

6. SUMMARY

Gulf of Katchchh (herein after termed as Gulf) occupying an area of 7300 Km² is biologically one of the most productive and diversified habitats along the west coast of India. The southern shore has numerous Islands and inlets which harbour vast areas of mangroves and coral reefs with living corals. The northern shore with numerous shoals and creeks also sustains large stretches of mangroves. A variety of marine wealth existing in the Gulf includes algae, mangroves, corals, sponges, molluscs, prawns, fishes, reptiles, birds and mammals.

Industrial and other developments along the Gulf have accelerated in recent years and many industries make use of the Gulf either directly or indirectly. Hence, it is necessary that the existing and proposed developments are planned in an ecofriendly manner to maintain the high productivity and biodiversity of the Gulf region. In this context, Department of Ocean Development, Government of India is planning a strategy for management of the Gulf adopting the framework of Integrated Coastal and Marine Area Management (ICMAM) which is the most appropriate way to achieve the balance between the environment and development. The work has been awarded to National Institute of Oceanography (NIO), Goa. NIO engaged Vijayalakshmi R. Nair as a Consultant to compile and submit a report on the status of flora and fauna of the Gulf based on secondary data. The objective of this compilation is to (a) evolve baseline for marine flora and fauna of the Gulf based on secondary data (b) establish the prevailing biological characteristics for different segments of the Gulf at macrolevel and (c) assess the present biotic status of the Gulf.

The project domain for the present study covers the water-spread areas of the Gulf. The southern coast of the Gulf extends from Okha to Navlakhi and the northern coast from Kandla to Kori creek. The western extremity of the Gulf consists of a vast complex of marshland criss-crossed by innumerable creeks. Kandla, Nakti and Hansthal creeks are the major tributaries of the inner Gulf and drain into the Little Gulf of Kachchh. The Gulf is endowed with a great diversity of natural ecosystems, of which the major systems are salt pans, intertidal zones, marine algae, sea grass and sand dunes, mangroves, coral reefs, creeks and open ocean.

6.1 Source of information

This status report on the biota of the Gulf has been prepared based on secondary data scattered over a wide array of technical reports, scientific reports and remote sensing data. These were procured, collated and assessed to describe the biotic setting of the Gulf.

6.1.1 NIO database

NIO has been conducting general and site-specific studies in the Gulf since 1981 with more frequent investigations in recent years due to several proposed and ongoing developments bordering the Gulf, particularly along the southern coast. A total of 51 investigations were carried out by NIO during 1981-2001 generating an extensive database. The Environmental Impact Assessment (EIA) reports of NIO cover different segments of the Gulf. There are 13 technical reports for Okha, 1 for Salaya, 7 for Vadinar, 5 for Sikka, 3 for Bedi, 1 for Navlakhi, 10 for Kandla, 4 for Mundra, 2 for Jakhau, 1 for Kharo creek and 2 for Kori creek, 1 report on status of corals in the Gulf and 1 report for a special block area in the outer Gulf.

6.1.2 Reports of other Institutions

Among the scientific reports from sources other than NIO, the recent reports from Gujarat Ecological Society and others by individual authors are significant as these are benchmark surveys consolidating the available data on geomorphology, marine ecology and

threats, coral reefs, environmental problems etc. Issues and problems involved in managing protected areas were also reported in detail.

6.1.3 Published papers

There is fairly large number of publications on the biological aspects of the Gulf. The major part of the studies are related to mangroves, corals, benthos and fishery.

The studies on algae cover mainly on their diversity, exploitation and chemical content in certain species. Status and ecological aspects of mangroves are well documented. There are only limited studies on phytoplankton and zooplankton. Several papers are available on benthos which includes pearl oysters, oysters, macrobenthos, species diversity of gastropods and pelycypods, echiuroids, crabs, holothuroids, sponges and sipunculids. Reports on fishery include details on chief schooling fishes, demersal fishery, fishery of major species found in the Gulf and fishery potential of the interior Gulf. The papers on prawn fishery include catch composition abundance and diversity of common shrimps and seasonal prawn fishery of Little Rann of Kachchh. Studies are available on the molluscan fishery of the Gulf which cover the pearl fishery potential, exploitation of chank fishery and oyster and cephalopod resources. Studies were conducted on *Artemia* and fish/ prawn resources of the saltpans of Gulf. Abundance and diversity of corals, their ecology and resource potential, research and management of coral reefs are some of the areas covered under corals. There are only a few papers on reptiles and mammals of the Gulf while information on birds of the Gulf is well documented. Anthropogenic pressure on the coastal marine ecosystem of the Gulf, the need for conservation of flora and fauna, habitat damages of corals and increase in the movement of oil and petroleum products are some of the areas which have received attention. Importance of remote sensing in coastal mapping and obtaining information on coral reef zonation, identification of seaweeds and mangroves etc. have been reported through a series of publications.

6.2 Types of ecosystems

Saltpans are unique tide water impounded enclosed system adjacent to creek environment. The distinct feature of the brine ecosystem is its biotic simplicity and stability. Species diversity is directly linked with salinity, the higher the salinity, the lower the species diversity. In the Gulf there are about 21 salt work units.

The intertidal habitat of the Gulf covers a wide range of ecosystems like sandy beaches, mud flats, rocky shore, sea grass beds, salt marshes and mangroves. The intertidal expanse of the Gulf increases towards upstream. The increase is from 0.5 to 2 km from Jakhau to Kandla and from around 1 km at Okha to over 10 km at Navlakhi. Gulf sustains a rich and highly diversified intertidal flora and fauna.

The area under mangrove cover along the Gujarat coast is the second largest in India, next only to the Sundarbans area. Majority of the mangrove cover of Gujarat area is confined to the Gulf. Of the 991 km² of mangrove cover for the state, Gulf contributes 96% of the total. Due to high salinity, grazing and cutting pressure the Kachchh mangroves have stunted growth and are only 1-2 m tall and at untouched patches gain a height upto 5 m.

The Gulf contributes to the maximum species and biomass of seaweeds for the west coast of India. The southern coast of Gulf supports luxuriant growth of marine algae while the northern shore has very poor algal biodiversity due to high turbidity. Ridges of loose sand drifted by wind often support sand dune vegetation and 5 species predominated the community.

Coral reefs are shallow water tropical marine ecosystem known for its high biological productivity. The coral formations of the Gulf are found exclusively along the coast of Jamnagar district. The Gulf is the only area in Gujarat where corals exist with high diversity and density. The reefs in Gulf are classified as fringing reefs, plat form reefs, patch reefs and coral pinnacles. The most northerly reefs are coral patches found at Munde reef and Pirotan Island, but solitary corals are found as far as Jakhau in the east and Dwarka in the Saurashtra coast.

There is a network of creeks and alluvial marshy tidal flats in the interior part of the Gulf. During dry season salinities upto 50 ppt have been recorded in the Little Gulf of Kachchh. However, during the monsoon period fresh water influx considerably dilutes the sea water in the creeks and salinities of < 10 ppt may occur. Depending on the salinity regime typical estuarine and oceanic communities prevail in the creek system.

The open ocean has very specific characters. Most evident are its uniformity and stability in environmental conditions, its three dimensional space and its vastness. Typical oceanic fauna exhibits high diversity. Data for open ocean of the Gulf are limited.

6.3 Marine National Park and Marine Sanctuary

The southern Gulf between Okha to Navlakhi of Jamnagar district is declared as MNP & S to protect and conserve the fragile ecosystem particularly the live intertidal and subtidal coral reefs and mangrove habitats of the Gulf. As per state Government notification, an area of 457.92 km² of MNP & S includes 148.92 km² of 42 small and big Islands with coral reefs and mangrove forests and 309 km² intertidal zone along the coast. Area of MNP is 162.89 km² where as the remaining protected areas have the status of Marine Sanctuary.

6.4 Flora and fauna

For effective assessment of the biotic status of the Gulf, the area is considered as southern Gulf (Okha, Salaya, Vadinar, Sikka, Bedi and Navlakhi) and northern Gulf (Kandla, Luni, Mundra, Jakhau, Khari creek and Kori creek). The results are presented separately for the southern Gulf (first para of each parameter) followed by the northern Gulf (second para of each parameter).

