Marine biodiversity of Gulf of Kutch located in North-eastern Arabian Sea

Abstract
Marine biodiversity depends of many factors viz. sediment quality, water quality, tidal waves, tidal amplitude, intertidal zone influence, depth of sea, bottom topography, etc. Here, we have analyzed for these factors to assess the impact on marine biodiversity especially benthos and planktonic organisms. The study of Gulf of Kutch shows that the area is rich in coral reef and benthos; it should not be disturbed in any case for commercial or any other uses.

Keywords: marine biodiversity, arabian sea, gulf of kutch, corals

Introduction
The Gulf of Kutch is opening towards the north-eastern Arabian Sea. The channel depths is varying from 20 m at the head to 60 m in central areas of the outer Gulf. Though water depths of 25 m exist in the broad central portion of Gulf up to a longitude 70° E, the actual fairway is obstructed by the presence of several fish flocks. The high tidal influx covers the low lying area of about 1500 km² comprising networks of creeks and alluvial marshy tidal flats in the interior region. The creek system consists of three main creeks namely Nakti, Kandla and Hansthal and little Gulf of Kutch interconnecting through many other big and small creeks. All along the coast, very few rivers drain into the Gulf of Kutch and they carry only a small quantity of freshwater, except during brief monsoon. The southern shore of the Gulf has abundant islands and inlets covered with mangroves and surrounded by coral reefs. The northern shore is mostly sandy or muddy provoked by several fish flocks.

Physiological conditions
The Gulf has mixed and predominantly semidiurnal type tides with a large diurnal inequality. This is because of complex bathymetry, rough bottom topography and undulation in the shoreline which produce highly non-linear tidal interactions. The tidal waves are entering from the west side and the tidal amplitude increases considerably in the upstream of Vadinar due to shallow inner regions and narrowing cross-section. The tidal elevations (m) are as follows: (Table 1).

| Location | MHWS | MHWN | MLWN | MLWS | MSL |
|----------|------|------|------|------|-----|
| Okha     | 3.47 | 2.96 | 1.20 | 0.41 | 2.0 |
| Sikka    | 5.38 | 4.35 | 1.74 | 0.71 | 3.0 |
| Rozi     | 5.87 | 5.40 | 1.89 | 1.0  | 3.6 |
| Kandla   | 6.66 | 5.17 | 1.81 | 0.78 | 3.9 |
| Navlakhi | 7.21 | 6.16 | 2.14 | 0.78 | 4.2 |

MHWS = Mean high water springs; MHWN = Mean high water neaps; MLWN= Mean Low Water Neap; MLWS= Mean low water springs; MSL= Mean Sea level

Over the stretch of the Gulf, the mean spring tidal range increases impressively from 3.47m at Okha to 7.21m at Navlakhi. The phase lag between Okha and Kandla is 2 h to 2 h 25 min while between Okha and Navlakhi it is 3 h to 3 h 20 min. Due to high tidal ranges in the inner regions, the vast mudflats and coastal low lands which get submerged during high tide are fully exposed during low tide (Figure 1).¹

Water quality
The yearly deviation of water temperature is between 20°C and 30°C, although the localized higher temperature goes upto 35°C which can result in isolated water pools formed in shallow intertidal depressions during low tide. Vertical profiles of temperature and salinity reveal a nearly homogeneous water column with no vertical stratification due to intense tidal-driven turbulence mixing.

The suspended solids (SS) are highly variable, spatially and largely resulted from the dispersion of fine sediment from the bed and the intertidal mudflats due to tidal movements. Obviously, near shore shallow region, invariably sustain higher suspended solids as compared to the central zones. The region between Okha and Sikka has high variable suspended solids (4-308 mg/L) whereas the inner Gulf areas sustain markedly higher suspended solids, even up to 304 mg/L.

Figure 1 Map of Gulf of Kutch.

