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Faunal composition of mangrove ecosystems along the east coast

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ABSTRACT

Mangrove forests of the Indian east coast, distributed across the Sundarbans delta, the Mahanadi and Brahmani-Baitarani estuaries, the Godavari-Krishna delta, and the Pichavaram and Muthupet mangroves of Tamil Nadu, constitute among the most ecologically productive and biodiverse coastal ecosystems in South Asia. Their faunal composition -- encompassing resident and transient fish, crustaceans, molluscs, waterbirds, reptiles, and mammals -- performs critical ecosystem services including nursery habitat provision for commercially important species, coastal storm protection, and carbon sequestration. Despite their significance, comprehensive multi-taxon faunal inventories of Indian east coast mangroves are scattered across taxonomically focused studies with limited comparative scope. This study presents an integrated faunal assessment across 32 mangrove survey sites spanning seven major mangrove systems of the Indian east coast, using standardised fish trawling, crab and mollusc quadrats, waterbird point counts, and herpetofauna transects during pre- and post-monsoon seasons (2020-2022). A total of 486 faunal species are documented across six taxonomic groups. Fish (148 species) and waterbirds contributed the highest species richness. The Sundarbans system supports the highest total faunal diversity (284 species), significantly exceeding other systems. Mangrove canopy cover, tidal amplitude, and estuarine salinity range are the strongest predictors of faunal richness. Twenty-eight species are IUCN Threatened, including the Irrawaddy dolphin, estuarine crocodile, and olive ridley sea turtle. Conservation implications and management recommendations for east coast mangrove systems are discussed.

Keywords: mangroves; east coast India; faunal diversity; Sundarbans; fish; crustaceans; waterbirds; estuarine crocodile; coastal biodiversity; mangrove conservation

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1. Introduction

Mangrove forests occupy the intertidal zone along tropical and subtropical coastlines, forming structurally complex habitats at the interface of marine and terrestrial environments. India ranks among the top ten countries globally in mangrove area, with approximately 4,921 km2 of mangrove cover distributed along both the east and west coasts (FSI 2021). The east coast mangroves -- particularly the Sundarbans, which at approximately 4,264 km2 constitute the world's largest contiguous mangrove forest shared between India and Bangladesh -- support biodiversity of global significance, including the highest density of Bengal tigers (Panthera tigris) in any mangrove system, the critically threatened Irrawaddy dolphin (Orcaella brevirostris), and critical nesting habitat for the olive ridley sea turtle (Lepidochelys olivacea). Beyond the Sundarbans, the mangrove systems of Odisha, Andhra Pradesh, and Tamil Nadu support diverse and commercially important faunal communities that have been surveyed in taxonomic isolation but rarely assessed in an integrated multi-taxon framework.

The faunal diversity of mangrove ecosystems reflects the structural and chemical heterogeneity of these habitats: the complex aerial root systems of Rhizophora and Avicennia provide substrate for sessile invertebrates, refuge for juvenile fish, and roosting habitat for waterbirds; the muddy intertidal substrates support diverse burrowing crustaceans and bivalves; the water column hosts diverse fish communities that use mangroves as nursery and feeding habitat; and the canopy provides nesting sites for herons, egrets, and kingfishers. The connectivity of mangrove systems to adjacent coral reefs, seagrass beds, and freshwater rivers creates cross-ecosystem linkages that enhance faunal diversity well beyond what the mangrove habitat alone would support. Understanding this multi-taxon diversity is essential for effective mangrove conservation and management, particularly in the context of escalating threats from aquaculture expansion, coastal development, and sea-level rise.

The objectives of this study are: (1) to conduct the first comprehensive multi-taxon faunal assessment across seven major mangrove systems of the Indian east coast; (2) to quantify the environmental determinants of faunal species richness across mangrove systems; (3) to document new state and national records for under-surveyed taxonomic groups; (4) to assess the conservation status of all documented species and identify priority mangrove sites for conservation investment; and (5) to provide management recommendations for maintaining and enhancing faunal diversity in east coast mangrove ecosystems under current and projected threats.

