

AN ECOLOGICAL ASSESSMENT OF MAJOR GROUPS OF FAUNAL BIODIVERSITY IN GAHIRMATHA MARINE WILDLIFE SANCTUARY, ODISHA, EAST COAST OF INDIA

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Abstract

The present work carried out, under the aegis of project on sea turtle funded by the 'Wildlife Institute of India', Dehradun that executed in Odisha coast and this project assist to carry out the ecological assessment of different faunal groups in Gahirmatha Marine Wildlife Sanctuary (GMWS) and its adjoining area along the east coast of Odisha, India. The adjoining area is also fallen under the Bhitarkanika Wildlife Sanctuary as it contributes significant biodiversity. A total ten months of field study yields the 338 animal taxa. The relative abundance was estimated for aquatic mammals i.e. the density (Di) of Indian humpback dolphin was 17.6 ± 7.3 per km^2 followed by 11.2 ± 3 per km^2 for finless porpoise and 6.4 ± 2.4 for bottlenose dolphin. The shallow water of Gahirmatha is also support world's largest amount of Olive Ridley breeding populations. Apart from this, 13 globally threatened avian species were also documented in and adjoining area of the sanctuary. In preliminary assessment it is evident that ecological assessment of faunal biodiversity in particular ecosystem which may help to park manager to implement proper management strategies for protection and conservation of species. Further, extensive research is required to assess the status and distribution of faunal species in the sanctuary.

Keywords: Biodiversity; Ecological assessment; Fauna; Gahirmatha; Marine; Sanctuary

Introduction

Biodiversity assessment in Protected Areas (PA) is the commonest tool primarily used for conservation of biodiversity *in situ* which has been recognized under Article 8 of the Convention on Biological Diversity (CBD). As defined in Article-2 of the CBD, Protected Area (PA) is "geographically defined area which is designated or regulated and managed to achieve specific conservation objectives". Ecological assessments of the PAs as a strategy for biodiversity conservation indicate that these are extremely important part of the programmes for the conservation of biodiversity and ecosystems. Particularly for fragile environments that require active measures for the survival of certain components or species or biodiversity, ecological assessment is a bare minimum requirement. The PAs also ensures the respect, living treasures, recognition and maintenance of sacred places, cultures and important traditions [1]. The attempt was made to assess the faunal diversity in Gahirmatha Marine Wildlife Sanctuary and adjoining area which is falling under Bhitarkanika Wildlife Sanctuary, one of the best sanctuary and national park with only significant mangroves habitat in the state. Geographical

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area of India is extent only 2.4% of the total land surface of the world. However, it supports a significant rich diversity of animal fauna about 6.4% of the entire fauna known from the world [2]. India has been internationally acclaimed as mega-biodiversity nation where four Biodiversity Hotspots are present out of 36 identified globally. The State of Odisha located in the east-coast having about 4.74% of the total geographical area of India having unique biogeographical features. The physiography of the Odisha is amalgamation of different biogeographic provinces like Chhotanagpur Plateau, Eastern Highlands, Lower gangetic plain and Eastern-Coastal plain and supports a large diversity of faunal life.

At the present, it is fact that biodiversity or 'the variability of life' is being eroded on a global scale due to various anthropogenic activities [3]. Worldwide loss of biodiversity has worried the people both politically and socially [4], where *in situ* model of conservation prevailing as a mean to reduce loss of biodiversity [5]. Effective management and conservation of biodiversity is of prime importance. For this purpose, prior information on the abundance, distribution and diversity of species is required so that significant changes could be detected for appropriate management interventions. Hence, a reliable and resourceful procedure is required for the rapid assessment of species abundance and richness for the determination of conservation priorities [6].

Current study was carried out in the prime breeding ground for Olive Ridley Sea Turtles which was also having important aquatic mammals wintering shore birds and adjoin Bhitarkanika area also falling under in an Important Bird and Biodiversity Areas (IBAs) [7]. Many ecological works have been done in GMWS, basically focused on Olive Ridley Turtles. The ecological studies were carried out on Olive Ridley turtles in onshore and offshore area of GMWS by different researchers. The most noteworthy work documented by several workers in this region [8-16]. In biodiversity standpoint, no reasonably assessment of the biodiversity wealth especially of faunal diversity of the Gahirmatha Marine Wildlife Sanctuary has been made till date. The vital information pertaining to available abundance of faunal species and their ecology in the Gahirmatha marine ecosystem is limited due to its remoteness and proximity to prohibited defense establishment (missile test range) which in turn leave a void in significant understanding of faunal biodiversity. The onshore habitat of the marine sanctuary, i.e. outside of protected area was threatened by various unregulated aquaculture activities. Thus, this investigation was carried out to provide an ecological assessment of faunal diversity in Gahirmatha Marine Wildlife Sanctuary as well as adjacent onshore habitat. In the current study, abundance indices or abundance of major faunal groups present in the sanctuary was documented so as to generate baseline information to be implemented in future conservation and management interventions.

Experimental

Study area

The Gahirmatha (Marine) Wildlife Sanctuary of Odisha, India that lies between the mouths of the Dhamra and Barunei Rivers covers 35 km of coast from 20.5049°N, 86.7602°E in the south to 20.7233°N, 87.0701°E in the north. In addition to territorial water area of Bay of Bengal, the sanctuary includes adjoining mangrove reserve forests, accreted beaches and sand bars and mud flats. The Sanctuary consists of 27km² of land mass area and 1,408km² area of water body with 725.50km² core area and 709.5km² of buffer area (Fig. 1). In order to manage properly, fishing and other derogatory have been either restricted or regulated inside the sanctuary.

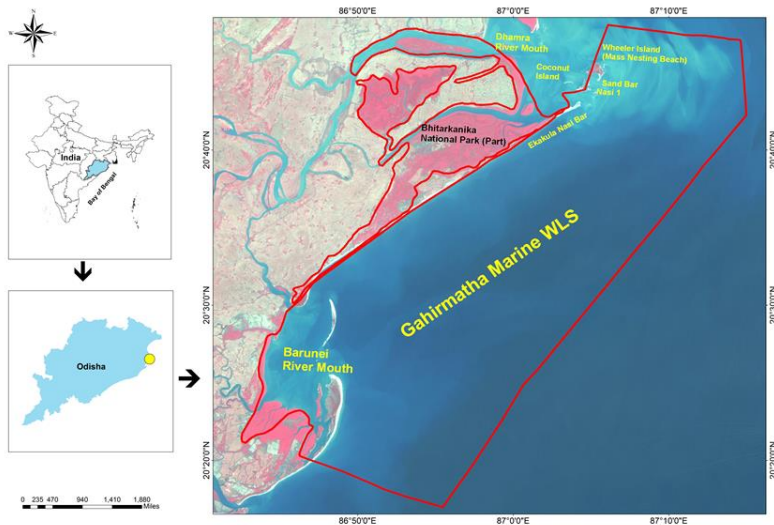


Fig. 1. The map of Gahirmatha Marine Wildlife Sanctuary (GMWS) spreads of 1435km² in land mass and water body, East coast of Odisha, India

Materials and methods

The attempt was made first time to quantify the faunal species akin to mammals, reptiles, amphibians, birds, fishes, molluscs, crustaceans etc. in the sanctuary during 2012 along with offshore Olive Ridley Turtle monitoring project. The following field methods were adopted to quantify individual group of animals in the sanctuary.

