Chapter 1: Status of Tigers in the Sundarban Biosphere Reserve (2012-2013)
National Park (East), Sajnekhali Wildlife Sanctuary, Basirhat Range, India

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Niladri Sarkar

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Abhijit Choudhury

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Preface

The transboundary Sundarbans located in India and Bangladesh is the only coastal wetland tiger habitat in the world. This mangrove forest has been recognised as a wildlife conservation area of regional and international importance, and has been identified as Level I (18) Tiger Conservation Unit (TCU). The fauna of the Sundarbans, particularly the tiger, are especially adapted to this difficult terrain that is subjected to a variety of changes over time, including variable salinity regimes, periodic high tides and tidal inundations, occasional tidal surges and frequent flooding, among others. This makes the tigers in this region significantly different from their counterparts inhabiting other ecosystems. Their behaviour is largely specific to individuals and cannot be generalized. Therefore, we are unable to replicate studies done on other tiger species within this landscape.

In 2012, WWF-India in joint collaboration with Sundarban Biosphere Reserve (SBR) Directorate carried out the first systematic camera trapping exercise for tigers in 24 Parganas (South) Forest Division using the landscape specific tiger monitoring protocol for Sundarbans. This study resulted in declaring an area of 556 sq. km as West Sundarbans Wildlife Sanctuary.

The current report presents the outcome of the camera trapping exercise in Sundarban Tiger Reserve, by WWF-India in collaboration with SBR Directorate, to establish the baseline for tiger population. This report also provides insights to the factors (tidal rhythmity, topography, habitat formations, prey-base occurrence and olfactory lures) governing the captures of animals in the aforementioned area using camera trap based Mark-Recapture framework. This report recommends significant ecological and management strategies to be implemented in the area for long term survival of the tiger population.

I extend my appreciation to the officials and the staff of Sundarban Tiger Reserve along with our collaborating partner, WWF-India, for carrying out this exemplary exercise. I hope similar initiatives and collaboration would continue in future years so as to conserve and manage this unique ecosystem.

Dr. R.P. Saini - IFS
Addl. PCCF & Director
Sundarban Biosphere Reserve, West Bengal
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**National Park (East):** Somnath Chatterjee (Ranger), Ranjit Biswas (Head Forest Guard), Khagendranath Das (Forest Guard), Swapan Mondal (Forest Guard), Balaram Mondal (Forest Guard), Arubindo Karmakar (Forest Guard), Samarendra Nath Ghose (Boatman), Niranjan Sardar (Bosorsamik), Jyotish Das (Bosorsamik) and Uttam Sarkar (Bosorsamik).

**Sajnekhali Wildlife Sanctuary:** Jayanta Basu (Ranger), Biplab Kumar Bhumik (Deputy Ranger), Biplab Ghosh (Deputy Ranger), Sabyasachi Hazra (Deputy Ranger), Dipak Kumar Bhadra (Head Forest Guard), Bijoy Krishna Gayen (Head Forest Guard), Krishna Chandra Sinha (Head Forest Guard), Harashit Mondal (Forest Guard), Khagendra Nath Mondal (Forest Guard), Ramashish Mahato (Forest Guard), Pintu Biswas (Forest Guard), Sanat Deb (Forest Guard), Krishnapada Mondal (Forest Guard), Provash Chandra Mondal (Forest Guard), Ramakrishna Dutta (Forest Guard), Jayanta Gucechait (Boatman), Bablu Mondal (Engine Driver), Himanshu Mondal (Majhi), Arjun Bairagi (Majhi), Swapan Bera (Majhi) and Mahadeb Mishry (Bosorsamik).

**Basirhat Range:** Subhasish Pal (Ranger), Tapas Adok (Beat Officer), Ayan Chakroborty (Beat Officer), Santanu Kulobhi (Beat Officer), Kalipada Sinha Thakur (Beat Officer), Farukh Hossain Khan (Head Forest Guard), Santosh Kumar Roy (Head Forest Guard), Sanjib Kumar Chatterjee (Forest Guard), Arun Kumar Barui (Forest Guard), Tapan Kumar Dutta (Forest Guard), Niladri Das (Forest Guard), Prosanto Joddar (Forest Guard), Niranjan Giri (Forest Guard), Gopinath Roy (Forest Guard), Abu Kalam Naskar (Forest Guard), Krishna Bhadra (Forest Guard), Bhaktaramanik (Forest Guard), Ajit Kumar Chapadar (Boatman), Dukhiram Mondal (Boatman), Rahim Gazi (Boatman), Sujit Ganguly (Boatman), Srijamapada Mondal (Boatman), Sachin Mondal (Boatman), Biswajit Mondal (Boatman), Bhandul Bag (Majhi), Pala Debnath (Bosorsamik), Bholanath Das (Bosorsamik), Asutosh Mali (Casual Daily Labourer), Pralhad Mondal (Casual Daily Labourer), Pintu Mondal (Casual Daily Labourer), Himanshu Kumar Mondal (Casual Daily Labourer), Dinabandhu Sardar (Casual Daily Labourer), Majuddin Gazi (Casual Daily Labourer), Nishikanto Sardar (Casual Daily Labourer), Ashok Gayen (Casual Daily Labourer), Kartik Sardar (Casual Daily Labourer), Bhandul Sardar (Casual Daily Labourer).

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EXECUTIVE SUMMARY

Effective conservation of species requires reliable estimates of population density and its associations with habitat to prioritize investments for conservation interventions. Such conservation planning approaches are based on knowledge of the species’ response to vegetation, land use, topography and other external cues. In ecosystems like the Sundarbans where the external environment of living organisms display rhythmic changes to tides twice a day, such factors are important for long term monitoring programmes.

Enthused by the findings of the 2012 camera trap studies on tigers carried out in 24–Parganas (South) Forest Division; WWF-India and Sundarban Biosphere Reserve Directorate extended the study to cover forest ranges under the Sundarban Tiger Reserve [National Park (East), Sajnekhali Wildlife Sanctuary and Basirhat Range] in line with Phase-IV tiger monitoring protocol for Sundarbans (NTCA, 2012). This study presents the findings of the first attempt to estimate the tiger population and factors (tidal rhythmicity, topography, habitat formations, prey-base occurrence and olfactory lures) behind the capture in the aforementioned area using photographic capture-recapture analysis.