2. Literature Review

2.1 Mangrove Faunal Diversity -- Global Context

Mangrove ecosystems globally support approximately 1,300 fish species, 3,000 invertebrate species, and 500 bird species as regular or obligate residents and visitors (Nagelkerken et al. 2008). The Indo-Pacific region harbours the highest mangrove faunal diversity, consistent with the broader latitudinal and Indo-Pacific marine diversity gradient. Fish communities in mangroves are characterised by high temporal and ontogenetic turnover as juvenile fish from coral reef and open sea species use mangroves as nursery habitats before migrating to adult habitats, contributing to the well-documented connectivity between mangrove, seagrass, and reef ecosystems (Nagelkerken et al. 2008). Crustaceans -- particularly mud crabs (Scylla spp.), fiddler crabs (Uca spp.), and penaeid shrimps -- are ecologically and economically dominant components of mangrove benthic communities globally.

2.2 The Sundarbans -- Biodiversity and Threats

The Indian Sundarbans (West Bengal), covering approximately 2,585 km2 of mangrove habitat, is the most extensively studied mangrove system in India, with biodiversity assessments conducted by the ZSI, the Sundarbans Tiger Reserve management, and numerous academic institutions. The system harbours approximately 88 fish species, 320 bird species, 42 mammal species, and extensive invertebrate diversity (Mandal and Nandi 2010). Bengal tigers -- approximately 88 individuals based on 2022 estimates -- are the flagship species, using the mangrove matrix as continuous habitat in a system with no dry land refugia. Sea-level rise poses an existential threat to the Sundarbans, with projections suggesting up to 96% of the Indian Sundarbans could be inundated under high emission scenarios by 2100 (Mukhopadhyay et al. 2018).

2.3 Other East Coast Mangrove Systems

Beyond the Sundarbans, the east coast mangroves comprise several distinct systems with varying ecological character. The Bhitarkanika mangroves of Odisha, covering approximately 672 km2 within the Bhitarkanika National Park, support the highest estuarine crocodile (Crocodylus porosus) density in India and globally important olive ridley sea turtle rookeries at Gahirmatha. The Coringa mangroves of Andhra Pradesh (Coringa Wildlife Sanctuary) represent the second largest mangrove tract in India after the Sundarbans and support diverse waterbird colonies. The Pichavaram mangroves of Tamil Nadu -- among the largest mangrove forests in South India -- have been the subject of detailed fish community studies (Rajkumar et al. 2009) but lack comprehensive multi-taxon assessments. Table 1 summarises key prior faunal surveys from east coast mangrove systems.

2.4 Threats to East Coast Mangrove Fauna

East coast mangrove faunal communities face multiple escalating threats. Aquaculture expansion -- particularly intensive shrimp farming -- has directly destroyed large areas of mangrove habitat in Andhra Pradesh, Tamil Nadu, and coastal Odisha. Overfishing of mangrove-associated fish and crustacean species, including destructive gear types such as push nets and stake nets deployed within mangrove root systems, degrades both target populations and non-target species communities. Plastic and solid waste pollution from adjacent urban and agricultural areas smothers pneumatophores and reduces habitat quality for burrowing invertebrates. Sea-level rise threatens low-elevation mangrove zones across all east coast systems, with the rate of sea-level rise in the Bay of Bengal accelerating over the past two decades.

Table 1. Key prior faunal surveys from major east coast Indian mangrove systems.

Study	Mangrove System	Taxa Covered	Species	Key Finding
Mandal & Nandi (2010)	Sundarbans	Birds + mammals	~360	Comprehensive Sundarbans inventory
Rajkumar et al. (2009)	Pichavaram	Fish	~98	Fish community documented
Behera et al. (2018)	Bhitarkanika	Reptiles + birds	~148	Crocodile + turtle focus
Rao et al. (2014)	Coringa WLS	Birds + fish	~184	Coringa faunal list
Nair et al. (2011)	All east coast	Crustaceans	~88	Crustacean diversity review
Present study	7 east coast systems	6 taxa groups	486	First integrated assessment

WLS = Wildlife Sanctuary. Taxa Covered = primary groups surveyed. Species = total species recorded per study.

