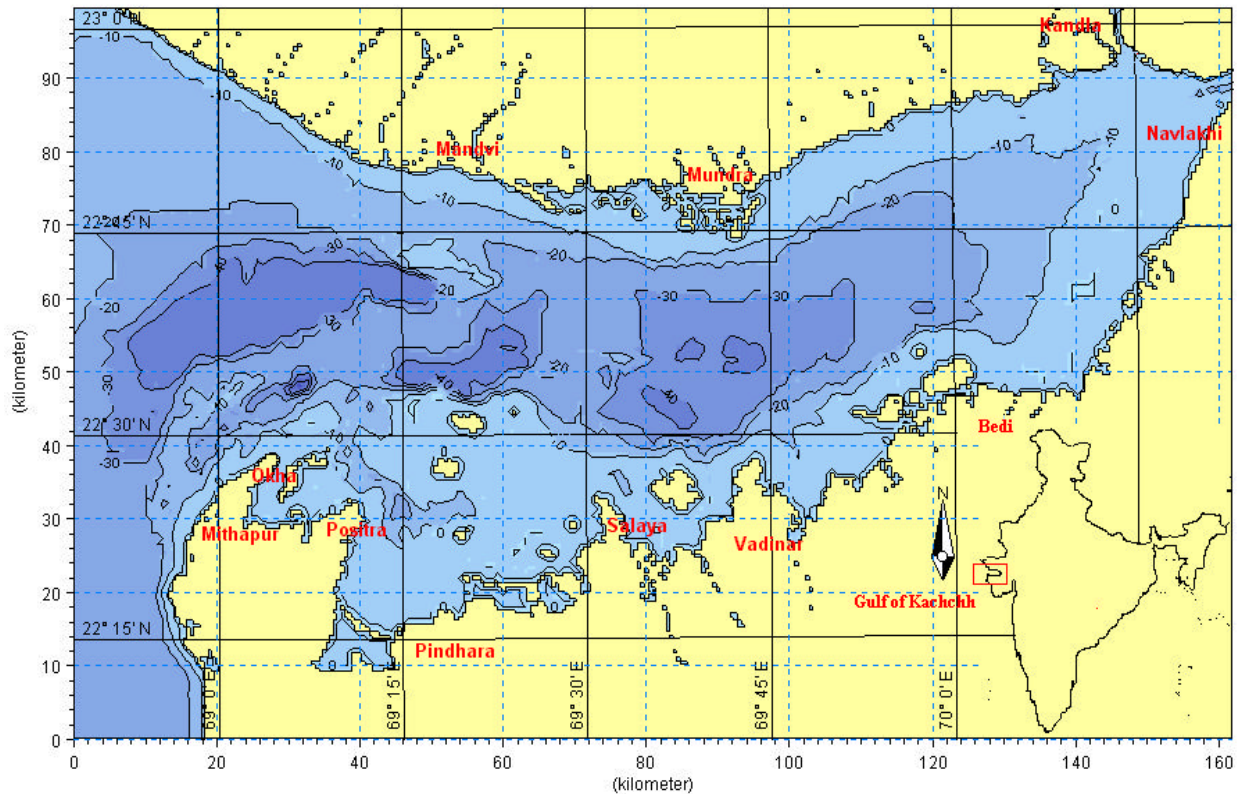


Status of The Flora and Fauna of Gulf of Kachchh, India



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March 2002

STATUS OF FLORA AND FAUNA OF GULF OF KACHCHH

**Prepared for
NATIONAL INSTITUTE OF OCEANOGRAPHY, GOA**

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MARCH 2002

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ACKNOWLEDGEMENTS

I record my grateful thanks and appreciation to:

1. Dr. E. Desa, Director, National Institute of Oceanography, Goa for entrusting me with this task.
2. Dr. M.D. Zingde, Scientist-in-Charge, RC of NIO, Mumbai for his help and guidance.
3. Dr. K.K.C. Nair, Scientist-in-Charge, RC of NIO, Kochi for providing necessary facilities for execution of work.
4. Dr. R. Sen Gupta, Project Co-ordinator, Gujarat Ecological Society, Vadodara, for gifting the reports of Gujarat Ecological Society as well as his publications, Dr. S. Nayak, Group Director, Space Application Centre, Ahmedabad for his papers on Satellite information for monitoring corals and wet lands and Commissioner of Fisheries, Gandhinagar for reports on Gujarat Fisheries Statistics.
5. Dr. K. Govindan, Scientist, RC of NIO, Mumbai for critical discussions on the subject.
6. Shri. V.N. Mohanan, T.O., RC of NIO, Kochi for the preparation of drawings and Smt. M. Mallika for secretarial assistance.

