Chapter-3

Study area-The Gulf of Kachchh

India has a coastline of about 5500 km in the mainland and about 2000 km in its offshore islands. The coastal area of the country is blessed with vast network of back waters, estuaries, creeks, lagoons and specialized ecosystems like mangroves and coral reefs. It has vast beaches all along the coast. The western state of India "Gujarat" faces the Arabian sea and the water of the Arabian sea wash 1650 km of the state-giving it the longest coastline among all the Indian maritime states. About 60% of the coastline comprises the indentations of the two gulfs viz. the Gulf of Kachchh and the Gulf of Khambhat.

3.1 Introduction of the study area

The present study was carried out in the Gulf of Kachchh, Gujarat. The Gulf of Kachchh is situated at western coast of India and located between 22°15' N and 23°40' N Latitudes and 68°20' E and 70°40' E Longitudes. It is approximately 125 km long and 75 km wide, funnel shaped, East–West oriented indentation of Gujarat coast. Biogeographically, the area falls in $8A_1$ – *Gulf of Kachchh* sub-biotic province (Rodgers and Panwar, 1988). The Gulf of Kachchh is the only site in Gujarat bestowed with one of the four major coral reef formations of the country. The southern margin of the gulf is fringed by coral reefs, islands and extensive mud flats, which possess a total of 42 islands (Pandey *et al.,* 2010), getting partially exposed during low tides. Patchy coral formations are evident on intertidal sandstones in the Gulf of Kachchh. Live corals are found at the edges of the seaward slope of the reef. (Bahuguna *et al.,*1992). Gujarat has one of the four major coral reef formations of the country that is concentrated on the southern shore of the Gulf of Kachchh. The gulf is a result of geological processes like wide indentation or subsidence that allowed encroachment of the Arabian Sea towards the land and the seismic instability is still continuous. The Gulf of Kachchh is one of the two inundations of Gujarat coast that stretches 1000 km out of the 1650 km of the Gujarat coastline. The Gulf of Kachchh is the east-west oriented funnel shaped indentation of Gujarat coast separating the state land mass into two parts by stretching~ 125 km inside the land. The mouth of the gulf is 75 km wide which joins near Surajbari at the eastern part of the state. The Gulf of Kachchh lies between the mainland of Kachchh in the north and the Saurashtra/Kathiawar peninsula in the south and is open to the Arabian Sea in the west. Due

to prevalent climate and reduced fluvial discharge, the Gulf water has homogeneous one layered structure (Pradhan *et al*., 2004).

The southern portion of the gulf trends E-W and stretches for about 250 km. The shoreline is rocky and configuration is highly crenulated and characterized by extensive mudflats, offshore islands and rocky platform with narrow beaches. There are several sluggish streams with downing mouths. The substrate is uneven and formed of hard basalts and soft tertiary sedimentary rocks. The littoral zone has a low gradient and is covered with a veneer of calcareous mud (GES, 1997).

The Southern margin of the Gulf of Kachchh is fringed by 42 islands and several coastal areas having coral reefs, mangroves and mudflats that fall in 3 districts *viz.*, Jamnagar, Devbhumi-Dwarka and partly Rajkot. The southern shore of the gulf consists of 20% of countries reef area. Most of the reefs are now in the regions of Marine Protected Areas (MPAs). Based on satellite image of 1991, the coral reef area is about 85 km^2 of the core area of Marine National Park. The coral reefs of the GoK are distributed among islands and coastal areas. In the Gulf of Kachchh, 19 islands, 6 submerged reefs and 5 adjoining areas of mainland consist of coral reef (Singh *et al.*, 2004).

The Gulf of Kachchh is a semi-arid region due to the weak monsoonal rains and high evaporation rate which in turn influences the seawater salinity to increase. The long-term mean rainfall on the surrounding area is nearly 42 cm/y leading to a rainfall volume of 3087 Mm^3/y (Nair, 2002). Thus, a negative water balance is exhibited by the Gulf. The region experiences four main seasons namely winter, summer, south west monsoon and post monsoon seasons (Nair, 2002). Except during late summer and southwest monsoon periods, the winds are light to moderate in the Gulf, throughout the year. Stronger winds are also encountered with the disturbances such as depressions and cyclones. This region is severely influenced by the storms occurring in June-July with devastating effects on coastal areas.