Mammals

The line transect method [17-18] was adopted to estimate the abundance of terrestrial mammals in 27 km² of land mass in the sanctuary. Boat line transect method had also been carried out for aquatic sea mammals in the sanctuary. Five footpaths parallel to coastline was laid in land mass (Mangrove and casuarinas plantations) of the sanctuary to estimate the encounter rate/km of mammalian fauna like wild pig, jackal, hyena, chital, porcupine. Each footpath is approx. 3 km in length (interval of 300 m apart from each other) and each footpath was walked continuous three days and same was carried out every month. Data generated through this observation was used to estimate rate of species encounter (index of abundance) by following formula:

$$\frac{\text{Total number of individual species observed}}{\text{Total distance (km) covered during that period}}$$

The cumulative value of all three walks was obtained for estimation of encounter rate for each species.

Sampling in offshore region was carried by moving on a seaworthy country boat having 9hp onboard engine. Monitoring of sea mammal akin to dolphin, porpoises, whale etc. was carried out in six transects having a stretch of 20 km each at an interval of 1 km parallel to the shore. Transects were determined with the help of GPS (Garmin 72, Garmin Inc.). Average boat speed was minimized to 9km/h to carry out observation for 2.5 to 3 hours in each of the transect.

The parameters which were used to record the existence of potential mammalian species during boat travel and walking included angular sighting distance using laser range finder, animal bearing using compass, individual species, cluster size, etc. The numbers of animals were counted manually after sighting and the distance of sighting was measured. The angle of

sighting was measured and adjusted so as to get an angle of 90° to the transect line [20-21]. Visual detection probabilities were modelled as a decreasing function of distance from the transect line. Modelling, estimation of densities of animal and their variances were carried out with the help of 'DISTANCE' programme [22].

Amphibians and Reptiles

Since study area is dominated by the occurrences of Olive Ridley Sea Turtles, their abundance was estimated through the line transect method by moving in boat, in conjunction with the estimation of abundance of sea aquatic mammals [16].

Intensive search (IS) was carried out along the terrestrial transect within a width of 6 m belt. All the microhabitats which included weathered and fallen logs, boulders, grass patches, dense bushes, leaf litters and tree crevices which were within transect line were thoroughly investigated by flushing & beating and overturning logs for amphibians and other reptilian fauna [23].

Birds

Birds were assessed primarily based on field work conducted in the potential sites from March 2012 to December 2012. A total of 242 days were spent in the field observing bird diversity. Birds were observed from 05:30 to 09:00h in morning and 15:30 to 17:30h in evening with the help of spotting scope and 8 x 40 Bushnell binoculars. Shore birds were surveyed in all along the Gahirmatha coast and all major habitats were covered including sand dune region during their wintering season. Surveys were conducted on foot in mangrove forests and agricultural fields while in the river and sea surveys were made with the help of mechanized or non-mechanized boats respectively [24]. The status and frequency of bird sightings have been noted basing on their occurrence. Species diversity indices and species richness were measured based on their frequency of occurrences.

The birds were identified in the field with the help of "Field guide to the birds of the Indian Subcontinent" [25-26].

Fishes

Altogether, fishing data was also collected from the field over a period of ten months similarly. The data were collected in regular interval of seven days from fishing trawlers, gill-netters and traditional fishermen. Fishing data also collected from nearest fishing harbours like Dhamra, Talachua and Paradeep jetties. Specimens were collected and preserved in 4% formalin for identification in the laboratory. The variations in the abundance of species were also estimated. Some of the species were identified and others were examined in the field laboratory with keys for identification as per Talwar and Kacker [27].

Molluscs

The specimens of molluscs were collected twice a month through hand picking method [28] from March 2012 to December 2012 along the shoreline of sanctuary and from the intertidal zone of Ekakula (Sanctuary area). The samples were collected in polythene bags before bringing to the laboratory and sorted out according to species. The specimens were preserved by providing a few drops of 70% alcohol. The shells were air dried then sundried and then kept in separate vials. The snail species were identified as per standard keys and catalogues prescribed in "Fauna of British India" [29] and "Book of Indian Shells" [30].

In additions to the above, two living fossils "Horseshoe crabs" under class Arachnida were enumerated in the area under study. Sampling of Horseshoe crabs were carried out in 'Ekakula' (19° 16'N; 84° 53'E) which is an estuarian ecosystem formed by the tributaries of two major rivers of Odisha State i.e 'Brahmani' and 'Baitarani'. Sampling in this site was done by demarcating a belt transect with 5m width × 900m length symmetric to the river mouth. The transect was further parted into three equal sections enumeration of horseshoe crabs following published protocols [31-33]. The transects were having different habitats. Towards the river mouth it was characteristically sandy, in the middle-mixed sand and mud and muddy sediment at the mangrove fringes. Data on abundance of species were collected fortnightly during full

moon and new moon high tides across the study site. Counting of species was done both for live and dead horseshoe crabs washed ashore at an interval of 2–3 days during full moon and new moon. The dead horseshoe crabs were marked on their carapaces with white paint and were dragged up the shore in order to avoid repeated counting during subsequent surveys.

The conservation status of the species provided in the checklist is based on the IUCN Red List, 2016.

Results and discussion

After 10 months of survey and monitoring, 11 species of mammals including terrestrial and aquatic, 38 reptilian species, 11 amphibian species, 149 avifaunal species including shorebirds, 64 species of marine and estuarine fishes, 41 species of molluscs, two species of horseshoe crabs, 16 crab species and 6 shrimp species have been recorded in the study site. Overall faunal assemblage is estimated to be 338 including all groups in the study area. The details ecological analysis of different groups of animals is as follows.

Mammals

During survey period four species of aquatic mammals i.e. dolphins including porpoises were documented in the sanctuary. The relative density of Indo-pacific humpback dolphin (*Sousa chinensis*) was 17.6/km² followed by finless porpoises (*Neophocaena phocaenoides*) 11.2/km² and bottle nose dolphin (*Tursiops aduncus*) was 6.4/km². The overall densities of dolphins were 30.8/km². One dead washed Irrawaddy dolphin (*Orcaella brevirostris*) was documented near Habalikhathi beach in 2012. The detail results are given in table 1.

Index of abundance of terrestrial mammalian species

As per rates of encounter of different species during survey, highest encounter has been found for jackal (*Canis aureus*) with mean (±SE) encounter rate of 13±0.62 individuals/km which was followed by wild pig (*Sus scrofa*) (7.3±0.13 animals/km), chital (*Axis axis*) (6±0.17 animals/km), porcupine (*Hystrix indica*) (0.6±0.17 animals/km) and striped hyena (*Hyaena hyaena*) (0.4±0.11 animals/km). The rhesus macaque (*Macaca mulata*) and smooth-coated otter (*Lutrogale perspicillata*) were sighted only two times along the footpath; therefore, their index of abundance was not estimated.

Table 1. Details of various parameters in distance sampling method to estimate dolphin density at Gahirmatha Marine Wildlife Sanctuary during 2012

Sl. No	Species	ESW (m)	D _i /km ² ± SE	% CV	LCL (95%)	UCL (95%)
1	Indian Humpback dolphin	76	17.6±7.3	27.4	14.6	48.3
2	Finless porpoises	69.3	11.2±3	27.1	6	20.8
3	Bottle nose dolphin	55.5	6.4±2.4	38.8	2.8	14.7
4	Irrawaddy dolphin	-	-	-	-	-
5	Overall density	48.5	30.8±9.1	25.6	22.9	69.2

D_i individual density, ESW effective strip width, LCL: lower confidence limit, UCL: upper confidence limit, CV: coefficient of variation

Reptiles and amphibians

Simultaneously, the relative densities of Olive Ridley Turtles were estimated through boat line transects along with the population estimation of aquatic mammals in sea. During pre-nesting season (December to January) the density of turtles were 22.1/km² followed by 154.4/km² in nesting season (February to March) and 1.4/km² in post nesting season (April to May). The overall densities of Olive Ridley Turtles were 78.3/km² and details are given in table 2.

