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WWF • MONITORING OF TIGERS IN THE SUNDARBAN BIOSPHERE RESERVE (2014-2015)

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Chapter 2

MONITORING OF TIGERS IN THE SUNDARBAN BIOSPHERE RESERVE (2014-2015)

24 Parganas (South) Forest Division, Basirhat Range, India

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Roy Chowdhury, D., Das, S. K, Sarkar, P. K., Choudhury, T., Borah, J. and Saha, R. (2018). *Monitoring of Tigers in the Sundarban Biosphere Reserve (2014-2015), 24 Parganas (South) Forest Division and Basirhat Range, India*. World Wide Fund For Nature-India, New Delhi.

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January, 2018

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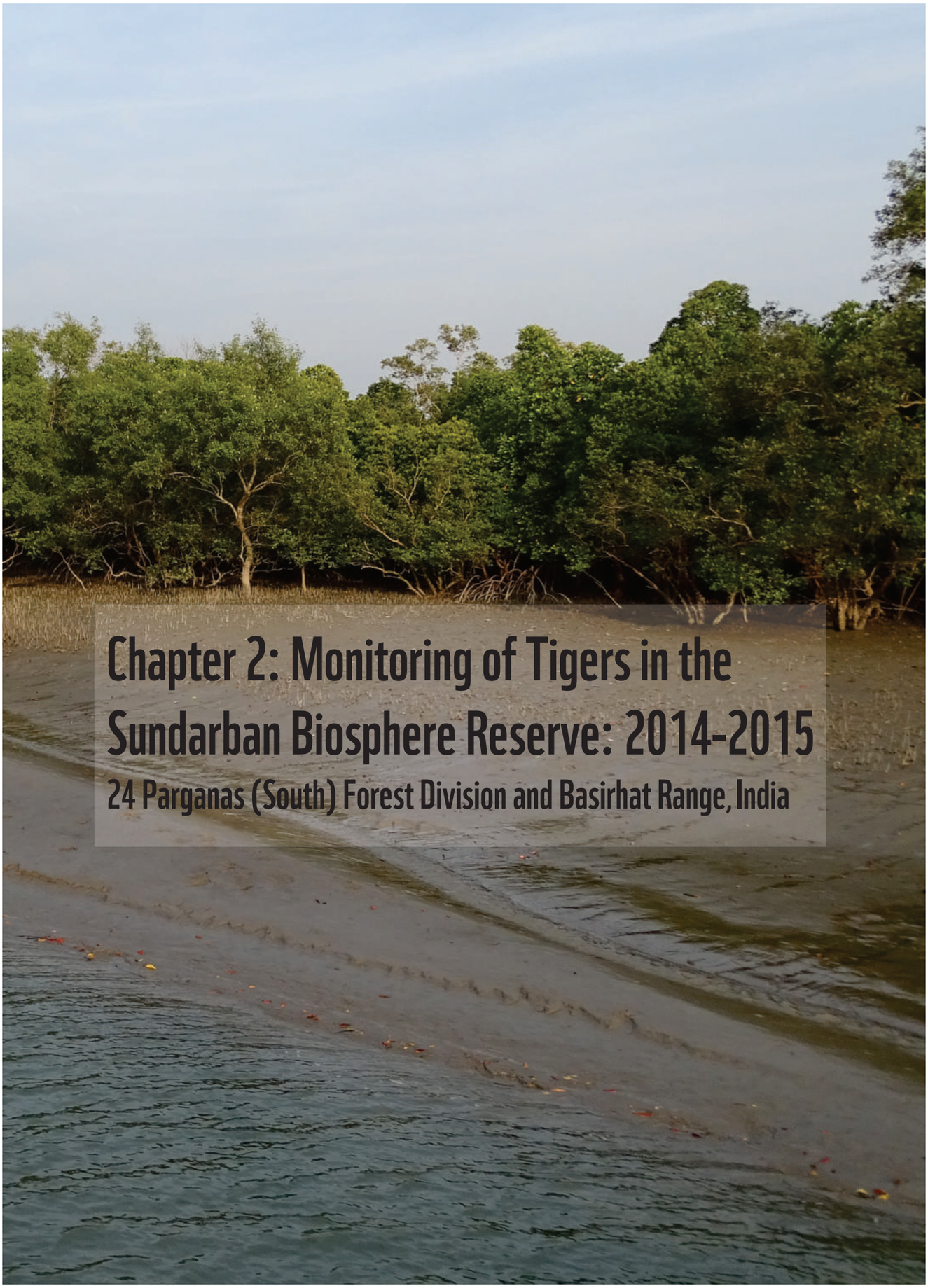

RATUL SAHA

Chapter 2: Monitoring of Tigers in the Sundarban Biosphere Reserve: 2014-2015

24 Parganas (South) Forest Division and Basirhat Range, India

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Dated: 16 January 2018

Preface

The Sundarban forest in its entirety in India and Bangladesh is about 10,000 sq. km, of which 60% lies in the southwest Bangladesh and the other 40% in southeast West Bengal in India. In India, the mangrove forest covers an area of about 4267 sq. km which is administratively divided into Sundarban Tiger Reserve (2585 sq. km) and 24-Parganas (South) Forest Division (1682 sq. km).

