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MACROBENTHOS OF THE SHELF WATERS OF THE WEST COAST OF INDIA

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T.V. JOYDAS

DEPARTMENT OF MARINE BIOLOGY, MICROBIOLOGY AND BIOCHEMISTRY
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI – 682 016, INDIA

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CERTIFICATE

This is to certify that the thesis entitled ***MACROBENTHOS OF THE SHELF WATERS OF THE WEST COAST OF INDIA*** is an authentic record of the research work carried out by Mr. T.V. Joydas, under my supervision and guidance in the Department of Marine Biology, Microbiology and Biochemistry, Cochin University of Science and Technology, in partial fulfilment of the requirements for the degree of ***Doctor of Philosophy*** in Marine Biology of the Cochin University of Science and Technology and no part thereof has been presented for the award of any other degree, diploma or associateship in any university.

Dr R. Damodaran
Dean,
Faculty of Marine Sciences,
Cochin University of
Science and Technology,
Kochi - 682 016.

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Abbreviations

%	:	Percentage
^0C	:	Degree Celsius
m	:	Meter
mm	:	Millimeter
g	:	Gram
kg	:	Kilogram
wt.	:	Weight
i.e.	:	That is
et al.	:	And others
cape	:	Cape Comorin
tvm	:	Thiruvananthapuram
klm	:	Kollam
klm1		Kollam, 30m depth
klm2		Kollam, 50m depth
kch	:	Cochin
vad	:	Vadanappilly
kzh	:	Kozhikode
kzh1		Kozhikode, 31m depth
kzh1		Kozhikode, 50m depth
knr		Kannur
knr1		Kannur, 51m depth
knr2		Kannur, 67m depth
mngr	:	Mangalore
cnpr	:	Coondapore
btkl	:	Bhatkal
btkl1		Bhatkal, 54m depth
btkl2		Bhatkal, 68m depth
rtngr	:	Ratnagiri
dbhl	:	Dabhol
dbhl1	:	Dabhol, 96m depth
dbhl2	:	Dabhol, 94m depth
ofmb1	:	Off Mumbai, 96m depth
ofmb2	:	Off Mumbai, 89m depth
almb1	:	Along Mumbai, 95m depth
almb2	:	Along Mumbai, 91m depth
almb3	:	Along Mumbai, 85m depth
almb4	:	Along Mumbai, 79m depth
prbn	:	Porbandar

dwrk	:	Dwarka
lat.	:	Latitude
long.	:	Longitude
N	:	North
E	:	East
FORV	:	Fishery and Oceanographic Research Vessel
SCUBA	:	Self Contained Underwater Breathing Apparatus
lbs	:	Pound
ICES	:	Interntional Conference on Environmental Science
m/s	:	Meter per second
sp	:	Species
spp.	:	More than one species
Fig.	:	Figure
S	:	Sand
SiS	:	Silty sand
SSi	:	Sandy silt
Si	:	Silt
CSi	:	Clayey silt
SiC	:	Silty Clay
SSiC	:	Sand silt clay
A	:	Abundant
M	:	Moderately present
R	:	Rare
No	:	Number
st.	:	Station
ml	:	Milli litre
L	:	Lit re
DO	:	Dissolved oxygen
OC	:	Organic Carbon
OM	:	Organic matter

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Chapter I

Introduction

Benthos refers collectively to all aquatic organisms which live in, on or near the bottom of a body of water. It was Haekel in 1890, who first used the term benthos, which is derived from Greek, meaning, 'depth of the sea'. The benthic community is composed of a wide range of plants, animals and microbes, thus forming an important component of all kinds of aquatic food webs. The term 'phytobenthos' is used when referring to the plant members (i.e., various algae and aquatic plants), whereas 'zoobenthos' is applied in reference to all consumers (i.e., benthic protozoans and metazoans). 'Benthic microflora' (bacteria, fungi and many protozoans) constitute the decomposer community and are involved in the recycling of essential nutrients.

The benthos is normally divided into three functional groups, infauna, epifauna and hyper-benthos, i.e., those organisms living within the substratum, on the surface of the substratum and just above it respectively (Pohle & Thomas, 2001). The division reflects differences in sampling techniques for the three groups. Sampling differences also result in the division of the benthos into two major habitat groups, the soft bottom benthos and hard bottom benthos.

According to size, benthic animals are divided into three groups. (i) macrobenthos (ii) meiobenthos and (iii) microbenthos (Mare, 1942). This distinction of benthos into three size categories is rather arbitrary and varies according to the workers and also according to the type of the substratum under investigation. Macrobenthos are organisms which are retained in the sieve having mesh size between 0.5 and 1 mm. For meiobenthos, the lowest size attributed is 63 μ and the upper limit depends upon the mesh size of the sieve used for separating macrobenthos from meiobenthos. The smallest size group, microbenthos, includes those organisms that are not retained in the finest sieve used for meiobenthos separation and include bacteria and most protozoans.

Benthic environment extends from intertidal region upto the deepest trenches. The most important feature of benthic environment is its heterogeneity. This heterogeneity and the greater number of benthic assemblages as compared with the pelagial is, atleast in part, a consequence of the infinite number of possible combinations between abiotic factors, either climatic or edaphic. This in turn results in greater number of species in benthos than plankton (Peres, 1982). Vertical expansion of the benthos is usually very small. Since benthos occupies a surface area, which is generally very large in comparison with the volume occupied, benthic environment is usually considered bi-dimensional.

The benthic fauna is of considerable importance in marine food chains (Mc Intyre, 1971) and the benthos like their counterparts, the plankton and nekton, are involved in the recycling of materials, the flow of energy through food chains, and the proliferation of their kinds (Schweitzer, 1974). It is generally recognized that a detailed understanding of the bottom fauna is necessary to obtain a comprehensive picture of the fishery potential of an area (Damodaran, 1973).

Benthic invertebrate communities are used as prime indicators of environmental conditions in estuaries and inshore waters, as,

(i) they have limited mobility and thus are unable to avoid adverse conditions;
(ii) they live in sediments, where they are exposed to environmental stressors, such as chemical contaminants and low dissolved oxygen level;
(iii) their life span are long enough to reflect the effects of environmental stressors; and
(iv) their communities are taxonomically diverse enough to respond to multiple types of stress.

Benthic monitoring is also a relatively sensitive, effective and reliable technique that can detect subtle changes that serve as early indicators before more drastic environmental changes occur. Most other monitoring methods (e.g. video monitoring for bacterial mats and sediment parameters) generally detect the later, more drastic changes.

Studies on the biomass of benthos in different areas of the ocean have shown that there is a general decrease of biomass with depth (Levinton, 1982; Peres, 1982). The distribution of the macrobenthos is closely related to water temperature, salinity and sediment types (Haiming *et al.*, 1996). The nutritional quality of sediment measured as organic carbon together with the hydrodynamic conditions seem to be the major factors, determining the trophic composition of the subtidal macrofaunal communities. The total amount of particular organic material in the sediment probably control the total infaunal biomass and density, generally resulting in high values in areas of high organic input (Dauwe *et al.*, 1996).

The benthic environment is recognized as a complex system directly coupled with surface water processes. Current interest in global biodiversity has focused attention back to functional aspects of biological diversity in benthic environments (Cosson *et al.*, 1997). The origin of such functional diversity may be derived from the tremendous patchiness of the benthos, considered one of the major features of benthic communities (Etter & Grassle, 1992). Compared to terrestrial and coastal marine ecosystems, our knowledge of large scale patterns of diversity in the deep sea is still restricted to a few major taxa and based on the very limited sampling and geographic coverage.

India, as a vast maritime nation, has a coastline of about 8129 km with a large number of rivers, rivulets and their tributaries opening into both Arabian Sea and Bay of Bengal. A number of reports on the benthos of the Indian Ocean has been published till date. Most of the information pertains to regional studies especially in and around various estuaries and only very limited information is gathered from the coastal waters beyond 50m depth. Attempts to study the entire shelf region of west coast of India have been made so far only by 3 workers. However, even these studies had many limitations like not sampling upto 200m (Harkantra *et al.,* 1980) and employing only dredge for hauling (Neyman, 1969). The study of Parulekar *et al.* (1982) was a compilation of scattered information gathered from various cruises conducted at different times, employing different gears. The paucity of information on benthic fauna in the entire west coast of India prompted the present investigation on the macrobenthos of the shelf waters of the west coast of India. The present benthic study is the first systematic attempt to monitor the entire shelf region of west coast, extending from off Cape Comorin to off Dwarka with sampling upto 200m depth. The main objectives of the present work are listed as follows:

- To estimate the standing crop of macrobenthos and its variation in relation to depth and latitudes.
- To understand the numerical abundance of macrobenthos and its spatial variation.
- To study the qualitative composition of all the groups and to have a detailed analysis of major groups.
- To know the community structure of benthos.
- To understand the hydrography and the sediment characteristics of the western continental shelf.
- To find out the correlation of macrobenthos with hydrographical and sediment parameters if any and
- To find out the trophic relationships of macrobenthos of the western continental shelf of India.

With the above aim, two cruises were conducted along the continental shelf of the west coast of India. The second cruise was conducted with a view to fill the gap, which occurred during the first cruise. The samples were collected using Smith Mc Intyre grab from different depths viz. 30, 50, 100, 200 meters on board Department of Ocean Development's Research Vessel, FORV Sagar Sampada. 75 stations were covered, which were distributed along 17 transects extending from off Cape Comorin to off Dwarka. Care had been taken not to exceed the distance between the stations in one transect to more than 30 nautical miles and also that all degree square areas are represented in the sampling. Altogether 147 grab samples were utilized for the study.

Chapter 2

Review of literature

The investigations on benthos date back to the middle of the eighteenth century. The first benthic study appears to be by two Italians, Marsigli and Donati, around the year 1750, by collecting the benthic organisms of shallow waters using dredge (Murray & Hjort, 1965). A modification of this tool - the naturalist's dredge - was used by O.F. Muller in 1799. Important dredging works to depths down to 400 fathoms were carried out during the British Antarctic Expedition from 1839 to 1843. In 1864, Michael Sars and G.O. Sars gave a list of 92 species living in depths between 200 and 300 fathoms and, a few years later showed that marine life was abundant down to depths of 450 fathoms (Murray & Hjort, *loc. cit.*). In 1868 Wyvelle Thomson and W.B. Carpenter carried out dredging in depths down to 650 fathoms, and proved beyond doubt that animal life is varied and abundant at those depths, and is represented by all the invertebrate groups (Murray & Hjort, *loc cit.*). The Challenger expedition (December 1872 to May 1876) carried out special investigations on many aspects including benthic studies of the oceans of world. Marion (1883a,b) described the nature of different bottom areas and the species composition of their flora and fauna on the entire shelf of the Gulf of Marielles (France) and extended his comparative analysis to include both the nature of the bottom and the faunal composition down to a water depth of 2000m.

All the above studies were concentrated only on the qualitative aspects, i.e., the list of species found on or in a given type of bottom. It was John Peterson (Peterson, 1911, 1913) who, first of all made a quantitative approach to benthic studies: the number of individuals and weight of living matter was expressed per unit of bottom area in this study. Placing paramount importance on those species, which predominate in weight, Peterson developed his community concept (Peterson, 1914, 1915,1918). He observed definable assemblages in the subtidal region. Brotskaja and Zenkevich (1939) substituted Peterson's community by new unit, which they called complexes. Nicholls (1935) introduced the term interstitial fauna to denote the organisms which exist in the capillary water of sand grains. Later, Swedmark (1964) adopted this, whereas Remane (1940) proposed the term mesopsammon for interstitial fauna. Thorson (1957) proposed additions to the community concept of Peterson and developed the isocommunity concept, which was the seed of vertical zonation.

Wieser (1953, 1960) studied the nutritional quality of nematodes with the help of pharynx organization. Wieser (1959) made the first general account of relationships between meiofaunal composition and granulometric characteristics of the sediment.

Sanders (1968, 1969) carried out epibenthic sled sampling in different coastal areas and compared population size as well as diversity in deep sea and shallow water soft substrata. He observed sharp decrease in biomass near the shelf edge and it was ascribed to the fact that in deep sea, the percentage of small sized species in the whole fauna is higher in comparison to that on the shelf. He found that increasing depth would affect abundance slightly and biomass considerably. Gerlach (1972) found that granulometric characteristics influence the composition of infauna and they largely influence the burrowing resistance and filter feeding conditions. Buchanan *et al.* (1978) made a seasonal study on the shelf bottom macrofauna from 20m down to 80m off the coast of Northumberland and observed that the seasonal changes in abundance and biomass appeared to be independent of the composition of the assemblage.

Bogdanos and Satsmadjis (1985) analyzed the macrobenthos of the Greek Gulf of Pagassitikos with a view to depict accurately the biocoenosis of the entire range of soft substrata. Gaston (1987) studied the feeding and distribution of polychaetes of the Middle Atlantic Bight and found that the proportion of carnivorous polychaetes were greatest in coarse sediments and decreased significantly with water depth across the continental shelf. Franz and Harris (1988) studied the seasonal and spatial variability in macrobenthic communities in Jamaica Bay, New York. Service and Feller (1992) made an analysis of seasonal and yearly trends in subtidal macrobenthic samples from sandy and muddy sites in North Inlet and showed large fluctuations in faunal abundance and high variability between replicate samples. Graf (1992) studied the benthic pelagic coupling and developed an energy flow equation for marine sediments.

Pancucci-Papadopoulou *et al.* (1999) studied the benthic invertebrate communities of NW Rhodes island in relation to hydrographical regime and geographical location. Powelleit and Kube (1999) studied the effects of severe oxygen depletion on macrobenthos in the Pomeranian Bay (southern Baltic Sea) and found changes in the macrobenthos which were attributed mainly to hypoxia or anoxia. Somerfield and Gage (2000) studied the community structure of benthos in Scottish Lochs. The results were compared with that of previous studies and it was concluded that studies carried out on a particular scale or a particular component of benthos were likely to be successful in predicting spatial relationships at other scales or for other components of benthos. Levin *et al.* (2000) studied the macrobenthic community structure within and beneath the oxygen minimum zone, NW Arabian Sea. Desrosiers *et al.* (2000) used multivariate analyses to show the trophic structure of macrobenthos in Gulf of St. Lawrence and on the Scotian Shelf. Martin *et al.* (2000) studied the spatial distribution and trophic structure of polychaetes inhabiting the soft bottoms of Alfacs Bay. Glover *et al.* (2001) studied the patterns in polychaete abundance and diversity from the Madeira Abyssal Plain, north east Atlantic.

It was the studies of Annandale (1907) and Annandale and Kemp (1915) on the ecology of Gangetic delta and the fauna of Chilka Lake, which pioneered the work on benthos in India. Panikkar and Aiyar (1937) studied the bottom fauna of the brackish water areas of Madras City. Samuel (1944) described the animal communities of the level sea bottom of Madras Coast. Kurien (1953) analyzed the occurrence of the bottom fauna in relation to the bottom deposits of the Travancore Coast. Later Kurien (1967, 1971) made an extensive survey of bottom fauna along the South West Coast of India. Seshappa (1953) made quantitative studies using grab samples, in the inshore sea bottom of Malabar Coast. Ganapati and Rao (1959) made a preliminary work on benthos in the continental shelf of north-east coast of India which was based on some grab and dredge hauls made at widely separated stations. During Indian Ocean Expedition, the Soviet research vessel 'Vityaz' carried out a number of studies on benthic communities and the work was published by Beljaev and Vinogradova (1961) and Sokolova and Pasternak (1962). Desai and Krishnankutty (1967a,b) studied the benthic fauna in and around Cochin. Sanders (1968) studied the bottom fauna of samples along the East and West Coast of India and studied their species diversity. Neyman (1969) made a detailed study on the bottom fauna of the shelves in the northern part of the Indian Ocean from the dredge collections. This was the first study, which covered the entire length of Indian coasts.

Damodaran (1973) studied the benthos of the mud banks of Kerala Coast and worked out the seasonal variation of both macro and meiofauna and also the correlation between benthos and fishery. This was the first quantitative study on macro and meiobenthos in Indian waters. Harkantra (1975) studied the benthos of the Kali estuary, Karwar. Parulekar *et al.* (1976) conducted the quantitative assessment of benthos off Bombay. Ansari *et al.* (1977) undertook an investigation of shallow water macrobenthos in five Bays along the Central West

Coast of India. Pillai (1977) studied the distribution and seasonal abundance of macrobenthos of Cochin backwaters.

Harkantra *et al.* (1980) studied the abundance, animal sediment relationships and biomass of benthos along the western Indian shelf together with a possible correlation between biomass and demersal fish stock by taking benthic samples within a depth range of 10-70m. Parulekar *et al.* (1980) assessed the annual cycle of environmental and biotic factors in relation to distribution, production and trophic relations in the Mandovi, Cumbarjua canal and Zuari estuarine system of Goa. Harkantra and Parulekar (1981) made a study on the ecology, distribution and production of benthic fauna in relation to demersal fishery resources of the coastal zone of Goa. The aspects of quantitative distribution, standing crop and annual production of benthos of the Indian Seas (Arabian Sea, Lakshadweep Sea, Andaman and Bay of Bengal) and the efficacy of the data for assessing the potential demersal resources, were also studied by Parulekar *et al.* (1982). Raman and Adiseshasai (1989) made studies on macrobenthos of the littoral areas off Visakhapatnam.

Vizakat *et al.* (1991) studied the community structure of benthos in relation to texture and organic carbon content of sediment and bottom water salinity in the Konkan coast. Saraladevi *et al.* (1991) studied the communities and coexistence of benthos in northern limb of Cochin backwaters. Sunil Kumar (1993) conducted a study on the benthic fauna of the mangrove swamps of Cochin area. Venkatesh Prabhu *et al.* (1993) studied the macrobenthic fauna in the nearshore sediments off Gangolli. Ansari *et al.* (1994) studied the macrobenthic assemblage in the soft sediments of Marmagoa harbour, Goa. Harkantra and Parulekar (1994) studied the population dynamics, biomass production and analysis of community structure of soft sediment dwelling macro invertebrates of the shallow waters of Rajpur Bay in relation to certain environmental parameters. Saraladevi *et al.* (1996) studied the bottom fauna and sediment characteristics of the coastal regions of South West and South East Coasts of India. Gopalakrishnan and Nair (1998) studied the macrobenthic fauna from Mangalore Coast, where effluents from a fertilizer factory and iron ore exporting company were discharged. Sheeba (2000) studied the distribution of benthic infauna in the Cochin backwaters in relation to environmental parameters. Joydas and Damodaran (2001) studied the diversity, and abundance of macrobenthic polychaetes along the shelf waters of the west coast of India.

As far as benthos are concerned sampling is an inefficient process, and because of this, our knowledge of species diversity of this group of organisms is very poor. The degree of difficulty in sampling benthos increases with depth. Thus the intertidal area, which is directly accessible at low tide, is relatively well studied than any other benthic region. The immediate subtidal, down to about 30m can be sampled and observed by SCUBA equipped biologists, but sampling efficiency declines rapidly with depth as the working time, manual dexterity and visibility decrease (Pohle & Thomas, 2001). From 30 to about 100m, the bottom can be observed using video cameras on Remotely operated vehicles

(ROV), tethered underwater vehicles controlled from a ship etc., however, most ROV's are incapable of effective sampling. Recent technological advances provide the diver with new equipments, like, underwater telephone, underwater tape recorder, portable suction sampler, photographic equipment, dry suits, drillling equipment etc. that have considerably enlarged the range of observation and improved underwater experimentation at least in some regions. Satellite imagery techniques are also being used in benthic studies (Rumohr, 1995).

Though the above listed modern technologies are being used in certain regions, devices such as the grabs, corers and dredges are still the widely used equipments for benthos sampling. Reviews of grabs and corers by Holme (1964) and Holme and Mc Intyre (1971) display a bewildering variety. The grabs are almost always lowered from a boat while the corers may be operated either remotely or by a SCUBA diver. The degree of difficulty generally increases with the hardness and increased particle size of the sediment. However, even in soft, virtually homogeneous sediments, biota, stones or debris can interfere with efficient sampling.

The distribution of the macrobenthos is closely related to water temperature, salinity and dissolved oxygen (Haiming *et al.*, 1996). Benthos varies greatly in their responses to variation in water quality. In the estuarine and backwater regions, it appeared that the most important factor governing quantitative distribution of benthos is the salinity (Desai and Krishnankutty, 1966). They found that areas of high salinity in the backwaters, which are rich in nutrients and chlorophyll, support a denser benthic population. Harkantra (1975) noticed that poor biomass during the monsoon coincided with the low salinity. Damodaran (1973) while working in Narakkal mud bank region noticed a decrease in bottom fauna after July – August due to poorly oxygenated condition of bottom water.

The nutritional quality of sediment (measured as organic carbon) seems to be another major factor determining the trophic composition of the subtidal macrofaunal communities. The total amount of particular organic material in the sediment probably controls the total infaunal biomass and density, generally resulting in high values in areas of high organic input (Dauwe *et al.,* 1996). Sanders (1958) hypothesized that deposit feeders were more abundant in muddy environments because fine sediments tend to be organic rich.

The relationship between the distribution of infaunal invertebrate species and the sediments in which they reside has been the subject of numerous correlative studies. In general, the studies have shown that there are many species that are characteristically associated with a given sedimentary habit, although their distributions are rarely confined to that environment. Some species show little affinity with any one particular sediment type and the fauna with in different sediment environments invariably show some degree of overlap.

From his observations, Sanders (1958) proposed the mechanism for the association between infauna and sediment, which was, the difference in food supply, resulting in the domination of sandy habi.tats by suspension feeders and muddy habitats by deposit feeders.

Various works clearly established a direct link between the benthic biomass and demersal fishery as benthos offered trophic support to all demersal fisheries. The study of Belegvad (1930) showed a direct connection between the variations in the quantity of benthic biomass and pelagic fishery. Seshappa (1953) correlated the settlement of *Prionospio pinnata* with the subsequent inshore migration of their predator, *Cyanoglossus semifasciatus*. Kurien (1971), Savich (1972), Damodaran (1973), and Harkantra *et al.* (1980) have made attempts to correlate the benthic standing crop as an indicator of the potential resources of demersal fish and prawn. As far as demersal resources are concerned, the benthic biomass, as rightly pointed out by Moiseev (1971), is a more valid parameter for projecting the potential demersal fishery. Parulekar *et al.* (1982) carried out the assessment of demersal fishery resources of the Indian Seas based on the benthic crop. Damodaran (1973) found that juvenile *Nucula* and polychaetes form an important food for fishes and prawns. Complete knowledge of bottom fauna is very essential for the determination and development of the demersal fisheries of any area. Nearly half of the world's commercial fish catch from the sea and estuary consists of shell fish and demersal fish whose main food comes from the bottom. The standing crop of benthic food resources is not only important to the demersal fishes which directly feed on them, but also to many pelagic fishes during certain phases of their life.

Chapter 3

Materials and methods

3.1. Study area

The area selected for the present study was the continental shelf region of the west coast of India. The Arabian Sea in the northwestern Indian Ocean forms the western boundary of India. *The total area of the Arabian Sea* extending from *latitudes 0^0 and 25^0* N *to longitudes 50^0 and 80^0* E *is about* 6.225 x 10^6 km^2. The Gulf of Aden, extended by the Red Sea, and the Gulf of Oman, extended by the Persian Gulf, are its principal arms. The Arabian Sea is an ocean basin closed by landmasses in the North, East and West and limited by the Equator in the South.

The Arabian Sea, though small, is a geochemically active area of the world ocean. As a result of monsoon dynamics and consequent high material flows, the region has been thought to have global significance in terms of bio-geochemical fluxes. The seasonal reversal of winds leads to strong seasonal upwelling of nutrient-rich water from the depths along the narrow continental shelf resulting in high surface productivity and high export particle flux from the euphotic zone (Qasim, 1982; Sen Gupta & Naqvi,1984)

The shelf is widest off Mumbai, extending upto about 300km and narrowest about 60km off Kochi.

75 stations representing various depths distributed along 17 transects were covered, which extended off Cape Comorin (08.03.96 N and 77.21.96 E) to off Dwarka (21.56.99 N and 67.57.69 E) (Fig. 3.1). The transects were Cape Comorin, Thiruvananthapuram, Kollam, Kochi, Vadanappilly, Kozhikode, Kannur, Mangalore, Coondapore, Bhatkal, Goa, Ratnagiri, Dabhol, Mumbai, Along Mumbai, Porbandar and off Dwarka. Sampling was conducted at 30, 50, 100 and 200m depths along each transect in order to study the depth-wise variation of fauna. Additional samplings from 75m depths were made in certain transects, where the shelf width was more. Those transects were, off Kollam, Kannur, Bhatkal, Goa, Ratnagiri and off Mumbai. Since the shelf was very steep beyond 100m off Thiruvananthapuram, sampling from 200m was not possible. In Mumbai region, because of the restriction for the entry to the Mumbai High region, one transect was created north of Mumbai High and was named as 'off Mumbai' and another, along this area was named 'along Mumbai'. Since this region has the maximum width in continental shelf, sampling was restricted upto 100m depth only. For convenience of analysis and presentation, the data from the above depths were pooled into specific depth ranges i.e., 30-50m, 51-75m, 76-100m, 101-150m and >150m. The details of stations are presented in Table 3.1.

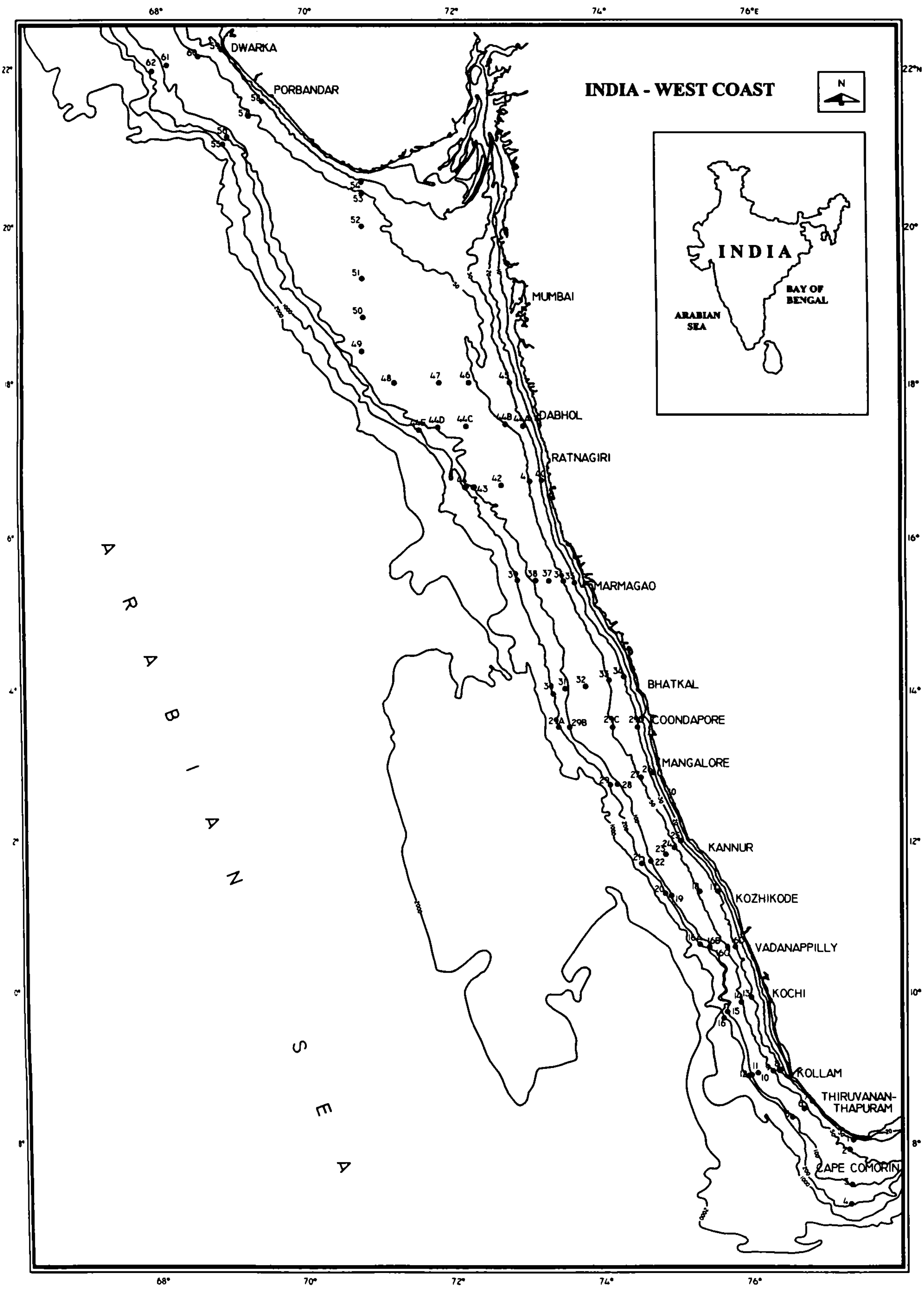


Fig. 3.1. Chart showing the location of sampling stations.

Table 3.1. Details of stations.

Transect	St. No	Latitude	Longitude	Depth (in m)
Cape Comorin	1	08.03.96 N	77.21.96 E	31
	2	07.54.75 N	77.20.67 E	51
	3	07.21.01 N	77.20.40 E	101
	4	07.10.37 N	77.20.09 E	208
Thiruvananthapuram	5	08.21.67 N	76.32.83 E	124
	6	08.27.89 N	76.42.53 E	59
	7	08.33.10 N	76.48.95 E	30
Kollam	8	09.00.40 N	76.23.92 E	31
	9	08.58.12 N	76.18.89 E	50
	10	08.55.33 N	76.05.70 E	74
	11	08.54.53 N	76.01.86 E	101
	12	08.54.70 N	75.58.56 E	238
Kochi	13	09.56.53 N	76. 00.85 E	33
	14	09.52.89 N	75.52.70 E	51
	15	09.45.80 N	75.41.18 E	101
	16	09.41.39 N	75.38.69 E	202
Vadanappilly	16A	10.28.45 N	75.25.52 E	197
	16B	10.28.97 N	75.31.57 E	103
	16C	10.28.98 N	75.42.60 E	53
	16D	10.27.25 N	75.51.45 E	36
Kozhikode	17	11.21.20 N	75.34.28 E	31
	18	11.19.50 N	75.21.28 E	50
	19	11.17.75 N	74.56.85 E	102
	20	11.18.97 N	74.51.83 E	219
Kannur	21	11.43.19 N	74.33.64 E	202
	22	11.44.97 N	74.40.81 E	102
	23	11.48.92 N	74.52.78 E	67
	24	11.56.14 N	75.00.86 E	51
	25	11.59.11 N	75.05.09 E	31
Mangalore	26	12.52.68 N	74.40.67 E	31
	27	12.49.20 N	74.32.49 E	51
	28	12.44.14 N	74.14.02 E	101
	29	12.43.89 N	74.6.45 E	205

Transect	St. No	Latitude	Longitude	Depth (in m)
Coondapore	29A	13.30.15 N	73.26.55 E	193
	29B	13.30.22 N	73.31.63 E	104
	29D	13.29.92 N	74.05.81 E	53
	29E	13.29.52 N	74.30.04 E	34
Bhatkal	30	13 .56.41 N	73.21.21 E	206
	31	14.00.09 N	73.31.57 E	101
	32	14. 04.36 N	73.48.61 E	68
	33	14.07.42 N	74. 04.67 E	54
	34	14.11.07 N	74.18.52 E	31
Goa	35	15.25.45 N	73.38.80 E	32
	36	15.25.74 N	73.30.49 E	52
	37	15.26.18 N	73.17.89 E	72
	38	15.25.74 N	73. 06.31 E	101
	39	15.26.09 N	72.52.51 E	206
Ratnagiri	40	16.44.02 N	73.12.27 E	32
	41	16.41.63 N	73. 02.94 E	51
	42	16.38.27 N	72.40.20 E	76
	43	16.37.90 N	72.17.39 E	101
	44	16.37.44 N	72.10.97 E	211
Dabhol	44A	17.29.39 N	72.57.22 E	35
	44B	17.27.74 N	72.43.09 E	58
	44C	17.28.27 N	72.16.25 E	96
	44D	17.28.42 N	71.49.11 E	94
	44E	17.25.81 N	71.26.74 E	192
Off Mumbai	45	18.00.04 N	72.47.01 E	33
	46	17.59.52 N	72.21.70 E	51
	47	17.59.98 N	71.50.42 E	96
	48	17.59.44 N	71.14.29 E	89
Along Mumbai	49	18.23.99 N	70.47.40 E	95
	50	18.49.71 N	70.48.11 E	91
	51	19.20.16 N	70.47.35 E	85
	52	20.00.02 N	70.47.65 E	79
	53	20.26.05 N	70.48.03 E	51
	54	20.34.05 N	70.44.69 E	32

Transect	St. No	Latitude	Longitude	Depth (in m)
Porbandar	55	21.34.62 N	69.28.75 E	210
	56	21.24.75 N	69.18.83 E	101
	57	21.09.02 N	69.00.64 E	53
	58	21.05.63 N	68.56.72 E	33
Dwarka	59	22.14.51 N	68.53.48 E	33
	60	22.09.68 N	68.38.24 E	52
	61	22.00.72 N	68.09.74 E	100
	62	21.56.99 N	67.57.69 E	200

3.2. Methodology

Materials for the present study were collected onboard Fishery and Oceanographic Research Vessel (FORV) Sagar Sampada, owned by Department of Ocean Development, Government of India (Plate 1). Two cruises, cruise no 162 and cruise no 192A were conducted along the shelf regions of the west coast of India, for the purpose. The first cruise was from 16-02-1998 to 06-03-1998 and the second from 20-02-2001 to 28-02-2001. Cruise number 162 covered 62 stations from 13 transects and cruise number 192A covered 13 stations from 3 transects.

Hydrographical data for temperature, salinity and dissolved oxygen were collected from each station. Sampling was done for sediment parameters like organic matter and texture and for macrobenthos from all the stations. In order to ensure precision, duplicate sampling was made from each station for macrobenthic study. Due to unfavourable conditions, only one grab sample

PLATE 1

could be collected from certain stations in the second cruise. A total of 147 grab samples (124 from cruise no 162 and 23 from cruise no 192A) were collected for the present work.