1. Rathoure, Ashok K. (2018). Marine biodiversity of Gulf of Kutch located in North-eastern Arabian Sea. International Journal of Avian & Wildlife Biology, 3(4), 312-318.
700 mg/L. The pH range of the Gulf water is remarkably constant (8.0-8.3) though wide variations (7.6-8.8) are not iced sometimes. The evaporation exceeds precipitation leading to salinities markedly higher than that of the typical seawater. This is particularly evident in the inner Gulf where salinities as high as 40 psu commonly occur off Kandla and Navlakhi. Although the salinities decrease considerably for a brief period in some creeks of the Little Gulf of Kutch under the influence of monsoonal runoff, the 20 impact of this decrease in the Gulf proper is small and salinities often exceed 36 psu at most of the locations.\(^3\)

The average DO is fairly high (35 mg/L) most of the times and the BOD is low (<0.1-6.3 mg/L) indicating good oxidizing conditions. The nutrients (PO\(_4^{3-}\), NO\(_3^-\), NO\(_2^-\), NH\(_4^+\)) are more or less uniformly distributed in the Okha-Sikka-Mundra segment and their concentrations indicate healthy natural waters. Their levels are marginally high in the Kandla-Navlakhi segment. Actually, the network of creeks of the Little Gulf of Kutch sustains high natural concentrations of nutrients perhaps due to high regeneration rates.

### Sediment quality

The central part of the Gulf of Kutch is rocky with sediments limited to the boundaries. The sediment near shore which consists of light gray silt, clay and fine sand with patches of coarse sand in-between, are poorly arranged with highly variable skewness. The major source of this sediment is considered to be the shore material and the load transported by the Indus River. The portion of sediment derived from the hinterland is considered to be small because of the low run-off. Furthermore, the streams discharging in the Gulf of Kutch are short with dams constructed on many of them.\(^4\)

### Methodology

The methodology and parameter adopted for this study mentioned in Table 2 below.\(^5\)–\(^16\)

#### Table 2 Mode of Data Collection and Parameters for Marine life

| Aspect          | Mode of data collection                                                                 | Parameters monitored                          | Remarks                                                                                           |
|-----------------|----------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------|
| Marine          | • Guidelines of APHA for water sample collection                                        | • Total genera                                 | Endangered, threatened and the most common fresh water and marine species.                        |
| Marine          | • Physical/virtual identification at site/direct sighting of fresh water or marine life.| • Major genera                                 |                                                                                                   |
| Marine          | • Confirmation from fisherman, local villagers, professionals, etc.                     | • Taxonomy                                     |                                                                                                   |
| Marine          |                                                                                        | • Nanoplanktonic Flagellates                   | By using Lackey’s drops method and light microscope                                              |
| Marine          |                                                                                        | • Cnidarians                                  | Physical/virtual identification                                                                |
| Marine          |                                                                                        | • Rotifera                                    | Verification by authentic agency (BSI, ZSI, FRI, NIO, etc.)                                      |
| Marine          |                                                                                        | • Chaetognatha,                               |                                                                                                   |
| Marine          |                                                                                        | • Polychaeta                                  |                                                                                                   |
| Marine          |                                                                                        | • Copepods                                    |                                                                                                   |
| Marine          |                                                                                        | • Cladocerans                                 |                                                                                                   |
| Marine          |                                                                                        | • Krill                                       |                                                                                                   |
| Marine          |                                                                                        | • Insect Larvae                               |                                                                                                   |
| Marine          |                                                                                        | • Tunicates, etc.                             |                                                                                                   |

\(1\) Rathoure AK. Marine biodiversity of Gulf of Kutch located in North-eastern Arabian Sea. *Int J Avian & Wildlife Biol.* 2018;3(4):312–318.

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Sampling locations

The sampling locations for marine biodiversity assessment are given in Table 3.

Table 3 sampling locations for marine biodiversity

| SNo | Locations | Code | SNo | Locations | Code |
|-----|-----------|------|-----|-----------|------|
| 1   | Okha      | MB1  | 9   | Ajad      | MB9  |
| 2   | Dholio Gugar | MB2  | 10  | Bural reef | MB10 |
| 3   | Dona      | MB3  | 11  | Dhani     | MB11 |
| 4   | Boria     | MB4  | 12  | Kalumbhar reef | MB12 |
| 5   | Mangunda  | MB5  | 13  | Narara reef | MB13 |
| 6   | Savaj     | MB6  | 14  | Goose reef | MB14 |
| 7   | Paga      | MB7  | 15  | Pirotan island | MB15 |
| 8   | Manmarudi | MB8  |      |           |      |

