



Reintroduction of Gharials (*Gavialis gangeticus*) in the Lower Ganga River, Murshidabad, West Bengal, India

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Abstract.—The Critically Endangered Gharial (*Gavialis gangeticus*), native to the Indian Subcontinent, is the sole surviving species of a once-diverse genus. Its population has declined by over 80% in the past two centuries due to habitat loss from water impoundment, sand mining, hunting, and intensive fishing. Only about 650 adult gharials remain in the wild, primarily in isolated stretches of the Ganga, Mahanadi, and Brahmaputra River Systems. A small, poorly documented population also exists in West Bengal. Focusing on conservation efforts to protect Gharials and their riverine ecosystem in the lower Ganga basin is urgent, especially in West Bengal. Therefore, a species-reintroduction program has been initiated by the West Bengal Forest Directorate to release captive-bred Gharials into suitable habitats. The goal of this program is to enhance the likelihood of long-term survival of the Gharials in the lower Ganga Basin. As part of this project, 37 young Gharials were released in February 2024 into the Ganga River in the Murshidabad District of West Bengal, India. The release was performed following established habitat assessment protocols, and recommendations for reintroducing the species. The progress of the released Gharials is being monitored, and local riparian communities are involved to ensure the long-term conservation of the Gharials. The released Gharials are acclimating to their new environment and are gradually spreading throughout the natural riverine habitat. Unfortunately, three Gharials became entangled in ghost nets and were lost within the first 15 days. Since then, the ghost nets have been removed from the river, and no further instances of Gharial mortality have been recorded.

The Gharial (*Gavialis gangeticus*), which is endemic to the Indian Subcontinent (Grigg and Kirshner 2015) and is the last surviving species of a once-diverse genus (Martin 2019), has a limited distribution and is the most threatened of all Indian crocodylians. Large-scale water control and extraction, sand mining, widespread hunting, and intensive fishing during the 19th and 20th centuries reduced Gharial numbers by over 80% throughout the species' former range (Lang 2018; Panda et al. 2023). At present, Gharials are restricted to a few isolated pockets along the Ganga and its major tributaries, as well as the Mahanadi and Brahmaputra Rivers (Lang et al. 2019). The number of extant Gharials is now estimated conservatively at ~ 650 (300–900) mature adults in the wild, with 77% confined in the River Chambal within the National Chambal Sanctuary (Lang et al. 2019). The species has been listed as Critically Endangered (CE) on the IUCN Red List (Choudhury et al. 2007; Lang et al. 2019) and is listed in Appendix I of CITES (2023). The Gharial also receives the highest degree of legal protection under Indian law, being listed in Schedule I of the Wildlife (Protection)

Amendment Act, 2022. Nevertheless, illegal trade remains a significant threat. Gharial eggs and skin are trafficked for use in traditional medicine and luxury goods. A recent case in June 2024 (Singh et al. 2024) involved the confiscation of 130 hatchling Gharials and 29 Red-crowned Roofed Turtles (*Batagur kachuga*) in northern India, marking an unprecedented scale of poaching. The animals were intercepted at Prayagraj Station, enroute to West Bengal, highlighting the ongoing risk of the illegal wildlife trade even for highly protected species.

At present, Gharial populations are found mainly in Protected Areas (PAs) such as the National Chambal Sanctuary in the Chambal River (Rajasthan, Madhya Pradesh, and Uttar Pradesh), Katarniaghat Wildlife Sanctuary in the Girwa River (Uttar Pradesh), Corbett National Park in the Ramganga River (Uttarakhand), Son Gharial Sanctuary in the Son River (Madhya Pradesh), Satkosia Gorge Wildlife Sanctuary in the Mahanadi River (Odisha), and Hastinapur Wildlife Sanctuary in the Ganga River (Uttar Pradesh) (Lang et al. 2018; Lang et al. 2019; Sharma et al. 2021). However,

a few small subpopulations exist outside Protected Areas in the Ghaghara River (Uttar Pradesh), Gandak River (Bihar), and Hugli and Ganga Rivers (West Bengal) (Singh 1978; Choudhary 2010).

