Chapter 2

STUDY AREA

Study Area-Gujarat

The current research work has been conducted in the coastal region of Gujarat province. It is situated on India's western coastline bounded by the vast Arabian Sea on its three sides. Gujarat state is located between 20°06' N to 24°42' N latitude and 68°10' E to 74°28' E longitude, shares a North-Western border with Pakistan and Rajasthan, a North-Eastern border with Madhya Pradesh, and a South-Eastern border with Maharashtra. It has a 1,96,024 Km^2 total surface area (including Daman and Diu UT) and the longest coastline (about 1,650 km) of India. That accounts for 22% of the total coastline available to the country, with 164,200 km^2 of the continental shelf (35.3% of the country) and 214,000 km^2 of Exclusive Economic Zone (EEZ) (9.9% of the country).

Gujarat's total coastline consists of different marine habitats, including 29% of muddy flats followed by 28% sandy beach, 22% marshy coast, and 21% rocky coast. Gujarat's coastal area extends from the Western Ghats in Valsad (Umargam) to Kori creek (Kachchh) on the North-Western coast. The Gujarat state's coastal area is very different in terms of geo-morphology from the rest of the West coast of India. The coastal zone of Gujarat state is divided into three major geographical parts, two major gulfs; namely the Gulf of Kachchh and the Gulf of Khambhat, and the Saurashtra coastline (fig. 2), each of which has its distinctive character,

climate variation, and diverse geo-environmental features, which embrace diverse coastal habitats as well as ecological significant biota. The three regions vary a lot regarding tidal variation and marine habitat diversity.

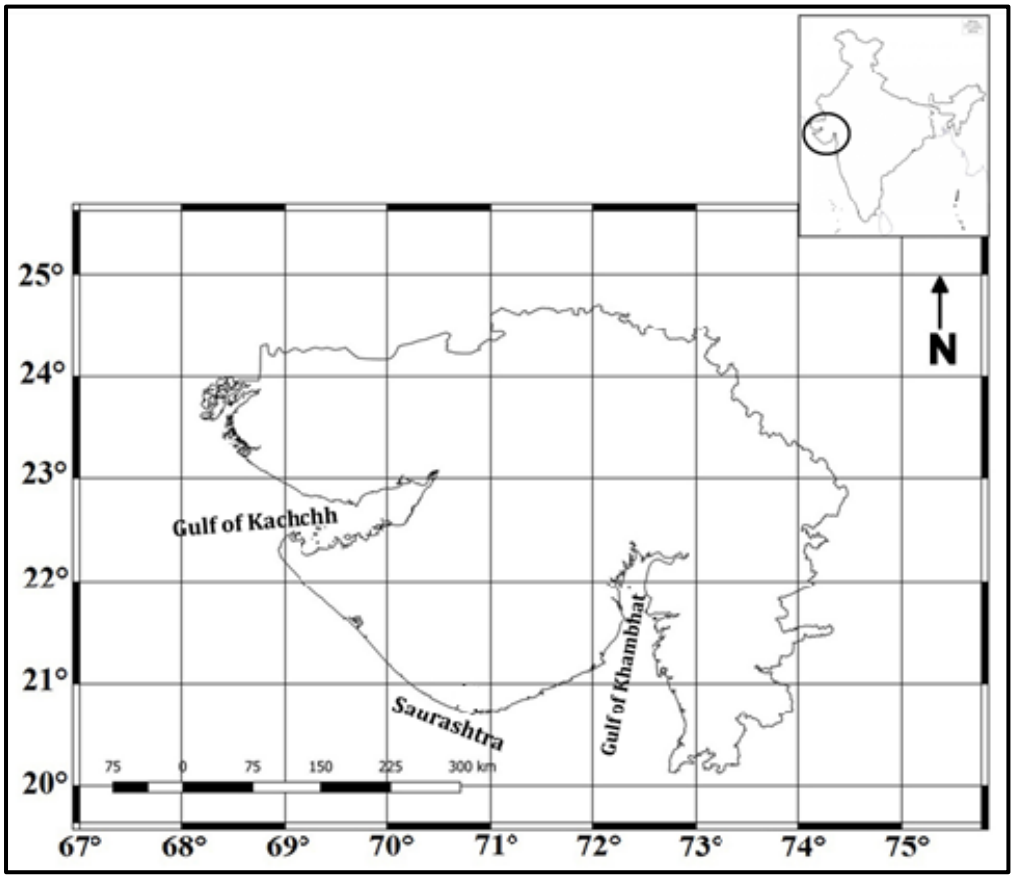

Figure 2 Map showing the division of study area into three major regions.