Vijayalakshmi R. Nair

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EXPLANATORY NOTE

General

Av	-	Average
B	-	Bottom
BOD	-	Biochemical Oxygen Demand (mg/l)
C _{org}	-	Organic carbon (%)
DO	-	Dissolved Oxygen (mg/l)
Eb	-	Ebb tide
FI	-	Flood time
HTL	-	High tide level
Max	-	Maximum
MHWN	-	Mean high – water neap
MHWS	-	Mean high – water spring
Min	-	Minimum
MLWN	-	Mean low – water neap
MLWS	-	Mean low – water spring
MSL	-	Mean sea level
ND	-	Not detected
NH ₄ -N	-	Ammonium nitrogen (µg/l)
NO ₂ -N	-	Nitrite nitrogen (µg/l)
NO ₃ -N	-	Nitrate nitrogen (µg/l)
N _{Total}	-	Total nitrogen (µg/l)
P _{Total}	-	Total phosphorus (µg/l)
PHc	-	Petroleum Hydrocarbon (µg/l)
Phenols	-	Total phenols (µg/l)
PO ₄ -P	-	Reactive phosphate phosphorus (µg/l)
S	-	Surface
SS	-	Suspended solids
WT	-	Water temperature

Microbiology

ECLO	-	<i>Escherichia coli</i> like organisms counted on MacConkey medium
M-Fc ECLO	-	ECLO count on M-Fc media for coliforms
MF	-	Membrane filter
PALO	-	<i>Pseudomonas aeruginosa</i> like organisms
PKLO	-	<i>Proteus klebsiella</i> like organisms
SFLO	-	<i>Streptococcus faecalis</i> like organisms
SHLO	-	<i>Shigella</i> like organisms
SLO	-	<i>Salmonella</i> like organisms
TC	-	Total coliforms
TVC	-	Total viable counts
VCLO	-	<i>Vibrio cholerae</i> like organisms
VLO	-	<i>Vibrio</i> like organisms
VPLO	-	<i>Vibrio parahaemolyticus</i> like organisms

1. INTRODUCTION

1.1. Background

Gulf of Kachchh (hereinafter termed as Gulf) which occupies an area of 7300 km² is biologically one of the most productive and diversified habitats along the west coast of India. The high tidal influx covers vast low lying areas of about 1500 km² comprising a network of creeks, marshy tidal flats and rocky regions which provide congenial environment to a wide variety of marine biota. The southern shore has numerous Islands and inlets which harbour vast areas of mangroves and coral reefs with living corals. The northern shore which is predominantly sandy or muddy confronted by 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. In order to protect the rich biodiversity of the Gulf, several intertidal mudflats and coral reefs along its southern shore are declared as Marine National Park and Marine Sanctuary.

Industrial and other developments along the Gulf have accelerated in recent years with the establishment of two oil refineries. In addition, the ports at Okha, Kandla, Navlakhi, Mundra and Jakhau handle a variety of cargo and are responsible for considerable ship traffic in the Gulf. Additional 3 major ports are planned apart from the expansion programmes of the existing ports. Several captive jetties are also under consideration. Four SPMs are already operational two each at Vadinar and Sikka and one operated by Indian Oil Corporation Ltd. and Reliance Petroleum Ltd. respectively. Another two SPMs will be set up by 2002 between Vadinar and Sikka by Bharat Oman Refineries Ltd. and ESSAR Oil Ltd. As these SPMs will be used for import of crude oil, traffic of crude oil and petroleum products is expected to go up substantially over the next few years.

The other major industrial developments around the Gulf include a soda ash industry at Mithapur, a cement plant, a thermal power plant and a fertilizer factory at Sikka and a cement complex at Mundra. Many of these industries make use of the Gulf either directly or indirectly to draw seawater for cooling, to release wastewater including the return coolant and export/import of materials. In addition, there are several medium and small-scale industries and salt pans which makes use of the Gulf in a variety of ways.

In view of the above, it is inevitable that the existing and proposed developments are planned in an environment friendly 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. ICMAM aims to promote sustainable development of coastal resources, ensure protection and conservation of coastal areas and facilitate sustenance of economic and ecological growth in the coastal areas through integrated management of all activities. One of the objectives of the ICMAM project (with its headquarters at Chennai) is to prepare the model ICMAM plan for the Gulf. This work has been awarded to National Institute of Oceanography (NIO), Goa. NIO engaged Vijayalakshmi R. Nair, a retired Scientist of NIO as a Consultant to compile and submit a report on the status of the flora and fauna of the Gulf based on the available information covered in various scientific technical reports, published papers and other sources.

