

GHARIAL ECOLOGY PROJECT

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in collaboration with Uttar Pradesh, Madhya Pradesh, and Rajasthan Forest Departments, and Ministry of Environment, Forests, and Climate Change, Government of India

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OVERVIEW

Gharial (*Gavialis gangeticus*) is a critically endangered crocodilian living in South Asian rivers. The only viable, self-sustaining population inhabits the Chambal River where a mass die-off occurred in 2007-2008. With GCA support, ecological studies (2008-2016) of these gharials have been conducted in the National Chambal Sanctuary (NCS), utilizing telemetry to record their movements, activities, and behaviours relevant to the die-off, and critical to their conservation. To date, the results reveal new information about gharial spatial habitat use and seasonal movement patterns, as well as social structure and breeding biology. For the first time worldwide, this project provides the biological basis for science-based conservation actions to protect the remaining wild gharials in their natural river habitats. A training/education component develops an awareness of this magnificent species among the river folk it lives with.

Telemetry Component: Monitoring, Tagging of Additional Large Gharial & Nesting Surveys

The major activities for this component in 2015 were: 1) tracking gharial tagged in 2013 and in 2014, 2) downloading GPS loggers from the seven larger gharial, tagged in Nov 2014, 3) making detailed observations on crèche attendance and hatchling guardians, 4) monitoring nesting success on the lower Chambal, and 5) tagging additional gharial with GPS loggers, including smaller ones. International zoos provided major funding for tracking, downloading, observing nest behaviors, and monitoring nest success in the NCS. Long distance seasonal movements of 200+ km are now well documented in this Chambal population of wild, free-living gharial, indicating the importance of an open, dynamic river ecosystem, free of dams and sand mining. The exceptional care behaviors shown by guardian adults, both male and female are documented in detail. A nesting survey, conducted yearly since 2010, was extended another 50+ km upriver to include a major site utilized by several tagged females for nesting.

Training Component: Part-time Coordinator, Training Workshops, Education Programs

In 2015, the training/education component supported a part time, but very experienced Training Coordinator, Ashutosh Tripathi. Previously, Ashutosh has conducted innovative training and education programs, in his capacity with TSA-India. Three workshops were conducted by GCA/TSA staff for FD personnel. Two of these were held in October at Garhaita village on the Chambal in UP for two groups of range officers and staff. Another was held in December at the Deori Centre, near Morena for MP Forest Department officers and staff. Ashutosh also conducted a Teacher Training Program for elementary school teachers in Etawah District, including those schools in river communities in gharial habitats. In addition, week-long environmental awareness programs and educational activities were conducted at the Garhaita base education centre and in the local schools with support, provided by major international zoos and generous donors.

ECOLOGY COMPONENT of the GHARIAL ECOLOGY PROJECT

BACKGROUND

The Gharial Ecology Project, also known as the Gharial Telemetry Project, and summarized in Lang & Kumar (2013), was designed to investigate the mass die-off of gharials in the 2-4m size class, totalling 110+ individuals in the lower Chambal River, National Chambal Sanctuary (NCS).

Previously, 20 radio-tagged gharials have been tracked successfully through the annual monsoon and dry periods, for an average of 2+ years/animal, since June 2008 through August 2013. Individual gharials show different patterns of seasonal movement and residency, dependent on size/age. Adult females move as far as 80-120 km each to join dry season basking-breeding aggregations (>60 adults), and to locate suitable nesting areas. In contrast, sub-adult gharials moved little, only 10-30 km seasonally, and occupy residencies only 5-15 km. Most sub-adults are sedentary, virtually not moving, either upstream or downstream any time.

In July 2013, project continuation was approved to provide a comprehensive picture of the spatial and reproductive ecology of gharial and mugger living in the NCS. Permission was granted for 25 gharial and 5 mugger to be tagged and monitored. Support from the international zoo community funded previous tagging and monitoring of radioed animals in 2013 and in 2014.

The overall study will demonstrate that individual gharials utilize the entire river for specific habitats as well as corridors, and aims to provide baseline information on the status of gharial populations within the NCS. In 2015, the Gharial Ecology Project continued in two phases: a) monitoring radioed animals throughout the year, and b) capture and tag in November 2015. The tagged individuals serve as indicators of what other members in the population may be doing at different times of year. These animals provide a "window" on the specific daily behaviors and activities of the population as a whole. Detailed behavioral observations are routinely made on all gharial, as well as locating and tracking those with radio tags.

LONG DISTANCE, SEASONAL MOVEMENTS

The most exceptional result to date are the extraordinary distances some of the tagged gharial are moving each season, up and down the river, in seasonal patterns related to nesting. One of the tagged gharial moved 210 km downriver to the confluence where she remained during the monsoon. Previously, she moved upriver 100+ km to the site where she nested and protected hatchlings that emerged from her nest in early June (female 24; Table 3). After the monsoon, in late 2015, she moved back 210 km upriver to the same site where she remains, as of March 2016. A subadult female made similar movements to the same nesting site upriver, but returned during the monsoon, a distance of 180 km to the site where she was tagged in 2013 (female 66; Table 1).

TRACKING RADIO-TAGGED GHARIAL

The international zoo community supported the final monitoring throughout the year for the remaining gharial and mugger tagged in November 2013. Their movements and activities are presented in Tables 1 and 2, and described in the following narrative. As late December 2015, it is noted that nearly all of these gharial and mugger no longer had functioning, trackable radios. Two juvenile gharial (90 & 94) were last recorded in January 2016. In particular, all of these animals were captured and tagged at a wide range of river locations, extending from 35 km downstream to 105 km upstream, or over approximately 70 km of river. Of special interest were 3 adults which included two adult females (50 & 54) and a young adult male (44/46). The movement patterns of these three adults contrasted markedly with the few adult females monitored in earlier group (described and discussed in previous reports). This result, in turn, suggests that adults generally may show variable movement patterns, presumably related to differences in their sizes/sexes/ages and reproductive status.

Table 1. Tracking summary for 20 resident wild Gharial (*Gavialis gangeticus*) in National Chambal Sanctuary, 2013-2016

Movements are summarized for 20 gharial tagged in Nov-Dec 2013. Most were tracked biweekly, weekly or more frequently; as of end January 2016, all radios were not functioning. Animal-specific locations from Dec 2013 thru end Jan 2016 totaled 1869; transmitter temperatures were recorded in 2060 instances (external transmitters mounted on tail or neck). Records are across all months, monsoon=Jun,Jul,Aug,Sept; rest=dry

ID	sex	tl	cp	mn	locs	kms	river loc	village locations	trans temp (N)	monsoon	D	shift	home
98	jF	1.8	GH	24	83	8	97 to 105	Ater to Ranipura	14-40 C (93)	no move		none	AT
52	saM	2.5	GH	25	100	6	97 to 103	Ater to Gohera	15-36 C (110)	no move		none	AT
50	aF	3.3	AT	22	44	66	97 to 163	Ater to Rhea	14-40 C (57)	no move	+50	up, +50	AT
54	aF	3.3	AT	23	116	26	79 to 105	NK to Ranipura	15-46 C (130)	upstrm	+14	dwn, +14	DN
96	jF	1.7	MG	9	11	12	93 to 105	Naan to Ranipura	27-32 C (13)	no move		none	GH
42	jM	1.8	MG	23	95	3	88 to 91	Hathkant to NaanTpl	14-38 C (109)	no move		none	MG
48	saM	2.6	MG	23	97	2	89 to 91	Magerpura to NTpl	14-38 C (111)	no move		none	MG
44	aM	4.3	MG	25	125	7	90 to 97	Magerpura to Ater	15-46 C (183)	upstrm	+5	up, +5	NT
94	jF	1.9	KM	26	130	2	73 to 75	Chilonga to Murong	15-36 C (125)	no move		none	MU
92	jF	1.3	MU	11	20	4	64 to 68	Udi Bdge to Baroli	15-35 C (21)	no move		none	BA
90	jM	1.4	CH	26	143	4	72 to 76	Lakan to Murong	15-36 C (167)	no move		none	CH
40	saM	2.1	CH	22	57	25	93 to 118	Naan to Harialpura	19-39 C (47)	variable		up, +24	RN
58	saF	2.6	BR	23	72	41	65 to 105	Barhi to Ranipura	16-35 C (75)	variable		up,dwn, 30	BA
60	saM	2.5	GY	25	129	5	49 to 54	Gyanpura to Khera C	14-37 C (132)	no move		none	GY
62	saM	2.8	GY	23	140	5	49 to 54	Gyanpura to Khera C	14-38 C (145)	no move		none	GY
66	saF	2.3	GY	22	100	195	15 to 210	Mahua S. to Tighra	16-40 C (106)	dwnstrm	+180	up, +180	PN
64	saM	2.7	PN	25	118	12	30 to 42	Sashon to Tumrakola	15-40 C (122)	variable	-8	dwn, -8	BC
68	saM	2.6	PG	22	92	11	33 to 44	Barchauli to Kasaua	15-41 C (96)	no move		none	PN
76	saF	2.0	PG	18	89	16	36 to 15	PN to Mahua Suda	15-36 C (104)	dwnstrm	-4	none	JG
80	saF	2.5	JG	25	108	56	0 to 56	Bhareh to Khera	15-37 C (114)	dwnstrm	-23	dwn, -15+	BC

Chambal River loc: GD=Godha; GH=Gohera; MG= Maghera ka Pura; DN=Dinnpura; KH=Khera Ajab Singh; KS=Kasaua; CT=Chikni Tower; TK= Tumrakola; PN= Pituwan ka Nagla; BR=Barchauli; SG=Sashon Ghat; Mahua Sunda=MS; PA=Patharra-Bihar; CF=Y-C confluence; SA=Sahson; JG=jagtouli; RH=Rhea (upstrm=163)YM=Yamuna; below confi: PD=Pachnada; BW=Bawain; cap/release sites=PN, KH, KS, BR, BA=Baroli, RN=Ranepura, GY=Gyanpura, BD=Badpura, BC=Barecha

legends: tl-m=total length, metres; cap=capture location; mn=months tracked; locs=animal-specific locations recorded ; kms= maximum movement distance, in kms; loc to CFL= location on Chambal, relative to confluence (CF; in kms)=0; D = seasonal movement, in kms (minus=dwnstrm; plus=upstrm). Neither 50 nor 54 nested in 2014, but both moved to and remained near nesting areas, upstream for 50, and downstream for 54. In 2015, both nested, 50 near home area, and 54 nested at the same downstream site, which she frequented in 2014 (DN, -14 km from AT capture site).