Selection of study sites

On the coast of Gujarat, a comprehensive field survey was conducted. The coastal region is divided into three major regions, and each coastal region is split further into the coastal districts. A total of 15 coastal districts were surveyed and based on the survey, 70 sites were selected from three coastal regions of Gujarat for the samplings. However, due to repeated seasonal accessibility, permissions from Government authorities in Marine National Park, and Defense Services Authorities in Kachchh district, 59 sites were finally selected for regular studies. Therefore, some of the critical island sites of Marine National Park and Northwestern creek habitats of Kachchh could not be surveyed. During the present study, the selections of the study sites from all the three major coastal regions have

been based on the three parameters: one was habitat type (e.g., sandy shore, rocky shore, muddy shore, mangrove mudflats, and coral reef); the second was the accessibility of the area, and the third one was the sample accessibility or availability.

2.1 Gulf of Kachchh

The Gulf of Kachchh is the region of peninsular Saurashtra-Kachchh in the western state of Gujarat and located between 22°15' N and 23°40' N Latitudes and 68°20' E and 70°40' E Longitudes. It is approximately 75 km wide, and 125 km long, narrow mouth funnel-shaped, East-West oriented indentation of Gujarat coast. On the northern side, the Gulf starts with Kachchh point and lies between the beaches of Devbhumi Dwarka and Jamnagar districts in the Saurashtra regions. The tides in the Gulf of Kachchh are mixed, predominantly semi-diurnal types with massive diurnal inequality. On the northern sides of the Gulf, the tides vary from 3 to 8 m, and on the southern sides, it's 3-5 m. The shape and orientation of the Gulf is the main reason for tide amplification. The high tidal range and tidal currents are important geological agents that play a significant role in sedimentation and shaping the land of the Gulf. The gulf comprises 4 coastal districts, namely, Kachchh, Rajkot, Jamnagar, and Devbhumi Dwarka. The narrow mouth funnel-shaped Gulf is covering an area of 7350 km^2, has channel depths varying from 20 m at the head to 60 m at the outer Gulf. The average depth is approximately 30 m, and the minimum is up to 5 m (Gupta and Deshmukh, 2000). It is a semi-enclosed coastal area with diverse coral reefs and a rocky ecosystem. The geophysical parameters suggest that the Gulf of Kachchh is quite different in many aspects from the Gulf of Khambhat. There are many major and minor islands in the Gulf of Kachchh; they support rich habitat diversity and biodiversity. According to official records, 42 islands in the GoK cover a total area of about 410.6 km^2.