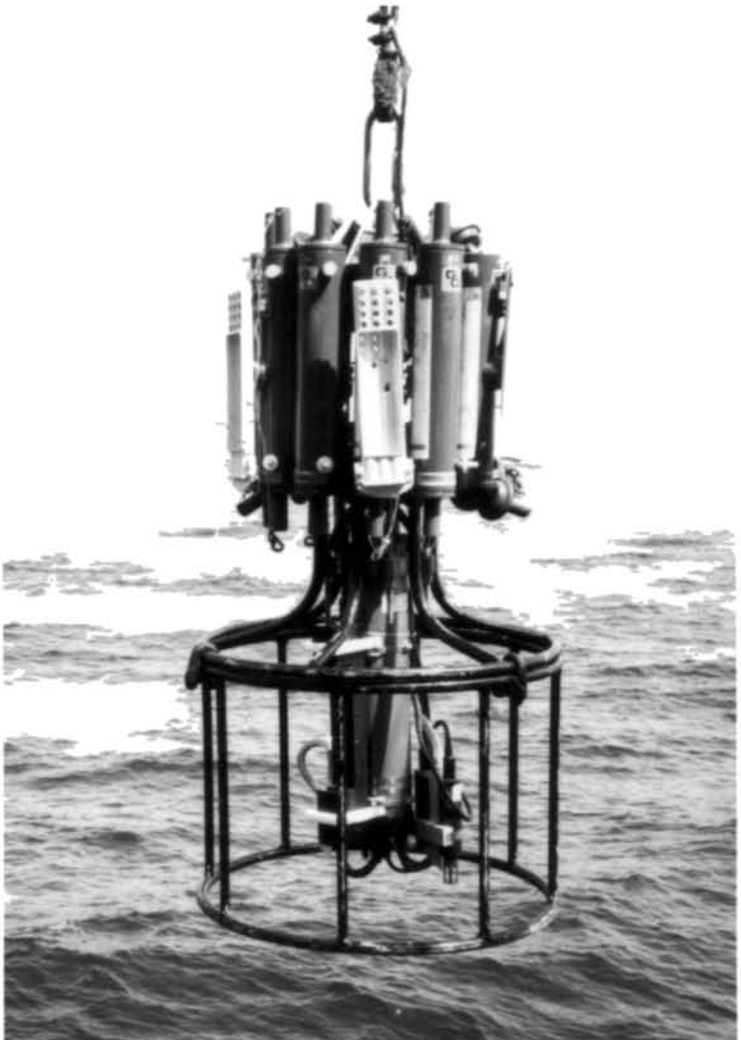
Sea-Bird CTD was used for procuring hydrographical parameters. It consists of the SBE 11 deck unit (for real-time readout using conductive wire) (Plate 2A) and the SBE 9 Underwater unit (Plate 2B).

The Sea-Bird underwater hardware consists of a main pressure housing comprising power supplies, acquisition electronics, telemetry circuitry, and a suite of modular sensors all mounted within a stainless steel guard cage (SBE 9CTD underwater unit). Surface hardware includes the SBE 11 Deck unit and a computer. The surface and underwater hardwares are connected with conductive wire and a slip ring equipped winch.

Conductivity, temperature and pressure sensors are digitized in the underwater unit (fish) at 32 scans per second. Resultant data in Manchester code is transmitted to the Deck unit via single conductor armoured cable. Fish power is supplied by the deck unit through the same cable. Standard sensors are SBE 3-01/F Thermometer, SBE 4-01/0 Conductivity meter, and paroscientific Digiquartz Model 4xK (specify 3000, 6000 or 10,000 psi range). An optional temperature sensor within the pressure transducer permits compensation for most of the ambient temperature related pressure errors. A pump is used to provide rapid and constant speed flushing of the conductivity cell. The dissolved oxygen (DO) sensor, which is a 'bolt on' auxiliary sensor, is also attached with

PLATE 2

2A. CTD - Deck unit



2B. CTD - Under water unit

SBE 9 underwater unit. DO sensor uses a 'Beckman' polarographic element to provide in-situ measurements at depths upto 3,400 meters.

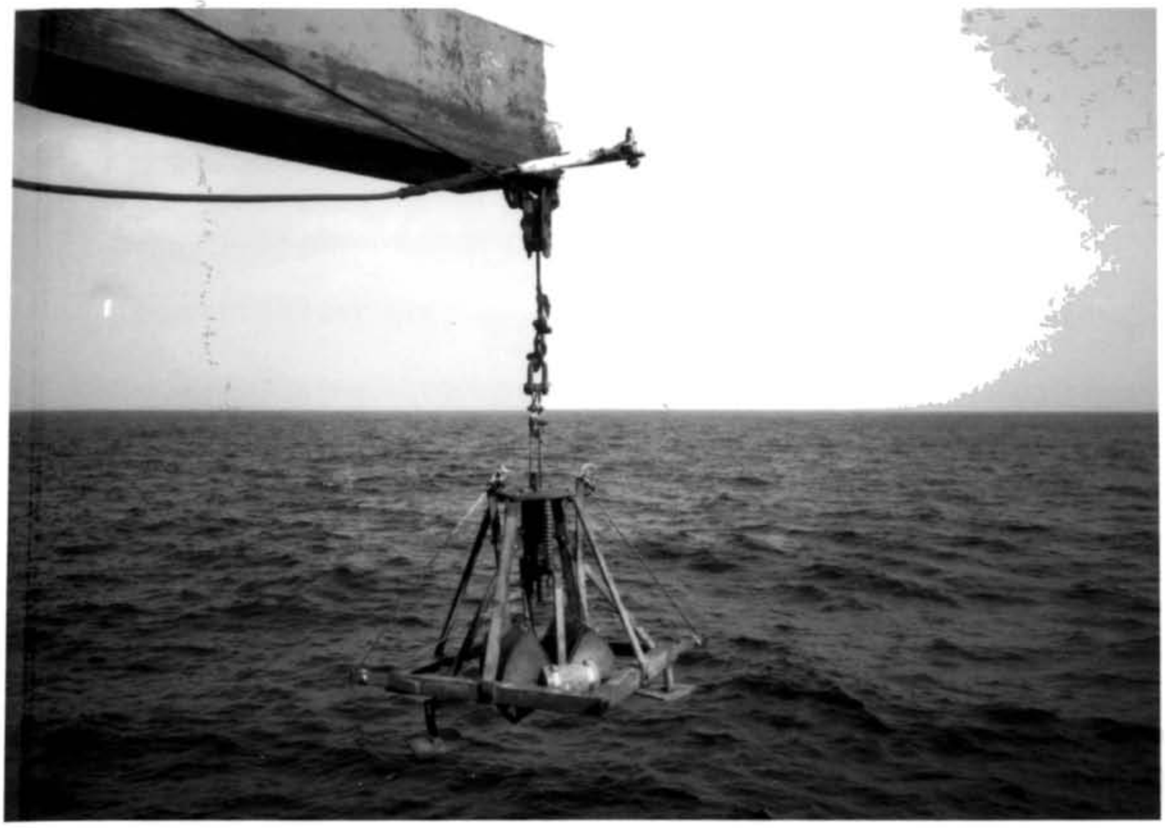
Accuracy:

Temperature	*0.004 ^0C year^{-1} (typical, 0.01 per 6-months guaranteed)*
Conductivity	*0.0003 S m^{-1} month^{-1} (typical, 0.001/month guaranteed)*
Depth	*0.05 % of full scale over the ambient temperature range of 0 to 25 ^0C (typical 0.1 % guaranteed)*
	0.2% with temperature compensation installed
D.O	*0.1 ml L^{-1}*

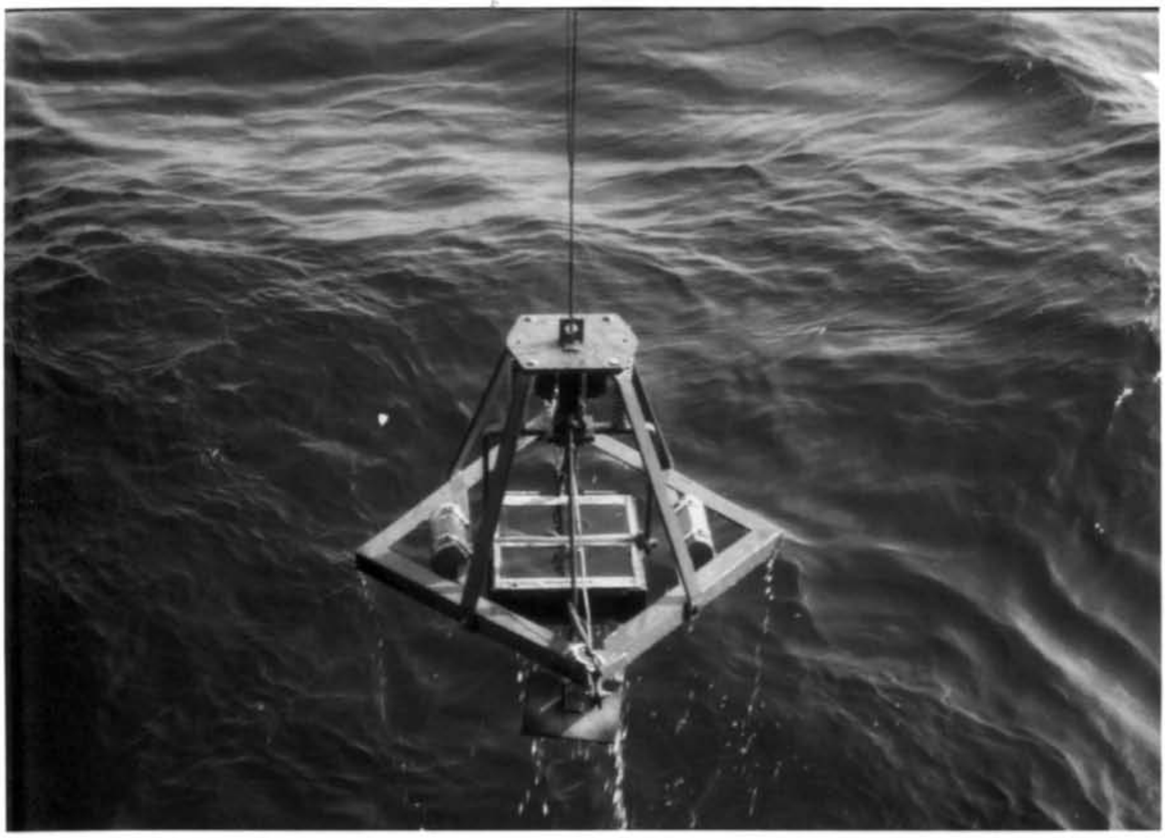
The General Oceanics Model 1015 Rosette Multi-Bottle Array was integrated with the CTD unit, which has a submersible bottle mounting array that enable an operator to remotely actuate a sequence of water sampling bottles. The array is used with Model 1010 Niskin Sampling Bottles in the standard size of 1.2 litre capacity.

The Kahlsico No. 214WA250 modified Smith-McIntyre grab was used for collecting sediment samples (Plate 3A&B). It traps a substantial volume, even of dense sediment, as its open mouth covers a surface area of 0.1m^2. The grab is mounted on a sturdy, weighted, steel frame, suspended from the lowering wire, with springs to force the two-jaw bucket into the ocean bottom, when released, achieving deeper penetration. Two tripping pads, positioned below the square-based frame, on which the bucket is suspended, make contact with the bottom

PLATE 3



3A. Smith-Mc Intyre grab: ready to deploy



3B. Smith-Mc Intyre grab: during hauling up first and are pushed upward to release two latches holding the spring-loaded bucket jaws. A free-fall from about 10 metres (33 ft) above the ocean floor is generally sufficient to allow sampling of even compacted bottoms. After the bucket has been driven into the sediment, raising of the wire exerts tension on cables connected to the end of each bucket-jaw arm. Increasing pull on the wire causes the jaws to tightly shut. A removable frame, fitted with a 2.5 mm (0.062") aperture stainless-steel screen, is attached at the top of each jaw. During the lowering operation sturdy rubber flaps fastened to the screen frames lift to allow water to flow freely through the screens and eliminate shock waves, which might disturb the surface layers of the sediment. The rubber flaps drop to completely cover the stainless-steel screens during the retrieval operation and prevent entrance of water, which might wash out any of the trapped material. A long-handled bar is furnished to provide easy cocking of the strong bucket springs. When released, the springs exert a force of more than 35 kg (75 lbs) to ensure good penetration of the open-mouthed bucket into hard sediments. Safety pull-pins are provided to prevent any premature or accidental release of the cocked assembly.

The steel frame is 75 cm (30") square and 65 cm (26") high complete with 2 removable 9 kg (20 lb) lead weights. The complete grab weighs approximately 87 kg (190 lbs).

During sampling the vessel was maintained stationary and the wire was kept as vertical as possible to ensure vertical set down and lift-up of the grab at right angles to the bottom. It is recommended that the final 5 m of descent be at a rate less than 0.5 m s^{-1} to minimize shock bow wave disturbance (ICES, 1994). The sample showed a distinguishable undisturbed surface layer often including loose flocculent deposits and no sign of sediment leakage, such as from incompletely closed buckets.

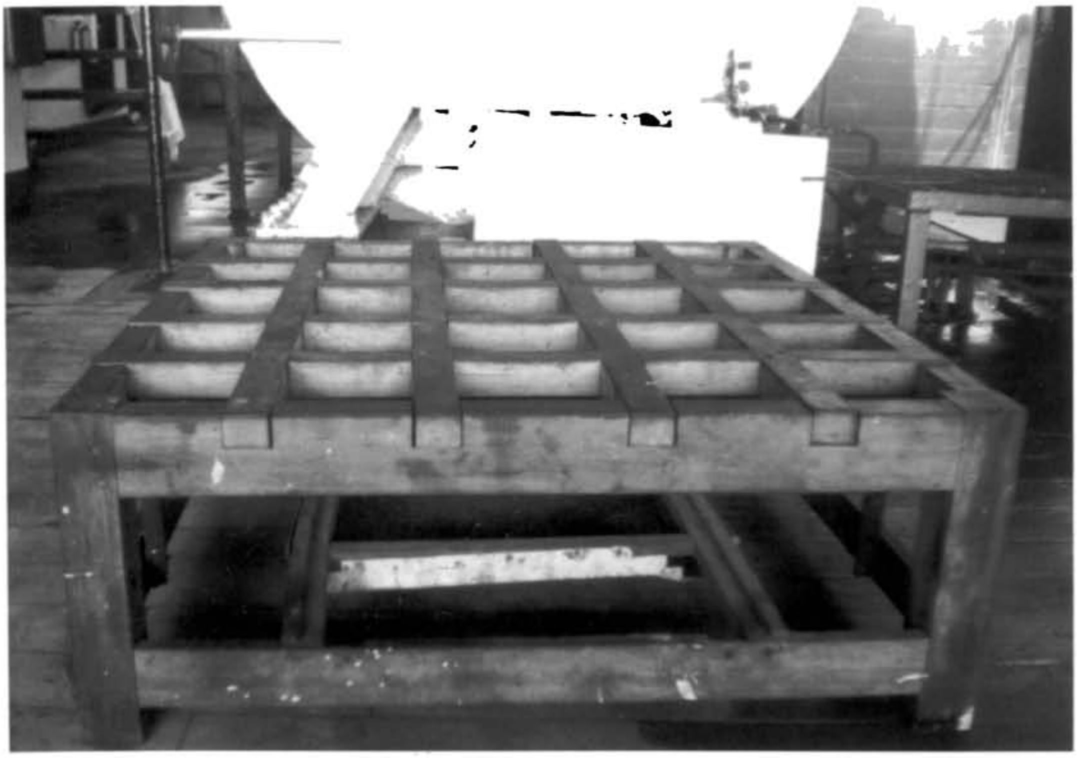
Sub sampling was made for the study of sediment characteristics. Approximately 150 grams of wet sediments from each station were taken for this purpose and dried onboard the ship at 60 ^{0}C in an oven. The dried samples were taken to the laboratory for further analysis.

After sub sampling, all the samples remaining in the grab were sieved through 0.5 mm sieve to separate specimens from the substrate (Plate 4A). For unloading the sediment from the grab and then sieving, a wooden platform was fabricated (Plate 4B). The sediment was unloaded in the conical aluminium portion of the platform, which was attached to the upper frame. The lower frame was modified in such a way so as to slide in and out the sieve in the form of a drawer, where the sediment unloaded will directly be collected in the sieve.

Mainly two types of mesh sizes were used for separating macrobenthos. For quantitative studies, both the mesh size of the sieve and the benthos sampler are of critical importance in determining the size ranges of the animals to be collected. For the present study, 0.5 mm screens were selected for macrobenthos separation. Meiobenthos and microbenthos, not considered for the present study were able to pass through this sieve.

PLATE 4

4A. Sediment Sieving.



4B. Wooden platform for transferring & sieving sediment.

The sieving was accomplished onboard the ship soon after sample collection in order to avoid sample degradation or fixing the sample before further processing. It was done by washing the sample with gentle jets of sea water. Mixing the sediment sample with sea water in a bucket and then sieving was proven successful.

Since immediate processing was not possible, sieved specimens and residual sediments were transferred into plastic bottles and were fixed in 5% neutral formaldehyde. Samples were properly labeled with details like cruise number, date, time, position and depth.

In the laboratory, samples were sieved through 0.5 mm sieve, all the macrobenthic specimens were picked out from the sediment and sorted out. Before sieving, samples were treated with Rose Bengal stain and kept overnight in order to enhance the colour contrast of the organisms.

Identification was carried out upto species level for polychahetes and upto family, order, genus or species level for crustaceans, molluscs and others. In some cases specimens could not be identified upto the species level due to damage or unresolved taxonomic problems. In case of doubtful identification the lowest reliable taxonomic level was given. As per Hallfors and Niemi (1990) uncertainties in identification was indicated by a question mark before the second epithet for a species binomen (e.g. *Capitella ?capitata*) and before the generic name at the genus level (*?Capitella*). If there was only one species within the genus, then that was indicated by "sp." following the genus (e.g. *Capitella sp.*), and in cases, where more than one species was found, it was indicated by "*spp.*" (*Capitella spp.*).

Identification was followed by a count of individuals per species (for polychaetes) and groups (for the rest of the organisms), and the determination of group biomass on a fresh/wet weight basis. Wet weight was converted into dry weight with the conversion factors developed by Parulekar *et al.* (1980). The conversion factors were 0.119 for polychaetes, 0.141 for crustaceans, 0.062 for molluscs and 0.09 for miscellaneous. The number and biomass were extrapolated into 1 m^2. Individual organisms having wet weight more than 0.5 g/0.1 m^{-2} were not multiplied in terms of 10 for extrapolating to 1 m^2, instead, taken as such in order to avoid a biased picture.

Visual observations were made on the nature of sediments and these were confirmed by combined sieving and pipette method in laboratory as described by Carvar (1971). Organic carbon in the sediment was estimated by wet oxidation method (El-Wakeel & Riley, 1957) which was then converted in to organic matter (Wiseman & Bennete, 1960). For this, salt was removed prior to the estimation.

3.3. Statistical Analysis

Statistical analysis helps to simplify massive data for clear interpretation. The data were subjected to analysis such as:

3.3.1. <u>Community structure:</u> PRIMER 5 for windows (version 5.2.8) was used for the estimation of community structure. Diversity indices such as Margalef's index (species richness), Pielou's index (evenness index), Shannon index (species diversity) and Simpson's index (species dominance) were computed separately for polychaetes alone and for all the groups together. The details of the diversity indices used is given below.

Species richness d = (S-1)/Log(N)

Pielou's evenness J' = H'/Log(S)

Shannon H' = -SUM(Pi*Log_2(Pi))

Simpson's Lambda' = SUM(Ni*(Ni-1)/(N*(N-1))

3.3.2. <u>Niche-breadth:</u> Niche breadth is highly valuable as they give insight into the biotic constraints, which are highly important in the dynamic processes of the animals. It remains as a theoretical ideal rather than a practical objective. Lydia Ignatiades (1994) has given an index for niche breadth as.

$$Nbi = Exp \left[\sum_{j=1}^{q} \{(n_{ij}/N_i) \times \log_e (n_{ij}/N_i)\}\right]$$

Where n_{ij} = no: of individuals of the i^{th} group/ species in the i^{th} station. Ni is the total number of individuals of the i^{th} group in all stations. The niche-breadth was calculated separately for polychaetes and also for all the groups

3.3.3. <u>Similarity index:</u> Similarity between stations with respect to polychaete species and all groups combined together were calculated using PRIMER 5 for windows (version 5.2.8). For this Bray-Curtis similarity index with square root transformation was opted. Dendrogram was plotted using the group average cluster mode for grouping stations with respect to polychaete species and also with respect to groups.

3.3.4. <u>Multiple regression predictive models:</u> Abundance can be related to the environmental parameters by means of linear regression. But this relation gives only the prediction efficiency of a single factor at a time. A number of factors are jointly controlling the bioactivities at a point of time or space. Therefore, it is very essential that all the quantification parameters be considered simultaneously to have the best predictive model. Pedersen *et al.* (1995) have given a method for choosing the minimal set of environmental variables that explain the variation in the plankton data. Here, an attempt has been made to choose the best predictive model (Jayalakshmy, 1998) from a set of 2^k predictive models containing individual factor effects and first order interaction effects where 'k' is the number of parameters used as the independent variables. Using explained variability as the criterion for selecting the best model (Snedecor & Cochran, 1967), the benthic productivity in terms of abundance of polychaetes has been determined.

Chapter 4

Hydrography

4.1. Introduction

Among the various biotic and abiotic factors which influence the physico-chemical properties of the environment and in turn the life of marine and brackish water organisms, temperature, salinity and oxygen represent the three most vital factors. Either individually or together they are known to be very important in influencing the biology of the organisms (Kinne, 1963).

With regard to life on earth, temperature is second only to light - the most potent environmental component. Temperature affects living systems in three principal ways: (i) it determines the rate and mode of chemical reactions and hence biological processes, (ii) it affects the state of water, the basic life supporting medium, (iii) it modifies the properties of living matter. In general, metabolic rates of organisms increase with the rise in ambient temperature rise upto the level of tolerance of the species.

Salinity affects functional and structural responses of marine organisms through changes in (i) total osmo-concentration, (ii) relative proportions of solutes, (iii) coefficients of absorption and saturation of dissolved gases and (iv) density and viscosity, possibly through changes in surface tension and absorption of radiation. Salinity may cause indirect effects by modifying the species composition of an ecosystem and thus changing the biotic background of the remaining forms.

Oxygen, dissolved in water, plays a significant physical as well as biochemical role in the life of aquatic organisms. The oxygen-hydrogen sulphide system is responsible for the development of the oxidation-reduction potential (rH). This system begins to operate when the oxygen supply becomes depleted, mostly due to the presence of large amount of organic matter associated with effective vertical separation of the water mass. Under anaerobic condition, bacteria which use the oxygen bound in sulphate for oxidation of their organic nutrients develop, with concomitant formation of gaseous hydrogen sulphide, which dissolves in the sea water. As hydrogen sulphide is a powerful biological poison, normal plant and animal life can no longer be sustained in such regions.

Hydrographical studies in most of the regions of the western continental shelf were limited till the International Indian Ocean Expedition, which was conducted between 1960 and 1965. The west coast of India has a peculiar hydrography because of the occurrence of thermocline, upwelling and monsoon.

There is a marked increase in temperature in the Arabian Sea from north to south in shallow waters while in the deeper areas, there is a decrease in temperature from north to south (Qasim,1982). Wyrtki (1971), while studying the temperature profile of Central Arabian Sea observed four layers viz. (a) a mixed layer, extending from 40 to 100m, (b) upper thermocline, between 70 and 300m with large temperature gradient, (c) lower thermocline, arbitrarily fixed from 300 to 1000m with weaker temperature gradient and (d) the deeper layer with relatively slow change in temperature and stretching from 1000m to the bottom.

In the inshore areas, the water was isothermal in the upper 30-40m, but in deeper parts, the isothermal layer extended from 75 to 125m, below which there was a sharp thermocline between 100 and 200m (Qasim, 1982). Qasim also observed a seasonal effect in temperature even at 100m. Babu *et al.* (1980) observed a weak thermal gradient in the mixed layer in the north, while a relatively stronger one was observed in the south. The top of the thermocline was found at an average depth of 100m except in south, where it shallowed to a depth of 75m. Below the thermocline, thermal gradients were relatively weaker in the southern part (200–300m range) compared to the northern part.

Upwelling is the most important hydrographical phenomenon in the Arabian Sea. It starts at the southern tip of the west coast by the end of May or early June and continues northwards with time (Madhuprathap *et al.*, 2001). Banse (1968) had noted that upwelling in the south west coast of India starts with the onset of south west monsoon. However, no upwelling occurs, north of Goa (Muraleedharan and Prasanna Kumar, 1996).

The monsoon circulation of the Arabian Sea is remarkably strong and steady in comparison to the storms that dominate mid-latitude locations. Two monsoons occur each year: the weaker NE monsoon in winter and the stronger

SW monsoon in summer. As the SW monsoon strengthens in summer, the wind changes in a counterclockwise direction. Two periods of mixed-layer deepening occur, coincident with the beginning of the two monsoons in December and June. The deepest mixed layer of the year is about 100m during the NE monsoon in January because of intense latent heat loss. In contrast, the much stronger SW monsoon produces a mixed layer of only 70m. The spring inter-monsoon restratification isolates much of the winter's deep mixed layer from the atmosphere. This deep isothermal layer persists through summer, after which it is apparently advected away.

Salinity in the surface layers of Arabian Sea decreases towards south (Babu *et al.*, 1980; Qasim, 1982). Below the surface, salinity shows maxima and minima in the north. Babu *et al.* (1980) and Shetye *et al.* (1991) found a layer of maximum salinity in the depth range of 50 to 100m. The core of this salinity maximum is generally southward to a depth of 100m at about 11^{0}N. Another layer of salinity maximum between 200 and 300m is encountered in the north region. The low saline water is usually confined to the shelf region of the south west coast. The low salinity in this region is due to the water that enter from Bay of Bengal as seen from Wyrtki's (1971) map. Darbyshire (1967) also explained low surface salinity in the south as due to Bay of Bengal waters which join the northward flowing Equatorial surface waters in winter.

The Arabian Sea exhibits distinct horizontal salinity gradients in the upper 1000m (Wyrtki, 1971). The reasons attributed by Shenoi *et al.* (1993) for this are, the rate of precipitation minus evaporation varies markedly over the sea, the precipitation varies from <0.2m annual average in the northern and western parts to 2.0m in the southern and eastern parts. According to Gill (1982) the south eastern corner of the sea is in communication with the eastern part of north Indian Ocean, the Bay of Bengal and the eastern equatorial oceans, where the annual precipitation can be as high as 4.0m.

Qasim (1982) found that the oxygen concentration at the surface in the Central Arabian Sea, ranged from 4.2 to 5.2 ml l^{-1} and increased from north to south. At 100m, they ranged from 0.9 to 4.5 ml l^{-1} and there was distinct decrease offshore from the coast. Sen Gupta *et al.* (1980) observed two oxygen minima in the central west coast of India. First minimum appeared at about 125m and extended upto 500m. The magnitude of oxygen concentration at this minimum layer decreased with increasing distance from the shore. The second minimum extended from about 700 to 1400m. The first oxygen minimum occurred due to biodegradation of organic matter and the second minimum was mainly due to the effect of water mass (Sen Gupta *et al.* 1980; Qasim, 1982).

4.2. Results

4.2.1. Temperature

4.2.1.1. **Depth-wise variation:** Depth-wise variation of bottom temperature in each transect is presented in Table 4.1. It showed a great variation with depth in each transect. The range of bottom water temperature was from a minimum of

Table 4.1: Depthwise variation of hydrographical parameters in each transect

Transects	St.no.	Depth (in m)	Temp (in ^0C)	Salinity (in ppt)	DO (in ml L^{-1})
cape	1	30.7	28.35	33.71	3.25
	2	50.6	28.07	33.74	3.14
	3	101	22.27	34.80	0.86
	4	208	13.92	35.06	0.14
tvm	7	30	29.42	34.10	3.28
	6	59	29.18	34.47	3.69
	5	124	17.36	35.05	0.26
klm	8	30.6	29.42	34.01	3.33
	9	50	29.13	34.19	3.08
	10	73.7	28.45	35.22	2.77
	11	101	22.45	35.33	1.45
	12	238	13.55	35.13	0.24
kch	13	33.3	29.29	34.07	3.30
	14	51	29.20	34.57	3.35
	15	101	23.12	35.60	1.50
	16	202	14.40	35.13	0.13
vad	16d	36.2	28.47	34.66	3.30
	16c	52.6	28.27	35.27	3.13
	16b	103.4	25.42	35.62	2.46
	16a	197.3	17.18	35.24	0.20
kzh	17	31	29.24	34.60	3.20
	18	50	29.06	34.48	3.07
	19	102	27.43	37.31	1.70
	20	219	12.90	35.21	0.15
knr	25	31	29.07	34.70	3.17
	24	51.2	29.12	34.83	3.10
	23	67	29.04	35.00	2.98
	22	102	27.73	36.31	2.92
	21	202	14.31	35.21	0.06
mngr	26	31	29.13	35.03	3.70
	27	50.8	29.15	35.10	3.11
	28	101	26.74	35.81	2.06
	29	205	13.75	35.27	0.04
cnpr	29E	33.9	28.48	34.60	3.87
	29D	53.6	28.34	35.56	3.54
	29B	104.3	25.90	35.83	2.26
	29A	193	16.04	35.30	0.11
btkl	34	31	28.16	35.07	3.02
	33	54.4	28.82	35.33	3.42
	32	68	28.80	35.85	2.29
	31	101	28.23	36.04	2.46
	30	206	13.78	35.31	0.04

Table 4.1: Continued.

Transects	St.no.	Depth (in m)	Temp (in ^0C)	Salinity (in ppt)	DO (in ml L^{-1})
goa	35	32	27.50	35.36	2.99
	36	52	27.82	35.40	3.00
	37	72	27.37	35.73	1.66
	38	101	24.84	35.84	1.52
	39	206	14.32	35.42	0.03
rtngr	40	32	26.67	35.42	3.20
	41	51.4	27.23	35.53	3.20
	42	76	27.31	35.71	1.85
	43	100.7	24.55	35.99	0.75
	44	211	15.06	35.49	0.04
dbhl	44A	35.3	26.70	35.68	3.87
	44B	57.1	26.66	35.60	3.72
	44C	95.7	25.69	35.68	2.03
	44D	94.3	26.10	36.00	3.43
	44E	191.6	16.18	35.47	0.00
ofmb	45	33	25.75	35.55	3.39
	46	51	26.49	35.74	3.35
	47	96	26.26	35.96	2.07
	48	89	25.81	36.06	1.98
almb	49	95	25.28	36.22	2.01
	50	91	25.60	36.34	2.62
	51	85.3	24.98	35.84	3.31
	52	79	25.39	35.95	3.35
	53	51	23.68	35.47	3.36
	54	32	23.39	35.40	3.46
prbn	58	33	24.05	36.11	3.59
	57	53	23.59	36.04	3.60
	56	101	24.12	36.46	2.94
	55	210	15.79	35.96	0.02
dwrk	59	33	22.64	36.12	3.56
	60	52	22.72	36.19	3.57
	61	100	23.64	36.44	3.10
	62	200	16.93	36.06	0.03

12.9 ^{0}C (off Kozhikode, 219m) to a maximum of 29.42 ^{0}C (off Thiruvananthapuram, 30m). When bottom water temperature in each transect was taken in to consideration, the decrease in temperature from 30 to 200m depth was less in higher latitudes than in lower latitudes. The maximum difference observed along one transect was off Kozhikode, where it was 16.34 ^{0}C. The minimum difference was noticed off Dwarka, where it was 5.71 ^{0}C. The difference was within the range of 11.3 ^{0}C (off Vadanappilly) to 16.34 ^{0}C (off Kozhikode) in the transects along south-west coast, whereas it was 13.18 ^{0}C to 5.71 ^{0}C (off Dwarka) in north west coast.