6.4.1 Bacteria

Data on bacterial population in water and sediment are available for some segments. TVC and TC are important in making comparisons between zones as the former indicates the fertility while the latter the health of the water. TVC is maximum (av. 1.6×10^3 /ml) at Okha with much lower values at Vadinar, Sikka and Bedi (av. 160-278/ml). TC values are the lowest at Okha (av. 12.5/ml) which marginally varied between 14-22/ml at the other segments. As can naturally be expected in sediment TVC and TC are at much higher level as compared to water. TVC in sediment was maximum at Bedi (17.48×10^4 /g dry wt) followed by Vadinar (15.21×10^4 /g dry wt) and the lowest value is at Okha (av. 10.27×10^4 /g dry wt). TC values in sediment are relatively high only at Vadinar. Levels of coliforms and pathogens indicate low-level contamination off Vadinar, Sikka and Bedi.

TVC values in water at Kandla are relatively more (14.1×10^3 /ml) as compared to Mundra (7.2×10^3 /ml) with low values at Luni (194/ml). TC is also low at Luni (7/ml) than that observed at Munda (3.3×10^2 /ml) and Kandla (44/ml). Proportionately high concentration of TVC and TC are found in the sediments of Kandla and Mundra. The presence of faecal coliform and some of the harmful pathogens, though in low numbers, is indicative of low-level contamination off Kandla, Luni and Mundra.

6.4.2 Mangroves and algae

The southern coast of Gulf has luxuriant growth of algae. Off Okha, *Avicennia marina* is the only species of mangrove found either as dense areas or in degraded patches with three associated halophytes. Okha segment harbours rich algal flora of 59 species. Sikka-Salaya region has extensive growth of mangroves. *Avicennia* stands near Salaya are scrubby in nature. Though *A. marina* is the dominant species, in some areas, four more associated species are found. Intertidal areas around Vadinar harbour dense mangrove forests constituted mainly by *A. marina*. Narara bet sustains 6 species of mangroves and 4 associated species. A total of 62 species of algae and 3 species of sea grasses are recorded from this region. At Kalubhar Island, the mangrove area is represented by 6 species, dominant being *A. marina*. There are 3 associated halophytes. The intertidal segment supports 47 species of marine algae and 3 species of sea grasses. 42 species of algae are reported from Sikka. Mangroves are comprised mainly by *A. marina* along with two species of halophytes. At Bedi mangroves are observed either as continuous fringing thick stretches or in large patches. 5 species of mangroves are found at Bedi with predominance of *A. marina*. The area supports 4 species of obligate halophytes. Extensive growth of sea weeds on the reef of Pirotan Island occur and a total of 44 species of marine algae are recorded from Pirotan. Beach vegetation of Pirotan Island has 4 species of sand dune flora. Mangroves of Navlakhi region are of the fringing type. There are 4 species of mangroves with the predominance of *Salicornia brachiata*. Two associated species are observed at Navlakhi.

In general, the northern shore of the Gulf supports very poor algal diversity. At Kandla there are patchy stretches of mangroves predominated by *A. marina* and the flora is dominated by 3 mangroves and obligate halophyte species each. The intertidal region of Luni has stray mangroves mainly of *A. marina*. At Luni the alga *Enteromorpha* sp. is common with occasional presence of the halophyte *Sueda maritima*. The mangroves around Mundra Port are some of the best mangrove formations along the northern shore of the Gulf. Mangroves are represented by two species with predominance of *A. marina* and 3 obligate halophytes. Jakhau with its extensive mud flats harbour dense mangroves. The dominant mangrove species is *A. marina* associated with 6 species. Patches of mangroves are seen towards the interior part of Kharo creek and the species seen is *A. marina*. Kori creek has vast mangrove coverage along east and north shores. *A. marina* dominated the area with 7 associated flora.

6.4.3 Phytoplankton

Primary productivity data are available only for Okha and Bedi segments. Rate of production at Bedi ($34.73 \text{ mgC/m}^3/\text{h}$) is much higher as compared to that of Okha ($7.1 \text{ mgC/m}^3/\text{h}$).

Chlorophyll *a* shows marginally higher concentration at Okha and Bedi (av. 1.5 mg/m^3), followed by Salaya (1.4 mg/m^3), Sikka (1.3 mg/m^3), Navlakhi (1.2 mg/m^3) and Vadinar (0.8 mg/m^3). Phaeophytin values are lower than chlorophyll *a* at all segments suggesting a delicate balance between the growth and mortality of algae. Cell count is maximum off Okha (av. $654.2 \times 10^3/\text{l}$) with moderate values at Bedi (av. $118 \times 10^3/\text{l}$) and Sikka ($71.7 \times 10^3/\text{l}$). Total number of genera represented in the samples is fairly high at all segments with comparable values (av. 9-11) except at Navlakhi (av. 17). Generic diversity of phytoplankton at Okha, Vadinar, Sikka, Bedi and Navlakhi are respectively 40, 43, 38, 32 and 17 indicating a rich faunal assemblage at all locations except Navlakhi. Temporal variation in phytoplankton pigments at different segments along the southern Gulf indicates that peak chlorophyll *a* concentration is observed either in the morning or evening at Okha, Vadinar and Bedi while at other segments the pattern is irregular. Effect of tide on the level of chlorophyll *a* shows maximum concentration during ebb at Okha, Salaya, Sikka and Bedi while flood period

sustained peak in chlorophyll *a* concentration at Salaya, Vadinar and Bedi. Phaeophytin on a few occasions show higher values at bottom as compared to chlorophyll *a*.

Chlorophyll *a* in the water column was maximum at Kori creek (2.3 mg/m^3) followed by Kharo creek (2.1 mg/m^3), Mundra (2.0 mg/m^3) suggesting moderately high primary production potential. The levels of chlorophyll *a* at Kandla, Luni and Jakhau are moderate ($1.0\text{-}1.4 \text{ mg/m}^3$). Phaeophytin values are mostly lower than chlorophyll *a* indicating a healthy condition. Phytoplankton population is high at Luni ($202.7 \times 10^3/l$), Mundra ($112 \times 10^3/l$) and Jakhau ($171 \times 10^3/l$). Moderate cell counts are observed at Kandla and Kori creek with very low value at Kharo creek. Maximum genera are found at Jakhau (av. 18) and Luni (av. 13). Moderate diversity is observed at other segments with very low value (av. 4) at Kharo creek. Total number of genera recorded at Kandla, Luni, Mundra, Jakhau, Kharo creek and Kori creek are respectively 27, 27, 22, 18, 18 and 28. Temporal variation in phytoplankton pigments does not indicate any regular pattern. In general, ebb period sustains higher concentration of pigments at Mundra and Kori creek. At Kandla and Jakhau the flood period has higher pigments while at Luni tidal difference is not imminent.

6.4.4 Zooplankton

Zooplankton standing stock is low off Okha (av. $3.4 \text{ ml}/100\text{m}^3$) and Vadnar (av. $4.9 \text{ ml}/100\text{m}^3$). Fairly high values are observed off Bedi ($8.7 \text{ ml}/100 \text{ m}^3$) and Sikka ($11.2 \text{ ml}/100\text{m}^3$) with high biomass at Salaya ($28.8 \text{ ml}/100\text{m}^3$) and Navlakhi ($22.1 \text{ ml}/100 \text{ m}^3$). Population density of zooplankton shows a different trend with the highest density off Okha ($209.3 \times 10^3/100 \text{ m}^3$) and fairly high values off Salaya and Bedi. Moderate values are observed at other segments. Faunal representation is almost consistent at all segments (av. 10-12). Zooplankton faunal groups represented at Okha, Salaya, Vadinar, Sikka, Bedi and Navlakhi are respectively 23, 16, 21, 23, 20 and 18 respectively. Temporal variation of zooplankton standing stock shows that the pattern of diel variation is comparable between biomass and population. Zooplankton biomass is maximum during the early hours like that observed at Okha, Salaya, Vadinar and Bedi. The pattern is irregular at other segments. Tidal variation shows maximum biomass during ebb period except at Sikka and Navlakhi.

Biomass of zooplankton is fairly high at the segments between Kandla and Jakhau with moderate value at Kori creek and very low value at Kharo creek. Maximum standing stock is seen at Kandla ($26.2 \text{ ml}/100\text{m}^3$). However, population density is highest at Kharo creek ($181.2 \times 10^3/100\text{m}^3$). Population density at other segments is moderately high except at Jakhau where the population is relatively low. Group diversity is comparable between segments except for the relatively low value at Kharo creek. Total number of groups recorded is more at Kandla, Mundra and Kori creek (20-21), relatively low at Luni and Jakhau (16-18) and the lowest at Kharo creek (14). Total number of faunal groups found at Kandla, Luni, Mundra, Jakhau, Kharo creek and Kori creek are respectively 20, 13, 20, 18, 14 and 21. Temporal variations in zooplankton biomass and population show comparable pattern of distribution. Peak in zooplankton standing stock is highest during morning or in the evening at Kandla, Mundra, Jakhau and Kori creek. Flood period shows peak in zooplankton standing stock at all segments except at Mundra.