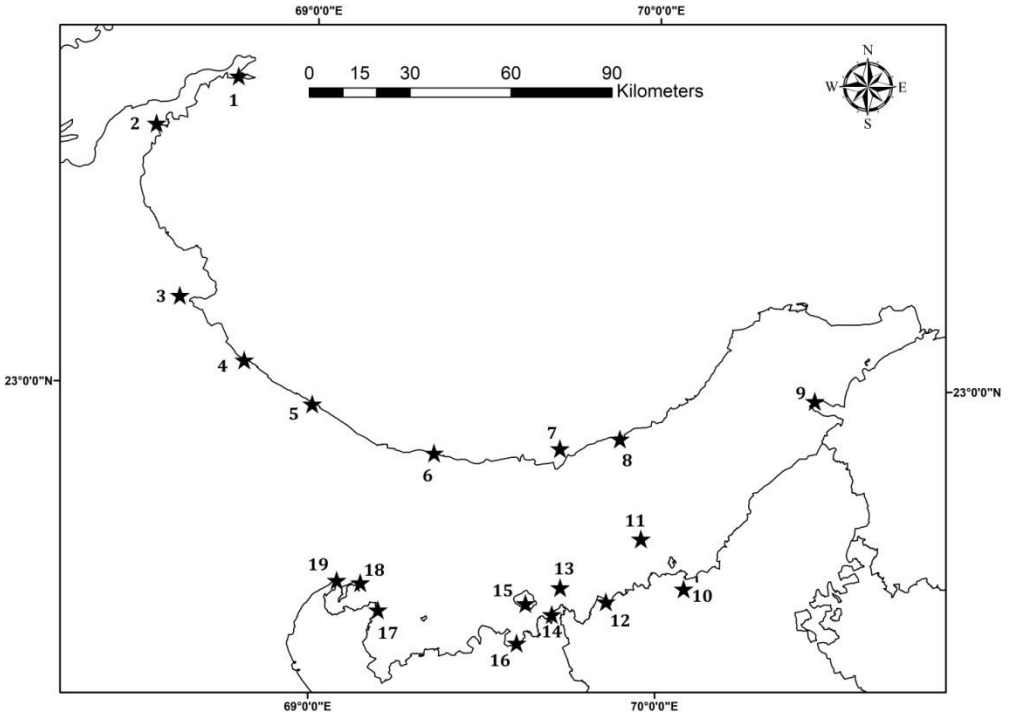

Figure 2.1 Map showing the sampling sites along the coastline of the Gulf of Kachchh; 1-Lakhpat; 2-Koteshwar; 3-Jhakhau; 4-Pingleshwar; 5-Chhachi; 6-Mandvi; 7-Mundra; 8-Bhadreshwar;9-Navlakhi; 10-Sikka; 11-Narara; 12-Jamnagar; 13-Vadinar; 14-Pirrotan Island; 15-Kalubhar Island; 16-Salaya; 17-Poshitra; 18-Beyt Dwarka; 19-Okha.

A total of 19 sites from 4 coastal districts (Kachchh, Rajkot, Jamnagar, and Devbhumi Dwarka) situated along the Gulf of Kachchh were surveyed from the collection of samples (fig. 2.1). Vast patches of mangroves also exist along the northern shore of the Gulf. In the Gulf, the intertidal zone is rocky-sandy supra-tidal zone, a muddy-rocky middle intertidal zone with boulders, and a lower zone with diverse coral reef zone. The Kori creek to Jakhau and Mundra to Kandla Port is irregular and exclusively muddy with mangroves patches. Navlakhi to Jodiya has mudflats, while from Jamnagar to Okha (trending E-W), the coast has a rocky shoreline (like rock mounds), the subtidal zone with water channels, submerged islands, sand bars, coral reefs, and mangroves. The GoK, Mithapur, Sivrajpur, and Dwarka are the only Gujarat areas where coral reefs exist. The GoK provides various kinds of habitats like coral reefs, mangroves, creeks, open mudflats (hard mud,

soft mud, and soup mud), islands, rocky shore, sandy shore, etc., which provide a suitable environment for a large range of fauna and flora.

2.2 Saurashtra Coast

The Saurashtra Coast is situated in the South-Western part of Gujarat and located between 20°72' N and 22°42' N Latitudes and 68°99' E and 70°98' E Longitudes. It is approximately 865 km^2 long, East-West oriented indentation of the Gujarat coast. It lies between the Gulf of Kutch on the north-west side and the GoKh on the south-east side and is surrounded by the Arabian Sea on the south and south-west. The Saurashtra coastline is very distinctive from the Gulf of Kachchh and the Gulf of Khambhat. The high tide surges maximum up to 5 m at the Saurashtra coast. The Saurashtra peninsular comprises 6 coastal districts, namely, Devbhumi Dwarka, Porbandar, Junagadh, Gir-Somnath, and Amreli. The minimum depth is about 3 m, and the average depth is up to 5 m. The topography of the coast changes all along the Saurashtra coast. The majority of the coastline of the Saurashtra coast is rocky and sandy with randomly distributed patches of muddy regions with heavy sediment load.