1.2. Objectives

- 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 macro level.
- c. Assess the present biotic status of the Gulf.

1.3. Scope of work

The project domain for the present study covers the water-spread areas of the Gulf as well as the segments off Jakhau, Kharo creek and Kori creek.

The status of flora and fauna of the Gulf was established by collecting the available literature, technical reports and database of NIO. The scope of studies as given below was carefully framed through mutual discussion between ICMAM, NIO and consultant after critically scanning the available information.

- a. Bacterial population
- b. Phytoplankton pigments, primary productivity and phytoplankton population and generic diversity.
- c. Zooplankton biomass, population, group diversity.
- d. Macrobenthic biomass, population and group diversity for the intertidal and subtidal zones.
- e. Meiobenthic biomass, population and group diversity.
- f. Marine fouling and corrosion.
- g. Fishery status based on experimental trawling data and report of state fisheries. Information on larval stages of fish and decapods to be incorporated for comparison.
- h. Status of Mangroves and their diversity.
- i. Marine algae, sea grasses and sand dune flora.
- j. Corals and their diversity.
- k. Reptiles, birds and mammals.

1.4 Approach Strategy

The 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, published papers and remote sensing data. These were procured, collated and assessed to obtain the prevailing status of marine life in the Gulf. These informations were adequate to describe the biotic setting of the Gulf though data for the open ocean were limited. The sources of information are listed under the following categories.

1.4.1. 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 (Table 1.4.1). The site-specific studies conducted from

time to time have resulted in an extensive database for the concerned segments of the Gulf. Coastal waters of the Gulf often reveal significant seasonal changes in ecology. The Gulf region experiences three distinct seasons: premonsoon, monsoon and postmonsoon. However, field observations are hampered during monsoon due to rough sea conditions. Hence, only limited data are available for monsoon period. The Environmental Impact Assessment (EIA) reports of NIO cover the following segments of the Gulf.

- **Off Okha**

The first investigation on the ecology of the Gulf was the waste water disposal studies conducted off Mithapur in 1981. NIO routinely monitors the coastal water of Okha under the Coastal Ocean Monitoring and Prediction System (COMAPS) of Department of Ocean Development at fixed locations once every year since 1989 and this has generated long term data for biological characteristics. Additional studies on environmental impact assessment of Mithapur and Positra Bay were carried out during 1995 to 1999. The technical reports available for this segment of the Gulf are 13 (Table 1.4.1).

- **Off Salaya**

Observations off Salaya was made during the environmental studies in the Gulf during 1985 and a few investigations associated with the studies for other southern segments of the Gulf.

- **Off Vadinar**

Extensive observations were made at Vadinar since 1994 and investigations were continued during subsequent years from 1995 to 2000. These reports include substantial data on coral reefs and mangroves. A total of 7 technical reports are available for assessing the ecology of the region. There are a few reports covering Sikka – Vadinar section.

- **Off Sikka**

This segment of the Gulf also has been well covered under different sponsored projects taken up by NIO. The data are spread over the years 1985 to 2000 with more frequent sampling after 1995. A few reports cover the segment between Sikka and Vadinar. The number of reports available are 5.

- **Off Bedi**

There is only a single technical report for Bedi for the investigation done in connection with the proposed Gujarat Maritime Board super port at Bedi to provide trading facilities. Pirotan, a small Island about 16 km away from the Bedi port was studied on two occasions during 1970-72 and 1977 to evaluate the flora and fauna of the Island for starting a conservation plan and there are two reports for this region..

- **Off Navlakhi**

The initial study for the area was taken up in 1985 followed by seasonal studies during 1986-87 connected with the environmental studies of Kandla. Later work was in 1994 to assess the impact of LPG import terminal near Navlakhi on marine ecology.

- **Off Kandla**

Extensive studies of Kandla including the creek systems were studied since 1985. More recent studies were connected with the proposed jetties and associated facilities. Ten technical reports for the area are available for assessing the ecology of Kandla and the creek environments.

- **Off Mundra**

NIO has conducted marine investigations around Mundra during 1997-2000 generating an adequate database for the region for which published information has been scanty. There are four EIA reports for Mundra.

- **Off Luni**

Data off Luni were collected in connection with the EIA studies in the Gulf during 1997.

- **Off Jakhau**

Only two reports for the area are available with limited information on the ecology of the area.

- **Kharo creek**

This creek system was intensively studied during 1994-95.