6.4.5 Biofouling and corrosion

Data on biofouling potential of the Gulf is limited to the observation on Kharo creek. Biofouling potential is fairly high at this creek and is dominated by hard-shelled fouling organisms like barnacles and oysters. The biomass build-up during 6 months of observation indicates a maximum of 5.95 kg/m^2 . The maximum corrosion rate is found to be 32.98 mils per year (mpy), while the six months cumulative rate scaled down to 16.48 mpy.

6.4.6 Intertidal macrobenthos

Intertidal macrobenthic biomass is very high at Vadinar (148 g/m^2) and Sikka (151 g/m^2) compared to Bedi (64.5 g/m^2) and Okha (11.7 g/m^2). Trend in population density followed the same pattern like that of biomass. Group diversity in the collection was maximum at Okha (av. 18) with comparable values for other segment (av. 9-10). Faunal representation is maximum at Vadinar (41) followed by Okha (32), Sikka (31) and Bedi (26).

Kharo creek has very rich intertidal benthic biomass (av. 509.1 g/m^2) and population (av. $59173/\text{m}^2$). Kori creek also sustains high intertidal biomass (av. 42.2 g/m^2) with moderate population (av. $1073/\text{m}^2$). Moderate to high standing stock is observed at Luni and Mundra. Kandla and Jakhau support low intertidal standing stock. Number of groups represented is relatively more at Mundra (av. 16) and Luni (av. 13), moderate at Kandla (av. 9) and low at Jakahu to Kori creek (av. 4-6). Total number of groups recorded from different segments shows maximum number at Mundra (28) followed by Kandla (23). Other segments registered 13 to 16 groups except at Kharo creek (6).

6.4.7 Subtidal macrobenthos

The subtidal macrobenthos at all segments are low as compared to intertidal standing stock except off Okha. Subtidal benthic biomass is maximum off Bedi (av. 44.5 g/m^2) with moderate values off Vadinar and Sikka. Biomass, population density and group diversity of subtidal benthos are low off Salaya and Navlakhi. Group diversity at other segments are fairly high (av. 9-11). Compared to group diversity of intertidal area, subtidal community shows relatively low number of groups except at Okha (av. 41). At other locations, the number varied between 24 and 28.

Subtidal benthic biomass and population are in general lower at different segments as compared to the values of intertidal data. High subtidal biomass (40 g/m^2) and standing stock (av. $14098/\text{m}^2$) are observed at Kharo creek. Low to moderate values of biomass are recorded at other segments with very low value at Kandla (1.3 g/m^2). Subtidal population is relatively high at Luni, Jakhau and Mundra with lowest values at Kandla and moderate population at Kori creek. Group diversity is moderately high at Luni and Mundra (av. 10-11) while the number is low at other segments (av. 3-5). Number of subtidal macrobenthic groups recorded are 24 at Kandla and Mundra, 18 at Luni, 17 at Jakhau, 13 at Kori creek and 6 at Kharo creek.

6.4.8 Meiobenthos

Information on meiobenthos is available only for Positra bay in Okha. Biomass (av. $1.5 \text{ mg dry wt}/10 \text{ cm}^2$) and population (av. $2362/10 \text{ cm}^2$) indicate fairly good standing stock. A total of 10 faunal groups are recorded from the area with predominance of nematodes, harpacticoids and turbellarians.

6.4.9 Fishery

Gujarat tops among the different states of India in marine fish production. During 1999 – 2000 total landing for Gujarat was $6.71 \times 10^5 \text{ t}$ contributing 23.64% to the National total of $28.34 \times 10^5 \text{ t}$. Percentage increase in marine fish landing for the year 1999-2000 was 21.62 while the growth rate of fish production for India was 5.12%. Value wise, Gujarat earned 7.61% (Rs. 389.38 crores) of the country's marine products export earning (Rs. 5116.67 crores).

The three districts of Gulf, namely Jamnagar, Rajkot and Katchchh have 23, 1 and 51 fishing centres respectively. The collective contribution of Gulf for 1999-2000 was 21.98% to the total production of Gujarat State. The major share is from Jamnagar and Katchchh districts with very low landings from Rajkot. Though there are fluctuations in total landings there is steady growth in fish production from 1983-84 onwards except for minor fluctuations in 1995-96 and 1998-99. A total of 27 categories of fish were recorded from the Gulf during 1999 to 2000. Sciaenids predominated the area. Common fishes in the area are pomfrets, Bombay duck, shrimps, ribbonfish, clupeids, shark and catfish.

Details of fishermen population in the three districts indicate that active fishermen are more in Kachchh as compared to Jamnagar and Rajkot districts. The number of trawlers is more at Jamnagar while the gill-netters are more at Katchchh district. The highest number of mechanised boats operate from Jamnagar followed by Kachchh district. The ratio of total gear for Jamnagar, Katchchh and Rajkot districts shows a respective percentage contribution of 74, 22 and 4.

Results of experimental trawling indicates good potential at Vadinar, Bedi and Sikka with an average catch rate of 41.3, 38.8 and 29.7kg/h. Catch rate is moderate off Okha and Navlakhi. Species diversity is high at Vadinar (av. 42), Sikka (av. 34) and Bedi (av. 44). Average number of species represented at Okha and Navlakhi are respectively 14 and 24. Catch rate by gill netting is generally low with higher values at Sikka than Navlakhi. Species found at different segments show that the Sikka supports very high assemblage of fishes and prawns, the total being 108. Vadinar and Bedi are also good in sustaining a diverse fishery (74 and 73). Navlakhi has moderate potential (av. 56) while the lowest number is obtained at Okha (av. 23).

Trawl catch is the highest at Jakhau (av. 33.8 kg/h) followed by Luni/ Kori creek (av. 21.6 kg/h). Catch rate is moderate at Mundra (av. 15.3 kg/h) and Kandla (av. 11.3 kg/h). Diversity is maximum at Kandla (30) and comparable values at Jakhau, Mundra, Kandla and Kori creek (18-22). Relatively low diversity is seen at Luni (12). Gill nettings at Mundra and Kandla show respective average rates of 7.6 and 4.1 kg/h. Diversity in gill net catch is high at Mundra (34) as compared to Kandla (11).

6.4.10 Corals

The southern coast of Gulf is known for its coral reefs with associated fauna. The diversity of coral species in the Gulf is the lowest of all Indian reefs. A recent monograph (1996) lists 40 species and 23 genera of stony corals, 3 species of soft corals and 4 species of sea fans from the Gulf. Most of these corals are hermatypes while only a few are ahermatypes.

Off Okha, there are 9 major coral reef systems. The Islands adjoining Okha coast harbour 34 species of corals. Salaya has a moderate live coral population with variety and they are under environmental stress due to heavy sedimentation. Sturdy corals like *Goniopora*, *Porites*, *Favia* and *Goniastrea* are common in the area. At Vadinar 29 species of corals are recorded from Narara Bet and 35 species from Kalubhar. At Narara Bet major species observed are *Porites*, *Goniopora* and *Favia*. The live coral colonies area is relatively more at Kalubhar as compared to Narara Bet. The corals at Kalubhar are represented mainly by the genera *Favia*, *Favites*, *Porites*, *Goniastrea*, *Goniopora*, *Turbinaria* etc. Off Sikka, live corals are represented by 24 species of Scleractinians and sturdy corals like *Goniastrea* and *Porites* dominated the area. Records indicate the presence of 22 species of corals at Bedi. The predominant species found in the area are *Goniopora*, *Goniastrea*, *Porites* and *Favia*. Navlakhi region does not have coral reefs as most of the intertidal area is muddy. The northern Gulf is devoid of the

corals. However, during a recent survey in 1999 live corals with associated flora and fauna have been observed off Mundra.

6.4.11 Reptiles

In the Gulf, the reptiles are mainly represented by marine turtles *Chelonia mydas* and *Lepidochelys olivacea*. They breed and spawn on the sandy beaches along the coast as well as on the Island particularly along the southern Gulf between Okha and Okha Madhi and Vadinar-Sikka coast and on the Islands within the MNP and S.

6.4.12 Birds

The Gulf area, which has many salt pans, Islands and intertidal coastal system with mangroves, offer favourable conditions for feeding, breeding and shelter to a variety of birds. All along the creek and in and around several Islands tall mangrove trees are seen crowded with Grey herons, Pond herons, Painted storks, large and small Egrets, etc. A total of 94 water birds have been reported from the Gulf. A recent study (1999) reveals high avifaunal diversity at Mundra region and 140 species have been documented.

