COMMUNITY STRUCTURE AND DIVERSITY OF ROCKY TIDEPOOLS FROM SOUTH SAURASHTRA COAST OF GUJARAT, INDIA

ABSTRACT FOR THESIS

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ABSTRACT

The marine environment, which covers more than 71% of the Earth's surface and contains 97% of its water, is critical to global biogeochemical cycles and primary productivity. This huge and diversified ecosystem has a variety of habitats, including oceans, seas, estuaries, and intertidal zones with high salt levels. The maritime environment is divided into two zones: benthic and pelagic, each with its own set of biological characteristics. Climate, temperature, substrate types, nutrient load, and salinity all have a significant impact on the composition and organization of marine ecosystems ranging from kelp forests and seagrass meadows to coral reefs. Foundation species including seagrass, corals, and mangroves have key roles by providing habitats and maintaining a broad range of marine life, while also giving critical ecosystem services such as coastal protection, water filtration, and carbon sequestration.

Because of their varying physical circumstances, intertidal and tidepool ecosystems, which create dynamic transitional zones between terrestrial and marine realms, have exceptional biodiversity. The rocky intertidal zones, with their different substrates and geomorphological characteristics, support a wide range of habitats that are impacted by wave action, temperature fluctuations, and salinity changes. Tidepools in these rocky intertidal zones are particularly noteworthy for their great species diversity and ecological significance. These microhabitats are shaped by intricate interactions between physical and biological processes, such as water volume, depth, and physical structure, all of which have a substantial influence on tidepool community distribution and diversity.

The community structure of tidepools is distinguished by complex ecological interactions and adaptations to harsh environments. Tidepool ecosystems include complex trophic dynamics that include primary producers (algae), primary consumers (herbivores), secondary consumers (predators), and apex predators. Competition for resources, predation pressures, and mutualistic relationships are all important factors in creating tidepool communities. Anthropogenic activities and climate change are putting these ecosystems' resilience and biodiversity at threat, emphasizing the need for continued study and conservation efforts. Understanding the form, function, and dynamics of tidepool ecosystems sheds light on wider ecological concepts and emphasizes the significance of protecting these unique and vulnerable environments.

This study examines at the community structure and diversity of rocky tidepools along the southern coast of Saurashtra, Gujarat, covering the gap left by prior studies on intertidal invertebrate macrofauna in the area. This study focuses on tidepools in order to better understand the unique biological processes and biodiversity that distinguish these environments. The study investigates species distribution, abundance, and interactions in rocky tidepools, providing important insights into their biological dynamics and differences from other intertidal zones. This study contributes to our understanding of tidepool habitats and their function in the larger intertidal landscape.

Gujarat's intertidal ecosystems, with their long coastline and unique geological characteristics, provide a complex variety of habitats for rich marine life. Previous research has mostly concentrated on intertidal invertebrate macrofauna but has largely ignored the distinct ecosystems present within rocky tide pools. This study seeks to fill that gap by looking at the community structure and diversity of rocky tidepools off the southern coast of Saurashtra, Gujarat. By focusing on these specialized habitats, the study hopes to understand the unique biological processes and biodiversity patterns seen in tidepool ecosystems, which are frequently distinct from other intertidal zones.

Gujarat, located between 20° 1' to 24° 7' N and 68° 4' to 74° 4' E, has a broad spectrum of coastal ecosystems due to its 1,650-kilometer coastline and vast Exclusive Economic Zone (EEZ). The studied area, notably the Saurashtra coast, has a diverse geological profile impacted by tectonic processes and previous sea-level variations. This diversity is reflected in the distribution of substratum types, which include sandy beaches, rocky shorelines, muddy flats, and marshy places. The research focuses on three locations along the South Saurashtra coast: Veraval, Mul Dwarka, and Chhara, each with distinct geological and biological characteristics.

Field surveys were done from February 2021 to September 2023, with monthly visits to these sites during low tide to document the physical characteristics and biological populations in tidepools. Visual surveys, quadrat sampling, and physical measurements were used to determine tidepool characteristics such as size, depth, and substratum type. Additionally, species richness, abundance, and community interactions were assessed by direct observation and sampling. This strategy is to gather comprehensive information on macrofauna diversity and distribution, as well as their interactions within tidepools.

The research methods includes precise measurements of tidepool dimensions and substrate characteristics, as well as systematic sampling of invertebrate macrofauna. Biodiversity indexes such as the Shannon-Weiner Index, Pielou's Evenness Index, and Berger-Parker Index were used to assess species diversity, evenness, and dominance in tidepools. These indicators shed light on the tidepools' biological dynamics and community structure, demonstrating patterns of species distribution and interactions in response to environmental factors and substrate characteristics.

