Tracking a rare inter-basin migration of an olive ridley turtle in the northern Indian Ocean

Olive ridley sea turtles (*Lepidochelys olivacea*) are among the most copious marine turtles in the northern Indian Ocean (NIO) and well known for their synchronised mass nesting events[1,2]. Despite their wide distribution, olive ridleys typically exhibit natal homing and strong site fidelity to specific rookeries[3]. In India, the east coast (specifically the Gahirmatha, Devi and Rushikulya) rookeries host the largest arribada population[4–6]. By contrast, the west coast supports only sporadic nesting, with no known arribadas[7]. Geographically, the Indian peninsula and its southern extension through the Palk Strait and Gulf of Mannar represent a natural barrier that has been assumed to restrict the movement of sea turtles between the Arabian Sea (AS) and the Bay of Bengal (BoB)[8]. The shallow bathymetry of Palk Strait and discontinuous sandy beaches along the Tamil Nadu coast further limit nesting opportunities and dispersal[9].

Sea turtles generally migrate between feeding and breeding areas, and for this migration they have to leave the continental shelf and move to the open ocean[10]. However, marine turtle movements are not solely constrained by geography. Ocean currents play a crucial role in shaping dispersal, migration, and foraging behaviour[11,12]. Juvenile turtles, in particular, depend on these currents for their dispersion from natal beaches to their pelagic habitat[10,13,14]. Additionally, the juveniles are also dependent upon the ocean current which brings plankton, upon which they feed[10,15]. Adult sea turtles, however, migrate between breeding and feeding grounds each year. For this shuttle journey, they rely on ocean currents to spend less energy[16]. Travelling journeys with the help of oceanic currents are taken along the coast[17,18]. Research on green sea turtles shows that, although the ocean currents deflect them from their optimal migratory route, the turtles travel with the current and reach the destination quicker[19]. The satellite telemetry also shows olive ridley sea turtles use oceanic currents for their long journeys[20]. The East India Coastal Current (EICC) reverses its direction under the spur of the monsoon cycle[21,22]. From September to October, the EICC moves northward, while from November to January its movement reverses and flows southward along the east coast, eventually feeding into circulation around Sri Lanka, and, in some cases, with the winter monsoon current, it enters the AS[23].

While earlier microsatellite analyses suggested that the BoB population is panmictic yet distinct from the global population[2], more recent research indicates that the Indo-West Pacific population is genetically closer to the Atlantic population than to the East Pacific group. Previous satellite telemetry studies on the olive ridleys nesting along the Odisha coast have a migratory corridor between Odisha, India, and Sri Lankan waters only[24]. Tagging, satellite telemetry and genetic studies have so far provided no evidence of large-scale cross-peninsula migration[2]. Evidence is presented of an olive ridley turtle migrating from the east coast to the west coast of India for nesting during January. The unusual movement is interpreted in the context of oceanographic processes, with its ecological and conservation implications also discussed.

Olive ridley sea turtles were routinely tagged and monitored at the Gahirmatha, Devi, and Rushikulya rookeries in Odisha between 2021 and 2025 as part of the Zoological Survey of India's (ZSI) flipper tagging study. Inconel tags were tagged on the flippers of turtles, and each tag carried a unique serial number on one side, and on the opposite side, "ZSI, NAPO, KOL-53, IN; director@zsi.gov.in" was engraved for communication. At Gahirmatha rookery, only nesting females were tagged during the Arribada of 2021. After tagging, the geolocations were taken using a Garmin eTrex GPS. A fibreglass tape was used to measure the curved carapace width (CCW) and curved carapace length (CCL), while a tree calliper was used to measure the straight carapace width (SCW) and straight carapace length (SCL).

The Ocean Surface Current Analysis Real-time (OSCAR) product, which has a 0.25° spatial resolution, provides the daily, level 4 sea surface current (SSC) data. Sea surface height, surface vector winds and SST from multi-satellite data and in situ measurements are used to calculate the horizontal velocities[25,26]. The current speed is calculated as $Current\,Speed = \sqrt{u^2 + v^2}$, where u is the zonal and v is the meridional current component.