Results and discussion

The Gulf of Kutch flourishes in marine wealth and is considered as one of the biologically richest marine habitat along the west coast of India. The marine flora is highly varied and includes sand dune vegetation, mangroves, sea grasses, macrophytes and phytoplankton. In all 31 species of Chlorophyceae, 33 species of Phaeophyceae and 55 species of Rhodophyceae have been identified with the dominance of Phaeophyceae. The dominant species of sand dune flora are Euphorbia caducifolia, E.nerifolia, Aloe Vera sp, Ephemda foliata, Urochordia setulosa, Sporobolus maderaspatanus, Eragrostis unioildies, Calotropis procera, Fimbristylis sp, Indigofera sp and Ipomoea pes-caprae. The common sea grasses found growing on the mud flats are Halophila ovata, H. beccarii and Zostera marina.

The most common marine algal species are Ulva fasciata, U. reticulata, Enteromorpha intestinalis, Dictyota sp, Hypnea musciformis, Sargassum tennerimum, S. ilicifolium, Gracilaria corticata, Cystosera sp, Padina tetrastoma, Corallina sp, Laurencia sp, Caulerpa racemosa, Bryopsis sp, Turbinaria sp, Ectocarpus sp, Acanthophora sp, Chondria sp, and Codium sp.

The primary production of the water column as assessed from chlorophyll a concentration is generally high in the outer Gulf but decreases in the inner regions. Phytoplankton represents about 31 genera and 41 species. The major phytoplankton genera are Rhizosolenia, Synedra, Chaetoceros, Navicula, Nitzschia, Pleurosigma, Thalassiothrix, Biddulphia, Stauroomeis, Coscinodiscus andSkeletonema. The Gulf also sustains good and variable zooplankton and benthic standing stock with diversity. The primary and secondary trophic levels offer congenial feeding grounds for prawns and fishes in the Gulf.

The intertidal zone of the Gulf of Kutch is rich in biota. Sheltered bays, creeks and mud flats provide ideal sites form mangrove vegetation over an estimated area of about 1066.9 km². The formations are of open scrubby type, with isolated and discontinuous distribution from Kandla-Navlakhi in the northeast to Jodia, Jamnagar, Sikka, Salaya and Okha in the southwest, as also at Pirotan, Positra, Dholani and Dwarka. Vast stretches of mangroves also exist along the northern shore of the Gulf. The dominant species of mangroves are Avicennia marina var acutissima, A. officinalis, Bruguiera parviflora, B. gymnorrhiza, Rhizophora mucronata, R. apiculata, Ageiceros corrigulata, Ceriops tagal and Sonneratia apetata alongwith the associated species of Salicornia brachiatia, Rosella Montana, Suaeda fruticosa, Artiplex stockii and lichen.

The marine fauna of the Gulf is rich, both in variety and abundance. Sponges having an array of colours are observed, both in the intertidal and subtidal biotopes. The common species of sponge is Adocia sp, associated with coral reef fauna. In sandy and silty mud shores, Tetilla dactyloidea (Carter) is common.

The most frequently encountered hydrozoans are Sertularia sp and Plumularia sp. The giant sea-anemone (Stoichiactis giganteum) is a common sight in the coral ecosystem. Sea anemones, belonging to Anemonia, Bunodactis, Paracordylactis, Anthopleura and Metapeachia, are wide spread. Azcoantharian, Gemmalaria sp, is found forming extensive hexagonal green mats in the coral pools. Another interesting actiniarian is the Cerianthus sp found in tubes in the soft mud. The Gulf has 42 islands, 34 of which have live corals. Siltation is the main cause affecting the coral growth. The species diversity however is poor with identification of 36 species of Scleractinian and 12 species of soft corals. A number of polychaete worms, both sedentaria and errantia, with the dominant genera of Eurythoe, Terellida, Polyonoe, Iphione and Nereis are rather common. Amongst a variety of sipunculid and echiruroid worms, the dominant species are Dendrostromum sp, Asphidosiphon sp and Ikadella misakiensis (Ikeda). The intertidal crustacean fauna is very rich and equally diverse with spider crab (Hyas sp) and furry crab (Pillumnus sp), as specialties.