Preliminary findings show considerable differences in community composition and variety across the three study locations, indicating the impact of local environmental variables and substratum types. The study's findings are likely to give important information regarding the ecological roles and biodiversity of rocky tidepools in Gujarat. By improving our understanding of these unique intertidal ecosystems, the study will help to influence conservation efforts and management methods aimed at maintaining the region's rich marine biodiversity.

Overall, this study highlights the significance of investigating specific intertidal zones, such as rocky tidepools, in order to acquire a better knowledge of coastal ecosystems. The findings of this study will serve as a platform for future research and lead to a better understanding of intertidal ecology, particularly in locations with complicated geological and biological environments, such as the Saurashtra coast.

The rocky littoral zones of India's Southern Saurashtra coast, which include Veraval, Mul Dwarka, and Chhara, were researched carefully to determine their structural and biological properties. The purpose of this study was to better understand the many characteristics of these coastal locations and how they affect marine biodiversity. The selected locations, which are characterized by Quaternary carbonate deposits from the Miliolite formation, have a variety of geological characteristics such as coastal cliffs, beach platforms, and marine notches. These formations are generally made up of well-organized, spherical allochems like molluscan shell pieces, corals, and coralline algae.

Observations indicated a wide range of structural characteristics within the rocky littoral zone. These include contorted cross laminae, solution channels, tidal pools, and marine notches. Each of these characteristics leads to the development of unique microhabitats. Tidal pools, for example, which vary greatly in size, depth, and form, have been discovered

to be home to a wide range of marine species, including barnacles, algae, and numerous gastropods. These microhabitats are formed in response to both maritime and subaerial processes, with significant implications for local biodiversity.

The study also emphasized the relevance of microhabitats in the intertidal zone. Eighteen distinct microhabitats were discovered, including big boulders, platform rocks, and algal beds. These microhabitats serve important ecological functions such as shelter, food supplies, and breeding sites for marine organisms. They also promote high biodiversity by providing a variety of ecological niches to meet the demands of different species. The varied terrain of the littoral zones, which includes cliffs, fissures, and pools, adds to the habitat's complexity.

Quantitative studies of tidepool characteristics were carried out at Veraval, Mul Dwarka, and Chhara to determine length, depth, breadth, radius, and form. Tidepools at Veraval vary in size from 35 to 520 cm long and 21 to 120 cm deep. The shape and size of tidepools have a considerable impact on their ecological functions. Elongated and irregular forms were linked to various microhabitats and nutrient flow patterns, whereas bigger pools supported more complex ecosystems.

Tidepools at Mul Dwarka vary in size from 48 to 1900 cm long and 7 to 52 cm deep. Variability in depth and shape influenced microhabitat stability and resident species richness. Large and deep tidepools have been discovered to provide more stable conditions and host a wider range of organisms. Irregularly formed pools helped to improve habitat complexity, resulting in greater species diversity.

Chhara showed tidepools ranging from 45 to 600 cm in length and 10 to 60 cm in depth. The different shapes, such as oval, elongated, and irregular, had an impact on the distribution of microhabitats and nutrient flow. Larger and deeper tidepools at Chhara were discovered to provide stable settings that accommodated a wide range of species, whilst smaller and shallower pools maintained specialized ecosystems suited to more adaptable circumstances.

Overall, this study demonstrates the importance of structural and functional variety in rocky littoral zones. Tidepools and microhabitats have distinct physical properties that contribute significantly to marine biodiversity. Understanding these characteristics gives

useful insights into the natural dynamics of coastal systems and highlights the need of conservation efforts to maintain these critical areas.

Tidepool habitats along the Indian coast, mainly at Veraval, Chhara, and Mul Dwarka, have a diverse macrofauna, with 151 species from nine phyla: Porifera, Cnidaria, Platyhelminthes, Nemertea, Annelida, Mollusca, Arthropoda, Echinodermata, and Chordata. This study focuses on the community structure, diversity indices, and seasonal and regional fluctuations of these species across a three-year period, from September 2021 to September 2023. The study seeks to understand trends in species distribution and abundance in response to seasonal changes and environmental conditions.

Porifera, which includes eight species, has significant population densities in the South Saurashtra coast, notably *Cliothosa delitrix, Cliona* spp., and *Halichondria panicea*. *Cliothosa delitrix* is ecologically adaptable throughout many littoral zones, but *Cinachyrella* spp. is limited to shallow high tide pools and upper mid-littoral zones. Cnidaria, which includes 22 species such as sea anemones, zoantharians, corals, hydrozoans, and a jellyfish, shows a significant change in dominance toward zoantharian colonies in upper and intermediate littoral zones, impacting algal vegetation.

Platyhelminthes has two species: *Pseudoceros susanae* lives in deep mid- and lower littoral pools, whilst Polycladida prefers shallow high tide pools. Nemertea, which includes *Evelineus mcintoshii* and *Baseodiscus hemprichii*, has a limited range, with Evelineus mcintoshii found exclusively at Veraval. Annelida has a broad range, with 16 species, including *Branchiomma* spp. and *Sabellastarte spectabilis* in specialized environments, as well as common Serpulidae that form dense colonies with zoanthids.