Along the Odisha coast, 11,632 olive ridley sea turtles were tagged at various locations. Recaptures were recorded at Gahirmatha, Rushikulya, and other sites along the Odisha coast, as well as at multiple locations in Sri Lanka[6]. Among these, one female turtle was recaptured at Guhagar, Maharashtra, on 27 January 2025 while nesting. The turtle was identified by tag serial numbers 03233 and 03234 (Figure 1) and was documented by the monitoring team from the Wildlife Institute of India and the Mangrove Foundation, Maharashtra. After examining the tag records, it was confirmed that the turtle was tagged at Wheeler Island of the Gahirmatha rookery, Odisha, on 18 March 2021 during arribada. The female had a CCW of 63.5 cm, CCL 68.5 cm; SCW 56.5 cm and SCL 61.8 cm.

Figure 1. A recaptured female olive ridley sea turtle showing the reverse side of the tag bearing the address of the Zoological Survey of India (ZSI) on the bottom (left) and the top side bearing tag no. 03233 (right).

The AS to the west and the BoB to the east make up the NIO. The NIO experiences seasonal reversal of the monsoon, where wind blows from the southwest (or northeast) during the summer (or winter) monsoon, which spans from May to September (November-February)[27]. As surface winds reverse their direction in different seasons, subsequently, the SSC also reverses its circulation accordingly in the NIO region[28].

The spatial distribution of weekly SSC from September 2024 to April 2025 in the NIO region is shown in Figure 2. The current speed varies from 0 to $>0.5\,\mathrm{m\,s^{-1}}$, with less intensity ($\leq 0.2\,\mathrm{m\,s^{-1}}$) in the AS and relatively higher ($>0.4\,\mathrm{m\,s^{-1}}$) along the western BoB and central equatorial regions. During early September, relatively weak currents ($\leq 0.2\,\mathrm{m\,s^{-1}}$) dominate most regions, interspersed with small-scale eddies along the western boundary. With the progression of the season into late September and October, current intensity strengthens markedly, with widespread velocities exceeding $\sim 0.4\,\mathrm{m\,s^{-1}}$, especially at the western boundary of the BoB, due to the EICC. Prominent anticyclonic eddies are observed along the western BoB region. During the winter monsoon, northeasterly winds drive the westward winter monsoon current toward the AS[28].

Surface currents in the BoB typically flow north along the eastern boundary and southwest along the western boundary, suggesting that the EICC reversal has been re-established during this season[29]. In the post-monsoon period (October-December), the AS exhibits a well-developed anticyclonic circulation in the central basin, while the eastward-flowing equatorial jets weaken progressively toward winter. Previous research has shown that BoB has anticyclonic circulation during the pre-monsoon, with