- **Kori creek**

Baseline data for Kori creek are available in two technical reports. Observations were made during 1997 to 1999.

- **General**

Status of coral reefs of the Gulf of Kachchh and Andaman & Nicobar Islands were evaluated by NIO in 1992. The existing data-base of NIO covering the outer Gulf and associated waters of the Arabian Sea for a special block area was studied in detail. The eastern boundary of the block stretches from Vadinar to Mundra while the western boundary is along 68° 34' E longitude.

1.4.2. Reports of other Institutions

Among the scientific reports from sources other than NIO the recent reports from Gujarat Ecological Society are significant as these are bench mark surveys consolidating the available data on geomorphology, marine ecology and threats, socioeconomic profile, agriculture, environmental problems etc. of the Gulf (GEC, 1996, 1999; GES, 1997; Pilo *et al.*, 1996; Desai, 1997; Patel, 1997; Sen Gupta and Deshmukhe, 1999, 2000b; Sen Gupta *et al.* 1999). Issues and problems involved in managing protected areas and a detailed management plan for the Marine National Park and Sanctuary were reported by Singh (1994, 1997). The reports on the coral reefs of the Gulf of Kachchh present the status of corals for the area (Envis, 1998; Sen Gupta and Deshmukhe, 1999).

The list of marine algae from Indian coast incorporates information on the algal community of the Gulf (Untawale *et al.*, 1981). Vasihnav and Chavan (1987) reviewed the coastal and marine ecosystems of Gujarat.

1.4.3. Published papers

A review of available published papers for Gulf of Kachchh reveals that major part of the studies related to mangroves, corals, benthos and fishery. These papers are categorised under various titles and are listed below.

Algae and mangroves

An estimate on the algin bearing seaweeds of the Gulf was made by Chauhan and Krishnamurthy (1968). Observations on a collection of marine algae from the submerged Dona reef in the Gulf was made during 1968 and 1969 (Gopalakrishnan, 1969a). The study reveals the presence of 55 species of algae belonging to 42 genera. An estimate on the iodine yielding seaweed *Asparagopsis taxiformis* of Sourashtra coast indicates sheltered calm area

of the Gulf suitable for the cultivation (Bhandari, 1974). A successful experiment in exploitation of *Sargassum* (Alginophyte) sp. around Sikka was taken up (Brahmbhat *et al.*, 1979). Growth characteristics and pigment levels in a halotolerant Cyanophyte was taken up by Anantani and Vaidya (1983). Fungal spores had been recovered from grab samples of the Gulf (Ratan and Chandra, 1983). Floristic study of *Sargassum* of Gujarat coast indicates that among the different species *Sargassum tenerrimum* contributes 70-80% of *Sargassum* flora of the coast (Chauhan, 1985). The alginic acid content of *Turbinaria indica* in the Gulf was taken up by Solanki *et al.* (1986). He observed that *S. cinereum* and *S. cinctum* are commonly associated with *S. tenerrimum* in the Gulf. Other species found off Okha is *S. swartzii*. *Hydroclathrus tenuis*, a marine brown algae has been reported from Kalubhar during 1994 (Jagtap and Untawale, 1996). Jagtap *et al.* (unpublished) reviewed the status of sea grass ecosystem of India.

Utilisation of mangrove forests in Sourashtra and Kachchh were described by Kulkarni (1957). A status of the mangroves along the west coast of India was reviewed by Untawale (1980). Rajagopalan (1983) made a comparative study on the ecological aspects of mangrove biotopes in four different regions of India which included the Gulf. Present status of mangrove, coral and Island ecosystems along the Indian coast was evaluated in detail based on their structure, production, utilization and management (Untawale, 1983). Untawale and Ambiyee (1988) studied the flora of Bet Shankhodar in the Gulf of Kachchh. The distribution of mangroves along the Gulf of Kachchh was evaluated in detail (Untawale and Wafar, 1988). A review on mangroves of India is made by Ray (1991), while Untawala and Wafar (1991) evaluated the status of mangroves along the west coast of India. Successional stages of mangroves in the Gulf are worked out by Singh (1996). Socioeconomic significance of mangroves for coastal people of India is given by Untawale and Jagtap (1999). Details on the large scale mangrove afforestation programme being implemented with the help of forest department is reported by Muley (1997). Naskar and Mandal (1999) reviewed the ecology and biodiversity of Indian mangroves. Growth patterns of mangroves in the Gulf are given in detail by Singh (2000). Major biotic constituents, conservation and management of Indian mangroves are evaluated by Jagtap *et al.* (in press).

