CHAPTER-5
TAXONOMY AND TROPHIC GROUP ANALYSIS

The benthic invertebrate organisms of Gulf of Kachchh have received attention since1909. Hornell (1909) has studied in detail fauna from Gulf of Kachchh (Okha coast) describing many benthic organisms like Brychaurians, Anomura, conchs (Molluscans), fishes and other invertebrate organisms. Later Gedeon et al. (1957); Gopalkrishnan (1969a, 1969b, 1970); Kundu (1965a, 1965b); Menon et al. (1961), Chappgar (1957a, 1957b, 1968) also worked and dealt with varied aspects of the shore ecology and fauna of the Gulf of Kachchh. The Crustacean faunas of the Mandvi area were first described by Desai et al (In press) reporting seven (brachyura) crabs from the study area, of which two are reported for the first time from the west coast of India, especially Gujarat and Maharashtra coast. Patel and Desai (1999, 2001) described some other Crustacean from the Mundra and Mandvi area and have discussed their behavioural activity and their biogenic structures.

5.1 CRUSTACEAN

Crustaceans are common inhabitants of shallow marine environment, exhibiting a broad spectrum of behavioural adaptations (Williams, 1965) and have adapted to survive in terrestrial, brackish and fresh water environments. Crab falls into two taxonomic categories: Infra Order: - Brachyura - the true crab and Infra Order: - Anomura - hermit crab. The crabs of order Decapod are segmentally organised, with six head segments. The typical Decapod has pair of appendages on every segment except the first. Morphologically, these are similar to each other, except for the 1st antennae. Another feature of the Decapod is the carapace, which is a shell of cuticle that extends back from the head to cover the thorax dorsally and laterally. It is fused to the thorax dorsally but laterally free (Williams, 1965). The thoracic appendages of a Decapod are modified for three functions: feeding, grasping and walking. The first three pairs are called Maxillipeds (biramous) and are deflected forward over the mouth and with the help of the other mouthpart, these are used to manipulate food. Posterior to the maxillipeds are the cheliped with claw or cheale adapted for grasping. The remaining four part of thorassic appendages are long pointed walking legs that are uniramous pleopods and a single pair of biramous uropods, the anus is at the end of abdomen (Warner, 1977).

The hermit crabs of the Infra Order Anomura are quite different from true crabs in their morphology and closely resemble lobster and shrimps. Their abdomen is not

protected by a calcified exoskeleton and is soft, asymmetrically coiled such that it fits into the gastropod shell and the uropods are adapted to cling to the shell deep within the coils. The pleopods are reduced so are the walking legs. These are modified to support the coiled shell of the gastropods. They live in the gastropod shells, which give them protection but way of life is similar to the crabs.

The other important groups of the crustaceans are found is to be belonging to the Order Stomatopoda, only Squillidean stomatopods are present in the intertidal zone of the Mandvi area. It has long, broad, elongated rostral plate the lateral margin of the plate covers apex. The rostral plate in Squillidean is of different shapes and sizes, it not only differs in length/width proportion but also in shape like trapezoidal, triangular, rectangular, with variable shape of apex viz., rounded or flattened; with or without median carina. The telson is a broad, end plate consisting of marginal spines consisting of series of larger and intermediate spines and pre-lateral lobes, these spines are not articulated, and is pointed. The telson also consists of denticles, of which the lateral is pointed, while the intermediate and submedian denticles are blunt. A denticular arrangement in Squillidean shows marginal denticles of telson, indicates that on each side of the mid line, there are three to four submedian, seven to nine intermediate and one lateral denticles. Another important characteristic of stomatopodean are its claw, which have series of teeth on dactylus along with presence of distal spine, this combination gives it a sinuate or flattened or evenly curved shape.

5.2 TAXONOMY

Brachyurans from the Indo-Pacific region were studied and a detailed account was provided by Alcock (1895, 1895a, 1895b, 1896, 1989, 1899, 1899a, 1899b and 1900); De Man (1887), Henderson (1893). The study of the Brachyuran from the West Coast is concerned; attempt has been made by Kemp as early as 1915-1919 and Graverly (1927). Kohli (1921-1922) described crabs from the Karachi area, while Pillai (1951) described crabs from Travancore. These two places represented the farthest extremes of the West Coast of India. Later, the Middle parts of the west coast of India extending from Okha to Karawar were systematically studied by Chhapgar (1957) in his momentous work as "Marine Crabs of the Bombay State".

Crustaceans are identified at species levels and their brief morphological characteristics, occurrences and feeding styles and behaviours are described as under.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order-Brachyuraya/ Family- Ocypodidae/Sub Family- Ocypodinae
Genus:- *Ocypoda* Fabricus
Species: - *Ocypoda ceratopathalma* Pallas

The species is distinguished by the eyestalk prolonged to form a style, the presence of a stridulating organ consisting of tubercles passing into striae, and the anterior surface of the poropdites of first two pairs of the legs being furnished with a brush of hairs. The species are abundant in the intertidal/subtidal zone, all along the Kachchh coastline. In the study area they were observed to be burrowing in the Wind Farm and Rawal Pir site. In these sites the zonation pattern of this crab *O. ceratopathalma* is documented. The adult *O. ceratopathlma* are found on upper beach portion and further extended to dune level. Young are found on lower part of beach and adjoining ridges and runnels while juveniles forms are found in runnels or small water pools near the low water line. The feeding styles were typical of *Ocypodes,* emerging after the tide and scrape the surface with their spooned bristly chelae. The sediments are rapidly sorted into fine and coarse fraction and later emerging as pseudo-faecal pellets. Feeding is continuos; alternate scoops are being supplied by the cheale and the rejected pellets appearing one after the other. The crabs walk slowly, forward as they feed and deposit the pellets to one side or the other. Feeding is often conducted along the radii of a circular area, the mouth of the burrow usually being at the centre. These feeding styles are common in all species of *Ocypode.* All three types of burrowing styles were observed during the study, they include (i) back burrowers, (ii) side burrowers and (iii) rotating burrowers.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order-Brachyuraya/ Family- Ocypodidae/Sub Family- Ocypodinae
Genus:- *Ocypoda* Fabricus
Species:- *Ocypoda platytarsis* Milne-Edward

This specimen resembles *O. ceratopathalma*, but differs from it in the absence of brushes of hairs on the anterior surface of the propodities of any of the legs. The dactyls are dorso-ventrally compressed and broad and fluted. The stridulating ridge on the inner surface of the palm is entirely granular. The upper edge of the inner surface of the ischium of the large claw is raised and rough, with no specific structures. The orbit of the eye is

hardly oblique. This crab is common along both the coasts of Indian peninsula as well as Sri Lanka. The tip of the appendages ends in a straight edge, somewhat like a ploughshare. Behind this, on one side are about eight close set setae; the other side bears distally spaced setae (Desai et al, *In press*). In the study area, *O. platyrsis* are found abundantly on the upper portion of the beach and berm region of Modwa Spit site, where the young ones were confined to runnels and lower part of ridges. The adult as well as young ones use specialised techniques like "rotating" for burrowing purposes.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order- Brachyuraya/ Family- Ocypodidae/ Sub Family- Ocypodinae
Genus: *Ocypoda* Fabricus
Species: *Ocypoda roundata* Miers

The specimen can be distinguished by the antero-lateral angles being rounded off, and the length of the stridulating organ being much less than half the greatest breadth of the palm. *O. roundata* are found abundantly on the upper portion of the beach and berm of the Modwa Spit site. The behaviour of the species is similar to the other species of *Ocypode* found in the study area.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order- Brachyuraya/ Family- Ocypodidae/Sub Family- Ocypodinae
Genus:- *Uca* Latreille
Species: *Uca annulipes* Latreille