This study used remotely triggered camera traps and the capture-recapture framework to estimate the population and density of tigers in three ranges of Sundarban Tiger Reserve. A total of 169 camera trap pairs were used in three ranges to cover about 1706 sq. km area. The total sampling effort of 2744 trap days (56 camera trap stations, each operating on 49 occasions) at National Park (East) yielded 245 photographs (of both flanks) of tigers. In Sajnekhali Wildlife Sanctuary, a total sampling effort of 2622 trap days (57 camera trap stations, each operating on 46 occasions) yielded 127 photographs (of both flanks) of tigers. In Basirhat Range, the total sampling effort of 1736 trap days (56 camera trap stations, each operating on 31 occasions) yielded 141 photographs (of both flanks) of tigers. From the study, the population is estimated to be 25 ± 5.3 (N-hat ± SE) individuals for National Park (East), 15 ± 1.2 (N-hat ± SE) individuals at Sajnekhali Wildlife Sanctuary, and 13 ± 0.32 (N-hat ± SE) individuals at Basirhat Range. Density is estimated at 3.69 ± 0.82 individuals/100 sq. km at National Park (East), 2.36 ± 0.64 individuals/ 100 sq. km at Sajnekhali Wildlife Sanctuary and 2.57 ± 0.76 individuals/ 100 sq. km at Basirhat Range.

The dataset reveals that tigers respond to both exogenous and endogenous processes in spatial usage. The ambient conditions; such as the coverage of vegetation, plant type, and water availability; influence each individual into having a specific set of preferred resources. Capture success of tigers was by far the highest at stations on pond banks or slopes. Well-designed monitoring programmes in the Sundarbans incorporating tiger distribution, their relative abundance, foraging ecology, and survival can provide robust data to wildlife managers for efficient long-term monitoring. It is also important to study and pinpoint factors that control structure and function of biological communities including vegetation dynamics in the Sundarbans which will eventually determine prey abundance. There is also a need for conservation interventions to address human-wildlife conflict inside the forest and to build the capacity of the protected-area staff to manage the conflict situation in a more effective manner.
1.1. BACKGROUND

During the period January - March 2012, in line with Phase-IV monitoring protocol (Jhala et al. 2011) to obtain minimum tiger numbers, WWF-India in collaboration with the Sundarban Biosphere Reserve (SBR) Directorate carried out a camera trapping exercise in the 24-Parganas (South) Forest Division using photographic capture-recapture analysis. This exercise used remotely triggered camera traps and the capture-recapture framework to estimate the minimum population and density of tigers in the two ranges of 24-Parganas (South) Forest Division. A total of 41 camera trap pairs were used in the two ranges to cover about 396 sq. km area (effective trapping area).

Tiger density was estimated as 4.5 individuals /100 sq. km. In addition to 20 tiger individuals, the exercise also photo captured pictures of others cats, viz. fishing cat, jungle cat and leopard cat, as well as prey and other species (Das et al. 2012). The outcome of the intensive camera trap study contributed towards the decision to declare about 556 sq. km of reserve forest area (west Sundarban forests) in 24-Parganas (South) Forest Division as the West Sundarbans Wildlife Sanctuary.

Enthused by the findings of the study, WWF-India and SBR extended the study to cover forest ranges under the Sundarban Tiger Reserve [National Park (East), Sajnekhali Wildlife Sanctuary and Basirhat Range]. Details of the study (from November, 2012 – April, 2013) to document the status of tigers in these three forest ranges are provided in this report. In ecosystems like the Sundarbans, where the external environment of living organisms displays rhythmic changes due to tides twice a day, conservation planning based on knowledge of the species’ response to vegetation, land use, topography and other external cues are important for long-term monitoring programmes.

In this study, tiger habitats have been sampled with camera traps to (a) estimate the minimum number of tigers; and (b) estimate the density of tigers. The sampling has been done in line with Phase-IV tiger monitoring protocol (NTCA, 2012). Environmental parameters collected from sampled sites have helped us draw conclusions about the status of tigers and provides explanations for observed patterns of tiger distribution and site-specific conservation actions. This study is the first attempt (NTCA, 2012) – to estimate the tiger population and their association with habitat in order to prioritize investments for conservation interventions – after the protocol signed on 6 September 2011 between India and Bangladesh on 'Conservation of Royal Bengal Tiger of the Sundarban'. The protocol was signed between two countries to undertake bilateral scientific and research projects that would promote understanding and knowledge of the Sundarbans Royal Bengal Tiger and its habitat.
1.2. FIELD METHODS

Each habitat is characterised by a specific set of biotic and abiotic conditions, which in turn affects its surrounding resources; such as the vegetation cover, plant type, and water availability (Huggett, 2004). Keeping these in mind and the limitations imposed by geographical specificities in the Sundarbans, 169 camera trap stations, in as many grids of 4 sq. km each, were established to have a maximum area coverage through camera trapping (Fig 1 and Fig 3).

Data was collected on 49 occasions (21 November, 2012 through 8 January, 2013 at National Park (East), on 46 occasions at Sajnekhali Wildlife Sanctuary (21 January through 7 March, 2013), and on 31 occasions at Basirhat Range (13 March through 12 April, 2013) (Fig 1 and Table 1). Scent lure was used with necessary permission from Forest Directorate, West Bengal (Geary, 1984; Schlexer, 2008; Mills and Marchant-Forde, 2010) to increase the probability of trap success. Scent lure is typically a liquid or viscous substance that draws an animal in through its sense of smell. It is unlike bait because it is not intended to be consumed. Lures exploit an animal’s hunger or curiosity, and stimulate social or territorial responses (Wyshinski, 2001).

Fig 1: Study area: National Park (East), Sajnekhali Wildlife Sanctuary and Basirhat Range
1.3. DATA ANALYSIS

Every tiger captured in the camera traps was given a unique identification number (e.g. SB 33 was assigned to the 33rd individual photo captured in the Sundarbans), as per the protocol on National Repository of Camera Trap Photographs of Tigers (NRCTPT), after manually examining the stripe pattern on the flanks, limbs, forequarters and sometimes even tail (see Fig 2 for an illustrative example of tiger identification and recapture).

![Decision tree to ascertain tiger identity and recapture.](image)

The ExtractCompare (v 1.8) (Hiby et al. 2009) software facilitates short-listing of most likely matches from a tiger photo database. A single pair of photographs of both flanks of a tiger obtained simultaneously is needed to “link” the left and right profiles and identify the animal permanently in the database. Camera trap images of tigers are characterized by a wide range of camera angles and body postures. Given the terrain and type of vegetation in the Sundarbans, it is often the case that getting both clear flanks of the tiger simultaneously is not possible. To overcome this limitation, the camera traps were set to video mode after a delay of 5 seconds. This often allowed the capture of both the flanks in a single camera. The video clip was cropped to provide photographs of both the flanks.