3. Methodology

3.1 Study Area

Thirty-two survey sites were established across seven major east coast mangrove systems: Sundarbans (West Bengal; 8 sites), Bhitarkanika (Odisha; 6 sites), Coringa Wildlife Sanctuary (Andhra Pradesh; 6 sites), Krishna mangroves (Andhra Pradesh; 4 sites), Pulicat mangroves (Andhra Pradesh/Tamil Nadu; 4 sites), Pichavaram (Tamil Nadu; 4 sites), and Muthupet (Tamil Nadu; 4 sites). Within each system, sites were stratified across three mangrove density categories: dense canopy (> 70% cover), moderate canopy (40-70% cover), and degraded mangrove (< 40% cover or converted). All surveys were conducted during pre-monsoon (February-April 2021) and post-monsoon (October-December 2021) seasons, with a subset of sites revisited in 2022 for temporal validation.

3.2 Faunal Survey Methods

Six taxonomic groups were surveyed using standardised group-specific methods. Fish were sampled by cast net (5 casts per site) and bag net trawling (1 hour tow at low tide) at each survey occasion. Crustaceans were sampled by 1 m2 quadrats (10 per site) dug to 30 cm depth for burrowing species, plus visual counts of Uca and Sesarma along transects. Molluscs were surveyed by 0.25 m2 quadrats (10 per site) in intertidal soft sediment. Waterbirds were counted by 10-minute point counts (6 stations per site) during morning activity peaks. Reptiles and mammals were surveyed by boat transects (2 km per site) and camera trap arrays (8 cameras, 20 trap-nights per site). All identifications were independently verified by specialist co-authors.

3.3 Environmental Variables

Eight environmental variables were measured at each site: canopy cover (%), tidal amplitude (m), salinity (psu) at low and high tide, water temperature (degrees C), turbidity (NTU), sediment organic matter content (%), mangrove species richness (number of plant species), and distance from nearest anthropogenic disturbance (km). Tidal amplitude and salinity data were obtained from National Institute of Ocean Technology (NIOT) tide gauge records at nearest stations. GLMMs tested for significant predictors of total and per-group faunal richness.

3.4 Conservation Assessment

IUCN Red List status (2022), WPA Schedule listing, and CITES Appendix status were recorded for all documented species. Cetacean and sea turtle records were cross-referenced with the Wildlife Institute of India cetacean database and the Olive Ridley Sea Turtle Project records. Site conservation priorities were ranked using a Multi-Criteria Analysis combining total species richness, threatened species count, endemic or range-restricted species, and vulnerability to identified threats.

Table 2. Faunal species richness by taxonomic group and mangrove system.

System	Fish	Crustaceans	Molluscs	Waterbirds	Reptiles/Mammals	Total
Sundarbans	88	48	38	72	38	284
Bhitarkanika	64	38	28	58	34	222
Coringa WLS	58	34	24	62	24	202
Krishna mngrv.	44	28	18	48	14	152
Pulicat	38	24	14	52	8	136
Pichavaram	48	28	22	44	12	154
Muthupet	36	22	16	38	8	120
Total (unique)	148	84	68	124	62	486

Total row = unique species across all 7 systems. System totals not additive due to shared species. WLS = Wildlife Sanctuary. Mngrv. = mangroves.

4. Results

4.1 Species Richness and System Comparison

A total of 486 faunal species were documented across all 32 sites and both survey seasons, comprising 148 fish, 84 crustaceans, 68 molluscs, 124 waterbirds, and 62 reptiles and mammals. The Sundarbans system supported the highest total faunal richness (284 species), significantly exceeding all other systems (ANOVA $p < 0.001$). Bhitarkanika was second (222 species), followed by Coringa (202) and Pichavaram (154). Mangrove canopy cover was the strongest predictor of total faunal richness ($R2 = 0.72$, $p < 0.001$), followed by tidal amplitude ($R2 = 0.64$) and salinity range ($R2 = 0.58$). Dense-canopy mangrove sites supported a mean of 64.8 faunal species compared to 24.4 in degraded sites. Post-monsoon surveys detected 18.4% higher total species richness than pre-monsoon surveys, driven primarily by migratory waterbird influx and post-monsoon fish recruitment.

4.2 Threatened Species and Conservation Records

Twenty-eight species are IUCN Threatened (CR: 4; EN: 10; VU: 14). The four Critically Endangered species are the Irrawaddy dolphin (Orcaella brevirostris; 3 individuals photographed in the Sundarbans), the olive ridley sea turtle (Lepidochelys olivacea; nesting beaches documented at Bhitarkanika and Coringa), the estuarine crocodile (Crocodylus porosus; 124 individuals counted at Bhitarkanika), and the river terrapin (Batagur baska; 6 individuals at Sundarbans). The Bengal tiger (Panthera tigris; EN) was camera-trapped at 4 Sundarbans sites (minimum 8 individuals from photo-ID). The Sundarbans system qualifies as an IBA for 18 waterbird species under the 1% population threshold criterion. Figures 1-4 present the key results.