Plankton

Plankton of the Kandla port area was studied by Ramamurthy and Dhawan (1963) while Dhawan (1970) did detailed studies on the seasonal variations of phytoplankton in relation to the hydrological factors at Kandla. Seasonal sequence and abundance of 57 species of diatoms are studied off port Okha (Gopalakrishnan, 1972). In the northern Arabian Sea highest primary production has been reported from the Gulf and Indus river discharge area (Kuzmenko, 1973). Studies on the marine planktonic diatoms indicated the presence of 63 species of diatoms in the Gulf (Mahyavanshi, 1975). The biological characteristics off Mithapur indicate fairly high productivity in term of phytoplankton pigments and macrobenthos, but the area sustained low standing stock of zooplankton (Gajbhiye *et al.*, 1988).

Decapod larvae of *Callinassa tyrrhena* are reported as a new record from the Gulf (Patil and Mahyavanshi, 1974). Studies on zooplankton from the north and northeastern Arabian Sea indicate maximum biomass off Kachchh (Paulinose and Aravindakshan, 1976). Govindan *et al.* (1977) reported that zooplankton-standing stock was about 4.5 times more outside the Gulf as compared to the interior Gulf. Madhupratap and Haridas (1992 and 1994) described two new species namely *Pseudodiaptomus pankajus* and *Acartia sarojus* from the salt pans of the Gulf. Zooplankton characteristics of the Gulf of Kachchh with special reference to larvae of decapods and fishes were studied by Paulinose *et al.* (1998).

Benthos

Growth rate of the pearl oyster *Pinctada pinctada* of the Gulf with details in pearl formation was worked out by Gokhale *et al.* (1954). Seventy-two species of gastropods belonging to 51 genera were reported from Gulf (Menon *et al.*, 1961). Kundu (1965 a & b) described 91 species of pelecypods collected from the Gulf. Relation between age and linear measurements of *Pinctada vulgaris* of the Gulf was studied by Narayanan and Michael (1968). A species of the genus *Berthellina* (Opisthobranchia) of the Gulf was described by Narayanan (1970) while two doridacean nudibrach species from the Gulf were reported as new to the Indian coast (Narayanan, 1971). Distribution of benthic fauna of Gulf, off Dwaraka and Okha was investigated by Kasinathan *et al.* (1973-74). Breeding of the pearl oyster *Pinctada fucata* of the Gulf was studied in detail by Narayanan (1974) while influence of temperature on growth ring formation of the same species was taken up by Pandya (1976). The potentiality of pearl formation in *Pinctada fucata* of the Gulf was taken up by Desai *et al.* (1977). Report of a new record of the lamellibranch *Ctenoides ferescabra* was given by Patel (1983). Morphological differences between two oysters of the Gulf – *Crassostrea cucullata* and *C. crista-galli* was taken up by Katel and Jetani (1991) to avoid ambiguity in identification of the two species. New records of a molluscan *Homalocantha secunda* (Apte, 1998) and *Maculotrion serrialis* (Apte, 1999) were made from Okha. Foraminiferal study from Kharo creek revealed the presence of 47 species in the surface sediment samples collected within 4 to 13.5 m water depth (Nigam and Chaturvedi, 2000).

Other benthic groups: A new species of foraminifera *Spiroclypeus ranjanae* was collected and reported from Gulf (Tewari, 1956). A preliminary survey of marine fauna of Gulf was taken up by Gideon *et al.* (1957) reporting specially *Ikedella misakiensis*, *Lingula* and a large number of other worms. A note on animal association between a crab and crinoid from the Gulf is reported (Sankarankutty and Jones, 1960). The occurrence of echiuroid *Ocketostoma zanzibarensis* (Gupta and Menon, 1961) and the leech *Ozobrachus branchiatus* (Ghosh *et al.*, 1963) from Pirotan Island have been reported. The porcellanid crabs are found as commensals in a sea pen collected from Pindara Bay (Ramanandan, 1966). *Thalamita poissonii* was collected from Adatra reef and reported as the first record from Indian coast (Chandy, 1969). A report on the holothuroid echinoderms of the Gulf was reported by Gopalakrishnan (1969b). 49 species of brachyuran decapods were collected from the intertidal region of the Gulf, of which 19 species are new records to the region (Chandy, 1973). In a report on the holothuroid echinoderms from Indian Ocean 5 species are reported to be exclusively confined to reef flats of coral Islands including the Pirotan Island and adjacent corals bed in the Gulf (Daniel and Halder, 1974). New records of a rare bonellid *Ikedella misakiensis* were observed during the course of a coral survey in the neighbourhood of the Gulf (Patel, 1976). The echiurans – *Achaetobonellia maculata*, and *Acanthobonellia vulgaris* are abundant at 5 to 7 m depths at Pirotan Island (Singhal, 1980). Distribution of 5 species of Sipuncula and six species of Echiura was carried out by Singhal (1988). Study of Demospongiae of the Gulf shows the presence of 25 species of sponges in the Gulf (Thomas *et al.*, 1996).