Daily activity patterns of tigers and its major prey species were studied through camera trap photographs using Overlap package in R (Ridout and Linkie, 2009). Software Oriana 4.2 (Kovach, 2011) was used to determine the overall and site-specific mean activity patterns of different species.

The National Tiger Conservation Authority (NTCA) issued a guideline, proposing to assign a unique identification (UID) number to each tiger captured through camera traps and establish an NRCTPT. NTCA intends to systematically collect tiger images and compile in a retrievable and useful manner so that these can assist in the protection, management and rigorous monitoring of wild tiger populations in India.
1.4. FINDINGS

1.4.1 Capture Dynamics

Out of these 47 individuals 3 were common between the ranges. Total number of unique individuals used for analysis were actually 44.

<table>
<thead>
<tr>
<th>Forest Division/Range</th>
<th>Total area (sq. km)</th>
<th>Total grids of 4 sq. km each</th>
<th>Camera trap grids</th>
<th>Trapping area (Grid) sq. km</th>
<th>Minimum Bounding Polygon (sq. km)</th>
<th>Sampling period (days)</th>
<th>Total sampling effort (Trap days)</th>
<th>Total grid with tiger captures</th>
<th>Total tiger photographs (both flanks)</th>
<th>Unique individuals</th>
<th>Male</th>
<th>Female</th>
<th>Unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Park (East)</td>
<td>810</td>
<td>155</td>
<td>56</td>
<td>224</td>
<td>402.2</td>
<td>21 Nov 12 -8 Jan 13 (49)</td>
<td>2744</td>
<td>43</td>
<td>245</td>
<td>21</td>
<td>4</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Sajnekhali Wildlife Sanctuary</td>
<td>430</td>
<td>103</td>
<td>57</td>
<td>228</td>
<td>313.4</td>
<td>21 Jan 13 -7 Mar 13 (46)</td>
<td>2622</td>
<td>36</td>
<td>127</td>
<td>13</td>
<td>4</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Basirhat Range</td>
<td>466</td>
<td>94</td>
<td>56</td>
<td>224</td>
<td>235.3</td>
<td>13 Mar 13 -12 Apr 13 (31)</td>
<td>1736</td>
<td>21</td>
<td>141</td>
<td>13</td>
<td>2</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1706</strong></td>
<td><strong>352</strong></td>
<td><strong>169</strong></td>
<td><strong>676</strong></td>
<td><strong>950.9</strong></td>
<td><strong>126</strong></td>
<td><strong>102</strong></td>
<td><strong>531</strong></td>
<td><strong>47</strong></td>
<td><strong>10</strong></td>
<td><strong>29</strong></td>
<td><strong>8</strong></td>
<td><strong>212</strong></td>
</tr>
</tbody>
</table>

*Out of these 47 individuals 3 were common between the ranges. Total number of unique individuals used for analysis were actually 44.

Trap days: It is usually measured by the number of camera traps multiplied by the sampling days.

A capture recapture matrix or a "frequency" format is a table in which each row represents a distinct capture history and is followed by an integer denoting how many individuals had that particular history.
Table 2: Capture frequencies of the tiger individuals

<table>
<thead>
<tr>
<th>Number of times</th>
<th>Sundarban Tiger Reserve Tiger ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>SB26, SB42, SB45, SB58, SB60, SB62</td>
</tr>
<tr>
<td>Two</td>
<td>SB25, SB28, SB67, SB70, SB71, SB78</td>
</tr>
<tr>
<td>Three</td>
<td>SB39, SB61, SB65, SB76</td>
</tr>
<tr>
<td>Four</td>
<td>SB21, SB27, SB32, SB36, SB40, SB50, SB53, SB75</td>
</tr>
<tr>
<td>Five</td>
<td>SB23, SB52, SB57</td>
</tr>
<tr>
<td>Six</td>
<td>SB30, SB55, SB66, SB69, SB72</td>
</tr>
<tr>
<td>Seven</td>
<td>SB29, SB35, SB38</td>
</tr>
<tr>
<td>Eight</td>
<td>SB31, SB49, SB73</td>
</tr>
<tr>
<td>Nine</td>
<td>SB24, SB33</td>
</tr>
<tr>
<td>Eleven</td>
<td>SB22</td>
</tr>
<tr>
<td>Twelve</td>
<td>SB68</td>
</tr>
<tr>
<td>Fourteen</td>
<td>SB48</td>
</tr>
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</table>
Fig 3: Camera trap stations with minimum bounding polygons
1.4.2 Tiger Population (N-hat)

The population estimation study was of short duration at each of the forest ranges compared to the life span of tigers and therefore, during the course of the study, it is likely that no tiger dispersed from the study area (Sunquist, 1981; Smith, 1993). Therefore, it would be reasonable to assume that the population was closed during the study period.

The software CloseTest (Stanley and Burnham, 1999) supported the population closure assumption (Table 3). The population size (N-hat) was estimated using the Program Mark (7.1) by modeling for variations in capture (p) and recapture (c) probabilities. Both non-mixture and mixture models were used to investigate the variation in capture and subsequent recaptures. Fit of models was evaluated using AIC (Burnham and Anderson 1998). Mh has been selected as the best fit model at National Park (East) and Sajnekhali Wildlife Sanctuary. In Basirhat Range, model Mo was the most strongly supported, based on AIC scores.

The population at the three sites were estimated to be 25 ± 5.3 (N-hat ± SE) individuals for National Park (East), 15 ± 1.2 (N-hat ± SE) individuals at Sajnekhali Wildlife Sanctuary, and 13 ± 0.32 (N-hat ± SE) individuals at Basirhat Range (Table 4 and Annexure A).

Table 3: The results of test of population closure using CloseTest

<table>
<thead>
<tr>
<th>Forest Divisions/ Range</th>
<th>p value in CloseTest</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Park (East)</td>
<td>0.08</td>
</tr>
<tr>
<td>Sajnekhali WS</td>
<td>0.07</td>
</tr>
<tr>
<td>Basirhat Range</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Table 4: Selected model and tiger population in study area.