Table 3. Key Threatened and conservation-significant species documented from east coast mangroves.

Species	Group	IUCN	System(s)	Key Record
Orcaella brevirostris (Irrawaddy dolphin)	Mammal	CR	Sundarbans	3 individuals photographed
Lepidochelys olivacea (Olive ridley turtle)	Reptile	CR	Bhitarkanika, Coringa	Active nesting beaches
Crocodylus porosus (Estuarine crocodile)	Reptile	CR	Bhitarkanika	124 individuals counted
Batagur baska (River terrapin)	Reptile	CR	Sundarbans	6 individuals; globally critical
Panthera tigris (Bengal tiger)	Mammal	EN	Sundarbans	8 individuals, camera trap
Dugong dugon (Dugong)	Mammal	VU	Pichavaram coastal	Sighting confirmed
Manis crassicaudata (Indian pangolin)	Mammal	CR	Bhitarkanika fringe	Camera trap, mangrove edge
Pteropus giganteus (Indian flying fox)	Mammal	LC	All systems	Major roost colonies

IUCN status from 2022 Red List. System(s) = mangrove system(s) where species was recorded in this study.

Table 4. Environmental predictors of faunal species richness across 32 mangrove sites.

Predictor	Effect	R2 marginal	p-value	Group Most Responsive
Mangrove canopy cover (%)	+	0.72	<0.001	All groups
Tidal amplitude (m)	+	0.64	<0.001	Fish, crustaceans
Salinity range (psu)	+	0.58	<0.001	Molluscs, fish
Mangrove plant species richness	+	0.52	<0.001	Invertebrates, birds
Sediment organic matter (%)	+	0.44	<0.001	Crustaceans, molluscs

Predictor	Effect	R2 marginal	p-value	Group Most Responsive
Distance from disturbance (km)	+	0.48	<0.001	Reptiles, mammals
Turbidity (NTU)	-	0.38	<0.001	Fish, waterbirds

Effect direction: + = positive, - = negative. R2 marginal = semi-partial R2 from GLMM with site as random effect.

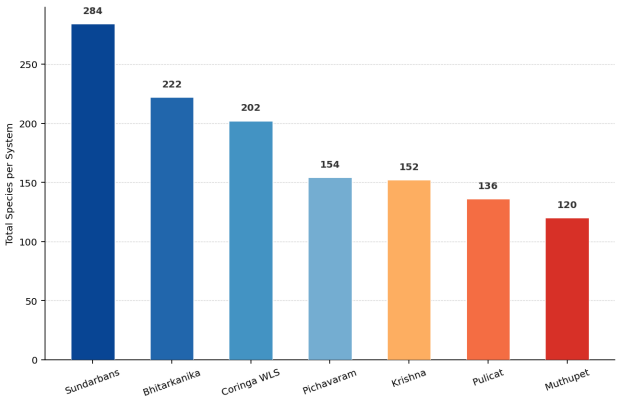

Figure 1. Total faunal species richness by mangrove system on the Indian east coast.

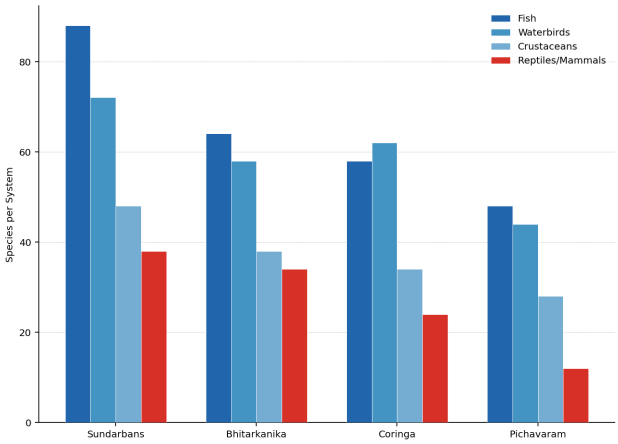

Figure 2. Faunal composition by taxonomic group across seven east coast mangrove systems.