Table 2. Tracking summary for resident wild Mugger crocodiles (*Crocodylus palustris*) in National Chambal Sanctuary, 2013-2015

Movements are summarized for 2 mugger tagged in Nov-Dec 2013. These were tracked biweekly, weekly and/or 2-3 times per week; Radios ceased to function by Dec 2015. Animal-specific locations from Dec 2013 thru Nov-Dec 2015 to end sampling period=224; transmitter temperatures= 247 instances (external transmitters mounted on tail). Records for monsoon=Jun,Jul,Aug,Sept; rest=dry.

ID	sex	tl	cp	mn	locs	kms	river loc	village locations	trans temp	monsoon	D	home	shift
56	jF	1.9	MK	24	107	8	97 to 105	Ater to Ranipura	14-39 C (119)	no move		Gohera	none
82	saM	1.7	BC	23	117	49	0 to 49	Bhareh to Gyanpura	14-37 C (128)	variable		KS, JG	none

Chambal River loc: GD=Godha; GH=Gohera; MG= Maghera ka Pura; DN=Dinnpura; KH=Khera Ajab Singh; KS=Kasaua; CT=Chikni Tower; TK= Tumrakola; PN= Pituwan ka Nagla (Philmunnagara); BR=Barchouli; SG=Sashon Ghat; Mahua Sunda=MS; PA=Patharra-Bihar; CF=Yamuma-Chambal confluence; YM= Yamuna; below confl: PD=Pachnada, BW=Bawain; cap/release sites=PN, KH, KS, BR. JG=Jagtouli;

legends: tl-m=total length, in metres; cap=capture location; mn=months tracked; locs=locations recorded; kms= maximum movement distance, in kms, maximum river distance upstream to downstream site ; loc to CFL= location on Chambal, relative to confluence (=0); Dkm= seasonal movement, in kms (plus=upstrm; minus=dwnstrm).

The movement parameters for the 20 gharial and 2 mugger are shown in Tables 1 and 2. With the exception of the three adults referred to above (ID 44, 50, 54), the remaining 17 gharial consisted of 6 juveniles (4 females, 2 males; Table 1), and 11 subadults (3 females, 8 males; Table 3), ranging in size from 1.4 to 2.8 m total length. The two mugger crocodiles (*Crocodylus palustris*) were juveniles, a male and a female, both less than 2m total length. These animals were captured, tagged, and released at sites ranging from Gohera (103 km upriver from Yamuna-Chambal confluence) to Jagtouli (34 Km upriver from Y-C confluence), in areas frequented by gharial tagged earlier.

In total, for these 20 gharial, 1869 animal-specific locations have been recorded, and 224 instances for the two mugger, or 2093 locations overall during the past 2+ yrs. In general, juvenile gharial were located less frequently than were subadults; animal-specific locations averaged 80 locations/animal for six juveniles and 100 for eleven subadults, ranging from 11 to 143 for juveniles and from 57 to 140 for subadults. In fact, some individuals proved difficult to locate regularly, e.g., ID 92, 96, 40, and 58, while others were reliably located at frequent intervals, e.g., ID 60, 62, 90, 94. The two juvenile mugger were regularly tracked at frequent intervals, with 117 and 107 locations for 82 (upstream at Gohera; =103 km) and 56 (downstream at Barecha; =38 km), respectively. Monitoring was spaced evenly throughout the monitoring period, with 4---8 locations per animal per month (Tables 1 & 2).

In brief, nearly all of the tagged gharial exhibited restricted, seasonal movements, similar to the sedentary subadults that were monitored earlier in the 2010 radio-tagged group. The two adult females were the only notable exceptions. One of these, ID 50, though apparently not nesting in 2014, moved extensively up and down 50---64 km of river, from her capture site at Ater upstream to Rhea, at least several times back and forth during the study months. The other female, ID 54, moved mostly downstream to two potential nesting areas, Nachnouli (---18 km downstream) and Dinnpura (---12 km downstream) prior to the monsoon high water, and then during the monsoon shifted upriver +14 km to Gohera, just above her capture site, during the monsoon. Both females nested in 2015. Female 54 nested at Dinnpura (see Figure 47), and female 50 disappeared during the nesting/incubation/hatching period, but reappeared post monsoon back at Ater near where she was tagged. Unlike these two adult females living in the same general area, the young adult male (ID 44) showed no dry season movements, and only shifted +7 km upstream during the monsoonal months of July---September in both years monitored (Table 1).

The majority (11 of 17) of the recently---tagged gharial (4 females=92, 94, 96, 98; 7 male=42, 90, 48, 52, 60, 62, 68) as well as the two juvenile mugger exhibited little or no movements during the study period. Of the remainder (6), two shifted dry season residencies soon after release (40, 58), moving upstream and then showed monsoonal movements, with a seasonal return to previous residences post monsoon a year post tagging. One (80) showed short, downstream monsoon movements both years. Two others (64, 76) showed downstream monsoon movement the first year, but were stationary the second monsoon season. Finally, a subadult female (66) moved downstream the first monsoon (2014), then upstream 195 km to the large nesting colony at Tighra (=210 km above the Yamuna-Chambal confluence) where another long-distance mover, female 24, nested in 2015. Then, she moved back 190 km downstream during the monsoon.

The two juvenile mugger exhibited variable movements that contrasted with each other. The upstream individual (ID 56; female) resided within ± 5 km of Gohera, where it was located most often. It did not shift residences nor migrate during the monsoon high water (Table 2). The other mugger (ID 82; male) was a dry season resident in the lower section of river. It made a monsoonal movement of ---25 km downstream, then returned to the same dry season residence it occupied prior to the monsoon (Table 2). In general, the movement patterns of the immature muggers were similar to those of the immature gharial with respect to the parameters listed in Tables 1.

LARGE GHARIAL WITH GPS LOGGERS

Last year, in 2014, for the first time, radio transmitters equipped with GPS loggers which could be remotely downloaded periodically, while still attached to free-ranging, wild resident gharial were utilized. Thus, units were capable of being remotely downloaded at intervals, but also emitted a VHF location signal that could be tracked manually. Representative images of manual tracking and riverside downloading of GPS loggers are shown in Figures 13-16, including photos of the variety of radios employed and their methods of attachment (Figs. 14, 18-20). These tags have been successful in producing very fine scale data on daily locations, resulting in 2-10 records per day, on an almost daily basis, for each tagged gharial. A total of seven GPS tagged gharial were monitored during 2015, and a summary table of results to date is presented here as Table 3. Representative movement maps for GPS tagged gharial are shown in Figures 1-12.

To date, as of March 2016, three gharial (28, 30, & 32) have been successfully tracked and the GPS data downloaded for the previous 15 months since tags were affixed (Figures 1, 5-8, 9-12). For these three, 3599 animal locations were logged, ranging from 991 for subadult male 28 to 1438 for large gharial male 30 (Table 3). These three gharial have been monitored for 462-466 days, more than a year (=Nov2014 to Mar2016), and daily records were obtained on 859 of 1390 total days, or 62% of the total days with the radios attached. In general, the least successful months for obtaining daily locations are the monsoon months (July through September) and the most successful months are the winter months (November through February) when gharial are basking on land on sunny, warmer days.

Partial location records were obtained for two other gharial equipped with GPS loggers, 931 records for a subadult female (=22) monitored for 301 days (with 213 daily locations or 71% of the total days monitored), and 472 records for an adult female (=26) monitored for 175 days (with 85 daily locations or 49% of the total days monitored). For two additional gharial (20, 24), the GPS loggers failed to allow remote download, and these are noted as “fail” in Table 3, and were only tracked successfully using the regular manual tracking procedure followed for all VHF radioed gharial during the course of study (female 24; Figure 14). Five of these large gharial were equipped with both VHF and GPS logging radios (20, 22, 24, 26, 30), and two gharial in this group (28 and 32) were only equipped with GPS units. The GPS units have a built-in VHF signal that allows limited manual tracking, but the signal has a short range, relative to the regular VHF radios utilized, which do not have GPS downloading capability.

In Table 3, the correspondence between the maximum river distance occupied by each animal is shown for the values determined using the manual tracking method, and the maximum river distance determined for each animal, based on the GPS locations obtained. In the cases of two gharial (22,30), the distances obtained using either method is very close, 10 vs. 13 km for 22, and 65 vs 67 km for 30. GPS determined values were only slightly higher in both instances, +3 km for 22, and +2 km for 30. This difference for Female 26 was almost double, =2X for the GPS determined locations (=19 km) vs. the manual tracking locations (=10 kms). For Female 32, one long trip upstream was not detected manually, but is evident from the GPS records, more than doubling the maximum range of river locations, from 30 km (=manual tracking) to 69 km (=GPS tracking).