In addition, hawksbill and green turtles were also occurring in Gahirmatha shallow water. However, during boat line transect their occurrence was minimal only three occasions juvenile

hawksbill turtle were encountered and one sub-adult green turtle encountered once in the off Gahirmatha. Therefore, their density was not estimated.

Table 2. Details of various parameters in distance sampling method to estimate density of Olive Ridley Turtles at Gahirmatha Marine Wildlife Sanctuary in 2012

Sl. No	Olive Ridley Turtles	ESW (m)	$D_i/\text{km}^2 \pm \text{SE}$	% CV	LCL (95%)	UCL (95%)
1	Pre-nesting	99.9	22.1 ± 6	21.4	12.2	40
2	Nesting	32	154.4 ± 70.1	14.4	53.5	445.2
3	Post-nesting	54	1.4 ± 0.3	22.7	0.6	3
4	Overall density	80	78.3 ± 30.5	15.6	35.5	172.5

D_i : individual density, ESW effective strip width, LCL : lower confidence limit, UCL : upper confidence limit, CV : coefficient of variation

The Asian water monitor lizard (*Varanus salvator*) frequently seen along the seashore of turtles nesting rookery and mangrove swamps area. The common Indian monitor lizard (*Varanus bengalensis*) also recorded in the *Casuarinas* plantation near Satabhaya village. The other reptilian fauna includes *Pangshura tentoria*, *Pelochelys cantorii*, *Chitra indica*, *Lissemys punctata*, *Hydrophis platurus*, *Enhydrina schistosa*, *Python bivittatus*, *Ahaetulla nasuta*, *Lycodon striatus*, *Lycodon aulicus*, *Dendrelaphis tristis*, *Boiga trigonata*, *Atretium schistosum*, *Amphiesma stolata*, *Ptyas mucosus*, *Enhydris enhydris*, *Xenochrophis piscator*, *Bungarus caeruleus*, *Bungarus fasciatus*, *Naja kaouthia*, *Naja naja*, *Ophiophagus hannah*, *Daboia russellii*, *Trimeresurus gramineus*; among lizards *Calotes versicolor*, *Sitana ponticeriana*, *Lygosoma punctatum*, *Lygosoma punctata*, *Hemidactylus leschenaultia*, *Hemidactylus frenatus*, *Hemidactylus flaviviridis*, *Chamaeleo zeylanicus* were documented in terrestrial and aquatic mangrove fringe area of sanctuary. One species of crocodiles *Crocodylus porosus* even recorded in the shallow coast of Gahirmatha Marine Sanctuary, though saltwater crocodile population were abundantly found in different creeks of Bhitarkanika National Park (Table 3).

Table 3. List of reptiles found in the sanctuary and along the Gahirmatha coast, East Coast of India

Sl.No	Family	Scientific Name	IUCN Status
Varanidae			
1	Bengal monitor/common Indian monitor	<i>Varanus bengalensis</i>	LC
2	Asian water monitor	<i>Varanus salvator</i>	LC
Geoemydidae			
3	Indian tent turtle	<i>Pangshura tentoria</i>	LC
Trionychidae			
4	Asian giant softshell turtle	<i>Pelochelys cantorii</i>	EN
5	Indian narrow headed softshell turtle	<i>Chitra indica</i>	EN
6	Indian-Flap shell turtle	<i>Lissemys punctata</i>	LC
Elapidae			
7	Yellow bellied sea snake	<i>Hydrophis platurus</i>	LC
8	Beaked sea snake/Common Sea snake	<i>Enhydrina schistosa</i>	LC
9	Common krait	<i>Bungarus caeruleus</i>	NE
10	Banded krait	<i>Bungarus fasciatus</i>	LC
11	Monocellate cobra	<i>Naja kaouthia</i>	LC
12	Indian cobra	<i>Naja naja</i>	DD
13	King Cobra	<i>Ophiophagus hannah</i>	VU
Pythonidae			
14	Burmese python	<i>Python bivittatus</i>	VU
Colubridae			
15	Common vine snake	<i>Ahaetulla nasuta</i>	NE
16	Northern wolf snake	<i>Lycodon striatus</i>	NE
17	Indian wolf snake	<i>Lycodon aulicus</i>	NE
18	Buff striped keel back	<i>Amphiesma stolata</i>	NE
19	Olive keel back water snake	<i>Atretium schistosum</i>	LC
20	Indian gamma snake	<i>Boiga trigonata</i>	LC
21	Tree snake/Daudin's bronzeback	<i>Dendrelaphis tristis</i>	NE
22	Indian rat snake	<i>Ptyas mucosus</i>	NE

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SL.No	Family	Scientific Name	IUCN Status
23	Asiatic water snake	<i>Xenochrophis piscator</i>	NE
	Homalopsidae		
24	Rainbow water snake	<i>Enhydris enhydris</i>	LC
	Viperidae		
25	Russels viper	<i>Daboia russelii</i>	LC
26	Bamboo pit viper	<i>Trimeresurus gramineus</i>	LC
	Agamidae		
27	Oriental garden lizard	<i>Calotes versicolor</i>	NE
28	Fan throated lizard	<i>Sitana ponticeriana</i>	LC
	Scincidae		
29	Common dotted garden shink/common snake shink	<i>Lygosoma punctata</i>	LC
30	Spotted supple skink	<i>Lygosoma punctatum</i>	NE
	Gekkonidae		
31	Bark Gecko	<i>Hemidactylus leschenaultia</i>	NE
32	House gecko	<i>Hemidactylus frenatus</i>	LC
33	Yellow belly gecko	<i>Hemidactylus flaviviridis</i>	NE
	Chamaeleonidae		
34	Indian chameleon	<i>Chamaeleo zeylanicus</i>	LC
	Crocodylidae		
35	Saltwater crocodile	<i>Crocodylus porosus</i>	LC
	Cheloniidae		
36	Hawksbill sea turtle	<i>Eretmochelys imbricate</i>	CR
37	Green turtles	<i>Chelonia mydas</i>	EN
38	Olive ridleys	<i>Lepidochelys olivacea</i>	VU

LC = Least concern, VU = Vulnerable, CR = Critically endangered, EN = Endangered, NE = Not evaluated, DD = Data deficient

The amphibian species observed in the study site included *Duttaphrynus stomaticus*, *Duttaphrynus melanostictus* (Bufonidae), *Fejervarya cancrivora*, *Euphlyctis hexadactylus*, *Hoplobatrachus crassus*, *Fejervarya orissaensis*, *Hoplobatrachus tigerinus*, *Sphaerotheca rolandae* (Dicroglossidae); *Microhyla ornata*, *Kaloula taprobanica* (Microhylidae) and *Polypedates maculatus* (Rhacophoridae) (Table 4). Population of *Euphlyctis hexadactylus* was abundant in freshwater ponds having dense vegetation near Ekakula. *Kaloula taprobanica* was recorded only from the dry area inside the Satabhaya village. All other species were observed all through the study site. The population of *Duttaphrynus melanostictus* (Bufonidae) in the study site was quite abundant. However, mostly its distribution was restricted to residential areas.