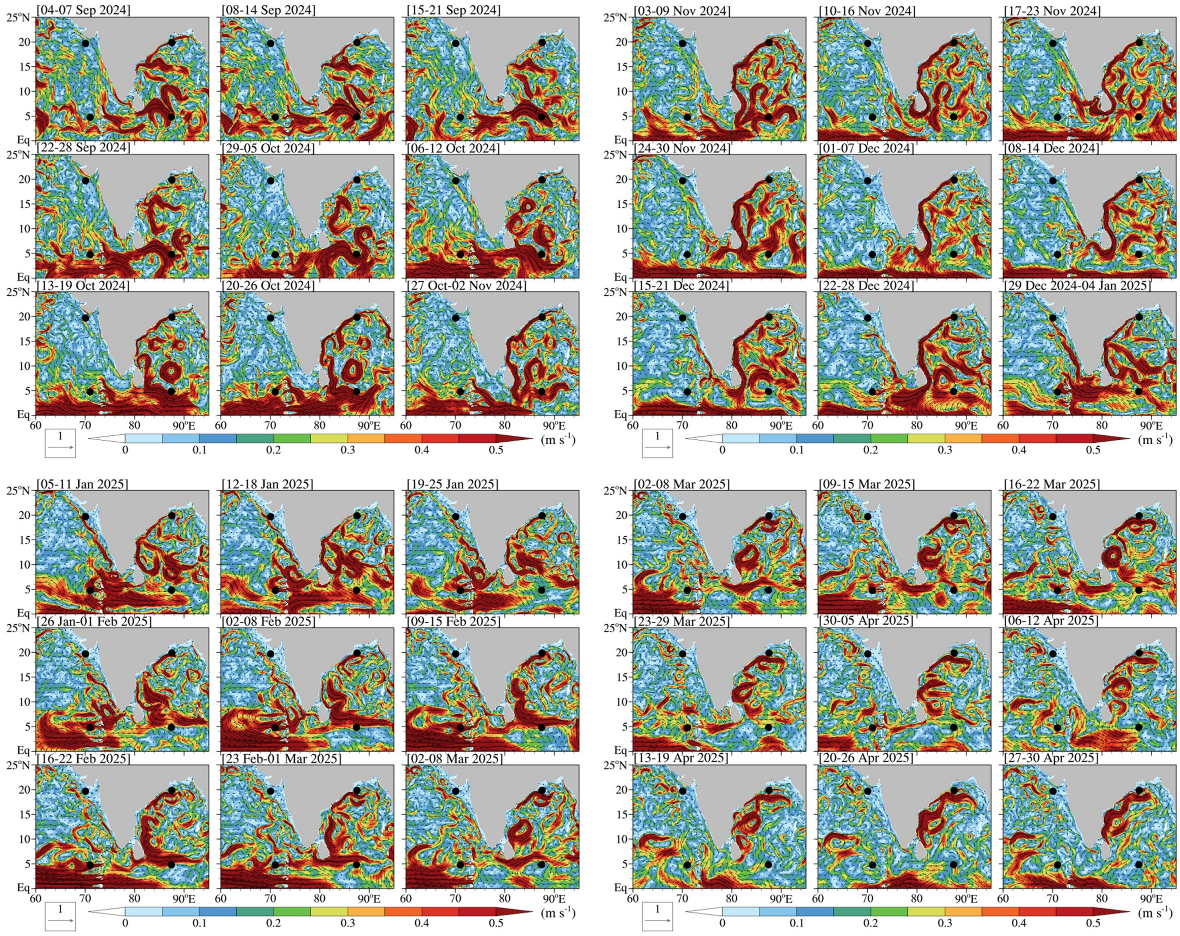

Figure 2. Weekly surface current patterns along the Indian coast from September 2024 to April 2025. Arrows indicate the direction of current movement, while the colour scale represents current speed ($m\,s^{-1}$).

a strong western boundary current (WBC) near an anticyclonic gyre in the western bay known as the EICC[30–32]. The EICC has fully developed and formed a strong WBC during the premonsoon (March-May), when the wind speeds are weaker. Furthermore, in the winter monsoon, the EICC advects low-salinity surface waters originating from huge riverine discharge in the northern BoB[33,34]. This freshwater plume circulates over the Sri Lankan coast before entering the AS after being advected southward along the bay's western edge. After the flow around India's southernmost point, it becomes the West India Coastal Current (WICC), which carries the diluted surface waters north along the country's southwest coast[35].

The study documents the migration of an olive ridley turtle to the AS from the BoB during the subsequent nesting season. While turtles are capable of active long-distance navigation[24], the coincidence of this migration with the seasonal reversal of ocean currents strongly suggests a role for oceanographic forcing. The EICC, which reverses south in November–January, may provide a 'conveyor belt' that facilitates the displacement of turtles from Odisha toward southern India[21,22]. The winter monsoon current looping around Sri Lanka and linking to the AS could then enable entry into west-coast waters[28]. Such coupling of currents has been documented for the dispersal of fish larvae, plankton, and even marine debris[36] and may similarly influence turtle movements. The AS is a region of high productivity due to winter monsoon-driven upwelling[37], and turtles may opportunistically track such resources. Also, while turtles generally exhibit natal homing, occasional straying could occur due to geomagnetic or environmental cues[11]. There are two possible shortest routes, which the turtle might have used. One is crossing the Palk Strait region, and the other route is crossing the south of Sri Lanka (Figure 3).

If east–west coast connectivity exists, even at low frequency, it challenges the assumption that BoB olive ridleys are entirely isolated from AS populations. This has important implications for population structure, genetic diversity and management strategies. Protection efforts should