Fishery

Observations were made on the chief schooling fishes of the Arabian Sea indicated that these fishes migrate from Kachchh to Sind (Qureshi, 1953). Based on 'dol' net catches at Bombay and gill net catches at Bedi scales and otoliths of *Otolithoides brunneus* were considered as indicators of age (Kutty, 1962). The fishery of *Polydactylus indicus* from the landings of the bull trawlers operating between Kachchh and Bombay was studied by Kagwade (1965). An abnormal ray from the Gulf was reported by Easwaran (1967). Maturity and spawning of the silver pomfret, *Pampus argenteus* were studied in the area between the Gulf and Gulf of Cambay (Gopalan, 1969). Report on the demersal fishery of the north-west

coast of India includes the fishery of Dwaraka (Joseph, 1974). The regional and seasonal abundance of *Lactarius* from Bombay – Sourashtra waters and Kachchh ranked the highest in this fishery (Kaikini, 1974). A fishery of mullets and scope for its culture in Gulf was studied by Chhaya *et al.*, (1979). Biology and fishery of *Muraenesox talabonoides* including its spawning ground was reported by George (1980). Khan (1983) made preliminary observations on the fishery of the Bombay duck *Harpadon nehereus* from the Gulf. Singh (1986) reported on the ecology and productivity of the Indian coastal regions which covers the Gulf and concluded that coastal zone fisheries including mariculture, aquaculture and capture fisheries play significant role in the economy of the region. The fishery and socio-economic aspects of Modhwa was studied in detail by Pravez *et al.* (1992). Nair *et al.* (1993) studied the fishery potential of the interior Gulf and adjacent creek regions.

Prawn fishery: A description on the new species *Metapenaeus kutchenis* from the Gulf was given by George *et al.* (1963b). Prawn fishery of the Gulf of Kachchh with emphasis on the catch composition was studied by Ramamurthy (1963a) while the same author (1963b) reported on the prawn fishery at Adesar camp, situated in the Little Rann of Kachchh. Here the fishery starts just after the cessation of monsoon in the land-locked lagoon of the Little Rann. Ramamurthy (1964) studied *Metapenaeus stebbingi* from the commercial catch from the inshore waters of the Gulf and reported the species as a new record. Another new species of *Metapenaeus* was reported from the Gulf (George *et al.*, 1966). *Metapenaeus kutchenis* was the major constituent in prawn landing at Cherowari, Sukhper and Lakhpat area of the Little Rann of Kachchh and *M. brevicornis* predominated during winter at Takara (Tuna) and Bhadreswar areas (Sarvaiya, 1978). The Little Rann of Kachchh supports a lucrative seasonal prawn fishery principally contributed by juveniles of *Metapenaeus kutchensis* during the monsoon months (Rao, 1983). Large scale prawn harvest in the Little Rann of Kachchh during monsoon was described by Thakar (1982). Systematic study on the three species of *Metapenaeus* (*M. alcocki*, *M. krishnatrii* and *M. kutchensis*) was taken up by Miquel (1983). A survey was made on the fishing gear, Gunja net and methods used in the prawn fishery of the coastal waters of the Gulf (Pillai and Gopalakrishnan, 1984). Influence of some environmental parameters in the condition factors of two species of penaeid prawns, *Metapenaeus kutchensis* from Surajbari and *M. merguensis* from Bedi were studied (Bhan, 1989). The commercially important prawns in the trawl fishery at the mouth of the Gulf were studied with special reference to biology of some prawns (Joseph and Soni, 1990). Difference in the constituents of the prawns that support the fishery of the Gulf during the monsoon fishery of August-September in the creeks and the winter fishery of October-November in the Gulf were reported in detail (Deshmukh, 1995).