Table 4. List of amphibians found along the coast and adjoins area of sanctuary, East Coast of India

Sl.No	Family	Scientific Name	IUCN Status
	Bufonidae		
1	Indian Marbled Toad	<i>Duttaphrynus stomaticus</i>	LC
2	Common Asian Toad	<i>Duttaphrynus melanostictus</i>	LC
	Dicroglossidae¹		
3	Indian Green Frog	<i>Euphlyctis hexadactylus</i>	LC
4	Crab Eating Frog	<i>Fejervarya cancrivora</i>	LC
5	Dutta's Cricket Frog	<i>Fejervarya orissaensis</i>	LC
6	Jerdon's Bull Frog	<i>Hoplobatrachus crassus</i>	LC
7	Indian Bull Frog	<i>Hoplobatrachus tigerinus</i>	LC
8	Indian Burrowing Frog	<i>Sphaerotheca rolandae</i>	LC
	Microhylidae		
9	Ornate Narrow – Mouthed Frog	<i>Microhyla ornata</i>	LC
10	Painted Bull Frog	<i>Kaloula taprobanica</i>	LC
	Rhacophoridae		
11	Common Indian Tree Frog	<i>Polypedates maculatus</i>	LC

LC = Least concern

Avifauna

A total of 149 species of birds were recorded in the sanctuary and adjacent area (Table 5). Of which 44 species of birds were winter visitors to the sanctuary. Considering the frequency in sighting of birds, species were categorized into common, uncommon, rare and vagrant species.

Table 5. Annotated checklist of avian species found in the Gahirmatha Wildlife Sanctuary and its adjoining area.

No	Family	Scientific name	Status	Frequency	IUCN
	Phasianidae				
1	Grey Francolin	<i>Francolinus pondicerianus</i>	R	Vagrant	LC
2	Red jungle fowl	<i>Gallus gallus</i>	R	Common	LC
	Rallidae				
3	Purple Swamp hen	<i>Porphyrio porphyrio</i>	R	Uncommon	LC
4	Common Moorhen	<i>Gallinula chloropus</i>	R	Uncommon	LC
5	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	R	Common	LC
6	Eurasian Coot	<i>Fulica atra</i>	WM	Rare	LC
	Dromadidae				
7	Crab Plover	<i>Dromas ardeola</i>	WM	Rare	LC
	Jacanidae				
8	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	R	Uncommon	LC
9	Bronze-winged Jacana	<i>Metopidius indicus</i>	R	Common	LC
	Recurvirostridae				
10	Black-winged Stilt	<i>Himantopus himantopus</i>	LM	Common	LC
11	Pied Avocet	<i>Recurvirostra avosetta</i>	WM	Rare	LC
	Charadriidae				
12	Grey-headed Lapwing	<i>Vanellus cinereus</i>	WM	Common	LC
13	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>	R	Uncommon	LC
14	Red-wattled Lapwing	<i>Vanellus indicus</i>	R	Common	LC
15	Grey Plover	<i>Pluvialis squatarola</i>	WM	Rare	LC
16	Little Ringed Plover	<i>Charadrius dubius</i>	WM	Common	LC
17	Pacific Golden Plover	<i>Pluvialis fulva</i>	WM	Common	LC
18	Lesser Sand Plover	<i>Charadrius mongolus</i>	WM	Common	LC
	Rostratulidae				
19	Greater Painted Snipe	<i>Rostratula benghalensis</i>	R	Uncommon	LC
	Scolopaciidae				
20	Pin-tailed Snipe	<i>Gallinago stenura</i>	WM	Common	LC
21	Common Snipe	<i>Gallinago gallinago</i>	WM	Rare	LC
22	Black-tailed Godwit	<i>Limosa limosa</i>	R	Common	NT
23	Bar-tailed Godwit	<i>Limosa lapponica</i>	WM	Rare	NT
24	Whimbrel	<i>Numenius phaeopus</i>	R	Common	LC
25	Eurasian Curlew	<i>Numenius arquata</i>	WM	Common	NT
26	Common Redshank	<i>Tringa totanus</i>	WM	Common	LC
27	Green Sandpiper	<i>Tringa ochropus</i>	WM	Common	LC
28	Wood Sandpiper	<i>Tringa glareola</i>	WM	Common	LC
29	Common Sandpiper	<i>Actitis hypoleucos</i>	WM	Common	LC
30	Little Stint	<i>Calidris minuta</i>	WM	Common	LC
	Haematopodidae				
31	Eurasian Oyster catcher	<i>Haematopus ostralegus</i>	WM	Uncommon	NT
	Laridae				
32	Pallas's Gull	<i>Ichthyaeus ichthyaeus</i>	WM	Common	LC
33	Brown-headed Gull	<i>Larus brunicephalus</i>	WM	Common	LC
34	Black-headed Gull	<i>Larus ridibundus</i>	WM	Common	LC
35	Gull-billed Tern	<i>Gelochelidon nilotica</i>	WM	Uncommon	LC
36	River Tern	<i>Sterna aurantia</i>	LM	Rare	NT
37	Whiskered Tern	<i>Chlidonias hybrida</i>	LM	Common	LC
38	Indian Skimmer	<i>Rynchops albicollis</i>	WM	Common	VU
39	Glossy Ibis	<i>Plegadis falcinellus</i>	R	Common	LC
40	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	LM	Common	NT
	Ciconiidae				
41	Painted Stork	<i>Mycteria leucocephala</i>	R	Common	NT
42	Asian Openbill	<i>Anastomus oscitans</i>	R	Common	NT
43	Lesser Adjutant	<i>Leptoptilos javanicus</i>	R	Rare	VU
44	Little Grebe	<i>Tachybaptus ruficollis</i>	LM	Common	LC
	Ardeidae				
45	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	R	Common	LC
46	Indian Pond Heron	<i>Ardeola grayii</i>	R	Common	LC
47	Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>	R	Uncommon	LC
48	Black Bittern	<i>Ixobrychus flavicollis</i>	R	Uncommon	LC
49	Grey Heron	<i>Ardea cinerea</i>	R	Common	LC
50	Purple Heron	<i>Ardea purpurea</i>	R	Common	LC
51	Large Egret	<i>Ardea alba</i>	R	Common	LC