Within 2,585 sq. km of Tiger Reserve area, about 1,330.12 sq. km of mangrove forest are demarcated as Core Area and declared as National Park since 1984, which is under strict management practices and kept free from all types of human interference. An area of 124.40 sq. km within the Core Area is preserved as primitive zone in accordance with the United Nations Educational Scientific and Cultural Organization (UNESCO) World Heritage Site to act as gene pool.

This report presents the outcome of the camera trapping exercise in two areas of Sundarban Biosphere Reserve, by WWF-India in collaboration with SBR Directorate, to monitor the tiger population in line with Phase-IV monitoring protocol of National Tiger Conservation Authority (NTCA), Government of India. Along with population parameter estimates, this report also provides insights to the variations in individual movement pattern, which would ultimately help in taking better management decisions and updating the earlier dataset of 2012 and 2014.

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 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
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Sundarban Biosphere Reserve, West Bengal

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ACKNOWLEDGEMENTS

This exercise is supported by WWF-Australia and WWF-Sweden.

We are grateful to PCCF and Chief Wildlife Warden, West Bengal; the Sundarban Biosphere Reserve Director, the Field Director; the Sundarban Tiger Reserve and Divisional Forest Officer, 24 Parganas (South) and the Forest Division for their collaboration and logistical support.

Dr. Punyasloke Bhadury, Indian Institutes of Science Education and Research (IISER) – Kolkata, contributed to this project despite time constraints by extending technical support towards the chemical analysis of soil and water samples from all the camera trap stations. We would like to thank the following Forest Department personnel in carrying out the study successfully.

24 Parganas (South) Forest Division: Joshodulal Banerjee (Ranger), Soumen Mondal (Ranger), Nilratan Guha (Ranger), Uttam Biswas (Deputy Ranger), Bibekananda Bera (Beat Officer), Babu Das (Beat Officer), Mujibar Rahaman Molla (Beat Officer), Braja Nath Halder (Head Forest Guard), Arup Kumar Maity (Forest Guard), Chakradhar Das (Forest Guard), Swapan Mondal (Forest Guard), Susanto Mondal (Forest Guard), Joydeb Adhikari (Forest Guard), Chitto Bera (Boatman), Chitto Mondal (Boatman), Hamid Chand Mondal (Boatman), Gopal Mondal (Bonosramik), Kartik Sardar (Bonosramik), Poresh Kulu (Bonosramik), Nibas Sardar (Bonosramik), Samrat Mali (Zookeeper), Bibekananda Sardar (Zookeeper), Alok Paul (Animal Attendant), Gour Mondal (Casual Daily Labourer), Abinash Mondal (Casual Daily Labourer), Nurul Haq Naskar (Casual Daily Labourer), Asraf Mondal (Casual Daily Labourer), Kalipada Bera (Casual Daily Labourer), Probir Mondal (Casual Daily Labourer).

Basirhat Range: Somnath Chatterjee (Ranger), Santanu Kulobhi (Deputy Ranger), Ayan Chakroborty (Deputy Ranger), Sabyasachi Hazra (Deputy Ranger), Harashit Mondal (Deputy Ranger), Provash Sarkar (Deputy Ranger), Santosh Kumar Roy (Head Forest Guard), Prosanto Joddar (Forest Guard), Niranjan Giri (Forest Guard), Abu Kalam Naskar (Forest Guard), Bhakto Paramanik (Forest Guard), Amalendu Haldar (Forest Guard), Panchanan Mondal (Forest Guard), Arun Haldar (Forest Guard), Tapan Bakshi (Majhi), Kripanath Mondal (Boatman), Ajit Kumar Chapadar (Boatman), Rahim Gazi (Boatman), Sachin Mondal (Boatman), Mrinal Kanti Biswas (Engine Driver), Bholanath Das (Bonosramik), Asutosh Mali (Casual Daily Labourer), Prahlad Mondal (Casual Daily Labourer), Pintu Mondal (Casual Daily Labourer), Kartik Sardar (Casual Daily Labourer), Brahma Sarkar (Casual Daily Labourer).

We would also like to thank the boat crew of *MB Sundari*; Sridam Gayen, Ishwar Chandra Shaw, Amol Mondal and Nikhil Borkondaj for their excellent services and on-board hospitality.

We are grateful to Dr. Jimmy Borah for reviewing the report at very short notice. His comments have strengthened this report.