In one instance, subadult male 28 was not detected at all for a full season, from Nov 2014 until September 2015 using the regular manual tracking procedure. However, during the monsoon months, this individual was observed visually at a downriver location for the first time in over 9 months (Figs. 5-8). Shortly thereafter, the GPS records were downloaded, and revealed that this individual had been living in and using a familiar stretch of river being routinely monitored on a weekly basis during this entire 9 month period. During this time, 547 GPS locations were logged, over 290 days, with 163 daily locations determined (Fig 7). Using the conventional manual tracking

Table 3. Tracking summary for 7 resident wild larger, adult sized Gharial (*Gavialis gangeticus*) in National Chambal Sanctuary, 2014-2016

Movements are summarized for 7 gharial tagged in mid Nov 2014. These larger gharial were tracked manually, utilizing the VHF radios attached to base of tail and/or neck. Tracking frequency was biweekly, weekly, or 2-3 per week, depending on season and daily conditions. In addition, each animal was outfitted with a custom designed GpS logger (Wildlink W510; Advanced Telemetry Systems, Isanti, MN USA) that was scheduled to take location "fixes" and log these, according to a pre-determined daily program, adjusted seasonally to maximize attempted readings when animals were likely to be on land, either basking during the cooler months, or resting on land in evenings and at night during the warmer months..

legends: tl=m-total length, metres; cap=capture location; mn=months tracked; locs=animal-specific locations recorded ; kms= maximum movement distance, in kms; loc to CFL= location on Chambal, relative to confluence (CF; in kms)=0; D = seasonal movement, in kms (minus=downstrm; plus=upstrm).

ID	sex	tl	cp	mn	locs	kms	river loc	village locations	trans temp	monsoon	home	GPSrec	days rec
20	aM	4.1	CH	12	70	61	38 to -10 0 to -13	BA, Gopiakar Gohani (Yamuna)	15-38C (81)	BA,PA	BA,PA	fail	none
22	saF	2.9	AT	12	57	10 (13)*	93 to 103 (92 to 105)*	Naan to Gohera Naan-dwn to RN*	14-40C (71)	no moves	GH	931	213/301
24	aF	3.1	GH	12	16	210	0 to 210	Bhareh to Tighra	23-32C (23)	CF=0	TG	fail	
26	aF	3.2	GH	12	29	11 (19)*	114 to 103 (116 to 97)*	Khndra to Gohera Halapura to Ater*	14-38C (36)	no move	RN	472	85/175
28	saM	3.1	JK	15	10	4 (116)*	34 to 30 (135 to 19)*	Jagtauli to Sahson Pinhut to Kheda*	-----	SA	JG	991**	282/462
30	aM	5.3	KS	15	89	65 (67)*	-10 to 55 (-9 to 56)*	Gopiakar to KH GP up to KH frnt*	15-40C (99)	CF=0, GP	KH, KS	1438**	298/466
32	aF	3.2	JK	15	25	30 (69)*	55 to 25 (91 to 22)*	Khera to Kundaul NaanT to Palighar	-----	SA	GY	1170**	279/462

Animal-specific locations from Nov 2014 onward are summarized below, for locations determined manually and also by GPS locations. Periodic downloading of the GPS loggers was attempted during the cool months when animals were on land for hours on sunny days. The Wildlink system downloads via UHF coupled with on-board VHF signal preset for fixed daily times, and depends on proximity of 200-500m and a strong, clear VHF signal when the radio GPS logger is not submerged and out of water. Consequently, downloading is limited to times when tagged gharial can be approached closely, and the radioed individual is out of the water. Records are across all months, monsoon=Jun,Jul,Aug,Sept; rest=dry, and are comparable to the records of radio-tagged gharial and mugger shown in Tables 1 & 2.

A single asterisk (*) signifies values for maximum upstrm vs. downstrm distances, based on GPS locations. The values above, and not indicated with asterisk in each pair is the maximum upstrm vs. downstrm distance, recorded, based on non-automated manual tracking by bike, foot, and/or vehicle. Single asterisk in the "village location" column indicates the village locations determined by inspection of the GPS record; the village locations immediately above for each individual is based on manual tracking locations.

Two asterisks (**) indicates values determined for GPS records downloaded on 2 March 2016. Gharial 22 and 26 turned OFF prior to complete downloads of their records, after 301 days and after 175 days, respectively. Two other GPS logging radios failed completely to allow any downloads of GPS records, e.g., gharials 20 and 24. Presumably, the units were damaged by fighting, biting, or mechanically distorted, in such a way that downloading via the short antenna of the UHF system could not occur.

Chambal River loc: GD=Godha; GH=Gohera; MG= Maghera ka Pura; DN=Dinnpura; KH=Khera Ajab Singh; KS=Kasaua; CT=Chikni Tower; TK= Tumrakola; PN= Pituwan Nagla; BR=Barchouli; SG=Sashon Ghat; Mahua Sunda=MS; PA=Patharra-Bihar; CF=Y-C confluence; SA=Sahson; G=jagtolui; RH=Rhea (upstrm=163)YM= Yamuna; below confl: PD=Pachnada, BW=Bawain; cap/release sites=PN, KH, KS, BR. BA=Baroli, RN=Ranepura, GY=Gyanpura, BD=Badpura, BC=Barecha

procedures, it was thought that this individual was no longer in the area or the radio had malfunctioned. In retrospect, neither of these scenarios were correct. This example demonstrates the value of the GPS logging system to successfully record animal locations and activities undetected using other conventional techniques.

For instance, male 28 had a maximum range of upstream vs. downstream river locations that was very limited, from kilometre marker 34 to 30, or just 4 km, based solely on 10 locations using manual tracking methodology (Table 3). In fact, this individual ranged over 116 km of river, and made an undetected upstream visit over several months, with multiple daily stopovers along the way upstream and downstream (Figs. 7-8). The extensive use of a much larger section of river was only revealed when the GPS locations were downloaded and plotted.

MORE GHARIAL TAGGED WITH GPS LOGGERS

In mid November 2015, another capture-tag operation was conducted to extend the number of gharial outfitted with GPS loggers and/or VHF radios for tracking. The timing of this capture-tagging coincided with the termination of many of the VHF radios, affixed to gharial in Nov-Dec 2014. A number of issues related to the programming of the GPS loggers were resolved with this second deployment, and a wider range of individuals including smaller gharial were included in this 2015 tagged group. The capture locations, animal measurements and markings, and details of the radios attached are listed in Table 4. All of these capture locations were in the lower Chambal, on the Uttar Pradesh side of the river. The capture and handling techniques were the same as those used in previous operations, namely in 2013 and in 2014. These are described and illustrated in detail in prior reports, and are not elaborated here. Representative images of the capture and tagging operation in 2015 are shown in Figures 21-24.

As of March 2016, all of these animals are presently being tracked manually, and periodically downloaded for GPS locations. One young adult female, tagged at Barchauli (G15D; river distance=33 km from confluence), moved upstream to Purieni, at a distance of 189 kms from the Yamuna-Chambal confluence, from its previous location at Barchauli in late December. This long distance movement totalled 156 kms within a 6 week period; eventually, the GPS locations for this individual will be downloaded, and its locations and activities revealed in detail for this long distance shift upstream. At the time of this reporting, all of the individuals shown in Table 4 are being tracked manually, and their GPS records are being downloaded during early March 2016.

CRECHE ATTENDANCE AND HATCHLING GUARDIANS

During the nesting season in 2015, a concerted effort was made to monitor several large crèches in the lower Chambal with infrared game cameras for continuous 24 hour periods for days at a time in order to determine which adult individuals were acting as protectors and guardians at each crèche, and to characterize the patterns of attendance, care, protection and guarding exhibited by adults remaining in the vicinity of large groups of hatchlings assembled at colonial nesting sites. The emphases during this year's hatching and post hatching period were to make detailed observations, supported with still, video, and remote game camera video clips, without interfering with the natural progression of daily activities. In other words, disturbance by human presence was minimized as much as possible. Creches were observed at safe distances that resulted in minimal, if any disturbance, in most cases. Whenever possible, observations were confined to opposite river banks, at distances of 100+m, so direct disturbance was avoided.

Table 4. Additional Gharial captured and tagged with GPS loggers in mid November 2015 in lower Chambal River, NCS in Uttar Pradesh, India

GHARIAL ECOLOGY PROJECT --CONTINUATION OF TELEMETRY STUDY 2013-2016, MADRAS CROCODILE BANK, CHENNAI											
SUMMARY OF CAPTURE/TAGGING OF GHARIAL IN NATIONAL CHAMBAL SANCTUARY, 19-25 NOVEMBER 2015 (MINISTRY OF ENVIRONMENT AND FORESTS, & UTTAR PRADESH / MADHYA PRADESH FOREST DEPARTMENTS)											
animal #	date	location		state permit	species	size/age	sex	total length (m)	weight (kg)	radio freq	tags
		UP Right bank	UP Left bank								
G15A	19.11.15	Katrauli	Patharra	UP	Gharial	subadult	F	2.25	36	.413,.714	Gf,Gb
G15B	19.11.15	Katrauli	Patharra	UP	Gharial	subadult	M	2.63	59	.213,.313	YPrpf,Rb
G15C	19.11.15	Katrauli	Patharra	UP	Gharial	subadult	F	2	20	.432,.734	RW,Yb
G15D	21.11.15	Sirsa	Barchauli	UP	Gharial	adult	F	3.15	112	.232,.755	Of,Ob
G15E	21.11.15	Sirsa	Barchauli	UP	Gharial	subadult	F	2.8	79	.0.355	Rt,Gb
G15F	22.11.15	Bindwakalan	PituwkaNagla	UP	Gharial	subadult	F	2.42	46	.0.335	Rf,Prb
G15G	23.11.15	Bindwakalan	PituwkaNagla	UP	Gharial	subadult	F	2.2	32	no radio	677
G15H	23.11.15	Bindwakalan	PituwkaNagla	UP	Gharial	subadult	M	2.7	59	.0.376	SC 8R clpd
G15I	24.11.15	Sankri**	Kasaua	UP	Gharial	adult	F	3.1	125	.252,.774	Yrt,Yb
G15J	24.11.15	Sankri**	Kasaua	UP	Gharial	subadult	M	2.87	82	.0.885	Yt,Gb
G15K	24.11.15	Sankri**	Kasaua	UP	Gharial	subadult	F	2.23	45	no radio	602
G15L	24.11.15	Sankri**	Kasaua	UP	Gharial	subadult	M	2.43	39	no radio	603
G15M	24.11.15	Sankri**	Kasaua	UP	Gharial	subadult	F	2.52	52	no radio	604
G15N	25.11.15	Kachuri**	Kasaua	UP	Gharial	subault	F	2.95	98	.273, .395	Rt,Rb
**=MP village											