4.2.1.2. **Latitudinal variation**: Within each depth line, there was difference in temperature along latitudes (Table 4.2 & Fig. 4.1). The temperature showed a progressive decrease from south to north upto 100m depth. In the 30-50m range, maximum temperature was 29.42 ^{0}C (off Thiruvananthapuram and off Kollam) and minimum was 22.64 ^{0}C (off Dwarka). The average bottom temperature of this depth range was 27.57 ^{0}C. The situation in the 51-75m depth range was also more or less similar. Here the highest temperature was 29.2 ^{0}C, recorded off Kochi and the lowest was 22.72 ^{0}C, recorded off Dwarka. The average value was 27.47 ^{0}C. In 76-100m, the maximum temperature noted was 27.31 ^{0}C (off Ratnagiri) and the lowest was 23.64 ^{0}C (off Dwarka), the average being 25.61 ^{0}C. In 101-150m depth, the central area extending from off Vadanappilly to off Bhatkal showed high values. Here the temperature ranged between 25.42 ^{0}C (off Vadanappilly) and 28.23 ^{0}C (off Bhatkal). The region on either side of this area exhibited comparatively less temperature and the

Table 4.2 : Latitudinal variation of hydrographical parameters in each depth range

4.2a: 30 - 50m depth range

St.no.	Transect	Depth (in m)	Temp (in ^0C)	Salinity (in ppt)	DO (in ml L^{-1})
1	cape	30.7	28.35	33.71	3.25
7	tvm	30.0	29.42	34.10	3.28
8	klm 1	30.6	29.42	34.01	3.33
9	klm 2	50.0	29.13	34.19	3.08
13	kch	33.3	29.29	34.07	3.30
16D	vad	36.2	28.47	34.66	3.30
17	kzh1	31.0	29.24	34.60	3.20
18	kzh2	50.0	29.06	34.48	3.07
25	knr	31.0	29.07	34.70	3.17
26	mngr	31.0	29.13	35.03	3.70
29E	cnpr	33.9	28.48	34.60	3.87
34	btkl	31.0	28.16	35.07	3.02
35	goa	32.0	27.50	35.36	2.99
40	rtngr	32.0	26.67	35.42	3.20
44A	dbhl	35.3	26.40	35.68	3.87
45	ofmb	33.0	25.75	35.55	3.39
54	almb	32.0	23.39	35.40	3.46
58	prbn	33.0	24.05	36.11	3.59
59	dwrk	33.0	22.64	36.12	3.56

Table 4.2b: 51 - 75m depth range

St.no.	Transect	Depth (in m)	Temp (in ^0C)	Salinity (in ppt)	DO (in ml L^{-1})
2	cape	50.6	28.07	33.74	3.14
6	tvm	59.0	29.18	34.47	3.69
10	klm	73.7	28.45	35.22	2.77
14	kch	51.0	29.20	34.57	3.35
16C	vad	52.6	28.27	35.27	3.13
24	knr 1	51.2	29.12	34.83	3.10
23	knr 2	67.0	29.04	35.00	2.98
27	mngr	50.8	29.15	35.10	3.11
29D	cnpr	53.6	28.34	35.56	3.54
33	btkl 1	54.4	28.82	35.33	3.42
32	btkl 2	68.0	28.80	35.85	2.29
36	goa 1	52.0	27.82	35.40	3.00
37	goa 2	72.0	27.37	35.73	1.66
41	rtngr	51.4	27.23	35.53	3.20
44B	dbhl	57.1	26.66	35.60	3.73
46	ofmb	51.0	26.49	35.74	3.35
53	almb	51.0	23.68	35.47	3.36
57	prbn	53.0	23.59	36.04	3.60
60	dwrk	52.0	22.72	36.19	3.57

Table 4.2c: 76 - 100m depth range

St.no.	Transect	Depth (in m)	Temp (in ^0C)	Salinity (in ppt)	DO (in ml L^{-1})
42	rtngr	76.0	27.31	35.71	1.85
44C	dbhl 1	95.7	25.69	35.68	2.30
44D	dbhl 2	94.3	26.10	36.00	3.43
47	ofmb 1	96.0	26.26	35.96	2.07
48	ofmb 2	89.0	25.81	36.06	1.98
49	almb 1	95.0	25.28	36.22	2.01
50	almb 2	91.0	25.60	36.34	2.62
51	almb 3	85.3	24.98	35.84	3.31
52	almb 4	79.0	25.39	35.95	3.35
61	dwrk	100.0	23.64	36.44	3.10

Table 4.2d: 101 - 150m depth range

St.no.	Transect	Depth (in m)	Temp (in ^0C)	Salinity (in ppt)	DO (in ml L^{-1})
3	cape	101.0	22.27	34.80	0.86
5	tvm	124.0	17.36	35.05	0.26
11	klm	101.0	22.45	35.33	1.45
15	kch	101.0	23.12	35.60	1.50
16B	vad	103.4	25.42	35.62	2.46
19	kzh	102.0	27.43	37.31	1.70
22	knr	102.0	27.73	36.31	2.92
28	mngr	101.0	26.74	35.81	2.06
29E	cnpr	104.3	25.90	35.83	2.26
31	btkl	101.0	28.23	36.04	2.46
38	goa	101.0	24.84	35.84	1.52
43	rtngr	100.7	24.55	35.99	0.75
56	prbn	101.0	24.12	36.46	2.94

Table 4.2e: >150m depth

St.no.	Transect	Depth (in m)	Temp (in ^0C)	Salinity (in ppt)	DO (in ml L^{-1})
4	cape	208.0	13.92	35.06	0.14
12	klm	238.0	13.55	35.13	0.24
16	kch	202.0	14.40	35.13	0.13
16A	vad	197.3	17.18	35.24	0.20
20	kzh	219.0	12.90	35.21	0.15
21	knr	202.0	14.31	35.21	0.06
29	mngr	205.0	13.75	35.27	0.04
29A	cnpr	193.0	16.04	35.30	0.11
30	btkl	206.0	13.78	35.31	0.04
39	goa	206.0	14.32	35.42	0.03
44	rtngr	211.0	15.06	35.49	0.04
44E	dbhl	191.6	16.18	35.47	0.00048
55	prbn	210.0	15.79	35.96	0.02
62	dwrk	200.0	16.93	36.06	0.03

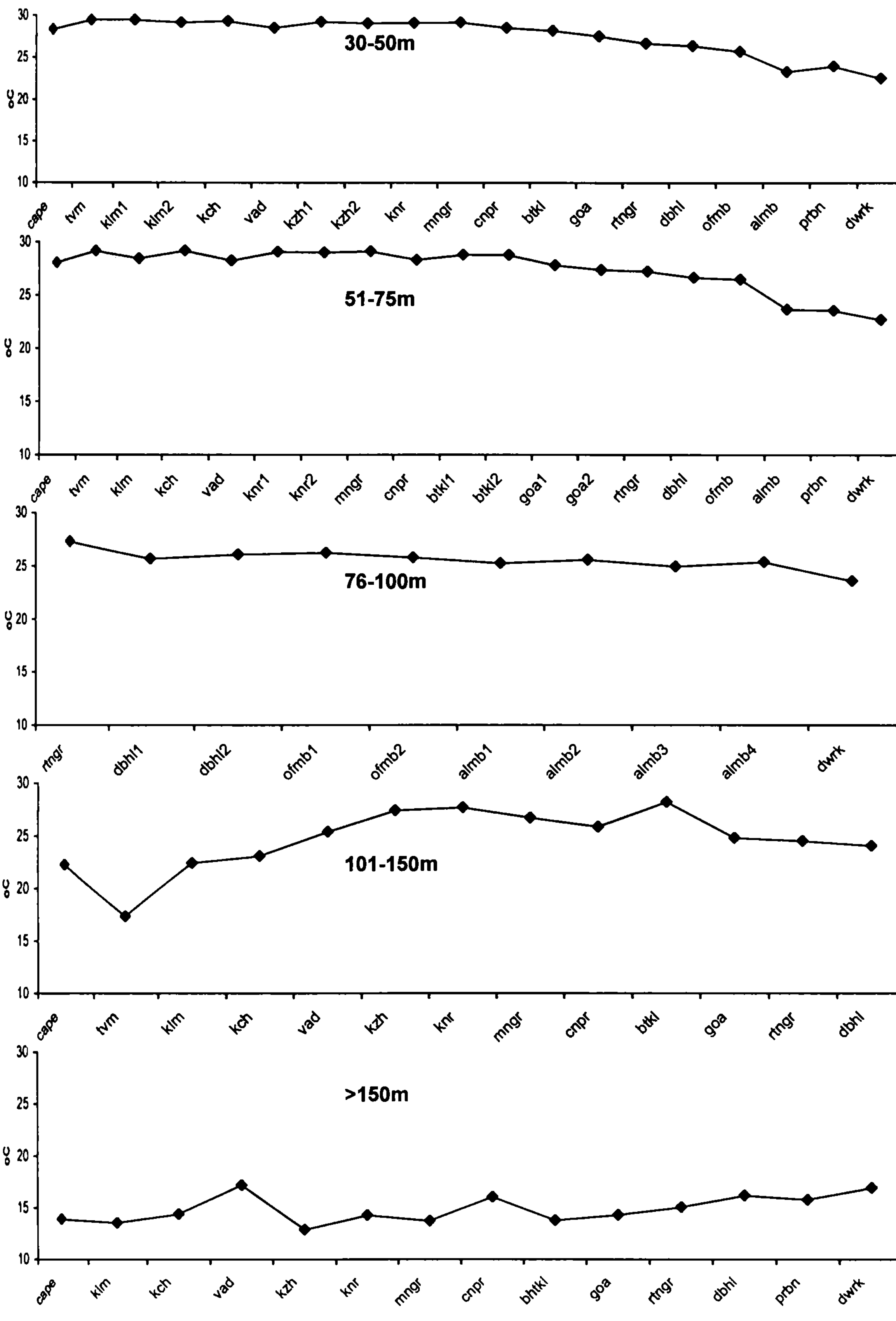


Fig. 4.1. Variation of bottom temperature in different depth ranges.

minimum values were noted in south-west region. The average temperature in this depth range was 24.63 ^{0}C. Beyond 150m, it showed a decreasing trend from south to north except off Vadanappilly and off Coondapore. The mean temperature in this line was 14.87 ^{0}C.

4.2.2. Salinity

4.2.2.1. **Depth-wise variation:** Depth-wise variation of bottom salinity in each transect is presented in Table 4.1. Salinity varied from a minimum of 33.71 ppt (off Cape Comorin, 31m) to a maximum of 37.31 ppt (off Kozhikode, 102m). Salinity showed only slight fluctuation with depth. In each transect, there was an increase in salinity towards deeper stations by a magnitude of 0.38 – 2.8 ppt. Maximum difference in salinity within a transect was 2.83 ppt noticed off Kozhikode, where 100m station showed abnormally high salinity of 37.31 ppt. The minimum difference in salinity observed was 0.38 ppt, off Dwarka. The difference was within the range of 0.78 ppt (off Mangalore) and 2.83 ppt (off Kozhikode) in south-west coast, whereas it was 0.38 ppt (off Dwarka) and 0.57 ppt (off Ratnagiri) in north west coast.

4.2.2.2. **Latitudinal variation:** Salinity variation in different latitudes and in different depth ranges was not apparently high (Table 4.2 & Fig. 4.2). A progressive change in salinity was observed from south to north along the shelf. In the 30-50m depth, salinity ranged between 33.71 (off Cape Comorin) and 36.12 ppt (off Dwarka) and the average was 34.89 ppt. In 51-75m, it ranged between 33.74 (off Cape Comorin) and 36.19 ppt (off Dwarka) with an average of

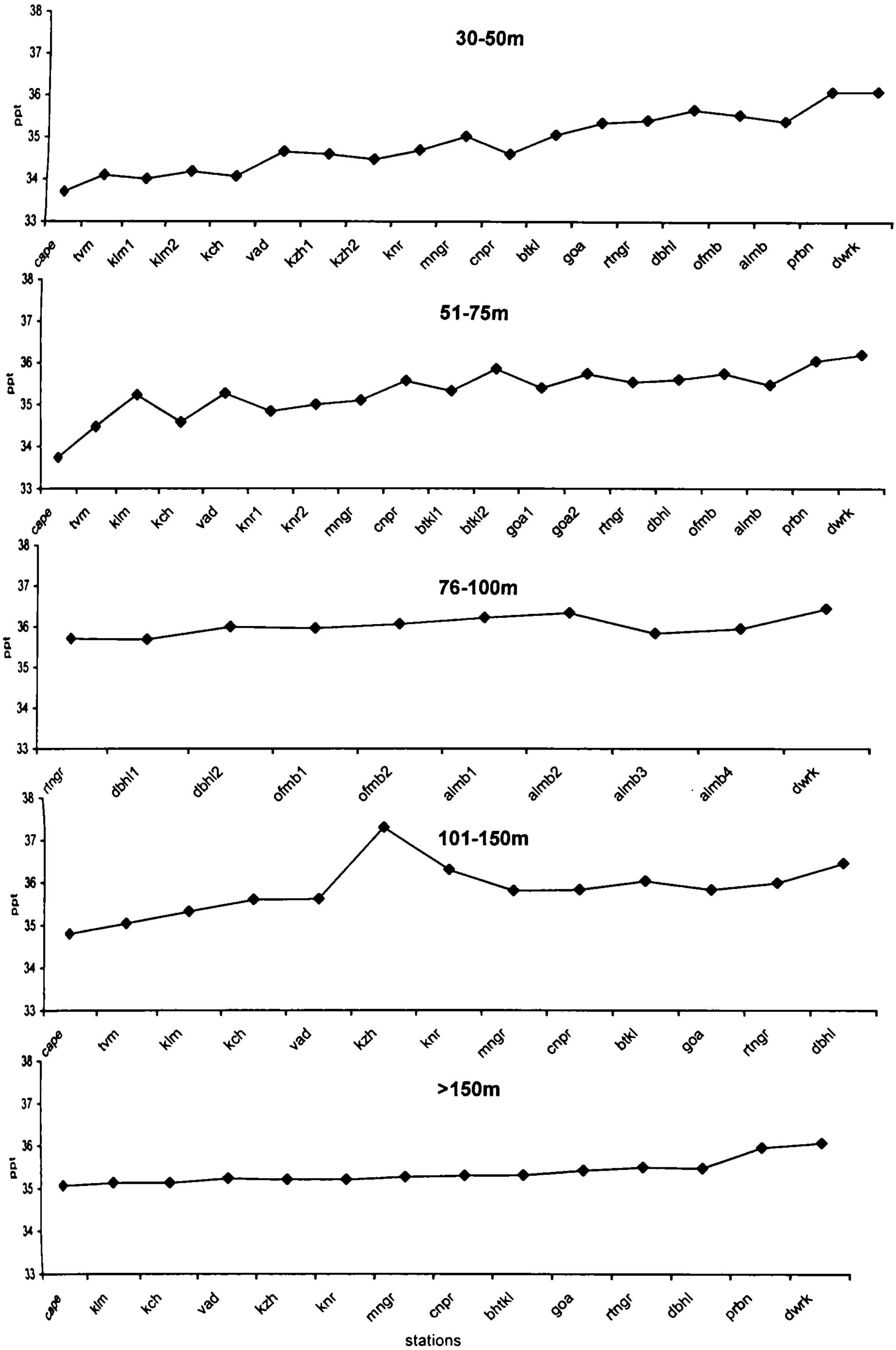


Fig 4.2 Variation of bottom salinity in different depth ranges.

35.30 ppt. In the 76-100m, it varied from 35.71 (off Ratnagiri) to 36.44 ppt (off Dwarka) with an average of 36.02 ppt. In the 101-150m, salinity varied between 34.80 (off Cape Comorin) and 37.31 $^{o}/_{oo}$ (off Kozhikode), the average being 35.85 ppt. In the depth beyond 150m, the range was between 35.06 (Off Cape Comorin) and 36.06 ppt (off Dwarka).

4.2.3. Dissolved Oxygen

4.2.3.1. **Depth wise variation:** Depth-wise variation of dissolved oxygen in each transect is presented in Table 4.1. There was a sharp decrease in dissolved oxygen with increase in depth. Along the shelf, it ranged between 0.0005 (off Dabhol, 191m) and 3.87 ml l^{-1} (off Coondapore, 30m). The percentage of decrease in oxygen from 30m to 200m ranged between 92.1 (Off Thiruvananthapuram) and 99.99 (off Dabhol). In general, the percentage of decrease increased from south to north. Near anoxic values were observed in the shelf edge of north west coast.

4.2.3.2. **Latitudinal variation:** There was not much significant difference in dissolved oxygen content among latitudes within each depth range (Table 4.2 & Fig. 4.3). In 30-50m, it varied from 2.99 (off Goa) to 3.87 ml l^{-1} (off Coondapore and off Dabhol) with an average of 3.35 ml l^{-1}. In the 51-75m, it ranged between 1.66 (off Goa, 72m) and 3.6 ml l^{-1} (off Thiruvananthapuram, 59m) and the average was 3.16 ml l^{-1}. In 76-100m, the range was between 1.85 (off Ratnagiri) and 3.35 ml l^{-1} (Along Mumbai, 79m) and the average was 2.6 ml l^{-1}. In the depth between 101-150m, the dissolved oxygen varied between 0.26 (off

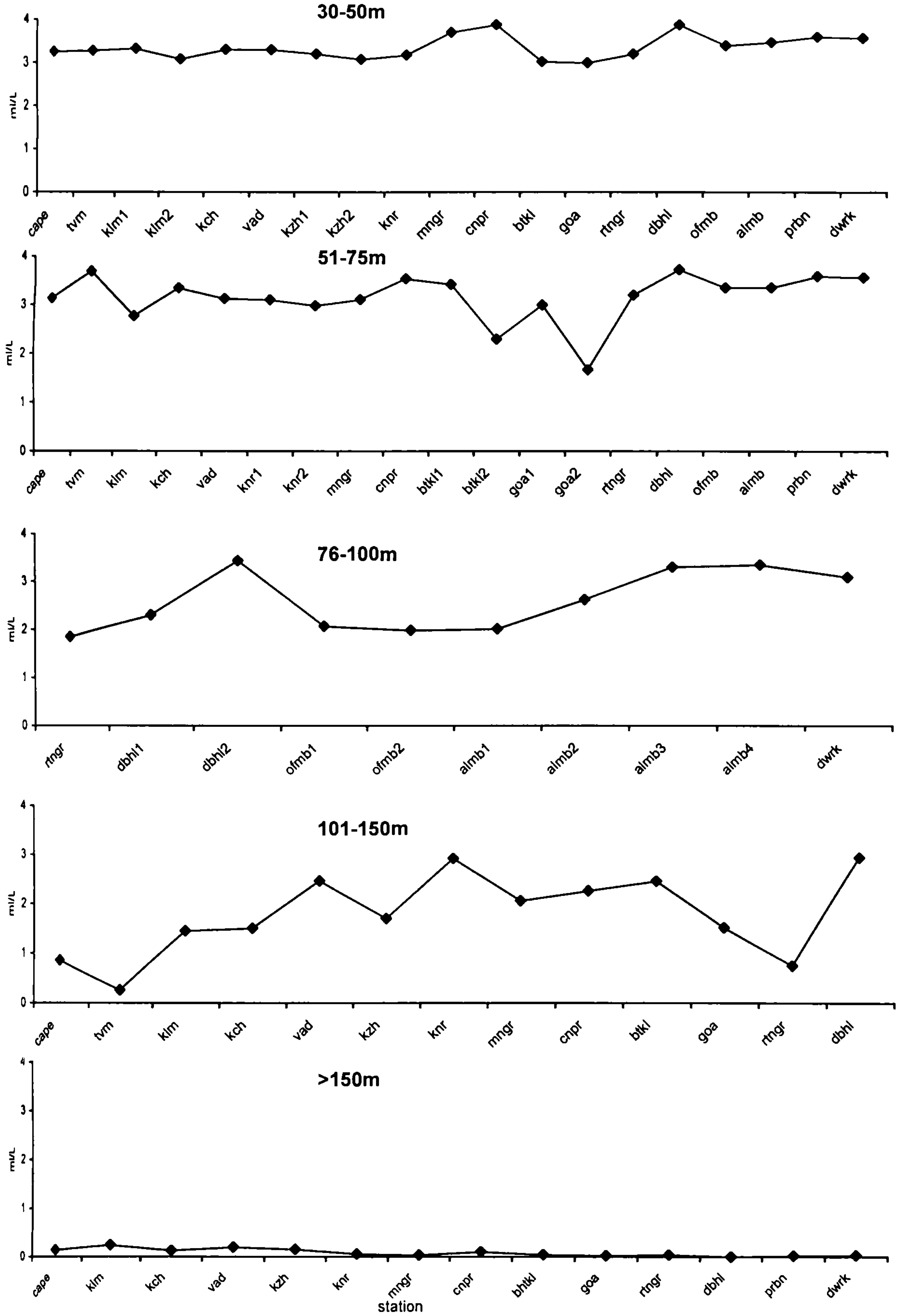


Fig. 4.3. Variation of bottom dissolved oxygen in different depth ranges.

Thiruvananthapuram) and 2.94 ml l^{-1} with an average of 1.78 ml l^{-1}. In the depth >150m, it ranged between 0.00048 (off Dabhol) and 0.24 ml l^{-1} (off Kollam) and the average was 0.09 ml l^{-1}.

4.3. Discussion

Among the hydrographical parameters, salinity showed least variation, latitudinal as well as depth-wise. Though the variation was small, a general increase in salinity from nearshore to shelf edge was observed. Moreover, it showed a progressive increase from south to north also. During the north east monsoon season, low saline water from Bay of Bengal joins the northward flowing equatorial Indian Ocean water and flows as a northward surface current along the west coast of India (Pankajakshan and Ramaraju, 1987). The lower salinity of southern region can be due to this incursion of low saline waters from Bay of Bengal to the south west coast (Darbyshire, 1967; Wyrtki, 1971). Hareesh Kumar and Mathew (1997) noticed that the maximum northward extension of this low saline water is upto about 12^0N in January but could be traced upto 17^0N in February-March. The higher salinity noticed in the northwest coast can be due to the effect of Persian water (Wyrtki, 1971). Varma *et al.* (1980) studied the thermohaline structure in the Northern Arabian Sea. They found that Persian water was present at about 300m. The low saline condition in the nearshore region can be attributed to the river discharge.

In the present study, there was a decrease in bottom temperature with depth. Temperature also showed latitudinal variation. Upto 100m, it showed a decrease from south to north and below that depth level it showed a reversal. Qasim (1982) has also noticed such a decrease of temperature from south to north in the surface waters while in the deeper waters, an increase in temperature was noticed from south to north. The temperature of sea water upto 100m is influenced by the seasons (Qasim, *loc. cit.*). The present study was conducted during winter season. The winter is more pronounced in the northern region of Arabian Sea than southern region as it is away from the equator (Darbyshire, 1967). This must be the reason for the decrease in temperature from south to north upto 100m depth. Beyond 100m depth, the temperature is influenced by water masses, especially Persian Gulf and Arabian Sea water masses. The Persian Gulf water mass is warmer and more saline which reaches the northern region and have higher temperature than the southern region in this depth range (Wyrtki, 1971; Sarupria *et al.,* 1988). Arabian Sea water mass is less warmer and influences the central region. This can be the reason for the increase in temperature from south to north. Recently, the study on the Indian Ocean circulation (Benny & Mizuno, 2000) showed a warm water advection during February from equator towards Dwarka region. Moreover, there were strong thermal gradients in the south compared to north. Babu *et al.* (1980) noticed such difference in thermal gradients and it is ascribed to the fact that thermocline gradually spreads towards north with its thickness varying from <100m in south to >200m in north.

Like temperature, oxygen also showed a significant decrease with depth. However, oxygen did not show any pronounced latitudinal changes in the depths upto 150m from the shore. But beyond 150m, northern stations showed considerable depletion of oxygen. This depletion of oxygen in the shelf edge of northern latitudes may be associated with the oxygen minimum layer described by Sen Gupta *et al.* (1976, 1980) and Qasim (1982). They have cited limited mixing, high organic production, sinking and decomposition of large amounts of organic matter as the reasons for this oxygen depletion.

Chapter 5

Sediment characteristics

5.1. Introduction

Sediments play a vital role in the benthic ecology of aquatic ecosystems. Sediment parameters viz. texture and availability of organic matter are the dominant factors controlling the distribution of macrobenthos.

The topography of the Indian western continental shelf is even with very gentle gradient to about 60m depth from the coast. The outer shelf (beyond 60m to the shelf edge), which ranges from 90 to 120m depth has uneven topography and is sometimes rugged, with local undulations of more than 5m (Nair and Hashimi, 1986). The shelf is floored with three different types of sediments (Hashimi, 1981). The first of these is the nearshore sand zone, extending from the shore to a water depth of 5-10m. Succeeding the sand is the mud (silt and clay) which extend to a depth of 50-60m (inner shelf). The shelf beyond 50-60m (outer shelf) is covered by coarse calcareous sand. These three different types of sediments have different origins. The first two are formed as a result of geological processes of weathering and erosion of the coastal rocks. The calcareous sands of the outer shelf are of late Pleistocene origin, when the sea level stood 60-90m below the present level. The radio-carbon ages of the calcareous sediments are between 9,000 and 11,000 years before the present, and therefore, the sediments are termed relict (Nair, 1974; Nair *et al.*, 1979).

Many studies have been conducted to know the substrata of the western continental shelf of India. Most of the works were regional including the estuaries, and only very few studies were made to obtain a synoptic view of the entire shelf. Parulekar *et al.* (1976) found, the substrata off Mumbai upto 60km to be of a uniformly muddy nature. Ansari *et al.* (1977) studied the sediment nature in nearshore regions of five bays viz. Vengurla, Goa, Karwar, Malpe and Mangalore, and noticed that the sediment characteristics varied from region to region. Harkantra *et al.* (1980) noticed 7 major types of substrata along the western continental shelf of India upto a depth of 75m. Hashimi and Nair (1981) observed clayey silt in the inner shelf and sand in the outer shelf off Karnataka. Hashimi (1981) made a comparative study of the western and eastern continental shelves around Cape Comorin upto a depth of 50m and found the predominance of sand from Kollam to south.

Vizakat *et al.* (1991) noticed relatively more muddy fractions in the near shore area than the off shore area in the Konkan region. Purnachandra Rao (1991) studied the sediment nature of continental shelf and slope off Saurashtra and found that the sediment of inner continental shelf and slope were silty clay or clayey silt, while the outer shelf sediment was sand. Pandarinath and Narayana (1991b) observed clayey silt and silty clay nature of the sediment in the inner shelf region off Gangolli. Ansari *et al.* (1994) studied the sediment texture of the Goa harbour which comprised of fine to very fine grains with varying proportion of sand, silt and clay. Harkantra and Parulekar (1994) noticed mostly silty sand, sandy silt and sand silt clay in Rajapur Bay along three transects across the depth contours of 5, 10 and 15m. Venkatesh Prabhu *et al.* (1997) studied the textural characteristics of near shore sediments off Honnavar and the sediments found were of clayey silt and silty clay. Sriram *et al.* (1998) studied the inner shelf sediments off Mangalore and noticed the silty nature of sediment upto 30m and beyond that fine sand was observed. Nair *et al.* (1998) studied the sediment nature of the Vashishti estuary, Maharashtra and found sandy or silty sand in most of the area.

Other significant studies in this respect were made by Stewart *et al.* (1965), Nair (1971), Veerayya and Murthy (1974), Nair (1975), Nair *et al.* (1978), Hashimi *et al.* (1978a,b), Shankaranarayana Guptha (1979), Nair *et al.* (1982), Sajan *et al.* (1992), Seetharamaiah and Swamy (1994), Narayana (1996).

Organic content of bottom sediments may be a more causal factor than sediment grain size in determining infaunal distribution because it is a dominant source of food for deposit feeders and indirectly for suspension feeders. Organic matter may influence benthos through the availability of food supply and the consumption of organic-matter-bound sediment and subsequent generation of faecal pellets will alter the mechanical composition of sediments. So far many works have been carried out to estimate the organic content of bottom deposits of marine as well as backwaters of west coast of India.

Parulekar *et al.* (1976) studied the organic matter off Mumbai, where the sediment was high in clay and silt and had higher organic matter than that of the sand. Harkantra *et al.* (1980) studied the percentage of organic carbon along the shelf of west coast of India upto a depth of 75m. They also observed high values for organic carbon in the fine substrata of clay and silt, whereas sandy substrata had a low organic carbon content. Parulekar *et al.* (1980) studied the organic carbon in the bottom deposits of Goa estuary and noticed higher values in the lower reaches than upper reaches. Harkantra and Parulekar (1981) noticed high organic carbon content in muddy bottom than the sandy substrata in the coastal zones of Goa.

In the Konkan region, organic carbon values ranged from 0.1 to 2.65% and were mostly related to substratum characteristics (Vizakat *et al.*, 1991). Pandarinath and Narayana (1991a) noticed the abundance of organic matter in the inner-shelf sediments off Gangolli. Here, the organic carbon ranged from 3.45 – 8.45% (Pandarinath & Narayana, 1991b), which was much higher than the reported value in the east and west coasts of India and also higher than the world average reported. Narayana and Venkatesh Prabhu *et al.* (1993) found comparatively high organic carbon in the sediments of 30-50m and 100-200m than 50-100m depth range off Honavar. In the Goa region Ansari *et al.* (1994) noted the organic carbon, ranging from 0.82 to 3.12%. In the Rajapur Bay, Harkantra and Parulekar (1994) reported organic matter within the range of 1.65 to 2.43%.

Other important works include that of Subba Rao (1963), Setty and Rao (1972), Rao and Rao (1975), Paropakari (1979a,b), Paropakari *et al.* (1987), Mohan and Rajamanickam (1994), Reddy (1995), Sunil Kumar (1996), Rajesh Reghunath and Sreedhara Murthy (1996) and Seetharamaiah and Swamy (1997).

These studies substantiated a general fact that finer sediments retained more organic matter than coarser one.

5.2. Results

5.2.1. Texture

Visual observation of the sediment nature was made during the collection. The colour of sediments was also noted. It was slightly greenish, greenish black, black or cream.

5.2.1.1. **Depth-wise variation in each transect:** The depth-wise variation of the texture in each transect is presented in Table 5.1.

Off Cape Comorin, sediment was slightly greenish in colour and was sandy in nature. It was coarser with considerably less percentage of mud. Coarseness decreased slightly towards 200m depth. A greater amount of

Table 5.1: Depthwise variation of sediment characters in each transect.

Transects	St.no.	Depth (in m)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Nomenclature
cape	1	30.7	2.18	98.63	1.05	0.33	sand
	2	50.6	0.44	99.00	0.86	0.14	sand
	3	101	1.74	96.37	2.97	0.66	sand
	4	208	2.73	86.09	11.18	2.73	sand
tvm	7	30	0.99	99.69	0.11	0.20	sand
	6	59	3.96	96.74	1.97	1.21	sand
	5	124	1.50	98.46	0.81	0.76	sand
klm	8	30.6	2.85	9.53	72.56	18.55	clayey silt
	9	50	1.19	96.89	1.83	1.28	sand
	10	73.7	1.31	97.53	1.64	0.83	sand
	11	101	2.73	85.80	11.05	3.05	sand
	12	238	2.26	92.85	5.61	1.54	sand
kch	13	33.3	1.35	95.47	1.69	1.84	sand
	14	51	5.46	82.36	12.63	5.02	sand
	15	101	3.44	68.69	25.34	5.97	silty sand
	16	202	2.57	84.45	12.16	3.39	sand
vad	16D	36.2	1.03	85.18	10.23	4.59	sand
	16C	52.6	1.78	72.23	20.66	7.12	silty sand
	16B	103.4	1.35	71.71	20.47	7.83	silty sand
	16A	197.3	1.62	71.99	21.20	6.81	silty sand
kzh	17	31	5.54	0.53	58.11	41.37	clayey silt
	18	50	2.53	79.39	15.16	5.45	sand
	19	102	3.13	87.22	9.12	3.66	sand
	20	219	4.95	88.94	7.45	3.62	sand
knr	25	31	6.71	0.40	47.69	51.91	silty clay
	24	51.2	4.95	50.13	36.47	13.40	silty sand
	23	67	3.64	84.64	10.12	5.25	silty sand
	22	102	4.00	53.92	38.76	7.32	silty sand
	21	202	4.11	60.46	31.27	8.26	silty sand
mngr	26	31	4.99	0.29	47.13	52.59	silty clay
	27	50.8	3.40	75.76	18.31	6.00	sand
	28	101	3.36	73.73	21.86	4.41	silty sand
	29	205	4.59	80.52	12.09	7.40	sand
cnpr	29E	33.9	4.27	1.55	69.99	28.46	clayey silt
	29D	53.6	0.47	97.17	2.44	0.39	sand
	29B	104.3	0.87	93.61	5.06	1.32	sand
	29A	193	1.58	83.39	11.56	5.06	sand
btkl	34	31	4.95	12.07	63.77	24.16	clayey silt
	33	54.4	2.29	94.67	4.21	1.28	sand
	32	68	1.74	97.47	1.58	0.95	sand
	31	101	4.04	29.20	65.69	5.11	sandy silt
	30	206	4.87	0.74	72.91	26.35	clayey silt

Table 5.1. continued.

Transects	St.no.	Depth (in m)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Nomenclature
⇩	⇩	⇩					
goa	35	32	5.28	0.72	48.73	50.56	silty clay
	36	52	4.43	22.25	45.66	32.10	sand silt clay
	37	72	4.99	65.41	27.61	6.98	silty sand
	38	101	5.06	80.39	16.99	2.62	sand
	39	206	2.91	85.62	10.55	3.83	sand
rtngr	40	32	3.24	0.38	44.69	53.35	slty clay
	41	51.4	4.62	1.03	53.90	45.07	clayey silt
	42	76	2.97	74.26	23.23	2.51	silty sand
	43	100.7	4.15	91.11	6.91	1.98	sand
	44	211	6.23	28.55	56.09	15.36	sandy silt
dbhl	44A	35.3	3.76	0.86	38.02	61.12	silty clay
	44B	57.1	4.87	0.54	44.01	55.45	silty clay
	44C	95.7	4.75	53.32	33.91	12.76	silty sand
	44D	94.3	0.67	95.15	3.41	1.44	sand
	44E	191.6	0.79	97.50	1.70	0.81	sand
ofmb	45	33	2.67	1.09	35.23	63.68	silty clay
	46	51	2.49	13.83	49.58	36.59	clayey silt
	47	96	3.03	86.79	9.47	3.74	sand
	48	89	2.49	78.50	14.62	6.88	sand
almb	49	95	0.87	99.60	0.29	0.11	sand
	50	91	0.91	99.74	0.19	0.08	sand
	51	85.3	1.31	88.16	6.91	3.41	sand
	52	79	1.78	4.87	63.01	32.16	clayey silt
	53	51	0.65	0.80	45.18	53.88	silty clay
	54	32	0.48	4.03	53.49	42.47	clayey silt
prbn	58	33	0.24	0.17	51.62	48.21	clayey silt
	57	53	1.25	1.42	47.59	50.99	silty clay
	56	101	2.08	8.58	90.58	0.84	silt
	55	210	2.79	1.46	47.70	50.85	silty clay
dwrk	59	33	0.59	80.08	8.30	11.61	sand
	60	52	0.48	0.12	45.29	54.59	silty clay
	61	100	1.90	79.53	13.77	6.17	sand
	62	200	3.48	2.29	54.64	43.08	clayey silt

molluscan shell fragments were also included in the sediment. Sand percentage varied from 86.09 (200m) to 99.00 (50m), silt percentage ranged from 0.86 (50m) to 11.18 (200m) and clay percentage varied between 0.14 (50m) and 2.73 (200m).

Off Thiruvananthapuram, sediment was found to be slightly greenish in colour and was composed of very coarse sand. Sand with pebbles was observed at 124m depth. Sand percentage varied between 96.74 (59m) and 99.69 (30m), silt between 0.11 (30m) and 1.97 (59m) and clay between 0.2 (30m) and 1.21 (59m).

Off Kollam, sediment colour was black in 30m and slightly greenish in other depths. Substrata were clayey silt in 30m and sandy beyond. But sand seemed to be fine unlike off Cape Comorin and off Thiruvananthapuram. Sand percentage varied between 9.53 (30m) and 97.53 (73m), silt ranged from 1.64 (73m) to 72.56 (30m) and clay varied between 0.83 (73m) and 18.55 (30m).

Off Kochi, colour of sediment was slightly greenish throughout the depths. In general, the sediment was fine sand and the percentage of silt and clay increased from 30 to 200m depth. It was silty sand in 100m depth. The sand percentage varied between 68.69 (100m) and 95.47 (30m), silt percentage varied between 1.69 (30m) and 25.34 (100m) and clay percentage varied between 1.84 (30m) and 5.97 (100m).

Off Vadanappilly, colour of the sediment was slightly greenish. It was fine sand in 30m and sand was replaced by more silt and clay beyond that depth. The sand percentage ranged from 71.71 (100m) to 85.45 (30m), silt varied between 123 (30m) and 20.66 (52m) and clay ranged from 4.59 (30m) to 7.83 (100m).

Off Kozhikode, sediment colour was slightly greenish. Texture was clayey silt in 30m. Towards deeper stations, it showed a progressive increase in percentage of sand and decrease in percentage of clay. The abundance of shell fragments was noticed in 50m depth. Sand varied from 0.53 (30m) to 88.94 (219m), silt varied from 7.45 (219m) to 58.11 (31m) and clay percentage varied from 3.62 (219m) to 41.37 (31m).

Off Kannur, colour of the sediment was slightly greenish. Sediment texture was silty clay in 30m and clay was replaced by sand in other depths. It was silty sand in these depths. The sand percentage varied from 0.4 (31m) to 84.64 (67m), silt varied from 10.12 (67m) to 47.67 (31m) and clay varied from 5.25 (67m) to 51.59 (31m).

The sediment colour off Mangalore was slightly greenish. Here also, like the previous transect, silty clay was observed in 30m and sand showed its dominance from 50m downwards. Sand percentage varied from 0.29 (31m) to 80.52 (205m), silt from 12.09 (205m) to 47.13 (31m) and clay varied between 7.4 (205m) to 52.59 (31m).