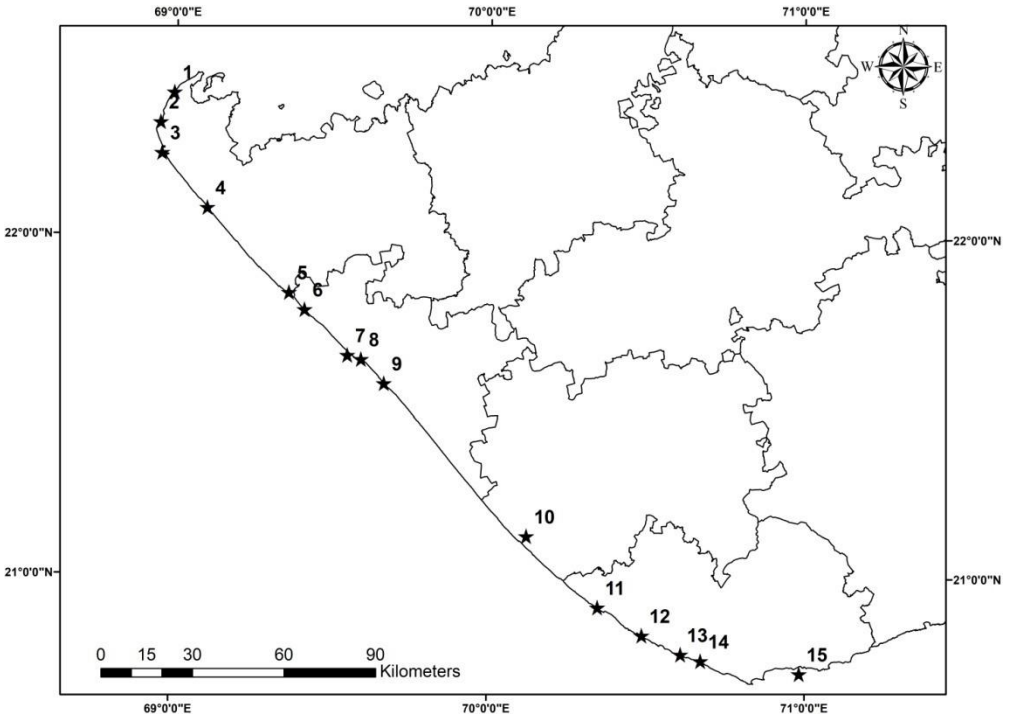

Figure 2.2 Map showing the sampling sites along the coastline of the

Saurashtra coast; 1-Okha; 2-Mithapur; 3-Shivrajpur4-Okhamadh; 5-Harshad; 6-Miyani; 7-Kuchhadi Reef; 8-Porbandar; 9-Odadar; 10- Mangrol; 11-Veraval; 12-Sutrapada; 13-Dhamlej; 14-Kodinar; 15-Diu.

A total of 15 sites from 4 coastal districts (Devbhumi Dwarka, Porbandar, Junagadh, and Gir-Somnath) were surveyed for the collection of samples (fig. 2.2). The intertidal zone of the Saurashtra coastline is unique in that the upper intertidal zone is rocky, somewhere sandy with mud, the middle intertidal zone is mostly rocky, with crevices, and the lower intertidal zone is mainly rocky with sparse sand. In the mid intertidal zone, tide pools are commonly found. The south coast of Saurashtra from Dwarka- Kodinar is about a 250 km patch, with straight and smooth sandy or rocky-sandy beaches. The Saurashtra coastline is rocky-sandy, the east and west (E-W) with Continuous beach with projecting rock mounds, wave-cut platforms, occasional cliffs, the central part is sandy, and more rocky-muddy beaches are found in the eastern part. The formation of milliolite limestone along the coast is remarkable. Due to its unique geomorphologic properties and hydrodynamic processes, it provides a suitable environment for a wide range of marine fauna and flora. The intertidal zone of the Saurashtra coast is not very wide; generally, dynamic wave action is seen due to this reason.

2.3 Gulf of Khambhat

The Gulf of Khambhat is situated between the Saurashtra peninsula and the mainland of Gujarat state and located between 20°30' N and 22°20' N Latitudes and 71°45' E and 72°53' E Longitudes. It is approximately 131 km long and 70 km wide, wide inverted mouth, narrow end funnel-shaped North-South oriented indentation of Gujarat coast. On the western side, the Gulf begins from Amreli Point and lies between Surat and Valsad districts on the eastern side. The Gulf is best known for its extreme tides (maximum 12 m), which vary significantly in height and run into excellent speed 3 m/sec. On the western sides of the Gulf, the tides vary from 3 to 12 m, and on the eastern sides, it is 6-10 m, and the shape of the Gulf is the main reason for tide amplification. The Gulf of Khambhat comprises 8 coastal

districts Amreli, Bhavnagar, Ahmadabad, Anand, Bharuch, Surat, Navsari, and Valsad. The funnel-shaped Gulf, which covers an area of 3,120 km^2 comprised mainly of mudflats with some rocky area, is shallow with depths varying from 5 m at the head to 40 m in the channels. The average depth is about 20 m, and the minimum is up to 5m (Gupta and Deshmukh, 2000). There are a few sandy patches that are also observed intermittently.