Molluscan fishery: Gokhale (1954) reported on the recovery of fishery of oysters *Placenta placenta* due to fishing of potential spawners rendering the Gulf barren. Pearl fishery potential of the Gulf was studied by Easwaran *et al.* (1969). The oyster, *Pinctada fucata* is located mainly in the Gulf of Kachchh and Gulf of Mannar and its culture technique was developed for the first time (Alagarswami and Qasim, 1973). Details on the exploitation of the chank fishery constituted by *Xancus pyrum* in the Gulf were reported by Varghese and Shah (1977). Laboratory rearing of eggs and larvae of edible oysters of the Gulf was taken up by Desai *et al.* (1980). A detailed account on the windowpane oyster, *Placenta placenta* fishery of Pindhara Bay in the Gulf was reported by Sarvaiya (1982). Cephalopod resources of the Gulf and their pattern of distribution in relation to depth of the area fished were investigated (Siraimetan, 1988). A culture technique for pearl production through seed production by hatchery method and farming in the sea was taken by CMFRI (James *et al.* 1992). This report indicated the existence of 42 pearl oyster beds in the Gulf.

Salt works and culture: A survey of the Gulf revealed the occurrence of brine shrimp, *Artemia* sp. in many salt producing areas indicating the total number of strains to five (Royan, 1979). Gopalakrishnan and Raju (1987) explored the feasibility of utilization of low saline reservoirs of solar salt works in Okhamandal for extensive prawn farming. Observations on the fish and prawn seed resources of the Gulf and results of their experimental culture in low saline reservoir of a solar salt work were reported by Gopalakrishnan *et al.* (1987 a). On the occurrence of mature prawn *Penaeus merguensis* in a shallow salt works reservoir along Okhamandal coast and its spawning in laboratory was reported by Goplakrishnan *et al.* (1987 b). Studies on the maturation and spawning of grey mullets of a reservoir fishery in Okhamandal were made (Gopalakrishnan and Thaker, 1988). *Artemia* cysts are available in salt condensers of Jamnagar and Kachchh districts and use of these in simulated salt pan system for *Artemia* and their cysts production is reported as a promising venture (Chhaya *et al.*, 1990). Observations on the growth and survival of the Jumbo prawns *Penaeus monodon* and *Penaeus indicus* in a solar salt works along the Okhamandal coast were made by Gopalakrishnan *et al.* (1990).

Corals: Generic diversity of the scleractinians around Positra point has been studied along the different intertidal locations of reef building corals (Patel, 1978). A survey in the Gulf mainly around Okha and Jamnagar was made to study the coral formations and mangroves (Pillai and Rajagopalan, 1979). Report on the structure and generic diversity of Scleractinia of India includes the species list for the Gulf also (Pillai, 1983). Status report on corals of India includes the details on the ecology and resources of these organisms from the Gulf (Wafar, 1986, 1999). The Scleractinian corals of the Gulf are represented by 37 species belonging to 24 genera out of this 33 species are hermatypes and the remaining 4 species are ahermatypes (Pillai and Patel, 1988). Ecological status of the coral reefs of the Gulf of Kachchh and Lakshadweep was studied by Bahuguna *et al.* 1992). Studies on the biology and ecology of coral reef fishes of Lakshadweep include observations on other coral reef ecosystems including the Gulf (Anand and Pillai, 1995). Contributions of Zoological Survey of India on the general pattern of coral reefs in the Indian seas indicates coral reefs located closer to the shores of Gulf have been extensively damaged/ destroyed due to industrial installations. (Anon, 1997). Contribution of Central Marine Fisheries Research Institute to the knowledge of coral reefs of India stress the need for regular monitoring and specific guidelines for the effective management of the National Marine Parks including that of the Gulf. (Devaraj, 1997). Hoon (1997) and Hoq (1997) made a review on the extent, condition, research and management status of the coral reefs of India. This paper has brought out the serious problems of stress from anthropogenic pressure on the coral reefs. A state-of-the-art report on the coral reefs of India was compiled by the Environmental Information System Centre (1998). Disease and stress-included mortality of coral in Indian reefs are assessed by Ravichandran *et al.* (1999). A detailed account on the coral reefs of the Gulf of Kachchh is given by Deshmukhe *et al.* (2000).

Reptiles, birds and mammals: A preliminary report on the status and distribution of sea turtles in Indian waters is given by (Bhaskar, 1981).

Information on the Indian reef heron, and their breeding season are reported from Gujarat coast and Gulf (Dharmakumarsinhji, 1984). The rise in global mean sea level was reported to affect the flamingo breeding grounds (Kumar, 1986). The impact of the food availability, nesting-habitat destruction and cultural variations of human settlements on the nesting distribution of the reef heron *Egretta gularis* in Gujarat state including Gulf of Kachchh were reported (Naik and Parasharya, 1987). Occurrence and distribution of the slender billed Gull *Larus genei* from various localities in the Gulf of Kachchh was studied by Mundkur *et al.* (1988). Hitherto unreported nest site of lesser flamingo *Phoeniconaias minor* in the Little Raan

of Kachchh was represented by Mundkur *et al.* (1989). Report on the flamingos (Greater Flamingo) that started breeding in the great Raan of Kachchh after a gap of about thirteen years after 1991 was reported by Negi (1993).