Status of Gharials in West Bengal.—Reports from the 20th and 21st centuries confirm the continued, albeit dwindling, presence of Gharials in various districts of West Bengal. These historical records document occurrences in Midnapore (O'Malley 1911), Hooghly (O'Malley and Chakravarti 1912), West Dinajpur (Sengupta 1965), and Malda (Sengupta 1969). More recent evidence includes confirmed sightings from local interviews in 2012 at 13 locations along the River Hugli in Murshidabad, Nadia, Burdwan, and Hooghly Districts (Ghosh 2013), with additional records from Bardhaman and Nadia in 2013 (VanTomme et al. 2012; Ghosh 2013), and a report from Murshidabad in 2019 (Bandyopadhyay et al. 2019).

Mid-20th-century district gazetteers also noted that Gharials were once common in the Nagar, Punarbhaba, and Mahananda Rivers, and various jheels in West Dinajpur, as well as the Tangan and Punarbhaba Rivers in Malda (Sengupta 1965, 1969). Currently, a small subpopulation of Gharials persists in the main stem of the River Hugli, alongside newly reintroduced individuals in the River Ganga. Unverified sightings also have been reported by local riparian communities in the Rivers Teesta and Mahananda, with possible but unconfirmed occurrences in the Jayanti (within the Buxa Tiger Reserve), Raidak, and Torsa Rivers. Population sizes in these rivers remain unknown (Khan and Chatterjee 2024). Given this fragmented and uncertain distribution, the species faces heightened risks, particularly in the face of climate change. Gharials are highly vulnerable to climate change due to their narrow ecological niche and reliance on specific riverine conditions. The impacts of climate change, such as altered flow regimes, habitat loss, and shifts in prey availability, exacerbate existing threats like pollution and human disturbance, underscoring the urgent need for targeted conservation measures. Effective strategies must integrate climate resilience by maintaining natural river flows, protecting critical nesting habitats, restoring fish populations, and reducing anthropogenic pressures to ensure the long-term survival of the species within the riverine ecosystems in the state.

The reintroduction program described herein offers a ray of hope by releasing captive-bred Gharials back into suitable habitats. Hence, the Forest Directorate, West Bengal, with technical support from WWF-India, released 37 captive-bred Gharials into the River Ganga in Murshidabad District. The joint team from both organizations conducted a habitat-suitability assessment to identify the site for the release and subsequently monitor the released animals per established protocols. We herein outline the methods used during the reintroduction of the Gharials and the initial find-

ings of post-release monitoring conducted between February and May 2024.

Methods for the Reintroduction of Gharials

Pre-release: Site-suitability assessment.—The release site was selected based on a rapid habitat-suitability assessment undertaken jointly by the West Bengal Forest Directorate and WWF-India in the River Ganga between Farakka (24.797425, 87.925139) and Kakamari Chor (24.2522, 88.7272) on 6–7 February 2024 (Fig. 1). Tiktikpada (24.277467, 88.7188) and Kakmari Chor received the highest habitat-suitability scores. These scores, based on field data and community input, included Gharial sightings/occurrence reports, habitat parameters, disturbance indicators, and focused discussion with local communities to assess perceptions and to document historical and current presence of the species. Tiktikpada was recommended as the release site because the braided channel provides a calm environment for the released animals to acclimate and opportunities to disperse both up- and downstream. The selected release site lies along the border between India and Bangladesh, where the Border Security Force (BSF) regulates human activity. Once the release site was identified, approval was obtained from the International Committee of the WWF to ensure that the standards for translocation and animal handling are upheld during the reintroduction of Gharials in the River Ganga, West Bengal. Following Choudhury et al. (1982) and Rao (1998), February was chosen as the most suitable time for the release of Gharials in the area.