Off Coondapore, colour of the sediment was slightly greenish. The substrata was clayey silt in 30m and mud was replaced by more of sand towards the deep. Sand percentage ranged between 1.55 (33.9m) and 97.17 (53.6m), silt ranged between 2.44 (53.6m) and 69.99 (33.9m) and clay ranged between 0.39 (53.6m) and 28.46 (33.9m).

Off Bhatkal, colour of sediment was slightly greenish. The sediment texture was clayey silt in 30m depth, and sand became dominant upto 68m depth like that of previous transects, but sand percentage decreased from 101m to 200m and silt became dominant again. Sand was coarser with shell pieces in 53.4m depth. The sand percentage varied from 0.74 (206m) to 97.47 (68m), silt varied from 1.58 (68m) to 65.69 (101m) and clay ranged from 0.95 (68m) to 26.35 (206m).

Off Goa, colour of the sediment was slightly greenish. Silty clay was observed in 30m depth and beyond, it was noticed that sand percentage progressively increased. At the same time, silt and clay percentage gradually decreased. Occurrence of sand silt clay was noticed in 52m depth. The sand percentage varied from 0.72 (32m) to 85.62 (206m), silt from 10.55 (206m) to 48.73 (32m) and clay from 3.83 (206m) to 50.56 (32m).

Off Ratnagiri, colour of the sediment was slightly greenish. The substrata were same as that of Goa. Sediment texture was silty clay in 30m and silt and clay percentage gradually decreased and sand increased upto 100 and then again silt was found to be dominant in 211m. The sand percentage ranged between 0.38 (32m) and 91.11 (100.7m), silt between 6.91 (100.7m) and 56.09 (211m) and clay between 1.98 (100.7m) and 53.35 (32m).

Off Dabhol, colour of the sediment was slightly greenish. Texture was silty clay upto 57m; clay was replaced by sand in 95m and then silt was also replaced by more sand beyond that depth. Sand percentage varied from 0.54 (57.1m) to 97.5 (191.6m), silt from 1.70 (191.6m) to 44.01 (57.1m) and clay from 0.81 (191.6m) to 61.12 (35.3m).

Off Mumbai, the sediment colour was slightly greenish. Texture was silty clay in 33m and clayey silt in 51m and sand was dominant in rest of the depths. The percentage of sand varied from 1.09 (33m) to 86,79 (96m), silt from 9.47 (96m) to 49.58 (51m) and clay from 3.74 (96m) to 63.68 (33m).

Along Mumbai High, colour of the sediment was slightly greenish. Here, percentage of silt and clay was more and it was either silty clay or clayey silt upto 79m. Sand dominated in the rest of the depths. The sand percentage varied from 0.8 (51m) to 99.74 (91m), silt percentage from 0.19 (91m) to 63.01 (79m) and clay from 0.08 (91m) to 53.88 (51m).

Off Porbandar, colour was slightly greenish. Soft sediment was noticed in all the depths. It was clayey silt in 33m, silty clay in 53m, silt in 101m and silty clay in 210m. The sand percentage varied from 0.17 (33m) to 8.58 (101m), silt from 47.7 (210m) to 90.58 (101m) clay from 0.84 (101m) to 50.99 (53m).

Off Dwarka, colour of the sediment was light brown in 51m and slightly greenish in all other depths. Sediment was coarser sand with pebbles and corals in 30m depth and silty clay in 52m. Again, sand dominated in 100m and clayey silt in 200m depth. The percentage of sand varied from 0.12 (52m) to 80.08 (33m), silt from 8.3 (33m) to 45.29 (52m) and clay from 6.17 (100m) to 54.59 (52m).

5.2.1.2. **Latitudinal variation in different depth ranges:** Latitudinal variation of texture in different depth ranges is presented in Table 5.2 and Fig. 5.1.

30-50m depth range: In general, sediment was of muddy nature, either silty clay or clayey silt, except certain transects of south west coast. Those transects were, off Cape Comorin, Thiruvananthapuram, Kollam, Kochi and Vadanappilly. Again off Dwarka, sediment was sandy with pebbles and corals.

51-75m depth range: Sand was the major sediment upto Goa. Significant percentage of silt were also noticed with sand off Vadanappilly, Kannur and Goa. The sediment was muddy in nature, either silty clay or clayey silt from North off Goa upto off Dwarka.

76-100m depth range: Generally, substrata in this range were sand with an exception Along Mumbai at 79m, where it was clayey silt. Silty sand was observed off Ratnagiri and Dabhol.

Table 5.2: Latitudinal variation of sediment characters in each depth range

Table 5.2a: 30 - 50m depth range

St.no.	Transect	Depth (in m)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Nomenclature
1	cape	30.7	2.18	98.63	1.05	0.33	sand
7	tvm	30.0	0.99	99.69	0.11	0.20	sand
8	klm 1	30.6	2.85	8.89	72.56	18.55	clayey silt
9	klm 2	50.0	1.19	96.89	1.83	1.28	sand
13	kch	33.3	1.35	95.47	1.69	2.84	sand
16D	vad	36.2	1.03	85.18	10.23	4.59	sand
17	kzh1	31.0	5.54	0.52	58.11	41.37	clayey silt
18	kzh2	50.0	2.53	79.39	15.16	5.45	sand
25	knr	31.0	6.71	0.40	47.69	51.91	silty clay
26	mngr	31.0	4.99	0.28	47.13	52.59	silty clay
29E	cnpr	33.9	4.27	1.55	69.99	28.46	clayey silt
34	btkl	31.0	4.95	12.07	63.77	24.16	clayey silt
35	goa	32.0	5.28	0.71	48.73	50.56	silty clay
40	rtngr	32.0	3.24	1.96	44.69	53.35	silty clay
44A	dbhl	35.3	3.76	0.86	38.02	61.12	silty clay
45	ofmb	33.0	2.67	1.09	35.23	63.68	silty clay
54	almb	32.0	0.48	4.03	53.49	42.47	clayey silt
58	prbn	33.0	0.24	0.17	51.62	48.21	clayey silt
59	dwrk	33.0	0.59	80.08	8.31	11.61	sand

Table 5.2b: 51 - 75m depth range

St.no.	Transect	Depth (in m)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Nomenclature
2	cape	50.6	0.44	99.00	0.86	0.14	sand
6	tvm	59.0	3.96	96.74	1.97	1.29	sand
10	klm	73.7	1.31	97.53	1.64	0.83	sand
14	kch	51.0	5.46	82.36	12.63	5.02	sand
16C	vad	52.6	1.78	72.23	20.66	7.12	silty sand
24	knr1	51.2	4.95	50.13	36.47	13.40	silty sand
23	knr2	67.0	3.64	84.64	10.12	5.24	sand
27	mngr	50.8	3.40	75.69	18.31	6.00	sand
29D	cnpr	53.6	0.47	97.17	2.44	0.39	sand
33	btkl	54.4	2.29	94.67	4.21	1.12	sand
32	btkl	68.0	1.74	97.47	1.58	0.95	sand
36	goa1	52.0	4.43	22.25	45.65	32.10	sand silt clay
37	goa2	72.0	4.99	65.41	27.61	6.98	silty sand
41	rtngr	51.4	4.62	1.03	53.90	45.07	clayey silt
44B	dbhl	57.1	4.87	0.54	44.01	55.45	silty clay
46	ofmb	51.0	2.49	13.83	49.58	36.59	clayey silt
53	almb	51.0	0.653	0.8	45.18	53.88	silty clay
57	prbn	53.0	1.25	1.42	47.59	50.99	silty clay
60	dwrk	52.0	0.48	0.12	45.29	54.59	silty clay

Table 5.2c: 76 - 100m depth range

St.no.	Transect	Depth (in m)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Nomenclature
42	rtngr	76.0	2.97	74.26	23.23	2.51	silty sand
44C	dbhl	95.7	4.75	53.32	33.91	12.76	silty sand
44D	dbhl	94.3	0.67	95.15	3.41	1.44	sand
47	ofmb1	96.0	3.03	86.79	9.47	3.74	sand
48	ofmb2	89.0	2.49	78.50	14.62	6.88	sand
49	almb1	95.0	0.87	99.6	0.29	0.11	sand
50	almb2	91.0	0.91	99.74	0.19	0.08	sand
51	almb3	85.3	1.305	88.16	6.91	3.41	sand
52	almb4	79.0	1.78	4.87	63.01	32.16	clayey silt
61	dwrk	100.0	1.90	79.53	13.77	6.70	sand

Table 5.2d: 101 - 150m depth range

St.no.	Transect	Depth (in m)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Nomenclature
3	cape	101.0	1.74	96.37	2.97	0.66	sand
5	tvm	124.0	1.50	98.46	0.81	0.73	sand
11	klm	101.0	2.73	85.80	11.05	3.15	sand
15	kch	101.0	3.44	68.69	25.34	5.97	silty sand
16B	vad	103.4	1.35	71.71	20.47	7.83	silty sand
19	kzh	102.0	3.13	87.22	9.12	3.66	sand
22	knr	102.0	4.00	53.92	38.76	7.32	silty sand
28	mngr	101.0	3.36	73.73	21.86	4.41	silty sand
29E	cnpr	104.3	0.87	93.61	5.06	1.32	sand
31	btkl	101.0	4.04	29.20	65.69	5.11	sandy silt
38	goa	101.0	5.06	80.39	16.99	2.62	sand
43	rtngr	100.7	4.15	91.11	6.91	1.98	sand
56	prbn	101.0	2.08	8.58	90.58	0.84	silt

Table 5.2e: >150m depth

St.no.	Transect	Depth (in m)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Nomenclature
4	cape	208.0	2.73	86.09	11.18	2.73	sand
12	klm	238.0	2.26	92.85	5.61	1.54	sand
16	kch	202.0	2.57	84.45	12.16	3.39	sand
16A	vad	197.3	1.62	71.99	21.20	6.81	silty sand
20	kzh	219.0	4.95	88.94	7.45	3.61	sand
21	knr	202.0	4.11	60.46	31.27	8.27	silty sand
29	mngr	205.0	4.59	80.52	12.09	7.39	sand
29A	cnpr	193.0	1.58	83.39	11.56	5.06	sand
30	btkl	206.0	4.87	0.74	72.91	26.35	clayey silt
39	goa	206.0	2.91	85.62	10.55	3.83	sand
44	rtngr	211.0	6.23	28.55	56.09	15.36	sandy silt
44E	dbhl	191.6	0.79	97.50	1.70	0.81	sand
55	prbn	210.0	2.79	1.45	47.70	50.85	silty clay
62	dwrk	200.0	3.48	2.28	54.64	43.08	clayey silt

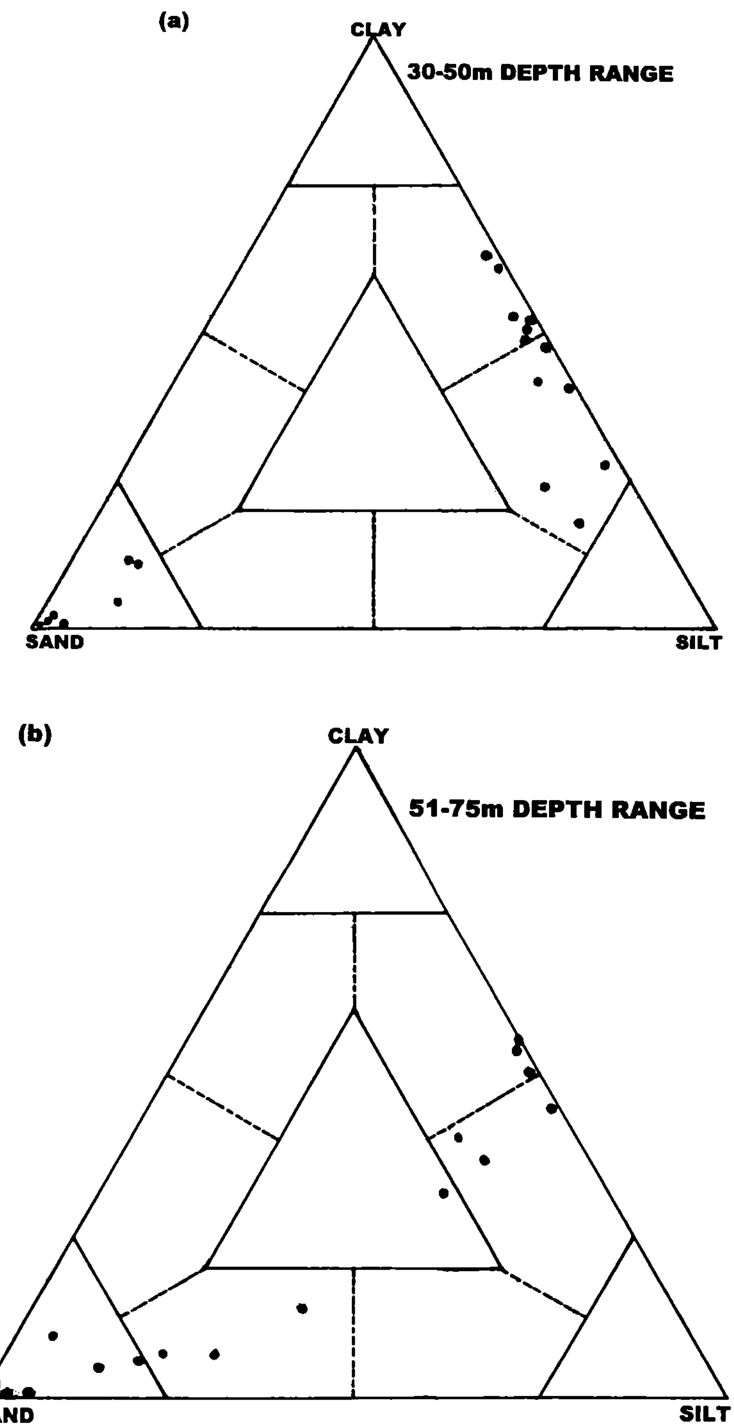


Fig. 5.1. a & b – Variation of sediment texture in different depth ranges

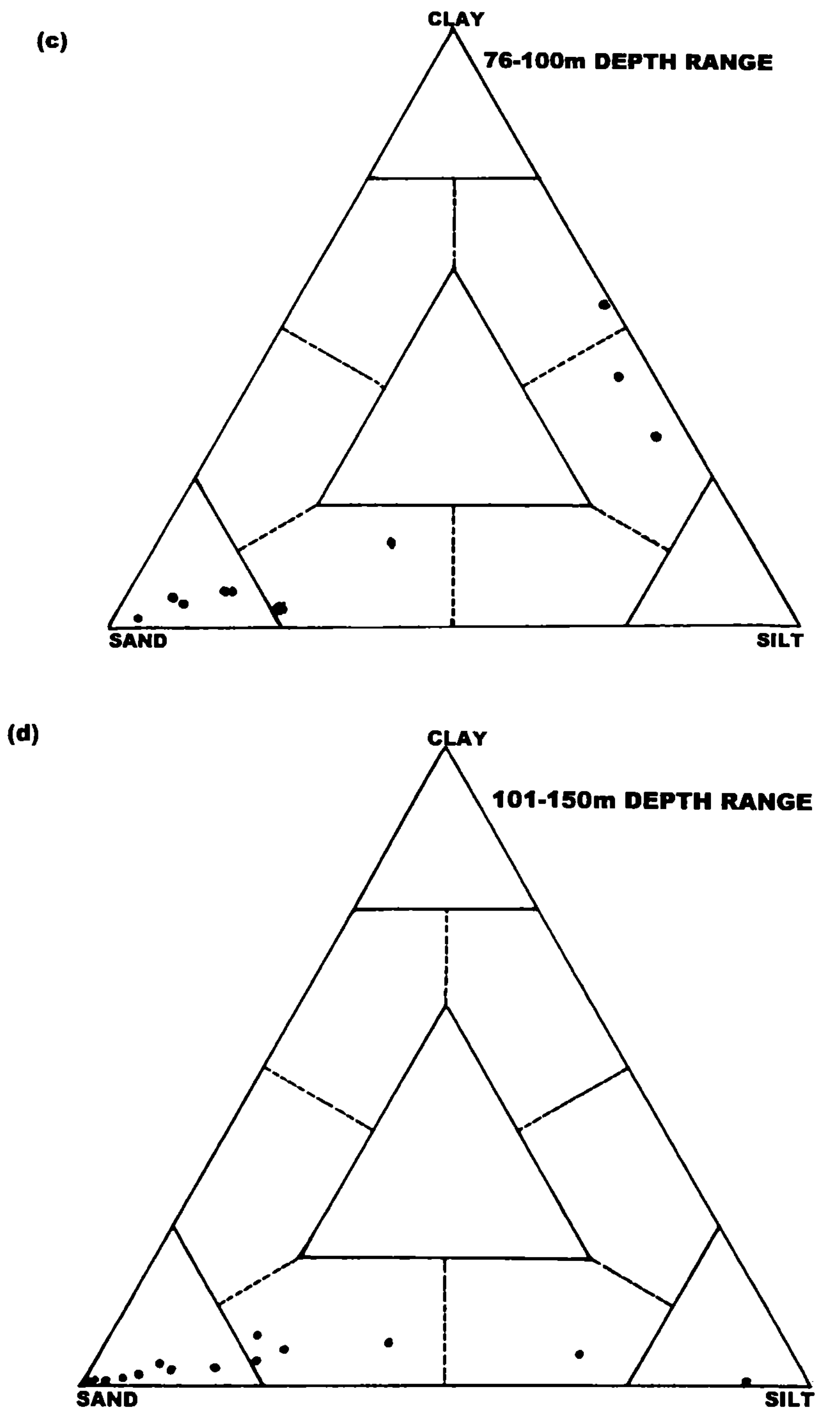


Fig. 5.1. c & d – Variation of sediment texture in different depth ranges

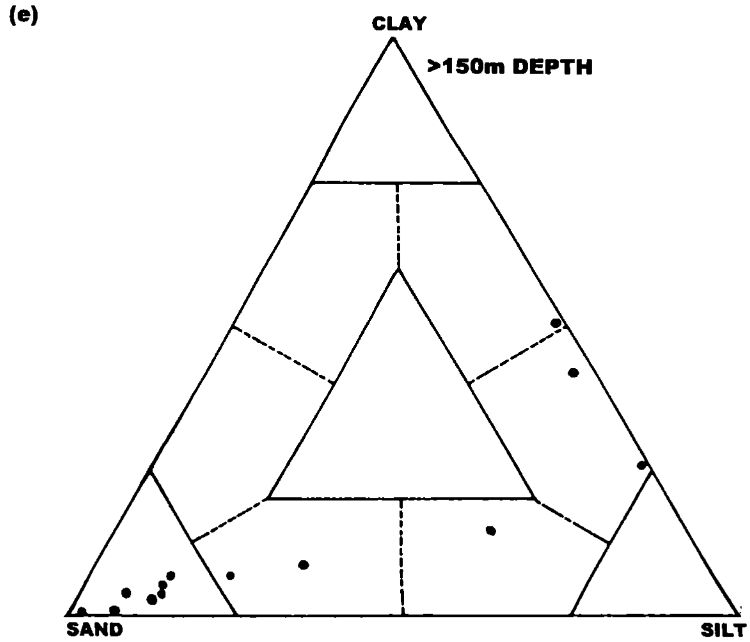


Fig. 5.1. e – Variation of sediment texture in different depth ranges

101-150m depth range: Sand was dominant in this depth range also. But silt admixture was noticed in lesser percentage off Kochi, Vadanappally, Kannur and Mangalore and greater percentage off Bhatkal and Porbandar. No predominance of clay was observed in this depth range.

>150m depth: In general, sand was the dominant sediment upto Dabhol with an exceptions, off Bhatkal and Ratnagiri, where sediment was clayey silt and sandy silt respectively. Off Porbandar and Dwarka, the sediment was silty clay and clayey silt.

5.2.2. Organic matter

Organic matter distribution was found to be related with substrata. In general, clay and silt retained more organic matter than sand.

5.2.2.1. **Depth-wise variation in each transect:** Depth-wise variation in percentage of organic matter in each transect is presented in Table 5.1.

Off Cape Comorin, percentage of organic matter ranged between 0.44 and 2.73, where the highest value noticed was in 208m and lowest was in 50.6m depth. Average value of organic matter in this transect was 1.77%. The distribution of organic matter was irregular though the substrata were sandy in all the depths.

Off Thiruvananthapuram, the highest value of 3.96% was noticed in the sandy area at 59m and lowest value of 0.99% was in 30m depth with an average of 2.15%.

Off Kollam, the percentage of organic matter ranged between 1.19 (50m) and 2.85 (30.6m). At 30.6m depth, the sediment was clayey silt. The average value in this transect was 2.07%.

Off Kochi, high organic matter content of 5.46% was noticed in 51m depth, where sediment was soft sand and the lowest was 1.35% in 33.3m with the average value for this transect at 3.2%.

Off Vadanappilly, the values were more or less uniform and ranged between 1.03 (36.2m) and 1.78% (52.6m). The average value was 1.44%.

Off Kozhikode, the percentage of organic matter ranged between 2.53 (50m) and 5.54 (31m). Here, the highest value was observed in clayey silt sediment. The average value for this transect was 4.04%.

Off Kannur, comparatively high values were noticed in all the depths. The values ranged between 3.64 (67m) and 6.71 (31m). The highest value was observed in silty clay sediment. The average value for this transect was 4.68%.

Off Mangalore also more or less higher values were noticed in all stations. The values ranged between 3.36 (101m) and 4.99% (31m). Here also the highest value was noticed in silty clay sediment. The average value for this transect was 4.08%.

Off Coondapore, the values ranged between 0.47 (53.6) and 4.27 (33.9m). The highest value was noticed in clayey silt substrata. The average value for this transect was 1.8%.

Off Bhatkal, the organic matter ranged between 1.74 (68m) to 4.95% (31m). Here high values were noticed in the stations with clayey silt and sandy silt and low values were observed in sandy sediments. The average value for this transect was 3.58%.

Off Goa, higher values were noticed in all the stations. The values ranged from 2.91 (206m) to 5.28% (32m). The highest value was noticed in silty clay sediment and lowest value in sandy sediment. The average value for this transect was 4.53%.

Comparatively higher values were observed off Ratnagiri also. The values ranged between 2.97% (76m) and 6.23% (211m). Highest value was noticed in sandy silt and lowest in silty sand substrata. The average value for this transect was 4.24%.

Off Dabhol, the values ranged from 0.67 (94.3m) to 4.87% (57.1m). The highest value was noticed in silty clay and lowest in sand. The average for this transect was 2.97%.

Off Mumbai, the values ranged from 2.49 (51 and 89m) to 3.03% (96m). The highest value was noticed in silty clay sediment and the lowest was observed in clayey silt and sand also. The average percentage for this transect was 2.67.

Along Mumbai High, comparatively low values were observed than any other transect. The values ranged from 0.653 (51m) to 1.78 (79m). The lowest value was recorded in silty clay sediment and highest in clayey silt. The average value for this transect was 1.00%.

Off Porbandar, the values ranged from 0.24 (33m) to 2.79% (119m). The lowest value was observed in clayey silt and highest in silty clay. The average for this transect was 1.59%.

Off Dwarka, the values ranged from 0.48 (52m) to 3.48% (200m). Here, the lowest value was noticed in silty clay and highest in clayey silt. The average for this transect was 1.61%.

5.2.2.2. **Latitudinal variation in different depth ranges:** Latitudinal variation in percentage of organic matter is presented in Table 5.2 and Fig. 5.2.

30-50m depth range: In general, higher values were noticed in the areas off Kozhikode to Dabhol, where it ranged between 2.53 to 6.71%. Either side of this area showed low values. The lowest value noticed was 0.24% off Porbandar. The average organic matter percentage of this depth range was 2.88.

51-75m depth range: In this range, higher values were observed in two regions i.e. off Kochi to Mangalore, where OM ranged between 3.4% and 5.46% with an

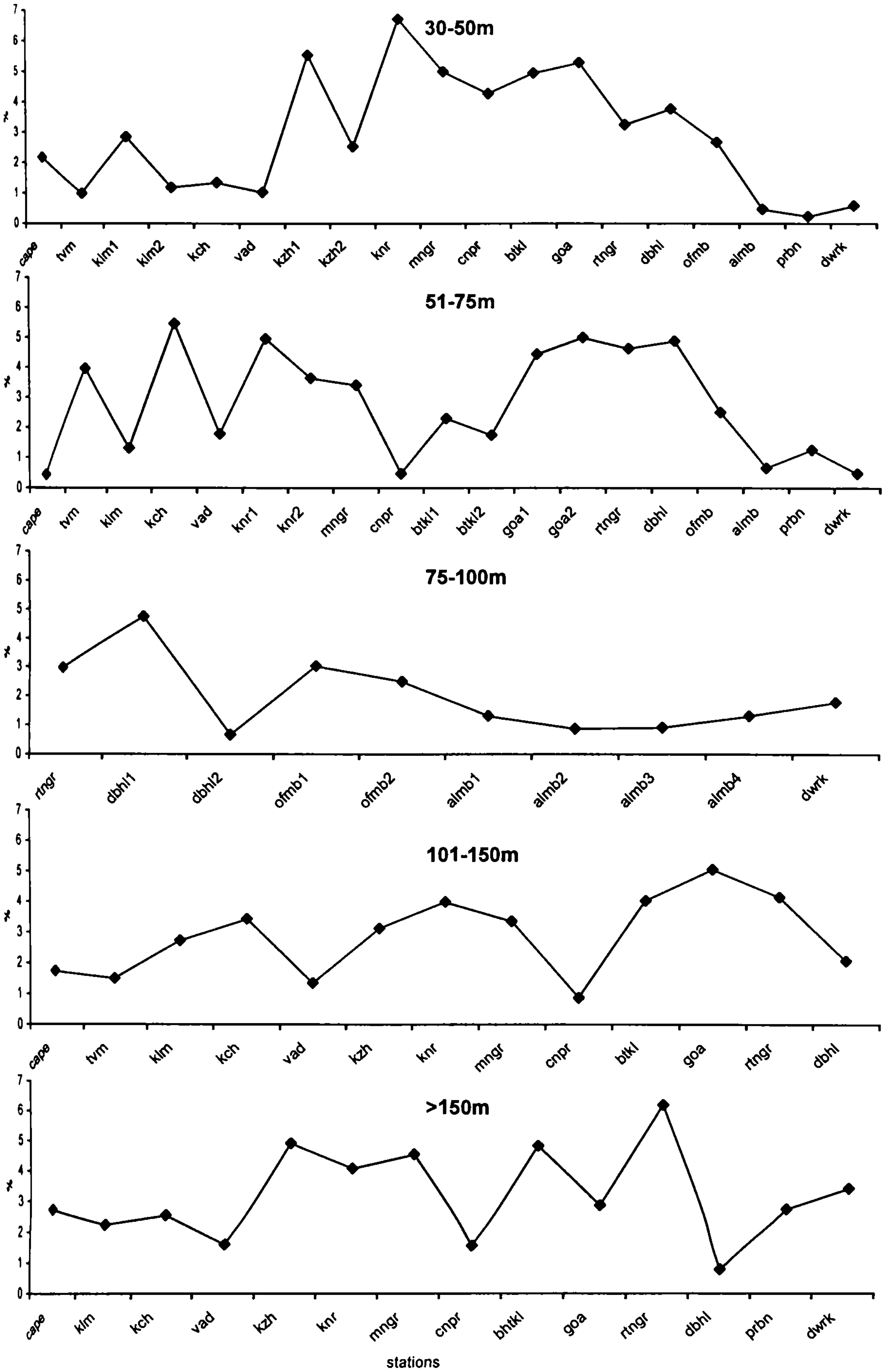


Fig. 5.2. Variation of percentage of organic matter in the sediments in different depth ranges

exception at Vadanappilly (1.78%) and off Goa to Dabhol, where the percentage ranged between 4.43 to 4.99%. The lowest value was 0.44 % off Cape Comorin and the average for this depth range was 2.80%.

76-100m depth range: In this range, comparatively low values were noticed. The highest value of 3.03 was noticed off Mumbai and the lowest was 0.67% off Dabhol. The average value for this transect was 2.07%.

101-150m depth range: In this depth range, more or less higher values were noticed off Kochi to Ratnagiri (3.13 - 5.06%) with two exceptions, one off Vadanappilly (1.35%) and another off Coondapore (0.87%). The highest value for this transect was 5.06% off Goa. The lowest of 0.87% was observed off Coondapore. The average for this transect was 2.88%.

>150m depth: Higher values were noticed off Kozhikode to Ratnagiri (4.11 – 6.23%) with two exceptions, one off Vadanappilly (1.58%) and another off Goa (2.91%). Lower values were observed elsewhere. The highest value in this depth range was 6.23% off Ratnagiri and lowest was 0.79% off Dabhol. The average value for this transect was 3.25.

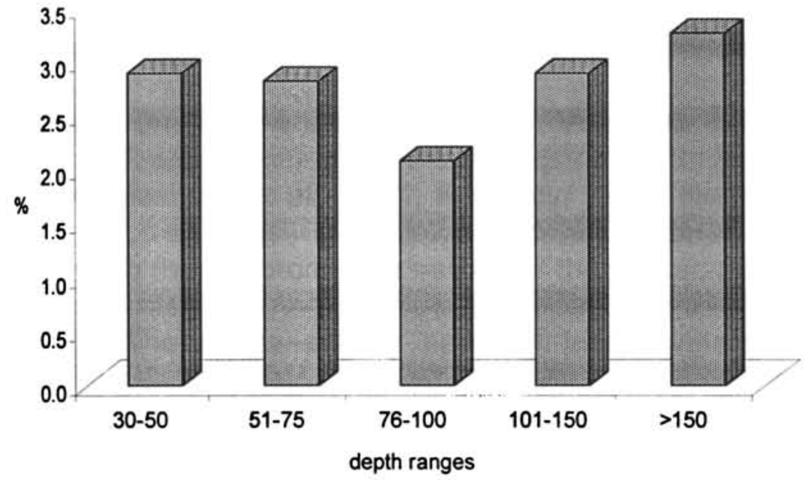


Fig. 5.3. Average percentage of organic matter in different depth-ranges

5.3. Discussion

5.3.1. Texture

There was an appreciable variation in substrata along the continental shelf region of the west coast of India. Seven different types of substrata was noticed, which were sand, silty sand, sandy silt, silt, sand-silt-clay, clayey silt, silty clay. Though, seven types were observed, sand, silty sand, clayey silt and silty clay were the major sediments.

In general, muddy nature of sediments is present in the nearshore region, except at extreme south and Dwarka region. With the increase in depth, sand seemed to replace the finer sediment. This trend was more prominant in SW region. But fine sediments were observed in the deeper stations of NW transects such as Ratnagiri, Porbandar and Dwarka.

The reason for the fine sediments in the inner-shelf is due to the trapping of coarser sediments in the estuaries and subsequent deposition of fine sediments in the inner-shelf (Allen, 1971; Veerayya & Murty, 1974; Hashimi & Nair, 1981; Hashimi *et al.,* 1981; Kennedy, 1984; Narayana & Suresh Kumar, 1994). During the monsoon, the salinity of the estuarine waters becomes as low as 2 ppt. These low salinity sediment-laden waters of the estuaries are discharged into the relatively higher saline (~35 ppt) waters of the inner-shelf. This mixing leads to flocculation, resulting in the deposition of fine-grained sediments. This type of deposition takes place within the 15 to 50m water depth corresponding to a distance of about 40km from the coast (Hashimi & Nair, 1981). This kind of nearshore deposition of river discharged sediments is common on the other continental shelves also (Drake, 1961; Barreto *et al.*, 1975).

The continental shelf of south-western India (offshore of Kerala) demonstrates the influence of estuaries on sediment texture of shelf areas (Nair & Hashimi, 1986). Off Cape Comorin to Kollam, the sediments are entirely calcareous sand. Between Kochi and Kollam, the estuarine area on the coastal plain is 400 km^2 while south of Kollam it is only about 25km^2 (Nair & Hashimi, 1986). In the 30m depth off Kollam, the present study showed clayey silty substrata, but in Kochi region, it is fine sand sediments. Hashimi *et al.* (1981) and Nair and Hashimi (1986) noticed either clayey silt or sand-silt-clay upto a depth of 20m from Kollam to Kochi, beyond which the sediment changed to sand and clayey sand. The high percentage of fine sediments in the nearshore region of Kollam is the result of the trapping of sediments by the Ashtamudi backwaters (Hashimi *et al.,* 1981). In Kochi region, though the Vembanad Lake does the trapping of coarse sediment (Veerayya & Murty, 1974), the flocculation and deposition of the fine-grained sediments may be happening below 30m depth, where, the sediment is composed of very fine material (Damodaran, 1973).

South of Kollam, rivers comparable to Periyar are absent. Hence the percentage of fine sediments decreases sharply and sand becomes the predominant sediment type in the shelf (Hashimi *et al.*, 1981). An additional reason for the predominance of sands may be the winnowing action by waves (Hashimi *et al.*, 1981).

In the 30-50m depth range, from Kochi to Porbandar the sediment was either silty clay or clayey silt. Various works have shown the effect of rivers and estuaries on the fine nature of sediments in the innershelf of this region: e.g., Kumbla-Shriya in north Kerala (Naryana & Suresh Kumar, 1994), Netravati and Gurpur in Mangalore (Hashimi & Nair, 1981), Sharavati river near Honavar (Narayana & Venkatesh Prabhu, 1993., Sriram *et al.*, 1998) Kalindi and Gangavalli near Karwar (Hashimi & Nair, 1981), Mandovi and Zuari in Goa (Hashimi & Nair, 1981). The deposition of fine sediment is also taking place in the region between Bombay and Dwarka. The rivers, Mahi, Narmada and Tapti empty in to the Gulf of Cambay, while the largest river, Indus drains the western portion of the Indo Gangetic Plain (Shankaranarayana Guptha, 1979), which exerts their influence on the sediment texture off Mumbai and Dwarka.

In general, the outer shelf was sandy in nature. This sandy nature of sediment may be due to the relict nature of sediments and the absence of conditions favourable for deposition (Hashimi & Nair, 1981). Both shelf waves and near-inertial internal waves winnow the silt and clay making the outer shelf sediments relatively sand rich (Narayana & Venketesh Prabhu, 1993). The low clay percentage in the relict sand zone was also attributed to the action of bottom currents (Hashimi *et al.*,1978a). The near-bottom tidal currents transport sediments in combination with wave currents. Upwelling may also be playing a dominant role in winnowing away fine particles from this zone (Narayana & Venketesh Prabhu, 1993).