Total caught and measured (>2m TL) =14 gharial, =0 muggers ; 10 tagged with radios (6 with GPS loggers+ VHF radios; 4 with VHF radios only). Approximately 10 additional gharial >1.5m were also caught in nets and immediately released; no gharial were injured or died. All captured individuals were measured, weighed, and marked with visible tags, and also scute clipped for permanent identification. Visual livestock tags attached to single caudal scutes (flags) and to double scutes at base of tail (buttons) in various color combinations (red=R, yellow=Y, blue=B, purple=Prp, green=G, white=W, orange=O)

* indicates significant portion of tail missing, therefore total length is not accurate estimate of animal size/age; weight is preferable indicatorage/size

Creches at two sites were sampled with game camera video continuously during hatching, within a week to 10 days post hatching, and later at 2-3 weeks post hatching (Figs. 25-28). Sets of game cameras, modified to take sequential 55 second video clips for 24+ hrs were installed, and changed daily to record complete records of activities at the crèche during the daytime and at night (Fig. 28). Representative stills from this extensive data set are shown in Figures 29-36.

Importantly, these crèche observations indicate two special features associated with the patterns of attendance and guarding of hatchlings. First, one of the nesting females, apparently among the largest at each site, appears to be dominant in protection of hatchlings. She visits the group(s) of young often, but does not remain constantly with them. Only one female seems to do the majority of the guarding, and she actively excludes other females from close approach to the hatchlings, under most circumstances. Typically, the dominant guarding female is assisted in hatchling protection by a large ghara male who associates himself with the crèche of young. When disturbances pose major threats occur to the hatchlings, the male replaces the dominant female at the crèche, and displays his presence with acoustic jawclaps, and loud exhalations that resonate through the large, cartilaginous ghara at the tip of his snout. The male assumes "guard" duty, providing protection for hatchlings against potential predators.

Detailed behavioural observations during the breeding and nesting and hatching periods in 2014 and in 2015 at one site upstream, Naangoan Temple nesting colony, strongly suggest that the guardian male at this site is a junior, not yet dominant male, with a ghara that has enlarged in size over the past 3 years. Male 44/46 was tagged in Nov 2014 and so is relatively easy to locate; his river travel is very limited to a small area, e.g., within 7 kms (Table 1). He has not been actively engaged in breeding, but has been the persistent guardian at a relatively large crèche consisting of 13-17 hatched nests in both 2014 and again at the same site in 2015 (Figure 25).

NESTING SUCCESS ON THE LOWER CHAMBAL

Nesting effort has been monitored for the past six years on the Uttar Pradesh section of the lower Chambal, in the National Chambal Sanctuary; the river distance above the confluence with the Yamuna is 163 kms. In 2015, several of the radio-tagged females ventured even farther upstream, to a river distance of 210 km above the Yamuna confluence, at Tighra. Consequently, observations were frequently made at Tighra on two large nesting groups (Figs. 37-40). In 2015, a longer river stretch (210 km) was surveyed from Tighra down to the confluence for evidence of nesting.

Within this stretch, 153 nests were located, based on either predation signs prior to hatching and/or evidence of hatching. Of these, 126 showed evidence of successful hatching, and many groups of young were observed in the vicinity of the numerous nest sites examined within several weeks of hatching. The survey was conducted during daylight hours, from pre-dawn through evening dusk, during 17-20 June, and followed up several weeks later to ensure that all hatched nests were tallied. A summary of nesting (2010-16) is shown in Table 5; in addition, 49 km above the upstream Rhea site were examined and resulted in 66 nests from Barsala to Tighra, with 59 of these producing hatchlings. Male guarding was prevalent at larger communal sites; nest lost from predation occurred at nest sites with relatively few nests, though some of these small groups of nests were guarded by males.

As noted above, during the 2015 nesting season, observations were targeted at larger nest sites, where creches were guarded by both male and female guardians. An effort was made to not disturb these groupings when making observations, by remaining on opposite banks, or at distances from the creche that left the hatchlings and adults undisturbed to determine the natural pattern of care.

Table 5: Spatial distribution of gharial nest sites on lower Chambal River, referenced on distance from Yamuna confluence (=0 km), left is upstrm, right is downstrm. Twenty one nest sites were used during six nesting seasons, producing 38, 76, 80, 62, 96, and 85 nests respectively from 2010-15. The number of nests that produced hatchlings in each year are shown for each location in the bottom panel. For example, the Rhea site (*RH*) had 11, 20, and 30 total nests, and 11, 19, and 28 nests hatched in 2010, 2011, and 2012, respectively. Bolded, underlined entry indicates that a male was observed guarding hatchlings at nest site, and resided nearby during hatch-post hatch.

distance river km	161	133	126	118	107	103	97	91	90	89	87	85	79	74	56	54	49	46	39	38	29		
nesting location	RH	KP	GA	HL	GD	GH	AT	NT	MG	HK	DM	DU	NK	CH	KF	KC	CT	KS	BA	PN	SG	total nests	nest sites
2010	11	2	-	-	4	3	-	-	-	-	-	-	3	3	4	4	-	3	-	1	-	38	10
2011	20	4	-	-	3	3	-	4	-	-	-	-	6	6	7	7	3	7	-	6	-	76	12
2012	30	-	-	-	-	-	-	-	-	-	12	8	-	-	20	-	3	-	-	7	-	80	6
2013	26	2	-	4	8	-	2	2	-	-	-	8	2	-	4	-	-	2	2	-	-	62	11
2014	20	4	3	21	-	-	3	15	-	1	7	-	-	2	13	-	-	3	-	1	1	96	14
2015	16	5	-	15	-	-	3	11	-	-	5	-	-	4	17	1	-	7	-	1	-	85	11
nesting location	RH	KP	GA	HL	GD	GH	AT	NT	MG	HK	DM	DU	NK	CH	KF	KC	CT	KS	BA	PN	SG	nests hatch	hatch sites
2010	11	pd	-	-	4	3	-	-	-	-	-	-	2	3	4	3	-	pd	-	1	-	31	8
2011	19	pd	-	-	pd	pd	-	pd	-	-	-	-	6	6	3	pd	3	5	-	6	-	48	7
2012	28	-	-	-	-	-	-	-	-	-	11	8	-	-	17	-	pd	-	-	5	-	69	5
2013	24	2	-	4	8	-	2	-	2	-	-	8	pd	-	2	-	-	pd	1	-	-	53	9
2014	18	4	2	21	-	-	3	13	-	1	7	-	-	2	13	-	-	3	-	pd	-	88	12
2015	16	2	-	6	-	-	3	11	-	-	2	-	-	2	17	1	1	7	-	pd	-	67	10
																			-				

Chambal River locations: RH=Rhea, KP=Kuerapura, GA=Gadarian, HL= Harlalpura, GD=Godha, GH=Gohera, AT=Ater, NT=Naangoan Temple, MG=Maghera ka Pura, HK=Hathkant, DM=Dinnpura MP, DU=Dinnpura UP, NK=Nauchnoli, CH=Chilonga, KF=Khera Ajab Singh, front, KC=Khera Ajab Singh, channel, CT=Chikni Tower, KS=Kasaua, BA=Barecha, PN=Pituwan ka Nagla, SG=Sashon Ghat

CONSERVATION BENEFITS OF GHARIAL ECOLOGY PROJECT

The Gharial Telemetry Project has been recognized by the National Tri-State Committee for Coordination of the Conservation in the National Chambal Sanctuary, and the recommendations of the project solicited for incorporation into the National Plan for Gharial Conservation, under consideration for adoption and implementation. The Principal Investigator presented a plenary paper in January 2015 at the Society for Integrative and Comparative Biology (SICB) meeting in Florida, and delivered talks at the U. Florida in Gainesville, St. Augustine Alligator Farm, and in late January 2015, at the Wildlife Conservation Society head office in New York City, based at Bronx Zoo. In April 2015, I visited the Herp Tag Meeting in Atlanta, Georgia and presented a talk on gharial ecology to the Crocodilian AZA group associated with Herp Tag. In late May and early June, I visited the Madras Crocodile Bank, and did a presentation for the Board of Trustees, and discussed the project and conferred with Romulus Whitaker, founding Trustee, and Zahida Whitaker, Director and Founding Trustee at MCBT. Publication in peer-reviewed journals is in preparation, as are popular articles. A summary of recent activities related to gharial conservation is scheduled to appear in the Jan-Mar 2016 issue of Croc Spec Group Newsletter, IUCN.