6.4.13 Mammals

In the Gulf, the mammals are chiefly represented by dolphin, whale and Dugong especially along the Jamnagar coast.

6.5 Southern and northern Gulf

Along the southern Gulf, Okha, Vadinar, Sikka and Bedi have rich algal fauna and dense as well as degraded patches of mangroves. Phytoplankton pigments and cell counts are relatively high at Okha, Bedi and Sikka while generic diversity is maximum at Vadinar followed by Okha, Sikka and Bedi. Standing stock of zooplankton in terms of biomass is maximum at Salaya followed by Navlakhi while the population density is maximum at Okha. Zooplankton faunal diversity is high at Okha, Sikka and Vadinar. The coastal stretch Vadinar – Sikka – Bedi supports high intertidal macrobenthic biomass and population with a diverse faunal assemblage, though quantitatively and qualitatively less, subtidal macrobenthic population along this stretch is relatively high. Catch rate of fish and diversity of fishes and corals are high at Vadinar, Sikka and Bedi. Along the southern coast, the zone between Vadinar and Bedi appears to be more productive followed by Okha.

An evaluation of the different biological parameters of different segments along the northern coast indicates that Mundra, Jakhau and Kori creek support dense mangrove forests. Phytoplankton pigments are high at Kori creek, Kharo creek and Mundra while cell count is high at Luni, Jakhau and Mundra. Generic diversity of phytoplankton is the highest at Kori creek followed by Kandla and Mundra. Zooplankton standing stock is high at Kandla, Mundra and Kori creek with high group diversity. Kharo creek supports rich intertidal and subtidal macrobenthic standing stock, but group diversity is low. Mundra segment has fairly high intertidal as well as subtidal macrobenthic population with high group diversity. Kori creek is also rich in standing stock of intertidal macrobenthos with moderate group diversity. In terms of fish catch, Jakhau, Luni and Kori creek predominate over other segments. Species diversity of fish is maximum off Kandla followed by Mundra and Jakhau. Overall, along the northern Gulf, the most productive segment is Mundra followed by Luni and Kandla.

6.6 Outer and inner Gulf.

For comparison, the Gulf is divided into outer Gulf (OG) covering Okha to Sikka along the southern shore and Luni to Kori creek on the northern shore. The inner Gulf (IG) encompasses Bedi to Navlakhi in the south and Kandla in north. Phytoplankton pigments show comparable values between OG and IG while cell count is 2.7 times higher at OG.

Zooplankton biomass is relatively high at IG while population density shows a reverse trend. Intertidal as well as subtidal macrobenthic standing stock are richer at OG as compared to IG. Catch rate of fish also indicates the higher fishery potential of OG than IG. A general evaluation of different biological parameters suggests that about 67% of the parameters studied indicate the higher production potential of the OG in comparison with IG.

6.7 Salt works

Investigations on the biological characteristics of the existing salt work at Mundra suggest good primary productivity in reservoirs with fair species diversity. Even condensers and crystallizers sustain fairly high and moderate concentration of chlorophyll *a* respectively with moderate species diversity and good number of phytoplankton cells. Zooplankton standing stock is fairly high and it decreases from reservoir to crystallizer. Total groups of zooplankton found in the reservoir varied from 3-11 (av. 7). The salt pans at Mundra are devoid of macrobenthos because sampling was done a few days after the leveling of the bed of the reservoir.

Most of the available information on salt pans are associated with culture, occurrence and ecology of *Artemia*. *Artemia* cysts in salt condensers of Jamnagar and Kachchh districts are limited to the premonsoon period.

6.8 Creek systems

Some of the creek systems like Kandla creek, Nakti creek and Sara creek and Phang creek have been studied well with less information on other creeks connected to the Little Rann of Kachchh. In general TVC (av. 219-2.7 x 10⁴/ml) and TC (av. 28-69/ml) in water are at higher levels due to moderate human interference. Microbial populations in sediment are at higher level than that of water. Chlorophyll *a* concentration on an average varied from 0.9 to 1.6 mg/m³. Cell count (av. 21.2-664.5 x 10³/l) is at moderate to high level with moderate generic diversity. Zooplankton standing stock in terms of biomass is moderate to very high (av. 9.1 to 37.4 ml/100m³) with fairly high faunal diversity. Intertidal as well as subtidal macrobenthic biomass is low with relatively higher values for population. Faunal diversity of benthos is also low. Trawl and gill net catch rates are low. During monsoon period, penaeid larvae are abundant in the inner creeks leading to a flourishing backwater fishery off Surajbari. Among the different creeks studied, Kandla is the most productive system. In general, the production potential of the interior creek system is only moderate.

6.9 North-south sector

A north-south sector of the Gulf between Luni in the north and Sikka in the south was studied in detail. The stations cover south, middle and northern part of the Gulf. The study indicates the following inferences. TVC values are low in water (91-112/ml) with slightly higher values in the middle Gulf (440/ml). Values of TC are low and pathogens are absent or present in very low numbers which indicates that the area is free from contamination. Bacterial population is higher in sediment as compared to water. Chlorophyll *a* values are marginally high in middle as compared to northern and southern segment. Cell count and generic diversity of phytoplankton are more in the northern part. Zooplankton standing stock is more in the middle Gulf. Subtidal macrobenthic biomass and population are very high along the southern segment. Faunal diversity is comparable between segments. Catch rate of fish is high along the northern segment while faunal diversity is more at southern segment. A comparison between the three zones of the Gulf indicates only marginal difference in biological potential, probably due to limited observations.

6.10 Gulf of Kachchh

Overall assessment on the biological characteristics of the Gulf indicates the high production potential of the area. Though phytoplankton pigment level is only moderate, cell count is high. The area supports high standing stock of zooplankton. The Gulf has rich intertidal macrobenthic standing stock. Subtidal macrobenthos is also moderately high. Catch rate of fish indicates that the nearshore waters support fairly high fishery resource. The Gulf abounds in a diverse floral and faunal assemblage of algae, mangroves, sponges, corals, crustaceans, molluscs and fishes. Compared to the northern Gulf the southern Gulf is more productive. Along the southern coast of the Gulf, the zone Vadinar to Bedi and Mundra and on the northern Gulf Mundra to Kandla appear to be the most productive segments.

7. REFERENCES

- Alagarwami, K. and S.Z. Qasim, 1973. Pearl culture-Its potential; and implications in India, *Indian J. Fish.* **20** (2): 533-550.
- Anand, P.E.V. and N.G.K. Pillai, 1995. Studies on some aspects of biology and ecology of coral reef fishes of Lakshadweep with observations on other coral reef ecosystems of India, *Mariculture research under the postgraduate programme in mariculture, Part – 6, Rangarajan, K. eds. Cochin, India*, **61**: 99-111.
- Anantani, Y.S. and B.S. Vaidya, 1983. Growth characteristics and pigment levels in a halotolerant cyanophyte, *Phykos*, **22** (1-2): 101-104.
- Anon, 1997. A brief on the contribution of ZSI to the research and knowledge of coral reefs in India, *Regional workshop on the conservation and sustainable management of coral reefs. Chennai, India, M.S, Swaminathan Res. Fond., C27-C28.*
- Apte, D., 1998. Record of *Homalocantha secunda* (Lamarck 1822) from Okha in Gulf of Kutch, *J. Bombay Nat. Hist. Soc.*, **95** (3): 526-527.
- Apte, D., 1999. *Maculotriton serrialis* (Deshayes in Laborde & Linnet 1834) from Okha, Gulf of Kutch: A new record, *J. Bombay Nat. Hist. Soc.*, **96** (2): 346.
- Bahuguna, A. and S Nayak, 1998. Coral Reefs of the Indian coast, SAC/RSA/RSAG/DOD-COS/SN/16/97 Space Applications Centre (ISRO), Ahmedabad, February, 1998, Sponsored by Department of Ocean Development, Govt, of India. 54pp.
- Bahuguna, A., A. Ghosh, S. Nayak, A. Patel and J.P. Aggarwal (1992). Ecological status of the coral reefs of the Gulf of Kachchh and Lakshadweep, In: *Proc.Nat. Symp. Rem. Sens. For sustainable Development*, Lucknow, 57-61.
- Bhan, S., 1989. Influence of some environmental parameters on the condition factors of two species of penaeid prawns off Gulf of Kutch. *10th annual session of the Academy of Environmental Biology, India, and International Symposium on Environmental Impact on Biosystems, December 13-17, 1989. The Academy of Environmental Biology, India*, 130.
- Bhanderi, P.P., 1974. An estimate of the iodine yielding seaweed *Asparagopsis taxiformis* (Delile) Collins and Harvey from some subtidal reefs of Saurashtra coast, *J. Mar. Biol. Assoc. India*, **16** (1): 288-289.
- Bhaskar, S., 1981. Preliminary report on the status and distribution of sea turtles in Indian waters, *Indian For.* **107** (11): 707-711.