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No	Family	Scientific name	Status	Frequency	IUCN
52	Little Egret	<i>Egretta garzetta</i>	R	Common	LC
53	Intermediate Egret	<i>Ardea intermedia</i>	R	Common	LC
54	Cattle Egret	<i>Bubulcus ibis</i>	R	Common	LC
	Anhingidae				
55	Oriental Darter	<i>Anhinga melanogaster</i>	R	Uncommon	NT
	Phalacrocoracidae				
56	Little Cormorant	<i>Phalacrocorax niger</i>	R	Common	LC
57	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	R	Common	LC
	Accipitridae				
58	White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	R	Common	LC
59	Pallas's Fish Eagle	<i>Haliaeetus leucoryphus</i>	WM	Rare	EN
60	Black Kite	<i>Milvus migrans</i>	R	Common	LC
61	Brahminy Kite	<i>Haliastur indus</i>	LM	Rare	LC
62	Black-shouldered Kite	<i>Elanus axillaris</i>	R	Common	LC
	Pandionidae				
63	Osprey	<i>Pandion haliaetus</i>	WM	Rare	
	Anatidae				
64	Common teal	<i>Anas crecca</i>	WM	Uncommon	LC
65	Bar headed geese	<i>Anser indicus</i>	WM	Rare	LC
66	Gadwall	<i>Mareca strepera</i>	WM	Common	LC
67	Eurasian Wigeon	<i>Mareca penelope</i>	WM	Common	LC
68	Ruddy Shelduck	<i>Tadorna ferruginea</i>	WM	Common	LC
69	Pintail	<i>Anas acuta</i>	WM	Common	LC
70	Lesser Whistling-duck	<i>Dendrocygna javanica</i>	LM	Common	LC
	Alcedinidae				
71	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>	R	Rare	LC
72	Black-capped Kingfisher	<i>Halcyon pileata</i>	LM	Common	LC
73	Brown winged kingfisher	<i>Pelargopsis amauroptera</i>	WM	Common	NT
74	Collard kingfisher	<i>Todiramphus chloris</i>	R	Common	LC
75	Common kingfisher	<i>Alcedo atthis</i>	R	Common	LC
76	Pied kingfisher	<i>Ceryle rudis</i>	R	Common	LC
77	White throated kingfisher	<i>Halcyon smyrnensis</i>	R	Common	LC
	Falconidae				
78	Common Kestrel	<i>Falco tinnunculus</i>	WM	Rare	LC
	Glareolidae				
79	Small Pratincole	<i>Glareola lactea</i>	WM	Rare	LC
80	Oriental Pratincole	<i>Glareola maldivarum</i>	WM	Rare	LC
	Columbidae				
81	Blue Rock Pigeon	<i>Columba livia</i>	R	Common	LC
82	Oriental Turtle dove	<i>Streptopelia orientalis</i>	R	Common	LC
83	Spotted Dove	<i>Spilopelia chinensis</i>	R	Common	LC
84	Eurasian Collared dove	<i>Streptopelia decaocto</i>	R	Common	LC
85	Orange-breasted Green Pigeon	<i>Treron bicincta</i>	R	Common	LC
	Psittaculidae				
86	Alexandrine Parakeet	<i>Psittacula eupatria</i>	R	Rare	NT
87	Rose-ringed Parakeet	<i>Psittacula krameri</i>	R	Common	LC
88	Blossom-headed Parakeet	<i>Psittacula roseata</i>	R	Vagrant	NT
	Cuculidae				
89	Greater Coucal	<i>Centropus sinensis</i>	R	Common	LC
90	Common Cuckoo	<i>Cuculus canorus</i>	LM	Uncommon	LC
91	Brainfever Bird	<i>Hierococcyx varius</i>	R	Common	LC
92	Indian Cuckoo	<i>Cuculus micropterus</i>	R	Vagrant	LC
93	Asian Koel	<i>Eudynamys scolopaceus</i>	R	Common	LC
	Strigidae				
94	Spotted Owllet	<i>Athene brama</i>	R	Common	LC
95	Brown Fish-owl	<i>Ketupa zeylonensis</i>	R	Rare	LC
96	Collared Scops Owl	<i>Otus lettia</i>	R	Common	LC
	Tytonidae				
97	Barn Owl	<i>Tyto alba</i>	R	Rare	LC
	Apodidae				
98	Asian Palm-swift	<i>Cypsiurus balasiensis</i>	R	Common	LC
99	House Swift	<i>Apus nipalensis</i>	R	Common	LC
	Meropidae				
100	Small Bee-eater	<i>Merops orientalis</i>	R	Common	LC
101	Blue Tailed Bee Eater	<i>Merops philippinus</i>	R	Common	LC
102	Chestnut-headed Bee Eater	<i>Merops leschenaulti</i>	LM	Vagrant	LC
	Coraciidae				
103	Indian Roller	<i>Coracias benghalensis</i>	R	Common	LC
	Upupidae				
104	Common Hoopoe	<i>Upupa epops</i>	R	Common	LC
	Megalaimidae				
105	Coppersmith Barbet	<i>Megalaima haemacephala</i>	R	Common	LC

No	Family	Scientific name	Status	Frequency	IUCN
	Picidae				
106	Rufous Woodpecker	<i>Micropternus brachyurus</i>	R	Common	LC
107	Black-rumped flameback	<i>Dinopium benghalense</i>	R	Common	LC
108	Greater flameback	<i>Chrysocolaptes guttacristatus</i>	R	Common	LC
	Pittidae				
109	Indian Pitta	<i>Pitta brachyura</i>	LM	Common	
110	Mangrove Pitta	<i>Pitta megarhyncha</i>	R	Common	NT
	Alaudidae				
111	Ashy Crowned Sparrow Lark	<i>Eremopterix griseus</i>	R	Common	LC
112	Oriental Sky Lark	<i>Alauda gulgula</i>	R	Common	LC
	Hirundinidae				
113	Barn Swallow	<i>Hirundo rustica</i>	WM	Common	LC
114	Red-rumped Swallow	<i>Hirundo daurica</i>	WM	Common	LC
	Motacillidae				
115	Forest Wagtail	<i>Dendronanthus indicus</i>	WM	Common	LC
116	Citrine Wagtail	<i>Motacilla citreola</i>	WM	Common	LC
117	Yellow Wagtail	<i>Motacilla flava</i>	WM	Common	LC
118	Grey Wagtail	<i>Motacilla cinerea</i>	WM	Uncommon	LC
	Campephagidae				
119	Large Cuckooshrike	<i>Coracina macei</i>	R	Vagrant	LC
120	Small Minivet	<i>Pericrocotus cinnamomeus</i>	R	Common	LC
	Pycnonotidae				
121	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	R	Common	LC
122	Red-vented Bulbul	<i>Pycnonotus cafer</i>	R	Common	LC
	Aegithinidae				
123	Common Iora	<i>Aegithina tiphia</i>	R	Common	LC
	Laniidae				
124	Brown Shrike	<i>Lanius cristatus</i>	R	Uncommon	LC
	Muscicapidae				
125	Oriental Magpie-robin	<i>Copsychus saularis</i>	R	Common	LC
	Turdidae				
126	Orange Headed Ground Thrush	<i>Zoothera citrina</i>	R/WM	Rare	LC
	Muscicapidae				
127	Black Redstart	<i>Phoenicurus ochruros</i>	R	Rare	LC
	Leiothrichidae				
128	Jungle Babbler	<i>Turdoides striata</i>	R	Common	LC
129	Common Babbler	<i>Turdoides caudatus</i>	R	Common	LC
	Cisticolidae				
130	Yellow-bellied Prinia	<i>Prinia flaviventris</i>	R	Common	LC
131	Ashy Prinia	<i>Prinia socialis</i>	R	Common	LC
132	Common Tailor Bird	<i>Orthotomus sutorius</i>	R	Common	LC
133	Paddy Field Warbler	<i>Acrocephalus agricola</i>	WM	Common	LC
	Phylloscopidae				
134	Common Chiffchaff	<i>Phylloscopus collybita</i>	WM	Common	LC
	Rhipiduridae				
135	White-throated Fantail	<i>Rhipidura albicollis</i>	R	Common	LC
	Nectariniidae				
136	Purple-rumped Sunbird	<i>Leptocoma zeylonica</i>	R	Common	LC
137	Purple Sunbird	<i>Nectarinia asiatica</i>	R	Common	LC
	Passeridae				
138	House Sparrow	<i>Passer domesticus</i>	R	Common	LC
	Ploceidae				
139	Baya Weaver	<i>Ploceus philippinus</i>	R	Common	LC
	Sturnidae				
140	Asian Pied Starling	<i>Sturnus contra</i>	R	Common	LC
141	Common Myna	<i>Acridotheres tristis</i>	R	Common	LC
142	Jungle Myna	<i>Acridotheres fuscus</i>	R	Common	LC
	Oriolidae				
143	Black-headed Oriole	<i>Oriolus larvatus</i>	R	Common	LC
144	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	R	Rare	LC
	Dicruridae				
145	Black Drongo	<i>Dicrurus macrocercus</i>	R	Common	LC
146	Ashy Drongo	<i>Dicrurus leucophaeus</i>	R	Common	LC
	Corvidae				
147	Rufous Treepie	<i>Dendrocitta vagabunda</i>	R	Common	LC
148	Large-billed Crow	<i>Corvus macrorhynchos</i>	R	Common	LC
149	House Crow	<i>Corvus splendens</i>	R	Common	LC