Amongst the invertebrate component of the marine fauna of the Gulf, the molluscs have the highest representatives. As many as 92 species of bivalves, 55 species of gastropods, 3 species of cephalopods and 2 species each of scaphopods and amphineurans have been reported. The most notable members of the molluscan fauna are octopus, pearl oyster and a variety of chanks, including the sacred chank. Pinna bicaler, the bivalve is commonly noticed in the coral reef flat. The echinoderm fauna, represented by 4 classes and 14 genera, have the commonest genera of Pelpmsis, Astropecten, Asteria, Temnoploea and Holothuria. The subtidal benthic fauna of the Gulf is dominated by polychaetes, crustaceans, echinoderms, gastropods and bivalves, with an average biomass of 25 g/m².

The Gulf of Kutch has a variety of exploitable species of finfishes and shellfishes. The sciaenids, polynemids, perches, eels, cat-fishes, elasmobranchs and prawns are commercially important groups with an average catch of 1.4 x 10³ ton/year. The fishing grounds for Ghoh, Karkara, Khaha, Dhoma, Magra and Musi exist in the Gulf. The Gulf region offers plenty of facilities for feeding, breeding and shelter to a variety of birds. In the mangrove forests lining the islands and along the coast, the birds find a near perfect environment. In addition, they are well placed to reach their food supply i.e. the shoals of fish, squids, mud skippers and other animals, during low tide. All along the creeks and around islands, mangrove trees and mudflats are seen crowded with Grey Herons, Pond Herons, Painted Storks, Large and small Egrets, Darters, Cormorants, Flamingos, Lesser Flamingos, etc. during the period of seasonal migration (November-March).37

The large congregations of uncommon coastal waders such as Bar-tailed Godwit (Limosa lapponica), Sanderling (Calidris alba), Large Sand Plover (Charadrius leschenaultii), Eurasian Curlew (Numenius
arquata), Eurasian Oystercatcher (Haemotopus ostralegus) and Crab Plover (Dromas ardeola) occur only in the Gulf. As per the Bird Life International Red Data List and IUCN 2002 Red Data Book, the MNP is home to several globally threatened species, such as Spot-billed Pelican (Pelecanus philippensis), Dalmatian Pelican (P. crispus), Greater Spotted Eagle (Aquila clanga), Indian Skimmer (Rynchops albicollis), Black-necked Stork (Ephippiorhynchus asiaticus) and Pallas’s Fishing Eagle (Paliaeetus leucoryphus). The Gulf region is also important for marine turtles and sea mammals.17

Though a detailed systematic survey of biota is lacking, following number of species have been reported: (Table 4)

### Table 4 Number of marine species

| Flora/fauna | Species (Nos.) |
|------------|---------------|
| Algae      | 130           |
| Molluscs   | 200           |
| Sponges    | 70            |
| Crabs      | 30            |
| Corals     | 36            |
| Birds      | 200           |
| Fishes     | 200           |
| Sea mammals| 3             |
| Sharks     | 8             |
| Sea turtles| 3             |
| Prawns     | 27            |

Because of its high bio-geographical importance and rich flora and fauna, several areas along the southern Gulf are notified under the Marine National Park (16,289 ha.) and the Marine Sanctuary (29,503 ha.) (Figure 2).

### Table 5 List of intertidal algae of the Gulf

| Name                        | Status* | Name                        | Status* | Name                        | Status* |
|-----------------------------|---------|-----------------------------|---------|-----------------------------|---------|
| Boodlea composita           | C       | Colpomenia sinuosa          | C       | Acanthophora delilei        | C       |
| Bryopsis indica             | C       | Gystoeira indica            | C       | A. specifera                | R       |
| B. plumose                  | C       | Dicryota atomaria           | C       | Anphira fragilissima        | R       |
| B. ramosa                   | C       | D. bartyrisiana             | R       | Asparagopsis taxiformis     | C       |
| Caulerpa crassifolia        | C       | D. cervicornis              | R       | Botryocladia leptopoda      | C       |
| C. cupressoideas            | C       | D. ciliolate                | C       | Calaglossa bombycans        | R       |
| C. racemosa                 | C       | D. dichotoma                | C       | Ceramium sp.                | C       |
| C. scaphelliformis          | C       | D. dwaricata                | R       | Chondria indica             | C       |
| C. sertularioides           | C       | Dicryopteris australis      | C       | Chondria ornata             | R       |
| C. taxiformes               | C       | D. woodwardii               | C       | C. dasypHylla               | R       |
| C. verticilata              | C       | Ectocarpus sp.              | C       | Coelorchium opuntia         | C       |
| Chaetomorpha indica         | C       | Hinskaia Mitchellle         | C       | Corallina officinalis       | C       |
| Chamaedoria auriculata      | C       | Hormophysa triqueta         | R       | Caryomorphe prismatic      | R       |
| Codonospora glomerata       | C       | Hydroclathus clathatus      | R       | Cryptopleur sp.             | R       |
| C. profifera                | C       | Iyengaria stellata          | C       | Dasya sp.                   | R       |
| Codium decorticatum         | R       | Myriokleora scirius         | R       | Desmio hormanni             | R       |
| C. dwarkensis               | C       | Nemacystus decipiens        | R       | Gastroclonium iyengarii     | R       |