<table>
<thead>
<tr>
<th>Model</th>
<th>Mt+1</th>
<th>N-hat</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Park (East) (at 95% CI)</td>
<td>Mh</td>
<td>21</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Mh</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Sajnekhali Wildlife Sanctuary (at 95% CI)</td>
<td>Mh</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

Note: N-hat= Population size, SE= Standard Error, Mt+1= Number of animals capture

4 Mo (Null) - simplest model where all individual animals have the equal probability of capture and recapture; Mh (Heterogeneity) - each animal or group has its own probability of capture, independent of all other members of the population; Mt (Time) - Animals have different probability of capture on each occasion; Mb (Behaviour) - capture probabilities do not vary among capture occasions, but instead are affected by the initial capture; Mbh (Behaviour and heterogeneity) - no effect due to capture occasion but a behavior effect from first capture; Mth (Time and heterogeneity) - capture probabilities differ between the mixtures and among capture occasions; Mtb (Time and Behaviour) - accounts for the assumption of change in the capture probability after the first capture and temporal changes also influence the capture probability and Mtbh (Time, behavior and heterogeneity) - capture and recaptures are different among and within the mixture groups.

5 The Akaike information criterion (AIC) is a measure of the relative quality of a statistical model, for a given set of data. In this case AICc was applied that corrects for small sample sizes.
1.4.3  **Tiger density (D-hat)**

Density estimation for tigers in the study area was performed using minimum bounding polygon, with habitat masking by using software Density (5.0) and Arc GIS (9.3) (Fig 3).

Density was estimated at 3.69 ± 0.82 individuals/100 sq. km at National Park (East), 2.36 ± 0.64 individuals/100 sq. km at Sajnekhali Wildlife Sanctuary and 2.57 ± 0.76 individuals/100 sq. km at Basirhat Range. It is expected that the captured individuals may move outside minimum bounding polygon area. Therefore the density was estimated through Spatially Explicit Maximum Likelihood Methods (MLSECR) to reduce the overestimation possibilities (Table 5).

### Table 5: Density estimation of tigers in the study areas

<table>
<thead>
<tr>
<th>Variables</th>
<th>National Park (East)</th>
<th>Sajnekhali Wildlife Sanctuary</th>
<th>Basirhat Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimation</td>
<td>SE</td>
<td>Estimation</td>
<td>SE</td>
</tr>
<tr>
<td>No. of Occasion</td>
<td>49</td>
<td>46</td>
<td>31</td>
</tr>
<tr>
<td>Camera Trap Stations</td>
<td>-</td>
<td>57</td>
<td>-</td>
</tr>
<tr>
<td>Trap Night Effort</td>
<td>2744</td>
<td>2622</td>
<td>1736</td>
</tr>
<tr>
<td>Population Estimate in Programme</td>
<td>25</td>
<td>5.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Minimum Bounding Polygon</td>
<td>402.2 sq. km</td>
<td>313.4 sq. km</td>
<td>235.3 sq. km</td>
</tr>
<tr>
<td>Detection Model</td>
<td>Hazard rate</td>
<td>Hazard rate</td>
<td>Hazard rate</td>
</tr>
<tr>
<td>Selected Model</td>
<td>g0{h2}[s{h2}]</td>
<td>g0{.] s{.}</td>
<td>g0{.]s{.}</td>
</tr>
<tr>
<td>Density in MLSECR</td>
<td>3.69/100 sq. km</td>
<td>2.36/100 sq. km</td>
<td>2.57/100 sq. km</td>
</tr>
<tr>
<td>g0</td>
<td>0.11</td>
<td>0.03</td>
<td>0.17</td>
</tr>
<tr>
<td>Sigma (meters)</td>
<td>795.68</td>
<td>1645.39</td>
<td>219.03</td>
</tr>
</tbody>
</table>

SE= Standard Error; g0= the probability of capture when the distance between the animal’s activity centre and the trap is zero; Sigma= distance between animal’s activity centre and trap

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To estimate tiger densities (D), Maximum Likelihood Spatial Explicit Capture Recapture (MLSECR) model was used in Density 5.0 software. This model considers point process where animal home range centres are distributed across the study area as point processes in space with density (D). Considering only one animal per trap, capture probability of the animal is a declining function of distance (d) between the range centre and the trap (Borchers and Efford, 2008). This function requires parameters g0 for overall magnitude and sigma which is actually distance between animal’s activity centre and trap. These parameters along with D define the individual based model of capture process.

As per the radio telemetry data from the Sundarbans (Jhala et al. 2011), tigers rarely cross channels wider than 1 km in width in a short span of time. Therefore, channels wider than 1 km and forest fringe villages were masked in a GIS platform.

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Occasion is the sampling day of a sampling period.
1.5. DISCUSSIONS

1.5.1 Capture Saturation

The camera trap study in three ranges of Sundarban Tiger Reserve (STR) was carried out over a period of 126 days – 21 November, 2012 through 12 April, 2013 – moving from south to north. This was done to factor in the breeze from the south that starts after the winter solstice, which was on 21 December in 2013, making waters choppy close to Bay of Bengal.

In National Park (East), the number of new capture of tigers reached saturation level on the 46th occasion with 103 usable photographic captures over a sampling period of 49 days (Fig 4a). The sampling period of Sajnekhali Wildlife Sanctuary was for 46 days. Here, captures of tigers reached saturation level on the 22nd occasion with 60 usable captures (Fig 4b). As the breeze gets stronger, water level started to rise and made the session shorter. As a consequence, the northern-most range (Basirhat Range) has the shortest session of 31 occasions.

In Basirhat on the 21st occasion, tiger captures reached saturation point with 65 usable captures over a sampling period of 31 days (Fig 4c). Not surprisingly, new capture saturation in this range was reached in the shortest period of 21 occasions, less than half of what it took in the southern-most range. This can be attributed to the fact that the northern-most range of STR has the smallest population, estimated as $13 \pm 0.32$ (N-hat ± SE), due to the fact that this range is closest to human habitation and constitutes the buffer of the Sundarban Tiger Reserve.
Fig 4a: Camera trap exercise attains saturation point on 46th occasion at National Park (East)

Fig 4b: Camera trap exercise attains saturation point on 22nd occasion at Sajnekhali Wildlife Sanctuary

Fig 4c: Camera trap exercise attains saturation point on 21st occasion at Basirhat Range
1.5.2 Topography

Topography has complex effects on animal movement and habitat use. Topography affects soil moisture, soil development, water flow and consequently, vegetation (Forman, 1995). Animal movement probably depends on patterns of resource use relative to availability across multiple scales (Senft et al. 1987; Wiens, 1989; Turchin, 1998; Pace, 2001), natural impediments in the landscape (With, 1994), the animal’s knowledge of its environment (including locations of conspecifics and primary prey), and human-induced habitat fragmentation and loss (Crooks, 2002).