- Brahmbhatt, G.K., D.N. Chanda, N.D. Chhaya and M.Bhaskaran, 1979. A successful experiment on exploitation of *Sargassum* (Alginophyte) sp. around Sikka in the Gulf of Kutch, *International Symposium on Marine algae of the Indian Ocean Region, CSMCRI. Bhavnagar, India*, 42.
- Chandy, M., 1969. *Thalamita poissonii* (Audouin & Savigny) de Man, (Crustacea: Brachyura). A new record to Indian coasts, *J. Bombay Nat. Hist. Soc.* **66** (3): 635-637.
- Chandy, M., 1973. New records of brachyuran decapods from the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **70** (2): 401-402.
- Chauhan, V. D., 1985. Floristic study of *Sargassum* of Gujarat coast. *All India Symposium on Biology of Algae*, University of Poona, Poona, India, 8-10.
- Chauhan, V.D. and V. Krishnamurthy, 1968. An estimate of algin-bearing seaweeds in the Gulf of Kutch, *Curr. Sci.*, **37** (22): 648.
- Chavan, S.A., 1985. Status of mangrove ecosystem in Gulf of Kachchh. *Proceedings of symposium on endangered marine animals and marine parks*, 475-482.
- Chavan, S.A., 1986. Endangered marine ecosystem of Gulf of Kachchh. *Proceedings of seminar on Gujarat endangered environment and ecosystems*. Gujarat Ecological Education and Research Foundation, 71-76.
- Chhaya, N.D., A.U. Buch and K.R. Narayanan, 1979. Observations on the fisheries of mullet and scope for its culture in Gulf of Kutch, *Indian J. Fish.* **26** (1-2): 47-51.
- Chhaya, N.D., M.I. Patel, C.R. Trivedi and S.A. Kadri, 1990. Simulated salt pan system- a test case for *Artemia* and their cysts production, *Seafood export j.*, **21** (6): 41-42.
- Commissionerate of Fisheries, 2000. *Gujarat Fisheries Statistics, 1999/2000*.
- Daniel, A. and B.P. Halder, 1974. Holothuroidea of the Indian ocean with remarks on their distribution, *J. Mar. Biol. Assoc. India*, **16** (2): 412-436.
- Desai, P. N., 1997. Coastal Marine Environment of Gujarat-a benchmark survey, Vol.1. Gulf of Kachchh. (and the references therein), *Gujarat Ecology Commisiion, Vadodara*.
- Desai, K., D. Nimavat and J.A. Pandya, 1977. Studies on the pearl oyster, *Pinctada ficata* (Gould) of the Gulf of Kutch, *Curr. Sci.*, **46** (21): 748-749.

- Desai, K.M., B. Patel and H. Dave, 1980. Laboratory rearing of eggs and larvae of edible oysters of the Gulf of Kutch, *Proceedings of the Symposium on Coastal Aquaculture, held at Cochin from January 12 to 18, 1980, Part 2 Molluscan Culture, Marine Biological Assoc. of India, Cochin, India*, 6: 704.
- Desai, P.S., Narain, A., Nayak, S.R., Manikiam, B., Adiga, S. and Nath, A.N., 1991. *Curr. Sci.*, **61**: 204-208.
- Deshmukh, V.M., 1995. A note on the prawn fishery in the Gulf of Kutch during 1962-63, *Indian J. Fish.*, **22** (1-2), 265-269.
- Deshmukhe, G., K. Ramamoorthy and R. Sen Gupta, 2000. On the Coral reefs of the Gulf of Kachchh, *Curr. Sci.*, **79** (2): 160-162.
- Devraj, M., 1997. A brief on the contribution of the Central Marine Fisheries Research Institute to research and knowledge of coral reefs of India, *Regional workshop on the conservation and sustainable management of coral reefs, Chennai, India, M.S. Swaminathan Res. Found.*, C21-C25.
- Dharmakumarsinhji, R.S., 1984. Some notes on the Indian heron, *J. Bombay Nat. Hist. Soc.*, **81** (1): 188-189.
- Dhawan, R.M., 1970. Plankton and hydrological factors at Kandla in the Gulf of Kutch during 1960-1963, *Indian J. Fish.*, **17**: 122-131.
- Easwaran, C.R., 1967. On an abnormal ray from the Gulf of Kutch, *J. Mar. Biol. Assoc. India*, **9** (1): 198-200.
- Easwaran, C.R., K.R. Narayanan and M.S. Michael, 1969. Pearl fisheries of the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **66** (2): 338-344.
- Environmental Information Syst. Cent. Parangipettai, Tamilnadu, India, 1998. Coral reefs of India: State-of-the-art report, *ENVIS. Parangipettai (India)*, **2/98**: 52.
- Envis, 1998. *Coral reefs of India-state of art report. Envis 2/98*, Environmental Information systems Centre, Parangipettai, 52pp.
- Frazier, J.G. and T. Mundkur, 1990. *Dugong dugong* Muller in the Gulf of Kutch, Gujarat, *J. Bombay Nat. Hist. Soc.*, **87** (3): 368-379.
- Gajbhiye, S.N., L. Krishnakumari, K. Govindan, S.A.H. Abidi and V.R.Nair, 1988. Studies on selected biological parameters off Mithapur (Gujarat). *Journal of Indian Fisheries Association.*, 18.
- George. M.J., Rao and P. Vedavyasa, 1966. A new species of *Metapenaeus* (decapoda, penaeidae), *J. Mar. Biol. Assoc. India*, **8** (1): 146-151.

- George, M.K., 1980. Biology and fishery of wam *Muraenesox talabonoides* (Bleeker), *Indian J. Fish.* **27** (1-2): 82-94.
- George, P.C., M.J. George, Rao and P. Vedavyassa, 1963. *Metapenaeus kutchensis* sp. Nov., A penaeid prawn from the Gulfg of Kutch, *J. Mar. Biol. Assoc. India*, **5** (2): 284-288.
- Ghosh, J.M., P. Johnson and C.K.G. Nair, 1963. On the occurrence of the Leech *Ozobranchus branchiatus* (Menzies 1791) (Hirudinea) in India (Gulf of Kutch), *J. Bombay Nat. Hist. Soc.* **60** (2): 469-471.
- Gideon P.W., P.K.B. Menon, S.R.V. Rao and K.V. Jose, 1957. On the marine fauna of Gulf of Kutch a preliminary survey, *J. Bombay Nat. Hist. Soc.* **54** (3): 690-706.
- Gokhale, S.V., 1954. Recovery of a fishery, *Curr. Sci.*, **23** (12): 404.
- Gokhale, S.V., C.R. Easwaran and R. Narsimhan, 1954. Growth rate of the pearl oyster, *Pinctada pinctada* in the Gulf of Kutch with a note on the pearl fishery of 1953, *J. Bombay Nat. Hist. Soc.* **52** (1): 124-136.
- Gopalakrishnan, P., 1969a. Some marine algae from the Gulf of Kutch, *Phykos.*, **8** (1-2): 61-67.
- Gopalakrishnan, P., 1969b. On the holothuroidea (Echinodermata) of the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **66** (2): 399-400.
- Gopalakrishnan, P., 1972. Studies on the marine planktonic diatoms off Port Okha in the Gulf of Kutch, *Phykos.*, **11** (1-2): 37-49.
- Gopalakrishnan, P. and V.K. Raju, 1987. Marine prawn farming along the coast of the Gulf of Kutch – its prospects and problem, *CMFRI, Spec. Publ.* **40**: 46-47.
- Gopalakrishnan, P. and S.R. Thaker, 1988. Studies of the maturation and spawning of grey mullets of a reservoir fishery in Okhamandal (Gulf of Kutch), *CMFRI, Spec. Publ.* **40**: 56.
- Gopalakrishnan, P., K. Raju, K.M. Pillai, K.D. Joshi, V.J. Somaiya and H.L. Devmurari, 1987a. Observations on the fish and prawn seed resources of the Gulf of Kutch and their utilization in aquaculture, *Fish. Technol. Soc. Fish. Technol. Cochin.*, **24** (1): 5-11.
- Gopalakrishnan, P., K. Raju, K.M. Pillai and S.R. Thaker, 1987b. On the occurrence of mature penaeid prawn *Penaeus merguensis* in a shallow solar salt works reservoir along the Okhamandal coast of Gulf of Kutch and its spawning in laboratory, *Fish. Technol. Soc. Fish. Technol. Cochin.*, **24** (1): 12-13.