R = Resident, WM = Winter migrant, LM = Local migrant, LC = Least concern, VU = Vulnerable, NT = Near threatened, EN = Endangered

The species like Grey francolin, Blossom-headed parakeet, Indian cuckoo, Chestnut-headed Bee eater and large cuckoo-shrike were considered as a vagrant species and individual species were documented well outside their normal range. Similarly Eurasian Coot, Crab Plover, Pied Avocet, Grey Plover, Common Snipe, Bar-tailed Godwit, River Tern, Lesser Adjutant, Pallas’s Fish Eagle, Brahminy Kite, Osprey, Bar headed geese, Stork-billed Kingfisher, Common Kestrel, Small Pratincole, Oriental Pratincole, Alexandrine Parakeet, Brown Fish-owl, Barn Owl, Orange Headed Ground Thrush, Black Redstart and Eurasian Golden Oriole were considered as rare birds of the area. The frequency and encounter rate of these birds were very unusual and individual populations were recorded very less. However, rest species were believed as a common and uncommon to the area. The 13 species of globally threatened birds were found in the sanctuary including adjacent mangrove area as well as paddy field (Table 6). The percentage of occurrence was estimated for globally threatened birds that found in the sanctuary and average occurrence was 7.7 during the study period. The species diversity index, Shannon Index (H) was calculated to be 4.4 and species richness was estimated 3 in the study area for the period of ten months. The Index value indicates that the structure of bird habitat is stable and balanced.

Table 6. Record of globally threatened avian species found in Gahirmatha marine sanctuary and adjoins area

Sl. no	Common name	Scientific name	Frequency of Sighting	Percentage occurrence
1	Black-tailed Godwit	<i>Limosa limosa</i>	51	31.09
2	Eurasian Curlew	<i>Numenius arquata</i>	31	18.90
3	River Tern	<i>Sterna aurantia</i>	14	8.53
4	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	15	9.14
5	Painted Stork	<i>Mycteria leucocephala</i>	6	3.65
6	Lesser Adjutant	<i>Leptoptilos javanicus</i>	6	3.65
7	Eurasian oystercatcher	<i>Haematopus ostralegus</i>	4	2.43
8	Oriental Darter	<i>Anhinga melanogaster</i>	7	4.26
9	Pallas’s Fish Eagle	<i>Haliaeetus leucorhynchus</i>	4	2.43
10	Brown winged kingfisher	<i>Pelargopsis amauroptera</i>	10	6.09
11	Indian Skimmer	<i>Rynchops albicollis</i>	7	4.26
12	Alexandrine Parakeet	<i>Psittacula eupatria</i>	8	4.87
13	Mangrove Pitta	<i>Pitta megarhyncha</i>	1	0.60

Ichthyofauna

During this survey 64 species of fishes were recorded from Gahirmatha coast (Table 7). Highest numbers of species were found at Paradeep fishing harbour followed by Dhamra harbour whereas Talachua witnessed a low turnout of species. The most noteworthy feature is that in December maximum numbers of species were recorded along the Gahirmatha coast as well as in three fishing harbor sites. However, in March and April minimum numbers of species were seen i.e. 43% less.

Different fishing gears like trawlers, gill-netters, and country boats were being used for fishing all along the coast. Country Boats were also used by fishermen in three fishing harbour for transportation of fish from river to shore.

Table 7. List of fishes found along the Gahirmatha coast, East Coast of India

Sl.No	Family	Scientific Name	IUCN Status
	Sillaginidae		
1	Sand whiting	<i>Sillago panijus</i>	NE
2	Silver sillago	<i>Sillago sihama</i>	LC
	Synodontidae		
3	Brushtooth lizardfish	<i>Saurida undosquamis</i>	LC
4	Bombay duck fish	<i>Harpodon nehereus</i>	NT
	Nemipteridae		
5	Japanese threadfin-bream	<i>Nemipterus japonicus</i>	NE
	Sphyraenidae		

Sl.No	Family	Scientific Name	IUCN Status
6	Banded Barracuda	<i>Sphyraena jello</i>	NE
	Cynoglossidae		
7	Carrot tonguesole	<i>Cynoglossus dubius</i>	NE
	Engraulidae		
8	Gangetic hairfin anchovy	<i>Setipinna phasa</i>	LC
9	Common hairfin anchovy	<i>Setipinna tenuifilis</i>	DD
	Hemiramphidae		
10	Common halfbeak	<i>Hemiramphus unifasciatus</i>	LC
	Scatophagidae		
11	Spadefish	<i>Scatophagies argus</i>	LC
	Belonidae		
12	Gar fish	<i>Tylosurus choram</i>	LC
13	Malabar halfbeak	<i>Rhynchoramphus malabaricus</i>	NT
	Kurtidae		
14	Indian hump head	<i>Kurtus indicus</i>	NE
	Haemulidae		
15	Blotched grunt	<i>Pomadasys maculatus</i>	LC
	Drepaneidae		
16	Spotted sicklefish	<i>Drepane punctata</i>	LC
	Ephippidae		
17	Spade fish	<i>Ephippus orbis</i>	LC
	Carcharhinidae		
18	Sliteye shark	<i>Loxodon macrorhinus</i>	LC
	Muraenesocidae		
19	Indian pike conger	<i>Congresox talabonoides</i>	NE
	Lutjanidae		
20	Blue-banded snapper	<i>Lutjanus kasmira</i>	LC
21	Snapper	<i>Lutjanus johnii</i>	LC
	Serranidae		
22	Duskytail grouper	<i>Epinephelus bleekeri</i>	DD
	Polynemidae		
23	Paradise threadfin	<i>Polynemus paradiseus</i>	LC
24	Fourfinger threadfin	<i>Eleutheronema tetradactylum</i>	EN
	Mugilidae		
25	Flathead grey mullet	<i>Mugil cephalus</i>	LC
26	Diamond-scale Grey Mullet	<i>Liza vaigiensis</i>	LC
	Stromateidae		
27	Chinese silver pomfret	<i>Pampus chinensis</i>	NE
28	Silver pomfret	<i>P. argenteus</i>	VU
	Ariidae		
29	Threadfin sea catfish	<i>Arius arius</i>	LC
30	Shovelnose sea catfish	<i>A. subrostratus</i>	NE
	Trichiuridae		
31	Longtooth hairtail	<i>Eupleurogrammus glossodon</i>	NE
32	Small head hairtail	<i>Lepturacanthus savala</i>	NE
	Terapontidae		
33	Crescent grunter	<i>Terapon jarbua</i>	LC
	Gerreidae		
34	Common silver-biddy	<i>Gerres oyena</i>	LC
	Sciaenidae		
35	Lesser tigertooth croaker	<i>Otolithes cuvieri</i>	NE
36	Bronze croaker	<i>Otolithoides biauritus</i>	DD
37	Bengal corvine	<i>Daysciaena albida</i>	LC
38	Blotched tiger-toothed croaker	<i>Pterotolithus maculatus</i>	LC
39	Largefin croaker	<i>Johnius macropterus</i>	LC
40	Belanger's croaker	<i>Johnius belangerii</i>	LC
41	Panna croaker	<i>Panna microdon</i>	LC
42	Chu's croaker	<i>Nibea chui</i>	DD
	Carangidae		
43	Torpedo scad	<i>Megalaspis cordyla</i>	LC
44	Yellowtail scad	<i>Atule mate</i>	LC
45	Malabar trevally	<i>Carangoides malabaricus</i>	LC
46	Indian threadfish	<i>Alectis indicus</i>	LC
	Sparidae		
47	King soldier bream	<i>Argyrops spinifer</i>	LC
	Lethrinidae		
48	Sand snapper	<i>Lethrinus frenatus</i>	LC
	Dasyatidae		
49	Stingray	<i>Megatrygon microps</i>	DD
	Pristigasteridae		