The sub-quadrilateral carapace with moderate convergent lateral borders distinguishes the species, the frot being a fifth to a sixth its breadth. The tip of the thumb of the chelipeds appears notched-truncate due to the presence of enlarged tooth. The species is common along the western coast and in the study area they are found abundant in lagoonal sediments of the Rawal Pir and Modwa Spit area. Feeding in *Uca* (Miller 1961) involves sorting process of differential flocculation in which food is mixed with exhaled water and agitated by the mouthpart. Heavy inorganic particle accumulates at the bottom of the mouth field where they go as rejected pellets. In sandy substrate, most of the organic matter is attached to the sand grains. These grains are held by the hairs of the 2nd maxillipeds and are swept across the outer face of the 1st maxillipeds. This brushing action dislodges organic particle, which can then be separated from the sand by flotation. The burrows of the *Uca* are short and they were found to employ the side burrowing

technique for making burrows, as they have advantage of one longer and stronger cheliped especially for burrowing.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order- Brachyuraya/ Family- Ocypodidae/Sub Family- Ocypodinae
Genus:- *Uca marionis* Desmarest

The species of the study area can be distinguished by the dimension of the front of the carapace, which is less than a fifth the breadth of the carapace and the larger hand (Cheliped) is less than thrice the carapace length. The upper surface of the wrist is granular, fingers are compressed and blade like and the edge of the thumb a simple S-shaped curve. Like other species of the genus *Uca* the *U. marionis* is also abundant in the lagoonal sediments and also feeds in similar fashion like *U. annulipes* from algal rich sandy substrates, where much of the organic matter is attached to the sand grains. These grains are held by the hairs of the 2nd maxillipeds and are swept across the outer face of the 1st maxillipeds. They were found to employ the side burrowing technique for making burrows, as they have advantage of one longer and stronger cheliped especially for burrowing.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order- Brachyuraya/ Family- Clappidae/Sub Family- Matutinae
Genus:- *Matuta lunaris* Forskal

The species is known to inhabit sandy substrates, and can be distinguished by distinct spine at the angle of the hand, where it comes in contact with the external angle of the arm. The specimens of the study area are found having coarse speckles on the carapace. The posterior appendages are flattened and modified to act as "oar" while swimming. They are abundant in Wind Farm area along with other species, i.e. *Ocypode ceratopathalma, Macropathalma pectinipes* and C*libanarus infraspinatus*. In runnels, where proportions of fine sediments are more, *Matuta* are also found but are less abundant. Many such crabs are apt at intercepting prey animals in the water column; yet the crabs may seek temporary shelter, or may conceal themselves from their prey, by burrowing shallowly into the substrate. They are efficient back burrowers and tilt the body backward and dig with the back legs. It utilises various morphological adaptations and works itself downward untill eyestalk or the antenna remains visible. As was observed the flattened fifth parapoids are pushed horizontally into the sediment while the chelipeds are

forced forwards thereby moving body backward into the substrate, thus making shallow, pocket like disruption in the sediment which are un-oriented and appears as temporarily embedded in soupy ground substrate.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order- Brachyuraya/ Family- Clappidae/Sub Family- Matutinae
Genus:- *Matuta*
Species:- *Matuta planipes* Fabricus

The spine is absent and only a tubercle at the angle of the hand, where it touches the external angle of the arm. Colour of the carapace is bright yellow with vermicular red lines forming spots and incomplete rings. They are abundant in Wind Farm and Rawal Pir area wandering on beach slope as well as in ridge and runnel systems, occasionally found with *Peneas japonicus* in runnels. The posterior appendages are flattened to function as oars, and are efficient swimmers intercepting prey animals in the water column; yet the crabs may seek temporary shelter, or may conceal themselves from their prey, by burrowing shallowly into the substrate. They are efficient back burrowers and tilt the body backward and dig with the back legs. It utilises various morphological adaptations and works itself downward untill eyestalk remains visible. The burrowing process is similar to the other species of the *Matuta* genus.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order- Brachyuraya/ Family- Portunidae/Sub Family- Portuninae
Genus:- *Portunus*
Species:- *Portunus tenuipes* De Hann

The species was first described from the Western Coast of India by the author (Desai et al *in press*). This is the only Indian species of *Portunus* in which the front is cut into three teeth (all the others have four teeth). The length of the carapace is about two-thirds its breadth. The antero-lateral borders are cut into nine teeth, of which the last is a long spine thrice as long as the other teeth. The arm of the chelipeds has three spines on its anterior border and one at the far end of the posterior border. These are strong spine on the inner angle of the wrist, and a much weaker one on the outer angle. The hand has a spine near the wrist-joint and another just behind its joint with the finger. Alcock's (1899) key states "posterior angle of Carapace Square" for *P. tenuipes*. His description is posterior border alightly curved and meets the postero-lateral border at a well-marked angle, which is sometimes slightly turned up. In the specimen examined by author, a

postero-lateral border appears to continue as a smooth curve with the posterior border. Below this level, however, the front edge of the abdomen does show an acute spiny angle. In view of the smooth curving of the postero-lateral borders into the posterior border and the distribution of *P. tenuipes* from the Andaman, as given by Alcock, it was first thought unlikely that the crab was *P. tenuipes*. However, the presence of only three teeth infront is so characteristics of this species that this together with the crab has been identified as *P. tenuipes*. Alcock has not described the coloration of *P. tenuipes* our specimen (after prolonged preservation) shows extensive irregular white spots characteristic of *P. pelagicus*, but on a light buff orange background, on the carapace and arm of the chelipeds. The finger and the thumb of both the claws are crimson red along their distal half. The species is abundant in all the sites and is efficient swimmers.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order- Brachyuraya/ Family- Grapsidae/Sub Family- Plagusiinae
Genus: *Plagusia*
Species: - *Plagusia depressa*
Variety: - *squamosa* Herbst
Plagusia depressa Var. *squamosa* Herbst

This is a littoral crab, distinguished by the absence of a true front, so that the antennular fossae are visible in a dorsal view as deep clefts in the anterior border of the carapace. The antero-lateral borders are cut into four teeth.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order- Anomura/Family- /Sub Family-
Genus: *Clibanarus*
Species: *infraspinatus*
Clibanarus infraspinatus

Hermit crabs are the deposit feeders although they are also capable of scavenging and even predating. Their method of feeding consists of scooping the muddy or sandy sediments with slightly spooned minor cheale and sorting it with the mouthpart. This process is accomplished by a 'fluttering' of the mouthpart in which the fine particles are combed into the mouth and the coarse particles rejected via the respiratory stream (Greenwood, 1972; Warner, 1977). Another method of feeding is to scrape organic matter from the shells or stones using stout serrated hairs on the end of the endopods.

Phylum-Crustacea/ Class- Malocostraca/ Order- Decapod/ Sub Order-Dendobranchita/Infra order-Penaeidea/ Super Family-Penaeoidea/ Family-Penaeidae

Genus: - *Penaeus* Marsupenaeus
Species: - *Japonicus*
Penaeus (Marsupenaeus) Japonicus Bate

The specimens have smooth carapace, with rostrum armed with 9-11 teeth on dorsal and a single tooth on ventral margin, with an accessory crest on the blade. Telson (Tail) armed with 3 pairs of movable spines. The carapace of the animal have antereolateral patches along with dorsal patches which are circular in dorsal view, with 2 bands, the anterior one in the middle of the carapace and last abdominal band discontinuous. The telsons with 3 pairs of movable spines and discontinuous last abdominal bands are characteristic of the species. The specimen is abundant in the lagoon of the Rawal Pir area, and often makes semi - permanent shallow burrows, with the movement of the telson. As was observed the telson is also used disturbing the water and sediment, in order to suspend sediments in the water, either for food or for protection.