During the exercise, camera trap stations were established in locations with varied topographic features such as bank/slope of fresh water ponds, meanders, and inland vegetation. This was not done by design except in case of ponds, but dictated by suitability of the location based on tiger/prey signs, unlikelihood of inundation of camera traps and pilferage/vandalism. A total of 169 camera trap stations were deployed in these areas; meander (n=68), freshwater pond (n=23), and inside vegetation away from any meander or pond (n=78). Vegetation included mangroves and its associates.

Photo captures from all trap stations indicate the maximum use of fresh water ponds by tigers, followed by “inside vegetation”, and then meander (Table 6).

Table 6: Topographic features and photo captures of tiger

<table>
<thead>
<tr>
<th>Topographic features</th>
<th>National Park (East)</th>
<th>Sajnekhali Wildlife Sanctuary</th>
<th>Basirhat Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trap station (Photo captures of Tiger/Trap stations) (%)</td>
<td>Photo captures of Tiger (Photo captures of Tiger/Trap stations) (%)</td>
<td>Trap station (Photo captures of Tiger/Trap stations) (%)</td>
</tr>
<tr>
<td>Meander</td>
<td>32.1</td>
<td>57.9</td>
<td>40.2</td>
</tr>
<tr>
<td>Freshwater pond</td>
<td>10.8</td>
<td>8.8</td>
<td>13.6</td>
</tr>
<tr>
<td>Inside vegetation</td>
<td>57.1</td>
<td>33.3</td>
<td>46.2</td>
</tr>
</tbody>
</table>

Capture success was by far the highest at stations on the pond banks/slopes by as much as four times of the average. The population estimate using Program Mark (7.1) from 23 stations on pond bank/slope at 95% confidence interval was $13 \pm 3.39$ (N-hat ± SE) with a range of 12.15-32.29 for National Park (East) (21 individuals were identified), 7.0 ± 1.36 (N-hat ± SE) with a range of 7-11.78 for Sajnekhali Wildlife Sanctuary (13 individuals were identified), and 11 for Basirhat Range (13 individuals were identified).

1.5.3 Habitat Formations

Species coexist under a variety of conditions, and therefore are likely to be subjected to different ecological processes in different localities. The examination of variation in the composition of biotas helps us to understand the underlying processes and variables that influence a community structure (Brown and Kurzius, 1987).

Mangrove soils are exposed to the coupled effects of salinity and water logging, making its structure and composition different from inland soils. Mangrove soil is distinguished by its saturated water condition, low oxygen content and sometimes free hydrogen sulphide ions caused by long term exposure to tidal inundation, low water
table and poor drainage conditions. The major factor inhibiting and dictating the growth and distribution of plants in mangrove forests is the soil characteristics which also determine growth, composition, distribution and the existence of mangrove organisms. All the 169 camera trap locations have been classified according to forest type (Chakrabarti, 1985). Attempts were made to find any correlation (Table 7) between habitat formation and prey-base captures, which ultimately has a significant effect in tiger captures.

The habitat with pure Cereops accounts for the maximum number of prey-base captures and hence, tiger captures, followed by Excoecaria-Cereops. Tiger and prey-base concentrations are lowest at Rhizophora-Bruguiera and Excoecaria-Phoenix, respectively.

Plant communities inland provided the next best capture success, especially at locations with pure Cereops, and Excoecaria-Cereops. Animals used those places with Rhizophora-Bruguiera, and Excoecaria-Phoenix the least, possibly due to proliferation of stilt roots.

### Table 7: Habitat formations and captures of tiger and its prey base.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Habitat</th>
<th>Prey Base captures (%)</th>
<th>Tiger captures (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Avicennia - Oryza</td>
<td>7.62</td>
<td>12.73</td>
</tr>
<tr>
<td>2</td>
<td>Avicennia - Sonneratia</td>
<td>3.48</td>
<td>3.27</td>
</tr>
<tr>
<td>3</td>
<td>Pure Cereops</td>
<td>41.39</td>
<td>33.09</td>
</tr>
<tr>
<td>4</td>
<td>Pure Excoecaria</td>
<td>1.98</td>
<td>3.64</td>
</tr>
<tr>
<td>5</td>
<td>Excoecaria - Cereops</td>
<td>37.16</td>
<td>30.55</td>
</tr>
<tr>
<td>6</td>
<td>Excoecaria - Phoenix</td>
<td>0.56</td>
<td>8.73</td>
</tr>
<tr>
<td>7</td>
<td>Pure Phoenix</td>
<td>1.41</td>
<td>6.18</td>
</tr>
<tr>
<td>8</td>
<td>Beach Forest</td>
<td>4.61</td>
<td>1.45</td>
</tr>
<tr>
<td>9</td>
<td>Rhizophora - Bruguiera</td>
<td>1.79</td>
<td>0.36</td>
</tr>
</tbody>
</table>

#### 1.5.4 Prey-Base Occurrence

While habitat-related factors influence tiger density at a given site, prey abundance appears to be the primary ecological determinant in most forest areas (Karanth and Nichols, 2002). Predator-prey interactions have an inherent tendency to fluctuate and show oscillatory behaviour (May, 1981). Wild ungulates are the major prey-base of the tiger and these species have a key role in maintaining the tiger populations. Prey selection by the large felids is a result of complex interactions of various ecological parameters (Sunquist and Sunquist, 1989).

To understand the prey-predator relationship in the study area, prey-base occurrence against the tiger occurrence was studied. The presence of tigers showed significant correlation with chital presence (Fig 5) followed by wild pig presence (Fig 6), a medium-sized prey.
The relative abundance indices (RAI) for each species (number of photo captures per 100 trap nights) were computed to facilitate comparisons within study sites in the Sundarban Tiger Reserve and provide information to wildlife managers for informed management decision. A significant difference in wildlife RAIs between the three study sites is observed. Chital was the most photographed species in the study area followed by wild pig, tiger, and fishing cat (Fig 8). Forest block wise RAI for chital are as under (Fig 7).

*To compute the RAI for each species, all captures over the entire session were summed, then multiplied by 100, and result was then divided by the total number of camera trap nights.*
Fig 7: Forest block wise RAI for chital in three study sites
Overall, average RAI for National Park (East) is 3.34, 6.38 for Sajnekhali Wildlife Sanctuary (SWLS), and 3.26 for Basirhat Range.