The high percentage of mud in the outershelf is difficult to explain. Such substrata were noticed in the transects - Bhatkal, Ratnagiri, Porbandar and Dwarka. Here the silt value ranged from 47.7% to 72.91%; clay 26.35% to 50.85% and sand 0.74% to 2.28%. Hashimi and Nair (1981) also noticed such muddy nature of substrata in the outershelf of Bhatkal and Malpe, where they found stiff clay balls, which suggested that some local physical agencies (waves and currents) were responsible for the removal of clay from the nearshore zone and depositing seaward (Hashimi & Nair, 1981). Such a seaward deposition due to current might be large off Dwarka, which could not return any fine sediments in the nearshore region off Dwarka.

5.3.2. Organic matter

Organic matter also showed considerable variation with respect to depth as well as latitude. In general, more organic matter is retained in the fine sediments i.e., silt or clay. The present study has recorded low organic matter value in the depth range of 76-100m. The organic matter content in the sediment was high, above and beyond this depth range. However, the highest mean value was noticed in the depth beyond 150m (Fig. 5.3). Narayana and Venketesh Prabhu (1993) noticed high organic content in 30-50m and 100-200m depth zone, whereas 50-100m depth zone contained comparatively low organic matter.

The organic matter content in sediments depends on three factors (Trask, 1939): (i) the quantity of organic matter produced in the surface waters in a given unit of time, (ii) degree of conservation or preservation of organic matter and (iii) rate of sedimentation. The higher organic matter in the shallower and deeper areas may be attributed to the fine-grained nature of the sediments and to the variation in the benthic productivity (Paropakari *et al.*, 1987). While studying the organic matter in the Honavar area, Narayana and Venkatesh Prabhu (1993) noticed that the grain size and biologic productivity are the major contributing factors for the variation in OM.

The present study has shown relatively high OM values in 30-50m depth zone, where the sediment is muddy in nature. This indicates that terrestrial derivation is the main source for accumulation of organic matter (Reddy, 1995; Seetharamaiah & Swami, 1997). The reason for the low content of organic matter in certain stations in this depth range is attributed to the relict nature of sediment and low biological productivity (Venkatesh Prabhu, 1992) or due to the greater turbulence and hence the greater aeration (Seetharamaiah & Swami, 1997).

The association between organic matter and grain size is considered to be due to the adsorption capacity of organic matter onto clays and the similarity in the settling velocity of organic particles and clays (Kemp, 1971) whereas, Kidwai and Nair (1972) have appended the associated reducing condition, to aid the preservation of organic matter. Hobbs (1982) has reported that association between clay content and the organic carbon is probably the result of great surface area presented by a large volume of clay particles and of the chemically active nature of clays. Kolla *et al.* (1981) have stated that the high organic matter content in the sediments of the Indian continental margin is primarily due to its preservation, which result from the impingement of low oxygenated water on the sea floor and from the high sedimentation rates. But Calvert *et al.* (1991) suggest that anoxic condition in the water column may not be a prerequisite for the preservation of organic matter in marine sediments.

The higher organic matter in the deeper area, as noticed in the present study could be due to the propitious physico-chemical, sedimentological and hydrographic conditions (Seetharamaiah & Swami, 1997). The increase of organic matter could be attributed to the preservation of deposited organic matter by fine grained nature of the sediments and similarity in settling velocity of fine grained sediments and organic matter (Trask, 1939) coupled with higher rates of sedimentation in these regions, which prevents its destruction by rapid burial (Subbarao, 1960).

A significant amount of organic matter is derived from algal and the bacterial flora (Godel & Texier, 1986). Observations by Setty and Rao (1972) and Mohan and Rajamanickam (1994) on the south west continental shelf and off Mumbai-Sourashtra coast also support this.

Chapter 6

Composition of macrobenthos

6.1. Introduction

Oceans occupy 71% of the surface area of the globe. The volume of sea water in the ocean provides 99.5% of the livable volume of the earth (Cohen, 1994). Marine habitats frequently have more different phyla but fewer species than terrestrial habitats i.e., higher taxonomic diversity but lower species diversity (Ormond, 1996). But on land, insects alone contribute three quarters of the biodiversity, mostly by beetles (Barnes, 1989). The ocean is the home to 29 animal phyla, of which 14 are exclusively marine (Grassle, 2001). it might harbour some 10 million species, and it has higher ecosystem diversity than that of the land (Norse, 1995). Because of the inaccessibility and vastness of the world's oceans, our knowledge of marine biodiversity is limited than our knowledge of terrestrial diversity.

Apart from the micro-organisms, about 98% of all species known to exist in oceans and coastal waters belong to the benthos (Peres,1982). This may be due to the diversity of the benthic environment. So far we have given our attention only to the biodiversity of the terrestrial ecosystem. Benthic ecosystem is the least known ecosystem on earth, because of its immensity and inaccessibility.

Based on the quantitative analysis of 233 box core samples from the continental slope and rise off east coast of North America, Grassle and Maciolek (1992) estimated 1 to 10 million macrofaunal species in the deep sea. May (1994) estimated 0.5 million from the study based on a portion of samples previously considered in the Grassle and Maceolek study. Poore and Wilson (1993) analyzed samples from the Southern Pacific Ocean off Australia and, estimated that there are 5 million species in the deep sea sediments. Reason for high diversity of species in the ocean include the long evolutionary history of the ocean, the vast area of deep sea floor (3 x 10^8 km^2) with relatively few barriers of disposal, and episodic nature of patch formation within and between habitats on a variety of spatial and temporal scales (Grassle, 2001).

Though many benthic studies have been made in the different parts of the world most of the information on benthic ecosystem is fragmentary, dealing with single taxa, such as polychaetes (Ben-Eliahu, 1989; Fauchald, & Rouse, 1997; Ding & Westheide, 1997; Carpizo-Ituarte & Hadfield, 1998), Bryozoa (Menon & Nair, 1967) amphipods (Budnikova, 1993; Cary *et al.*, 1996) isopods (Brusca & Iverson, 1985; Cohen & Poore, 1994) decapods (Thessalou-Legaki, 1992; Wahle, 1995; Barnes, 1997), molluscs (Barash & Danin, 1988/1989; Jalk, 1992; Zenetos and Van Aartsen, 1994; Choi, 1996) or echinoderms (Ghiold and Rountree, 1994; Balch & Scheibling, 1994).

In the case of Indian waters, most of the qualitative studies on benthos were localized in and around various estuaries (Damodaran, 1973; Parulekar *et al.*, 1980; Harkantra & Parulekar, 1981; Vizakat *et al.,* 1991; Venkatesh Prabhu *et* al., 1993; Ansari *et al.*, 1994; Harkantra & Parulekar, 1994; Saraladevi *et al.*, 1996; Gopalakrishan & Nair, 1998; SunilKumar, 1999; Sheeba, 2000). Harkantra *et al.* (1980) recorded the major fauna of the shelf region of west coast up to a depth of 75m. In general, most of the studies showed that polychaetes were the most abundant fauna followed by crustaceans or molluscs. Some authors have indicated the abundance of echiurids (Venketesh Prabhu *et al.*, 1993; Harkantra & Parulekar, 1994), echinoderms (Harkantra *et al.,* 1980; Venketesh Prabhu *et al.*, 1993) and sipunculids (Harkantra & Parulekar, 1994) in certain regions. Sheeba (2000) in her study of the diversity of mangrove region, has recorded an abundance of tanaids and amphipods, which outnumbered all other groups in certain stations.

This chapter deals with the macrofaunal composition of the Indian western continental shelf. Being the dominant group, diversity indices were worked out separately for polychaetes. Diversity indices were also worked out considering the entire fauna as specific 'groups'. Niche-breadth and similarity index were estimated and cluster analysis was done for polychaete species and groups. Predictive regression model was applied to understand the effects of individual environmental factor and first order interaction on polychaete abundance.

Four different terms of diversity indices with different ecological importance were used. They were, species richness, species evenness, species diversity and species dominance. The species richness (Margalef's index) is used to estimate the total number of species in a given area. Species richness is a straightforward count of the number of species. More the number of species in a sample or more the species present in a species list of a given environment, the greater will be the species richness. The term evenness is used for the numerical percentage of composition. High evenness occurs, when the species present are virtually in equal abundance, which, is conventionally equated with high diversity. The less numerically equal the species are, the less diverse the sample is or, conversely, the greater dominance in the fauna. (Sanders, 1968). Species dominance is the relative occurrence of species with other species. The dominant species will have high relative occurrence. The term species diversity is used for the number of species per number of individuals. The highest species diversity possible is when only one individual represents every species and the lowest diversity possible is when community consists of only one species (Soetaert & Heip, 1990). Species diversity measurements are often more informative than species counts alone because they take into account two factors, species richness and evenness (Magurran, 1988).

Niche is the address and profession of an organism: the position it occupies within the community, the various interrelationships it has with other organisms around it and the role it plays in the operation of the community as a whole (Elton, 1927). Hutchinson (1959) presented the niche as the hypervolume, defined as the sum of all interactions of an organism and its (abiotic and biotic) environment. Ecologically speaking, the most important feature of a niche is its position on the resource continuum, its spread, and its overall shape and form (Putman & Wratten, 1984). The niche width is a measure of the breadth of exploitation of a given resource by an organism; it is a complex function of how much generalized or specialized the organism may be in that particular element of its ecology (Putman & Wratten, *loc. cit.*).

6.2. Result

6.2.1. Faunal composition

Polychaetes were the major form followed by crustaceans. Molluscan representation was poor compared to the other two groups. Other than these three groups, some other groups contributed to the biomass in certain stations and they are termed as 'others'. Since polychaetes were the predominant form, they were identified up to species level. Rest of the fauna were either identified up to species level or identified up to family or order level. The detailed list of macrofaunal composition is presented in Table 6.1.

6.2.1.1. Polychaetes

Altogether 165 species of polychaetes were isolated from the continental shelf of Indian west coast. Among this, group Errantia was represented by 70

Table 6.1a. FAUNAL COMPOSITION OF MACROBENTHOS OF CONTINENTAL SHELF OF WEST COAST OF INDIA
30-50M (in no per sq m)

Transect →	cape	tvm	klm 1	klm 2	kch	vad	kzh1	kzh2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk	Niche breadth
Depth →	31	30	31	50	33	36	31	50	31	31	30	31	32	32	35	33	32	33	33	
Station No. →	1	7	8	9	13	16D	17	18	25	26	29E	34	35	40	44A	45	54	58	59	
Hydrozoans	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	10	
Sea anemones	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	—	
Nematodes	—	—	—	10	—	—	—	—	—	—	—	10	—	—	—	—	15	—	10	
Sponges	—	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
POLYCHAETES																				
Errantia																				
Aphroditidae																				
Sthenelais boa	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.319
Amphinomidae																				
Pseudeurythoe sp	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.728
Euphrosine spp	—	—	—	10	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—	7.853
Eurythoe parvecarunculata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	12.303
Phyllodocidae																				
Phyllodoce dissotyla	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.556
P. spp	—	—	—	40	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	19
Other phyllodocids	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	8.048
Pilargidae																				
Ancistrosyllis parva	—	10	90	—	10	355	25	—	420	120	60	375	295	170	40	75	55	100	—	12.303
A. constricta	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	20	—	20	19
A. spp	—	—	50	—	—	10	—	—	10	—	—	—	30	—	—	—	—	—	—	12.303
Hesionidae																				
Syllidia sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	19
Hesione pantherina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40	10	—	10.657
Other hesionids	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	12.303
Syllidae																				
Syllis ferrugina	20	—	20	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.048
S. spongicola	20	—	—	10	—	—	—	20	—	—	—	—	—	10	—	—	—	—	30	8.048
Eusyllis blomstrandi	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	8.048

Transect →	cape	tvm	klm 1	klm 2	chn	vad	cal 1	cal 2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nereidae																				
Ceratonereis mirabilis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	3.965
Nereis agulhana											10	—	—							12.303
N. sp	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	10.657
Other nereids	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	10	—	—	—	10.657
Nephtyidae																				
Nephtys inermis	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
N. dibranchis	20	—	45	70	—	15	55	—	50	45	75	80	20	35	20	50	55	—	—	13.052
N. polybranchia	20	—	—	—	—	—	20	—	—	—	50	—	—	—	—	—	10	—	—	6.061
N. sp2	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	35	5.065
N. sp3	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	10	—	12.303
Lacydonidae																				
Paralacydonia paradoxa	—	—	—	10	—	—	—	—	—	—	—	30	—	10	—	10	—	—	40	6.965
Glyceridae																				
Glycera longipinnis	70	—	—	—	—	—	—	—	15	15	—	25	30	20	—	20	10	—	10	8.889
G. rouxii	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	12.303
G. sp1	10	20	40	—	—	—	—	10	—	—	—	—	—	40	—	—	115	—	10	5.904
G. sp2	50	10	30	—	—	10	—	—	—	—	—	—	—	—	—	—	—	10	15	7.21
G. spp	—	—	10	—	—	10	—	—	—	—	—	—	—	—	30	—	—	10	—	7.66
Goniada emerita	—	—	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
G. sp	—	—	10	—	—	—	—	—	10	—	—	30	—	—	—	—	15	—	—	7.562
Eunicidae																				
Eunicinae																				
Eunice indica	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
E. coccinea	—	30	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	6.353
E. tentaculata	—	—	—	—	—	—	—	20	—	—	—	—	—	—	—	—	—	—	10	8.048
E. spp	10	—	—	—	—	10	—	20	—	—	—	—	—	—	—	—	—	—	—	8.441
Nematonereis unicornis	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
Onuphinae																				
Diopatra. sp	—	—	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	—	5.728
Onuphis holobranchiata	—	30	—	—	—	—	—	20	—	10	—	—	—	—	—	—	—	—	240	2.69
O. investigatoris	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.728
O. sp1	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303

Transect →	cape	tvm	klm 1	klm 2	chn	vad	cal 1	cal 2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk	Niche breadth
Lumbrinerinae																				
Lumbrineris latreilli	10	10	60	110	—	50	10	90	160	220	160	170	20	30	30	20	—	50	50	11.881
L. aberrans	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.728
L. simplex	—	—	—	10	—	—	—	—	—	—	—	—	—	10	—	—	—	—	—	10.657
L. heteropoda	—	—	—	—	—	10	—	40	—	—	—	—	—	—	—	—	—	—	—	5.252
L. spherocephala	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	25	6.618
L. spp	—	—	—	—	—	110	—	—	—	—	—	—	—	—	—	—	—	—	—	2.254
Arabellinae																				
Arabella iricolor iricolor	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	12.303
Dorvilleinae																				
Protodorvillea egena	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	12.303
Dorvillea rudolphi	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Sedentaria																				
Spionidae																				
Spiophanes bombyx	10	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10.657
Malacoceros indicus	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Aonides oxycephala	—	220	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.627
Scolelepis sp	—	—	—	—	60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.344
Prionospio cirrifera	20	—	10	—	—	—	—	—	120	—	—	—	—	—	—	—	—	30	—	3.968
P. pinnata	—	1225	20	—	—	90	75	70	—	—	100	995	—	—	40	—	—	20	265	4.522
P. cirrobranchiata	—	—	—	—	—	85	—	—	—	—	—	—	—	—	10	—	—	—	—	3.131
P. spp	—	—	—	—	—	50	—	—	240	180		45	415	380	40	60	50	15	50	7.281
Laonice cirrata	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.556
L. sp	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Other spionids	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.556
Magelonidae																				
Magelona cincta	—	—	—	10	—	4775	75	10	20	—	—	245	—	—	—	30	—	40	10	1.533
Cirratulidae																				
Dodecaceria capensis	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Tharyx ?marioni	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	10	10.657
T. sp	—	—	—	—	—	—	—	—	—	—	—	—	—	270	—	—	—	—	—	1.514
Cirratulus sp1	—	—	—	—	10	95	10	—	—	—	—	—	—	—	—	10	—	10	—	4.403
Cirratulus dasylophius	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	10	30	—	—	7

Transect →	cape	tvm	klm 1	klm 2	chn	vad	cal 1	cal 2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk	Niche breadth
Cirriformia sp1	—	20	—	—	—	—	—	10	—	—	—	—	—	—	—	—	210	—	10	2.566
C. sp2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	12.303
Trochochaetidae																				
Poecilochaetus serpens	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	7.853
Orbinidae																				
Scoloplella sp	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Phylo ?foetida foetida	—	30	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.353
P. sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	7.853
Scoloplos johnstonei	—	—	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	10	6.353
S. chavaliem	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	—	—	10	—	10.657
S. sp	—	50	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.613
Other orbinids	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40	—	5.204
Paraonidae																				
Aricidea sp1	—	10	—	—	—	—	—	—	—	—	—	—	—	20	—	—	—	—	—	8.048
A. sp2	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Cirrophorus sp	—	—	—	10	—	20	—	20	—	25	10	100	95	45	20	20	—	30	25	9.766
Paraonides sp	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Paraonis gracilis gracilis	20	35	10	—	—	50	—	10	—	—	—	—	—	155	—	—	—	—	20	5.366
Ophelidae																				
Armandia intermedia	30	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.974
Polyophthalmus pictus	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Other ophelids	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40	—	—	4.566
Cossuridae																				
Cossura coasta	—	—	—	—	—	50	—	10	—	20	90	60	215	45	25	45	75	85	—	8.874
Capitellidae																				
Pulliella armata	—	—	—	—	—	—	—	—	40	—	—	440	50	90	—	45	80	—	—	4.145
Notomastus sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	—	7.853
Dasybranchus ?cadacus	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
D. spp	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.556

Transect →	cape	tvm	klm 1	klm 2	chn	vad	cal 1	cal 2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	ofmb	almb	prbn	nwrk	Niche breadth
Maldanidae																				
Maldanids	—	—	40	10	—	30	—	10	—	—	—	10	—	—	10	—	10	—	10	9.014
Sternaspidae																				
Sternaspis scutata	—	—	10	—	—	15	—	—	—	15	50	10	—	—	190	—	10	1335	30	2.282
Pectinariidae																				
Pectinaria sp	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	12.303
Ampharetidae																				
Melinninae																				
Melinna cristata	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
M. sp1	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Ampharetinae																				
Amphicteis gunneri	10	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	20	20	—	8.213
A. sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	7.853
Sabellides sp	—	—	—	—	—	—	—	—	—	—	—	—	—	20	—	—	—	—	—	7.853
Other ampharetids	—	—	—	—	—	15	—	—	—	—	—	—	—	—	—	—	—	—	40	5.276
Terebellidae																				
Trichobranchinae																				
Terebellides stroemi	—	—	—	—	—	25	—	—	30	10	10	10	—	—	—	—	—	10	—	8.494
Terebellinae																				
Pista brevibranchia	—	—	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	—	5.728
P. indica	—	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
P. ?unibranchia	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	12.303
P. sp2	—	—	—	—	—	—	—	40	—	—	—	—	—	—	—	—	—	—	—	4.556
P. sp3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	18.999
P. spp	—	—	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
Sabellidae																				
Megalomma vesiculosum	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
M. sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	30	5.728
Potamila sp	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Jasmineira elegans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	7.853
Other sabellids	—	10	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	10.657
Serpulidae																				
Serpulinae																				
Hydroides norvegica	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
H. albiceps	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	12.303

Transect →	cape	tvm	klm 1	klm 2	chn	vad	cal 1	cal 2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	sfmh	almb	pdbn	dwrk	Niche breadth
Un-identified polychaetes																				
1	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
2	—	—	—	—	20	—	—	10	—	—	—	—	—	—	—	—	—	—	—	8.048
5	—	10	60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	4.598
Crustaceans																				
Amphipods																				
Gammarus sp	540	10	15	—	—	55	—	30	10	—	20	150	50	160	—	—	15	30	220	
Quadrivicio bengalensis	10	—	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	10	
Quadrivisio boneri	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Grandidierella gelesi	10	—	—	—	—	30	—	—	—	—	20	—	—	—	40	—	—	—	—	
Corophium sp	1800	—	20	40	—	—	20	20	—	10	—	15	10	—	—	20	10	15	—	
Eriopisa sp	30	—	—	—	—	—	—	—	—	—	20	—	—	—	—	—	—	10	—	
Eretmocaris sp	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Caprellids	1140	20	10	20	—	10	—	—	10	40	30	20	15	40	10	10	35	10	—	
Other amphipod	180	60	50	120	20	—	—	120	10	20	40	110	70	110	—	—	500	35	470	
Isopods																				
Isopods	310	90	175	155	20	70	40	—	40	35	10	20	20	10	—	10	55	45	50	
Tanaids																				
Tanais sp1	150	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Tanais sp 2	20	10	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Apseudes chilkensis	30	10	10	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40	
Other tanaids	10	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	50	
Copepods	—	20	20	70	10	215	—	—	40	140	765	20	295	20	155	20	725	125	25	
Cumaceas	80	10	10	20	—	20	—	30	—	—	—	—	10	—	—	—	50	30	—	
Ostracods	—	—	—	—	—	50	—	—	—	—	50	10	—	10	—	—	20	—	—	
Pycnogonums	—	—	10	—	—	10	—	—	—	—	—	10	10	20	10	10	0	—	—	
Mysids	20	10	—	—	—		—	—	—	—	—	—	—	—	—	—	10	—	—	
Decapods																				
M. dobsoni	—	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Alpheius malabaricus	—	—	20	25	—	—	—	30	40	—	—	75	10	350	—	10	—	—	—	
Prawn	—	20	—	—	—	10	—	—	—	—	—	10	—	10	—	—	—	—	—	
Crab	---	---	10	35	---	---	10	60	---	---	---	55	---	30	---	30	60	10	20	

Transect →	cape	tvm	klm 1	klm 2	chn	vad	cal 1	cal 2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	ohmb	almb	prbn	dwrk
Hippa	20	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—
Megalopa larvae	10	—	10	10	—	—	—	—	—	—	—	10	10	20	—	10	10	—	10
Other decapods	—	—	10	—	—	80	—	—	—	—	70	—	—	—	10	—	—	—	10
Stomatopods																			
Alima larvae	—	—	—	—	—	10	—	—	—	—	—	—	10	—	—	—	—	—	—
Sergestids	—	—	—	—	—	—	—	—	—	—	50	—	—	—	—	—	—	—	—
Molluscs																			
Musculista senhausia	—	—	—	—	260	10	—	—	—	—	—	—	—	—	—	—	—	—	—
Arca sp	—	—	—	—	—	—	95	—	10	—	—	—	10	—	—	—	10	—	—
Donax sp	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—
Tapes sp.	—	50	—	25	20	20	—	—	—	10	—	15	—	—	—	—	—	10	10
Other clams	—	60	100	20	30	10	—	—	—	10	—	—	10	—	20	15	20	—	10
Gastropods	—	10	110	—	—	10	—	—	—	—	—	—	—	—	—	—	55	—	—
Dentalium	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Echnoderms																			
Brittle Star	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20
Sea urchin	—	—	—	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	10
Cake urchin	—	—	—	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—
Star fish	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—
Sipunculids	—	40	170	80	—	—	—	—	—	—	—	—	—	—	—	—	40	395	—
Amphioxus sp	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Echiuroids	—	—	—	—	—	—	—	—	60	—	—	—	30	—	—	—	—	—	—
Fishes	—	—	—	—	10	—	10	15	—	10	—	—	—	15	—	20	15	20	—
Unidentified organisms	30	510	80	310	235	40	75	55	130	90	125	250	130	80	30	150	400	535	50

Transect →	cape	tvm	ktm	kch	vad	kanr 1	kanr 2	mngr	cnpr	btkl 1	btkl 2	goa 1	goa 2	rtngr	dbhl	otmb	almb	prbn	dwrk	Niche breadth
Depth →	51	59	74	51	53	51	67	51	53	54	68	52	72	51	58	51	51	53	52	
Station No. →	**2**	**6**	**10**	**14**	**16C**	**24**	**23**	**27**	**29D**	**33**	**32**	**36**	**37**	**41**	**44B**	**46**	**53**	**57**	**60**	
Foraminiferans	—	—	—	—	—	—	—	—	85	—	—	—	—	—	—	—	—	—	—	
Hydrozoans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	—	
Nematodes	10	—	35	—	—	—	—	—	35	25	30	—	—	—	—	—	10	—	—	
Flatworms	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	
POLYCHAETES																				
Errantia																				
Aphroditidae																				
Sthenelais boa	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	9.322
S. sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	7.78
Other Aphroditids	10	—	—	—	—	10	—	—	10	—	—	—	—	—	—	—	—	—	—	5.252
Amphinomidae																				
Paramphinome indica	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	12.303
Pseudeurythoe sp	—	170	30	—	—	—	—	—	—	—	30	—	10	—	—	—	—	—	—	12.303
Euphrosine spp	—	—	10	30	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.048
Eurythoe mathaii	—	—	—	—	—	—	—	—	90	—	—	—	—	—	—	—	—	—	—	7.577
E. Parvecarunculata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	—	8.048
E. sp	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	7.853
Pisionidae																				
Pision oerstedi	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.441
Phyllodocidae																				
Phyllodoce spp	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Alciopidae																				
Alciopids	—	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.048
Pilargidae																				
Ancistrosyllis parva	—	20	10	—	40	75	—	20	340	30	—	195	—	50	185	25	50	60	55	12.303
A. constricta	10	—	10	—	—	—	—	—	25	—	—	10	—	10	—	—	30	—	10	6.92
A. spp	20	—	—	—	—	—	—	10		10	—	240	—	—	—	—	40	—	—	3.046
Hesionidae																				
Hesione pantherina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	7.853
Leocratus claparedii	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	12.303

Transect -	[redacted]																			
Syllidae																				
Syllis ferrugina	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
S. spongicola	30	—	10	—	—	—	15	—	—	—	10	—	—	—	—	10	—	—	—	8.245
S. spp	—	—	10	—	—	—	—	—	40	—	—	—	—	—	—	—	—	—	—	5.252
Exogone sp	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Other syllids	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	12.303
Nereidae																				
Nereis sp	—	20	10	—	—	—	—	—	—	—	20	—	—	—	—	—	—	—	—	7.577
Other nereids	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
Nephtyidae																				
Nephtys inermis	—	20	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.048
N. dibranchis	20	20	—	20	—	10	40	40		30	20	105	40	30	25	100	30	—	20	12.487
N. polybranchia	20	—	30	—	—	—	—	—	—	—	10	—	20	—	—	—	—	35	—	7.365
N. sp1	—	10	—	—	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.106
N. sp2	—	50	—	—	—	—	—	—	—	—	15	—	10	—	—	10	—	—	—	5.944
N. sp 3	—	—	—	—	30	—	—	—	—	—	—	—	—	—	—	15	—	—	—	6.21
Lacydonidae																				
Paralacydonia paradoxa	—	10	15	—	10	10	—	—	—	—	—	—	—	—	—	10	—	—	—	10.08
Glyceridae																				
Glycera longipinnis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	20	6.964
G. sp1	55	30	10	—	10	10	15	—	—	50	40	—	20	—	—	—	—	—	—	8.852
G. sp2	—	30	10	—	—	—	—	—	—	—	—	—	—	—	60	—	—	—	10	5.356
G. sp3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	—	12.303
G. spp	—	—	—	—	20	—	—	—	10	—	—	—	—	—	45	—	—	10	—	6.249
Goniada sp	—	—	—	—	—	15	—	—	—	10	—	—	—	35	—	20	—	40	10	7.658
Eunicidae																				
Eunicinae																				
Eunice tentaculata	10	—	20	—	—	10	—	—	—	—	10	—	10	—	—	—	—	—	10	10.073
E. spp	—	—	—	25	30	—	20	10	—	—	—	—	20	—	—	—	—	—	—	7.729
Nematonereis unicornis	—	70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.998

Transect →	cape	fvm	klm	chn	vad	kanr	kanr	mngr	cnpr	btkl	btkl	goa	goa	rtngr	dbhl	cfmb	almb	prbn	dwrk	Niche breadth
Onuphinae																				
Diopatra neopolitana	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	12.303
Onuphis holobranchiata	65	—	—	—	—	10	10	10	—	15	20	—	—	—	20	—	10	—	—	7.988
Lumbrinerinae																				
Lumbrineris latreilli	—	20	10	120	30	—	70	40	15	20	—	60	20	10	30	40	20	20	50	12.881
L. aberrans	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
L. simplex	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5.728
L. heteropoda	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	12.303
L. spherocephala	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	12.303
L. spp	—	—	—	—	80	—	—	—	—	—	—	—	30	—	—	—	—	—	—	3.598
Arabellinae																				
Arabella iricolor iricolor	—	—	—	—	—	80	—	—	—	—	—	—	—	—	—	—	—	—	—	2.74
Dorvilleinae																				
Protodorvillea egena	—	40	—	—	10	—	—	—	40	—	—	—	—	—	—	—	—	—	—	5.271
Dorvillea rudolphi	—	—	—	—	—	10	—	—	—	—	—	—	30	—	—	—	—	—	—	6.353
Sedentaria																				
Spionidae																				
Polydora sp	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	10	—	—	—	10.657
Prionospio cirrifera	—	—	10	—	—	20	—	—	—	—	—	—	—	—	—	—	10	—	10	8.934
P. pinnata	—	40	80	—	—	—	—	—	—	10	295	—	—	140	80	—	—	10	10	5.225
P. cirrobranchiata	—	—	—	—	10	—	—	—	—	—	—	—	—	—	60	—	—	—	—	3.965
P. krusadensis	—	10	—	—	—	—	—	20	—	15	—	—	—	—	—	—	—	—	—	8.047
P. spp	—	—	—	—	10	90	75	20	20	—	210	230	155	200	—	20	60	40	40	9.334
Laonice sp	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
Other spionids	20	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.964
Magelonidae																				
Magelona cincta	10	—	10	10	15	360	25	1540	10	—	—	120	90	—	210	—	60	3870	520	3.908
Cirratulidae																				
Tharyx ?marioni	—	—	—	10	—	—	10	—	—	—	—	—	40	—	—	—	—	—	—	5.949
T. sp	10	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.353
Cirratulus dasylophius	—	—	—	—	—	—	—	—	10	—	10	10	130	—	—	30	—	—	—	3.965
Cirratulus sp1	10	10	—	—	60	—	—	—	—	—	—	—	—	—	540	10	—	—	—	2.021
C. sp2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	12.303
Cirriformia sp1	—	—	20	—	—	—	10	20	20	10	—	—	25	—	—	—	20	—	20	10.16
Other Cirratulids	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303

Transect →	cape	tvm	klm	chn	vad	kanr	kanr	mngr	cnpr	btkl	btkl	goa	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk	Niche breadth
Trochochaetidae																				
Poecilochaetus serpens	—	—	—	—	10	—	—	—	—	90	30	—	35	—	—	—	—	—	—	4.744
Chaetopteridae																				
?Chaetopterus sp	—	—	—	—	70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.998
Orbinidae																				
Phylo ?foetida foetida	—	—	—	—	—	—	10	—	—	25	—	10	—	—	—	—	—	—	—	7.665
Scoloplos johnstonei	—	70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	3.566
S. chavaliem	—	20	—	—	—	—	—	—	—	10	—	—	40	—	—	—	—	10	—	6.588
S. marsupialis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	12.303
S. sp	—	—	15	—	—	—	—	—	—	—	—	—	40	—	—	—	—	—	—	5.276
Other Orbinids	20	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	8.048
Paraonidae																				
Aricidea fauveli	—	—	—	—	10	—	—	—	20	—	—	—	—	—	—	—	—	—	—	8.048
A. sp1	—	20	10	—	—	—	—	—	—	—	—	—	10	—	—	—	—	10	—	8.934
Cirrophorus sp	—	—	20	—	10	10	45	40	—	—	40	75	40	—	15	—	55	—	30	10.331
Paraonides sp	—	—	—	—	—	—	—	—	—	—	—	—	80	—	—	—	—	—	—	2.74
Paraonis gracilis gracilis	—	40	10	—	20	—	20	—	90	—	—	—	—	—	20	—	15	—	10	7.342
P. sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	12.303
Other paraonids	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	12.303
Opheliidae																				
Armandia intermedia	—	—	—	—	—	—	10	—	20	—	—	—	15	—	—	—	—	—	—	8.047
A. sp	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Cossuridae																				
Cossura coasta	10	—	—	10	10	—	—	10	—	—	—	250	10	25	120	50	210	100	1390	3.835
Scalibregmidae																				
Hyboscolex longiseta	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Capitellidae																				
Pulliella armata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	12.303
Notomastus aberans	—	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	12.303
N. sp	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	12.303
Maldanidae																				
Maldanids	—	10	—	10	60	30	—	150	10	10	40	—	110	—	—	—	—	10	—	6.835
Sternaspidae																				
Sternaspis scutata	—	10	—	10	—	10	—	—	—	10	—	10	—	—	30	—	20	15	80	7.871

Transect →	cape	tvm	klm	chn	vad	kanr	kanr	mngr	cnpr	btkl	btkl	goa	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk	Niche breadth
Flabelligeridae																				
Diplocirrus capensis	—	—	—	—	—	—	—	—	10	—	—	—	10	—	—	—	—	—	—	10.657
Pectinariidae																				
Pectinaria sp	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	12.303
Ampharetidae																				
Melinninae																				
Melinna sp1	—	—	—	—	—	—	—	30	—	—	10	—	10	—	—	—	—	—	—	7
Ampharetinae																				
Amphicteis gunneri	10	10	—	—	—	10	—	—	10	10	—	—	10	—	30	10	—	—	—	10.362
A. sp	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Sabellides sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	—	12.303
Other ampharetids	—	10	—	—	—	—	15	—	—	—	—	—	20	—	—	—	20	—	—	8.073
Terebellidae																				
Trichobranchinae																				
Trichobranchus sp	10	10	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10.246
Terebellinae																				
Pista *brevibranchia*	—	—	—	—	—	—	—	—	—	—	20	—	—	—	—	—	—	—	—	7.853
P. indica	10	—	—	—	10	—	—	—	—	—	—	—	15	—	—	—	—	—	—	9.322
P. ?unibranchia	—	—	—	10	—	10	20	—	—	—	25	—	—	—	—	—	—	—	—	7.78
P. sp3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40	—	4.556
P. spp	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	12.303
Other terebellids	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
Sabellidae																				
Potamila ehleri	—	20	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	8.048
Jasmineira elegans	—	20	—	—	—	—	—	—	10	—	20	—	—	—	—	—	—	—	—	7.577
Other sabellids	—	—	—	—	—	10	—	—	20	—	—	—	—	—	—	—	—	—	—	8.048
Serpulidae																				
Serpulinae																				
Pomatoleios crosslandi	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.853
Filograninae																				
Portula tubularia	20	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.048
Un-identified polychaetes																				
2	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12.303
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	10	—	—	8.048
4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—	12.303
5	10	—	—	—	—	—	10	—	—	45	—	—	10	—	—	—	—	—	10	6.92