Phylum-Crustacea/ Class- Malocostraca/Sub Class- Hoplocarida/ Order-Stomatopoda/ Superfamily- Squilloidea/ Family-Squilidae.

Genus: *Oratosquilla* Manning
Species: *striata* Manning

The specimens have rostral plate slightly longer than broad, appearing elongate, lateral margins covering on rounded apex. Dactylus of claw with 6 teeth, outer margin faintly sinuous, with obtuse projection basally. Telson flattened, slender, slightly longer than broad. The dorsal surface of telson is ornamented with numerous, well-developed longitudinal carinae. The specimens are found in the lower intertidal zone of the Wind Farm, Rawal Pir and Modwa Spit sites, They are suspension feeders and make "*Ophiomorpha*" like burrows, which are more than a meter deep, with pelleted outer wall in lower intertidal zone. (Patel and Desai, 2001). The animal quickly responds to earthquake and other related activity and seldom shows abnormal behaviour. (Patel and Desai, 2001). These Crustaceans are 1-35 cm in length, are active, alert, highly visual predators exhibiting agnostic behaviour while defending their cavities (Cladwell and Dingle, 1975). A suspension feeding mantis shrimp-*Oratosquilla striata* is confined to runnels, its population increases in stagnant water body of the runnels

Phylum-Crustacea/ Class- Malocostraca/Sub Class- Hoplocarida/ Order-Stomatopoda/ Superfamily- Squilloidea/ Family-Squillidae.
Genus: *Oratosquilla*
Species: *hindustanica*
Oratosquilla hindustanica Manning

The specimen is characterised by the rostral plate appearing elongate, length and width subequal, or width slightly greater. Dactulys of the Claws with 6 teeth, outer margin of dactulys faintly sinuous. Dorsal ridge of carapace undivided. Telson Flattened, longer than broad. It is a common species of the Indian coast, and is found in the intertidal zone of the Rawal Pir sites. Their burrowing and feeding activity is similar to the *O. striata* and also constructs similar type of burrows.

5.3 POLYCHAETES

Polychaetes are the most frequent and abundant marine metazoans in benthic environments, they are among the 'species-rich' groups and often encompasses a number of species belonging to a variety of life styles and trophic levels (Jones, 1961; Fauchald and Jumars, 1979). Polychaetes are particularly useful in behavioural studies on account of their simple repertories of behaviour. Polychaetes often show interesting range of responses including those involved in habitat selection, feeding, tube construction, escape from predators, fighting, pairing, swarming, commensalism and learning. Photonegative behaviour is complex patterns of behaviour in polychaetes and are often organised as a series of responses elicited by different stimuli. The annelid besides its characteristic segmentation, has (i) a body cavity or coelom, surrounding the complete digestive tract; (ii) a single pre-oral segment; (iii) a muscular body wall with an external circular layer and an internal longitudinal layer; (iv) a central nervous system with a pair of preoral ganglia and (v) a closed circulatory system of main and lateral branches. In addition to these common features, some of them have non-chitinous cuticle and chitinous bristles or setae (chaetae). The Class Polychaeta is strongly segmented predominantly marine worms with numerous somites and lateral parapodia that bear bristles. The head region is with tentacles and the anterior end of the digestive tract is generally equipped with tiny chitinous hooks or teeth. Although all polychaetes are divided into free swimming or more correctly free moving forms and sedentary forms. Comparatively few species are free swimming through out the life. By far, the majority of the species live in some sort of

tube or burrow. A typical body segment has on each side a muscular parapodium that bears bundles of bristles and filamentous sensor organs known as "cirri". The setae of each bundle project from a large sack and each setae arise from a single cell at a bottom of the sack. The parapodium is bilobed and each lobe has a strong needle like internal bristle, the "aciculm", to which are attached the muscles that operate the whole bundle of setae. The head consists of modified segments bearing eyes, sensory tentacles and palps. Below these structures is the anterior end of the digestive tract consisting of the buccal region or mouth, which is lined with tiny chitinous denticles and the pharynx, which carries a set of powerful chitinous jaws. The buccal region can be everted and retracted at will, so that when the worm grasps food it can bring powerful jaws into direct contact with the object.

5.4 TAXONOMY

Polychaetous annelids from the Indian waters were studied as early as 1853, but very few species were reported. There were a few scattered mentions for the Polychaetes in "Fauna of Karachi" (Bindra, 1927). After that nearly three hundred species were recorded in Fauvel's report (1932) and nearly 450 species were described in the book entitled "Fauna of India, including Pakistan, Ceylon, Burma and Malaya (Annelid Polychaeta)" by Fauvel (1953). To classify the polychaetes the cladistic classification of Rose and Fauchald, (1997) is followed. Hence Linnaean categories are used only for Genus and Species level.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Euncida/Amphinomidae
Genus:- *Amphimome* Bruguiere
Species:- *Amphimome rostrarta* Pallas

Body Square in section, prostomium small rounded, with two eyes, caruncle smooth. Median tentacle short inserted on the anterior margin of the caruncle. Lateral tentacle short, sublate. Palps conical. Dorsal cirrus inserted under the brachial cluster. Dorsal setae of two kinds, (i) long, slender, more or less serrated at the tips (ii) stout bristles with ventral fangs. The species are abundant on the ridges of the Rawal Pir area along with *Nephthys* and other species of Amphinomidae family. Generally they are carnivores with the mouth having eversible lower lip used for rasping and possibly squeezing food material. The burrowing styles are usually that of the Anchoring technique mechanism as suggested by Clark (1964) in polychaetes. This is based on the formation of two types of

anchors, first by dilation of part of the body above the distal extremities to form what has been termed as 'penetration anchor' and secondly by distension of the extremity to produce a 'terminal anchor' (Trueman, 1968). When the tip of the animal is protracted by the contraction of circular or transverse muscles the penetration anchor prevents the animal from being thrust upward out of the substratum and enables the terminal region to be extended further into it. The terminal anchor is formed by the body wall at the lower extremity of the animal being pressed outwards against the substratum and allows the upper part to be drawn into the burrow by contraction of retractor or longitudinal muscles (Trueman and Ansel, 1969).

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Euncida/Amphinomidae
Genus:- *Chloeia* Savigny
Species:- *Chloeia flava* Pallas

The body of the polychaete is oval, composed of plaited crest, arising from a horizontal plate, folded along its margin. Median dorsal purple spots varying in shape from a narrow ellipse to a circle. Setae varying from almost pure white to bright yellow. Tentacles and dorsal cirri ore or less violet, Caruncle extends posteriourly to the commencement of the 4th segment and ends with a free tapering extremity. The specimens are found to occur in the lagoonal areas of the study area, viz., Rawal Pir and Modwa Spit lagoon, they are found to be co-occurring with *Oniphus eremite.* The characteristics of these species are found to be inhabiting the mounds created by other worms, especially by *Nephthys* and *Oniphus*. The Burrowing mechanism is similar to "the Double Anchor Technique", while the feeding behaviour is similar to the Amphimonedae family and *Arenicola.* From the observations it was found that the specimens have adapted to exploit the discarded sediments (mounds) which are rich in organic matter.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Phyllodocida/ Nereididae
Genus: *Lycastis* Savigny
Species:- *Lycastis indica* Southern

All feet are uniramous, longitudinal groove of the head ending in a pit; eyes situated more or less in a line and provided with a lens. Dorsal cirri rather narrow length and breadth varying. Dorsal setae missing. The specimens are found abundant in Wind Farm sites, occurring in dense accumulations on the beach and flat intertidal zone. The feeding styles are common to that of *Nereidae,* in which, mouths are jawed with eversible

pharynges, often with small auxiliary jaw pieces. They form mucus tubes and feed preferentially from mouth of such tube and are capable of leaving the tubes. They are found to be bioturbating in sediments just below the sediment interface. The burrowing mechanism are similar to that of the "Double Anchor technique" (Clark, 1964; Trueman, 1968).