![Relative Abundance Index (RAI) of photo captured species](image)

### 1.5.5 Activity pattern and Tidal rhythmicity

The external physical environment of any living organism displays well known rhythmic changes. The biological or "internal clock" of an organism in itself first generates “imprecise” rhythms, which are temporally altered and adapted to the fluctuation of environmental influences only by means of the synchronizer signals or Zeitgeber (Aschoff, 1960) key external conditions. In a natural environment the duration of the biological cycles of organisms correspond exactly to the period of the environmental rhythms (e.g., light/dark or high tide/low tide) to which plants, animals, and human beings must adjust (Klein, 2007).

In the Sundarbans, the water level rises and falls with lunar-tidal frequency. A lunar day includes four tidal force fluctuations, which occur at intervals of 6.2 hours on an average. The tidal rhythms of vertebrates are simply direct responses to the rhythmic ebbing and flooding of the tides. These responses are results of interplay between an endogenous oscillator and an environmental cyclic variable, to which the biological clock imprecisely adjusts its period and phase to the environmental cycle (Golombek et al. 2010).

Information on temporal activity pattern of tigers, chitals and wild pigs were obtained through photographs captured by camera traps. In total we obtained 529 photo captures of tigers, 1234 of chital and 1284 of wild pigs.

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7 Total photographic captures of chital in Sajnekhali Wildlife Sanctuary is 505 in a total of 2622 trap night effort, whereas in National Park (East) the exercise yielded 107 photographic captures in a total of 2744 trap night effort and in Basirhat Range, 56 photographic captures in a total of 1736 trap night effort. As a part of the management plan of Sundarban Tiger Reserve, chitals were released in two of the camera trap locations in Sajnekhali Wildlife Sanctuary thus skewing the dataset.

8 An environmental cue, such as light, that helps to regulate the biological clock in an organism. Zeitgebers are events that keep the circadian rhythms regulated.
In general, the data indicated that tigers have a bimodal peak of activity, during morning (6:00 hrs to 9:00 hrs) and late evening (17:00 hrs to 19:00 hrs) (Fig 9), with an overall circular mean of 16:29 hrs (95% CI 12:29 – 20:28 hrs). A similar pattern of activity was noticed with chital with activity peaks during morning (05:00 hrs to 09:00 hrs) and again in the afternoon (15:00 hrs to 17:00 hrs), although the overall circular mean indicated a more diurnal activity pattern (circular mean of 10:52 with 95% CI from 10:09 – 11:36 hrs). Wild pigs displayed a uni-modal activity pattern with a circular mean of 11:06 hrs (95% CI 10:44 – 11:28 hrs).

To assess differences in time activity patterns in relation to management regimes in the study area, species-specific photo captures obtained from the National Park (East), Sajnekhali Wildlife Sanctuary and Basirhat Range were compared (Table 8 and Fig 10).

Fig 9: Activity pattern of tiger and its prey base in study area

To assess differences in time activity patterns in relation to management regimes in the study area, species-specific photo captures obtained from the National Park (East), Sajnekhali Wildlife Sanctuary and Basirhat Range were compared (Table 8 and Fig 10).
Table 8: Circular statistics of temporal activity pattern of different species in three study sites

<table>
<thead>
<tr>
<th>Species</th>
<th>National Park (East)</th>
<th>Sajnekhali Wildlife Sanctuary</th>
<th>Basirhat Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample size</td>
<td>Circular mean</td>
<td>95% CI</td>
</tr>
<tr>
<td>Tiger</td>
<td>123</td>
<td>10:52 hrs.</td>
<td>08:02 - 13:42</td>
</tr>
<tr>
<td>Chital</td>
<td>178</td>
<td>11:04 hrs.</td>
<td>11:12 - 04:13</td>
</tr>
<tr>
<td>Wild Pig</td>
<td>80</td>
<td>11:05 hrs.</td>
<td>11:39 - 10:05</td>
</tr>
</tbody>
</table>

*** - P<0.0001, ** - P<0.001, * - P<0.05

Fig 10: Species specific differences in time activity patterns in three study sites
The extent of overlap between time activity patterns of Tigers and their prey (Chital and Wild Pigs) was also assessed. Using the time of capture from the photographic records, an overlap of 0.798 (95% CI 0.709 – 0.832) between tiger and chital and an overlap of 0.778 (95% CI 0.6134 – 0.851) between tiger and wild pigs (Fig 11 and Fig 12) was estimated. Both these estimates reveal a high degree of overlap between tigers and the principal prey found in the Sundarbans, highlighting the importance of both species to the conservation of tigers in this unique ecosystem.

The dataset obtained from this exercise correspond with the hypothetical model of “internal clock” adapted to tidal fluctuation (Fig 13).
Fig 13: Tidal rhythmicity of tigers and its prey-base in the study area
1.5.6 Olfactory Lures

Application of scent-stations as a viable index to estimate species distribution, abundance and monitor mammalian densities has proven effective in wild mammal census conducted over large areas (Humphrey and Zinn, 1982; Moruzzi et al. 2002; Romain-Bondi et al. 2004). These areas are compounded with variables like varying seasonal or regional movement, behaviour patterns, and other factors including age, sex, weather, food supply, and the influence of habitat (Linhart and Knowlton, 1975). An olfactory lure was applied during camera trap exercise to increase the chances of tiger captures and subsequent recaptures. The lure was applied twice at an interval of a minimum of fifteen days to each trap station. To study the effectiveness of the lure, the time of the tiger captures were plotted against each session at the three sites. Capture cluster was visible after the application and reapplication of the lure in each session (Fig 18, Fig 19 and Fig 20).

The capture dataset of tigers indicates a capture success of 62% unique tiger individuals within the first seven days of establishment of respective camera stations. Basirhat Range has 69% success while National Park (East) and Sajnekhali Wildlife Sanctuary has 62% and 54% success, respectively (Table 9). Tigers have responded strongly to the application of lures in each camera trap stations and have overridden its endogenous factor. Capture cluster was visible in each session (Fig 18, Fig 19 and Fig 20).

As seen in Figure 5, there is a strong correlation between tiger and chital occurrence in the study area. However, after application of lure, for the first five days, the correlation between occurrence of tiger and chital is significantly weakened (Fig 14). Thereafter, the correlation is somewhat restored (Fig 15), until reapplication of lure (Fig 16). From the sixth day of reapplication of lure until withdrawal of camera traps (Fig 17), the correlation between tiger and chital occurrence is again as strong as in Figure 5.