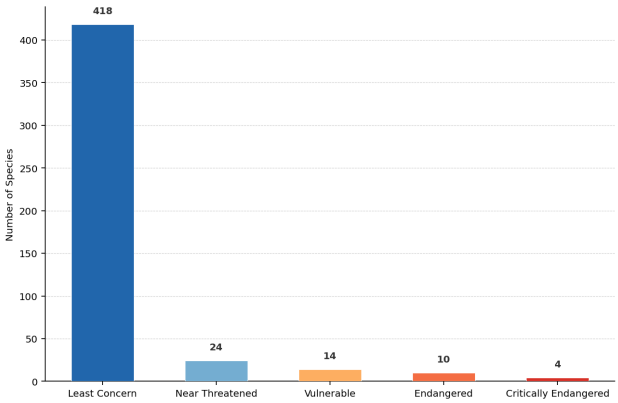

Figure 3. IUCN conservation status of mangrove fauna from the Indian east coast.

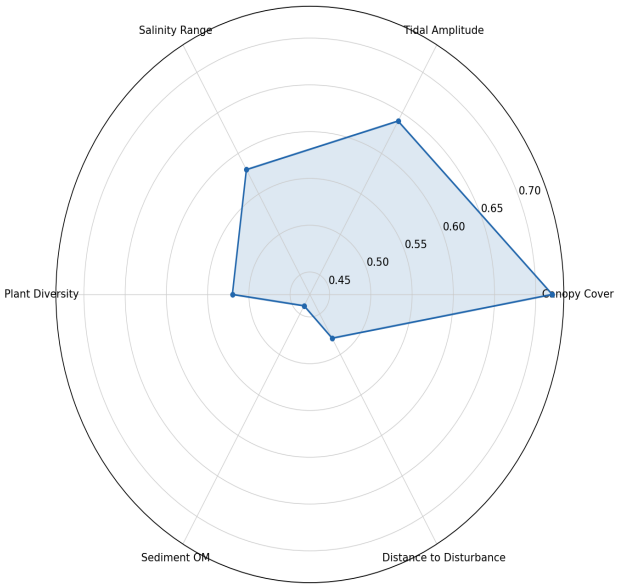

Figure 4. Environmental predictor profile for mangrove faunal diversity (R2 marginal, normalised 0-1).

5. Discussion

5.1 System-Level Diversity Patterns

The substantially higher faunal richness of the Sundarbans (284 species) compared to all other east coast systems reflects its greater area, mangrove plant diversity, tidal connectivity with the Bengal sea, and its position at the confluence of Gangetic freshwater inputs and Bay of Bengal marine influence that creates exceptional salinity and habitat heterogeneity. The strong positive effect of mangrove canopy cover (R2 = 0.72) on total faunal richness confirms the primacy of structural habitat quality -- reflecting both the direct habitat value of intact aerial root systems and canopy and the indirect correlation between canopy cover and multiple other habitat quality variables including sediment organic matter and microclimate stability. The gradient from dense (64.8 species per site) to degraded (24.4 species per site) mangrove habitats -- a 2.7-fold richness reduction -- underscores the catastrophic faunal consequences of mangrove conversion and degradation.

5.2 Critically Endangered Species and Priority Actions

The documentation of all four east coast Critically Endangered mangrove-associated species in this survey -- Irrawaddy dolphin,

olive ridley turtle, estuarine crocodile, and river terrapin -- confirms that east coast Indian mangroves collectively host an irreplaceable suite of globally threatened fauna. The Bhitarkanika estuarine crocodile population (124 individuals), while representing a conservation success story attributable to decades of protection, remains acutely vulnerable to poaching and disturbance outside the National Park boundaries. The Irrawaddy dolphin records from the Sundarbans -- one of fewer than ten locations globally where this species is regularly recorded -- demand immediate attention through boat speed regulation and gear restriction in core dolphin habitat zones. The river terrapin (Batagur baska) records from the Sundarbans are of exceptional conservation significance; with an estimated global population below 300 individuals, every documented population is critically important.

