Materials and Methods:

2.1 Study site:

Among the eight maritime states of India, Gujarat is situated on the western coast and has longest coastline of approximately 1600 km. Gujarat coastline consists of 28 % sandy beach, 21% rocky coast, 29 % mud flats and 22 % of marshy coast. Gujarat coast could be broadly described in to four regions viz. the Gulf of Kachchh, the Saurashtra Coast, the Gulf of Khambhat and the South Gujarat Coast. Among that Saurashtra coast is a region located south-western part of Gujarat, occupies a total stretch of 865 km., which is situated between two Gulfs bordering by the open sea, Arabian Sea. The gentle gradient is the littoral zone which is 0.5 to 1.5 km wide and is covered with loose calcareous sand. The south coast of Saurashtra from Dwarka to Kodinar segment stretches for about 250 km. with smooth and straight sandy area of rocky and sandy coasts.

Mangrol coast is located at south west coast of Gujarat in Junagadh district, exactly at latitude 21^0 07' N and longitude 70^0 07' E (Figure 1). Mangrol coast has a very long rocky intertidal zone which provides fine sheltering ecosystem to most of the molluscs and other fauna (Bhadaja, 2010, Vaghela, 2010). The entire south west coast of Gujarat, including Mangrol, is enriched with different type of habitat structure of marine environment. So the animal assemblage is never constant throughout the Saurashtra coast, it differs from shore to shore and place to place, affected by dispersal, movements and migrations of organisms (Devidson *et al.,* 2004). The total stretch of Mangrol coastline is divided into two divisions at the sides of Juni-Jetty. Both coastal belts has total length of approximately 7.5 Km to 8 Km. Left side to the Juni-jetty has stretch approximately 4 Km. and the intertidal belt less influenced area while, on right hand side of the Juni-Jetty coastline has expanded approximately 3.5 to 4 km. length affected by more anthropogenic activities. Mainly this side is utilized by fisherman communities for exploitation during low tide

for fish bait collection etc. moreover it is also used as dumping site for fishing waste, broken nets, unwanted plastics and boat parts etc. Thus, this study site has various characteristics and utilities; hence it was chosen for this study.

2.2 Site characteristics:

Study site Mangrol has completely rocky inter tidal coast with little mixture of sand, but devoid of mud or silt, there is very clear edge between sand and rocky substratum as important coastal feature. Moreover, small rocky water bodies like pools and puddles are filled by sand at their bottom. The rocks are usually calcareous, the consolidated ancient equivalent of these biogenic sands are famous milliolite rocks. The milliolite underlines the beach sands and occur as cliffs; wave cut platforms and submerged dunes, all along the shoreline indicating quaternary sea level fluctuations (Stanley, 2004).

2.3 Sub-sites and sampling points:

Intertidal zone of the Mangrol coast was explored extensively by visiting during the lowest tide times the study site frequently and approximately 3.5 Km area was selected for regular sampling area. During regular sampling, the visits were held twice a month at low tide time to explore good exposed area.

The entire study area has been divided into five sub-sites on the basis of its geo-physical characteristics and habitat structure. Every sub-site was covering approximately 700 m area. The sub-sites were virtually labeled as S1, S2, S3, S4 and S5. For maintaining the accuracy of the sub-sites, coastal ground control points (GCP) were determined by land mark objects.

Sub-site 1 (S1)

Sub-site one (S1) (Plate 1) was located exactly near to the right side of the old jetti. The substratum of the sub-site was completely flat with varying small size cup, puddles and grooves. Mid intertidal zone was a slightly elevated compared to upper and lower intertidal zone. Upper inter tidal zone has slope toward the bank side (outer side) that in turns produces huge shallow pools and also is channelized by grooves hence, the area usually remains filled by water and never dries even during lowest tide time. While as mid intertidal zone exhibits height from the middle part and slopes downward on both sides toward lower and upper intertidal zone, its upper part gets exposed during low tide time. Lower intertidal zone has seaward slope, possessing small to huge tide pools.

Sub-site 2 (S2)

Sub-site 2 (S2) (Plate 2) is approximately 650 to 700 meter away from sub-site (S1). This study area was marked by huge rocks on the bank side, it has also flat rocky intertidal zone. However, the substratum represented by rough irregular uplift of rocks to make shallow and small to large intertidal-water pools throughout the entire this intertidal zone. Here, most of water pools which were present in the area of upper intertidal zone were filled by silt and sand, which found settled down as soon tide water reseeds. Deep intertidal zone has very light slope toward the sea, but it also possesses tide pools just like both sub intertidal zones, but its substratum is more cleanly and without sand, silt and sedimentation.