Last but not the least, we are grateful to Mr. Ravi Singh, SG & CEO, WWF-India; Dr. Sejal Worah, Programme Director, WWF-India; and Dr. Dipankar Ghose, Director, Species and Landscapes Programme, WWF-India for their inputs.

EXECUTIVE SUMMARY

Camera trapping in combination with closed population capture–recapture (CR) models to estimate densities of tiger numbers is very useful to investigating variation across space and/or among individuals at a specific location. In addition, studies continued at the same site(s) over multiple years help to understand and manage populations of large carnivores. Such multi-year studies can yield estimates of rates of change in abundance (O'Connell *et al*., 2011). As the marked individuals are tracked through time, biologists can investigate deeper into factors driving changes in abundance such as rates of survival, recruitment and movement.

Keeping the above in mind, the entire tiger habitat of 24 Parganas (South) Forest Division and Basirhat Range was monitored in 2015 to see the variations in individuals and movement of tigers, which would ultimately help in taking better management decisions and updating the earlier dataset of 2012 and 2014. This monitoring exercise used remotely triggered camera traps and the capture-recapture framework to estimate the minimum population and density of tigers in 24-Parganas (South) Forest Division and Basirhat Range of the Sundarban Tiger Reserve.

In 24 Parganas (South) Forest Division, a total sampling effort of 2993 trap days yielded 192 photographs (of both flanks) of tigers. A total of 21 tigers were individually identified. Out of these 21 individuals, 4 were identified as cubs. In Basirhat Range of the Sundarban Tiger Reserve, a total sampling effort of 3339 trap days yielded 192 photographs (of both flanks) of tigers. A total of 18 tigers were individually identified. Population was estimated to be 17.5±1.6 (N-hat±SE) individuals in 24 Parganas (South) Forest Division and 16.02±0.87 (N-hat±SE) individuals in Basirhat Range.

Using MLSECR (Maximum Likelihood Spatially Explicit Capture Recapture) analysis, estimated tiger density was 3.42±0.09 individuals/100 sq. km in the 24 Parganas (South) Forest Division and 3.33±0.09 individuals/100 sq. km in the Basirhat Range. Baseline estimates of abundance and density are critical to monitoring the success of conservation activities. However, low sample size and low probabilities of capture and recapture may lead to uncertainty, particularly when monitoring large rare carnivores such as tigers and in areas like the Sundarbans, where climatic conditions and factors plays an important role in studies like the present one. It is therefore important to study and pinpoint factors that control structure and function of biological communities, including vegetation dynamics in the Sundarbans which determine prey and, probably, tiger abundance. It would be more useful if the entire Sundarban Biosphere Reserve is sampled at one time. This should also be done simultaneously with the Bangladesh part of the Sundarbans to arrive at the best estimate for the Sundarbans as a whole.

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2.1. BACKGROUND

During the period January 2012 - April 2013, in line with Phase-IV monitoring protocol to obtain minimum tiger numbers, WWF-India in collaboration with the Sundarban Biosphere Reserve Directorate, carried out a camera trapping exercise in the Sundarban Biosphere Reserve to establish the baseline for the Sundarbans. In 24 Parganas (South) Forest Division, the exercise was carried out from January 2012 to March 2012. Twenty unique individuals were identified from this division and Range-wise density was calculated for the Forest Division. Using MLSECR (Maximum Likelihood Spatially Explicit Capture Recapture) analysis, estimated tiger density was 3.8 (±SE 1.5) individuals/100 sq. km for Ramganga Range and 5.2 (±SE 1.7) individuals/100 sq. km for Raidighi Range. In Basirhat Range, the exercise was carried out from March 2013 to April 2013. Thirteen unique individuals were identified from this Range. Tiger density was estimated to be 3.67/100 sq. km for Basirhat Range.

In addition to tigers, the exercise also photo captured other felids, viz. fishing cat, jungle cat and leopard cat, as well as prey and other species. Since country-wide tiger estimation was undertaken in 2014, camera traps were installed in Ramganga Range of 24 Parganas (South) Forest Division. Five unique individuals were identified from this Range. Estimated tiger density was 1.88 (±SE 0.9) individuals/100 sq. km for Ramganga Range. Camera traps could only be deployed in 20 locations in Basirhat Range for a short period of time due to rough weather conditions. The data from this exercise was not taken into account.

In 2015, camera traps were again placed in Basirhat Range of Sundarban Tiger Reserve and in the entire tiger habitat of 24 Parganas (South) Forest Division comprising three Ranges (Ramganga, Raidighi and Herobhanga Range). The entire tiger habitat of Basirhat Range and 24 Parganas (South) Forest Division was monitored in 2015 to see the change in recruitment rate and movement of tigers. This would ultimately help in taking better management decisions and updating the two-year-old dataset pertaining to this area.