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Phyllodocida/ Nereididae
Genus: *Nereis* Cuvier
Species:- *Nereis diversicolor*

Body elongated; two subulate tentacles; two massive joint palps and four pairs of tentacles. Proboscis armed with a pair of horny jaws, feet biramous. The feeding styles are similar to those of the other species of the genus. They form mucus tubes and feed preferentially from mouth of such tube and are capable of leaving the tubes.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Phyllodocida/ Nereididae
Genus: *Nereis* Cuvier
Species:- *Nereis unifasciata* Willey

Tentacular cirri longer, reaching backward. Anterior feet with short rounded lobes, two in each ramus. Middle and posterior feet dorsal ramus are marked with two sub-equal, triangular. Divergent lingules. They are most abundant in the area of Wind Farm and Rawal Pir in lower runnels and ridges. They feed near the surface as deposit feeders, by their jaws and often form mucus tubes. Their burrowing style is similar to other polychaete species of the same area.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Phyllodocida/ Nereididae
Genus: *Nereis* Cuvier
Species:-*Nereis costoe* Grube

Tentacular cirri rather short, prostomium not incised. The anterior feet composed of three dorsal lingules, the median one shorter. In posterior feet the dorsal ramus over shadows the ventral one. Dorsal cirri longer, ventral cirrus shorter. The specimens are collected from mucus binded tubes and burrows in the lower intertidal and runnels on the Rawal Pir and Modwa Spit area. They are found to be feeding in the sediment layer just below the sediment water interface, and are known as shallow deposit feeders.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Phyllodocida/ Nereididae
Genus: *Nereis* Cuvier
Species:-*Nereis sp* Cuvier

Body vermiform with numerous segments and two tentacles. Two ovoid palps, four eyes; two pairs of tentacular cirri. Proboscis with two horny curved jaws. Abundantly found in ridges and flat intertidal zone of the Wind Farm and Rawal Pir sites.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Phyllodocida/ Nereididae
Genus: *Perinereis* Kinberg
Species:- *Perinereis sp* Kinberg

The specimens have biramous parapodia and horny paragnaths on both sides of the proboscis. Paragnaths sometimes transverse, ridge shaped. Tentacles shorter than the conical palps. The feeding habit varies according to the flow conditions, changing from shallow deposit feeders to surface deposit feeders and some times carnivorous. They form mucus tubes and feed preferentially from mouth of such tube. They are abundant in the flat intertidal zone of the Wind Farm sites, and produce, shallow burrows composed of surfacial outlets with faecal mounds.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Phyllodocida/ Nephthydidae
Genus: *Nephthys* Cuvier
Species:- *Nephthys inermis* Ehlers

These are most abundant and celebrated Nephtyidae worms from the study area. Prostomium square with two anterior, very short button like tentacles and two posterior very minute tentacles at the hind part in from of two very small eyes. Jaws are triangular and chitinous and inverted very far back in the pharynx. Dorsal and ventral rami widely apart and short, with conical setigerous lobes, anterior seta ciliated but not camerated. They have very large eversible pharynges. Internally, the pharynges have a pair of small jaws. These worms are common all along the study area, and are found to be making branched, ramified, galleried, burrow system, which are connected to the surface and the surfacial openings are sometimes marked by mound of faecal or rejected material. Their feeding habits are typical and are composed of switching between suspension feeding to surface feeding, during the receding tides on soft substrate.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Phyllodocida/ Nephthydidae
Genus: *Nephthys* Cuvier
Species: -*Nephthys diabranchis* Grube

Branchiae from fifth setigerous segment, reduced or missing in the posterior segments. In the mid-body segments, branchiae are long and coiled, inward with long dorsal cirrus. The specimens too are abundant in the lower intertidal and flat intertidal zone of the study area and are found to be making branched, ramified, galleried, burrow system, which are connected to the surface and the surfacial openings are sometimes marked by mound of faecal or rejected material. Their feeding habits are typical and are composed of switching between suspension feeding to surface feeding, during the receding tides on soft substrate. Mechanism of burrowing found common to both the species are with the help of the peristaltic locomotory waves utilised for movement along a burrow and during burrowing processes. In this process, one part of the body may be dilated with contraction of longitudinal muscles, forming *points d'appui* equivalent to the penetration anchor, while anteriorly the circular muscles contract so as to cause extension, as in the earthworm (Gray and Lissman, 1938; Trueman and Ansell, 1969). These contraction occur as peristaltic locomotory waves passing along the body, invariably in a retrograde movement (from head to tail) in worms (Clark, 1964). In this case the direction of movement depends upon two factors (1) the direction of the peristaltic wave i.e. direct or retrograde and (2) the phase of contractile cycles at each segment is attached to ground when fully shortened and the body moves forward.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Euncida/ Onuphidinae
Genus: *Diopatra* Audouin and Milne-Edwards
Species: - *Diopatra neopolitana* Delle Chiaje

Body large and very long, rounded anteriorly depressed and bristles in the posterior region. Palps small globular. Ringed ceratophore of tentacles much shorter than the palpostyle. Two anterior tentacles shorter than the three posterior ones; Gills large; lower jaws of the two pieces. Upper jaw with a pair of mandibles, three pair of toothed plates and an unpaired one. The organisms are abundant in the intertidal zone especially in the runnels all along the study area in all sites. These *Onuphidae* construct permanent tubes, made by secreting mucus and binding all available material to them. The tubes show growth rings indicating daily addition to the tubes. The animals are suspension feeders and feed on variety of foods like foraminifers, algae, sponges, bryozoans etc.

According to Fauchald and Jumars (1979) these worms are omnivorous scavengers, and have specialised prionognath jaws.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Euncida/ Onuphidinae
Genus: *Onuphis* Audouin and Milne-Edwards
Species:-*Onuphis eremita* Audouin and Milne-Edwards

The gills begin on the first foot, simple on the 10-22 succeeding feet, pectinate in the succeeding region and attain 5-6 filaments. The worms are found to be abundant in the Rawal Pir lagoon. They create group funnel burrows and have adapted themselves inhabiting in the peaty, reducing conditions of the lagoon, the burrows are branched and have numerous openings which circulates the oxygenated water in the reduced sediments.

Articulata/Annelida/Polychaeta/Palpata/Aciculata/Euncida/Lumbrinereinae
Genus: - *Lumbriconereis* Blainville
Species: - *Lumbriconereis pseudobifilaris* Fauvel

Body long slender, cylindrical and deeply annulated. Each of the first two achaetous segments is about the same size as the following. On the ventral side of the peristomium, three longitudinal grooves reaching across next segments. Several dark acicula, dorsal and ventral cirri absent. Lower jaws whitish, broad and denticulate. Upper jaw mandibles with long smooth fang of basal teeth. Uniramous parapodia and large eversible jaw consisting of a pair of mandibles and four pair of maxillae. Though they are considered as carnivores by most of the workers (Fauchald and Jumars, 1979), some selective deposit feeders are also observed, they feed on the surface and are capable of secreting temporary mucus housing. They are found abundant in the Wind Farm area.