It is observed that lure efficacy lasts for about 7 days, and it was found that 13 tiger individuals out of 21 in National Park (East), 7 tiger individuals out of 13 in Sajnekhali Wildlife Sanctuary, and 9 tiger individuals out of 13 in Basirhat Range were photo captured within seven days of installation of camera traps.

Table 9: Unique individuals and capture success of tigers within 7 days of camera installation in three study sites.

<table>
<thead>
<tr>
<th>Area</th>
<th>Total tiger individuals</th>
<th>Unique tiger individuals (within 7 days of installation of camera stations)</th>
<th>Capture success (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Park (East)</td>
<td>21</td>
<td>13</td>
<td>62</td>
</tr>
<tr>
<td>Sajnekhali Wildlife Sanctuary</td>
<td>13</td>
<td>7</td>
<td>54</td>
</tr>
<tr>
<td>Basirhat Range</td>
<td>13</td>
<td>9</td>
<td>69</td>
</tr>
<tr>
<td>Total</td>
<td>47*</td>
<td>29</td>
<td>62</td>
</tr>
</tbody>
</table>

* Out of these 47 individuals 3 were common between the ranges. Total number of unique individuals used for analysis were actually 44.
Table 10: Effectiveness of olfactory lure to capture tigers in camera traps

<table>
<thead>
<tr>
<th>Forest Division</th>
<th>Trap stations</th>
<th>Sampling occasion</th>
<th>Total Trap night effort</th>
<th>Tiger capture success (%)</th>
<th>Chital capture success (%)</th>
<th>Trap night effort</th>
<th>Tiger capture success (%)</th>
<th>Chital capture success (%)</th>
<th>Trap night effort</th>
<th>Tiger capture success (%)</th>
<th>Chital capture success (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Park (East)</td>
<td>56</td>
<td>49</td>
<td>2744</td>
<td>4.48</td>
<td>3.90</td>
<td>280</td>
<td>11.78</td>
<td>1.07</td>
<td>896</td>
<td>3.24</td>
<td>4.02</td>
</tr>
<tr>
<td>Sajnekhali Wildlife Sanctuary</td>
<td>57</td>
<td>46</td>
<td>2622</td>
<td>2.67</td>
<td>19.26</td>
<td>285</td>
<td>5.96</td>
<td>13.33</td>
<td>969</td>
<td>2.37</td>
<td>32.09</td>
</tr>
<tr>
<td>Basirhat Range</td>
<td>56</td>
<td>31</td>
<td>1736</td>
<td>4.72</td>
<td>3.22</td>
<td>280</td>
<td>7.50</td>
<td>2.50</td>
<td>560</td>
<td>3.93</td>
<td>3.21</td>
</tr>
</tbody>
</table>

**Fig 14: Correlation between tiger and chital captures for the first five days after application of lure**

![Correlation graph](image-url)

R² = 0.6015
Fig 15: Correlation between tiger and chital captures (per trap night effort) for the 6th day to reapplication of lure

Fig 16: Correlation between tiger and chital captures (per trap night effort) for the first five days after reapplication of lure

Fig 17: Correlation between tiger and chital captures (per trap night effort) for the 6th day to withdrawal of camera trap
Fig 18: Capture cluster of tigers in National Park (East)
Fig 19: Capture cluster of tigers in Sajnekhali Wildlife Sanctuary
Fig 20: Capture cluster of tigers in Basirhat Range
### Tiger Movements

The least-cost path analysis and individual-based movement for wide-ranging animals depend crucially on an understanding of how and where individuals move (DeAngelis and Gross 1992; Bergman *et al.* 2000; Bunn *et al.* 2000; Paquet *et al.* 2001). Methods for recording animal movements have ranged from direct observation of individuals to the use of radio tracking. Mark and Recapture methods retain information in the form of activity fields and need not disrupt the movement of animals during the study period.

A total of 44 individuals were photo captured of which it was possible to create minimum convex polygon (MCP) depicting minimum movement during the session for 22 individuals (Fig 23). Out of 22 tigers, seven were males and 15 were females. The MCP area for males ranged between 21.78 sq. km to 174.97 sq. km (Fig 21). In case of females the MCP area ranges between 2.90 sq. km to 69.39 sq. km (Fig 22).

Competition between two individuals arises from the utilization of the same resource. Variation in resource use or prey availability is often identified as an important factor in explaining the intra-specific variation in the home range size (Sandell, 1989; Grigione *et al.* 2002) and density (Carbone and Gittleman, 2002) thus exhibiting a characteristic pattern of individual’s location and activities. The distribution of an individual’s time as a function of location defines an activity field (Waser and Wiley, 1979). The boundaries of this field delimit the individual’s home range or activity space (Burt, 1943; Weeden, 1965). Such a field could also include activities related to resource use, for instance, the time spent feeding. An activity field that pertains to an individual’s use of a particular resource is also called as “utilization distribution” (Van Winkle, 1975).

In general, MCP of tiger individuals in National Park (East) is larger than the other two ranges. In Sundarbans, if the camera trapping exercise is repeated successively for another two to three years, the minimum convex polygons of the tigers can be compared to establish its home range size and activity space.
Fig 21: Minimum convex polygon (MCP) area of male tigers in study area

Fig 22: Minimum convex polygon (MCP) area of female tigers in study area
Fig 23: Minimum Convex Polygon (MCP) of tiger individuals in study area obtained during study period
1.6. RECOMMENDATIONS

The studies should be carried out simultaneously in all ranges of Sundarban Tiger Reserve to enhance accuracy and to account for inter range movement of animals in season across ranges. In the paragraphs that follow, significant ecological and management strategies are recommended.

Habitat Features and Prey Availability

Patterns of tiger distribution and abundance observed in the present study are influenced by local variation in prey densities, habitat type, and local scale variations in anthropogenic disturbance. The data indicates that there is a strong association between habitat classes (Pure Cereops and Excoecaria–Cereops) and prey-base captures which ultimately regulates tiger captures.

a) For the study to be resource efficient, during subsequent exercises, camera trap stations may be established at fresh water ponds as these are frequented by tigers and prey animals most often, followed by locations within Pure Cereops, and Excoecaria–Cereops.

b) In terms of prey availability, the RAI of chital is highest in Pirkhali compartment of Sajnekhali Wildlife Sanctuary; possibly due to periodic introduction. However, the underlying causes of low RAI for chital in other compartments should be investigated, as it may provide the information necessary to initiate appropriate action to improve abundance of chital, the primary prey for tigers in the Sundarbans.

c) Low secondary production is observed from soil samples across camera stations. This may be verified through repetitive sampling across seasons to ascertain the status of net primary production in the ecosystem.

d) Also, it is important to study and pinpoint factors that control structure and function of biological communities, including vegetation dynamics in the Sundarbans. This will determine prey abundance and subsequently the abundance of tigers.