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Camera trap deployment. Photo credit: Sridam Gayen

2.2. METHOD

The standard method of camera trapping in accordance with Capture-Recapture framework (Otis *et al.* 1978; Pollock *et al.* 1990) was followed to collect and analyse data.

2.2.1 Pre-Field Work

As the Sundarbans ecosystem is subjected to tides twice a day with varying tide levels, there is high risk of the camera traps being inundated with water. The first step was to analyse the tidal fluctuation from the data available through tide tables (Survey of India, 2015).

High resolution images of the study areas were procured and processed for its use in the reconnaissance survey and thereafter. The study areas were divided into grids of four sq. km each, thus systematically dividing the area and helping the team plan the reconnaissance survey. It also helped to decide on the sites and minimum distance between camera trap stations.

2.2.2 Reconnaissance Survey

Reconnaissance survey was carried out in different grids for potential camera trap locations. Geo-coordinates of the survey and suitable sites were recorded using a handheld Global Positioning System receiver (Garmin 72 H). These tracks and points were laid over gridded high-resolution images in Geographic Information System environment using MapInfo 8.5.

The grids were selected based on the following criteria: (i) tiger pugmarks (ii) comparatively high elevation areas unlikely to get submerged even during high tides, and (iii) to avoid excessive human disturbance.

2.2.3 Data Collection

Data was collected on 41 occasions (days), commencing from 20December, 2014 and ending on 29January, 2015 in 24 Parganas (South) Forest Division. It was collected on 53 occasions (days), commencing from 21February, 2015 and ended on 14 April, 2015 in Basirhat Range. Cameras with heat-motion sensors were deployed to capture tigers and other fauna. The distance between two camera trap stations was kept at a minimum of 1 km to maximise the capture probability. At each station, two camera units were deployed between 40 and 50 cm height from the ground in such a way that both flanks of the animal are captured. The camera delay was minimised to ensure photo captures of tigresses with cubs in case such an event occurred. To maximise both tiger captures as well as recaptures, an olfactory lure was applied.
All the camera trap stations at the Range were monitored periodically to check the status of camera traps and if required, the height of camera trap was changed or comparatively high elevation sites within the same grid were selected. This was done due to the high water mark presence in the sampling session which may inundate camera trap units in the particular sites.

Every tiger captured in the camera traps was examined visually for the stripe pattern on the flanks, limbs, forequarters and sometimes even the tail, and also with Extract Compare V1.08 (Hiby 2009) software.

2.2.4 Analytical Details

The population size (*N-hat)* was estimated using the Program MARK (7.1) by modeling for variations in capture (p) and recapture (c) probabilities. Data was analysed in Capture-Recapture framework, which uses various suitable models[1] under the basic assumptions of demographic and geographic closure in the study area, given the unique habitat condition and dataset. To establish demographically closed population, closure test was performed using the CloseTest software.

The most appropriate population estimation (N-hat) model for a given data set (Otis *et al*. 1978) was selected after analysis of X-matrix using a series of hypothesis tests in Program MARK.

Both non-mixture and mixture models were used to investigate the variation in capture and subsequent recaptures. Fit of models was evaluated using AIC_c[2] (Burnham and Anderson 1998).

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

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[1] 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.

[2] 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.

[3] 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 within a short span of time. Therefore, channels wider than 1 km and forest fringe villages were masked in a GIS platform.

2.3. RESULTS

Table 1. Data metrics

Forest / Range	Total area (sq. km)	Total grids of 4 sq. km each	Camera trap grids	Trapping area [sq. km] (Grid)	Session date (start-end)	Total sampling days	Total grid with tiger captures	Tiger Individuals Identified		
								Old	New	Total
Ramganga	562	51	33	132	20.12.2014 - 29.01.2015	41	21	3	5*	8
Raidighi	229	48	33	132			21	7	4**	11
Herobhanga	58	14	7	28			4	1	1	2
Basirhat	466	94	63	252	21.02.2015 - 14.04.2015	53	29	8	10	18

*In Ramganga Range out of 5 new individuals 2 are cubs (SB 92 and SB 93) of SB 83. SB 96 is common between Ramganga and Raidighi Range.

**In Raidighi Range out of 4 new individuals 2 are cubs (SB 94 and SB 95) of SB 7.

2.3.1 Capture Dynamics

24 Parganas (South) Forest Division

Total sampling effort of 2993 trap days (73 camera trap stations, each operating on 41 occasions) at 24 Parganas (South) Forest Division yielded 192 photographs (both flanks) of tigers. A total of 46 out of 73 camera trap stations recorded the photographs. There were no tiger captures on 17% occasions. A total of 21 tigers were individually identified. Out of these 21 individuals, 4 cubs (SB 92, SB 93, SB 94, and SB 95) were not used for analysis as all of them are less than one year old. In the standard X-matrix of the software Density 5, 84 captures and recaptures were used. This included ten captures of SB 90, nine captures of SB 9 and SB 83, eight captures of SB 13, six captures of SB 3 and SB 7, five captures of SB 10, four captures of SB 14, SB 91, SB 97 and SB 98, three captures of SB 19, SB 20, SB 96 and SB 99, two captures of SB 18 and single capture of SB 15 (Table 1, Fig 1 and Annexure A).

