tiger tracking, orienteering, prey assessment and tiger trapping (Table 3).

Table 3. Skills and experience acquired by Forest Department staff

Personnel	*Tracking*	*Compass*	*GPS*	*Mapping*	*Pellet surveys*	*Bait site selection*	*Snare setting*	*Tiger capture*	*Radio tracking*	*General safety*
ACF 1										
ACF 2										
Forest Guard 1										
Forest Guard 2										
Forest Guard 3										
Forest Guard 4										
Forest Guard 5										
Forest Guard 6										
Forest Guard 7										
Forest Guard 8										
Forest Guard 9										
Forest Guard 10										
Forest Guard 11										
Forest Guard 12										
Forest Guard 13										
Boat driver 1										
Boat driver 2										
Wildlife tech. 1										
Wildlife tech. 2										
Wildlife tech. 3										

Note: Orange denotes proficiency and yellow denotes some level of experience. ACF stands for Assistant Conservator of Forests.

To facilitate training over a wider scale we developed *The Forest Department's Sundarbans Handbook*, which covers the basic field wildlife field skills needed for assessing the status of tigers and their prey (Fig. 13).

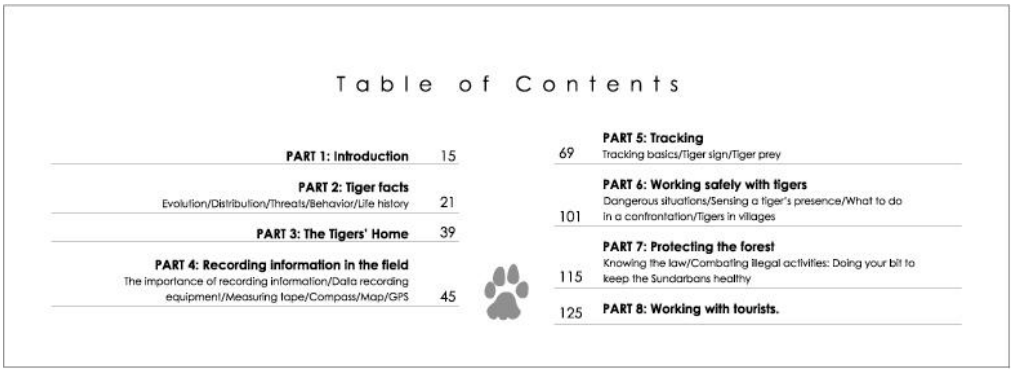

Figure 13. Table of contents page for field handbook

This handbook was developed primarily by Adam Barlow and CCF Md. Osman Gani with the help of other members of the tiger research team. The layout and graphics were produced by Tanjilur Rahman. The cover design background was made from the stripes of Jamtola Rani, the first tiger to be fitted with a radio/GPS collar in the Sundarbans (Fig 14) and the size of the booklet was designed so it would fit in the shirt pocket of a uniformed forest guard. A brief forward introduces the main purpose of the book, followed by an overview of the main objectives of the Sundarbans Tiger Project.

Figure 14. Cover of The Forest Department's Sundarbans Handbook

The introduction covers the general conservation need for protecting the Sundarbans and its tigers. More detailed information on tiger threats, distribution, behavior, life history characteristics and evolution is then covered in the *Tiger Facts* section. The *Tiger's Home* gives some basic ecological background on how the various components that make up the Sundarbans interact. The *Data recording* section provides step by step guide to map reading, orienteering and GPS (Fig. 15).

