Conclusion and Recommendations

Information on species composition and habitat preference of marine invertebrates is the fundamental requirement to understand the presence of difference species in benthic communities, which also provide base line information for successful conservation of the habitat and benthic fauna. Studies on the distribution and diversity of local fauna are of great importance because these studies lead to the best understanding of structure, function and problems of the local animal community (Fransozo et al., 1992; Hebling et al., 1994).The marine intertidal area forms the transition from land to sea and in this particular area organisms experience both marine and terrestrial conditions during high tide and low tide respectively. In coastal areas, the intertidal zone is considered most diverse and productive because with in the area of few meters various kinds of flora and fauna are observed (Underwood, 2000). The major highlights and recommendation for the future studies are listed below.

- The variation in the distribution and abundance of organisms in different zones of intertidal area has provided basis for so many ecological experiments and such complex patterns of variation have been studied well, especially for the organisms of rocky intertidal area
- In the present study specific intertidal zonation pattern was established for all the study sites based on dominant animal communities inhabiting the particular intertidal zone.
- In the present study area, the upper intertidal zone is made of sandy shore. Amongst all the faunal communities inhabiting the sandy shore of the study area, brachyuran crab *Ocypode ceratophthalma* was observed to be the dominant species. The species shows peculiar kind of distribution pattern, in which adult crabs make their burrow on the upper part of the sandy shore while sub adult and juveniles inhabit mid and lower part of the sandy shore respectively.
- The upper intertidal zone was identified as *Ocypode ceratophthalma* zone.

- In the seasonal distribution patter, the maximum abundance of the species was observed during pre monsoon season which is believed to be the juvenile recruitment season of the species.
- The seasonal variations in the abiotic parameters like sediment pH, temperature and salinity have showed moderate impact on the seasonal distribution of the species.
- The mid intertidal zone was dominantly occupied by gastropod species. Amongst various species of gastropods recorded from mid intertidal zone of all the study sites, five species like *Turbo intercoastalis, Lunella coronata, Astrea stellata, Cerithium scabridum* and *Cerithedia cigulata* were observed to be dominant.
- The mid intertidal zone was identified as gastropod zone.
- All the five dominant species of gastropod showed variation in the distribution pattern in the intertidal zone as all the species utilizes different kind of micro habitats.
- In seasonal variation, maximum abundance of the species was observed in the summer seasonal followed by winter and monsoon.
- Amongst the various abiotic parameters, sea water temperature and pH showed significant impact on the seasonal variation of the abundance of the dominant species.
- The lower intertidal zone of study area was dominated by three species of zoanthids like *Palythoa mutuki, Palythoa tuberculosa* and *Zoanthus* sp.
- Amongst the three species reported, the distribution of *P. tubeculosa* was not observed at Veraval study site.
- *P. mutuki* was observed to be dominant species of the zoanthid distributed in the lower intertidal zone. *Zoanthus* sp. required specific kind of micro habitat and its maximum abundance was observed in the lower part of the zone where tide pools are available which remained fill with the water during low tide.
- In seasonal variation, maximum abundance and density of the species was reported in summer followed by winter and monsoon.
- Amongst the different abiotic parameter recorded, sea water pH showed significant effect on the seasonal distribution of all the zoanthid species.

Brachyuran Crabs are a highly important group of marine decapods and so far total 6,793 species belonging to 1,271 genera and subgenera, 93 families and 38 subfamilies have been reported worldwide (Ng et al., 2008). In India, so far more than 705 species of brachyuran crab were recorded (Venkatraman et al., 2005). Out of 705 species reported maximum number of species is reported from east coast of India as compared to west coast of India. Recently Dev Roy (2013) has compiled the list of marine brachyuran crabs inhabiting west coast of India and identified presence of 222 species. As compared to other states of western coast of India, the brachyuran crab fauna of Gujarat coast is least studied. Chhapagar (1957) has conducted study on the brachyuran crab fauna of Bombay state in which he has surveyed some parts of Gulf of Kachchh and Gulf of Kambhat and reported 42 species. It is noteworthy that in all old studies on brachyuran crab fauna of Gujarat, Gulf of Kachchh is maximally explored as compared to other coastal areas of state. Only few studies have been carried out on the brachyuran crabs Gulf of Khambhat (Pandya, 2010). But so far no study has been carried out on the brachyuran crab fauna of Saurashtra coast.

- In the present study total 30 species belonging to 22 genera, 13 sub families and 10 families were recorded.
- Amongst all the families recorded family Xanthidae and Portunidae were observed to be dominant in the study area.
- In the present study, species like *Scylla tranqubarica, Hyastenus dicanthus, Dromia dormia* and *Conchoecetesartificious* were first time reported from Gujarat. The species were previously reported from Maharashtra, Tamilnadu and Andaman Nicobar islands.
- Two crab species like *Leptodius affinis* and *Leptodius exaratus* were reported first time from western coast of India. Lee et al., (2013) had established a distribution range of *L. affinis* from eastern coast of India to the central Pacific Ocean. In the present study, the species is reported outside the predefined distribution range of the species. *Atergatis ocyroe* is very close to *A. floridus* but it differs in several morphological characters like color pattern of vermiculated lines on the carapace, red colored marking on the maxillipeds, chelae and abdomen. The species was reported by Jeyabaskaran et al., (2002) from Gulf of Mannar on the eastern coast of India.

- So the present study adds five more species to the checklist of brachyuran crabs of Gujarat and two more species to the checklist of brachyuran crabs of western coast of India.