Such studies will facilitate better habitat management strategies, thus promoting biodiversity and sustain diverse taxa including reptiles, amphibians and birds.

Strengthening Protection to Minimize Anthropogenic Impacts on Forested Islands

The impact of current extraction levels on the mangrove forest has not been quantified, but temporal change detection studies (Hazra et al. 2010) show that forest compartments with the least degree of statutory protection have experienced reduction in forest cover by about 12 percent over the past decade, whereas this figure is about 3.75 percent for forest compartments with the highest degree of statutory protection. This could be due to anthropogenic factors. However, apart from anthropogenic factors, decrease in forest cover can also be attributed to erosion / submergence and natural conversion to saline blanks/salt pans.

Access to biological resource plays an important role in supporting the livelihood of the fishermen in Indian Sundarbans. For the purpose of extraction of fish within designated areas of the Reserve, about 700 boat license certificates (BLCs) are in circulation. Given the development constraints in the region, the extractors are also exposed to different externalities like high-intensity weather events and recurring human-wildlife conflict.
Often, the licensees overstay or extract other resources in addition to fish. Illegal extraction is in the form of honey, or fuel wood beyond immediate requirement during fishing trips, and timber - all of which have a significant bearing on the habitat. Forest offence records over a period of 10 years (2000-2010) show a five-fold increase in offence and indicates high eco-resource dependence and potential exposure to conflict situations. The detection of offences varies in the three study areas due to their prevailing protection regime (Fig 24). The offence record over a period of ten years (2000-2010) from Basirhat Range showed a very low detection rate due to the prevailing reserve forest protection regime. The National Park (East) also has a less detection rate of offence due to its protection status and because of its distance from human habitation; whereas in Sajnekhali Wildlife Sanctuary, the offence detection is comparatively high than the other study areas. This may be due to the fact that this area is very close to the forest fringe villages and the local communities have an easy access to this area.

Between 1985 and 2010, 666 persons were attacked by tigers of which 410 were recorded by the Forest Directorate indicating that over 250 victims were illegal entrants. In case of death/injury of licensee within designated zones, compensation is paid. However, tiger attacks in “no-go areas” go unrecorded and are not compensated. Therefore, every time there is an incident, the family of the deceased/injured faces challenges in claiming and receiving compensation. This leads to animosity between fishing communities and the Forest Department. To counter these issues:

a) Efforts are required to enhance the enforcement status of these areas and build the capacity of protected area staff.

b) The capacity of forest department staff needs to be enhanced to effectively patrol and protect wildlife, through approaches such as SMART patrolling or any other Landscape Enforcement Monitoring (LEM) tool.

c) GPS-based applications (like Vessel Monitoring Surveillance), which track and monitor boats anytime and anywhere, should be adopted. Issues in Sundarban can be addressed along the same lines with fine scale spatial information; the precise location of the boat can be displayed on the system, automated alerts can be sent out to the boat when it approaches the Geo fence (boundary of the demarcated area) and the system can generate multifarious reports. This would help the Forest Department to manage the situation more effectively. These measures, if accepted by the fishermen, have the potential to address animosity.
Coexistence between wildlife and humans
Incentivize Blood-Free Honey Extraction

Wild honey collection from the Sundarbans forest by traditional honey collectors (*moulis*) is one such activity that accounts for about 34 percent of deaths attributed to human-tiger conflict, despite being a short seasonal activity lasting from March to May. Therefore, the moniker ‘blood honey’. Compared to fishing, honey collection is more lucrative; on an average, each honey collector earns about INR 5800/month as opposed to about INR 3000/month earned by a fisherman. Therefore, *moulis* in large numbers enter forest areas in search of bee hives. Over a thousand legal permits are issued to honey collectors. Many more venture in without a valid permit. The current practice of honey collection brings humans and tigers into conflict, often resulting in human deaths, making it difficult to solicit support for tiger conservation; more so in case of death of an illegal honey collector or of a permit holder in a no-go area in the Protected Area.

The following measures would encourage community support towards tiger conservation in the Sundarbans.

a) The dismantling of the permit regime whereby any bona fide resident who wishes to collect honey is allowed to do so, provided the country boat owner allows an electronic tracker to be installed in the boat.

b) Instead of wild honey collection, honey collectors can be allowed to place apiary boxes at designated locations in forest or on stationary floating platforms.

c) Instead of Forest Development Corporation (FDC) deciding the price and quantum of honey, the market can be allowed price discovery.

Management of all tiger conservation landscapes requires information on tiger density, population size, movement, and information’s on prey-base and habitat characteristics. As discussed in chapter 5, there are various factors affecting distribution and abundance of tigers and prey species. Detailed studies need to be conducted in the future, in order to develop a better understanding of the ecology and issues of tiger conservation in the Sundarbans.
REFERENCES


**Web References:**

ANNEXURE
CAPTURE OF TIGERS NATIONAL PARK (EAST) RANGE

A total of 20 tigers were recorded in 24 Parganas (South) forest division (Das et al. 2012). The exercise has subsequently been carried out in National Park (East), Sajnekhali Wildlife Sanctuary and Basirhat Range. The tigers have been assigned UID in succession during the current exercise starting with SB 21. SB 47 was recorded in 24 Parganas (South) Forest Division while camera trapping exercise for melanistic leopard cat.
Both flanks were not available in case of few tiger individuals. After manually examining the stripe pattern on the limbs, forequarters and sometimes even tail of such individuals', unique identification number were assigned (see Fig 2 for an illustrative example of tiger identification and recapture). Tiger numbers are not continuous as only single left flank individuals are considered.
NATIONAL PARK (EAST) RANGE
SAJNEKHALI WILDLIFE SANCTUARY

CAPTURE OF TIGERS  BASIRHAT RANGE

SB 63L  SB 64L

SB 65L  SB 66L  SB 67L  SB 68L
SB 65R  SB 66R  SB 68R
CAPTURE OF TIGERS          BASIRHAT RANGE

SB 69L          SB 69R          SB 70L          SB 70R

SB 71L          SB 71R          SB 72L          SB 72R

SB 73L          SB 73R          SB 75L          SB 75R

SB 76L          SB 76R          SB 79L