On 24 February 2024, the West Bengal Forest Directorate in collaboration with WWF-India released 37 captive-bred juvenile Gharials from the Rasikbeel Mini Zoo (Cooch Behar) that met minimum length criteria and were deemed suitable for release (Figs. 1–2). The joint team of Nadia-Murshidabad Forest Division and WWF-India conducted short-term post-release monitoring of the released Gharials in the 7-km stretch of the River Ganga between Bamnabad and Kakmari Chor from 25 February to 10 March 2024 (Fig. 3). In addition, five fortnightly post-release monitoring sessions also were implemented to assess the dispersal pattern of released animals, their responses to the natural environment, and their state of acclimatization. The field team also engaged local riparian communities to make them aware of the non-aggressive nature of Gharials, their ecological importance, and their legal status.

Pre-release: Preparation of release stock and transportation.—A release stock of 37 captive-bred juvenile Gharials at the Rasikbeel Mini Zoo was segregated and removed from public display in preparation for release. These Gharials were hatched in late 2021 and reared in captivity. Each Gharial was tagged with a unique number chip (Trovan Transponder Animal Implantable Needle, Batch ID-100C).



Figure 1. Map showing the surveyed stretch of the River Ganga along the border between West Bengal, India, and Bangladesh. Study sites are indicated by red dots and the Gharial release site is indicated.

The chip was inserted under the loose skin opposite the occipital groove. Zoo staff, under the supervision of veterinarians, recorded morphometric measurements of the Gharials, including total body length, tail length, snout length, girth, and weight, but did not determine sex. The batch of Gharials had an average weight of 2.3 kg and average total body length (TBL) of 1.2 m. On 23 February 2024, veterinarians conducted a preliminary physical health check, including assessment of tail fat reserves and evidence of ectoparasites and/or injuries. Following Choudhury et al. (1982), Gharials were transported overnight to the release site in special containers (ventilated PVC pipes of 1.5 m length and 200 mm diameter) to Tiktikpada (release site), Murshidabad, West Bengal (Fig. 2). The front and rear openings of the container pipes were covered with galvanised iron lids, which were well cushioned from the inside with a high-density sponge to protect the snouts and tails of the Gharials. The containers were fastened to a bamboo-frame structure in the truck to ensure ventilation and proper spacing. Gharials were sprinkled with water every 1–2 h during transport. All containers were marked with head

and tail directions and kept horizontal throughout the journey. The entire cargo-bed of the truck body was covered with agro-net to protect it from direct sunlight and allow proper



Figure 2. The field team taking the Gharial containers by truck to the release site.

ventilation. The speed of the vehicle was maintained within 20–40 km per hour depending on the nature of the road. The distance of about 550 km from the Cooch Behar Mini Zoo to the release site was covered in 15 h.

Pre-release: Community awareness and engagement with district administration.—Prior to the release, the Nadia-Murshidabad Forest Division organized awareness programs involving 60–70 local residents, mainly fishermen and regular river users who were selected based on the proximity of their villages to the release site. These awareness sessions informed the community about the Gharial reintroduction, addressed concerns, and promoted coexistence. Residents were encouraged to participate in the release so they could take pride and accept stewardship of the released animals. Local border outposts of the Border Security Force (BSF) were actively involved and sensitized to the reintroduction program through a series of meetings and discussions focused on the planned release of Gharials into the river.

Release of Gharials.—The juvenile Gharials were released into the river soon after reaching the release site. Containers were placed in a row about 1.5 m from the water with heads facing the river. The field team then removed the container lids and physical restraints, setting the Gharials free one by one. The Gharials took some time to get oriented but then smoothly entered the water. Considering the possibility of

any animal or human being injured during the process, both medical doctors and veterinarians were present at the release event.