- Gopalakrishnan, P., V.K. Raju and S.R. Thaker, 1990. Some observations on the growth and survival of the jumbo prawns *Penaeus monodon* Fabricius and *Penaeus indicus* H.M. Edwards in a solar salt works along the Okhamandal coast in the Gulf of Kutch, *Fish. Technol. Soc. Fish. Technol. Cochin*, **27** (2): 120-122.
- Gopalan, U.K., 1969. Studies on the maturity and spawning of silver pomfret, *Pampus argenteus* (euphr.) in the Arabian sea, *Bull. Natl. Inst. Sci. India*, **38** (2): 785-796.
- Government of Gujarat, 1998. *Gujarat Forest Statistics- As on 31-03-96. Office of Principal Chief Conservator of Forest, Gandhinagar.*
- Govindan, K., R. Kasinathan and B.N. Desai, 1977. Biomass and composition of zooplankton in and around (the) Gulf of Kutch, *J. Indian. Fish. Assoc.* **7** (1-2): 64-76.
- Gujarat Ecology Commission, 1996. Biological diversity of Gujarat, Printed at the M.S. University of Baroda, Press, Baroda, 330pp.
- Gujarat Ecology Commission, 1999. Draft final report for development of GIS for Gulf of Kachchh and Gulf of Khambhat-Primary data. Submitted to ICMAM Cell of Department of Ocean Development, GES and GUIDE.
- Gujarat Ecological Society, Vadodara, August, 1997. Coastal Marine Environment of Gujarat, A Benchmark Survey, Report 1- Gulf of Kachchh. 169pp.
- Gupta, A.K.D. and P.K.B. Menon, 1961. Occurrence of the Echiuroid *Ochetostoma zanziberense* Stephen in the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **58** (1): 829-830.
- Hoon, Vineeta, 1997. Coral reefs of India: review of their extent, condition, research and management status. In. *Proc. Regional workshop, conservation and sustainable management of coral reefs.* 1-27.
- Hoq, M.E., 1977. Coral reefs of India: Review of their extent, condition, research and management status, *Regional workshop on the conservation and sustainable management of coral reefs, Chennai, India, M.S. Swaminathan Res. Found.*, B1-B25.
- Jagtap T. G., D.S. Komarpant and R. Rodrigues. Status of seagrass ecosystem: An ecologically sensitive wetland habitat from India. (Unpublished: communicated to *Wet-land*).
- Jagtap T. G., P. S. Murthy and D.S. Komarpant. Mangrove ecosystem of India: Major biotic constituents, conservation and management, *Hydrobiology of lentic ecosystems*. (Ed, B.B. Hosetii) in press.

- Jagtap, T.G. and A.G. Untawale, 1996. Occurrence of *Hydroclathrus tenuis* Tseng and Baoren, (Phaeophyta) from Gulf of Kutch, northwest coast of India, *Indian. J. Mar. Sci.*, **25** (3): 277-279.
- James, P.S.B.R., 1994. Endangered vulnerable and rare marine fishes and animals, Threatened fishes of India, *Proceedings of the national seminar on endangered fishes of India, held at national bureau of fish genetic resources, Allahabad on 25th and 26th April 1992*. Dehadri, P.V., Das, P. and Verma S.R. eds. Muzaffarnagar-India nature conservators, 271-295.
- James, P.S.B.R., K.A. Narsimham, A.C.C.Victor, S. Dharmaraj, T.S. Velayudhan and A. Chellam, 1992. The Indian marine pearls: A culture technique for pearl production, *CMFRI, Cochin, India*, 24.
- Jani, M.M. and M.I. Patel, 1995. On first record of sei whale, *Balaenoptera borealis* (Less) from Gulf of Kutch, *Fish. Chimes*, **15** (3): 52-53.
- Joseph, A. and V.C. Soni, 1990. A study on the prawn fishery of the mouth of Gulf of Kutch with special reference to certain biological aspects of some prawn species, *Indian J. Fish.* **37** (3): 175-182.
- Joseph K.M., 1974. Demersal fisheries resources off the north west coast of India, *Bull. Expl. Fish. Proj.* Bulletin No. 1. FSI, Bombay, 47pp.
- Kagwade, P.V., 1965. *Polydactylus indicus* (shaw) in the landings by bull trawlers operating in Bombay and Saurashtra waters during 1956-'63. *Indian J. Fish.*, **12** (2): 459-472.
- Kaikini, A.S., 1974. Regional and seasonal abundance of the white fish *Lactarius lactarius* (Schneider) in the trawling ground off Bombay-Saurashtra coasts 1957-'63, *Indian J. Fish.*, **21** (1): 89-108.
- Kasinathan R., K. Govindan and B.N. Desai, 1973-1974. Distribution of benthic fauna in the Gulf of Kutch, *J. Indian, Fish. Assoc.* **3&4** (1-2): 68-79.
- Katel, S.K. and K.L. Jetani, 1991. Study of oysters from Gulf of Kutch, *Fish Chimes*, **11** (5): 56-57.
- Khacher, L., 1998. *Dugong dugong* in the Gulf of Kachchh, *J. Bombay Nat. Hist. Soc.*, **95** (3): 499.
- Khan, M.Z., 1983. Preliminary observations on the fishery of Bombayduck *Harpodon nehereus* in the Gulf of Kutch, *Indian. J. Fish.*, **30** (1): 110-115.
- Krishnan, S., R. Pravez and A.P. Mansuri, 1995. Fishery and anthropogenic pressure in the Gulf of Kachchh, India, *J. Mar.Biol.Assoc.India*, **37** (1-2): 49-55.

- Kulkarni, D.H., 1957. Utilisation of mangrove forest in Saurashtra and Kachchh. *Proc. Mangrove Symposium*, Calcutta.
- Kumar, R.A., 1986. Rise in global mean sea level has it affected the flamingo breeding grounds?, *J. Bombay Nat. Hist. Soc.* **83** (2): 433-435.
- Kundu, H.L., 1965(a). On the marine fauna of the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **62** (1): 84-103.
- Kundu, H.L., 1965(b). On the marine fauna of the Gulf of Kutch, Part 3 – Pelecypods, *J. Bombay Nat. Hist. Soc.* **62** (1): 211-236.
- Kutty, M.N., 1962. Scales and otoliths of the Koth *Otolithoides brunneus* (Day) as age indicators, *Indian J. Fish.*, **8** (1): 145-151.
- Kuzmenko, L.V., 1973. Primary production of the northern Arabian sea, *Oceanology*, **13** (2): 251-256.
- Madhupratap, M. and P. Haridas, 1992. New species of Pseudodiaptomus (Copepoda: Calanoida) from the salt pans of the Gulf of Kutch, India and a comment on its speciation, *J. Plankton Res.* **14**, 555-562.
- Madhupratap, M and P. Haridas, 1994. Descriptions of *Acartia* (*Euacartia*) *southwelli* Sewell 1914 and *Acartia* (*Euacartia*) *sarajus* n. sp. from India and status of the subgenus *Euacartia* Steuer 1923. *Ecology and morphology of copepods*, Ferrari, F.D.; Bardley, B.P. eds. **292-293**: 67-74.
- Mahyavanshi, I.N., 1975. Further studies on the marine planktonic diatoms in the coastal waters of Saurashtra, *Phykos.*, **14** (1-2): 99-111.
- Menon, P.K.B., A.K.D. Gupta and D.D. Gupta, 1961. On the marine fauna of the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **58** (2): 475-494.
- Miquel, J.C., 1983. Supplementary notes on species of *Metapenaeus* (decapoda, penaeidae), *Crustaceana*, **45** (1): 71-76.
- Mohan, R.S.L., 1963. On the occurrence of *Dugong dugong* (Muller) in the Gulf of Kutch, *J. Mar. Biol. Assoc. India.*, **5** (1): 152.
- Muley, D., 1997. Restoring the magic of mangrove forests, *Eco-Dimensions*, **4**: 23-26.
- Mundkur, T., L.M. Raol and S.N. Varu, 1988. Distribution of the slenderbilled Gull (*Larus genei* Breme) in the Gulf of Kachchh, Gujarat, *J. Bombay Nat. Hist. Soc.* **85** (2): 420-422.
- Mundkur, T., R. Pravez, S. Khachar and R.M. Naik, 1989. Hitherto unreported nest site of lesser flamingo *Phoeniconaias minor* in the Little Rann of Kutch, Gujarat, *J. Bombay Nat. Hist. Soc.*, **86** (3): 281-285.