Sl.No	Family	Scientific Name	IUCN Status
50	Raconda	<i>Raconda russeliana</i>	LC
51	Bigeye ilisha	<i>Ilisha megaloptera</i>	LC
52	Indian pellona	<i>Pellona ditchela</i>	LC
Clupeidae			
53	Hilsa shad	<i>Hilsa ilisha</i>	LC
54	Blue sardine	<i>Sardinella leiogaster</i>	LC
55	Indian oil sardine	<i>S. longiceps</i>	LC
56	Bleeker smoothbelly sardinella	<i>S. clupeioides</i>	NE
57	Fringescale sardinella	<i>S. fimbriata</i>	LC
58	Chacunda gizzard shad	<i>Anodontostoma chacunda</i>	NE
Engraulidae			
59	Ramcarat grenadier anchovy	<i>Coilia ramcarati</i>	DD
60	Goldspotted grenadier anchovy	<i>C. dussumieri</i>	LC
61	Hamilton's thryssa	<i>Thryssa hamiltonii</i>	LC
62	Malbar anchovy	<i>T. malabarica</i>	DD
Scorpaenidae			
63	Common lionfish	<i>Pterois miles</i>	LC
Latidae			
64	Asian sea bass	<i>Lates calcarifer</i>	LC

LC = Least concern, VU = Vulnerable, NT = Near threatened,
EN = Endangered, NE = Not evaluated, DD = Data deficient

Normally two types of nets are being used to catch all types of available fish species in the coast. These were gill net and trawl net. There are three types of Trawl nets: mini high opening shrimp-cum fish trawl net, high opening trawl net and Low opening trawl net. Gill nets and trawl nets are made up of monofilament and multifilament nylon respectively. Gill nets are being used to catch small size fishes whereas trawl nets are used to catch both big and small ones. Mesh size and length of trawl nets are smaller than gill net.

Few groups of fishes were observed in both marine and estuarine water habitats. Their occurrence in both these habitats was restricted to particular season due to their migration from sea to river and vice versa in search of food and to spawn.

Molluscs

Total 41 species of molluscs were recorded along the coast during the study period. Of which nassa mud snail, spindle cone, horn snails, button tops and clams were encountered more in the area followed by others. The list of mollusks was recorded from the sanctuary have given in table 8.

The living fossils "Horseshoe crabs" (Marine arachnids)

Total 5,025 specimens of *Tachypleus gigas* (live and dead) and 601 individuals *Carcinoscorpius rotundicauda* were recorded from Ekakula during the study. Sighting frequency of horseshoe crabs during the new and full moon phase were statistically similar for *Tachypleus gigas* ($t = -0.320$, $p = 0.579$) and *Carcinoscorpius rotundicauda* ($t = 0.624$, $p = 0.431$). However, sighting of both the species was less in winter season. It is a matter of concern to observe more dead individuals than alive during the period of study where dead individuals accounted for 95.3 and 92.5% for *Tachypleus gigas* and *Carcinoscorpius rotundicauda* respectively. Only 63 live *Tachypleus gigas* with 20 males and 43 females and 21 live *Carcinoscorpius rotundicauda* with 15 males and 6 females were recorded.

Although the abundance of horseshoe crabs at Ekakula, varied among the transects over time, the mean density of live and dead *Tachypleus gigas* and *Carcinoscorpius rotundicauda* was 1.16 and 0.11 individuals/m² respectively. Sighting was highest in the summer season (April-June) for both species. In addition to this, the group decapods crustaceans including *Ocyropode macrocera*, *Ocyropode ceratophthalma*, *Ocyropode brevicornis*, *Matuta victor*, *Doclea rissonii*, *Scylla olivacea*, *Scylla tranquibarica*, *Portunus pelagicus*, *Portunus sanguinolentus*, *Charybdis feriata*, *Metopograpsus latifrons*, *Metopograpsus messor*, *Metapalax distinct*, *Uca rosea*, *Uca triangularis*, and *Uca annulipes* were documented and among shrimps *Melicertus canaliculatus*, *Metapenaeopsis stridulans*, *Metapenaeus affinis*, *Metapenaeus brevicornis*,

Penaeus monodon, and mantis shrimp (*Stomatopods spp.*) were also documented during the study period.

Table 8. List of molluscs found along the Gahirmatha coast, East Coast of India.

Sl No	Family	Scientific Name
	Nassariidae	
1	Sea snails	<i>Bullia melanoides</i>
2	Marine gastropod mollusks	<i>Bullia turrita</i>
3	Nassa mud snail	<i>Cyllene sulcata</i>
4	Nassa mud snail	<i>Cyllene oblique</i>
5	Cone-shaped Nassa	<i>Nassarius conoidalis</i>
6	Cone-shaped Nassa	<i>Nassarius acuticostus</i>
7	Nassa mud snails	<i>Nassarius cerritensis</i>
8	Channelednassa	<i>Nassarius dorsatus</i>
9	Dog whelks	<i>Nassarius stolatus</i>
10	Marine gastropod mollusks	<i>Nassaria teres</i>
	Donacidae	
11	Cuneate donax	<i>Donax cuneatus</i>
	Veneroidae	
12	Backwater hard clam	<i>Meretrix casta</i>
	Mytilidae	
13	Northern horse mussel	
14	Yellow banded horse mussel	<i>Modiolus metcalfei</i>
	Potamididae	
15	Horn snail	<i>Telescopium telescopium</i>
16	Girdled horn shell	<i>Cerithidea cingulata</i>
17	Mud Creeper	<i>Cerithidea obtuse</i>
18	Belitong snail	<i>Terebralia sulcata</i>
19	Giant mangrove whelk	<i>Terebralia palustris</i>
	Littorinidae	
20	Scabra periwinkle	<i>Littorina scabra</i>
21	Robust shell	<i>Littorina undulate</i>
22	Common periwinkle	<i>Littorina littorea</i>
	Arcidae	
23	Blood clam	<i>Anadara granosa</i>
	Myidae	
24	Sand gaper	<i>Mya arenaria</i>
	Solenidae	
25	Solen bivalve	<i>Neosolen aquaedulcioris</i>
	Tonnidae	
26	Tun snail	<i>Tonna dolium</i>
	Veneridae	
27	Yellow clam	<i>Meretrix meretrix</i>
28	Venus clams	<i>Paphia textile</i>
29	The button tops	<i>Umbonium vestiarium</i>
	Tellinidae	
30	Tellina bivalve	<i>Tellina angulata</i>
	Mesodesmatidae	
31	Marine bivalve	<i>Donacilla cornea</i>
	Olividae	
32	The olives	<i>Agaronia gibbosa</i>
	Turbinidae	
33	Blue-mouthed turban	<i>Astralium stellar</i>
	Ovulidae	
34	Rosy spindle cowry	<i>Phenacovolva rosea</i>
	Naticidae	
35	Bladder moon snail	<i>Neveritadidyma</i>
36	Lined moon snail	<i>Tanea lineate</i>
37	Moon snails	<i>Natica maculosa</i>
38	Moon snails	<i>Natica picta</i>
39	White Moon Snail	<i>Polinices mammilla</i>
	Ficidae	
40	Paper fig shell	<i>Ficus ficus</i>
	Cultelidae	
41	Razor clam	<i>Neosolen aquaedulcioris</i>

Total 16 species of crabs and six species of shrimps were listed that includes occurrence in inter-tidal area, benthic and pelagic habitat of the sanctuary.