Post-release monitoring.—To record the dispersal of released Gharials and their acclimation to the new environment, a joint team of the Nadia-Murshidabad Forest Division and WWF-India undertook daily bi-directional monitoring of released Gharials in the 7-km-long stretch of the river between Bamnabad (3.5 km upstream of the release site; 24.290585, 88.690165) and Kakmari Chor (3.5 km downstream of the release site; 24.245051, 88.728312) from 25 February to 10 March 2024 (Fig. 3). Subsequently, five fortnightly post-release monitoring sessions were conducted on 23 March, 9 April, 29 April–1 May, 16–17 May, and 29–30 May along a 9-km-long stretch of the river from Bamanabad (24.3586, 88.9242) to Kashmahal (24.4289, 88.9108). During these monitoring sessions, field teams consisting of two observers and one recorder recorded direct sightings of Gharials, habitat parameters, and disturbance factors every kilometer of the river while travelling in a paddle boat in mid-stream (Yadav et al. 2013).

Results

Release-site selection.—Based on the presence or absence of suitable habitat parameters and minimal disturbances, the site with the highest score was selected for Gharial release (Table 1). All favorable habitat parameters were present in two adjoining sites, Tiktikpada (a side-channel of the River Ganga) and Kakmari Chor (main stem of the River Ganga) and these sites received the maximum scores. Although the riparian community had low awareness, the fishermen were willing to help with the conservation of the Gharials and associated species.

The site chosen for the release was Tiktikpada, as this location would allow the released Gharials to acclimate to the calmer and smaller channel before migrating to the main stem of the river at the Kakmari Chor site, which is about 3–4 km downstream. The release site also was readily accessible by road.

Gharial release.—The 37 captive-bred juveniles were released into a braided channel of the River Ganga at Tiktikpada, under the jurisdiction of Sagarpara gram panchayat, Jalangi Block, Murshidabad, on 24 February 2024. Released animals were in good health based on tail-fat reserves and were active at the time of release. No signs of injury or ectoparasites were found.

Daily bidirectional monitoring.—Although Gharials are capable of long-distance movements, released individuals were unlikely to disperse far from the release site within a few days. Typically, they remained near the release location for a day or two before gradually moving up- or downstream. Consequently, daily bi-directional monitoring was an effective