- Naik, D.M., 1991. Ecosystem in the Gulf of Kutch, *National seminar on Conservation and Management of Mangrove Ecosystem with special reference to Sunderbans, December 6-8, 1991*. pp.9.
- Naik, R.M. and B.M. Parasharya, 1987. Impact of the food availability, nesting-habitat destruction and cultural variations of human settlements on the nesting distribution of the coastal bird *Egretta gularis*, in western India, *J. Bombay Nat. Hist. Soc.* **84** (2): 350-360.
- Nair, V.R., K. Govindan, Neelam Ramaiah and S.N. Gajbhiye, 1993. Fishery potential of the Gulf of Kachchh, *J. Indian Fish. Assoc.*, **23**: 91-103.
- Narayanan, K.R., 1970. On a species of the genus *Berthellina* (Opisthobranchia, Notaspidae) of the Gulf of Kutch, *J. Mar. Biol.Assoc. India.*, **12** (1): 210-212.
- Narayanan, K.R., 1971. On two doridacean nudibranchs (Molluscs: Gastropoda), from the Gulf of Kutch, New to the Indian coast, *J. Bombay Nat. Hist. Soc.* **68** (1): 280-281.
- Narayanan, K.R., 1974. Preliminary observations, on the breeding of pearl oysters, *Pinctada fucata* (Gould) of the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **71** (1): 32-40.
- Narayanan, K.R. and M.S. Michael, 1968. On the relation between age and linear measurements of the pearl oyster *Pinctada vulgaris* (Schumacher) of the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **65** (2): 444-452.
- Naskar, K. and R Mandal, 1999. Ecology and biodiversity of Indian mangroves, Part – 1, Global status, *Daya publishing house, Delhi*, 1-186.
- Nayak, S., 1994. Application of remote sensing in the study of mangrove ecosystems, In: Conservation of mangrove forest genetic resources. A training manual (Eds. S.V. Deshmukh and V. Balaji). M.S. Swaminathan Research Foundation, CRSARD, Madras, 203-220.
- Nayak, S., A. Bahuguna, P. Chauhan, H.B. Chauhan and R.S. Rao, 1996(a). Remote sensing applications for coastal environmental management in India, *MAEER'S MIT PUNE JOURNAL*, **IV** (15 & 16): 113-125.
- Nayak, S., P. Chauhan, H.B. Chauhan, A Bahuguna and N. Nath, 1996(b). IRS-IC applications for coastal zone management, *Curr. Sci.* **70** (7): 614-618.
- Nayak, S., A. Pandeya, M.C. Gupta, C.R. Trivedi, K.N. Prasad and S. A. Kadri, 1989. Application of satellite data for monitoring degradation of tidal wetlands of the Gulf of Kachchh, Western India. *Acta astronautica*, **20**: 171-178.

- Negi, A.S., 1993. A visit to the flamingo city in the great Rann of Kutch (Gujarat), *Indian For.* **119** (5): 354-359.
- Nigam, R. and S.K. Chaturvedi, 2000. Foraminiferal study from Kharo Creek, Kachchh (Gujarat), north west coast of India. *Indian. J. Mar. Sci.*, **29** (2): 133-138.
- Pandya, J.A., 1976. Influence of temperature on growth ring formation in the pearl oyster, *Indian J. Mar. Sci.*, **5** (2): 249-251.
- Parulekar, A.H., 1988. Bio-ecology of the Gulf of Kachchh. In: *Marine Archaeology of Indian Ocean Countries*, NIO, Goa, 129-132.
- Parulekar, A.H. 1995. Marine conservation and recreation: case studies on feasibility and conceptual plan for oceanarium, dolphinarium, amusement park and marine land complex along the Indian coast, *Seminar on Recent Advances in Ocean Engineering and Underwater Technology 10-11 November, 1995. CIFE, Bombay, India*, 24-25.
- Patel, M.I., 1976. New record of a rare Bonellid *Ikedella misakiensis* (Ikeda), *Curr. Sci.* **45** (4), 155-156.
- Patel, M.I., 1978. Genetic diversity of Scleractinians around Positra Point, Gulf of Kutch, *Indian, J. Mar. Sci.*, **7** (1): 30-32.
- Patel, M.I., 1983. Record of a lamellibranch *Ctenoides ferescraba iredale* from the Gulf of Kutch, *J. Mar. Biol. Assoc. India*, **20** (1-2): 167.
- Patel, M.I. 1985. Conservation of patchy corals of the Gulf of Kutch. In: *Proc. Symp. Endangered marine animals and marine parks, 4: paper no. 56*.
- Patel, M.I and I.N. Mahyavanshi, 1974. Larva of *Callianassa tyrrhena* (Petagna) (Crustacea, Decapoda, Callianassidae), a new record from the Gulf of Kutch, *J. Mar. Biol. Assoc. India*, **16** (1): 308-309.
- Patel, P.P., 1997. Ecoregions of Gujarat, *Gujarat Ecology Commisiion, Vadodara*.
- Paulinose, V.T. and P.N. Aravindakshan, 1976. Zooplankton biomasss, abundance and distribution in the north and northeastern Arabian sea, *Proceedings of the symposium on warm water zooplankton. NIO, Dona Paula, Goa, India*, 132-136.
- Paulinose, V.T., C.B. Lalithambika Devi, Vijayalakshmi R. Nair, Neelam Ramaiah and S.N. Gajbiye, 1998. Zooplankton standing stock and diversity in the Gulf of Kachchh with special reference to larvae of decapoda and pisces, *Indian J. Mar. Sci.* **27** (3 & 4): 340-345.
- Pillai, C.S.G., 1983. Structure and genetic diversity od recent Scleractinia of India, *J. Mar. Biol. Assoc. India.*, **25** (1-2): 78-90.

- Pillai, N.S. and K. Gopalakrishnan, 1984. A brief account on the "gunja net" fishing of the Kutch backwaters (Gujarat), *Fish Technol. Soc. Fish. Technol. Cochin*, **21** (2): 147-149.
- Pillai, C.S.G. and M.I. Patel, 1988. Scleractinian corals from the Gulf of Kutch, *J. Mar. Biol. Assoc. India*, **30** (1-2), 54-74.
- Pillai, C.S.G. and M.S. Rajagopalan, 1979, Preliminary report on a reconnaissance survey of the major coastal and marine ecosystems in the Gulf of Kutch, *Mar. Fish. Inf. Ser. Tech. Ext. Ser.*, 14: 16-20.
- Pilo, B., *et. al.*, 1996. Biological Diversity of Gujarat-Current Knowledge, *Gujarat Ecology Commission, Vadodara*.
- Pravez, R., S. Krishnan, A.P. Mansuri, R.M. Naik and M.S. Murthy, 1992. The fishery and socio-econominc aspects of Modhwa, Gujarat, *J. Mar. Biol. Assoc. India.*, **34** (1-2): 38-46.
- Qureshi, M.R., 1953. Some schooling fishes of the Arabian Sea, *Pak. J. Sci.*, **6** (2): 117-118.
- Rajagopalan, M.S., 1983. A comparative study of ecological aspects of mangrove biotopes in four different regions of India, *Marine Plants., Papers presented at the All India Symposium on Marine Plants, their Biology, Chemistry and Utilization Dona Paula, Goa, Oct 30 to Nov. 1, 1983*, V. Krishnamurthy, A.G. Untawale eds. Seaweed Res. And Utilization Assoc. Madras, India, 231-244.
- Ramamurthy, S., 1963a. A note on the prawn fishery at adesar camp *J. Mar. Biol. Assoc. India*, **5** (2): 318-320.
- Ramamurthy, S., 1963b. A note on the prawn fishery of Kutch, *J. Mar. Biol. Assoc. India*, **5** (1): 146-148.
- Ramamurthy, S., 1964. On a new record of *Metapenaeus stebbingi* Nobili, in Indian waters, *J. Mar. Biol. Assoc. India*, **6** (1): 170-171.
- Ramamurthy, S. and R.M. Dhawan, 1963. On the characteristics of the plankton at Kandla in the Gulf of Kutch during August 1958-July 1960, *Indian J. Fish.*, **10** (1): 94-101.
- Ramanandan, R., 1966. On the occurrence of *Porcellanella picta* Stimpson (Decapoda, Anomura) in the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.* **63** (3): 770-771.
- Rao. G.S., 1983. Observations on the seasonal prawn fishery of the Little Rann of Kutch during 1980, *Indian J. Fish.* **30** (1): 124-134.