There is now wide recognition of the importance and significance of the biological findings of the Gharial Ecology Project, and in particular, how these inform and are directly relevant to ongoing conservation and management efforts. This is especially important for the remaining gharial populations in the National Chambal Sanctuary, living in a protected, free-ranging, wild river habitat. The success of efforts to date to continue the study attest to the interest and commitment by the state and central governments, particularly the MoEF and the Forest Departments of Madhya Pradesh, Rajasthan, and Uttar Pradesh for the shared objectives outlined for this project.

TRAINING COMPONENT of the GHARIAL ECOLOGY PROJECT

BACKGROUND

With an aim to involve members of the local communities of the Chambal region in the conservation efforts for the gharial, GCA started its education and awareness programme in the region in April 2012. Sensitization of the local communities towards the region's biodiversity and finding more sustainable ways to extract natural resources and also to restrict their extraction were identified as the key steps in this programme, which has been on-going since it started. An informative and illustrated story book was developed in the local language Hindi for adults as well as children of the local river-side communities. This book focuses on the Chambal River, its fauna and the threats faced by this region in the form of a story to engender interest towards local biodiversity and its conservation. Along with this we also developed four posters which will be displayed in the focal villages. Through these educational materials we intend to clear the misconceptions held by the local communities about the local wildlife, especially the gharial and enable them to understand their environment properly which will help change their existing perceptions and foster positive attitudes towards the wildlife they co-exist with. This will indirectly lead to sensitization among the local communities and strengthen the foundation for future conservation activities.

EDUCATIONAL PROGRAM COORDINATOR

During 2015, part time Program Coordinators, Soham Mukherjee and Ashutosh Tripathi have worked in conjunction with Dr. Jeffrey W. Lang, MCBT have been engaged in capacity building for the Forest Departments in Uttar Pradesh, Madhya Pradesh, and Rajasthan. In particular, Ashutosh Tripathi joined the Gharial Ecology Project in July, and has taken the lead in developing an active training and education program schedule for the frontline staff of all concerned Forest Departments, as well as a critical education training program for elementary school teachers in the districts along the National Chambal Sanctuary. Previously, Ashutosh has conducted programs for more than five years as the main educational officer with the Turtle Survival Alliance—India Program, with a main focus on the Chambal ecosystem.

CHAMBAL RIVER ECOLOGY MANUAL

Developed in 2014, the Chambal River Ecology Manual provides a short introduction to rivers, and details the specifics related to the Chambal River. It also includes an historical narrative about the religious and cultural significance of the Chambal region, in the context of the history of north India. The ecological focus of the manual is on the development of the National Chambal Sanctuary, the longest river sanctuary in the country and the only tri-state protected area.

Within the NCS, the total species of fish is 147, of reptiles is 56, of birds is 308, and of mammals is 60; these include 6 that are critically endangered, 12 endangered, and 18 vulnerable species. The NCS has the largest population of gharial and red-crowned roof turtle in the world, and it is one of the most important habitats for the Gangetic dolphin, narrow headed soft shelled turtle, three-striped roofed turtle, and the Indian skimmer, Saurus crane, and mahaseer. The manual goes on to list the important threats to this unique riverine habitats, including power plants and water extraction, sand mining, fishing and poaching, riverside cultivation, and grazing. It concludes with sections on basic methods for monitoring resident crocodilians, and on overall protection strategies and ways to value and conserve wildlife and natural habitats.

FOREST DEPARTMENT WORKSHOPS

During 2015, the major focus of the training component were the workshops held for local Forest Department staff in Uttar Pradesh, at the Garhaita base for GCA on the Chambal, and in Madhya Pradesh, at the Deori Eco-Centre run by the MPFD and located near the Chambal outside Morena.

In October 2015, a two day workshop was held at the Garhaita base and along the Chambal River nearby the village. There are two ranges in the UP stretch of the NCS, one in the lower Chambal, the Etawah Range, and one upstream, the Bah Range. The main objectives of the workshop were: 1) to provide information on species identification, 2) to train staff on basic survey techniques, 3) to outline confiscation details, and 4) to demonstrate methods of nest location, handling, protection, and translocation for turtles and crocodilians. Workshop staff included: Soham Mukherjee, Ashutosh Tripathi, Pankaj Kumar, Ramraj, Deepu, and RWW Gurmeet Singh and Ranger Suresh Chandra Rajpoot. All together, the workshops on 3 and 4 October were attended by 12 and 19 FD staff, respectively and included classroom sessions, hands-on identification and animal handling at the local facility, and field trips to stretches of the Chambal River nearby. A custom made Resource Packet was provided for all participants, including handouts on gharial natural history, a list of bird species, fauna and flora lists for the Chambal, snakebite information, survey datasheets, and a manual on turtle identification and protection. A draft version of the FD manual on Chambal River Ecology was distributed, and utilized for portions of the workshop training, and further refined in design.

In December 2015, a one day workshop was held at the Deori Eco-Centre, run by the MPFD, and this full day of activity was attended by 18+ participants from the Morena, Bhind, and Sheopur Ranges in Madhya Pradesh, particularly those in the NCS. Dr. R.K. Sharma was present and participated in some of the presentations. The principal GCA staff included Ashutosh Tripathi, Pankaj Kumar, Anand Kumar, and Deepu. The curriculum for this workshop was similar to the earlier October program in UP. Since many of the turtle species, as well as gharial, are held in captivity at Deori, hands-on sessions in identification and handling were conducted for all participants as well. A primer on telemetry, both terrestrial (VHF) and aquatic (sonic) was also provided as it relates to on-going studies on Chambal turtles and crocodilians.

TEACHER TRAINING WORKSHOP

In early January (2016), a Teacher's Training Workshop was jointly organized by Gharial Conservation Alliance, Madras Crocodile Bank Trust, Uttar Pradesh Forest Department and District Primary Education Department. Initially, this workshop was to be conducted in December, but it had to be postponed because the teachers were required to do election duty in December. The main objective of this workshop was to train elementary school teachers and children of riverside schools on the need for conservation of the endangered Gharial (*Gavialis gangeticus*) through adopting an innovative (village) cluster based approach and managed to educate over 500 students, 25 teachers and several more community members from 25 riverside schools and villages. The session in the workshop was "Introduction and concept of TTP", "Our River and its Social, Cultural, Economic and Ecological importance", "A brief description about Gharial (*Gavialis Gangeticus*); its importance and threats), "About National Chambal Sanctuary" & "Role of schools & teachers in Gharial and its habitat Conservation". A number of eco-games were performed with teachers to conceptualize the play way learning methods for the teachers for the school kids.

Currently, the follow up session is being conducted in selected 25 schools, in which GCA team is visiting to help in building the capacity of teachers and to enhance the knowledge of students using didactic and demonstrative/interactive approaches. After completing the follow up session, an educational mela will be organized among kids from 25 schools, in which school kids will participant in the mela as representative of their school and will perform activities like skits, card board handicraft, models, cutouts of aquatic fauna of Chambal etc. The objective of the mela is to bring all these 25 schools together to unify the conservation awareness and concern.

Follow up classroom activities are scheduled for the first half of 2016, with school visits to reinforce the materials introduced by teachers as a result of their participation in the training program held in early January. An example of one of these follow up visits is shown in Figures 79-82.

CONSERVATION BENEFITS FROM TRAINING

Regular events like these will leave a strong influence among the locals especially children and also give them an interesting platform to learn as well as express themselves. These training activities have the potential to engage and motivate members of the local communities as well as the field staff of the forest departments and promote conservation efforts for Chambal River and its associated biodiversity, particularly for the resident gharial in the NCS and elsewhere.



Figure 1. GPS plot, with location points connected by pink lines, for female 32, a young adult female tagged in Nov 2014. With manual, conventional VHF tracking, this female was located 25 times in 462 days (=15.4 mons), ranging 30 km of river from Khera to Kundaul. With GPS locations (total=1170 in 12 mons), as shown here, she ranged over 69 km of river, from Naangoan Temple to Palighar (Table 3).

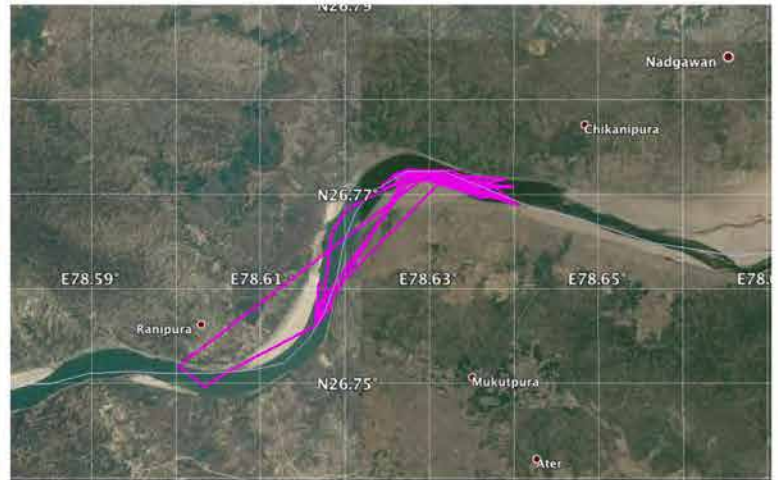


Figure 2. Dry season location (Nov14 to Mar15) for female 22. GPS plot, with location points connected by pink lines, for female 22, a subadult female tagged in Nov14. With conventional VHF tracking, this animal was located 57 times in 12 mons, ranging over only 10 km of river, Naangoan to Gohera. With GPS locations (total=931 in 301 days), she ranged only an additional 3 km (Table 3)