Transect →	cape	tvm	klm	chn	vad	kanr	kanr	mngr	cnpr	btkl	btkl	goa	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk
Crustaceans																			
Amphipods																			
Gammarus sp	345	60	20	10	—	30	30	—	30	60	35	100	10	20	15	10	20	115	10
Quadrivicio bengalensis	55	10	10	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Quadrivisio boneri	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Grandidierella gelesi	100	—	—	—	—	—	—	—	40	—	—	—	—	—	—	—	—	—	—
Corophium sp	100	10	—	10	—	10	10	—	—	—	—	—	—	—	—	—	20	—	50
Eriopisa sp	20	—	—	—	—	—	—	—	15	20	10	—	—	—	—	—	—	20	—
Caprellids	150	55	70	—	—	—	10	—	10	10	20	15	25	10	—	10	10	—	55
Other amphipod	100	90	30	40	—	10	—	40	70	50	50	10	40	—	—	10	65	90	670
Isopod																			
Isopods	75	120	10	10	10	10	10	10	70	—	20	—	10	10	—	—	60	20	30
Tanaid																			
Tanais sp1	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tanais sp 2	40	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Apseudes chilkensis	40	225	—	—	—	—	10	—	—	—	—	10	—	10	—	—	—	—	—
Other tanaids	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	10	—	10
Copepods	10	10	10	—	20	—	10	50	—	20	50	20	60	10	150	—	1295	20	160
Cumaceans	10	85	15	10	—	—	—	20	20	—	70	—	30	—	—	—	10	—	—
Ostracods	—	10	20	—	—	—	10	20	50	25	15	—	—	—	—	—	—	—	—
Pycnogonums	—	—	—	—	—	—	—	10	—	—	—	10	10	—	—	—	—	—	10
Mysids	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Decapod																			
Alpheius malabaricus	—	30	—	—	—	10	—	—	—	10	10	35	—	65	20	—	—	—	10
Prawns	—	—	—	—	10	—	—	—	—	—	—	—	—	—	10	—	30	—	—
CrabS	25	—	20	40	70	20	—	—	—	10	—	40	10	—	—	25	—	—	—
Hippa sp	10	15	—	—	—	—	20	10	—	—	20	—	—	—	—	—	—	—	—
Aristaeomorpha sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	—
Megalopa larvae	40	—	10	—	—	—	—	10	—	20	—	10	10	—	—	—	10	—	10
Other decapods	70	60	10	—	—	—	—	—	10	170	10	—	—	—	—	—	15	—	—
Stomatopods																			
Squilla sp	—	10	—	—	—	10	10	—	—	—	—	—	—	—	15	—	10	—	—
Other stomatopod	—	—	—	—	—	20	—	20	—	—	—	—	—	—	—	—	—	—	—
Acetus sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10
Other Sergestids	—	—	—	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	10
Unidentified crustaceans	10	10	—	—	—	—	—	—	10	—	10	—	—	—	—	—	60	—	—

Transect →	cape	tvm	klm	chn	vad	kanr	kanr	mngr	cnpr	btkl	btkl	goa	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk
Molluscs																			
Arca sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—
Tapes sp.	—	25	—	10	—	15	10	10	60	—	—	—	—	—	20	—	—	—	—
Other clams	—	70	20	20	70	—	—	20	10	—	—	—	—	—	10	10	—	—	—
Gastropods	—	20	—	—	10	—	—	—	—	—	—	—	15	—	—	—	—	—	—
Echnoderms																			
Brittle Star	40	—	20	—	—	—	—	40	10	15	10	—	—	—	—	—	—	—	—
Sea urchin	—	35	—	—	—	—	—	—	—	—	15	—	—	—	—	—	—	—	—
Cake urchin	—	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—
Star fish	—	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sipunculids	—	—	20	10	—	—	—	—	—	—	—	—	—	—	—	—	180	455	220
Amphioxus sp	25	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Echiuroids	—	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—
Eleutheronema sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	30	—	—	—	—
Other Fishes	—	—	—	—	—	—	10	20	—	10	—	10	—	—	—	—	10	—	10
Un identified organisms	65	120	100	70	20	90	60	—	905	235	60	40	50	—	60	30	200	1280	—

Table 6.1c. FAUNAL COMPOSITION OF MACROBENTHOS OF CONTINENTAL SHELF OF WEST COAST OF INDIA
76-100M (in no per sq m)

Transect →	rtngr	dbhl 1	dbhl 2	ofmb 1	ofmb 2	almb 1	almb 2	almb 3	almb 4	dwrk	Niche breadth
Depth →	76	96	94	96	89	79	85	91	95	100	
Station No. →	42	44C	44D	47	48	52	51	50	49	61	
Foraminiferans	---	20	40	---	---	---	---	60	---	---	
Hydrozoans	---	---	---	---	10	---	---	---	---	---	
Sea anemones	---	10	---	---	---	---	10	---	---	---	
Nematodes	10	10	---	---	---	20	---	---	---	20	
POLYCHAETES											
Errantia											
Aphroditidae											
Other Aphroditids	---	10	---	---	---	---	---	---	---	---	5.655
Amphinomidae											
Pseudeurythoe sp	---	---	---	---	---	---	410	---	---	30	1.449
Phyllodocidae											
Phyllodoce spp	---	---	---	---	---	---	---	---	---	10	5.406
Pilargidae											
Ancistrosyllis parva	35	40	20	10	15	10	50	---	---	20	7.179
A. constricta	---	---	---	---	---	---	10	---	---	---	5.655
Hesionidae											
Other hesionids	10	---	---	---	---	---	---	---	---	---	5.655
Syllidae											
Syllis spongicola	10	---	---	10	10	---	---	---	30	---	4.938
S. spp	---	---	---	---	10	10	---	---	---	---	5.406
Other syllids	---	10	180	---	---	---	---	---	---	---	1.57
Nephtyidae											
Nephtys dibranchis	---	---	10	---	---	---	20	---	---	10	4.931
N. polybranchia	20	---	---	10	10	10	10	---	---	10	6.949
N. sp2	10	10	---	10	10	10	---	---	---	20	6.949
N. sp 3	---	30	---	---	---	---	---	---	---	---	2.85

Transect →	rtngr	dbhl	dbhl	ofmb	ofmb	almb	almb	almb	almb	dwrk	Niche breadth
Lacydonidae											
Paralacydonia paradoxa	20	---	---	20	---	---	10	---	---	60	4.072
Glyceridae											
Glycera longipinnis	10	---	---	---	10	---	---	---	---	10	5.72
G. sp1	---	---	---	---	---	---	10	---	---	20	4.284
G. sp2	---	20	---	---	10	---	10	---	---	10	5.6
Goniada sp	---	---	---	10	---	---	---	---	---	20	4.28
Eunicidae											
Eunicinae											
Eunice tentaculata	30	---	---	---	---	---	30	---	10	10	4.692
E. spp	10	10	80	10	---	---	10	---	---	---	3.622
Nematonereis unicornis	---	---	---	---	---	---	---	---	---	10	5.655
Onuphinae											
Diopatra neopolitana	---	---	---	---	---	40	---	---	---	---	2.412
Onuphis holobranchiata	10	---	---	---	80	25	55	20	---	10	4.98
O. sp1	---	---	---	---	---	---	---	---	---	10	5.655
Lumbrinerinae											
Lumbrineris latreilli	20	10	---	40	0	10	80	---	---	30	5.094
L. spp	---	90	---	---	---	---	---	---	---	10	2.052
Arabellinae											
Arabella iricolor iricolor	10	---	---	---	---	---	---	---	---	---	5.655
Sedentaria											
Spionidae											
Prionospio pinnata	10	70	120	10	---	---	55	---	---	95	4.8612
P. cirrobranchiata	---	35	70	---	---	---	---	---	---	---	2.703
P. spp	---	---	---	---	10	---	90	---	---	---	2.053
Magelonidae											
Magelona cincta	90	70	80	---	---	10	60	10	---	20	5.713
Cirratulidae											
Cirratulus dasylophius	---	---	---	10	---	---	10	---	---	20	5.273
Cirratulus sp1	---	20	20	0	10	---	20	---	---	---	1
Cirriformia sp1	---	---	---	10	30	---	0	20	---	---	4.238

Transect	rtngr	dbhl	dbhl	ofmb	ofmb	almb	almb	almb	almb	dwrk	Niche breadth
Orbinidae											
Phylo ?foetida foetida	---	---	---	---	---	---	10	---	---	---	5.655
Scoloplos chavaliem	---	---	---	---	---	10	---	---	---	---	5.655
S. sp	---	---	---	---	130	---	---	---	---	---	1.465
Paraonidae											
Aricidea fauveli	---	10	50	---	---	---	---	---	---	10	3.338
A. sp1	---	---	---	---	---	---	10	---	---	---	5.655
Cirrophorus sp	10	---	---	25	---	---	30	---	---	10	4.82
Paraonis gracilis gracilis	30	20	50	---	---	---	20	---	---	10	5.167
P. sp	---	---	---	---	---	---	30	---	---	---	2.85
Ophelidae											
Armandia intermedia	---	---	---	---	---	10	---	---	---	---	5.655
Cossuridae											
Cossura coasta	---	20	---	10	---	---	---	---	---	20	4.65
Scalibregmidae											
Hyboscolex longiseta	10	---	---	---	---	---	---	---	---	---	5.655
Other scalibregmids	---	10	---	---	---	---	---	---	---	---	5.655
Maldanidae											
Maldanids	---	---	80	---	---	30	---	---	---	---	2.547
Sternaspidae											
Sternaspis scutata	---	---	---	---	10	---	---	---	---	10	5.4058
Flabelligeridae											
Other flabelligerids	---	30	---	---	---	---	---	---	---	---	2.85
Pectinariidae											
Pectinaria sp	---	---	---	---	---	---	---	---	10	---	5.655
Ampharetidae											
Melinninae											
Melinna sp1	---	---	10	---	---	---	---	---	---	---	5.655
Ampharetinae											
Amphicteis gunneri	---	---	---	---	10	---	---	---	---	10	5.406
Sabellides sp	---	70	---	---	---	---	---	---	---	---	1.8311
Ampharete sp	---	---	20	---	---	---	---	---	---	---	3.674
Other ampharetids	20	160	10	10	---	---	---	---	---	30	3.062

Transect	rtngr	dbhl	dbhl	ofmb	ofmb	almb	almb	almb	almb	dwrk	Niche breadth
Terebellidae											
Trichobranchinae											
Terebellides stroemi	---	---	---	---	---	---	10	---	---	10	5.406
Trichobranchus sp	---	60	---	---	---	---	---	---	---	---	1.962
Terebellinae											
Pista brevibranchia	---	---	10	---	---	---	---	---	---	---	5.655
P. ?unibranchia	---	---	---	---	---	---	---	---	---	10	5.655
P. spp	---	750	50	---	---	---	---	---	---	---	1.36
Sabellidae											
Potamila ehleri	---	---	50	---	---	---	---	---	---	30	2.99
Jasmineira elegans	---	80	10	10	---	---	---	---	---	20	3.363
Other sabellids	---	20	---	---	---	---	---	---	---	---	3.673
Serpulidae											
Serpulinae											
Pomatoleios crosslandi	---	---	---	40	---	---	---	---	---	---	2.412
Un-identified polychaetes											
5	---	---	---	---	---	---	30	10	---	---	3.546
6	---	---	30	---	---	---	---	---	---	---	2.85
Crustaceans											
Amphipods											
Gammarus sp	30	10	30	30	20	65	---	30	10	20	
Quadrivicio bengalensis	---	---	---	---	---	20	---	---	---	---	
Grandidierella gelesi	---	20	10	---	---	---	20	---	---	---	
Corophium sp	---	---	---	10	---	---	40	---	20	20	
Eriopisa sp	---	---	---	---	---	---	---	20	---	---	
Caprellids	10	---	10	20	10	20	40	20	---	50	
Other amphipod	35	10	90	40	30	70	60	---	20	160	
Isopods											
Isopods	10	10	20	35	---	20	20	10	---	20	
Tanaids											
Tanais sp 2	---	---	---	---	---	10	---	---	---	---	
Apseudes chilkensis	---	---	30	---	---	---	---	---	---	---	

Transect →	rtngr	dbhl	dbhl	ofmb	ofmb	almb	afmb	almb	almb	dwrk
Copepods	170	140	120	50	20	70	50	30	---	40
Cumacea	10	---	---	---	---	10	---	---	---	40
Ostracods	20	220	110	0	0	10	120	10	---	205
Pycnogonums	10	---	---	---	10	70	---	---	---	80
Mysids	---	---	---	---	---	---	10	---	---	---
Decapods										
Alpheius malabaricus	20	10	---	---	---	---	10	---	---	20
Crab	20	20	---	---	10	---	---	---	---	---
Hippa sp	---	---	---	---	10	---	---	---	---	---
Aristaeomorpha sp	---	---	---	10	30	---	---	---	---	---
Megalopa larvae	10	20	---	---	10	70	---	---	---	80
Other decapods	---	10	10	20	30	10	---	20	---	10
Stomatopods										
Squilla sp	---	10	---	---	---	---	---	---	---	---
Other stomatopods	---	---	---	10	---	---	---	---	---	---
Sergestids	---	---	10	---	---	---	---	---	---	---
Unidentified crustaceans	---	---	---	---	10	---	---	---	---	10
Molluscs										
Tapes sp.	10	---	10	---	---	10	20	---	---	---
Other clams	---	---	20	---	10	---	---	35	10	15
Gastropod	---	---	---	---	---	10	---	10	---	---
Echnoderms										
Brittle Star	---	10	---	---	---	30	20	---	---	---
Sea urchin	---	---	---	---	10	---	---	---	---	---
Cake urchin	---	---	---	---	---	---	50	10	---	---
Sipunculids	---	---	---	---	---	20	---	---	---	40
Echiuroids	---	10	---	---	---	---	---	---	---	---
Fishes	---	---	10	---	---	---	---	---	---	---
Unidentified organisms	---	20	190	60	50	---	70	10	---	215

Table 6.1d. FAUNAL COMPOSITION OF MACROBENTHOS OF CONTINENTAL SHELF OF WEST COAST OF INDIA 101-150m (in no per sq m)

Transect →	cape	tvm	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr	prbn	Niche breadth
Depth →	101	124	101	101	103	102	102	101	104	101	101	101	101	
Station No. →	3	5	11	15	16B	19	22	28	29B	31	38	43	56	
Nematodes	10	120	10	30	10	---	---	20	30	10	---	20	---	
POLYCHAETES														
Errantia														
Aphroditidae														
Sthenelais boa	---	10	---	---	---	---	---	---	---	---	---	---	10	7.018
S. sp	10	---	---	---	---	---	---	---	---	---	---	---	---	7.724
Other Aphroditids	---	---	---	---	20	---	---	---	10	---	---	---	---	5.423
Amphinomidae														
Paramphinome indica	---	20	20	---	---	---	---	---	10	---	---	10	---	6.234
Pseudeurythoe sp	---	---	10	---	---	---	---	10	---	---	---	---	10	7.113
Euphrosine spp	---	30	---	20	---	---	---	---	10	---	---	---	---	4.983
Eurythoe mathaii	---	10	---	---	---	---	---	---	---	---	---	---	---	7.724
E. Parvecarunculata	---	---	---	---	---	---	---	---	---	---	---	---	10	7.724
Other amphinomids	---	---	---	---	---	---	---	---	10	---	---	---	---	7.724
Phyllodocidae														
Phyllodoce dissotyla	15	20	---	---	---	---	---	---	10	---	---	---	---	5.817
P. spp	20	20	10	---	---	---	---	---	---	---	---	---	---	5.548
Pilargidae														
Ancistrosyllis parva	---	10	---	35	20	10	---	---	20	---	10	30	40	7.889
A. constricta	40	20	---	---	---	---	---	---	---	---	---	---	---	3.821
A. spp	---	30	---	---	---	---	---	---	---	---	---	---	---	3.7
Hesionidae														
Ophiodromus sp	---	20	---	---	---	---	---	---	---	---	---	---	---	4.92
Syllidae														
Syllis spongicola	20	130	---	---	---	---	---	---	---	---	---	---	10	2.524
Exogone sp	---	115	---	20	---	---	---	---	---	---	---	---	---	2.307
Other syllids	10	---	---	---	10	---	---	---	20	---	---	---	---	6.004

Transect →	cape	tvm	klm	chn	vad	cal	kanr	mngr	cnpr	btkl	goa	rtngr	prbn	Niche breadth
Nereidae														
other nereids	10	40	30	50	---	---	---	---	---	---	---	10	---	5.355
Nephtyidae														
Nephtys dibranchis	---	---	---	---	15	---	10	10	---	---	10	---	---	7.082
N. polybranchia	25	---	---	---	---	---	---	---	---	---	10	---	10	5.512
N. sp1	---	---	---	10	10	---	---	---	---	---	---	---	---	7.018
N. sp2	---	---	---	---	---	---	20	10	---	---	---	---	10	6.005
N. sp 3	---	---	---	---	15	---	---	---	20	---	---	---	---	5.171
Lacydonidae														
Paralacydonia paradoxa	---	---	---	---	---	---	---	---	---	---	---	---	20	4.92
Glyceridae														
Glycera longipinnis	---	20	---	---	---	---	10	10	---	20	20	20	---	7.408
G. sp1	10	10	---	---	---	---	---	---	---	---	---	10	---	7.113
G. sp2	---	10	40	0	60	0	10	---	---	10	---	---	---	4.842
G. spp	---	---	---	10	---	---	---	---	10	---	---	10	---	7.113
Goniada sp	10	---	---	20	---	10	10	---	---	20	20	---	---	7.46
Eunicidae														
Eunicinae														
Eunice tentaculata	---	---	---	---	---	20	---	---	---	10	---	10	10	6.627
E. spp	---	---	---	---	10	---	---	---	10	---	---	---	---	7.018
Onuphinae														
Hyalinoecia tubicola	---	---	---	---	---	---	---	---	---	---	10	---	---	7.724
Onuphis eremita	---	---	---	---	---	---	---	---	---	---	10	---	---	7.724
O. holobranchiata	30	25	---	---	---	---	---	---	60	---	---	10	---	4.621
O. sp1	---	---	---	---	---	---	---	---	---	---	---	---	45	2.823
Lumbrinerinae														
Lumbrineris latreilli	---	55	0	30	55	---	10	30	40	20	10	---	10	8.05
L. aberrans	---	---	---	10	---	---	---	---	---	---	---	---	---	7.724
L. heteropoda	---	---	---	---	---	20	10	10	10	---	---	---	10	7.271
L. spp	---	---	---	---	20	---	---	---	---	---	---	---	---	4.92
Dorvilleinae														
Protodorvillea egena	10	---	---	---	---	---	---	---	10	---	---	---	---	7.018
Dorvillea rudolphi	20	40	---	---	---	---	---	---	---	---	---	---	---	3.821

Transect →														
Sedentaria														
Spionidae														
Malacoceros indicus	10	---	---	---	50	---	---	---	---	---	---	---	---	3.265
Prionospio cirrifera	---	---	---	---	---	---	---	---	---	40	60	---	---	3.212
P. pinnata	800	115	10	120	230	120	125	0	0	85	155	190	50	7.183
P. cirrobranchiata	10	---	---	---	45	---	---	---	---	---	---	---	---	3.474
P. krusadensis	---	---	10	30	---	---	---	---	---	---	---	---	---	4.391
P. spp	---	---	---	---	70	---	120	40	90	310	---	---	---	4.214
Laonice sp	---	---	---	---	---	---	---	25	---	---	---	---	---	4.204
Other spionids	---	---	---	---	80	---	---	0	---	---	---	---	---	2.037
Magelonidae														
Magelona cincta	30	30	10	30	30	10	40	---	40	10	20	---	10	10.013
Cirratulidae														
Tharyx ?marioni	---	---	---	70	---	---	15	---	---	---	---	---	---	2.839
T. sp	15	---	---	---	---	---	---	---	---	---	---	20	---	5.171
Cirratulus dasylophius	---	---	---	---	20	---	---	---	---	---	20	---	---	4.546
Cirratulus sp1	---	20	---	---	60	10	---	0	---	---	20	---	---	6.956
Cirriformia sp1	---	50	10	---	---	---	---	10	---	20	20	20	10	4.866
Other Cirratulids	50	20	---	10	---	---	---	---	---	---	---	---	---	4.075
Trochochaetidae														
Poecilochaetus serpens	---	---	---	10	---	---	---	---	---	20	15	---	---	5.817
Orbinidae														
Phylo ?foetida foetida	---	---	---	10	---	10	---	---	---	---	---	---	---	7.018
Scoloplos chavaliem	---	10	---	---	---	---	---	10	10	---	---	---	20	6.627
S. sp	---	---	---	---	---	---	---	---	---	---	---	---	10	7.724
Other Orbinids	---	10	---	---	---	---	---	---	---	---	---	---	10	7.018
Paraonidae														
Aricidea fauveli	---	---	---	---	10	20	---	10	---	---	---	---	---	6.005
A. sp1	---	---	---	---	---	---	---	---	---	0	15	---	10	10.589
Cirrophorus sp	---	10	---	60	10	10	---	---	---	20	20	20	20	7.365
Paraonides sp	---	20	---	---	---	---	---	---	---	---	---	---	---	4.92
Paraonis gracilis gracilis	---	70	---	45	40	---	10	---	---	10	---	10	10	5.925
P. sp	---	---	---	---	---	---	---	---	---	---	---	---	10	7.724

Transect														
Ophelidae														
Armandia intermedia	---	---	40	---	---	---	---	---	---	---	---	---	---	3.045
Cossuridae														
Cossura coasta	---	---	---	---	---	---	---	20	---	20	15	---	35	5.57
Capitellidae														
Pulliella armata	---	10	---	---	---	---	---	---	---	---	---	---	---	7.724
Notomastus aberans	20	---	---	---	---	---	---	---	---	---	---	---	---	4.92
N. giganteus	10	---	---	---	---	---	---	---	---	---	---	---	---	7.724
Dasybranchus spp	---	---	110	---	---	---	---	---	---	---	---	---	---	1.761
Maldanidae														
Maldanids	---	20	---	10	20	---	---	---	---	---	---	---	20	6.066
Sternaspidae														
Sternaspis scutata	---	---	---	---	---	---	---	10	---	---	---	---	---	7.724
Pectinariidae														
Pectinaria sp	---	---	---	---	---	---	---	---	---	---	---	10	---	7.724
Ampharetidae														
Melinninae														
Melinna sp1	10	---	---	10	---	---	---	---	---	---	---	---	---	7.018
Ampharetinae														
Amphicteis gunneri	40	---	---	---	---	---	---	10	---	---	10	10	---	5.09
Sabellides sp	---	---	---	---	---	---	---	10	---	---	---	---	---	7.724
Other ampharetids	10	10	---	---	---	---	---	---	---	---	40	70	---	4.064
Terebellidae														
Trichobranchinae														
Trichobranchus sp	---	---	---	---	---	---	---	---	---	---	10	---	---	7.724
Terebellinae														
Pista quadrilobata	---	---	---	---	---	---	---	---	---	---	---	110	---	1.761
P. indica	20	---	---	---	---	---	---	---	---	---	40	---	---	3.821
P. ?unibranchia	---	20	---	10	10	---	---	---	---	---	---	---	---	6.005
P. sp1	10	---	---	---	---	10	---	---	---	---	---	---	---	7.018
P. spp	---	---	---	---	10	---	---	---	10	---	---	---	---	7.018
Sabellidae														
Jasmineira elegans	30	35	---	10	---	---	---	---	---	10	---	50	---	5.415

Transect -														
Serpulidae														
Filograninae														
Portula tubularia	30	---	---	---	---	---	---	---	---	---	---	---	---	3.7
***Un-identified polychaetes* 5**	---	25	---	---	---	---	10	---	---	---	---	---	---	4.849
total polychaetes	1315	1100	310	630	630	250	400	225	400	625	560	620	410	
Crustaceans														
Amphipods														
Gammarus sp	215	85	10	20	---	---	---	10	100	10	---	10	20	
Quadrivicio bengalensis	20	10	---	---	---	---	---	---	---	---	---	---	---	
Grandidierella gelesi	---	---	---	---	---	---	---	---	20	---	---	---	---	
Corophium sp	225	10	10	---	---	---	10	10	---	30	---	---	10	
Eriopisa sp	10	---	---	---	---	---	---	---	---	---	---	---	---	
Caprellids	630	40	---	---	---	---	15	---	---	30	10	---	10	
Other amphipods	60	120	70	40	10	20	20	---	---	15	---	---	45	
Isopods														
Isopods	70	35	---	140	---	---	30	10	10	10	50	30	50	
Tanaids														
Tanais sp1	20	---	---	---	---	---	---	---	---	---	---	---	---	
Tanais sp 2	10	---	---	---	---	---	---	---	---	---	---	---	---	
Apseudes chilkensis	10	---	---	10	---	---	---	---	10	---	10	---	---	
Copepods	50	10	---	---	10	---	20	---	---	---	---	40	215	
Cumaceans	20	---	---	---	---	---	---	10	---	---	---	20	20	
Ostracods	30	---	10	10	---	10	---	10	---	70	---	---	85	
Pycnogonums	10	10	---	10	---	---	10	---	10	10	---	10	---	
Mysids	---	---	---	---	---	---	---	---	10	---	---	---	---	
Decapods														
Alpheius malabaricus	---	---	---	---	30	65	40	95	---	40	10	0	25	
Prawns	---	---	---	---	---	10	---	---	---	---	---	---	---	
Crabs	---	---	---	---	---	0	---	30	---	---	---	---	---	
Lobsters	---	30	---	---	---	---	---	---	---	---	---	---	---	

Transect →	cape	tvm	klm	chn	vad	cal	kanr	mngr	cnpr	btkl	goa	rtngr	prbn
Hippa sp	40	10	10	---	10	---	---	---	10	---	---	---	---
Megalopa larvae	10	20	---	20	---	---	10	---	---	10	---	10	---
Other decapods	20	---	---	---	20	---	10	---	---	20	20	10	---
Stomatopods													
Alima larvae	10	---	---	---	---	---	---	---	---	---	---	---	---
Other Sergestids	---	---	---	---	---	---	---	---	---	---	---	---	10
Unidentified crustaceans	---	---	---	---	---	---	---	---	---	10	---	---	---
Molluscs													
Oyster	---	10	---	---	---	---	---	---	---	---	---	---	---
Tapes sp.	---	---	---	10	10	---	---	---	---	---	---	20	---
Other clams	---	20	10	---	---	10	---	---	10	---	20	---	20
Gastropods	---	---	---	---	10	---	---	---	---	---	---	---	---
Echnoderms													
Brittle Star	10	10	---	---	---	---	---	---	---	---	---	10	150
Sea urchin	---	---	---	10	---	---	---	---	---	---	---	---	---
Cake urchin	---	---	---	---	---	---	---	---	---	---	---	---	15
Amphioxus	---	---	20	---	---	---	---	---	60	---	10	10	---
Eel					10								
Other fishes	---	---	---	---	---	---	---	10	---	10	---	---	---
Unidentified organisms	20	30	---	---	90	---	---	20	110	10	190	100	110

Table 6.1[illegible] FAUNAL COMPOSITION OF MACROBENTHOS OF CONTINENTAL SHELF OF WEST COAST OF INDIA >150M (in no per sq m)

Transect →	cape	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr	dbhl	prbn	dwrk	Niche breadth
Depth →	208	238	202	197	219	202	205	200	206	206	211	192	210	200	
Station No. →	4	12	16	16A	20	21	29	29A	30	39	44	44E	55	62	
Foraminiferans	—	—	—	—	—	—	—	—	—	—	—	—	20	—	
Hydrozoans	—	—	—	—	—	—	65	—	10	—	—	—	—	—	
Sea anemone	—	—	—	—	—	—	—	10	—	—	—	—	—	—	
Nematodes	30	120	—	—	—	—	—	—	—	—	—	—	—	—	
Sponges	—	—	—	—	—	—	—	—	—	—	—	80	—	—	
POLYCHAETES															
Errantia															
Amphinomidae															
Paramphinome indica	—	—	—	—	—	—	—	10	—	—	—	—	—	—	8.451
Pseudeurythoe sp	—	—	—	—	—	—	—	—	—	—	—	—	20	—	5.37
Eurythoe Parvecarunculata	—	—	—	—	—	—	—	—	—	—	—	—	35	—	3.592
E. sp	—	—	—	—	—	—	—	—	—	—	—	—	—	30	4.008
Phyllodocidae															
Phyllodoce dissotyla	20	—	—	—	—	—	—	—	—	—	—	—	—	—	5.37
Alciopidae															
Alciopids	—	—	—	—	—	—	—	—	—	—	—	10	—	—	8.451
Pilargidae															
Ancistrosyllis parva	—	—	—	—	—	—	—	10	—	—	—	—	20	10	6.385
A. spp	—	—	—	—	—	—	—	—	—	—	—	—	10	—	8.451
Hesionidae															
Other hesionids	—	—	—	—	—	—	—	20	—	—	—	—	—	—	5.37
Nereidae															
Other nereids	—	—	—	—	—	—	—	—	—	—	—	30	—	—	4.008
Nephtyidae															
Nephtys dibranchis	—	—	—	10	—	10	—	—	—	—	—	—	—	—	7.588
N. polybranchia	10	—	—	—	—	—	—	—	—	—	—	—	—	—	8.451
Glyceridae															
Glycera sp1	—	10	—	—	—	—	—	—	—	—	—	—	—	—	8.451
G. sp2	—	—	20	10	—	—	—	—	—	—	—	—	—	—	5.829
Goniada sp	20	10	—	—	10	10	—	—	—	—	—	—	—	—	6.99

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Eunicidae															
Eunicinae															
Eunice spp	30	—	—	—	—	—	—	—	—	—	—	10	—	—	4.694
Onuphinae															
Onuphis holobranchiata	20	—	—	—	—	—	—	—	—	—	—	—	—	—	5.37
Lumbrinerinae															
Lumbrineris latreilli	—	20	—	—	—	—	—	—	—	—	—	—	—	—	5.37
Dorvilleinae															
Dorvillea sp	—	—	—	—	—	—	—	—	—	—	—	10	—	—	8.451
Sedentaria															
Spionidae															
Spio ?filicornis	—	—	—	—	—	—	—	140	—	—	—	—	—	—	1.663
Prionospio cirrifera	—	240	—	—	—	—	75	—	65	—	—	—	—	—	2.952
P. pinnata	135	30	10	1890	145	145	—	—	—	35	—	—	—	—	2.342
P. cirrobranchiata	—	—	—	—	—	—	—	310	—	—	—	—	—	—	1.313
P. krusadensis	—	—	10	—	—	—	—	—	—	—	—	—	—	—	8.451
Aonides oxycephala	—	—	—	—	—	—	—	—	—	—	—	—	40	—	3.275
Other spionids	—	—	—	20	—	—	—	—	10	—	—	—	—	—	5.83
Magelonidae															
Magelona cincta	20	95	25	50	—	—	—	—	—	10	—	—	—	—	4.733
Cirratulidae															
Tharyx ?marioni	—	—	10	—	30	20	—	—	—	—	—	—	—	—	5.245
T. sp	10	—	—	—	—	—	—	—	—	—	—	—	—	—	8.451
Cirratulus dasylophius	—	20	—	—	—	—	60	—	120	—	—	—	—	—	5.83
Cirratulus sp1	—	—	—	20	—	—	—	10	—	—	—	—	—	—	8.451
C. sp2	—	—	—	—	—	—	—	10	—	—	—	—	—	—	1.715
Cirriformia sp1	10	265	—	—	—	—	—	—	10	—	—	—	—	—	3.257
Other Cirratulids	—	—	20	—	—	—	—	—	—	—	—	—	—	—	5.37
Orbinidae															
Other Orbinids	—	—	—	—	—	—	—	—	—	—	—	—	—	20	5.37
Paraonidae															
Aricidea fauveli	240	—	10	30	—	10	0	10	—	—	—	—	—	—	2.516
A. sp1	—	—	—	—	—	—	30	—	—	—	—	—	—	—	4.008
Cirrophorus sp	100	—	—	—	10	10	—	10	—	—	—	—	—	—	3.186
Paraonis gracilis gracilis	295	—	10	80	—	10	—	10	—	—	—	—	75	10	3.636

Cossuridae															
Cossura coasta	—	—	50	—	—	10	20	—	20	10	—	—	10	—	6.347
Capitellidae															
Dasybranchus spp	—	—	—	—	—	—	—	—	—	10	—	—	—	—	8.451
Maldanidae															
Maldanids	40	—	—	—	—	—	—	—	—	—	—	—	—	—	3.275
Ampharetidae															
Melinninae															
Melinna sp1	15	—	—	—	—	—	—	—	—	—	—	20	—	—	5.535
Ampharetinae															
Amphicteis gunneri	—	—	—	—	20	20	—	—	—	—	—	—	—	—	5.19
A. sp	—	—	—	—	—	—	—	—	—	—	—	40	—	—	3.275
Other ampharetids	—	—	—	—	—	—	—	—	—	—	—	10	—	—	8.451
Terebellidae															
Terebellinae															
Pista ?unibranchia	10	—	—	—	—	—	—	—	—	—	—	—	—	—	8.679
Sabellidae															
Megalomma quadriculatum	—	—	—	—	—	—	—	—	—	—	—	230	—	—	1.413
Potamila ehleri	25	—	—	—	—	—	—	—	—	—	—	—	—	—	4.572
P. sp	—	—	—	—	—	90	—	—	—	—	—	—	—	—	2.019
Other sabellids	—	—	—	—	—	—	90	—	—	—	—	—	—	—	2.019
Un-identified polychaetes 2	—	—	—	—	—	10	—	—	—	—	—	—	—	—	8.451
Crustaceans															
Amphipods															
Gammarus sp	20	—	—	—	—	10	—	20	—	—	—	10	—	—	
Quadrivicio bengalensis	20	—	—	—	—	—	—	—	—	—	—	—	—	—	
Corophium sp	175	—	—	—	30	—	—	—	—	10	15	—	60	30	
Caprellids	235	—	—	—	20	—	—	10	—	—	10	—	70	50	
Other amphipod	310	—	—	—	—	15	—	—	10	—	—	—	80	30	
Isopods															
Isopods	275	10	20	—	20	40	10	—	—	20	35	10	55	20	
Tanaids															
Other tanaids	—	—	—	—	—	—	—	10	—	—	—	—	20	—	

Transect →	cape	klm	chn	vad	cal	kanr	mngr	cnpr	btkl	goa	rtngr	dbhl	prbn	dwrk
Copepods	75	—	—	500	—	—	10	15	—	—	35	60	240	1565
Cumaceans	—	—	—	—	—	10	10	10	—	—	—	—	—	—
Ostracods	10	—	—	620	—	—	—	—	—	—	10	—	—	—
Pycnogonums	10	—	—	—	—	—	—	—	—	10	—	—	40	—
Decapods														
Alpheius malabaricus	—	—	—	—	10	30	45	100	20	—	—	—	—	—
Crabs	—	—	—	—	—	—	—	—	—	—	—	20	—	—
Hippa sp	—	—	—	—	—	—	—	—	—	—	—	0	10	—
Aristaeomorpha sp	—	—	—	—	—	—	—	—	—	—	—	—	—	10
Megalopa larvae	10	—	—	—	—	—	—	—	—	10	—	10	40	—
Other decapods	40	—	115	10	10	—	10	—	—	—	—	10	10	10
Stomatopods														
Alima larvae	—	—	—	—	—	—	—	—	—	—	10	—	—	—
Sergestids	—	—	—	20	—	—	—	10	—	10	—	—	10	10
Unidentified crustaceans	—	—	—	—	—	—	—	—	—	—	—	—	—	10
Molluscs														
Arca sp	—	—	—	—	10	—	—	—	—	—	—	—	—	—
Other clams	20	—	—	—	—	—	—	—	—	—	—	—	80	20
Gastropods	—	—	—	—	—	—	—	—	—	—	—	—	10	—
Dentalium	—	—	—	—	—	—	—	10	—	—	—	—	—	—
Fishes	—	—	10	—	—	—	—	—	—	—	—	—	—	—
Un identified organisms	30	—	—	100	30	40	40	140	70	—	—	—	—	40

species, group Sedentaria by 89 species and 6 were unidentified. These species are from 13 families of Errantia and 19 families of Sedentaria.