- Rashid, M.A., 1985. Gujarat's Gulf of Kachchh-A marine paradise, *Proceedings of symposium on Endangered Marine Animals and Marine Parks*, 467-474.
- Ratan, R. and A. Chandra, 1983. Palynological investigation of the Arabian Sea sediments: fungal spores, *Geophytology*, **13** (2): 195-201.
- Ravindran, J., Raghukumar, C. and Raghukumar, S., 1999. Disease and stress induced mortality of corals in Indian reefs and observations on bleaching of corals in the andamans, *Curr. Sci.*, **76** (2): 233-237.
- Ray, A., 1991. Mangrove Ecosystem in India, Mangroves of Sunderbans and elsewhere: *Proc. Natl. Synp. Cons. & Manage. Mangroves*: 6-26.
- Royan, J.P., 1979. Occurrence of *Artemia* sp. in the Gulf of Kutch, *Mahasagar*, **12** (4): 271-272.
- Sankarankutty, C. and S. Jones, 1960. Notes on animal associations. 3. A Parthenopid crab, *Harrovia Albolineata adams* and white on a Mariametrid crinoid, *Lamprometra* sp., *J. Mar. Biol. Assoc. India*, **2** (2): 194-195.
- Sarvaiya, R.T., 1978. Prawn fisheries of Kutch with special reference to Sukhpur and Lakhpat, *Indian J. Fish.* **25** (1-2): 35-40.
- Sarvaiya, R.T., 1982. Window pane oyster fishery of Pindhara Bay in the Gulf of Kutch, *Seafood Export J.* **14** (8): 25-28.
- Saurashtra University, 1991. Coastal marine ecosystems and anthropogenic pressure in the Gulf of Kachchh. Department of Biosciences, Saurashtra University, Rajkot, *Technical report*.
- Sen Gupta, R. and G. Deshmukhe, 1999. Coral reefs of the Gulf of Kachchh-present status, Gujarat Ecological Society, Vadodara, Sponsored by Gujarat Ecology Commission, Vadodara, April 1999.
- Sen Gupta, R. and G. Deshmukhe, 2000a. The Gulf of Kachchh (Kutch) and threats to its critical habitats, *Journal of Indian Ocean studies*, **7** (2 & 3): 201-221.
- Sen Gupta, R. and G. Deshmukhe, 2000b. Coastal and maritime environments of Gujarat: Ecology and economics, Gujarat Ecological Society, Vadodara, Gujarat, 148pp.
- Sen Gupta R., G. Deshmukhe, G.A. Thivakaran, K. Krishnamoorthy, Richa Chandra S. Serebiah and S. Bandyopadhyay, 1999. Ecology of the Gulf of Kachchh and threat to its biotic resources, Paper presented at the workshop on the Gulf of Kachchh, 23-24 September, 1999 at Ahmedabad organised by ICMAM Directorate, DOD, Chennai.

- Sen Gupta, R., S.P. Fondekar and R. Alagarsamy, 1993. State of oil pollution in the northern Arabian sea after the 1991 Gulf oil spill. *Marine Pollution Bulletin*, 27.
- Singh, N.T., 1986. Ecology and productivity in the Indian coastal region, *J. Andaman Sci. Assoc.*, 2 (2): 1-10.
- Singh, H.S., 1994. Management Plan for Marine National Park and Sanctuary, *Marine National Park, Jamnagar*.
- Singh, H.S., 1996. Successional stages of mangroves in the Gulf of Kutch, *Indian Forest.*, 212-219.
- Singh, H.S., 1997. Issues and problems involved in managing marine protected areas: a case study on marine national park, Jamnagar, *Proceedings of the workshop on integrated Coastal Zone Management, Ahmedabad*, 105-122.
- Singh, H.S., 2000. Growth patterns of mangroves in the Gulf of Kutch, *J. Bombay Nat. Hist. Soc.*, 97 (2): 202-207.
- Singhal, R.N., 1980. Ecological notes on a few Echiuran animals, *Indian J. Mar. Sci.*, 9 (2): 139-140.
- Singhal, R.N., 1988. Distribution of Sipuncula and Echiura in the Gulf of Kachchh, northwest coast of India, *Indian J. Mar. Sci.*, 17 (2): 170-171.
- Siraimetan, P., 1988. Cephalopod resources off the Gulf of Kutch in Gujarat coast, *J.Mar.Biol.Assoc. India*. 32 (1-2): 227-235.
- Solanki, H.U., C.B. Trivedi, G.K. Brahmabhatt, 1986. Alginic acid content of *Turbinaria indica* in the Gulf of Kutch, *Fish. Chimes.*, 5 (10): 19-20.
- Subramanian, B.R., 1999. Development of model integrated coastal marine area management plans for selected sites along coastline of India, *Proceedings of the workshop on Integrated Coastal and Marine Area Management Plan for Goa, DOD, Chennai, India*, 24-33.
- Tewari, B.S., 1956. The Genus Spiroclypeus from Kutch, Western India, *Curr. Sci.*, 25 (10): 319-320.
- Thakar, V.J., 1982. Large scale prawn harvest in the little Rann of Kutch during monsoon, *Seafood Export J.* 14 (2): 15-17.
- Thomas, P.A., C.S.G. Pillai and M.S. Rajagopalan, 1996. Demospongiae of the Gulf of Kutch, *J. Mar. Biol. Assoc. India*, 38 (1-2): 124-132.
- Untawale, A.G., 1980. Present status of the mangroves along the west coast of India. *Proceedings of Asian Symposium. Mangrove Environmental Research and Management, University of Malaya, Kuala Lumpur*, 1-26.

- Untawale, A.G., 1983. Mangrove, coral and island ecosystems along the Indian coast, *ESCAP/SACEP Symposium on environmental Management of Mangrove, Coral and island ecosystem*, 1-13.
- Untawale, A.G. and V. Ambiyee, 1988. Flora of Bet Shankhudar in the Gulf of Kachchh. In: *Proceedings of the first Indian Conference on marine archaeology of Indian Ocean Countries* (Ed. S.R. Rao), NIO, Goa, 139-141.
- Untawale, A.G. and T.G. Jagtap, 1999. Socioeconomic significance of mangroves for coastal people of India: A changing scenario, *Proceedings of symposium on significance of Mangrove Ecosystems for Coastal People, Hat Yai, Songkla Province, Thailand, 19-21 August 1996*. Kunstadter, P. ed. *Int. Soc. For Mangrove Ecosystems. Okinawa, Japan*. 91-101.
- Untawale, A.G. and S Wafer, 1988. Distribution of mangroves along the Gulf of Kutch, In: *Marine Archaeology of the Indian Ocean Countries, NIO, Goa.*, 135-138.
- Untawale, A.G. and S. Wafer, 1991. Environmental impact assessment of mangrove along the west coast. Mangroves of Sundarbans and Elsewhere. *Proc. Natl. Symp. Cons. Manage. Mangroves*. 247-253.
- Untawale, A.G., V.K. Dhargalkar and V.V. Agadi, 1981. Status report on marine algal resources of the Indian coast for research and development. National Institute of Oceanography, Goa.
- Vaishnav, H.A. and S.A. Chavan, 1987. Coastal and marine ecosystems of Gujarat, *Technical Report, Department of Forests, Gujarat*.
- Varghese, M.A. and P.H. Shah, 1977. Exploitation of the Chank fishery in Gujarat, *Seafood Export J.*, **9** (7), 15: 17-19.
- Wafar, M V M., 1986. Corals and coral reefs of India, *Proc. Indian Acad. Sci. (Anim. Sci./Plant Sci.) Suppl.* 19-43.
- Wafar, M.V.M., 1999. Status report India, *Coral reef degradation in the Indian Ocean: Status reports and project presentations, 1999*, Linden, O. (ed.) *Stockholm Univ. Sweden CORDIO / SAREC Marine Science Program*, 1999: 25-26.
- Zingde, M.D., 1998. Quality of coastal waters in India, In: *Proceedings of the workshop on Integrated Coastal Zone Management*, Ahmadabad, April 1997.
- Zingde, M.D., 1999. Marine pollution-Ehat are we heading for?, *Ocean science: Trends and future directions*. Somayajalu, B.L.K. ed. *Indian National Science Academy, New Delhi (India)*, 229-245.

Zingde, M.D. and M.N. Anand, 1994. Implication of coastal refineries to the ecology of the Gulf of Kachchh, *Proceedings of seminar on ocean and industry realities and expectations held on October 25 and 26, 1994* at National Institute of Oceanography, Dona Paula, Goa. Srivastava, P.S. ed., New Delhi, India, 67-76.

Zingde M.D., V. R. Nair, K. Govindan and M.M. Sabins, 1998. Marine environmental impact assessment of proposed tidal power development in the Gulf of Kachchh, *Proc. International Symp. Tidal Power Development, New Delhi. February, 1998.* 205-208.