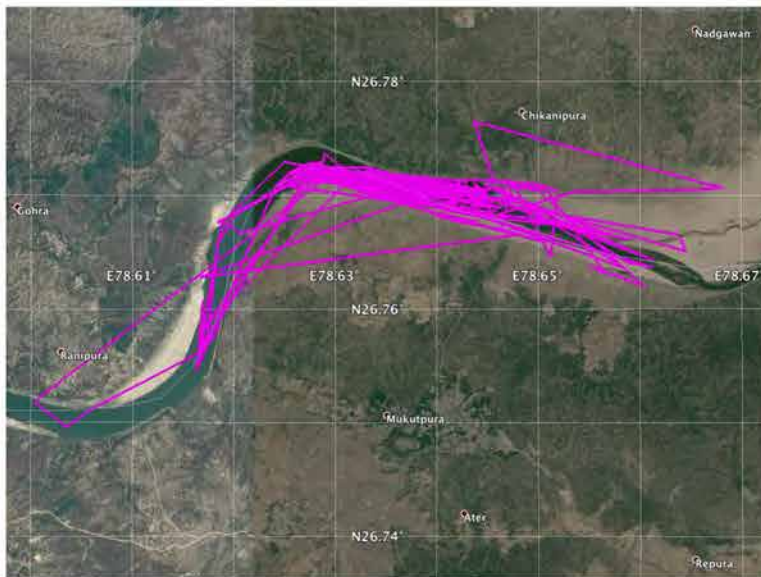


Figure 3. Monsoon locations (April-Nov2015) for female 22. Compare with Fig. 2 (=dry season only) for this same animal. This subadult female did not make a long distance monsoon move down-stream. But, she did expand her spatial use of the river slightly downstream and also across the wide extent of flooded river valley as well as into adjacent "nullahs" (=small creeks, tributaries draining ravines, into main river channel. Note point near Chikanipura which was excursion by this female up into a narrow tributary running into main river during high water/flooding during seasonal monsoon in August.



Figure 4. GPS plot, with location points connected by pink lines, for female 26, an adult female tagged near this site in Nov 2014. With manual, conventional VHF tracking, this animal was located 29 times in 12 mons, ranging over 11 kms of river, from Khendra to Gohera. Her GPS record of 472 locations in 175 days indicated she traveled almost twice this distance, ranging over 19 km (Table 3). None of the females shown in Fig 1-4 nested during 2015, based on visual observations and extensive tracking records.



Figure 5. Subadult male 28, tagged in Nov 2014, was outfitted with only a GPS radio tag. He was not detected using conventional tracking until late August 2015 despite frequent attempts to relocate him. He was noted by observation and photographed (shown here) from a bridge during the monsoon high water, and then his GPS record was obtained.



Figure 6. Close-up of GPS radio on tail of subadult male 28, photographed during the monsoon flooding downriver near Sahson. His GPS logger was subsequently downloaded after a nine month period of non-detection, using manual VHF tracking of the limited range VHF radio that was part of the GPS logger radio package.



Figure 7. GPS plot, with location points shown as green dots, for male 28, a subadult male tagged in Nov 2014. With only a few location points determined by manual tracking, his river km range was only 4 km. But GPS locations revealed that he ranged over 116 km of river (Table 3).

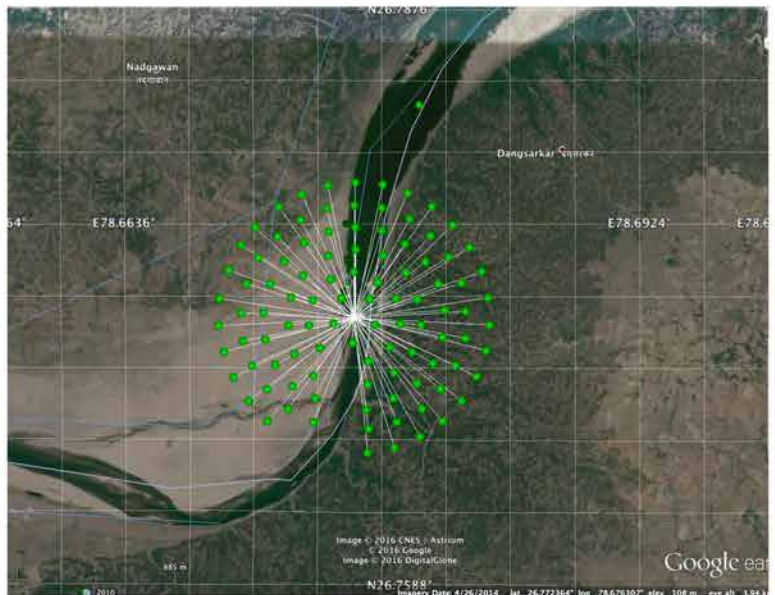


Figure 8. GPS plot, with multiple fixes at same location, shown as an "exploded" starburst of green dots, indicating that male 28 spent many days at this midriver location, Naangoan Temple site, in mid 2015, prior to summer monsoon when he was located downstream near his capture site. A total of 991 GPS locations were logged over 462 days for this animal, and downloaded remotely after 15+ months.



Figure 9. Male 30, a 5.3m (totl) "large ghara" male radiotagged with VHF radio on his neck, and another radio with GPS logger affixed to his tail. Tagged in 2014, he was tracked manually at frequent intervals during the intervening 15+mons (as of March 2016). 89 locations indicated a limited range of 65 km, primarily downriver, monsoon movements to the Yamuna River confluence.



Figure 10. GPS plot, with location points shown as green dots, for male 30. Over 466 days, a total of 1438 locations were logged, and are plotted on this Google Earth image of lower Chambal. This animal had two distinct residences, an upstream, dry season site at Khera, Chikni, and Kasaua, and a summer, monsoon residence near the Yamuna River. He ranged 10 km below confluence during this period, but primarily stayed above the confluence in lower Chambal section (Table 3).



Figure 11. GPS plot of dry season locations for male 30, a large ghara, dominant male that maintained a breeding "territory" at Khera Channel, where he was often located (see Figure 12; Table 3).

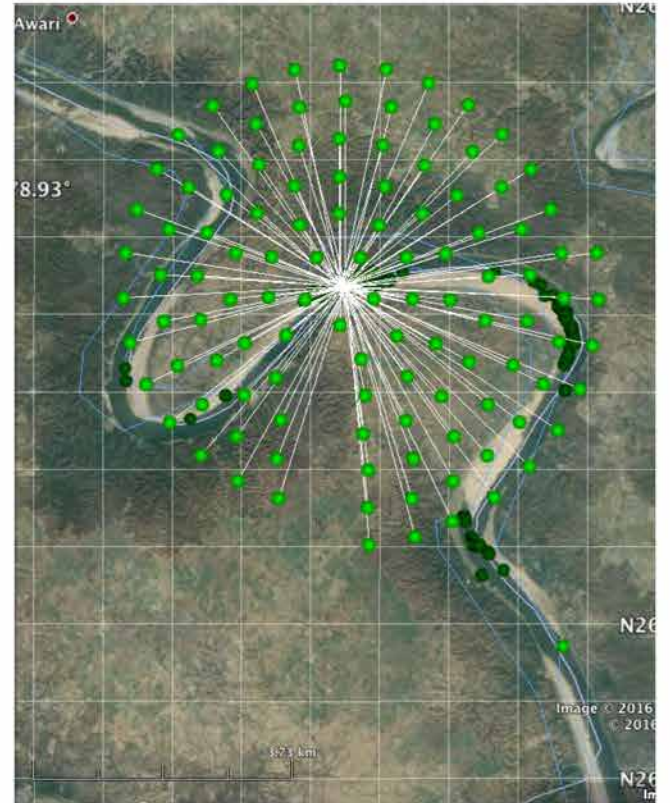


Figure 12. GPS plot, on Google Earth, of multiple occupancies by male 30 of the same location at Khera Channel, during dry season, pre-monsoon period in 2015. This male remained at this site where one female nested, and he acted as guardian for hatchlings when they appeared in early June.



Figure 13. Soham Mukherjee, Project Consultant and Capture-Handling expert with gharial, instructs Iri Gill, Deputy Curator, Herpetology, London Zoo in the "fine art" of VHF radio tracking. Iri is using a five element directional Yagi antenna to "locate" a radioed gharial on the island, visible in mid channel, lower Chambal, Khera Channel. In order to download GPS locations remotely via UHF, a strong VHF signal from the GPS logger must be present.



Figure 14. Female 24, an adult tagged at Gohera (river km=103) but subsequently relocated during the breeding and nesting season, 2015, at Tighra, an upstream nesting site at 210 km, from Yamuna-Chambal confluence. This female carried a conventional VHF radio on her neck, and a GPS logging radio on her abbreviated tail (from former injury), just behind a yellow button on a tail scute. This female is a long-distance mover, upstream 107 km to Tighra, then 210 km downstream to confluence, then back 210 km upstream to same site by late 2015 where she remains, as of March 2016. Unfortunately, the GPS logger has not functioned properly, so her whereabouts has been determined solely by manual tracking, relying on only 16 locations since tagging. In 2015, she nested at Tighra, where "industrial" sand mining is a major disturbance.



Figure 15. Pankaj Kumar is the principal tracker, with red scarf, and his co-workers Soham Mukherjee, Ramraj, and Deepu, set up for downloading GPS data, with portable laptop computer, UHF antenna, battery, and related gear. The gharial with the logger ideally is within 350 m, and located out of the water, on land, with a clear VHF radio signal. Each download takes 1-3 hours to reach location and complete the procedure.



Figure 16. Another download attempt to obtain logged GPS locations. GPS logging radios are programmed prior to deployment to attempt GPS fixes at pre-determined times throughout the day. For Chambal gharial, a year-long schedule was adjusted monthly to compensate for seasonal patterns of movements onto land.