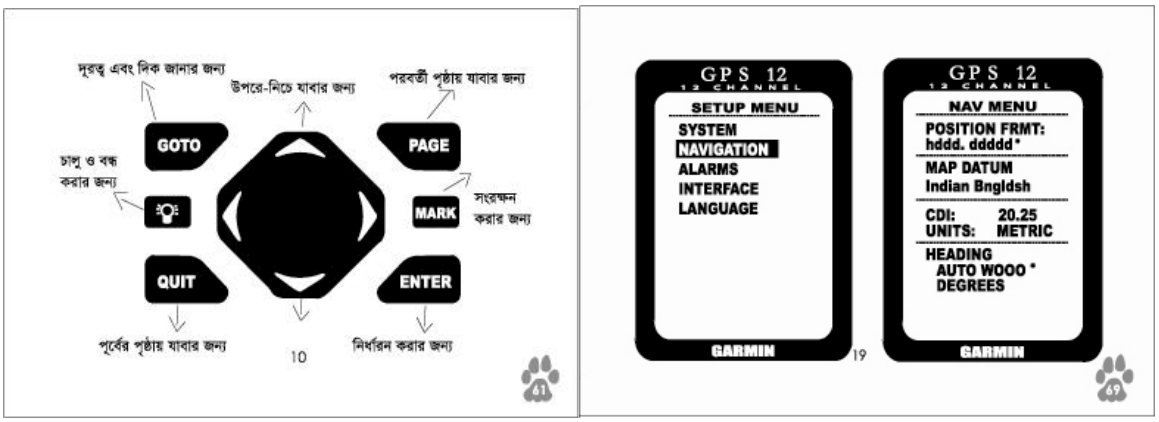

Figure 15. Example of pages from the *Data collection* section

The *Tracking* section covers all the sign tigers leave behind in the jungle and how to interpret them. The *Protecting the forest* section outlines, the laws that give the Forest Department the authority to regulate human activities in the Sundarbans. That is followed by *Working safely in the jungle* and *How to work with tourists.* The book is being printed and will be distributed to the forest guards working in the Sundarbans. Both the English and Bengali versions will eventually be free to download from the web site.

3.6 Conservation awareness activities

A total of 20 presentations were given to various groups; tourists (8), diplomats (2), schools (2), a village, government officials (3) and the media (4).

The project web site was created in mid April by Mohammad Akib, Tanjilur Rahman and Adam Barlow (Fig. 16).

Figure 16. Example of project web site page

It contains general information about tiger conservation, as well as giving an account of the project in terms of background, objectives, methodology and personnel. The site was updated weekly with new photographs and reports from the field activities. At the time of writing the web site has been visited by over 11,300 independent computers. The *Tiger Library* section of the web site will be developed to have a wide range of reference material for anyone interested in tigers or the Sundarbans.

The Sundarbans Tiger Forum has been established but meetings have proven difficult due to differences in schedules. However, many members are now in contact on a regular basis. The project was also the subject of several national (>10) and international (>6) newspaper reports.

3.7 Tiger-human conflict mitigation

The Tiger Response Team was started in mid March. Two calls were received; one from Chadpai village and one from Chaprakhali. The response team traveled to Chadpai village where a tiger had entered the village and injured 4 people. What is thought to be the same tiger, also killed several cattle in the same area. After discussions with the villagers it was decided to postpone any definite action until further behavior of the tiger could be ascertained. The villagers of Chaprakhali asked for assistance with a tiger that was regularly coming into their village to look for food and water. It had entered a thatch building on 1 occasion and had killed a domestic goat on another. This contact lead to the eventual capture of the second tiger to be collared (CR). The number of man-eating cases was low for the start of 2006 (4 in April-May). The incidents were spread out enough to suggest that different tigers were to blame, so no direct action was required of the response team.

4. Discussion and recommendations

4.1 Tiger Capture

Valuable lessons were learnt regarding how to capture tigers living in a mangrove habitat. As this was the first project of its kind in this setting, there was from the outset considerable experimentation with trapping methodology. The research team had to quickly learn from each new experience and adapt their approach. For example, the high salinity of the soil quickly rusted the snare wires if they were left in the ground for to long. Likewise, the snare springs lost their strength if set for weeks on end. The result was faulty equipment that considerably decreased chances of tiger capture. At the beginning of the study snares were set out around live cows; later we shifted to setting out baits without placing snares in the vicinity. Snares were set after a cow was killed. In nearly every case of

baiting, some kind of corral was set up around the cow so that the tiger would have limited options of approach. Snares were put at the entrance/exit points and in some instances along nearby trails or scent trees. From our experience we concluded that (1) in general tigers living in the Sundarbans were somewhat wary of killing cows at first sight, (2) female tigers were less likely than males to take the baits, and were also more easily disturbed from a kill, and (3) tigers were wary of approaching both live and dead bait, but (4) there was considerable variation in tiger behavior; some would never kill the bait while others always did. Considering the alternatives (box traps, different bait types etc), however, the cow-snare combination still appears to be the safest and most reliable capture method currently available.

4.2 Home range analysis

It is interesting to note that both collared tigers have very small home ranges (average 14.75 km^2) relative to all other published data on tigers across the species range. In comparison, female home range sizes recorded from Nepal were 14-51 km^2. Although more tigers need to be collared in different areas of the Sundarbans, these preliminary data suggest that the mangrove habitat type holds one of the highest tiger densities in the world. Furthermore, if these small home range sizes are typical over the Sundarbans, then this mangrove habitat may support one of the largest remaining wild tiger populations.