Articulata/Annelida/Polychaeta/CanaliPalpata/Terebellida/Acrocirridae
Genus: - *Scolopos* Blainville
Species: - *Scolopos latus* Chamberlin

These are reef builder polychaetes, the body of which is large and depressed in the anterior part, semi cylindrical in the middle and posteriorly, ventral side convex. Prostomium small, conical and blunts. Two small rounded nuchal organs. Dorsal ramus with a conical dorsal cirrus, a short setigerous lobe with a bundle of serrate capillary setae. The species are abundant in the lower intertidal shore platforms of the Rawal Pir area and occur as prominent sand reef builders. These are filter feeder, and adapted to feed on the food available from the water column.

Articulata/Annelida/Polychaeta/Scolecida/ Maldanidae
Genus: - *Clymene* Savigny
Species: - *Clymene spa* Savigny

In the Maldanidae the head, anterior segment and the pygidium, provide the most important features, which differentiate species and genera. *Clymene* is characterised by slanting, rimmed, cephalic plate. Acicular ventral bristles in the first three setigerous segments. Pygidium funnel shaped bordered with cirri. Anus at the tip of a cone enclosed in the funnel. The species are abundant in the Rawalpir lagoons.

Articulata/Annelida/Polychaeta/Scolecida/ Maldanidae
Genus:- *Clymene* Savigny
Species:- *Clymene spb* Savigny

Clymene is characterised by slanting, rimmed, cephalic plate. Acicular ventral bristles in the first three setigerous segments. Pygidium funnel shaped bordered with cirri. Anus at the tip of a cone enclosed in the funnel. The species are abundant in the Rawal Pir lagoon.

Articulata/Annelida/Polychaeta/Scolecida/Capitellidae
Genus: - *Heteromastus* Eisig
Species: -Heteromastus filiformis Southern

Heteromastus filiformis is an anoxic condition dwelling annelids, abundant in the Rawal Pir and Modwa Spit lagoons of the study area, characterised by thorax with eleven setigerous segments. Prostomium conical, pear shaped. Peristomium long and achaetous. Abdomen with only shorter hooks inserted on tori. The parapodial gills are an extension of the ventral tori, and is also characterised by median anal cirri. The worm is a deep deposit feeder and capable of burrowing with peristaltic wave techniques, which enables circulation of oxygenated water in anoxic mud.

Articulata/Annelida/Polychaeta/CanaliPalpata/Sabellida / Serpulidae
Genus: - *Serpula* Linnaeus
Species: -*Serpula vermiculris* Linnaeus

Sabellaridae worms are reef building polychaetes, the feeding apparatus consist of paired ciliated groups of tentacles on either side of the prostomium, creating water currents that lead towards the mid line. Collar setae bayonet-shaped, with two conical processes at the base of the blade. Mucus embalmed food particles are transported along

ciliated paths to the mouth from the medially attached edge of the tentacular fields. Abundant on the shore platforms of the Rawal Pir area and all along the coast on any rocky exposures.

Nemertea- Unsegmented worms

Genus: *Cerebratulus*
Species: *Cerebratulus marginatus* Renier

Worm with length more than 100cm, width upto 25 mm or more, colour greyish brown often recorded in the literature as eyeless for eyes are small and inconspicuous. Similar to *C. fuscus,* swims rapidly and actively, head illustrated inside view shows canal of cerebral organ opening into cephalic slit; the worms are found abundant in the Modwa Spit lagoon, often dwelling in the anoxic mud, comes to the surface for feeding.

5.5 TROPHIC GROUP ANALYSIS

A community often subdivides the endobenthic habitat into many ecological niches, each occupied by species specialised for a particular way of life. Thus the biogenic structures present in sediments are result of those species occupying the ecospace. The analysis of the Trophic Group involves assessing the species in similar feeding behaviour, by grouping them in functional groups and knowing their biotic interactions and to study the utilization of the ecospace in the intertidal zone.

Biotic interactions among organism community have a variety of effects on the sediments. In benthic marine environments, most of the assemblages of infauna are dominated numerically by three taxonomic groups of macro-fauna: bivalve, polychaetes and crustaceans (Woodin, 1983). Interacting species have a tremendous influence on each other's population densities. The various mechanisms for these biotic influences are quite different from that of abiotic factors. Biotic factors regulate the size of populations more intensely and influence interactions at different levels within the community and its habitat. There are numerous factors that determine the regulation of an existing community in both ecological and evolutionary time frames. Coastal environment provides a fundamental trade off to organisms between the effects of high environmental stress and high resources availability (Bambach, 1977; Jablonski and Bottger, 1991). A

community in high stress environment such as intertidal zone may be the result of dynamic shifts in physical energy regimes and seabed dynamics.

Crustaceans and polychaetes are one of the most abundant organisms in the study areas both at generic level and at higher taxonomic levels. These organisms subdivide the intertidal and subtidal zone in numerous sub-zones, which reflects their niche utilization and habitat preference. In following Figures- 22 and 23, intertidal zonation for the polychaetes and crustaceans are shown respectively. Polychaetes of the study area show marked preference for their habitat (Figure-22), they are totally absent from the supratidal zone. In the intertidal zone, they subdivide the area in to numerous regions, based on the

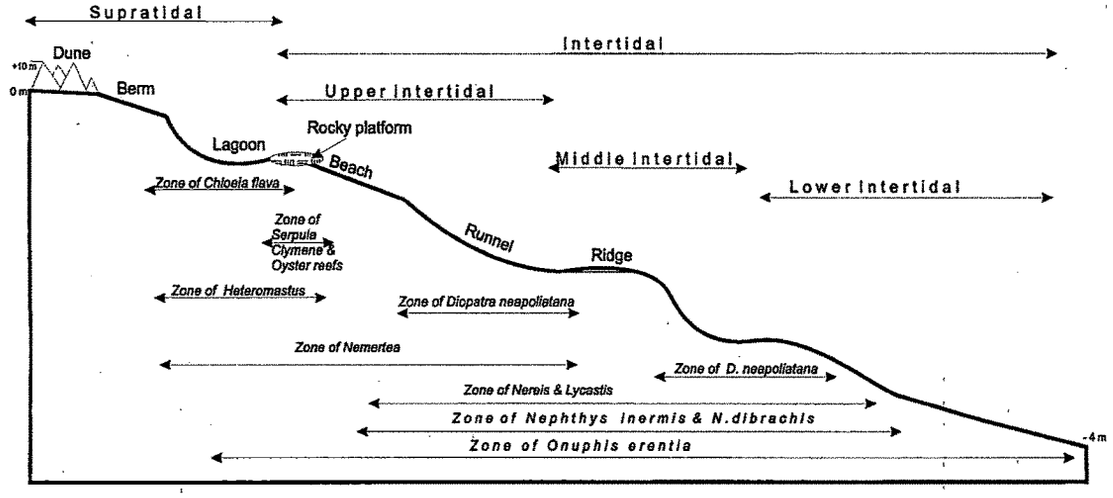

Figure-22 Zonation of the polychaete species across the intertidal zone.