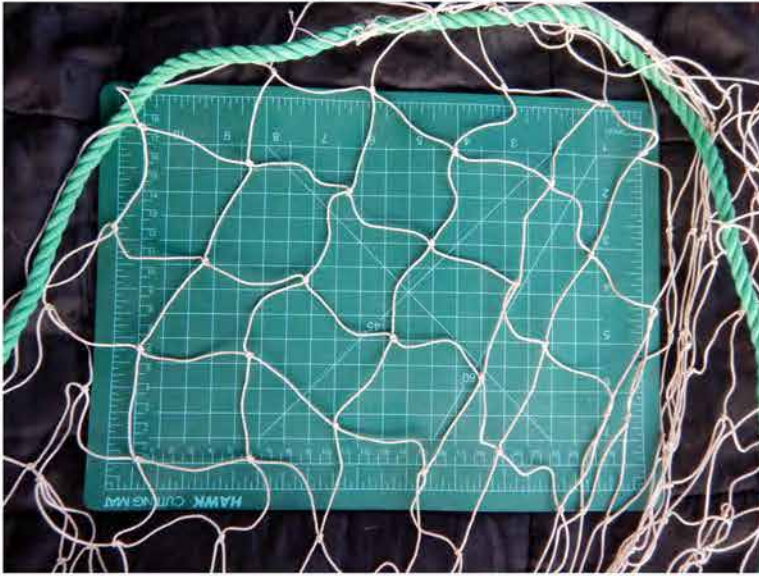


Figure 17. The nets used to capture gharial safely are heavy, stronger versions of large mesh fishing nets used commercially. The mesh size is referred to as "8 finger", "12 finger", etc and is the space between diagonal mesh knots that accommodate different numbers of fingers when the hand is held "on end." The top rope is fixed with floats, and the bottom line is tied with lead weights. Net lengths vary from 50-200m in length, and from 3-5m in depth/width (=top to bottom, hung in water).



Figure 18. View of conventional VHF radios (foreground) and GPS logger radios (back), used for gharial tracking, and designed and built by ATS (Advanced Telemetry Systems, Isanti, Minnesota USA). The life of these units is 2-3 years, have a range of 1-4 km, and weigh 100-300 gms. A temperature circuit can be integrated to allow ambient readings of unit.



Figure 19. VHF radio, on gharial 76, damaged possibly by a "bite" from another animal. The position of attachment is evident, sutured in place through skin and scutes with kevlar fishing line, and secured with metal swages/crimps. Radios affixed in this manner remain attached for 5+ years, and result in no noticeable injury to the animal. This radio was attached for 2+ yrs despite being damaged and non-functional.



Figure 20. GPS logger radio, with VHF signal, attached to dorsal surface of tail of tagged gharial. Radios are sutured in place, using eye-rings positioned laterally at base of radio, 3-4 per side / unit. Kevlar fishing line is passed through tail skin, across the entire width of the tail, just above tail muscle bundles, through base of scutes, and tied to eyelets. Line was secured with knots & metal swages/crimps. GPS logger radios have two whip antennas, i.e., a long VHF antenna, as in conventional VHF radios, and a short, stiff antenna for UHF downloading.



Figure 21. Munuswamy K., a crocodile handling expert from the Madras Crocodile Bank in Chennai, lifts a lightweight ladder into position so that the restrained gharial can be lashed tightly to it. Once the gharial is tied to the ladder, it is relatively easy to move and handle, and can be tagged with radio, weighed, and measured. Our capture team has done more than 6 major capture-tagging operations safely and efficiently. There are 6 fishermen with boats and nets, and another 4-6 staff experienced at handling crocodilians.



Figure 22. Munuswamy K., a crocodile handling expert from the Madras Crocodile Bank in Chennai, at rear of animal, is assisted by Iri Gill, Deputy Curator, Herpetology, London Zoo in restraining a subadult gharial away from the shore where it can settle quickly and quietly. The entire process of taking measurements, and affixing radios and tags takes about 30-45 minutes per animal. Major concerns are avoiding overheating in direct sunlight, and keeping the head and eyes covered.



Figure 23. Munuswamy K., a crocodile handling expert from the Madras Crocodile Bank in Chennai, on front of gharial, assisted by Soham Mukherjee and Iri Gill, with Kishore, the head fisherman holding a middle position. The stick to the left of the gharial's head is a precaution to prevent the gharial turning its head quickly when released.



Figure 24. Netting gharial was focused on downriver sand points where groups of animals tend to congregate, like this mid-river sandbar at Kasaua (river km=44). In this instance, nets were laid out below the point, then team waited patiently for gharial to "cross" the nets and begin basking. Once a number were on land, several team members swam quietly in the river from the upstream side, and then startled the basking gharial. Five gharial were caught at one time in this operation, and then they were weighed and measured, and several radiotagged.



Figure 25. Male 44, a "junior" male, not yet fully grown, and not yet dominant, swims near a large creche of hatchlings at a communal nest site, Naangoan Temple site, where 11 nests hatched in 2015. At this site, 13 nests hatched in 2014. This male was tracked by VHF radio for 25+ mons, Nov13-Dec15. He was the dominant guardian male at this communal nest site in two successive years, 2014 and 2015. He was definitely not the breeding male in the area, where a larger sized, large ghara male is the dominant breeder (Table 1).



Figure 26. Hatchlings remain tightly grouped in a dense creche at nest site where there was communal nesting. Hatchlings spend the early morning and late evenings on land, midday at the shoreline or in the water, and then disperse in shallow water in the nest vicinity at night (see Figures 29-36---game camera night images at creches). After 2-4 weeks post hatching, young actively feeding (see Figures 55-56) and widely dispersed at night near the nest site.



Figure 27. A female "guardian" at a nest site typically remains in close proximity to the creche, but she is not necessarily always present. At each nest site, a singular female, one of the larger sized animals, assumes a dominant, guardian role, and appears to actively exclude other females from the area she occupies while attending the creche. Here, a hatchling perches on the female guardian's head while other hatchlings float in the water nearby. Females remain with creches until high water floods the shoreline near the nest site, and then leave the young when adults disperse downriver, or upriver, and away from the nest site.



Figure 28. Batteries of game cameras, modified to record near-continuous, short video clips, were installed at each of two communal nest sites, one upriver and one downriver. These were operated for 3-6 days continuously, 24 hrs early (within a week to 10 days) and late (3 wks) post hatching. Using this set-up, it has been possible to monitor guardians at the creche, and determine who is guarding when among the adults in the nest vicinity. This site, Khara front side, had 17 nests, and all of these hatched, producing 500+ hatchlings in 2015.



Figure 29. (above) Game camera infrared image at creche site: a large-ghara male "guardian" comes ashore amidst a shoreline lined with hatchlings (=small eye shines in distance at shore).

Figure 30. (below) Game camera infrared image at creche site: a female attending the creche, approaches hatchlings at shore. Other cameras are visible in the distance. Note open jaw position of the young in the water, an effective "fish catching" posture.

Figure 31. (above) Game camera infrared image at creche site: a "guardian" female rests at shoreline while hatchling perches on her back

Figure 32. (below) Game camera infrared image at creche site: Female "guardian" rests at shoreline, with jaws agape. Hatchlings visible in foreground, and in distance on shore and at shoreline (=small eyeshines in distance)





Figure 33. (above) Game camera infrared image at creche site: Guardian female rests at shoreline, with hatchlings astride her body, and remaining nearby.

Figure 34. (below) Game camera infrared image at creche site: a "guardian" female floats at water surface offshore near hatchlings at creche site, monitored 24 hrs continuously, early and late post hatching. Game cameras visible distant shoreline.



Figure 35. (above) Game camera infrared image at creche site:

Female guardian lounges at shoreline in middle of night at creche. Eyeshines lining the shoreline in distance are visible as small "white" dots, reflecting in infrared camera light.

Figure 36. (below) Game camera infrared image at creche site:

Large-ghara male approaches a female guardian at creche. Typically, one or the other adult remains close to hatchlings, but occasionally both female and male guardians are in attendance, usually for only a short time.





Figure 37. Close-up telephoto shot of tractors and trolleys, removing sand from Rithora(MP)-Tighra(Raj) sandbank on Madyha Pradesh side of river. Tractors shown here were only some of 35-40 tractors counted at site in late afternoon, early June 2015. Wide angle image of same scene shown in Figure 34.



Figure 38. Panoramic view of sandbar on Chambal River, 5 km below Rajghat, at Rithora-Tighra villages. Here, 35-40 tractors operated almost 24 hours in the several pre-monsoon months of May-June to remove trolley loads of sand, on an industrial scale, to be used for building and construction in major metropolitan areas. This activity is strictly illegal, but widely engaged in by a sand mining "mafia."



Figure 39. At Rithora-Tighra sandbar (see Figs 37-38), there were two large, communal nest sites used by gharial, an upper site with 16 nests and lower site with 13 nests. A total of 25 of 29 nests hatched in 2015; two nests were predated at each site. Shown here is a tractor-trolley in the distance, and two gharial on the shoreline in foreground. Nesting area (upper site) was located just to the right of photo on shoreline (see Figure 40).



Figure 40. Concentration of nests at upper communal site (16 nests; 14 hatched) at Rithora-Tighra. Three females are visible on land near excavated nests (evident as sand disturbances on surface), and one female remains at shoreline. Jackals closely approached unattended nests and scavenged damaged eggs and consumed injured hatchlings. Nest excavation and/or predation by jackals was usually interrupted by guarding females. Sand removal was underway on an industrial scale, almost 24/7 at this season, immediately behind these nests.