Mollusca is the most diverse phylum, with 56 species, notably dominated by Gastropoda. Seasonal patterns show a diversified gastropod fauna in shallow high tide pools. Arthropoda, the second most diverse phylum with 27 species, varies in abundance among localities, with *Clibanarius rhabdodactylus* and *Clibanarius zebra* being common in Chhara and *Pilumnus* spp. in Mul Dwarka. Echinodermata is comprising seven species, the majority of which are brittle stars and sea stars with distinct habitat preferences in tidepools and coastal zones.

The Shannon-Wiener diversity index shows variety in biodiversity among sites, with Chhara having the most richness yet seeing a considerable reduction throughout the

research period. Mul Dwarka saw a gain in biodiversity, whereas Veraval witnessed a progressive deterioration. Pielou's Evenness Index demonstrates moderate to high evenness in species distribution, implying stable ecological conditions in certain places while exposing possible disruptions elsewhere. The Berger-Parker Index shows temporal alterations in species dominance, indicating changes in ecological balance and health.

Seasonal study findings of motile species suggests that Veraval has a high variety throughout the winter, which decreases during the monsoon and recovers after the monsoon. Chhara's motile variety reduces dramatically throughout the summer and drops after the monsoon. Mul Dwarka has stable but modest variety throughout the year, with periodic changes caused by environmental stresses. Sessile animals, such as Cnidaria and Porifera, follow seasonal cycles, with high diversity in the winter and considerable declines during the monsoon.

The study emphasizes the importance of seasonal and regional fluctuations in marine biodiversity, as well as the resilience and flexibility of tidepool ecosystems. Understanding these processes is critical for developing successful conservation and management measures, especially in light of anthropogenic pressures and climate change. The findings add to our understanding of tidepool community structures and how they respond to environmental change, providing insights into the health and stability of these crucial coastal ecosystems.

Tidepools are dynamic microhabitats where macrobenthic populations perform complex ecological interactions. These interactions involve a range of community dynamics, including as feeding habits, camouflage, competition, and predation, all of which have a major impact on the composition and functioning of the ecosystem. Through a study of the complex relationships seen in tidepool habitats, this research sheds light on community dynamics and the many roles that various species play in preserving ecological equilibrium.

A key characteristic of tidepool ecology is competition, which can take both intraspecific and interspecific forms. Interspecific competition is a competition for vital resources

including light, space, and nutrients. It has been observed in algae like *Ulva lactuca*, *Padina* spp., *Sargassum* spp., and *Scinaia carnosa*. Notably, *Palythoa heliodiscus* and *Cinachyrella* spp. interact competitively for limited hard substrates, which impacts both species' ability to procreate and expand. There is also intraspecific competition, with species such as *Halichondria panicea* and *Anthopleura elegantissima* vying with one another for resources and space inside the tidepool. The distribution of species and the overall composition of communities are significantly influenced by these interactions.

Tidepool communities are further influenced by predation dynamics. The function of predation in influencing species abundance and distribution is demonstrated by observations of interactions between predators and prey, such as those between *Pilumnus* spp. and *Aplysia oculifera*. Prey's defensive adaptations, like *Aplysia oculifera* ink production, show how evolution has responded to stresses from predation. Predation has a significant influence on the general well-being and stability of tidepool ecosystems, as demonstrated by these predator-prey connections.

Another essential survival method in tidepools is camouflage. Certain species, such as the rock goby (*Bathygobius cocosensis*), alter their colour that fits in with their environment, making them less visible to predators and prey. The significance of camouflage in improving survival and reproductive success in the difficult tidepool habitat is highlighted by this adaptive behavior.

Ecological equilibrium and the cycling of nutrients depend on feeding interactions. For example, *Pilumnus* spp. feed on *Cladophoropsis*, affecting the distribution of nutrients and the development of algae. Similar to this, herbivores like *Hypselodoris maritima* and detritivores like *Ophiuroidea* spp. are important in breaking down organic materials and controlling algal populations. The recycling of nutrients and the preservation of ecosystem dynamics are aided by these eating habits.

There is a complicated trophic structure that characterizes the food web in tidepools. Primary producers, which are the foundation of the food chain and transform sunlight into energy, include phytoplankton and seaweeds. These main producers have been consumed by herbivores like periwinkles and limpets, while herbivores are consumed by secondary consumers like crabs and snails. The control of secondary consumer populations by apex predators, like gulls, preserves ecological balance. The complex

interactions among different trophic levels indicate how organisms are interdependent in tidepool ecosystems.

In summary, study on tidepool communities uncovers a complex web of interactions that maintain the ecological equilibrium of these distinct environments; comprehending these dynamics offers important new perspectives on the adaptability and resilience of tidepool ecosystems to changing environmental conditions and anthropogenic interference.