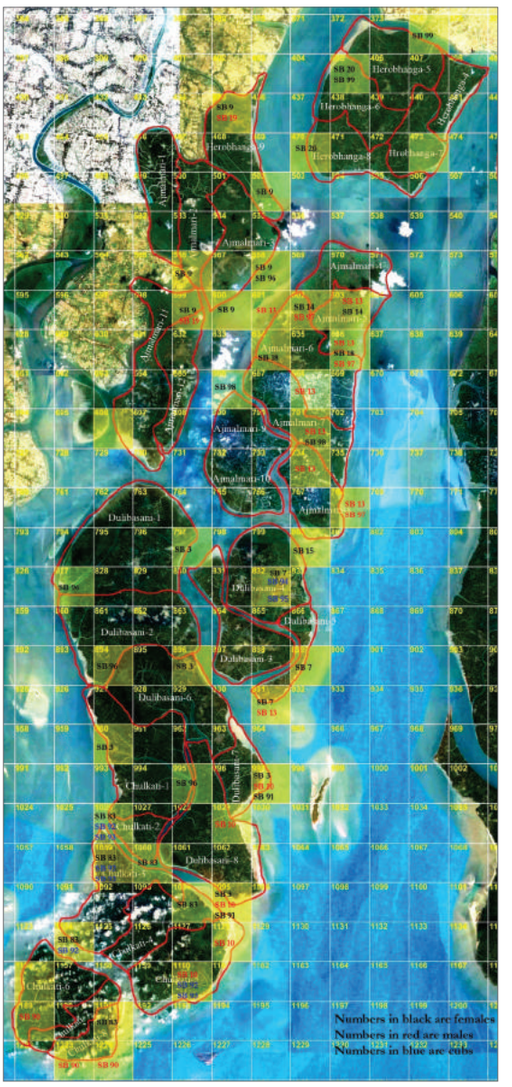
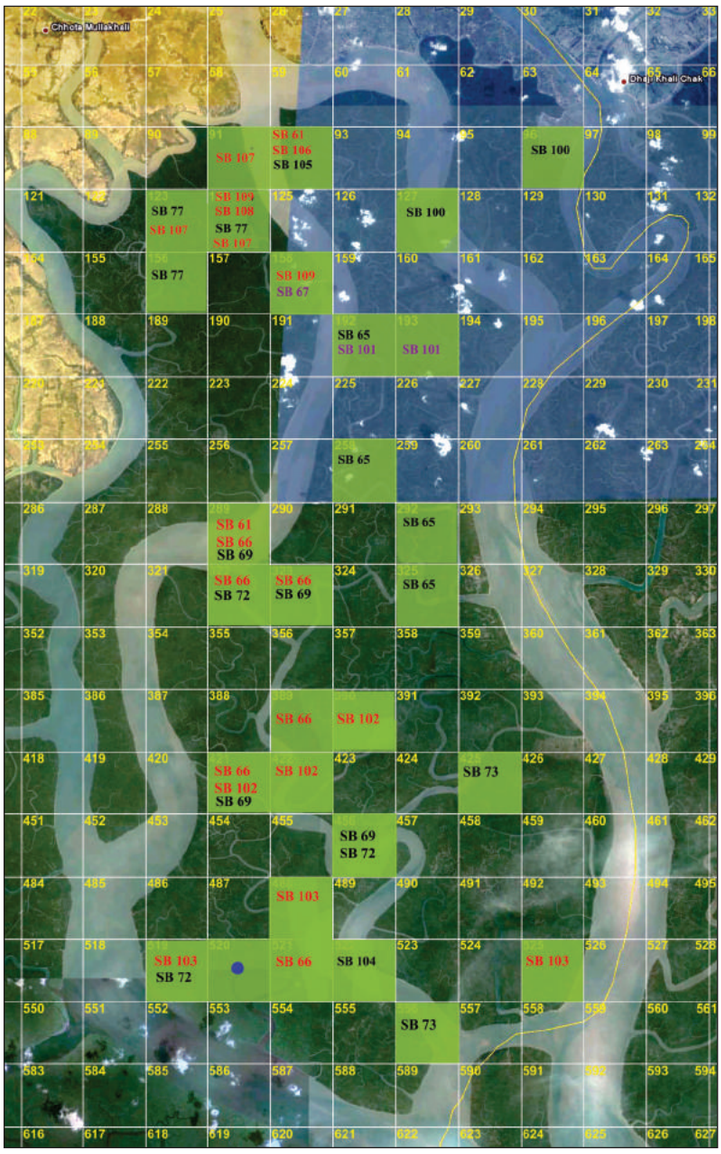