sediment types, hydrodynamics, location of food resources and feeding styles. The lagoonal area is characterised by exclusively dwelling species such as *Chloeia flava,* and Nemertea *Cerebratulus marginatus,* while species such as *Oniphus eremita* and *Heteromastus filiformis* are common in the lagoon, beach and lower runnel transition. This is because of the conditions of the lagoon, which are at times becomes more hostile than the adjoining beach region. These species have adapted themselves into living in anoxic sediment conditions. The beach portion is also less populated in comparison to the ridge and runnels. As such no characteristic beach species was found, but species characteristic of ridge and runnel niches were found to be overlapping the beach niches. In shore platform niche was characterised by species of *Serpula, Clymene,* and *Oysters*. The polychaete species such as *Diopatra neapoliatana* are characteristic of the runnels. Like polychaetes, crustaceans were also found to be zoned (Figure-23), but there were no clear-cut distinctions between their niches. However, some zonation was found among the age

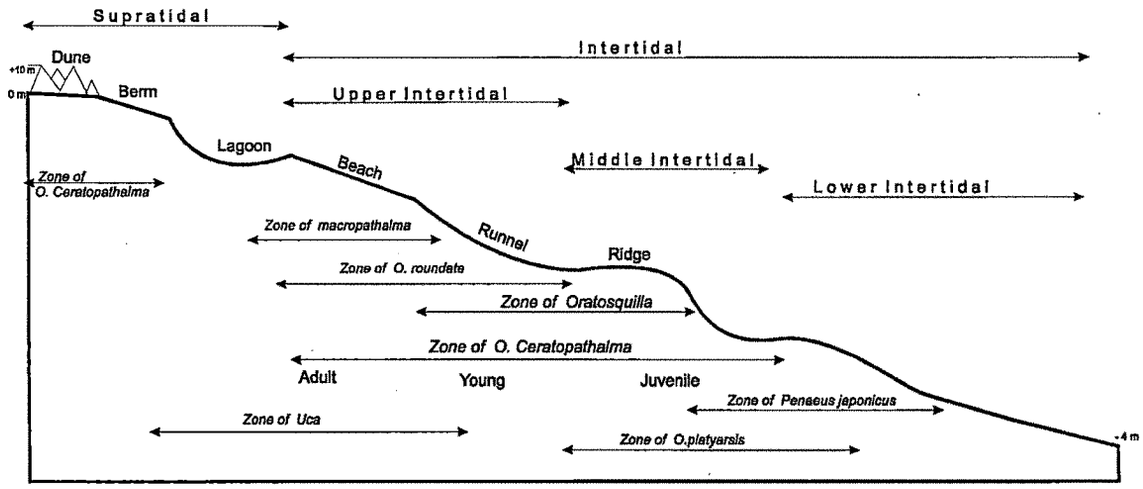

Figure-23: Zonation of the crustacean species across the intertidal zone.

groups of the same species like *Ocypoda ceratopathalma,* whereby the adult were limited to the upper intertidal and supratidal zones and juvenile were restricted towards the lower intertidal zone. Similar case was also observed by Patel and Desai, (1999) in Mundra tidal flats. Prawns and stomatopodean were restricted to the lower intertidal zones. *Uca* was restricted to the upper intertidal zone and lagoonal area.

5.5.1 Functional Morphology

Probably the most serious problems that confront in studying animal sediment relationships are categorising the organisms in to feeding categories. Organisms inhabiting sedimentary environments do appear to fall into a limited number of categories (Woodin, 1983). One can use these categories as functional groups to compare assemblages and their feeding activity. Earlier workers, like, Petersen, (1915); Thorson, (1957) did recognised and attempted to categorising animals in same ways. Later Sanders (1958) was first to recognise in a quantitative way the importance of sediment stability for the infauna. Sanders (1958) idea was extended by Rhoads and Young (1970) and discussed the role of organisms in changing the structures of the sediment in which they lived.

In order to classify the organism Woodin and Jackson (1979) introduced term "functional group", which includes organisms that use and affect their environment in similar ways. According to Woodin and Jackson (1979) it can be defined as "a group of species that exploits the same class of environment resources in similar ways and include representatives of a wide variety of benthic taxa". All the animals found in the study area

were primarily classified according to the functional groups. The categories erected are on the basis of how the organisms relate to the sediment and thus may also be useful in the context of avoidance of predators, disturbance agents and physical factors. Woodin and Jackson (1979) remarked that their term "Functional group" was rather different from the concept of a "guild" concept, which was defined solely on the basis of modes of exploitation of resources and is used for comparing time intervals. Following two functional groups are erected by Woodin and Jackson (1979).

1 Sediment destabiliser: -

a) Mobile destabiliser-Mobile burrowers organisms whose movements causes the sediment to be more easily resuspended and eroded. Also true for the deposit feeders.

b) Sedentary destabiliser-organisms whose activities (primary feeding and defecation) causes the sediment to be more easily suspended.

c) Sedentary destabiliser-organisms that project both above and below the sediment surface changing both local hydrodynamic regimes and rate of resuspension and erosion (at low and moderate density: destabilising effect)

2 Sediment stabiliser: -

a) Sedentary organisms that project both above and below the sediment surface changing both local hydrodynamic regimes and rate of resuspension and erosion (at high-density stabilising effect).

b) Tube building organisms within the sediment can stabilise the sediment.

c) Do not appear to have any significant effect on the surrounding sediment.

These groups of burrowing organisms whose activity cause the sediment to be more easily resuspended and eroded. Most of the organisms can be assigned easily to a category-1a The table- 3 gives the details of the organism and their related categories. Majority of the organism from the study area falls in this category.

Organism	Mobile/ Sedentary	1a	1b	1c	2a	2b	2c
Macropathalmus	M	#					
Uca	M	#	#				
Ocypode	M	#	#				
Plagusia	M	#					
Graspus	M	#	#				
Portunus	M						#
Scylla	M						#
Neptunus	M						#
Matuta	M	#					
Oratosquilla	M	#	#		#		
Squilla	M	#			#		
Diopatra	M				#	#	
Onuphis		#			#		
Lumbriconereis	M				#	#	
Nereis	M	#			#		
Lycastis	M	#			#	#	
Nephthys	M	#			#	#	#
Serpula	S				#		#
Clymene	S				#		#
Heteromastus	M	#			#		
Amphinome	M	#					
Chloeia	M	#					
Nemertea	M				#		
Clibanarus	M	#					
Gastropod	M	#			#		
Gastropod	M	#			#		
Bivalves	M				#		
Bivalves	M		#		#		
Holothouria	M				#		
Fat innkeper	M			#			
Starfish and Feather star	M						#
Barnacle	S				#		#

Table-3: Functional groups of the organisms found in the Study area (Classified and modified after Woodin 1983, Woodin and Jackson 1979)

The data from the above table indicates that majority of the activity shown by the organisms are mainly restricted to the sediment destabiliser types, and majority of their activity is feeding, especially deposit feedings. Though, some complex activities are also observed like young species of the genus *Ocypode*, which, burrows into the sediments, falling in destabilising type and also secretes a large amount of mucus belonging to

stabilising type, thus it neither falls in destabiliser group nor it totally falls into stabilising group of Woodin and Jackson (1979). Like ways the species of *Oniphus* can maintain a group funnel burrow but can also build sand tubes in different settings. Other organisms other than crustaceans and polychaetes, like feather star, starfish, barnacle, Fat innkeper, Holothouria are less influential as either sediment stabiliser or destabiliser. According to De (1999), the concentration of crustacean burrows on beach, tend to bioerode the sediments; thus, falling in destabilising group, but contrary to his view, it was observed in the present study that the crustacean burrowing did not tend to affect the sediment either to destabilise or stabilise it.

5.5.2 Feeding Guilds

A guild is defined as "a group of species that exploit the same class of environmental resources in a similar way. This term groups together species, without regard to taxonomic position, that overlap significantly in their niche requirements." (Root, 1967). The Trophic Guild: "a group of species that exploit the same class of trophic resources in a similar way..." (Burns, 1989). This concept is based on adaptive morphologies, space utilization, and food sources and separates taxonomic units into groups with common trophic resources according to how they obtain energy allowing for higher unit analysis of hierarchies.