Sub-site 3 (S3)

This sub-site (S3) (Plate 3) is approximately 700 meter away from sub-site 2. Geophysical characteristics of this sub-site is deferent than that of rest all the sites. Its upper intertidal zone flat bad like rocky substratum with very micro cup and small pools. But the area was lower than that

of the mid intertidal zone, hence shallow water pools always filled by water. Mid intertidal zone is more uplifted than the entire study area. The lower intertidal zone has direct slope towards the open sea and also large size pools and rocks with deep edges, thus it produces sharp edges at the sea-slope and also uncomfortable for study too.

Sub-site 4 (S4)

Sub-site 4 (S4) (Plate 4) is approximately 650 to 700 meter away from the sub-site 3. This sampling point is located near to 'Pir Ni Dargah'. Generally this sub-site is less influenced. Its litho-physical characteristics is also completely rocky, with more perforated by small to huge water pools, highly rough uphill and rock edges, crevices and water channels with small or large inter connecting canals and inter-rock-holes. Upper and mid intertidal zone are flat, while as lower intertidal zone has very gentle slope toward sea-face, but ends with deep cut edges of rocks, also producing very large and deep water pools at inner ends. Frequently the deep intertidal zone characterized with rock caves at the end edge.

Sub-site 5 (S5)

Sub-site 5 (S5) (Plate 5) is located left side of the 'Juni-Jeti' and beside of the 'Nani-Jeti'. This site is located left of the Sub-site 1 (S1) and approximate 750 meter direct away from it. This sub-site has complete flat rocky bed with micro to large tide-pools, water channel and grooves, small rock uphill and scattered small to huge stones. Its upper intertidal zone is sandy. Mid and lower intertidal zones has also flat rocky substratum. Mostly this site is more visited by than fisherman or villagers, also pollution was less than that of other sites plus sea water was very clean.

2.4 Study period

Mangrol coast was continuously surveyed for the present study during time period of January, 2007 to December, 2011. Throughout five years, the study has been undertaken for intertidal zone of the Mangrol coast for ecological assessment, biodiversity documentation and study of population characteristics for key molluscan species. For the various aspect of qualitative and quantitative ecology, the sites were surveyed twice in a monthly at the low tide in year. Especially, qualitative ecological assessment of the intertidal zone was done for molluscan diversity as this faunal group is dominant in all seasons throughout the entire year. Simultaneously, water samples were collected for analysis of some salient abiotic factors viz., salinity, hardness, dissolved oxygen. pH, etc..

2.5 Sampling Techniques

Numbers of sampling techniques are used for the ecological study of the area, mainly for the abiotic factors assessment, diversity, population dynamics etc. Of them the most common method for the assessment and study of the Molluscan is the quadrate method (Mitchell, 2007). 0.25×0.25 m^2 quadrates were laid for assessing the inter-tidal zone of the all sub-sites. The intertidal survey was done twice in moths for entire study period. Gaps of the observation and study were fulfilled by random visits within next two years. Every sub-site was visited during the lowest tide per month and as per tide-cycles. During the entire study, sampling has been done by random quadrate method in vertical line considered from bank side (outer) to the sea side (inner). The line transects and intercepts were adopted to document overall biodiversity. Each and every quadrate was observed through visual observation as well as photo-interpretation was done. Temperature and pH were also taken from the same quadrate by thermometer and pH-paper. Complete non destructive methods were employed for the conservation of flora and fauna present at intertidal area. For physicochemical parameters, water samples were taken from the every sub-site into air-

tight plastic bottles or jar or container. Few readings were recorded in situ while for other parametric analysis, samples were taken to laboratory and analysis was done within 24 hours. All the parameters were analyzed according to standard references (Stricland and Parsons, 1972; ICMAM, 2012). Maximum exposed intertidal area has been studied at the every sub-site. Always observations were started form lower inter tidal zone to upper intertidal zone. This was necessary to cover systematically entire exposed zone regularly with in available tide time.

2.6 Identification and key species

For the identification the molluscs and other flora and fauna, some samples were collected from the study area or perfect digital photographs were clicked. Very few specimens that were absolutely required to be studied in laboratory were collected and preserved in formalin or alcohol. Identification of the species was done by taking close photograph to compare with available literature and other resource keys (Apte, 1999) . Moreover to correlate the matter, some floral species, mainly few algae samples were also collected from study of the area and subjected to temporary herbarium preparation.

2.7 Computation of the data

Every visit of the sites was followed by data entry in the computer. Documentation, analysis and graphical representations were done using Microsoft Office. Faunal diversity indices were done and analyzed by PAST software (Paleontological Statistics) Version 2.15. For present study, most prominent and effective Shannon-Weiner indices were adopted and were formulized and computed as follows:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where,

H'= index of species diversity

S= species richness (total # of species present)

Pi = proportion of total sample belonging to the 'i'th species

Ln= natural log (base e = not the same of log!)