Ecological assessment is a process for identifying and quantifying the number of species occurrence in an ecosystem and providing a scientifically justifiable approach to ecosystem management. Odisha, with its unique bio-geographic features like the Chhotanagpur Plateau, Eastern Highlands, Lower Gangetic Plains and Eastern Coastal Plains supports a large diversity of faunal assemblage in the state. The high faunal diversity is attributed to a large number of estuaries, coastal ecosystems, rivers and the presence of many pristine forests with high mountains.

Out of six hundred fifty-six globally threatened faunal species in India, sixty-nine (10% of India) distributed in Odisha, comprising 16 critically endangered, 21 endangered and 32 vulnerable categories. The faunal diversity of Odisha was recently compiled based on available data, new discoveries and comprises 114 species of mammals (103 wild and 11 domestic mammals), 537 avifaunal species, 131 reptilian species, 29 amphibian species, about 800 fish species and thousands of other invertebrates [34].

The Gahirmatha marine wildlife sanctuary and its neighboring area were found to support 338 faunal species which is very significant in relevance to species for the conservation and management of biological diversity of that particular site. The river Brahmani and Baitarani forms a large estuary and opening at the sanctuary and also many small river and rivulets opens to the Gahirmatha sanctuary, which provides more diversified habitats for large amount of faunal diversity. Generally, the global or continental diversity is well described by the abundance or richness of species [35], whereas regional or landscape diversity is less well described [36] and local diversity is often poorly described [37, 38]. The abundance and distribution of most faunal species may vary temporarily in relation to daily, seasonal or long-term cycles or fluctuations in their environments. This variation indicates the presence of greater genetic diversity and the diversity of communities to which the species belongs. Thus, sampling and observation of various faunal groups should be undertaken in day or night and in the seasons of highest activity. However, in present study the assessment of faunal species was undertaken for ten months merely. In this view, the random sampling was adopted for different groups of animals residing in the study site. In other case, expertise of the observer to record the species during ecological assessment of the faunal diversity is very important. Particularly in case of amphibians and birds the expertise and experience of the observer becomes very crucial for the identification of species with specific calls, and behavior. In the case of mammals, it is very important to identify from indirect evidence such as scats, droppings, pugmarks, footprints, scrape and feeding signs, etc.

Inventories of species are used in wide contexts and can be analyzed in many different views. As previous study states, "Look at species lists in a standard ecological paper and check how accurate are the data sets that, often, are analyzed with the most robust statistical analysis" [39]. In a given time window, no continuous sampling was done for faunal assessment in the sanctuary, it could have a greater number of species variations if the long-term monitoring of faunal biodiversity is allowed there. However, repeated surveys provide Long-term monitoring of faunal biodiversity is required to get basic information on the seasonal, annual and other cyclical changes and also to obtain detailed ecological assessment of rare, endangered, threatened or uncommon species in a particular location [40]. However, these are very cumbersome and expensive activities.

Gahirmatha is dignified to be the largest mass nesting rookery for Olive Ridley Sea Turtles in the world [41, 42]. The coastal water of Gahirmatha was declared as wildlife sanctuary in September 1997 to protect the Olive Ridley Sea Turtles in both nesting beaches

and in near-shore habitats. Conservation measures need to be taken up for safeguarding of the offshore congregation sites of the turtles. For this purpose, generation of base level information on the abundance and distribution of Olive Ridley Turtles in offshore water of Gahirmatha marine sanctuary is very much important. Off rookery congregations or “reproductive patch” of the turtles are observed up to a distance of 5-7km from the seashore, hence, such sites need to be identified and effective protection measures need to be taken up to protect the breeding turtles in a targeted manner with effective use of available resources. This is very much necessary to avoid guarding large number of spatial entities which may or may not be active in turtle habitats. Various studies have indicated the dynamic nature of the congregation patches in the breeding season of turtles. Hence, conservation measures need to be based on area specific rather than time specific in offshore for Olive Ridelys at Gahirmatha rookery or elsewhere in the world. Such reproductive patches need to be identified in every breeding season and demarcated with floats. Gahirmatha area encounters large number of fishing activities, incidental capture of Olive Ridley turtles occurs in trawl fisheries, longline fisheries, gill net and other net fisheries. As a major threat to this species in this site, intensive patrolling need be carried out in these potential sites to prevent any harmful fishing activities. Participatory approach to management which includes awareness, dialogues, discussions with various organizations, local fishermen and other stakeholders to get cooperation and coordination, has been highly stressed for this purpose [14].

Monitoring faunal biodiversity studies are of great significance in the ecological estimation of living resources occurring in distinct geographical locations of the world, defining extension of protected areas and documenting local extinctions or invading species for inferring impeding impact as well as assessment of environmental interferences [43]. In this context, the mammals, amphibians, reptiles, avifauna, fishes, mollusks, crustaceans, arthropods (arachnids) are important, as a number of species were documented in the sanctuary as well as adjoining Bhitarkanika area and an incredible assortment of little forms contributes to the complexity and function of ecosystems. The sanctuary area potentially rich in fisheries resources and three fishing harbours mostly depends on these sites for fishing. Therefore, fishing resources data have been obtained from these three harbours and other sources. The information on some crustacean species like *Ocypode macrocera*, *Ocypode ceratophthalma*, *Ocypode brevicornis*, *Matuta victor*, *Doclea rissonii*, *Scylla olivacea* species occurring in the study site have been confirmed (As per personal interaction with Dr. Anil Mahapatra).

With the purpose to develop a feasible conservation policy for horseshoe crabs, there is an urgent need of action which need to include sensitization of local law enforcement agencies like Forest Department. Effective implementation of monitoring protocols across the vulnerable intertidal areas of the Gahirmatha coast will further strengthen the conservation. Involvement of local fishermen and non-government organizations (NGOs) motivated for conservation are important part for this purpose. More particularly the activation of the fishing community only may fulfil major part of the purpose to conserve the horseshoe crabs. As the current study revealed the occurrence of great number of dead crabs along the stretch of coast and in spawning grounds, mass awareness programmes need be initiated to highlight the local conservation of horseshoe crabs [33]. Similarly, trained bird watchers may be deployed in the study area during annual bird census programme to confirm the accurate species and avian diversity. Odisha coast harbors 11 species of dolphins and one species porpoise, however, during this present study documented three species of dolphins and one porpoise in the sanctuary area. As previous study, the other dolphins are inhabited with deep or coastal water in Odisha coast [44]. Many threatened fish species documented in this study and those species export to neighbor states through the nearest fishing harbour. Therefore, fishing harbour close

to the study sites need monitor properly and should aware them to on threatened category species, not to catch those species, if accidentally caught, release back to sea immediately and these to be carried out through public participations. Rampant trawl fishing, standing net and aquaculture practice in near shore area major threats to the faunal biodiversity.

Conclusions

The sanctuary and adjacent area harbours the major faunal species and these areas need to be monitored properly. Consequently, it is extremely necessary for ecological assessment of faunal biodiversity in particular ecosystem which may help to park manager to implement proper management strategies for protection and conservation of various species before they undergone. Further, a comprehensive study in this site is required to explore details on the distribution and status of various faunal groups in this important marine sanctuary.

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