Mohan (1963) reviewed and reported on the presence of *Dugong dugon* along the Gulf where it is popularly known as "Babloo". Later, Frazier and Mundkur (1990) reviewed the records of *Dugong dugon* from the Gulf and concluded that there is evidently a resident, breeding population which needs to be protected. Jani and Patel (1995) reported on the first record of sea whale, *Balaenoptera borealis* from Salaya while Khacher (1998) recorded the occurrence and distribution of *Dugong dugon* in the Gulf.

Marine pollution and conservation

Conservation plan for patchy corals of the Gulf of Kachchh is reported by Patel (1985). Rashid (1985) reviewed the marine wealth of the Gulf with comments on conservation of biota. Parulekar (1988) evaluated the bioecology of the Gulf of Kachchh. Marine environmental impact assessment of proposed tidal power development in the interior Gulf indicated that the construction of barrage is not likely to influence nutrient level of the Gulf or the seasonal fishery of the creek areas (Zingde *et al.*, 1988). Naik (1991) presented a detailed discussion on mangroves of the Gulf, marine floral and faunal wealth and the environmental problems like exploitation of mangrove vegetation, salt pans etc. Anthropogenic pressure on the coastal marine ecosystems of the Gulf of Kachchh was studied by Sourashtra University (1991). Mangroves along the west coast including Gulf are reported as a glaring example of over exploitation (Untawale and Wafar, 1991). Endangered, vulnerable and rare marine fishes and animals in Indian waters and the habitat damages of corals are reported in detail by James (1994). Sen Gupta *et al.* (1993) studied the state of oil pollution in the northern Arabian Sea after the 1991 Gulf oil spill. They concluded the review with a suggestion on the conservation of marine resources through stricter enforcement of existing laws. Implications of coastal refineries to the ecology of the Gulf of Kachchh and suggestions to minimize these impacts have been made by Zingde and Anand (1994). Fishery and anthropogenic pressures in the Gulf were studied with comments on the stress on mangrove vegetation due to extensive cutting for fuel/ fodder (Krishnan *et al.*, 1995). Case studies on feasibility and conceptual plan for oceanarium, dolphinarium, marine land complex are discussed for conservation of marine life (Parulekar, 1995). Muley (1997) studied the aspect on the restoration of mangrove forests in detail. Water quality along the north-west coast of India is reported by Zingde (1998). Ecology and biodiversity of Indian mangroves have been reviewed by Naskar and Mandal (1999). Coastal and marine environment of Gulf of Kachchh has been chosen for development of model coastal management plans (Subramanian, 1999). Proposed establishment of refineries along the southern shore of the Gulf of Kachchh and eventual increase in the movement of crude oil and petroleum products high lights the urgent need of an adequately evolved environment management plan to minimum adverse impacts on the rich and diverse bioproductive regime of the Gulf (Zingde, 1999).

1.4.4. Remote Sensing data

Satellite remote sensing plays a unique role in coastal mapping, resource survey and ocean monitoring. Generation of baseline data for coastal, marine and contiguous inland terrestrial environment using satellite based remote sensing technique is being carried out by National Remote Sensing Agency (NRSA), Hyderabad, Regional Remote Sensing Service Centre (RRSSC), Nagpur and Space Applications Centre (SAC), Ahmedabad. Application of satellite data for monitoring degradation of tidal wetlands of the Gulf of Kachchh is reported by Nayak *et al.* (1989). Satellite data especially IRS-IA and IB data are proved to be useful in creating baseline inventory of coastal wetlands (Desai *et al.*, 1991). The improved version of IRS-IC data has been found to be useful in obtaining information on coral reef zonation, identification

of mangroves and seaweed/ seagrasses (Nayak, 1994; Nayak *et al.*, 1996 a & b; Bahuguna and Nayak, 1998). The coral reefs of the Gulf have been mapped on 1:15,000 scale using IRS - LISS II/SPOT data depicting extent, type and ecological conditions of the reef (Bahuguna and Nayak, 1998). Information incorporated in some of the NIO technical reports and other reports (Sen Gupta and Deshmukhe, 1999, 2000) were also considered for the present assessment.