In the GoK, the air temperature varies from 10°C to > 36°C throughout the year. January is considered to be the coldest month with night temperatures falling below 10°C while May and June are considered to be the hottest months with mean maximum temperature of 36°C during day and mean minimum of 26°C during night (Nair, 2002). The relative humidity is

generally high during monsoon months and range from 70 to 80%. Whereas, rest of the year, humidity ranges between 55 and 70% (Nair, 2002).

Marine Sanctuary and National Park were the first declared MPA established in the years 1980 and 1982 respectively under the Wildlife (Protection) Act, 1972. The area falls under the Jamnagar and Devbhumi-Dwarka districts of Gujarat. The MNP&S is situated in the intertidal zone of the Northern Saurashtra, extending to nearly 150 km in the Gulf of Kachchh and falls under the districts Jamnagar and Devbhumi-Dwarka. The Marine Protected Area (MPA) covers 620.81 km², which includes 148.90 km² areas of islands and 309.02 km²of intertidal zones along the coast. The national park covers an area of 162.89 km² and the rest is sanctuary (Singh *et al*., 2004).

3.2 Coral Reefs of the Gulf of Kachchh

Coral reefs of the Gulf of Kachchh are the northern most distribution in the Indian continent. Patchy type of coral growth can be seen on intertidal sandstones fringing, barrier or atoll types of reefs do not occur in the Gulf of Kachchh. Here narrow reefs can also be observed. Live corals can be found at the edges of the seaward slope of the reef. They also consist of dead coral blocks and pebbles (Bahuguna *et al*., 1992).

Coral distribution in the Gulf of Kachchh is evident on Islands as well as few coastal locations along the mainland. 25 Islands with corals (6 submerged reefs) and 5 coastal locations with corals along the mainland are present in the Gulf of Kachchh.

Types of coral reef in the Gulf of Kachchh

a. **Fringing reefs:** This reef is adjacent to the coast or separated by a shallow channel. Fringing reefs are found near Okha, Bet Dwarka, Dhani to Sikka, Jindra, Narara, Chhad and Pirotan.
b. **Platform reefs:** Platform reefs are generally rounded or ovoid, broad, flat and larger than a mile or more. In the Gulf of Kachchh, they are found at Paga, Boria, Bural Chank, Kalubhar and Mundeka.
c. **Patchy reefs:** These reefs are also rounded or ovoid but smaller than platform reefs. Patchy reefs are present in Goose and Ajad reef area.
d. **Coral pinnacles:** These rounded reefs, smaller than platform and patchy reefs are approximately 100 m large. Chandri reef has coral pinnacles.

In the present study, southern shore of the East-West distribution of the coral reefs has been considered. On the basis of occurrence of the coral reefs, a total of 6 locations were selected

for the present study. With reference to mainland, 3 locations are islands, 2 are submerged reefs and one is attached to mainland which is described below:

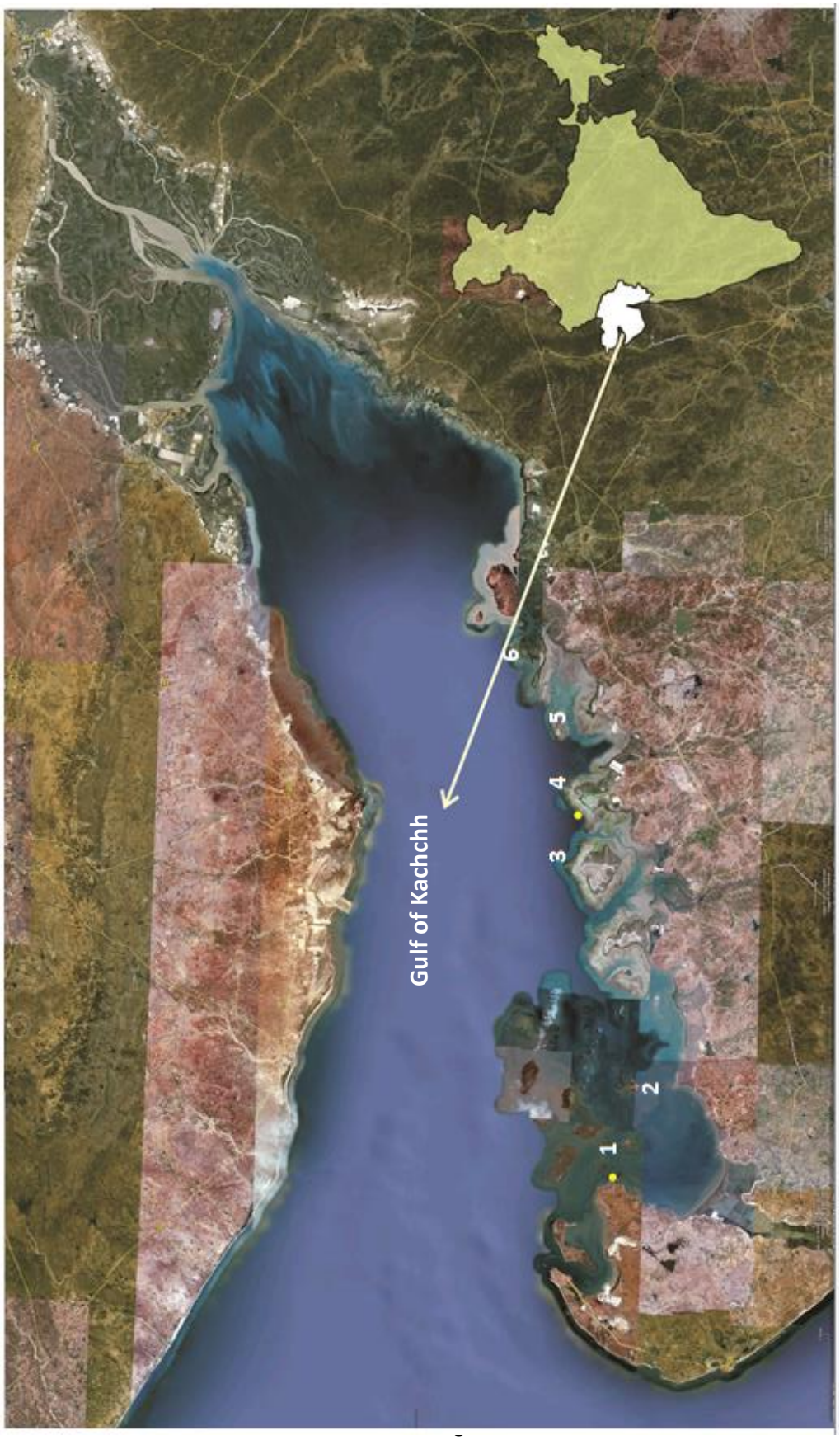

Figure 3.1 Showing Study area -*the Gulf of Kachchh;* 1- Boria, 2- Ajad, 3- Kalubhar, 4- Narara, 5- Goose, 6-Dedeka-Mundeka (map not to scale)

1. Boria

Location: 22^{o}23.8' to 22^{o}26.0' N; 69^{o}11.4' to 69^{o}13.6' E

Area: 98.6 ha

Reef type: Platform reef

Approach: It is approachable by boat from the Poshitra village

General features: Boria reef is one of the most beautiful submerged reefs in the Gulf of Kachchh. The reef is situated just in front of Poshitra reef, hardly some distance away. Even after comprising of small area, this reef represents most of the species of flora and fauna of the MPA (Singh *et al.,* 2004). Boria reef is endowed with dense and diverse coral fauna. Pillai and Patel (1988) had recorded about 23 coral species during their survey while Singh *et al.,* (2004) reported a total of 40 species on Boria reef, out of which 8 species were from soft corals. This reef showcases very diverse forms of coral associated reef fauna.

Major pressures: Fishing activity takes place around the reef (GEC, 2011).

2. Ajad

Location: 22^{o} 22.2' to 22 ^{o} 23.0' N and 69^{o} 19.5' to 69^{o} 20. 5' E

Area: 2284.4 ha

Reef type: Patchy reef

Approach: It is approachable by boat from the Poshitra village

General features: Ajad is one of the inhabited islands in the MPA. The population engaged in fishing as well as agriculture. There are agricultural lands on the island which are believed to be very fertile. A small patch of algal ridge is found in the NW and NE of the island. Fore reef is limited up to the eastern and central regions of the island whereas no fore reef has been identified in the western flank of the island. The reef flat is present in the eastern flank of the island exactly after the fore reef and in the SE part of the island. In Ajad reef area, Pillai and Patel (1988) had recorded about 13 coral species during their survey later on Singh *et al.* (2004) recorded a total of 36 species of corals which included 29 species of hard corals and 7 species are soft corals.