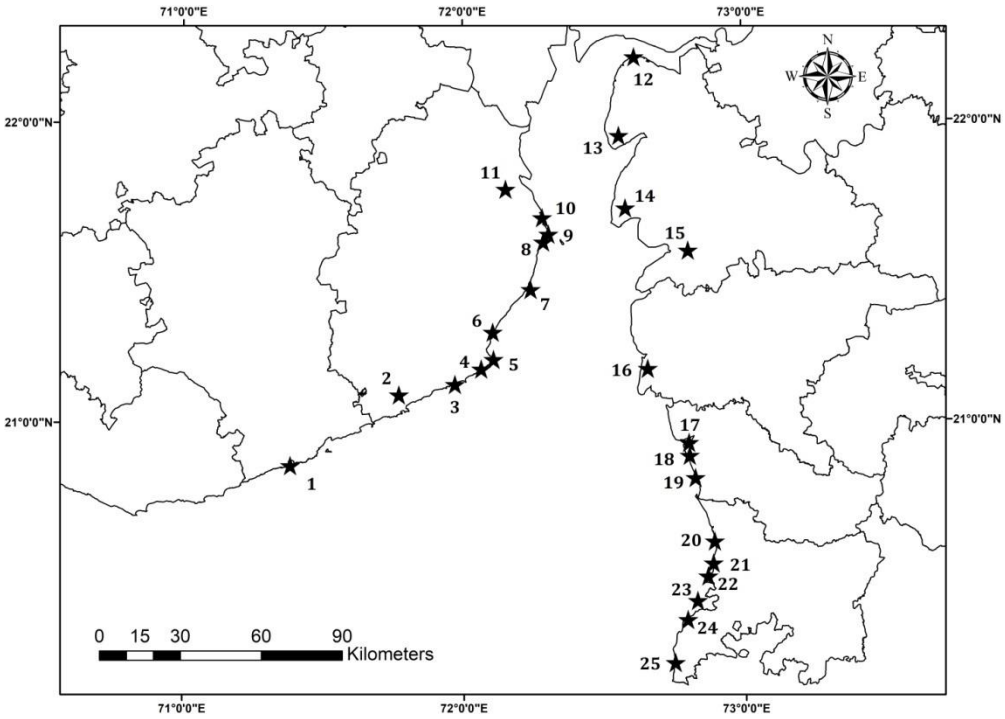

Figure 2.3 Map showing the sampling sites along the coastline of the Gulf of Khambhat; 1-Jafrabad; 2-Mahuva; 3-Unchakotda; 4-Jhanjhmer; 5-Sartanpar; 6-Gopnath; 7-Alang; 8-Koliyak; 9-Kuda; 10-Gogha; 11-Bhavnagar; 12-Kamboi; 13-Nada; 14-Dahej; 15-Hansot; 16-Hazira; 17-Vansi-Borsi; 18-Dandi; 19-Onjal; 20-Thithal; 21-Umersadi; 22-Udwada; 23-Daman; 24-Fansa; 25- Umargam.

A total of 25 sites from 6 coastal districts (Amreli, Bhavnagar, Bharuch, Surat, Navsari, and Valsad) situated along the Gulf of Khambhat have been surveyed for the collection of samples (fig. 2.3). The rocky beaches (some rocky patches) are commonly found from Mahuva to Gopnath, reducing towards Ghogha and Bhavnagar. The Gulf receives freshwater from several inlets like major rivers, especially in monsoons such as Sabarmati, Mahi,

Narmada, Tapi, Shetrunji, and many minor rivers. All the rivers from estuaries and their inflow carry solid suspended sediments into the Gulf. A medium-sized delta is present near Sartanpur, known as the Shetrunji River delta between Gopnath and Ghogha. The excessive turbulence churns the seabed and produces enormous quantities of silt and clay, making the seawater turbid and brownish, so that the light rays are impermeable. The Gulf's marine ecosystems, comprising mangroves, estuaries, creeks, and vast intertidal mudflats, are known to have rich biodiversity and several endemic flora and fauna.