Polychaete species based on the abundance were differentiated in to three groups as "abundant", "moderately present" and "rare". The 'abundant' ones were those observed at least in 50% of stations in any of the depth range. The 'rare' corresponds to those which were represented by one or two individuals in a single grab haul in one depth range only. The 'moderately present' were those, which occupy an intermediate position between the above two. As a whole, 15 species were considered abundant, 116 moderately present and 34 rare. The list of these three groups is presented in Table 6.2.

In the 30-50m depth range, a total of 117 polychaete species were noticed. Among this, 51 species were from Errantia, 63 species were from Sedentaria and 3 were unidentified. Among these 15 were abundant, 82 moderately present, and 20 rare. Of the total individuals, 28.82% were from errantian group and 71.18% of individuals were from sedentarian group. Very high occurrence of *Magelona cincta* was noticed off Vadanappilly (St. no. 16D) and *Sternaspis scutata* off Porbandar (St. No. 58). Most abundant species in this depth range was *Ancystrocyllis parvae, Nephtys dibranchis, Lumbrineris latreilli, Prionospio pinnata, P. spp. Magelona cincta, Cirrophora sp, Cossura costa* and *Sternaspis scutata.*

In the 51-75m depth range, a total of 114 species were observed. Among this, Errantia was represented by 51 species, Sedentaria was represented by 59

Table 6.2. List of polychaete species and its occurrence in various depths

S = Sand; SiS = Silty sand; SSi =Sandy silt; Si = Silt; CSi = Clayey silt; SiC = Silty clay; SSiC = Sand silt clay; A =abundant; M =Moderately present; R =Rare

No	Species	Occurrence	Depth	Sub. Preference
	Errantia			
	Aphroditidae			
1	*Sthenelais boa*	M	30-75 & 101-150	S,SSiC,Si
2	*Sthenelais sp*	M	51-75 & 101-150	CSi,S
3	Other Aphroditids	M	51-150	S,SiS
	Amphinomidae			
4	*Euphrosine spp*	M	30-75 & 101-150	S,SiS
5	*Eurythoe mathaii*	M	51-75 & 101-150	S
6	*E.parvecarunculata*	M	30-75 & 101-200	CSi,SiC
7	*E. sp*	M	51-75 & >150	CSi
8	*Pseudeurythoe sp*	M	30-150	S,SiS,Si,Sic
9	*Paramphinome indica*	M	51-75 & 101-200	S
10	*other amphinomids*	M	76-150	S
	Pisionidae			
11	*Pision oerstedi*	R	51-75	S
	Phyllodocidae			
12	*Phyllodoce dissotyla*	M	30-50 & 101-200	S
13	*P. spp*	M	30-150	S
14	*other phyllodocids*	M	30-50	S
	Alciopidae			
15	*Alciopids*	M	51-75 & >150	S
	Pilargidae			
16	*Ancysistrosyllis parva*	A	30-200	S,SiS,SSiC,Si,CSi,Si
17	*A. constricta*	M	30-150	S,CSi,SSiC,SiC
18	*A. spp*	M	30-75 & 101-200	CSi,SiC,S,SSiC
	Hesionidae			
19	*Hesione pantherina*	M	30-75	CSi,SiC
20	*Leocratus claparedii*	R	51-75	SiC
21	*Ophiodromus sp*	R	101-150	S
22	*Syllidia sp*	R	30-50	S
23	Other hesionids	M	30-50, 76-100 &	CSi,S,SiS
	Syllidae			
24	*Syllis ferrugina*	M	30-75	S,CSi
25	*S. spongicola*	M	30-150	S,Sic,CSi,SiS,Si
26	*S. spp*	M	51-75	S
27	*Eusyllis blomstrandi*	R	30-50	S
28	*Exogone sp*	M	51-75 & 101-150	S,SiS
29	*other syllids*	M	51-150	S
	Nereidae			
30	*Ceratonereis mirabilis*	R	30-50	CSi
31	*Nereis agulhana*	R	30-50	CSi
32	*Nereis sp*	M	3075	S,CSi

No	Species	Occurrence	Depth	Sub. Preference
33	*other nereids*	M	30-75 & 101-200	S,SiC,SiS
	Nephtyidae			
34	*Nephthys inermis*	M	30-75	CSi,S
35	*N. dibranchis*	A	30-200	S,CSi,SiC,SiS,SSiC
36	*N. polybranchia*	A	30-200	S,CSi,SiS,SiC
37	*N. sp1*	M	51-75 & 101-150	S,SiS
38	*N. sp2*	A	30-150	S,SiS,CSi,Si
39	*N. sp 3*	M	30-150	CSi
	Lacydonidae			
40	*Paralacydonia paradoxa*	M	30-50	S,CSi,SiC,SiS,Si
	Glyceridae			
41	*Goniada emerita*	R	30-50	S
42	*Goniada sp*	M	30-200	S,CSi,SiC,SiS,Ssi
43	*Glycera longipinnis*	M	30-150	S,CSi,SiC,SiS,Ssi
44	*G. rouxii*	R	30-50	S
45	*G. sp1*	M	30-200	S,CSi,SiC,SiS
46	*G. sp2*	M	30-200	S,CSi,SiC,SSi
47	*G. sp3*	R	51-75	SiC
48	*G. spp*	M	30-75 & 101-150	CSi,SiC,SiS
	Eunicidae			
	Eunicinae			
49	*Eunice indica*	R	30-50	S
50	*E.coccinia*	M	30-50	S
51	*E.tenteculata*	M	30-150	S
52	*E.spp*	M	30-200	S,SiS
53	*Nematonereis unicornis*	M	30-100	S
	Onuphinae			
54	*Diopatra neopolitana*	M	51-100	S,CSi
55	*D. sp*	M	30-50	S
56	*Hylenicoecia tubicola*	R	101-150	S
57	*Onuphis eremita*	R	101-150	S
58	*O. holobranchiata*	M	30-200	S,SiC,SiS,
59	*O. investigatoris*	M	30-50	S
60	*O.sp1*	M	30-50 & 76-150	S,Si
	Lumbrinerinae			
61	*Lumbrineris aberrans*	M	30-75 & 101-150	S,CSi,SiS
62	*L.latreilla*	A	30-200	S,CSi,SiC,SSiC,SiS,
63	*L.simplex*	M	30-75	S,SiC
64	*L. heteropoda*	M	30-75 & 101-150	S,CSi,SiS,Si
65	*L. spherocephala*	M	30-75	S,SiC
66	*L.spp*	M	30-150	S,SiS
	Arabellinae			
67	*Arabella iricolor iricolor*	M	30-100	S,SiS
	Dorvilleinae			
68	*Protodorviellea egena*	M	30-75 & 101-150	S,CSi
69	*Dorvillea rudolphi*	M	30-75 & 101-150	S,SiS
70	*D. sp*	R	>150	S

No	Species	Occurrence	Depth	Sub. Preference
	Sedentaria			
	Spionidae			
71	*Polydora sp*	M	51-75	CSi
72	*Laonice cirrata*	M	30-50	S
73	*L. sp*	M	30-75 & 101-150	S,SiS
74	*Spiophanes bombyx*	M	30-50	S
75	*Malacoceros indicus*	M	30-50 & 101-150	S
76	*Spio ?filicornis*	M	>150	S
77	*Prionospio cirrifera*	M	30-75 & 101-200	S,CSi,Sic,SiS,SSi
78	*P.pinnata*	A	30-200	S,CSi,SiC,SiS,Si
79	*P. cirrobranchiata*	M	30-200	S
80	*P. krusadensis*	M	51-75 & 101-150	S,SiS
81	*Prionospio spp*	A	30-150	S,CSi,SiC,SiS,SSiC,S
82	*Aonides oxycephala*	M	30-50 & >150	S,SiC
83	*Scololepis sp*	M	30-50	S
84	*Other spionid*	M	30-75 & 101-200	CSi
	Magelonidae			
85	*Magelona cincta*	A	30-200	S,CSi,SiC,SiS,SSiC,S
	Cirratulidae			
86	*Cirriformia sp1*	A	30-200	S,CSi,SiS,SiC,Ssi,Si
87	*C.sp2*	R	30-50	CSi
88	*Cirratulus dasylophius*	M	30-200	S,SSiC,SiS,CSi,SiC
89	*C. sp1*	M	30-200	S,CSi, SiC, SiS, Ssi,
90	*C. sp 2*	M	51-75 & >150	CSi
91	*Dodecaceria capensis*	R	30-50	S
92	*Tharyx ?marioni*	M	30-75 & 101-200	S,CSi,SiS
93	*T. sp*	M	30-75 & 101-200	S,SiC
94	*Other cirratulids*	M	51-75 & 101-200	S,SiS
	Trichochaetidae			
95	*Poecilochaetus serpens*	M	30-75 & 101-150	S,SiS,Ssi,Si
	Chaetopteridae			
96	*?Chaetopterus sp*	M	51-75	SiS
	Orbinidae			
97	*Scoloplella sp*	R	30-50	S
98	*Phylo ?foetida foetida*	M	30-150	S,SSiC,SiS
99	*P.sp*	R	30-50	S
100	*Scoloplos johnstonei*	M	30-75	S,SiC
101	*S. chavaliem*	M	30-150	S,CSi,SiS,SiC,Si
102	*S. marsupialis*	R	51-75	SiC
103	*S. sp*	M	30-150	S,CSi,SiS,Si
104	*Other orbinids*	M	30-75 & 101-200	S,CSi,Si
	Paraonidae			
105	*Arecidea fauveli*	M	51-200	S,SiS
106	*A. sp 1*	M	30-200	S,SiC,SiS
107	*A. sp 2*	R	30-50	S
108	*Cirrophorus sp*	A	30-200	S,CSi,SiC,SiS,SSiC,S
109	*Paraonides sp*	M	30-75 & 101-150	S,SiS

No	Species	Occurrence	Depth	Sub. Preference
110	*Paraonis gracilis gracilis*	A	30-200	S,CSi, SiC,SiS,SSi,Si
111	*P. sp*	M	51-150	S,Si
112	Other paraonids	R	30-50	S
	Ophelidae			
113	*Armandia intermedia*	M	30-150	S,CSi,SiS
114	*A. sp*	R	51-75	S
115	*Polyophthalmus pictus*	R	30-50	S
116	Other ophelids	M	30-50	CSi
	Cossuridae			
117	*Cossura coasta*	A	30-200	S,SiC,CSi,SiS,SSiC,S
	Scalibregmidae			
118	*Hyboscolex longisepta*	M	51-100	S,SiS
119	*Other scalibregmids*	R	76-100	SiS
	Capitellidae			
120	*Puliella armata*	M	30-75 & 101-150	S,SiC,CSi
121	*Notomastus aberans*	M	51-75 & 101-150	S
122	*N. giganteus*	R	101-150	S
123	*N. sp*	M	30-75	CSi
124	*Dasibranchus ?cadacus*	R	30-50	S
125	*D. spp*	M	30-50 & 101-200	S
	Maldanidae			
126	*Maldanids*	A	30-200	S,CSi,SSiC,SiC,SiS,S
	Sternaspidae			
127	*Sternaspis scutata*	A	30-150	S,SiC,CSi,SiS,SSiC
	Flabelligeridae			
128	*Diplocirrus capensis*	M	51-75	SiS
129	*Other flabelligerids*	M	76-100	SiS
	Pectinaridae			
130	*Pectinaria sp*	M	30-150	S,CSi
	Ampharetidae			
	Melinninae			
131	*Melinna cristata*	R	30-50	S
132	*M. sp*	M	30-200	S
	Ampharetinae			
133	*Amphicteis gunneri*	M	30-200	CSi
134	*A. sp*	M	30-75 & >150	S,CSi,SiS,CSi,
135	*Sabellides sp*	M	30-150	S
136	*Ampharete sp*	R	76-100	SiC,SiS
137	*Other ampharetids*	A	30-200	S,SiS,SiC
	Terebellidae			
	Trichobranchinae			
138	*Trichobranchus sp*	M	51-150	S
139	*Terebellides stroemi*	M	30-50 & 76-100	S,SiC,CSi
	Terebellinae			
140	*Pista quadrilobata*	M	101-150	S
141	*P. brevibranchia*	M	30-100	S
142	*P. indica*	M	30-75 & 101-150	S,SiS

No	Species	Occurrence	Depth	Sub. Preference
143	*P. unibranchia*	M	30-200	S,SiS
144	*P. sp1*	M	101-150	S
145	*P. sp2*	M	30-50	S
146	*P. sp3*	M	30-75	CSi,SiC
147	*P. spp*	M	30-150	S,SiS
148	*Other terebellids*	R	51-75	SiS
	Sabellidae			
149	*Megalomma vesiculosum*	R	30-50	S
150	*M. quadriculatum*	M	>150	S
151	*M. sp*	M	30-50	S
152	*Potamila ehleri*	M	51-200	S
153	*P. sp*	M	30-50 & >150	S,SiS
154	*Jasmineira elegans*	M	30-150	S,SiS,SSi
155	*Other sabellids*	M	30-100 & >150	S,SiS
	Serpulidae			
	Serpulinae			
156	*Pomatoleios crosslandi*	M	51-100	S
157	*Hydroides norwegica*	R	30-50	S
158	*Hydroides albiceps*	R	30-50	S
	Filograninae			
159	*Portula tubularia*	M	51-75 & 101-150	S
	Unidentified specimen			
160	*1*	R	30-50	CSi
161	*2*	M	30-75	S,SiS
162	*3*	M	51-75	CSi,SiC
163	*4*	R	51-75	SiC
164	*5*	M	30-150	S,SiS,SiC
165	*6*	M	76-100	S

species and 4 were unidentified. There were 15 abundant, 92 moderately present and 7 rare polychaetes in this depth range. Here also sedentarians contributed more individuals. Sedentaria contributed 73.9% of individuals and Errantia contributed 26.1% of individuals. Very high occurrence of *Magelona cincta* at Porbandar off and Mangalore off and *Cossura coasta* at Dwarka off were noticed. Most abundant species were *Ancystrocyllis parvae, Prionospio pinnata, P. spp, Magelona cincta, Cirrophora sp* and *Cossura coasta.*

In the 76-100m depth range, a total of 67 species were observed. Among this 27 were from Errantia, and 38 from Sedentaria and 2 were unidentified. On the basis of abundance 15 were abundant, 50 moderately present and 2 rare. Sedentaria contributed 60.1% of individuals and Errantia contributed 40% of individuals. Dominance of no single species was noticed in any of the stations in this depth range. However, a notable abundance of *Prionospio spp* noticed in Dabhol (96m). Other abundant species were *Ancystrocyllis parvae, Prionospio pinnata* and *Magelona cincta.*

In 101-150m depth range, altogether 90 species were observed. In this, 42 were errants, 47 were sedentarians and 1 was unidentified. Of this, 15 were graded as abundant, 71 moderately present and 4 rare. In general, sedentarians contributed larger number in this depth also. 69.38% of individuals were from Sedentaria and 30.62% of individuals were from Errantia. *P. pinnata* was seen in large numbers off Cape Comorin and maintained high abundant status in several other stations also. Other abundant ones were *Lumbrineris latreilli, Prionospio* spp. and *Magelona cincta.*

In >150m, a total of 52 species were noticed - 19 from Errantia, 32 from Sedentaria and 1 unidentified. Of these 12 were abundant, 39 moderately present and 1 was rare. Sedentarians were the dominant forms. 93.05% of individuals were from Sedentaria and only 6.95% were from Errantia group. Most abundant species were *P. pinnata,* which showed high numerical abundance off Vadanappilly and *Paraonis gracilis gracilis,* off Cape Comorin.

Among the abundant species only *Prionospio pinnata* was observed as the most abundant in the entire shelf area. *Magelona cincta* was most abundant up to 100m. *Ancistrosyllis parvae* was considerably abundant up to 100m. *Nephthys dibranchis, P. spp, Cirrophorus sp, Cossura coasta* were slightly higher in representation up to 75m depth level. *Lumbrineris latreilli* was very abundant up to 100m depth with less representation in 76-100m depth range. *Sternaspis scutata* showed its dominance in 30-50m while *Paraonis gracilis gracilis* was very abundant only in >150m depths.

5.2.1.2. Crustacea

Crustacea formed the second dominant group among the benthic fauna of the present study area. Amphipods and decapods were the major groups among crustacea. This was followed by caprellids, copepods, isopods, tanaids, cumaceans, ostracods and pycnogonids. Stomatopods and mysids were also represented but very rarely. Among the amphipods, *Gammarus sp* and *Corrophium sp* and among decapods, *Alpheus malabaricus* were numerically important in many stations.

In 30-50m depth range, large numbers of *Gammarus sp, Corrophium sp* and Caprellids were noticed off Cape Comorin, while *Alpheus malabaricus* was abundant off Ratnagiri and copepods off Coondapore and along Mumbai. Tanaids showed their presence only in southern stations, while decapods were observed throughout this depth range. Mysids and stomatopods were represented poorly.

In 51-75m depth range, *Gammarus sp-* off Cape Comorin, *Apseudes chilkensis-* off Thiruvananthapuram and copepods along Mumbai contributed heavily in terms of numerical abundance.

In 76-100m depth range, none of the species contributed significantly to the numerical abundance. However, notable number of copepods at Ratnagiri off and Dabhol off and ostracods at Dabhol off and Dwarka off were noticed.

In 101-150m depth range, *Gammarus sp, Corrophium sp,* caprellids and isopods off Cape Comorin and copepods off Porbandar were the numerically important forms.

Beyond 150m depth range, *Corrophium sp,* caprellids and isopods off Cape Comorin, copepods and ostracods off Vadanappilly and copepods at Porbandar and Dwarka were the numerically important forms.

:2.1.3. Molluscs

Among molluscs, bivalves were the significant group, gastropods were poorly represented and scaphopods occurred rarely. Except *Musculista senhausia* at Kochi (30m) no individual species were significant numerically among molluscs. *Tapes sp* was common in depths up to 150m depths. *Arca sp* and *Donax sp* were the other bivalves which were present in certain stations.

:2.1.4. Others

Foraminiferans, sponges, hydrozoans, anthozoans, nematods, echinoderms, nemertines, sipunculids, echiuroids, *Amphioxus sp* and pisces constituted the others. Among this, echinoderms, nemertines and sipunculids were comparatively common. Echinoderms were represented by 3 orders, Asteroidea, Echinoidea and Ophiuroidea. Though sponges were numerically unimportant, it significantly contributed to the biomass at 30m depth off Thiruvananthapuram. Sipunculids were noted in higher number in the northern transects, off Porbandar and off Dwarka, either at 30-50 or 51-75m depths.

:2.2. Community structure based on polychaete species

:2.2.1. Species richness (Margalef's index, d) (Table 6.3 & Fig. 6.1): In 30-50m depth range, it varied from 1.07 (off Kozhikode, 30m) to 4.55 (off Dwarka) with a mean of 2.37. Species richness showed a general decrease from off Cape Comorin to off Kozhikode with an exception off Vadanappilly and then increased uniformly towards northern latitudes. In 51-75m, 'd' ranged between 1.13 (off

Table. 6.3. Community structure based on polychaetes.

Table. 6.3a. 30-50m

	Sps no S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
cape	23	530	3.51	0.93	4.22	0.06
tvm	23	1830	2.93	0.47	2.11	0.47
klm 1	22	615	3.27	0.92	4.08	0.07
klm 2	16	390	2.51	0.84	3.38	0.14
kch	8	150	1.40	0.87	2.61	0.21
vad	33	6080	3.67	0.32	1.63	0.62
kzh1	7	270	1.07	0.87	2.44	0.21
kzh2	23	510	3.53	0.90	4.09	0.08
knr	11	1115	1.43	0.75	2.58	0.22
mngr	10	660	1.39	0.76	2.51	0.23
cnpr	10	615	1.40	0.88	2.91	0.15
btkl	16	2635	1.90	0.71	2.83	0.21
goa	10	1180	1.27	0.75	2.49	0.23
rtngr	16	1350	2.08	0.78	3.14	0.16
dbhl	11	455	1.63	0.82	2.84	0.21
ofmb	13	405	2.00	0.91	3.38	0.11
almb	19	865	2.66	0.85	3.63	0.11
prbn	23	1895	2.92	0.45	2.05	0.50
dwrk	33	1135	4.55	0.80	4.05	0.11
mean	17	1194	2.37	0.77	3.00	0.22
SD	7.83	1346.00	1.01	0.17	0.76	0.15
co variation	45.49	112.74	42.37	22.41	25.41	70.79

Table. 6.3b. 51-75m depth range.

	Sps no S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
cape	26	480	4.05	0.94	4.41	0.06
tvm	33	925	4.69	0.90	4.55	0.06
klm	26	420	4.14	0.93	4.36	0.07
kch	13	285	2.12	0.80	2.97	0.21
vad	25	610	3.74	0.91	4.21	0.07
knr 1	18	780	2.55	0.68	2.85	0.25
knr 2	17	420	2.65	0.90	3.70	0.10
mngr	15	1970	1.85	0.37	1.46	0.62
cnpr	27	890	3.83	0.75	3.55	0.17
btkl 1	18	410	2.83	0.90	3.74	0.10
btkl 2	20	885	2.80	0.75	3.26	0.18
goa 1	13	1325	1.67	0.82	3.05	0.14
goa 2	30	1105	4.14	0.88	4.34	0.07
rtngr	8	500	1.13	0.78	2.33	0.26
dbhl	17	1490	2.19	0.76	3.12	0.18
ofmb	19	420	2.98	0.89	3.78	0.10
almb	17	670	2.46	0.85	3.46	0.14
prbn	17	4320	1.91	0.21	0.86	0.80
dwrk	24	2375	2.96	0.48	2.18	0.39
mean	20	1067	2.88	0.76	3.27	0.21
SD	6.42	967.64	0.98	0.20	1.01	0.20
co variation	31.86	90.66	34.17	26.31	30.93	95.58

Table. 6.3c. 76-100m depth range.

	Sps no S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
rtngr	18	365	2.88	0.90	3.76	0.10
dbhl 1	24	1655	3.10	0.70	3.19	0.23
dbhl 2	19	950	2.63	0.89	3.76	0.09
ofmb 1	16	245	2.73	0.94	3.75	0.09
ofmb 2	14	355	2.21	0.78	2.96	0.20
almb 1	11	175	1.94	0.93	3.21	0.12
almb 2	25	1090	3.43	0.76	3.54	0.17
almb 3	4	60	0.73	0.96	1.92	0.27
almb 4	3	50	0.51	0.86	1.37	0.43
dwrk	31	605	4.68	0.92	4.57	0.06
mean	17	555	2.48	0.86	3.20	0.17
SD	8.96	524.02	1.23	0.09	0.94	0.11
co variation	54.30	94.42	49.64	10.19	29.38	64.12

Table. 6.3d. 101-150m depth range.

	Sps no S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
cape	28	1325	3.76	0.58	2.77	0.37
tvm	35	1110	4.85	0.90	4.64	0.05
klm	11	300	1.75	0.83	2.88	0.19
kch	22	630	3.26	0.89	3.97	0.08
vad	24	920	3.37	0.86	3.94	0.10
kzh	11	250	1.81	0.78	2.68	0.26
knr	13	400	2.00	0.77	2.84	0.20
mngr	15	225	2.58	0.94	3.69	0.09
cnpr	18	400	2.84	0.88	3.67	0.11
btkl	15	625	2.17	0.70	2.74	0.28
goa	22	560	3.32	0.86	3.85	0.11
rtngr	18	620	2.64	0.80	3.33	0.15
prbn	24	410	3.82	0.94	4.29	0.06
mean	20	598	2.94	0.83	3.48	0.16
SD	7.05	336.75	0.91	0.10	0.66	0.10
co variation	35.81	56.31	30.91	12.48	18.84	61.31

Table. 6.3e. >150m depth.

	Sps no S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
cape	16	1000	2.17	0.75	3.01	0.18
klm	8	690	1.07	0.71	2.12	0.29
kch	9	165	1.57	0.91	2.90	0.16
vad	8	2110	0.91	0.25	0.74	0.80
kzh	5	215	0.74	0.65	1.51	0.48
knr	11	345	1.71	0.74	2.54	0.26
mngr	5	275	0.71	0.92	2.14	0.24
cnpr	10	540	1.43	0.57	1.89	0.40
btkl	5	225	0.74	0.74	1.71	0.38
goa	4	65	0.72	0.86	1.73	0.35
rtngr	0	0	0	0	0	0
dbhl	8	360	1.19	0.62	1.87	0.43
prbn	7	210	1.12	0.88	2.48	0.21
dwrk	4	70	0.71	0.92	1.84	0.30
mean	7	448	1.06	0.68	1.89	0.32
SD	3.84	548.65	0.54	0.27	0.80	0.19
co variation	53.76	122.51	51.05	39.25	42.19	58.65

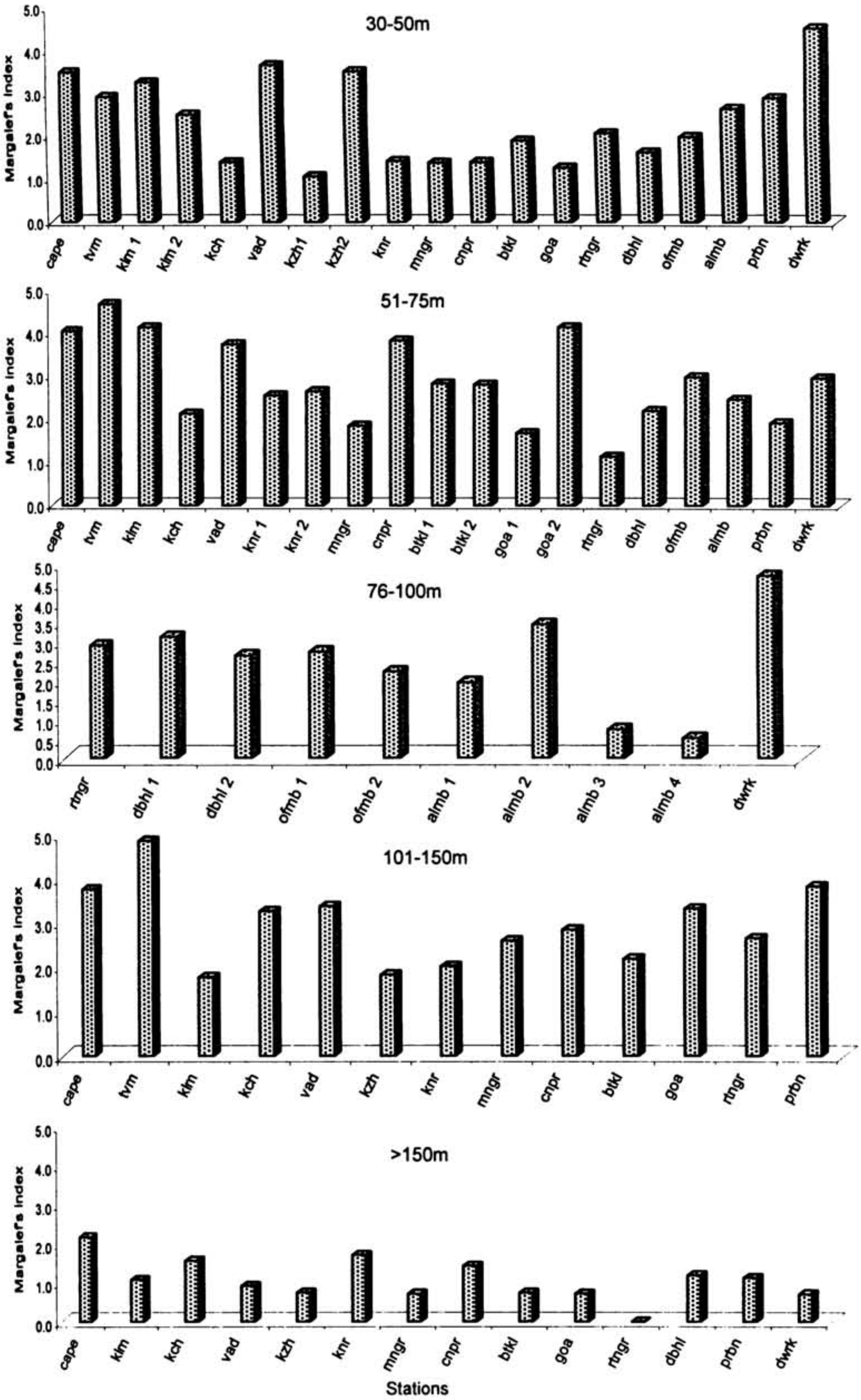


Fig. 6.1. Species richness index of polychaetes in different depth ranges.

Ratnagiri) and 4.69 (off Thiruvananthapuram) with an average of 2.88. In 76-100m, variation of 'd' was 0.51 (Along Mumbai, 79m) to 4.68 (off Dwarka) with an average of 2.48. In 101-150m, d' varied from 1.75 (off Kollam) to 4.85 (off Thiruvananthapuram) with an average of 2.94±0.91. It showed an increase from off Kozhikode to off Porbandar in this depth range with two exceptions, off Bhatkal and off Ratnagiri. In >150m, it varied from 0 (off Ratnagiri) to 2.17 (off Cape Comorin) with an average of 1.06. Maximum variation in 'd' with respect to latitudes was noticed in >150m (51.05%) and minimum at 101-150m (30.91%). Average species richness showed an increase with depth up to 101-150m, beyond which it decreased rapidly (Fig. 6.5).

6.2.2.2. Evenness index (Pielou's index, J') (Table 6.3 & Fig. 6.2): In 30-50m depth range J' ranged between 0.32 (off Vadanappilly) and 0.93 (off Cape Comorin) with an average of 0.77. In 51-75m, the range was from 0.21 (off Porbandar) to 0.94 (off Cape Comorin) with an average of 0.76. In 76-100m, J' varied between 0.58 (off Cape Comorin) and 0.94 (off Mangalore & off Porbandar) with an average of 0.83. In >150m, J' ranged from 0 (off Ratnagiri) to 0.92 (off Mangalore & off Dwarka) with an average of 0.68. There was minimum spatial variation of J' in 76-100m (10.19%) with maximum at >150m depth (39.25%). Average values showed more or less same evenness index in 30-74m depth. Highest index was noticed at 76-100m (0.86) and beyond that it decreased uniformly and minimum (0.68) was noticed at >150m (Fig. 6.5).

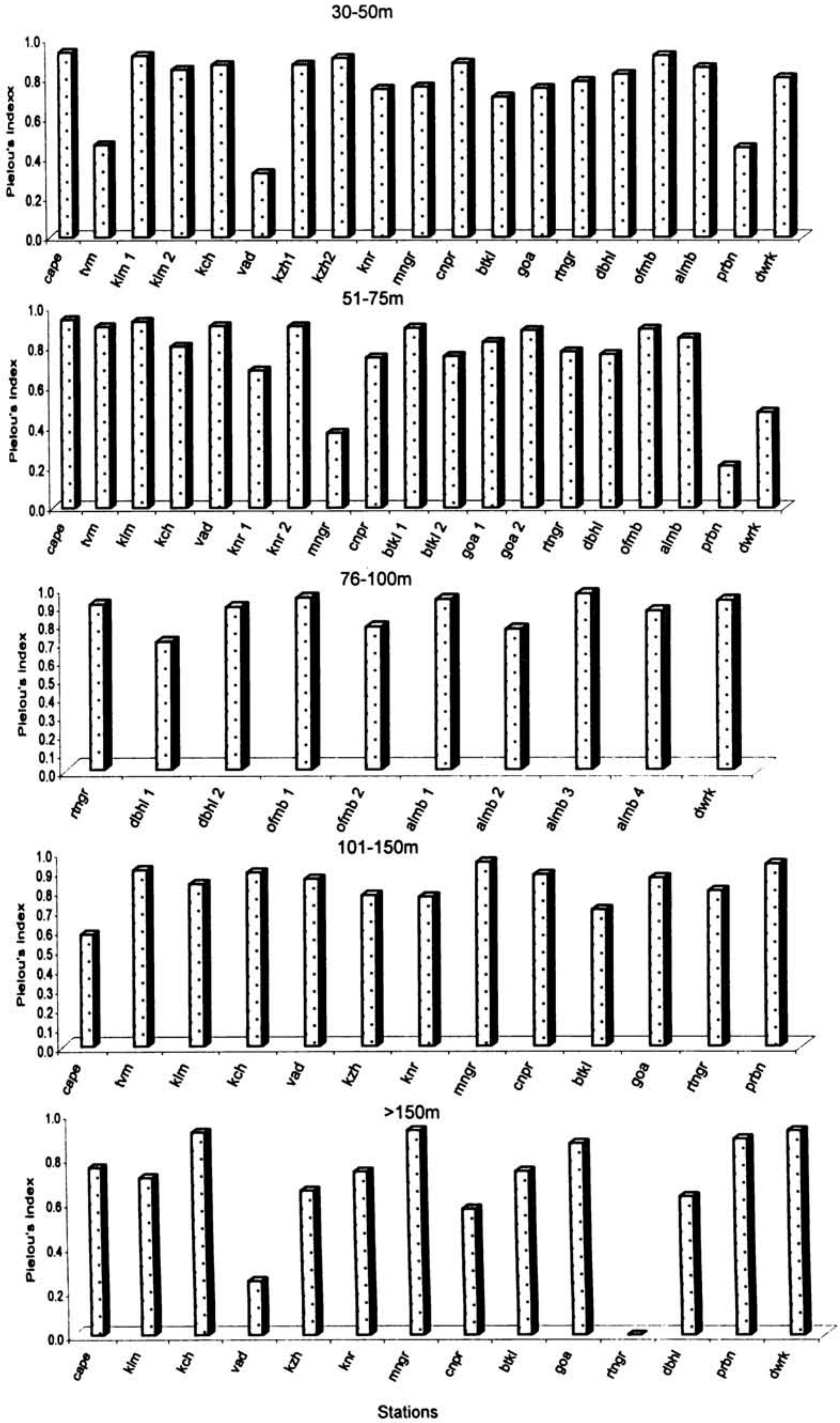


Fig. 6.2. Evenness index of polychaetes in different depth ranges.