Feeding guild concept together with functional group concept of Woodin and Jackson (1979) is used to recognise major methods adapted by crustaceans and polychaete in space utilization, location of food resources and feeding strategies. The animals are further classified according to feeding and morphological structures used in feeding. Polychaetes used variety of feeding apparatus like jaws, tentacles, sac like pharynges, etc. (Table-4).

The families of Serpulidae are filter feeders, using tentacles for feeding, while other families Maldanidae, Capitellidae and Amphinomidae use sac like pharynges. The families of Eunicidae, Nereidae and Nepthydae use jaws, but shows wide variety of feeding guilds. Special mention should be made for the species of Nepthydae. It was observed that the species of *Nephthys* are "interface feeders" (*sensus* Dauer et al., 1981 *in* Taghon and Greene, 1992), ability of many infauna to switch between deposit feeding and suspension feeding, depending upon flow regime (Taghon and Greene, 1992; Taghon et al, 1980; Barfield and Newell, 1961; dauer et al., 1981).

Similarly, observed data on crustacean (Table-5) feeding apparatus and behaviour shows majority of burrowers are deposit feeders and made use cheliped and mouth together in combination to scoop

Polychaete Guilds				
Family	Genus	Feeding	Motility	**Morphological structures used** in feeding
Eunicidae	Diopatra Onuphis Lumbriconereis	Filter feeder	Motile	Jawed
Nereidae	Nereis Lycastis	Suspension/ Deposit Feeder	Motile	Jawed
Nephthydae	Nephthys	Suspension/ Deposit feeder	Motile	Jawed
Serpulidae	Serpula	Filter feeder	Sessile	Tenteculate
Maldanidae	Clymene	Deposit feeder	Sessile	Sac like pharynges
Capitellidae	Heteromastus	Deposit feeder	Motile	Sac like pharynges
Amphinomidae	Amphinome Chloeia	Deposit feeder	Motile	Sac like pharynges

Table-4: Feeding guild of the polychaetes

Crustacean Guilds				
Sub-Family	Genus	Feeding	Motility	Morphological Structures used in feeding
Macrophthalminae	*Macropathalmus*	Deposit Feeder	Motile Burrowers	Cheliped / mouth
Ocypodinae	*Uca, Ocypode*	Deposit feeder	Motile burrowers	Cheliped / mouth
Palagusiinae	*Plagusia*	Deposit feeder	Motile burrowers	Cheliped / mouth
Grapsinae	*Graspus*	Deposit feeder	Motile burrowers	Cheliped / mouth
Portuninae	*Portunus*	Suspension/ Deposit feeder	Motile Swimmers	Cheliped / mouth
Lupinae	*Scylla, Neptunus*	Suspension/ Deposit feeder	Motile Swimmers	Cheliped / mouth
Matutinae	*Matuta*	Suspension/ deposit feeder	Motile Swimmers burrowers	Cheliped / mouth
Squillinae	*Oratosquilla* *Squilla*	Suspension Feeder	Motile burrowers	Claw

Table- 5: Feeding guild of the Crustaceans

out freshly deposited sediments and sort out the organic matter from the sediments with the help of mouth. Stomatopodean and swimmers were found to be suspension feeders, but were less significant. In case of stomatopodean it was observed that the organism

with the help of body movements created water to flow with sediments, and then filtered the water for food.

5.5.3 Location of Food Resources

The food resources are distributed unevenly in the intertidal zone and the sediment-water interface (SWI) is the site of high biological activity. The SWI is also a site of a relatively high concentration above and below it (Zobell and Anderson, 1936; Trask, 1939; Sverdrup et al., 1942). Figure -24 shows modified annotated diagrammatic

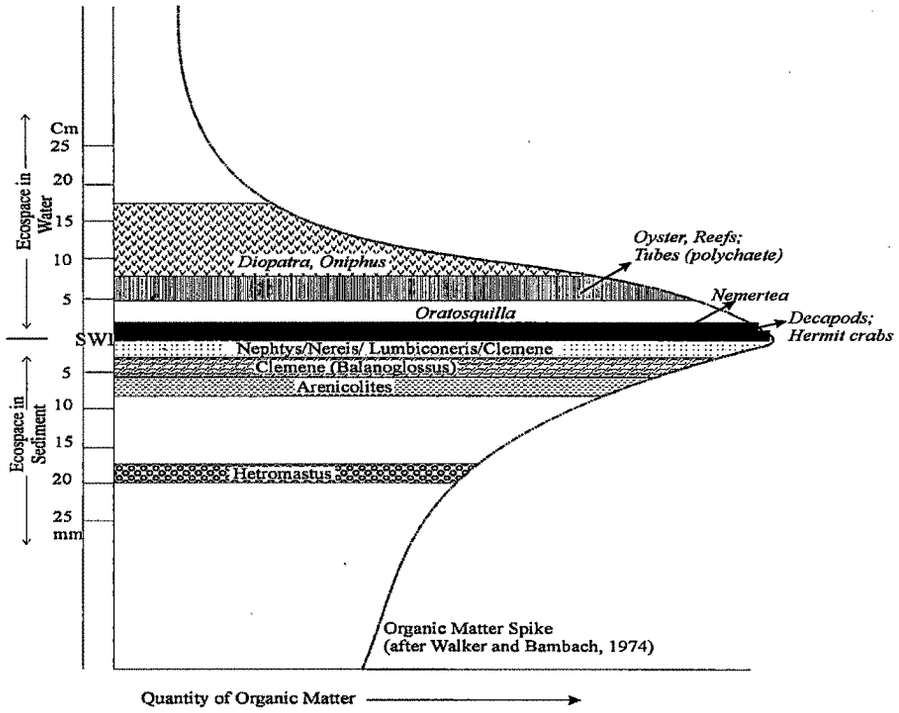

Figure-24: Observed depth and height of the feeding area of individual organisms plotted at the SWI and its relation with organic matter (modified after Walker and Bambach, 1974).

summary of the organic matter concentration with respect to the sediment water interface with observed feeding depths of the various organisms. This feeders indicates the feeding activities of benthic organisms are usually directed towards using the food resources as one of the three general levels of the resource location in the sediments, SWI and overlying water mass. The quality and quantity of food varies from level to level. Majority of animals is restricted to the SWI, few suspension feeder uses above lying water mass for feeding, while some use unexplored deep sediments for feeding. Organism likes *Diopatra, Oniphus,* have tubes extending out of sediment water interface, which in peak

flow conditions, remain erect at about 10-12 cm above SWI, and it collected food from the water above it. Thus, resuspended particulate materials enrich this water immediately above SWI (Marshal, 1970). This ecospace is also utilised by sessile, attached, and colonial organism like oysters, polychaetes, and serpulids. *Oratosquilla* uses about 1-5 cm above the SWI. Majority of organisms like, Decapod, Nemertea, Hermit crab, gastropods, uses SWI for feeding purposes, this surface is highly concentrated in organic material (Sverdrup et al, 1942; Trask, 1939). This zone is also active, and experiences daily changes in food resource input by changing tides. The ecospace just below the SWI is utilised by majority of polychaetes, which also behaves as interface deposit feeders. The nutrient organic matter concentration does not change much upto 20-mm but beyond that it decreases, this ecozone is utilised for feeding by deep deposit feeding polychaete like *Heteromastus*. The observed ecospace of feeding of animals found in study area when plotted against the organic matter curve at SWI indicates majority of animals utilises that zone in which there is abundance of food resources.