Small populations are very sensitive to even low levels of poaching or environmental stresses, so it is the last relatively large populations like the Sundarbans population that represent the tiger's best chances of survival into the future. As such the Sundarbans should be considered a high priority for tiger conservation efforts and resources.

Research in the 2006-2007 season will focus on (1) radio collaring tigers from different habitat types, (2) calibrating variance in khal track counts and (3) developing a rigorous technique for estimating absolute prey abundance.

Analysis of the telemetry data will use Fixed Kernel Polygons (FKP) to investigate home range size and utilization. Second and third order habitat selection will be investigated using the type III compositional analysis function available in the BIOTAS software package. This is a multivariate technique that compares expected to observed distribution of point data occurring in differing coverage types. Compositional analysis uses individual animals as the sampling unit rather than the estimated location (Aebischer et al. 1993). Habitat selection for tigers will be tested for using each tigers' daily locations and their 95% FKP. Three 95% home ranges will be used: total 95% FKP, total dry season 95% FKP, and total wet season 95% FKP. In this way selection of different vegetation

types and other ecological strata (such as prey density, salinity and human disturbance levels) between seasons will be analyzed. A minimum sample size of 6 tigers is required for this type of analysis (Aebischer et al. 1993).

To better understand the social organization of tigers and to provide preliminary data on the ratio of male to female home range size, we will also attempt to collar 2 males tigers. We recommend that this is an initial goal of the project, rather than a limit; the best tiger research and conservation projects in the world are the Terai Arc Landscape Project in Nepal, where 37 tigers have been collared (Seidensticker 1976; Sunquist 1981; Smith et al. 1999), and the Siberian Tiger Project in Russia, where 33 tigers have been collared (Miquelle et al 1999; Kerley et al. 2003).

4.3 Prey assessment

The circular plots set up along transect lines proved easier to set up and check than the larger square plots. Pellet groups were detected in cleared plots after 10-20 days. We need to develop this technique by determining the spatial variance within and between transects in the same geographic locality and similar forest type. The tidal and general water level fluctuations in the Sundarbans place constraints on the time period available for conducting pellet count surveys. The best time of year to carry out this type of work is February and March, when inundation is at its lowest.

After a pilot study in late 2006 and early 2007 we will begin a Sundarbans wide prey survey in mid-February 2007. Five strata, representing the major vegetation types, will be sampled. A total of 160 transects (2,400 plots) will be established, with equal number of transects (32) in each vegetation type. In subsequent years we will stratify sampling based on variance estimates across different vegetation classes. Eight clusters of four transects will be randomly distributed along the navigable waterways throughout each vegetation type. Then the starting points for each transect will be randomly selected within 500 m from the cluster center and not more than 100 m from the nearest waterway. Each transect will run perpendicular to the nearest waterway. If the transect line is blocked by another khal or other obstacle, then a new direction (90º from the original bearing) will be taken.

An existing herd of captive chital, kept at Karamjol (Chadpai range, Sundarbans), will be used to determine defecation rate. The deer are fed on vegetation that wild chital utilize in the mangroves. Each day the enclosure will be cleared of old pellet groups, and the next day the number of new pellet groups will be counted. The number of pellet groups per day will be divided by the number of deer to give pellet groups/deer/day. The variation in this statistic will be quantified by repeat counts. We assume that the behavioral and environmental constraints on the captive herd will not affect the deer's metabolism to such an extent that they produce very different quantities of pellet groups from

what they produce in the wild. The ~ 20 chital in the captive herd includes representatives of both sexes and all major age classes. The mean defecation rate and its variance will be used to estimate deer density from the pellet count transects conducted in the wild.

4.4 Monitoring the tiger population

Every two years a selection of khals will be surveyed for the presence of tiger tracks. Encounter rate of tiger tracks along khals measures relative abundance of tigers and has the potential of being a cost effective and robust means to monitor changes in tiger abundance (Hayward et al. 2002). Sampling units will be compartments or sub-compartments (larger compartments will be split up along major river courses so that sampling units are approximately 50 km^2). The navigable waterways in each sample unit will be surveyed for tiger tracks, the frequency of which (track sets/km of khal) will be used to compare different areas or times, and to deduce relationships between various ecological variables (salinity, vegetation type, etc). This monitoring design will provide an early indication of areas that may require additional management. The degree of change in tiger abundance that can be detected will be dependant on (1) the suitability of the sampling design, (2) the relationship between track rate and tiger numbers, and (3) the variance in track rate. These factors will be investigated during the course of pilot surveys and will incorporate tiger home range size data from the radio telemetry study.