Major pressures: Fishing activity is carried out in the area by local fishermen of Ajad and Salaya (GEC, 2011).

3. Kalubhar

Location: $22^{0}24.4'$ – $22^{0}27.5'$N and $69^{0}35.3'$ – $69^{\circ}39.4'$E.

Area: 6867.4 ha

Reef type: Platform reef

Approach: It is approachable by boat from the Sikka Jetty, Salaya Port and Vadinar Jetty

General features: Kalubhar is located in the central part of the Marine National Park & Sanctuary. It is oval in shape and prominently bifurcated by creeks. It is the largest island in the MPA. The major land cover classes on this island are coral reefs, mangroves and mudflats among which reef flat/mud over reef covers maximum area *i.e.,* 2592.72 ha. The algal ridge can be seen in the northern boundary of the Kalubhar while towards the island side it is bordered with fore reef and then the reef flat. Reef cover can be demarcated in the northern part of the reef while the southern regions of the island are covered by mudflats. The Island supports a fair amount of corals and reef associated fauna as compared to the other islands of MPA. Live coral cover on the island is about 17.15% and the density of recruits of different genera found on this island is 15 recruits /100 m^2 (Pandey *et al.,* 2010). Pillai and Patel had recorded 6 coral species during their survey in 1988 which increased to a total of 38 species of corals in the reef area which includes 33 hard corals and 5 soft corals as per the survey by Singh *et al.* in 2004.

4. Narara

Location: 22°25.8' to 22°28.3' N and 69°42.1' to 69°44.7' E

Area: 6153 ha

Reef type: Fringing reef

Approach: It is approachable by road as well as by boat from the Sikka Jetty

General features: As a result of encroachment by humans, this island has become a part of mainland as there is no distinguished marking of the mainland. It is directly accessible by road up to the reef area. This is also known for the nature camps to study marine fauna and flora. Narara reef is one of the vast expansions of corals and the associated fauna in the MPA. One can observe live corals with moderate distribution along the reef in Narara. Live coral cover on the island is about 4.93 % and the density of recruits of different genera found on this island is 21 recruits/100 m^2 (Pandey *et al.,* 2010). Pillai and Patel had recorded about 6 coral species during their survey in 1988.

5. Goose

Location: 22°28.6' to 22°30.6' N and 69°47.0' to 69°50.4' E

Area: 913.7 ha.

Reef type: Patchy reef

Approach: It is approachable by boat from the Sikka Jetty

General features: Goose reef is not an island but an attractive submerged reef which is having diversified reef invertebrates. It is situating just opposite to Sikka port. This reef is oval in shape and represents fair amount of flora and fauna. The Goose reef has a fair coverage of corals and the associated fauna, though situated near the disturbed area of port activities like Sikka and Reliance industries. Pillai and Patel had recorded about 10 coral species on this submerged reef during their survey in 1988 where as Pandey *et al*. recorded 16 genera in 2010 on the same reef. Live coral cover on the island is about 23.6 % and the density of recruits of different genera found on this island is 51recruits /100 m^2 (Pandey *et al.,* 2010). A total of 29 species of corals have been recorded in Goose reef, which includes 7 species of soft corals.

6. Dedeka-Mundeka

Location: 22°30.8' to 22°33.2'N and 69°51.8' to 69°56.2'E

Area: 5634.9 ha.

Reef type: Platform reef

Approach: It is approachable by boat from the Sikka Jetty

General features: These two islands, situated western to Pirotan are yet, another group of islands with great diversity and density of mangrove. A total of 10 species of island vegetation have been recorded on Dedeka Island, which belongs to 6 families and 8 genera. This can be further divided into 6 species of mangroves and 4 species of the associated flora of mangroves. The coral fauna in Dedeka-Mundeka reef contributed a total of 16 species of coral.