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| Name                      | Status* | Name                      | Status* | Name                      | Status* |
|--------------------------|---------|--------------------------|---------|--------------------------|---------|
| C. elongatum             | C       | Padina gymnospora        | R       | Galaxaura oblongata      | C       |
| Dictyosphaeria cavernosa | C       | R. tetrastromatica       | C       | Gelidella acerosa        | C       |
| Enteromorpha intestinale | C       | Pocockiella sp.          | C       | Gelidiosps gracilis      | C       |
| Halideda tuna            | C       | Rosenvingia intricata    | R       | Gigartina sp             | R       |
| Pseudobryopsis mucronata | R       | Sargassum johnstonii     | C       | Gracilaria corticata      | R       |
| Spongamorpha sp.         | C       | S. tenerrimum            | C       | G. pygmaea               | C       |
| Udoea indica             | C       | S. plagiophyllum         | R       | Gastroclonium iyengarii  | R       |
| Ulva fasciata            | C       | S. swartzii              | C       | Galaxaura oblongata      | C       |
| U. lactuca               | C       | S. weightii              | R       | Gelidella acerosa        | C       |
| U. reticulata            | R       | Spathoglossum asperum    | R       | Valonia utricularis      | R       |
| Valonia utricularis      | R       | S. variable              | C       | Valloniopsis spachynema   | R       |
| Valloniopsis spachynema   | R       | Gelidiosps gracilis      | C       | -                        | -       |
| Stoechospermum marginatum| C       | Gigartina sp             | R       | -                        | -       |
| Spathoglossum asperum    | R       | Gracilaria corticata     | R       | -                        | -       |
| S. variabile             | C       | G. pygmaea               | C       | -                        | -       |
| Stoechospermum marginatum| C       | G. verrucossa            | R       | -                        | -       |
| Turbinaria ornata        | R       | Grateloupia inica        | C       | -                        | -       |
|                          |         | G. felicina              | R       | -                        | -       |
|                          |         | Haloplegma sp.           | R       | -                        | -       |
|                          |         | Holymenia florea         | R       | -                        | -       |
|                          |         | H. parphyroides          | C       | -                        | -       |
|                          |         | H. venusta               | C       | -                        | -       |
|                          |         | Helminthoclodia clayadosii| C       | -                        | -       |
|                          |         | Heterosiphonia mueller   | C       | -                        | -       |
|                          |         | Hypnea cervicornis       | C       | -                        | -       |
|                          |         | H. musciformis           | C       | -                        | -       |
|                          |         | Hypoglossum spathulatum  | R       | -                        | -       |
|                          |         | Laurencia papillosa      | C       | -                        | -       |
|                          |         | L. pediculatioides      | C       | -                        | -       |
|                          |         | Liagora crenoides       | R       | -                        | -       |
|                          |         | Lophocladia lallemandi   | R       | -                        | -       |
|                          |         | Neurymenia fraxinfolia  | R       | -                        | -       |
|                          |         | Polysiphonia sp.         | C       | -                        | -       |
|                          |         | Rhodymenia australis     | C       | -                        | -       |
|                          |         | R. palmate               | C       | -                        | -       |
|                          |         | Scinaia indica           | C       | -                        | -       |
|                          |         | S. furcellata            | R       | -                        | -       |
|                          |         | Sebdenia polyactyla      | C       | -                        | -       |
|                          |         | Spyridia alternans       | C       | -                        | -       |
|                          |         | Soleria robusta          | C       | -                        | -       |