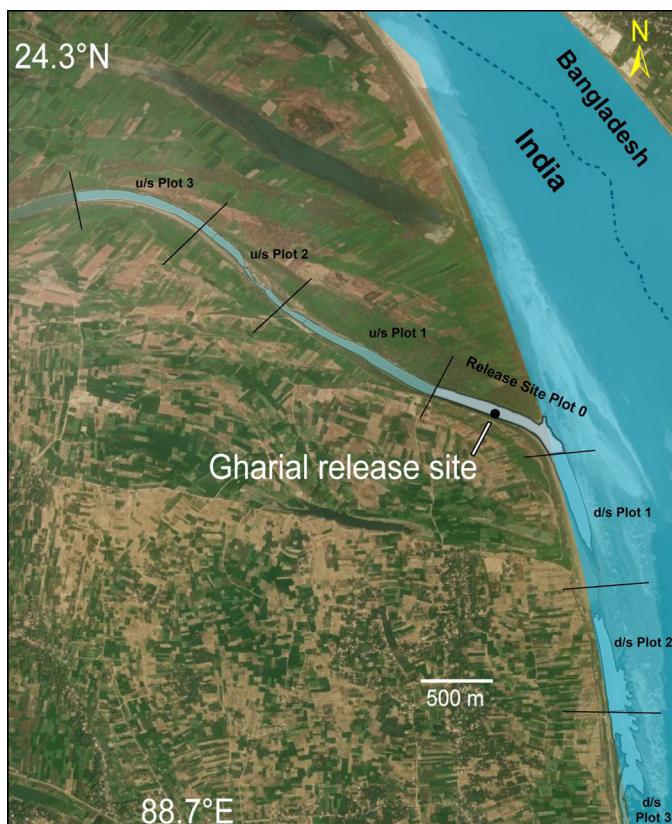


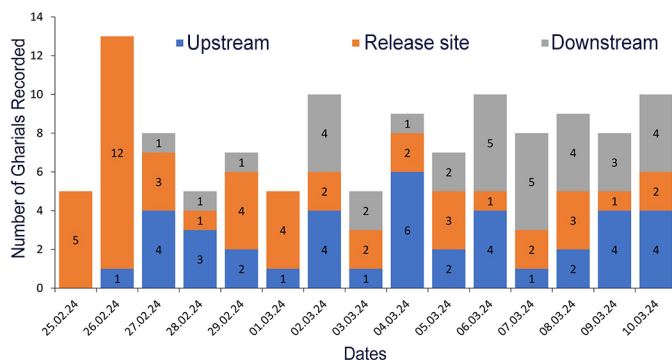
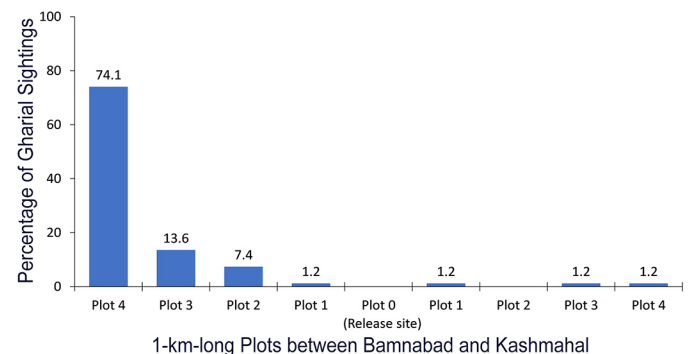
Figure 3. Surveyed stretch of the River Ganga showing sites where bidirectional post-release monitoring was conducted.

Table 1. Suitability criteria matrix for locations proposed as Gharial release sites along the River Ganga in Murshidabad, West Bengal, India.

	Presence of Gharial reported by local fishermen, BSF personnel, or forest staff (Yes = +1, No = -1)	Physical parameters (present = 1, absent = 0)					Disturbances (high = 1, medium = 2, low = 3)	Distance from human habitation (far = 3, moderately distant = 2, close = -1)	Overall water quality (within permissible limits = 1, beyond permissible limits = 0)	Total Score
		Shallow water	Deep water (< 2 m)	Sandy banks/island for basking	Sandy banks/island for nesting	Shelter (side channel/creeks)				
Nimtita Haatpada (Main stem Ganga River)	0	1	1	1	0	0	2	1	1	7
Lalgola (Maya) (Main stem Ganga River)	0	1	1	1	1	0	1	1	1	7
Shivpur Ghat (Braided channel of Ganga River)	0	1	0	0	0	0	1	2	1	5
Tiktikpada (Braided channel of Ganga River)	1	1	1	1	1	1	3	3	1	13 (Recommended)
Kakmari Chor (Main stem Ganga River)	1	1	1	1	1	1	3	3	1	13

tive method for assessing their initial acclimatization to the new environment and reflected the standard post-release monitoring practice used in Gharial reintroduction programs across India. During post-release monitoring, Gharials gradually dispersed both up- and downstream from the release site. The field team recorded released individuals as far as 3 km up- and downstream of the release site. However, local fishermen reported an even greater dispersion. Total sightings of released animals per day ranged between 5–13

individuals for the 15-day monitoring period. The average total sightings per day at the release site and 3 km up- and downstream were 2.6, 3.1, and 2.2 individuals/day, respectively (Fig. 4). Of 37 released gharials, about one-third were recorded during the first 15 days of post-release monitoring. During this period, weather was sunny except for the first day, which might explain the low number of gharial sightings on day one. Why more released gharials moved up- instead of downstream is unknown.

**Figure 4.** Daily distribution of Gharial sightings up- and downstream of the release site.**Figure 5.** Percentage distribution of Gharial sightings along the surveyed stretch of the River Ganga between Bamnabad and Kashmahal in West Bengal, India.