5.5.4 Trophic Categories

Based on above data on feeding apparatus, food resources and functional groups, it is possible to categorise the animals in to trophic categorise, which is a combination of these factors and a simplification of mechanisms which allows the definition of groups of organism which feed in same fashion. The feeding styles of polychaetes is more diverse than that of crustaceans suggest that nearly 80% of polychaete species are deposit feeders, while 13% are suspension feeders, and remaining 7% are filter feeders (Figure- 25). Therefore these can be further subdivided on the basis of Trophic modes into (i) Surface deposit feeders, (ii) Shallow tier deposit feeders (iii) Middle tier deposit feeders (iv) Deep tier deposit feeders. (v) Suspension feeders.

5.5.4.1 Deposit Feeders

Deposit feeding species typically exploit a reservoir of organic rich sediment. Deposit feeders are also known to strongly influence the physical characteristics of the environment, particularly by active burrowing (Rhoads and Young, 1970; Posey, 1986; Levington, 1989). The most common effects are an increase in water content especially in sediment with high silt and clay content (Rhoads and Young, 1970) and the redistribution of sediment particles (Levington, 1989). Bock and Miller (1996) put forward a hypothesis

concerning deposit feeding based on small-scale pattern. According to them, deposit feeding is a function of local food value, the scale of which is determined by the diameter of the feeding area. The feeding area diameter is determined by the length of the feeding appendages and the propensity of the organism to extend its anterior out of the safety of its burrow (Woodin, 1982). Livinton and Bambach (1975) suggested that, in both recent and ancient communities, species are vertically stratified within the sediment because of competition for food and space. It has also been suggested that the diversity of the deposit feeding species represents a condition in which niches have become finely partitioned through competitive interactions in a stable environment (Sanders, 1968; Grassels and Sanders, 1973).

The study is characterised by deposit feeding mode for polychaetes in several division of which nearly 42 % are of interface deposit feeders, 25 % shallow; middle deposit feeders accounted for 17%, while surface and deep deposit feeders accounted for 8% respectively (Figure-25b).

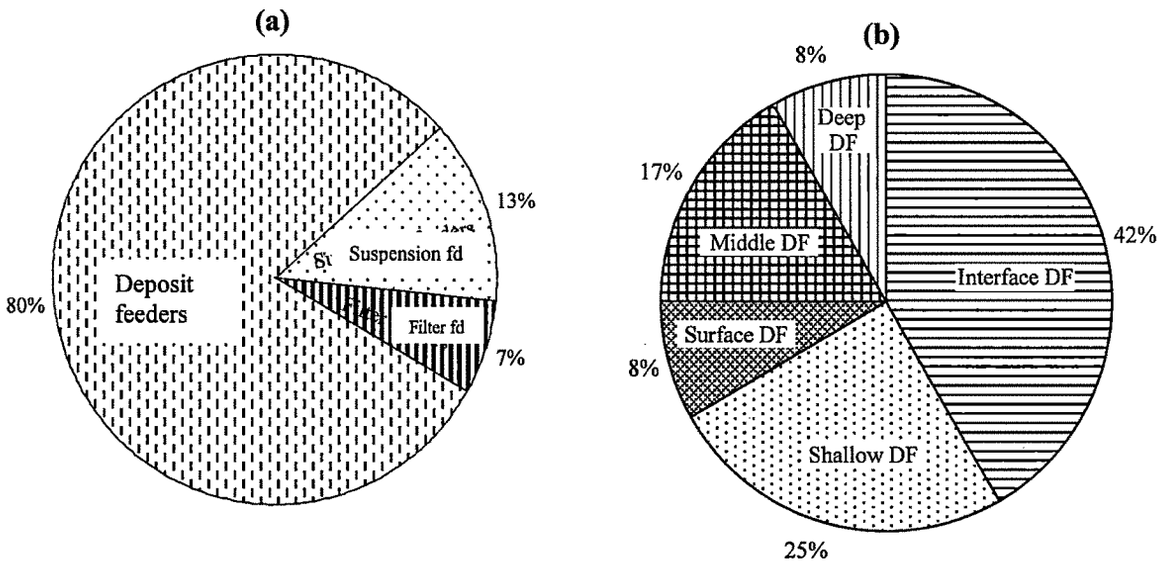

Figure-25: Percentage of feeding styles observed in polychaetes (a) total feeding styles and (b) variation in deposit feeding styles.

5.5.4.2 Interface Feeders

Nereidae and Nephthydae represents larger fraction of the polychaete species, and these species are habituated for switching their feeding styles. Their burrows (chapter-6) show combination of excreta mounds, with surfacial and shallow surface feeding excavations. This is a particularly dramatic example in some infauna to switch between

deposit feeding and suspension feedings. The excreta mound represents suspension feeding activity, while surface excavation represents deposit feeding. The worms were observed to come out from the burrow, feed on surrounding areas, in low tide conditions, and surfacial water was nearly 1-3 cm above SWI at low speed. According to Taghon and Greene (1992), at low flow speed, feeding in interface feeders is almost on particles on the sediment surface, while at higher flow speed, distinct shift in feeding behaviour occur and animal change its behaviour to suspension feeding. This is so because the flow regime is such that particles of higher nutritional values are both concentrated in the overlying water and supplied at a higher rate, it may be energetically profitable to switch from deposit feeding to suspension feeding.

5.5.4.3 Surface Deposit Feeders

According to Levinton (1972) animals that obtain nutrient from particulate organic matter incorporated in to the sediments. These categories are also known as "detritus feeders" according to Bromley (1996), any deposit feeders that feeds on the nutrient rich top most layer of the substrate. There are many organisms that fall into these categories, including all of the brychuryans, *Ocypoda ceratopathalma, Ocypoda roundata, Ocypoda platytarsis, Uca marionis, Uca annulipes, Graspus strigosus, Macropathalmus pectinipes, Macropathalmus.* Sp. Some of the polychaete species like *Nephthys* and *Nereis* feeds on surface during the low tide. Nemetrea, Hermit crab and gastropod are also some of the surface deposit feeders found in the study area.

5.5.4.4 Shallow Tier Deposit Feeders

Shallow tier deposit feeding is a method employed by the organisms that exploits detritus that are present in the sediment at a shallow depth, probably near the surface. Polychaetes like *Nephthys, Nereis, Clymene,* and *Chloeia* Sp. are found to be shallow tier deposit feeders. Especially, the *Nephthys* and *Nereis* are the two polychaetes that employ this mode. They excavate a shallow detritus layer, generally 2-5 cm below the surface.

5.5.4.5 Middle Tier Deposit Feeders

Crustacean like Shrimp and Prawns, are middle tier deposit feeders, generally they work at a depth deeper than the shallow deposit feeders.

5.5.4.6 Deep Tier Deposit Feeders

Only one species of the Polychaete *Heteromastus filiformis* was found in the category of the deep tier deposit feeders. This was restricted in the lower beach and lagoon. Like many animals, they spend their lives oriented vertically or obliquely in the substrate-head downward, ingesting the sediment at depth.

5.5.4.7 Suspension Feeders

Many different devices have been developed by suspension-feeding burrowers to intercept the seston suspended in the water current, including tentacles, sieve created by hairs on limbs and nets of slime. Burrow dwellers control their own current and protection for their filtering equipment. They may colonise environments that are unsuitable for epibenthic suspension feeders. In the study area many animals are to be found that follow this lifestyle. *Oratosquilla striata*-a mantis shrimp and polychaete, such as *Diopatra and Oniphus* have adapted to suspension feeding life styles.