Note: C=Common, R=Rare

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Table 6: Distribution of corals in the Gulf

| Species/Location | MB1 | MB2 | MB3 | MB4 | MB5 | MB6 | MB7 | MB8 | MB9 | MB10 | MB11 | MB12 | MB13 | MB14 | MB15 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| Exannulacora digitata | -   | -   | -   | -   | -   | -   | +   | -   | -   | -    | -    | -    | -    | -    | -    |
| Acropora humilis  | -   | -   | +   | -   | -   | +   | +   | -   | -   | -    | -    | -    | -    | -    | -    |
| A.squamosa       | -   | -   | +   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Montipora explanata | +  | -   | +   | -   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| M.venosa         | -   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| M.turgescens     | +   | +   | +   | +   | +   | +   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| M.hispida        | -   | -   | +   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| M.foliosa        | -   | -   | +   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| M.monasteriata   | -   | -   | +   | -   | +   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Cacosclerion monile | +  | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| Siderastrea      | +   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| savignyana       | +   | -   | +   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Pseudosiderastrea | +  | -   | -   | -   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| tayani            | +   | -   | -   | -   | +   | +   | +   | +   | -   | -    | -    | -    | -    | -    | -    |
| Goniopora        | +   | +   | -   | +   | +   | +   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| planolata         | +   | -   | -   | +   | +   | +   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| G.minor           | +   | -   | +   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| G.nigra           | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| Porites leutea    | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| Flithen           | +   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Pcompressa        | +   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Favites speciosa  | -   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| F.favus           | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| Favites complanata | +  | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| F. melicus       | +   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Goniastrea       | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| pectinata         | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| Platygyra sinensis | +  | +   | +   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Hydnopora exesa   | +   | +   | +   | +   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Plesiastrea       | +   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| versipora         | +   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Leptastrea        | +   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| purpurea          | +   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Cyphastrea serelia | +  | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| Symphylia radian  | -   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Acanthastrea      | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| simplex            | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| Mycedium          | -   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| elephantotus      | -   | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Paracorynus stokesi | +  | -   | -   | -   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Polycorynus verrilli | +  | +   | +   | +   | -   | -   | -   | -   | -   | -    | -    | -    | -    | -    | -    |
| Tubastrea aurea   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| Turbinaria crater | +   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
| T.peltata         | -   | +   | +   | +   | +   | +   | +   | +   | +   | +    | +    | +    | +    | +    | +    |
Marine biodiversity of Gulf of Kutch located in North-eastern Arabian Sea

Planktonic and Benthic Habitat

Survey was conducted for the study of planktonic and benthic habitat. Study of biological status of any water body play an important role in assessing the causes of impact on water body and quality of the water. Here the biological parameter considered during EB survey are primary productivity, phytoplankton count, pigment analysis, zooplankton count, availability of benthic organism, fish and other micro habitat (Table 5&6).

In recent years, biodiversity of Marine Park/Marine Sanctuary has been under threat on several scores like extraction of corals and sands by cement industries, increased turbidity of water, oil refineries, chemical industries and mechanized fishing boats. Kumar et al.,\(^2\) have reported 31 species of corals in the Marine National Park. There were two catastrophic and localized bleaching events happened in this region.\(^3,4\) Coral bleaching and associated mortality not only have negative impacts on coral communities, but they also impact fish communities and the human communities that depend on coral reefs and associated fisheries for livelihoods and wellbeing. Bleached corals are likely to have reduced growth rates, decreased reproductive capacity, increased susceptibility to diseases and elevated mortality rates. Nearly everything in a coral-reef ecosystem depends on corals, or on the reef structure in some way. Coral colonies provide a source of food and shelter for countless reef-associated organisms and their health is of critical importance to the ecology of the reef community.

Conclusion

The area in question is rich in marine biodiversity especially Corals and some part of the Gulf has been protected under Marine National Park and Marine Sanctuary in 1980 under the provision of the Wildlife (Protection) Act, 1972 of India. There are many illegal fishing, fish trade, goods transport and many other activities reported from the area in question. The situation is going to worsen due to increase in ship transportation. There is an urgent need to implement the effective ecological management plan to restore the marine biodiversity of the Gulf of Kutch.

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Conflict of interest

Author declares that he has no conflict of interest.

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