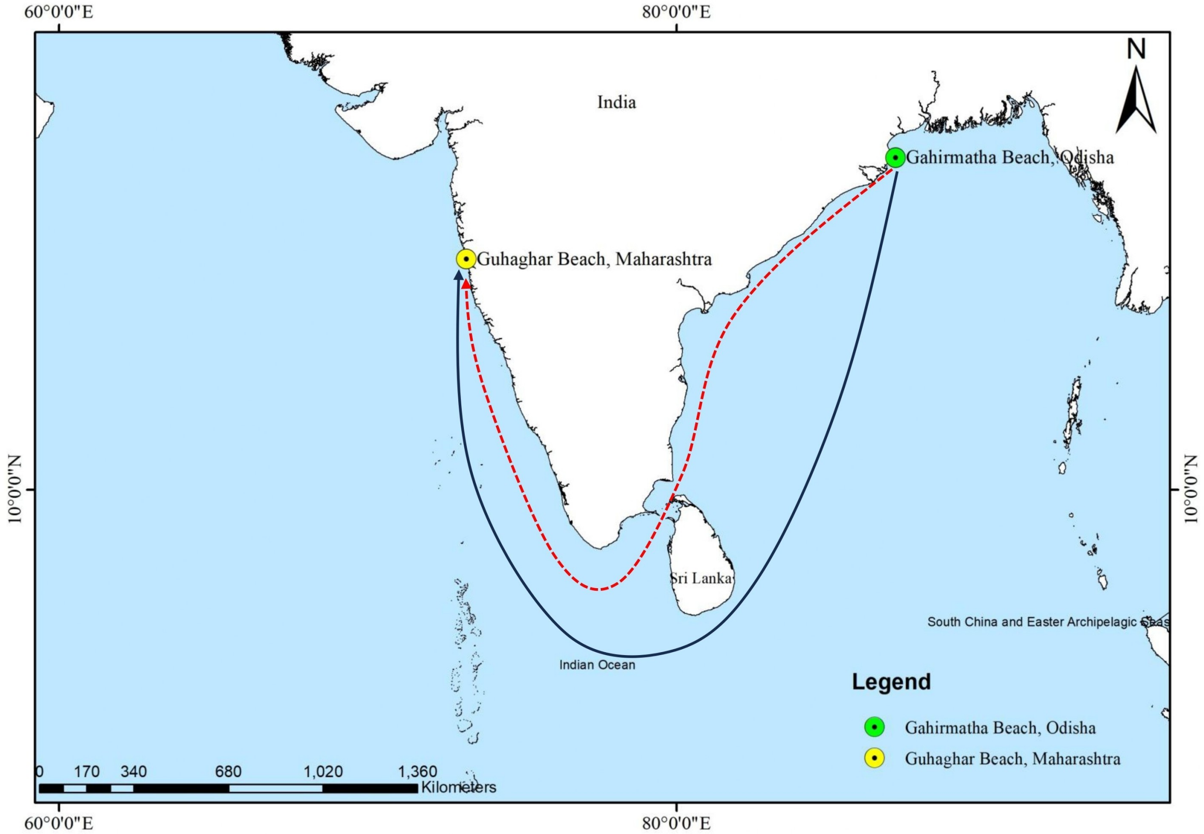

Figure 3. Possible movement pathways of the tagged sea turtle from Gahirmatha, Odisha, to Guhagar, Maharashtra.

therefore consider potential cross-basin connectivity to support the conservation of olive ridleys in the BoB and AS.

The present study documents evidence of olive ridley turtles crossing from the BoB to the AS for nesting, facilitated by seasonal ocean currents during January. While such rare events highlight the importance of integrating physical oceanography into our understanding of sea turtle ecology, further telemetry studies coupled with ocean circulation modelling are essential to evaluate the frequency and drivers of such movements. Recognition of this connectivity is vital for designing conservation measures across the broader NIO.

Funding: The present study was supported by the Department of Science and Technology, Government of India, under Grant No. CRG/2019/004586.

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ACKNOWLEDGEMENTS. The authors thank the Director, Zoological Survey of India, for providing the necessary support for the study. The authors are grateful to the Ministry of Environment, Forests and Climate Change, Government of India, and the Principal Chief Conservator of Forests (Wildlife), Government of Odisha, for approving the procurement of tags and granting the necessary permits. The authors also acknowledge the Department of Science and Technology, Government of India (CRG/2019/004586), for financial support through the Science Engineering Research Board – Core Research Grant and fellowship support to AKD, and National Band & Tag Company, Newport, USA, for providing the Inconel tags. The authors acknowledge the information provided by the field research team of the Wildlife Institute of India and the Mangrove Foundation, Mumbai, regarding the recovery of the tagged turtle at Guhagarh. SKB thanks the Indian National Centre for Ocean Information Services, Hyderabad, for including the present article as its 715th contribution.

Received 5 June 2026; accepted 28 August 2026.

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