4.5 Sundarbans Tiger Conference

It is desirable to work towards a trans-boundary approach to tiger conservation in the Sundarbans. To facilitate this, a conference between forest officers from India and Bangladesh will be held in Kolkotta, India in February 2007. The meeting objectives will be to exchange information, standardize field methodology, and plan trans-boundary tiger conservation initiatives.

6.6 Capacity Building

There are two levels of capacity building that need to be targeted; (1) ground level Foresters, Forest Guards and Boat men, and (2) higher level officers (ACF's and above). The training program for ground level staff needs to be continued to enhance the Forest Department's ability to conduct effective research, monitoring and tiger-human conflict mitigation programs. The current organization of the Forest Department means that staff are often transferred between posts after 1-2 years. It would improve management capabilities if staff that show ability and motivation for working with tigers are retained in positions that allow them to use their growing experience in that field.

Long-term tiger conservation would also benefit from continuing further education programs for Forest Department officers. Two Deputy Conservators of Forests are currently enrolled as PhD candidates at the University of Minnesota, and there are 1-2 ACFs that have good potential for graduate level work. Funding needs to be secured to support these officer's studies.

For problem tiger management, 3-4 Forest Department staff need to be trained in immobilization techniques. This can be done by combining field experience with attendance of immobilization workshops conducted by wildlife capture experts. Such a workshop is currently being planned for Thailand in 2007. Although their will be core teams of staff with specialized skills, it is also necessary to improve general capabilities and motivation of all ground level staff working in the Sundarbans. The *Forest Department's Sundarbans Handbook* will provide information on tiger conservation, data collection, safety, and legislation. This will provide the base line information required for Sundarbans staff to carry out their work effectively. The video being produced for the Forest Department will support certain aspects of the books content, and provide additional motivational material. The book will be distributed for free, and the program will be shown at all Sundarbans patrol posts. A pre and post book/video distribution survey will measure any increase in knowledge or motivation.

6.7 Conservation awareness

The web site has received positive feedback from government officials, tiger conservationists, students and the public in general. The challenge is to develop the *Tiger Library* section and *Discussion Forum* sections so that it can act as a substantial resource for all those interested in tiger conservation, or for that matter anyone working in the Sundarbans.

Since working on tigers is politically sensitive, it is necessary to communicate to the general public the approach being taken and the rational behind it. The key lesson learnt during the course of this study is that a pro-active approach to supplying information through the media (by writing articles or contacting sympathetic journalists) helps to portray the work and reputation of the Forest Department in a positive light. So far, the media response had been largely positive, and communication between the Forest Department and the press has been improved through meetings and timely release of information. The international press has also welcomed Bangladesh government's efforts to lead the way in tiger conservation in the region. Public support is essential for the relevant ministries to carry out this type of research and to develop future management strategies. Filming of the government's conservation efforts for both national and international audiences should be encouraged, as this will further increase awareness and support.

Conservation awareness is also facilitated through education material. School text books and syllabuses that incorporate tiger biology and general Sundarbans ecology would help produce future generations of tiger scientists, managers and conservation advocates. At present there is no substantial texts covering these issues; the information regarding tigers and the Sundarbans is either very limited or scattered amongst a small number of reports and journal articles. The project aims to compile and produce a text book for use in secondary schools comprehensively covers the ecology and conservation of the Sundarbans and its biodiversity. Contacts have already been made with some people that have a relevant field of expertise and who can potentially contribute content. Book structure is being developed, and writing will start in 2007.

Timetable of project activities

Objective	Activity	2006			2007			2008			2009			2010		
1. Determine resource needs of tigers	Tiger capture and monitoring															
	Prey abundance survey															
	Analysis of results															
	Publication of findings in journals															
	Khal track survey															
2. Capacity building	Data collection training															
	Research training															
	Immobilization workshop															
	Collect footage for training video															
	Produce training video															
	Show video to patrol posts															
	Collect material for field skills handbook															
	Produce field skills handbook															
	Problem tiger response team															
3. Increase conservation awareness	Sundarbans Tiger Forum meetings															
	Web site															
	Press conferences															
	Filming															
	Primary level educational material															
	Secondary level educational material															
	University level educational material															

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