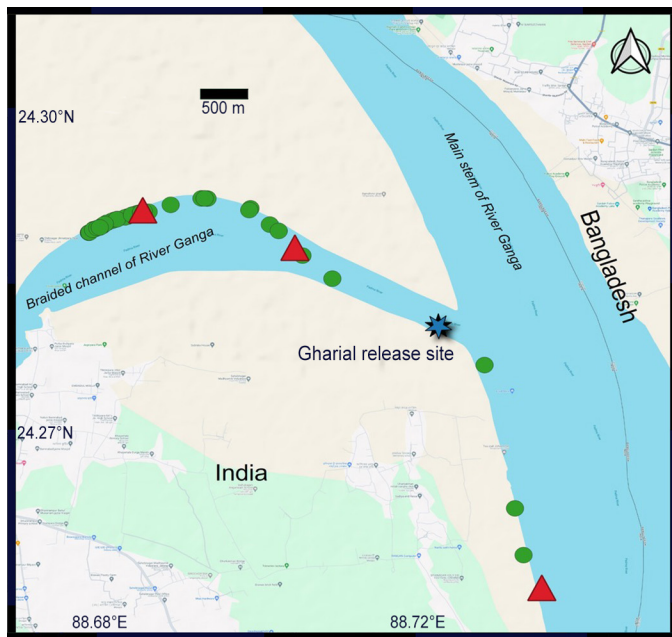


Figure 6. Gharial distribution recorded during the fortnight of monitoring. Sightings are indicated by green dots, mortality of released individuals by red triangles.

Fortnightly monitoring.—We undertook five fortnightly monitoring sessions in a longer stretch of the River Ganga from Bamnabad to Kashmahal, a distance of 9 km (Figs. 5–6). There were 81 Gharial sightings, 78 of which (96.3%) were upstream and three (3.7%) downstream of the release site.

The field team received reports from local fishermen of 3–4 Gharials at Kashmahal, about 5 km downstream of the release site. They also reported sightings in the main stem of the Ganga. Based on field observations and the reports of local fishermen and BSF officials, some Gharials dispersed downstream and reached the main stem of the River Ganga within the first few days after release (Fig. 7). Three or four

of these individuals remained on a midchannel island near the confluence of the braided channel and main stem of the Ganga, while others moved up- or downstream in the river.

The river had a low flow during the survey, with an average depth recorded using an acoustic depth finder of 1.1 m, including a minimum depth of 0.23 m in the braided channel and a maximum depth of 3.65 m in the main stem of the river. River width, determined by using a rangefinder, was quite variable as we moved downstream. The average width was 78.4 m, ranging from approximately 6 m in the upper reaches of the braided channel to about 1,000 m in the main stem of the River Ganga.

Disturbance.—We concluded that fishing and the presence of ghost nets were the major threats to Gharials in the area. We found a negative correlation ($p = -0.25973$) between the presence of Gharials and that of fishing boats, suggesting that animals avoided areas where boats operated. Unlike active nets, overnight deployment of which is not permitted due to the proximity of the international border, the abandoned nets posed a significant and immediate threat to reintroduced Gharials. Entanglement in these ghost nets resulted in the mortality by drowning of three reintroduced gharials. Although the main source of such ghost nets was discarded fishing nets, we also noted that local farmers used nets to keep granivorous birds out of their fields and that these nets often were discarded after use and ended up in the river (Fig. 8).

Mortality.—Early post-release mortality is common in reintroduction programs and often is attributed to the challenges faced by individuals as they transition from a controlled captive environment to a complex and unfamiliar natural habitat, where they must independently locate food, avoid threats, and adapt to new ecological conditions (Khadka 2022). We recorded three gharial mortalities caused by ghost net entanglement, two at Kakmari Char on 29 February and 10 March 2024 and one at Bamnabad on 2 March 2024. Forest officials were immediately informed of these incidents.



Figure 7. A Gharial basking on the bank of the River Ganga near Bamnabad, West Bengal, India.