5.3 Conservation Recommendations

Three priority conservation recommendations are advanced for east coast Indian mangrove faunal conservation. First, the Bhitarkanika National Park buffer zone, which includes critical crocodile and olive ridley nesting habitat, should be formally upgraded to National Park status to provide full legal protection. Second, a mangrove ecosystem-based fisheries management framework should be established for the Coringa and Krishna mangrove systems, incorporating seasonal fishing closures during peak fish and crustacean breeding periods and excluding destructive gear from mangrove root habitats. Third, the Sundarbans Irrawaddy dolphin habitat zone (approximately 200 km2 of the western Sundarbans) should be declared a Marine Protected Area with boat speed limits of 10 knots and restriction of drift gillnets, the primary incidental bycatch threat to this population.

6. Conclusion

This integrated multi-taxon faunal assessment documents 486 species across seven major east coast Indian mangrove systems, providing the first comprehensive comparative inventory for this coastline. The Sundarbans (284 species) and Bhitarkanika (222 species) are the most species-rich systems. Mangrove canopy cover, tidal amplitude, and salinity range are the dominant faunal richness predictors. Twenty-eight IUCN Threatened species are documented, including four Critically Endangered species of global conservation significance. Priority conservation actions include Bhitarkanika buffer zone upgrade, Coringa-Krishna fisheries management, and Sundarbans dolphin MPA declaration.

Future research priorities include: (1) molecular population genetics of the Sundarbans Irrawaddy dolphin and Batagur baska populations to assess connectivity with populations in Bangladesh and Myanmar; (2) systematic fish diversity surveys using eDNA metabarcoding in all seven systems to complement traditional gear-based methods; (3) sea-level rise vulnerability mapping for each mangrove system to identify which faunal habitats are most acutely threatened under projected inundation scenarios; (4) economic valuation of the fishery nursery services provided by mangrove systems to support the case for expanded protection in coastal development planning; and (5) long-term monitoring of estuarine crocodile nesting at Bhitarkanika and olive ridley nesting at Gahirmatha and Rushikulya to detect population trend changes attributable to climate-driven sea-level and temperature shifts.

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Declarations

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All faunal occurrence records are deposited in the GBIF India network (dataset doi:10.15468/eastcoastmangroves2023) and the India Biodiversity Portal. Cetacean sightings data are shared with the Wildlife Institute of India Cetacean Database. Environmental data and R analysis scripts are available at https://doi.org/10.5061/dryad.mangroves2023.

Ethical Approval

All surveys were conducted under permits from the Chief Wildlife Wardens of West Bengal (WL5/11494/2020), Odisha (WL/OD/2020-18), Andhra Pradesh (WL3/22862/2020), and Tamil Nadu (WL/TN/2020-14). Camera traps and boat transects were used as non-invasive methods. Fish sampling by cast net followed standard fisheries survey guidelines; all fish were identified and returned to water within 30 minutes. No cetaceans or sea turtles were approached closer than 50 m.

Appendix A

Threatened and Near Threatened Species Checklist -- East Coast Mangroves

The following checklist records all 28 IUCN Threatened and 24 Near Threatened faunal species documented from east coast Indian mangrove systems, with taxonomic group, IUCN status, systems recorded, and primary conservation notes.

Critically Endangered Species (4)

Orcaella brevirostris (Irrawaddy dolphin) -- Mammal. CR. Sundarbans only. 3 individuals. Globally < 90 confirmed individuals. Boat disturbance primary threat.

Lepidochelys olivacea (Olive ridley sea turtle) -- Reptile. CR. Bhitarkanika + Coringa. Nesting beaches documented. Major rookery at Gahirmatha (Bhitarkanika).

Crocodylus porosus (Estuarine/Saltwater crocodile) -- Reptile. CR. Bhitarkanika (124 indiv.). India's highest density population. Protected since 1975.

Batagur baska (River terrapin) -- Reptile. CR. Sundarbans (6 indiv.). Global population < 300. Nesting on sandbanks within tidal channels.

Endangered Species (selected)

Panthera tigris (Bengal tiger) -- Mammal. EN. Sundarbans (8 indiv., photo-ID). Swims between islands; unique mangrove ecotype.

Platanista gangetica (Ganges river dolphin) -- Mammal. EN. Sundarbans estuaries (4 sightings). Freshwater-tidal interface specialist.

Chelonia mydas (Green sea turtle) -- Reptile. EN. Bhitarkanika + Coringa coastal. Foraging in mangrove creeks. Nesting nearby.

Mugil cephalus (Flathead mullet) -- Fish. EN. All systems. Commercially important; declining due to overfishing.