Fig 1. Capture and recapture at 24 Parganas (South) Forest Division

Basirhat Range

Total sampling effort of 3339 trap days (63 traps station each operation on 53 occasions) at Basirhat Range yielded 192 photographs (both flanks) of tigers. A total of 29 out of 63 camera trap stations recorded the photographs. There were no tiger captures on 43.3% occasions. A total of 18 tigers were individually identified. Two sub-adult individuals SB 107 & SB 109 were found dead in July, 2015. These individuals were not used for further analysis. In the standard X-matrix of the software Density 5, 52 captures and recaptures were used. This included nine captures of SB 66, five captures of SB 65, SB 69 and SB 77, four captures of SB 102, three captures of SB 72, SB 103 and SB 105, two captures of SB 61, SB 67, SB 73, SB 100, SB 101, SB 106 and SB 108 and single capture of SB 104 (Table 1, Fig 2 and Annexure A).



Numbers in black are females
Numbers in red are males
Numbers in purple where sex identification not possible
● Identification not possible

Fig 2. Capture and recapture at Basirhat Range

2.3.2 Capture Saturations

The camera trap study in two study sites of Sundarban Biosphere Reserve (SBR) was carried out over a period of 116 days – 20December 2014 through 14 April 2015 – 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 2014, making waters choppy close to the Bay of Bengal.

In the 24 Parganas (South) Forest Division, the number of new capture of tigers reached saturation level on the 29th occasion with 84 usable photographic captures over a sampling period of 41 days (Fig 3). The sampling period of Basirhat Range was for 53 days. Here, captures of tigers reached saturation level on the 31st occasion with 52 usable captures (Fig 4).

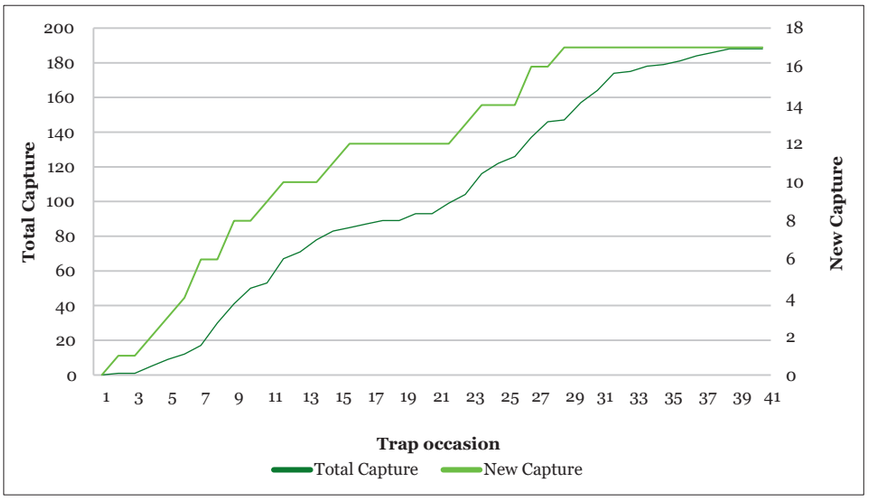


Fig 3: Camera trap exercise attains saturation point on 29th occasion at 24 Parganas (South) Forest Division

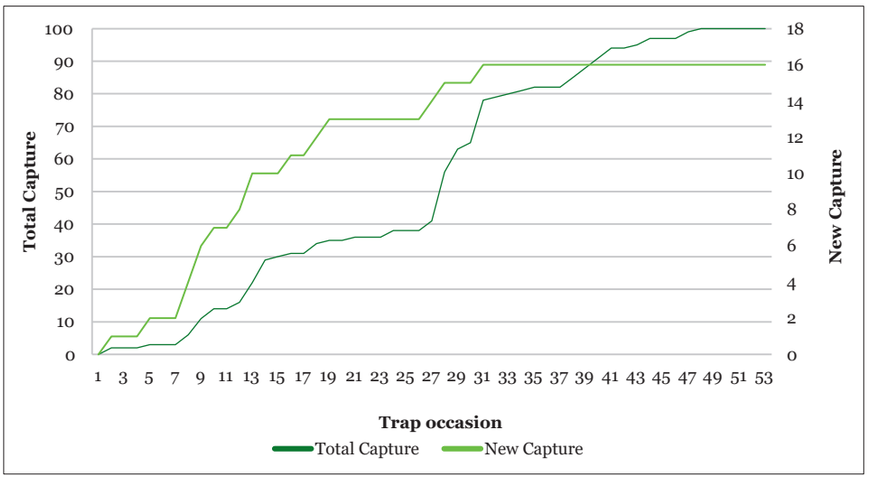


Fig 4: Camera trap exercise attains saturation point on 31st occasion at Basirhat Range

2.3.3. Tiger Population (N-hat)

24 Parganas (South) Forest Division

On the basis of Lowest AICc score, Heterogeneity model (Mh) was found to be the best fit model after analysis of the capture-recapture matrix through software Mark 7.1. It indicates that each animal or group has its own probability of capture, independent of all other members of the population. Population was estimated to be 17.5 ± 1.6 (N-hat ± SE) individuals (Table 2 and Annexure A).