Decapod crustaceans are common invertebrates inhabiting the coastal marine environment. High diversity values are usually recorded in tropical and subtropical regions (Fransozo and Negreiros-Fransozo, 1996; Boschi, 2000). Crustaceans are themost crucial groups of tropical benthic communities. The larger and more abundant species are important for human consumption while the incredible variety of small species contribute importantly to the complexity and functioning of tropical ecosystems; for e. g. on rocky shores, crabs are prime predators on molluscs, small crustaceans and other invertebrates, but on the other side they also provide prey base for fish, decapods and some terrestrial vertebrates. So the intertidal distribution of brachyuran crabs has potential influence on the behaviour, distribution and abundance of their own as well as neighbouring communities.

- In the present study, specific distribution pattern was observed for various brachyuran crab species reported.
- Out of 30 species reported, 19 species were reported from gastropod zone. Family Xanthidae and Portunidae are observed to be dominant in this zone.
- Maximum numbers of micro habitat were also available in the gastropod zone which makes it more inhabitable for the brachyuran crab species.
- Tide pools covered by algae were inhabited by maximum number of crab species because algae provide food to the herbivore species while it provide ambush site for carnivore crab species.
- The tide pools with different zoanthid species were mainly inhabited by poisonous crab species belonging to family Xanthidae. Because zoanthids releases toxic chemicals in the surrounding environment.
- Crabs belonging to family Grapsidae, Plagusidae and Eriphhidae were mostly observed in the rock crevices and under rock habitats.

- Rock crevices and under rock habitats provide hiding and feeding site for the brachyuran crabs.
- Brachyuran crabs belonging to family Majidae, Dromidae, Partehnopidae were reported from the pelagic environment where they live in sea grass beds and sponge beds.
- The brachyuran crabs distributed in different zones control the population of other macro fauna by predating on them while, the small sized crabs provide pray base to some fishes, molluscans and other macrofauna.

Crabs are very active burrowers in the intertidal soft sediment and greatly affect the surface sediment properties. The burrow morphology in brachyuran crabs is mostly species specific; however, in contrast of wide variety of environmental factors along with sediment and vegetation type, the crab species might change or modify the burrow structure to adjust the specific environmental condition in changing environment (Wolfrath, 1992). Brachyuran crabs are larger in size as compared to other burrowing macro fauna and in some species, intra specific variation is observed in burrow architecture with relation to sediment type, sediment hardness and vegetation root mass (Bertness and Miller 1984). Brachyuran crabs belonging to genus *Ocypode,* commonly known as ghost crabs, are commonly distributed on the sub-tropical and tropical sandy beaches. *Ocypode certophthalma* is commonly distributed species on tropical sandy beaches and exhibits interesting behaviour pattern in the burrow construction.

- In the present study 7 different shapes of burrows were identified in which Y shape with double opening, Bulb shape, Multi branched and U shape of burrows were not reported in the previous studies carried out on burrowing crabs.
- The crab carapace width showed significant correlation with the burrow opening diameter, depth and volume which shows that the burrow morphology is highly influenced by the crab size.
- Specific pattern was observed in the burrow constructing by juveniles and adults individuals of the species.
- Juveniles made Y shape, j shape and single tube burrow with shallow depth and less volume. The juvenile burrows were situated near the water line

because juvenile need to go to water to change their respiratory water frequently.

- The burrows of adult crabs were deeper and large with chambers at the base. The chamber provides specific site for refuge and mating purpose.
- No difference was observed in the burrow construction between different sexes of the species.
- Peculiar gradient was observed in the burrow temperature in which the temperature dropped up to 15˚C at the deepest part of the burrow as compared to the surface temperature. The pattern showed that the burrow provides suitable environment for the crab in harsh environment.

Recommendations for future study

- The coastal areas of Saurashtra coast supports different kinds of marine habitats like rocky shore, muddy with rocky bottom and mudflat habitat. In the present study, zonation pattern was established for only four study site supporting rocky shore but future studies can be carried to establish zonation pattern based on dominant animal community in other marine habitat available at other sites.
- Zoanthid zone was inhabited by specific species of brachyuran crabs so future study can be carried out on the impact of bioactive compound released by the zoanthids on brachyuran crabs and other macrofauna.
- Zoanthids are known to trap the sediment in their exoskeleton and sediment deposition triggers the growth of zoanthids. Due to the development of coastal mining associated industries huge amount of sediment is entering in the coastal waters. Study should be carried out to predict the impact of sedimentation on the coastal ecosystem as well as on macro fauna using zoanthids as an indicator species.
- *Ocypode ceretophthalma* has been identified as an indicator species to predict the impact of anthropogenic pressure on the sandy shore. The largest fish landing centres of Gujarat are located on the Saurashtra coast where greater anthropogenic pressure is observed. So, future study can be carried out

to predict the effect of anthropogenic pressure on the coastal areas of Saurashtra coast using *O. ceratophthalma* as an indicator species.

- Total 30 species of brachyuran crabs including few new records of brachyuran crabs for the state and western coast of India are reported. The results suggested that the Saurshtra coast has enormous potential and scope for taxonomical studies on brachyuran crabs and remaining areas of Saurashtra coast should be explored for brachyuran crab studies.
- In the present study, intertidal distribution and habitat preference of brachyuran crabs was studied on sandy and rocky habitat. Similar kind of study should be carried out on the mudflat habitat available on the Saurashtra coast.
- The burrow morphology of brachyuran crab *Ocypode ceretophthalma* has been studied in the present study. Similar kind of studies should be carried out on other burrowing crab species occurring in the mudflat habitat of Saurashtra coast.