Figure 41. Sandbank used for nesting in 2015 at Puraini, river km=189 (from confluence). Nests are evident as disturbed sand, near bush on photo right-center, and at left-center halfway up the bank. A creche of hatchlings rested at shoreline, directly below bush, photo right. Nine nests hatched at Puraini in 2015.



Figure 42. Nesting sandbank at Shankarpur, Rajasthan at river km 205. Excavated, hatched nest at exact center of photo, halfway up bank, just below compacted (dark shadow) sediment. The one nest at this site hatched in 2015, but no male was associated with it.



Figure 43. Low-lying nesting sandbank at Rhea, site of large, communal nesting in previous years. In 2015, there were 16 gharial nests and 1 mugger nest; 15 gharial nests hatched. Hatchlings tended to form less coherent, less compacted groups at this site. Abundant aquatic vegetation may have provided additional protection at site. Adult protection for these hatchlings was not evident in 2015 at site. In 2012, 28 of 30 nests at this site produced 800+ hatchlings, which were protected by a large ghara male, not likely to have been the "parent" of these offspring, since he chased the male breeder away prior to nesting, but after breeding by the deposed large ghara male.



Figure 44. Very high nests, showing evidence of recent excavation (5 visible near top of sandbank, center of photo). A puzzling feature of the many nests found at this site is the lack of hatchling and/or adults near by the excavated, and obviously hatched site. In 2014, there were 21 hatched nests, but few hatchlings evident. In 2015, there were 15 nests, but only a small pod of hatchlings near a hatched nest.



Figure 45. Nesting bank at Baba Singh Gir (river km=201). Excavated nest sites were located two-thirds up, at base of compacted layer evident with vegetation. A small creche was observed at base of nest bank (see Figure 46, below)



Figure 47. Nesting bank at Dinnpura (river km=87), near a village water access trail, heavily used by villagers for washing, laundry, cleaning, etc. A guardian male and five females, including a radioed adult female, ID=54 (Table 1), used this nesting location in 2015. Excavated nest is visible right center, halfway up sloping bank.



Figure 46. Nesting bank at Baba Singh Gir (river km=201). Excavated nest sites were located two-thirds up, at base of compacted layer evident with vegetation. A small creche was observed at base of nest bank (see Figure 45, above)



Figure 48. A nesting female mugger rests between her nest, evident in burrow entrance, with egg shell fragments visible, (upper left at photo corner). Another burrow/cave is visible above the resting female, upper right of photo. Muggers usually nest on mud banks opposite sandbanks used by gharial, but occasionally locate nests within nest colonies of gharial. If so, hatchlings are moved away immediately when they hatch by the mugger female. Location=Shankarpur(=205).



Figure 49. Groups of gharial adults and subadults congregate at Yamuna-Chambal confluence during the monsoon flooding each July-August-September. Often, up to 6 or more large ghara males are seen closely associated on basking banks, or feeding in the shallows.



Figure 50. Feeding is a common activity of congregated gharial at outflow areas, such as the Yamuna-Chambal confluence (shown here, with muddy Yamuna on left; gharial feeding in center of photo, near boundary between river flows). At these junctures, there are numerous eddies and currents.



Figure 51. Feeding is a common activity of congregated gharial at outflow areas, such as the Yamuna-Chambal confluence (shown here, with muddy Yamuna on left; gharial feeding in center of photo, near boundary between river flows). Here, a large ghara male swallows a large river fish.



Figure 52. Feeding is a common activity of congregated gharial at outflow areas, such as the Yamuna-Chambal confluence (shown here, with muddy Yamuna on left; gharial feeding in center of photo, near boundary between river flows). Here, a large ghara male repositions a large river fish in order to align it for swallowing.



Figure 53. Feeding is a common activity of congregated gharial at outflow areas, such as the Yamuna-Chambal confluence. At these junctures, there are numerous eddys and currents. Here an adult female repositions a small fish, possibly a tilapia, before swallowing.



Figure 54. Feeding is a common activity of congregated gharial at outflow areas, such as the Yamuna-Chambal confluence. At these junctures, there are numerous eddys and currents. Here, a large ghara male repositions a small fish.



Figure 55. Hatchling captures a small fish at shoreline. Hatchlings begin feeding within 1-2 weeks, and will continue to feed frequently before water rises with monsoon flooding.



Figure 56. Hatchling captures a large fish at shoreline. Hatchlings begin feeding within 1-2 weeks, and will continue to feed frequently before water rises with monsoon flooding.



Figure 57. Regional Wildlife Warden, Gurmeet Singh talks with front-line UPFD staff during workshop conducted at Garhaita base, with support from international zoo community.



Figure 58. Ranger Suresh Chandra Rajpoot explains the importance of protecting wildlife and enforcing regulations within the National Chambal Sanctuary, while Soham Mukherjee and Gurmeet Singh look on, during UPFD Capacity Building Workshop, October 2015.



Figure 59. Soham Mukherjee, Project Coordinator, Gharial Ecology Project, explains the distribution of crocodilians and turtles in north India and south Asia, as part of UPFD Workshop, Garhaita base, October 2015.



Figure 60. Ashutosh Tripathi, Education/Training Coordinator, Gharial Ecology Project, presents a summary of survey techniques utilized to estimate reptile populations in NCS, during the UPFD Workshop, held at Garhaita base, October 2015.



Figure 61. Participants at the Capacity Building Workshops, include middle level managerial staff and all frontline staff that patrol the riverfront on daily/weekly basis, as well as conduct surveys and environmental activities.



Figure 62. Ashutosh Tripathi (right) and Gurmeet Singh (left) outline the main size class categories of gharial to be used when censusing NCS population numbers and habitat usage. This talk was part of the program for the Capacity Building Workshop for UPFD, October 2015.



Figure 63. Group photo of UPFD Workshop participants, first day. A total of 12 staff attended the program. Garhaita base, October 2015



Figure 64. Group photo of UPFD Workshop participants, second day. A total of 19 staff attended the program, October 2015.



Figures 65-68. Views of MPFD Capacity Building Workshop, held 24 December 2015 at Deori Eco Centre, Morena, Madhya Pradesh. The workshop program followed the same agenda utilized in the program held at Garhaita base, in October 2015.



Figures 69-70. (above) Participants in the MPFD Capacity Building Workshop held on 24 December 2015, at Deori Eco Centre, Morena, MP. News article describing the workshop and summarizing the program (below).



घड़ियाल-कछुओं के संरक्षण के लिए दिया गया प्रशिक्षण



देवरी घड़ियाल केंद्र पर कार्यशाला में उपस्थित विभाग के अधिकारी व कर्मचारी।

भास्कर संवाददाता | मुरैना

चंचल में संरक्षित किए जा रहे घड़ियाल व कछुओं की देखभाल व पहचान कैसे की जाए इस संबंध में देवरी ईको सेंटर पर प्रशिक्षण कार्यशाला का आयोजन किया गया। जिसमें वन विभाग के कर्मचारियों को महत्वपूर्ण जानकारी उपलब्ध कराई गई। कार्यक्रम का आयोजन घड़ियाल कंजर्वेशन एलायंस, मद्रास क्रोकोडाइल बैंक ट्रस्ट व मध्यप्रदेश वन विभाग द्वारा संयुक्त रूप से किया गया।

कार्यशाला में डा. आरके शर्मा व आशुतोष त्रिपाठी ने वनकर्मियों को बताया कि घड़ियाल क अंडों को

किस तरह चिन्हित किया जाता है, उनका परिवहन कैसे होता है। साथ ही कछुओं की अलग-अलग प्रजाति को कैसे पहचाना जाता है और इनका रखरखाव में क्या ऐहतियात बरते जा सकते हैं।

इस दौरान में प्रशिक्षण ले रहे वन कर्मचारियों के सुवालों का जवाब भी अधिकारियों ने दिया और उन पर अमल करने के लिए कहा गया। देवरी ईको सेंटर अधीक्षक जयप्रकाश शर्मा ने भारतीय वन्यजीव अधिनियम व अनुसूचित संबंधी जानकारी दी। इस अवसर पर वन मंडलाधिकारी जीएल जोनवार, घड़ियाल केयर टेकर देवरी ज्योति डंडोतिया, दीपू, आनंद मौजूद रहे।

Teachers Training Program

On Gharial Conservation

4 January 2016



7536044350, 9219551156

Collaborative program of



Supported by



Figures 71-74. Slides from a powerpoint presentation used for Teacher Training Workshop, held on 3-4 January 2016, Etawah, UP.

Conservation is a process which should go through one generation to other generation and keep going on



This program is purely designed to awareness school kids for conservation of River eco-system.

Purpose.....

- To train teachers about the fact of river reptiles mainly on Gharial and its conservation
- So the teachers could enhance the knowledge of students using didactic and demonstrative/ interactive approaches.



Figures 75-78. Representative scenes from the Teacher Training Workshop, supported international zoo community, and conducted as part of the Training Component of the Gharial Ecology Project.





Figures 79-82. Follow up visits to local schools to reinforce the environmental themes and activities presented to teachers for classroom use and participation. Ashutosh Tripathi shown here on a local school visit, with active involvement of classes of different levels.





Figure 83. Local village kids on a school holiday, listen and view a video on the Gharial Ecology Project, with Jeff Lang (sitting near computer) explaining his role in the study, and Ramraj (with antenna on shoulder) helps interpret what the project activities involve. This video lasts 5 minutes, and is available in HINDI, as well as in English.



Figure 84. Screen print of FACEBOOK page set up for Gharial Ecology Project, with video clips and stills from project files. The video "Last Chance for the Gharial" produced by Reptiland in USA is available for viewing on the site.