Basirhat Range

On the basis of Lowest AICc score, Null model (M0) was found to be the best fit model after analysis of the capture-recapture matrix through software Mark 7.1. It indicates that all individual animals have the equal probability of capture and recapture. Population was estimated to be 16.02±0.87 (N-hat±SE) individuals (Table 2 and Annexure A) .

Table 2. Selected model and tiger population in study area

Model	Mt+1	N-hat	SE
24 Parganas (South) Forest Division (at 95% Confidence Interval)			
Mh	17	17.5	1.6
Basirhat Range (at 95% Confidence Interval)			
Mo	16	16.02	0.87

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

2.3.4. Tiger Density (D-hat)

Density estimation for tigers in the study area was performed using Minimum Bounding Polygon (MBP), with habitat masking done with the help of Density (5.0) software and Arc GIS (9.3).

Density was estimated as 3.42 ± 0.09 individuals/100 sq. km at 24 Parganas (South) Forest Division with a minimum bounding polygon area of 463.12 sq. km, and 3.33 ± 0.09 individuals/100 sq. km at Basirhat Range with 278.64 sq. km (Fig 5, 6 and Table 3).

It is expected that the captured individuals within the minimum bounding polygon were also present outside. To reduce the possibility of overestimation, density was calculated through Spatially Explicit Maximum Likelihood Methods (MLSECR).

Table 3. Density estimation of tigers in study areas

Variables	24 Parganas (South) Forest Division		Basirhat Range	
	Estimation	**SE**	**Estimation**	**SE**
No. of Occasion	41	-	53	-
Camera Trap Stations	73	-	63	-
Trap Night Effort	2993	-	3339	-
Population Estimate in Programme MARK, N	17.5	1.6	16.02	0.87
Minimum Bounding Polygon	463.12 sq. km	-	278.64 sq. km	-
Detection Model	Half normal	-	Half normal	-
Selected Model	g0 [b]s [.]	-	g0 [.] s [.]	-
Density MLSECR	3.42/100 sq. km	0.09	3.33/100 sq. km	0.09
g0	0.74	0.25	0.88	0.19
Sigma (meters)	4755.78	374.36	3495.01	388.07

Note: SE= Standard Error; g0= the probability of capturewhen the distance the animal's activity centre and the trap in zero; Sigma = distance between animal's activity centre and trap.

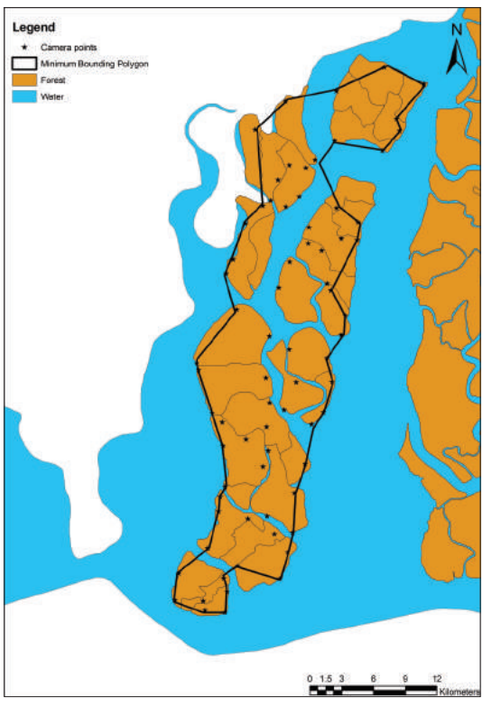


Fig 5. Map showing camera traps and Minimum Bounding Polygon at 24 Parganas (South) Forest Division