Figure 8. Abandoned fishing nets (green dots) found in agricultural fields during the fortnightly monitoring. The Gharial release site is indicated by the red dot and start and end points of the survey are marked by blue triangles.

Post-mortem of the deceased animals performed by the Forest Directorate and Directorate of Animal Resources and Animal Health indicated death by drowning.

Since the first mortality reported in the river on 29 February 2024, the Forest Directorate actively located and removed around 150 kg of ghost nets from the river by 10 March 2024. This effort continued until no ghost nets were found in the river.

Awareness and outreach.—After the gharial release, the field team reached out to 181 local residents in Jalangi Block, Murshidabad, between 24 February and 30 May 2024. These 175 men and six women from various backgrounds including shopkeepers, farmers, and fishermen, lived in nearby villages that included Dhaniarampur, Kazipara (Debipur GP), Sagarpara, Char Gopalpur Khasmahal (Saheb Nagar GP), Khayramari (Khayramari GP), and Arazi Sibnagar (Sagarpara GP) under Jalangi Block, Murshidabad. In addition to public meetings, the Nadia-Murshidabad Forest Division also installed signage at key Gharial areas along the riverfront to raise awareness among villagers about the legal status, conservation importance, and ecology of the species.

During interactions with the field team, some fishermen expressed concerns that the Gharial release in the river could

affect their daily fishing activities. They were informed that Gharials, unlike Mugger Crocodiles (*Crocodylus palustris*), do not attack humans. They were also informed that Gharials are piscivorous specialists; however, as ectotherms, their food requirements are minimal compared to other animals of comparable size. During one session, a fisherman reported an incident in the last week of April 2024 when a Gharial became entangled in a fishing net. Fortunately, the fisherman acted promptly and released the animal into the river without causing it any harm.

Way Forward

The Forest Directorate, West Bengal, in collaboration with WWF-India, will continue monitoring the released Gharial population, habitat, and threats. Efforts also will be made to identify suitable sites (ecologically and socially) across the state for the possible release of additional captive-bred Gharials in the future. Awareness programs for local fishermen and other stakeholders will continue until the target audience demonstrates a sufficient understanding of the species, its importance, and conservation issues. Continuing efforts to find and remove ghost nets are critical and must involve support of the local community. Local riparian communities also should be encouraged to refrain from discarding used fishing nets into the river.

Because Gharials are highly aquatic and unable to lift their bodies off the ground, relying instead on dragging themselves across sand, they cannot travel far from water, which sometimes leaves them stranded in suboptimal habitats like canals. In cases of stranded Gharials or accidental entanglement in fishing nets, standard operating procedures for rescuing Gharials in Yadav et al. (2023) are to be followed.

The success of a Gharial reintroduction program is greatly enhanced when conducted within a Protected Area in its natural habitat (Rao 1998). Therefore, protecting the reintroduction site from all forms of disturbance is critical and, ideally, the area should be designated as a Protected Area, such as a Community Reserve.

While the initial phase of the Gharial reintroduction program in West Bengal has shown promise, several limitations must be acknowledged to guide future conservation efforts. Early post-release mortalities underscore the challenges these animals face due to entanglement in discarded fishing gear, which warrant sustained community engagement and cleanup initiatives. Additionally, limitations of boat-based monitoring, particularly in sensitive transboundary areas along the Indo-Bangladesh border, pose logistical challenges to long-term population tracking. These constraints suggest critical research opportunities, including the need for improved monitoring techniques (e.g., telemetry or GPS tracking), better understanding of post-release movements and mortality patterns, and assessments of habitat suitability across other stretches of rivers in the state. Long-term success will depend

on addressing these concerns, enhancing protection measures, and fostering continued collaboration among stakeholders.

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Disclaimer

The maps used in the article are not legal descriptions nor do they reflect any expressions, opinions, or advice of any nature, or accuracy and the current situation and associated limitations; instead they are strictly representational depictions.

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