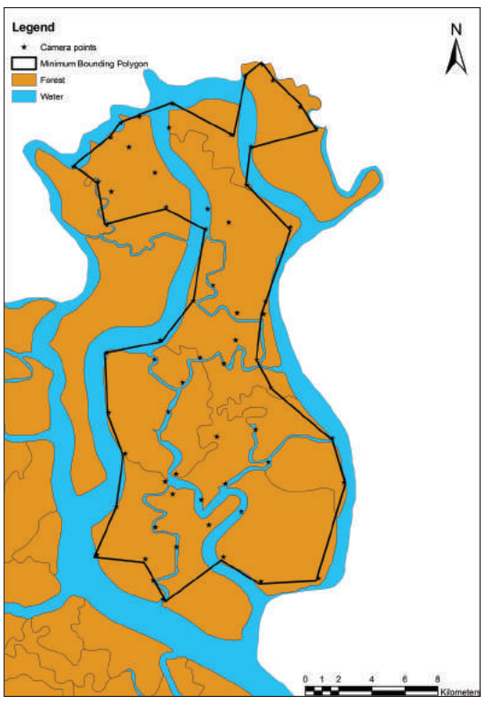


Fig 6. Map showing camera traps and Minimum Bounding Polygon at Basirhat Range

2.4. WAY FORWARD

Effective conservation of species requires reliable estimates of population size and density, and its association with habitat, to prioritize investments for conservation interventions. Such conservation-planning approaches are, to a large extent, based on knowledge of the species' response to vegetation, land use, topography and other external cues (Humphrey and Zinn, 1982). In ecosystems like the Sundarbans where the external environment of living organisms displays rhythmic changes to tides twice a day, such factors are important for long term monitoring programmes.

The Sundarbans eco-region is also faced with the constant threat from frequent occurrence of cyclones, storm surges, relative sea-level rise, and reduced flow of freshwater into the mangrove system. Adding to this in recent times, tilting of the delta towards east and rising seawater level along with increased anthropogenic activities, has altered the balance between fresh water and saline water in this ecosystem (Allison *et al.* 1998; Stanley and Hait 2000).

During earlier tiger estimation exercise in the Sundarban Biosphere Reserve, environmental samples were collected from different tiger habitat sites. The data have helped us understand the status of tigers and provides explanations for observed patterns of tiger distribution and site-specific conservation actions. The dataset reveals that tigers respond to both exogenous and endogenous processes in spatial usage (Roy Chowdhury *et al.* 2018). The ambient conditions that affect its surrounding resources, such as the coverage of vegetation, plant type, and water availability, leads each individual to have a specific set of preferred resources.

Baseline estimates of abundance and density are critical for monitoring the success of conservation activities. However, low sample size and low probabilities of capture and recapture may lead to uncertainty; particularly when monitoring large, rare carnivores, such as tigers; and in areas like the Sundarbans, where climatic conditions and factors as mentioned above, plays an important role in studies like the present one. Tiger densities in Basirhat Range and 24 Parganas Forest Division ranged from 3.33 to 3.42 per 100 sq km. The tiger densities, when compared to earlier estimates from the same area, seem to be stable. However, the earlier estimates were from limited area, while during the current study the entire 24 Parganas Forest Division and the Basirhat Range were covered in their entirety, thus providing more robust and reliable estimates. It would be more useful if the entire Sundarban Biosphere Reserve is sampled at one time. If done simultaneously with Bangladesh part of the Sundarbans, the best estimate for the Sundarbans as a whole can be arrived at.

It is important to study and pinpoint factors that control structure and function of biological communities, including vegetation dynamics in Sundarbans, which determine prey abundance and probably the tigers. Thus, studies are being carried out to study the productivity of tiger habitat and to link habitat nutrients with prey-base, based on statistical approaches. Understanding nutrient dynamics, including variation in trace elemental composition in Sundarban's soil along with assessment of changing pH (Acidity) using benthic foraminifera as biological proxy, would highlight the capacity of the Sundarbans to sustain mangrove plant assemblages from the context of nutrient availability and the resulting implications for predator-prey management. Information generated will ultimately help towards informed management decisions by the Forest Department.

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ANNEXURE

TIGER PROFILE IN 24 PARGANAS (SOUTH) FOREST DIVISION RAMGANGA RANGE

SB3 L

SB3 R

SB10 L

SB10 R

SB83 L

SB83 R

SB90 L

SB90 R

SB91 L

SB91 R

SB92 L

SB92 R

SB93 L

SB93 R

SB7 L

SB7 R

SB9 L

SB9 R

SB13 L

SB13 R

SB14 L

SB14 R

SB15 L

SB18 L

SB18 R

SB19 L

SB19 R

SB94 R

SB95 R

SB97 L

SB97 R

SB98 L

SB98 R

COMMON INDIVIDUAL BETWEEN RAMGANGA AND RAIDIGHI RANGE

SB96 L

SB96 R

SB20 L

SB20 R

SB99 L

SB99 R

SB61 L

SB61 R

SB65 L

SB65 R

SB66 L

SB66 R

SB67 L

SB69 L

SB69 R

SB72 L

SB72 R

SB73 L

SB73 R

SB77 L

SB77 R

SB100 L

SB100 R

SB101 L

SB101 R

SB102 L

SB102 R

SB103 L

SB103 R

SB104 L

SB104 R

SB105 L

SB105 R

SB106 L

SB106 R

SB107 L

SB107 R

SB108 L

SB108 R

SB109 L

SB109 R