:2.2.3. Species diversity (Shannon index, H') (Table 6.3 & Fig. 6.3): In 30-50m, H' ranged from 1.63 (off Vadanappilly) to 4.22 (off Cape Comorin) with an average of 3.00. A general increase in species diversity was observed from off Kannur to off Dwarka in this depth range with an exception off Porbandar. In 51-75m, H' ranged between 0.86 (off Porbandar) and 4.55 (off Thiruvananthapuram) with an average of 3.27. In 76-100m, H' varied from 1.37 (Along Mumbai, 79m) to 4.57 (off Dwarka) with an average of 3.20±0.94. In 101-150m, H' varied between 2.68 (off Kozhikode) and 4.64 (off Thiruvananthapuram) with an average of 3.48. In >150m, H' ranged from 0 (off Ratnagiri) to 3.01 (off Cape Comorin) with an average of 1.89. Latitudinal variation was minimum at 101-150m (8.84) and maximum at >150m (42.19). From the average values, it was noticed that species diversity showed a progressive increase with increase in depth up to 101-150m, beyond which it decreased rapidly (Fig. 6.5).

6.2.2.4. Species dominance (Simpson's index, Lambda') (Table 6.3 & Fig. 6.4): In 30-50m, Lambda' ranged from 0.06 (off Cape Comorin) to 0.62 (off Vadanappilly) with an average of 0.22. In 51-75m, Lambda' ranged between 0.06 (off Cape Comorin) and 0.8 (along Mumbai) with an average of 0.21±0.20. In 76-100m, Lambda' varied from 0.06 (off Dwarka) to 0.43 (Along Mumbai, 79m) with an average of 0.17. In 101-150m, it varied between 0.05 (off Thiruvananthapuram) and 0.37 (off Cape Comorin) with an average of 0.16. In >150m, it ranged from 0 (off Ratnagiri) to 0.8 (off Vadanappilly) with an average of 0.32. Species dominance showed a progressive decrease from 30-50m to

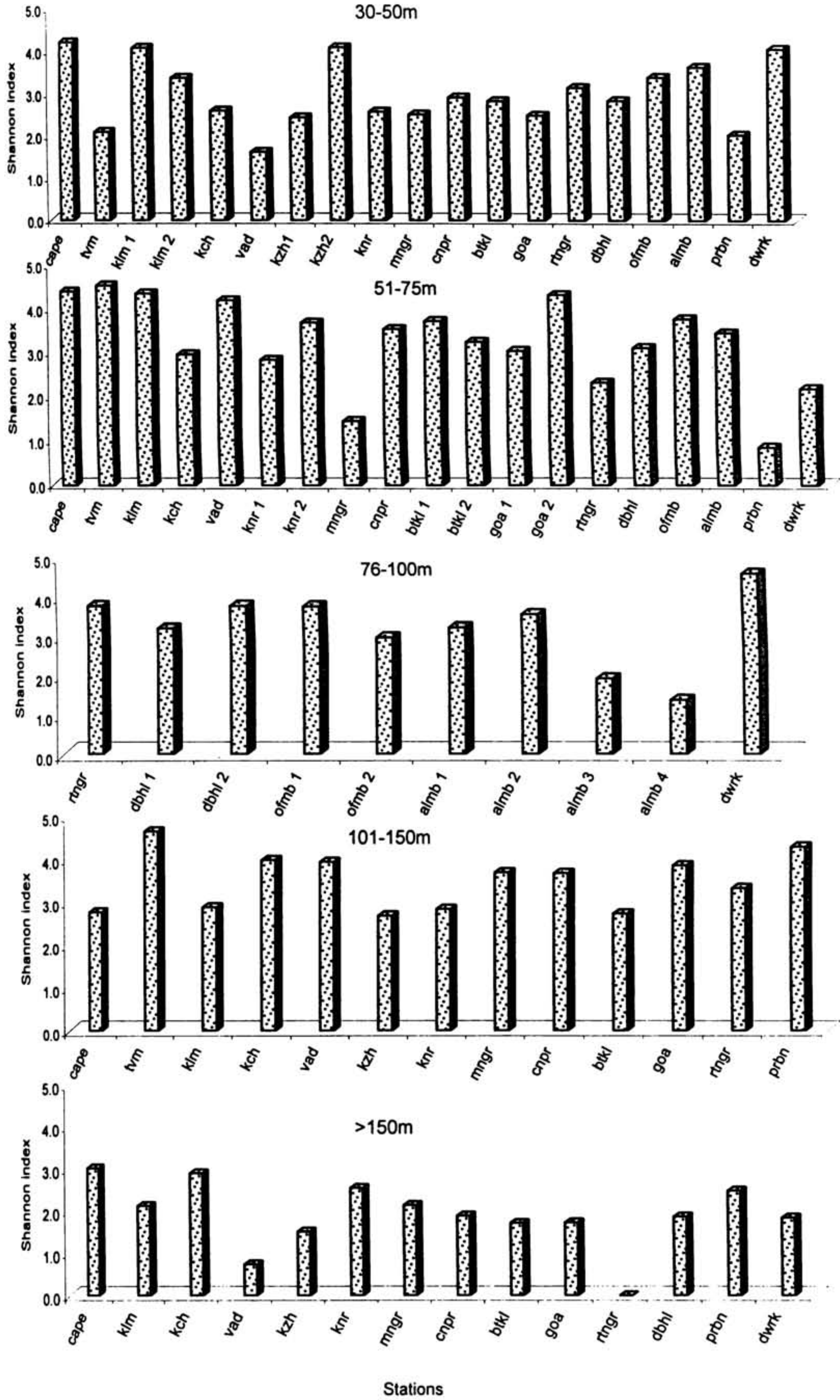


Fig. 6.3. Species diversity index of polychaetes in different depth ranges.

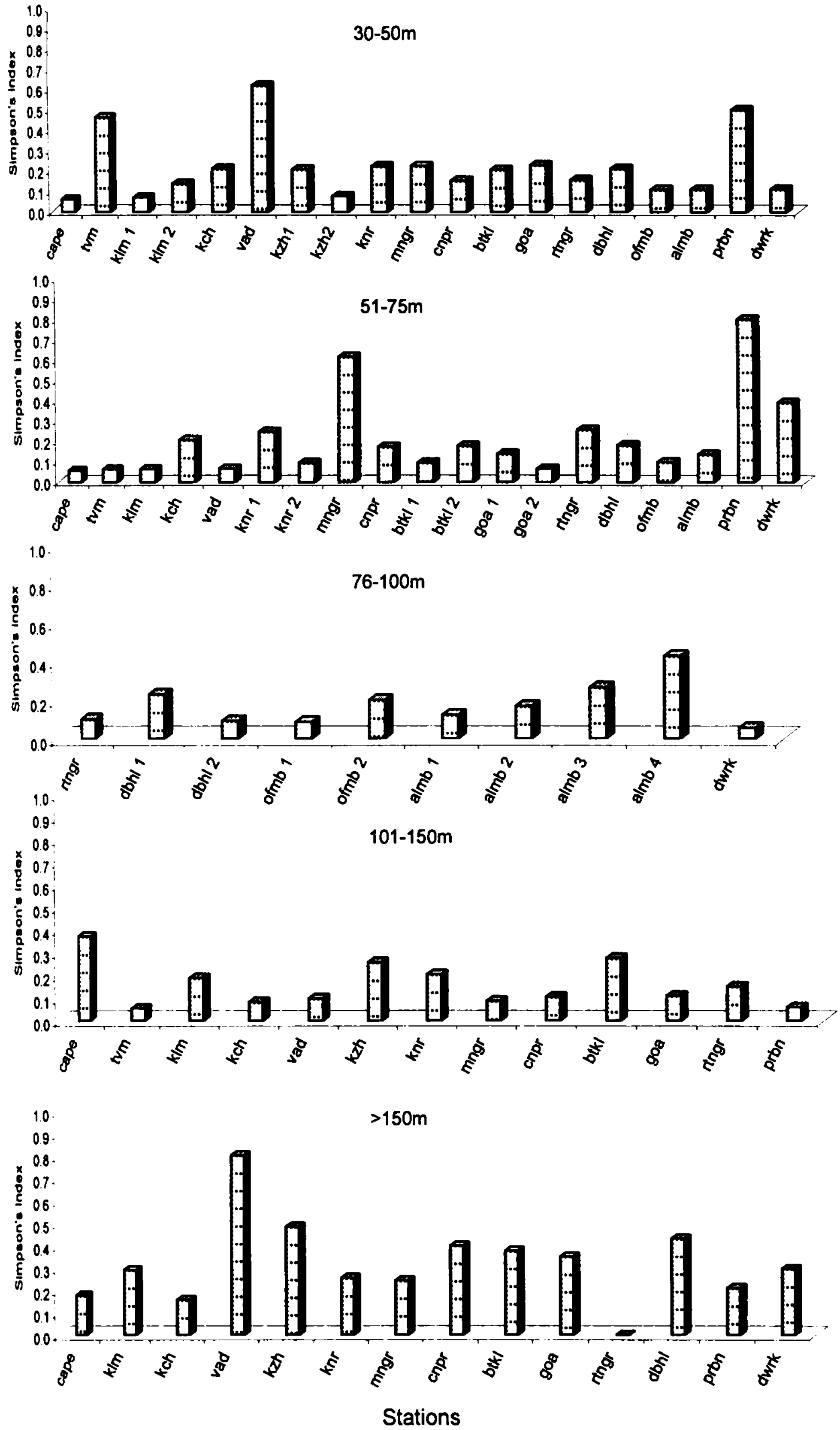


Fig. 6.4. Species dominance index of polychaetes in different depth ranges.

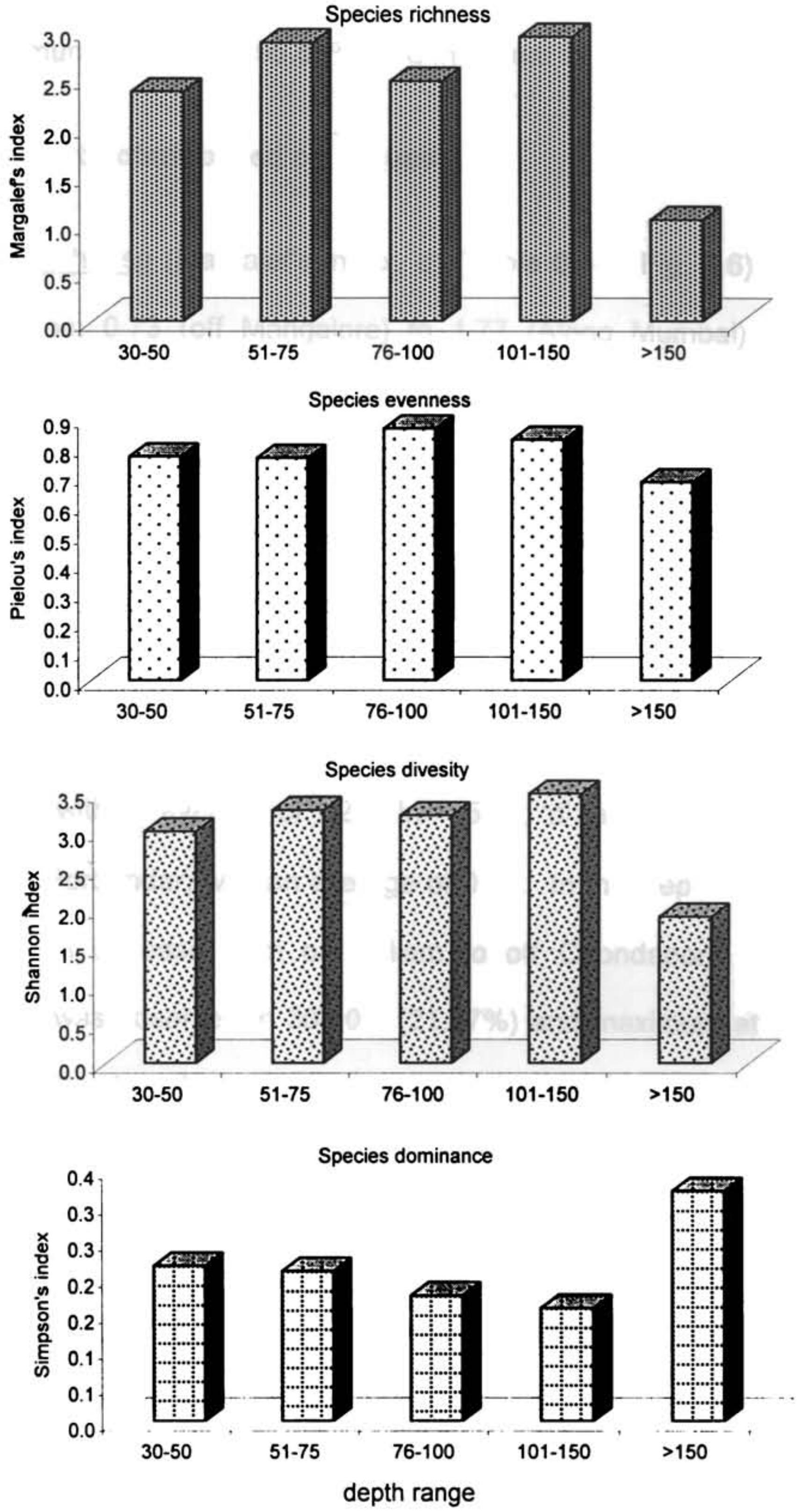


Fig. 6.5. Average diversity indices of polychaetes in different depth ranges

'01-150m. But beyond 150m, it increased rapidly (Fig. 6.5). Variation within latitude was maximum at 51-75m (95.58%) and minimum at >150m (58.65).

6.2.3. Community structure based on groups

6.2.3.1. Species richness (Margalef's index, d) (Table 6.4 & Fig. 6.6): In 30-50m, 'd' varied from 0.73 (off Mangalore) to 1.77 (Along Mumbai) with an average of 1.27. It decreased from off Thiruvananthapuram to off Mangalore and then showed an increase upto along Mumbai in this depth range. In 51-75m, it ranged from 0.7 (off Porbandar) to 1.97 (off Thiruvananthapuram) with an average of 1.32. It showed a decrease from off Bhatkal to off Mumbai In 76-100m, ranging between 0.43 (Along Mumbai, 79m) and 1.98 (Along Mumbai1) with an average of 1.37. In 101-150m, 'd' ranged from 0.68 (off Kozhikode) to '7 (off Porbandar) with an average of 1.27. In >150m, 'd' ranged from 0.45 (off Kollam) to 1.6 (off Porbandar) with an average of 0.96. In this depth range, the richness showed an increase from off Kollam to off Coondapore Minimum latitudinal variation was observed in 30-50m (21.67%) and maximum at >150m (31.60%). Mean 'd' value showed an increase in species richness up to 76-100m (1.37) and beyond that it decreased, with the minimum (0.96) found beyond 150m (Fig. 6.10).

6.2.3.2. Evenness index (Pielou's index, J') (Table 6.4 & Fig. 6.7): In 30-50m, J' ranged from 0.2 (off Vadanappilly) to 0.74 (off Kollam) with an average of 1.27. In 51-75m, J' varied from 0.26 (off Mangalore) to 0.71 (off Thiruvananthapuram) with an average of 0.49. It showed a decrease from off Thiruvananthapuram to

Table 6.4. Community structure based on groups.

Table 6.4a. 30-50m depth ranges.

	Group no. S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
cape	11	4970	1.17	0.49	1.69	0.49
tvm	14	2360	1.67	0.40	1.51	0.61
klm 1	13	1460	1.65	0.74	2.73	0.23
klm 2	12	1070	1.58	0.79	2.83	0.20
kch	9	560	1.26	0.60	1.91	0.38
vad	13	6750	1.36	0.20	0.75	0.81
kzh1	9	535	1.27	0.71	2.26	0.31
kzh2	7	855	0.89	0.63	1.77	0.41
knr	8	1345	0.97	0.37	1.10	0.69
mngr	6	935	0.73	0.55	1.41	0.53
cnpr	9	1780	1.07	0.67	2.12	0.31
btkl	10	3205	1.11	0.31	1.04	0.69
goa	12	1850	1.46	0.51	1.84	0.44
rtngr	9	2145	1.04	0.50	1.58	0.45
dbhl	9	720	1.22	0.54	1.70	0.45
ofmb	9	560	1.26	0.51	1.62	0.54
almb	15	2760	1.77	0.68	2.67	0.21
prbn	11	2680	1.27	0.45	1.55	0.53
dwrk	12	2130	1.44	0.51	1.81	0.39
mean	10	2035	1.27	0.53	1.78	0.46
SD	2.41	1599.53	0.28	0.15	0.56	0.17
co variation	23.14	78.59	21.67	28.25	31.18	36.95

Table 6.4b. 51-75m depth ranges.

	Group no. S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
cape	12	1805	1.47	0.66	2.35	0.29
tvm	16	2045	1.97	0.71	2.83	0.24
klm	13	750	1.81	0.63	2.33	0.35
kch	8	455	1.14	0.62	1.86	0.42
vad	7	595	0.94	0.57	1.61	0.47
knr 1	9	965	1.16	0.38	1.20	0.67
knr 2	11	560	1.58	0.46	1.58	0.57
mngr	13	2250	1.55	0.26	0.97	0.77
cnpr	12	1365	1.52	0.69	2.48	0.29
btkl 1	12	915	1.61	0.67	2.39	0.28
btkl 2	12	1270	1.54	0.50	1.81	0.50
goa 1	10	1600	1.22	0.33	1.10	0.69
goa 2	10	1345	1.25	0.36	1.20	0.68
rtngr	7	625	0.93	0.41	1.14	0.65
dbhl	9	1650	1.08	0.34	1.07	0.69
ofmb	6	495	0.81	0.37	0.95	0.72
almb	13	2455	1.54	0.54	1.99	0.36
prbn	7	5080	0.70	0.30	0.83	0.73
dwrk	11	3640	1.22	0.47	1.63	0.47
mean	10.42	1571.84	1.32	0.49	1.65	0.52
SD	2.65	1179.72	0.34	0.15	0.61	0.18
co variation	25.45	75.05	25.95	29.92	37.01	34.91

Table 6.4c. 76-100m depth ranges

	Group no. S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
rtngr	10	730	1.37	0.65	2.16	0.32
dbhl 1	12	2195	1.43	0.39	1.41	0.58
dbhl 2	12	1470	1.51	0.54	1.94	0.44
ofmb 1	7	470	0.98	0.73	2.06	0.33
ofmb 2	9	565	1.26	0.58	1.84	0.43
almb 1	14	700	1.98	0.81	3.09	0.16
almb 2	12	1560	1.50	0.49	1.75	0.50
almb 3	10	305	1.57	0.90	2.98	0.14
almb 4	3	110	0.43	0.85	1.35	0.42
dwrk	13	1435	1.65	0.74	2.73	0.23
mean	10.20	954.00	1.37	0.67	2.13	0.36
SD	3.26	669.89	0.42	0.17	0.61	0.15
co variation	31.95	70.22	30.80	24.71	28.76	41.17

Table. 6.4d. 101-150m depth ranges.

	Group no. S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
cape	14	2825	1.64	0.50	1.90	0.37
tvm	10	1650	1.21	0.52	1.73	0.48
klm	8	450	1.15	0.57	1.70	0.47
kch	11	990	1.45	0.55	1.91	0.43
vad	9	1070	1.15	0.30	0.94	0.74
kzh	5	365	0.68	0.58	1.36	0.51
knr	7	565	0.95	0.56	1.56	0.52
mngr	10	440	1.48	0.63	2.08	0.35
cnpr	11	680	1.53	0.59	2.03	0.39
btkl	9	890	1.18	0.51	1.62	0.51
goa	7	690	0.92	0.40	1.13	0.67
rtngr	11	810	1.49	0.44	1.53	0.59
prbn	13	1175	1.70	0.78	2.90	0.19
mean	9.62	969.23	1.27	0.53	1.72	0.48
SD	2.50	660.28	0.31	0.12	0.49	0.14
co variation	26.01	68.12	24.18	21.77	28.23	29.86

Table 6.4e. > 150m depth.

	Group no. S	Abundance N	Margalef's d	Pielous' J'	Shannon H'(log2)	Simpson's Lambda'
cape	10	2230	1.17	0.67	2.21	0.29
klm	4	840	0.45	0.42	0.84	0.70
kch	5	320	0.69	0.68	1.59	0.40
vad	6	3270	0.62	0.53	1.37	0.48
kzh	7	335	1.03	0.64	1.81	0.44
knr	7	490	0.97	0.56	1.56	0.51
mngr	7	435	0.99	0.61	1.71	0.44
cnpr	10	735	1.36	0.45	1.48	0.56
btkl	5	295	0.70	0.53	1.23	0.60
goa	6	125	1.04	0.80	2.08	0.32
rtngr	6	115	1.05	0.91	2.35	0.22
dbhl	6	560	0.79	0.63	1.64	0.45
prbn	12	955	1.60	0.84	3.00	0.16
dwrk	8	1815	0.93	0.31	0.93	0.75
mean	7.07	894.29	0.96	0.61	1.70	0.45
SD	2.23	919.65	0.30	0.17	0.57	0.17
co variation	31.60	102.84	31.60	27.10	33.79	37.75

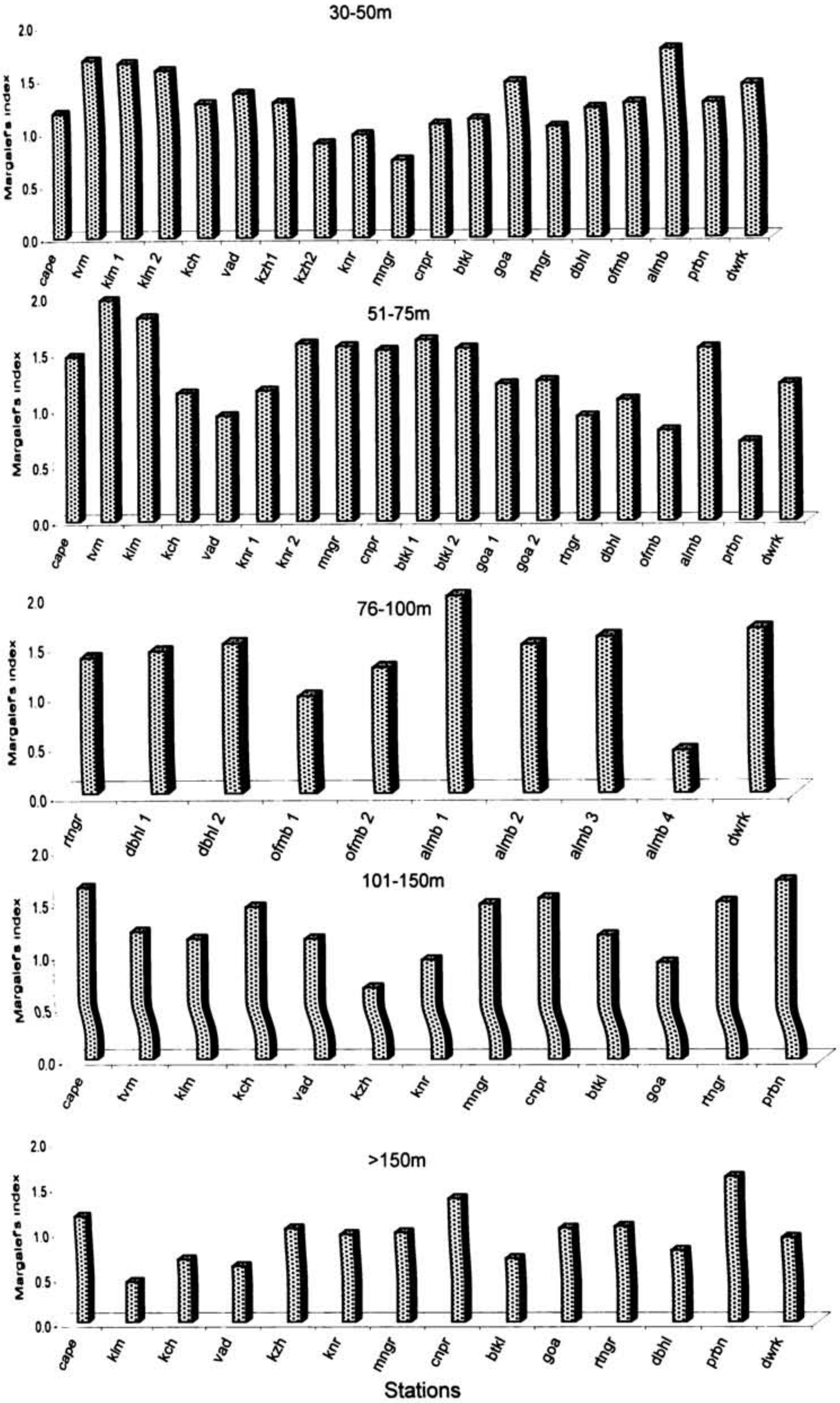


Fig. 6.6. Richness index of groups in different depth ranges.

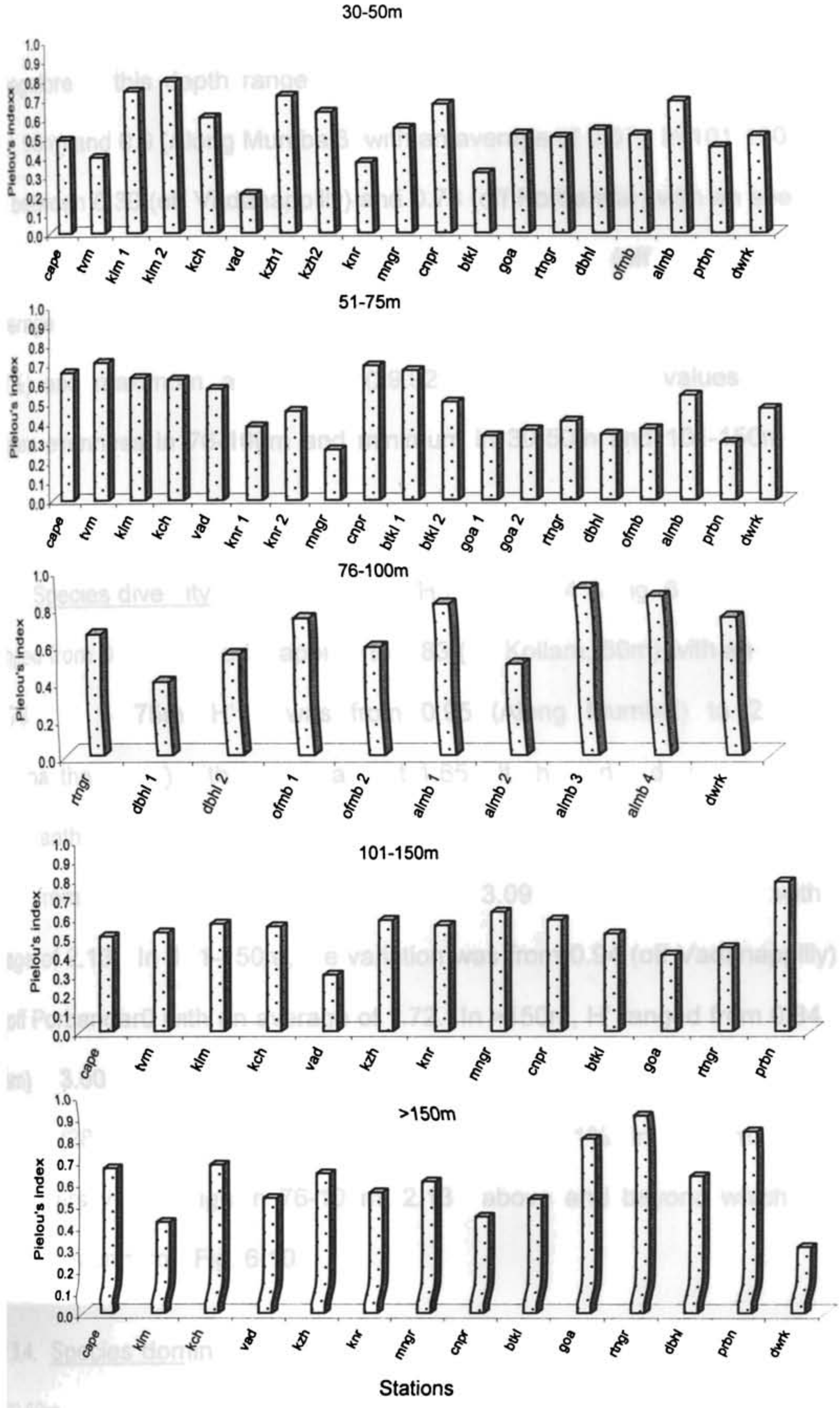


Fig. 6.7. Evenness index of groups in different depth ranges.

Mangalore in this depth range. In 76-100m, J' ranged between 0.39 (off [illegible], 96m) and 0.9 (Along Mumbai3) with an average of 0.67. In 101-150m, J' [illegible] between 0.30 (off Vadanappilly) and 0.78 (off Porbandar) with an average [illegible].53. In >150m, it ranged from 0.31 (off Dwarka) to 0.84 (off Porbandar) with [illegible] average of 0.61. Minimum latitudinal variation was noticed in 101-150m ([illegible]77%) and maximum at 51-75m (29.92%). Average J' values showed [illegible]mum evenness in 76-100m and minimum in 30-50m and 101-150m (Fig. [illegible]).

[illegible].3.3. Species diversity (Shannon index, H') (Table 6.4 & Fig. 6.8): In 30-50m, [illegible] ranged from 0.75 (off Vadanappilly) to 2.83 (off Kollam, 50m) with an average [illegible] 1.78. In 51-75m, H' it was from 0.95 (Along Mumbai) to 2.83 (off [illegible]uvananthapuram) with an average of 1.65. It showed a decrease from off [illegible]uvananthapuram to off Mangalore in this depth range. In 76-100m, H' ranged from 1.35 (Along Mumbai, 79m) to 3.09 (Along Mumbai2) with an [illegible]erage of 2.13. In 101-150m, the variation was from 0.94 (off Vadanappilly) to [illegible] (off Porbandar0 with an average of 1.72. In >150m, H' ranged from 0.84 (off [illegible]lam) to 3.00 (off Porbandar) with an average of 1.70. Latitudinal variation was [illegible]mum (28.23%) in 101-150m and maximum (37.01%) in 51-75m. Average [illegible] diversity was high in 76-100m (2.13), above and beyond which, it was [illegible]re or less uniform (Fig. 6.10).

[illegible].3.4. Species dominance (Simpson's index, Lambda') (Table 6.4 & Fig. 6.9): [illegible] 30-50m, it ranged between 0.20 (off Kollam2) and 0.81 (off Vadanappilly) with

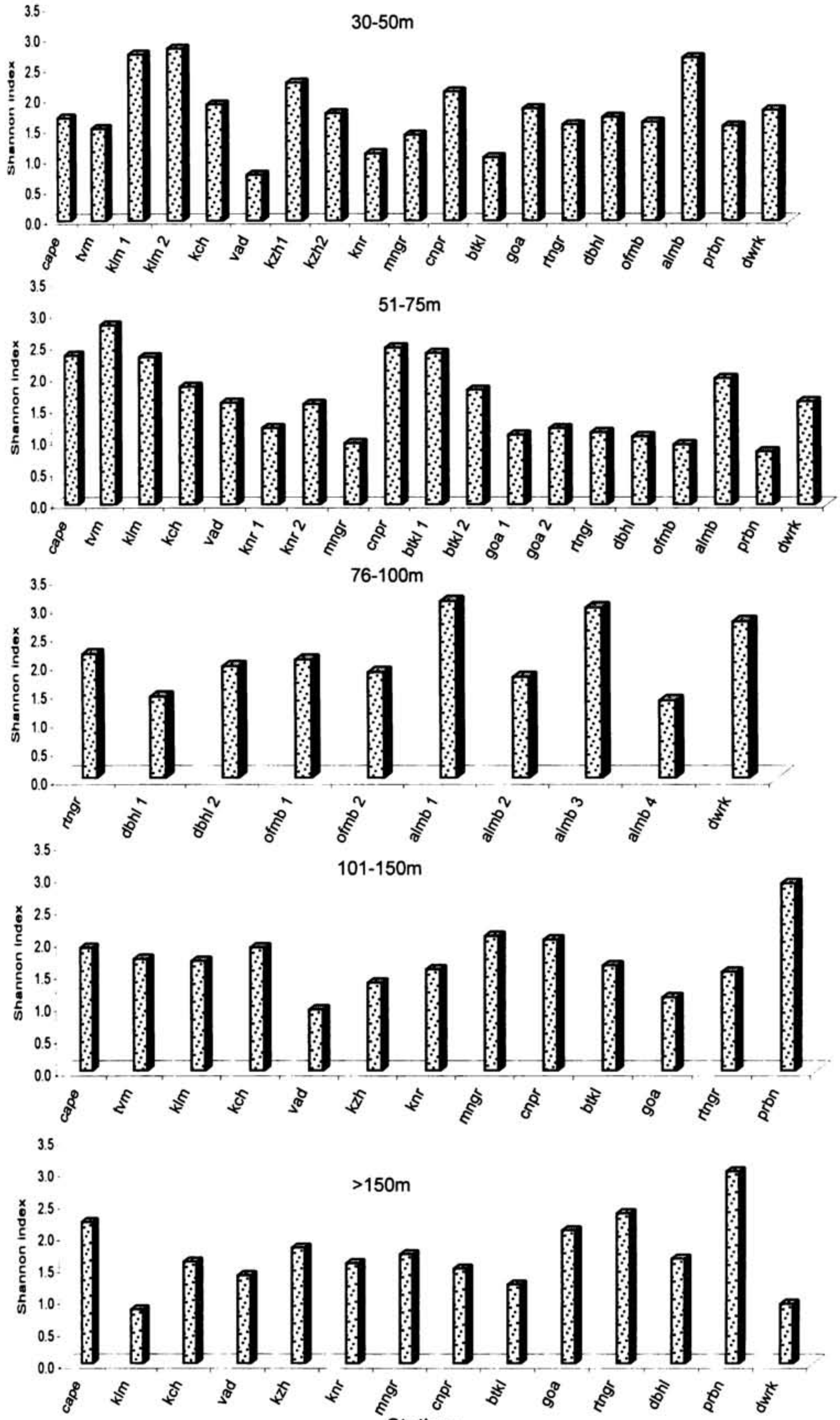


Fig. 6.8. Diversity of groups in different depth ranges.

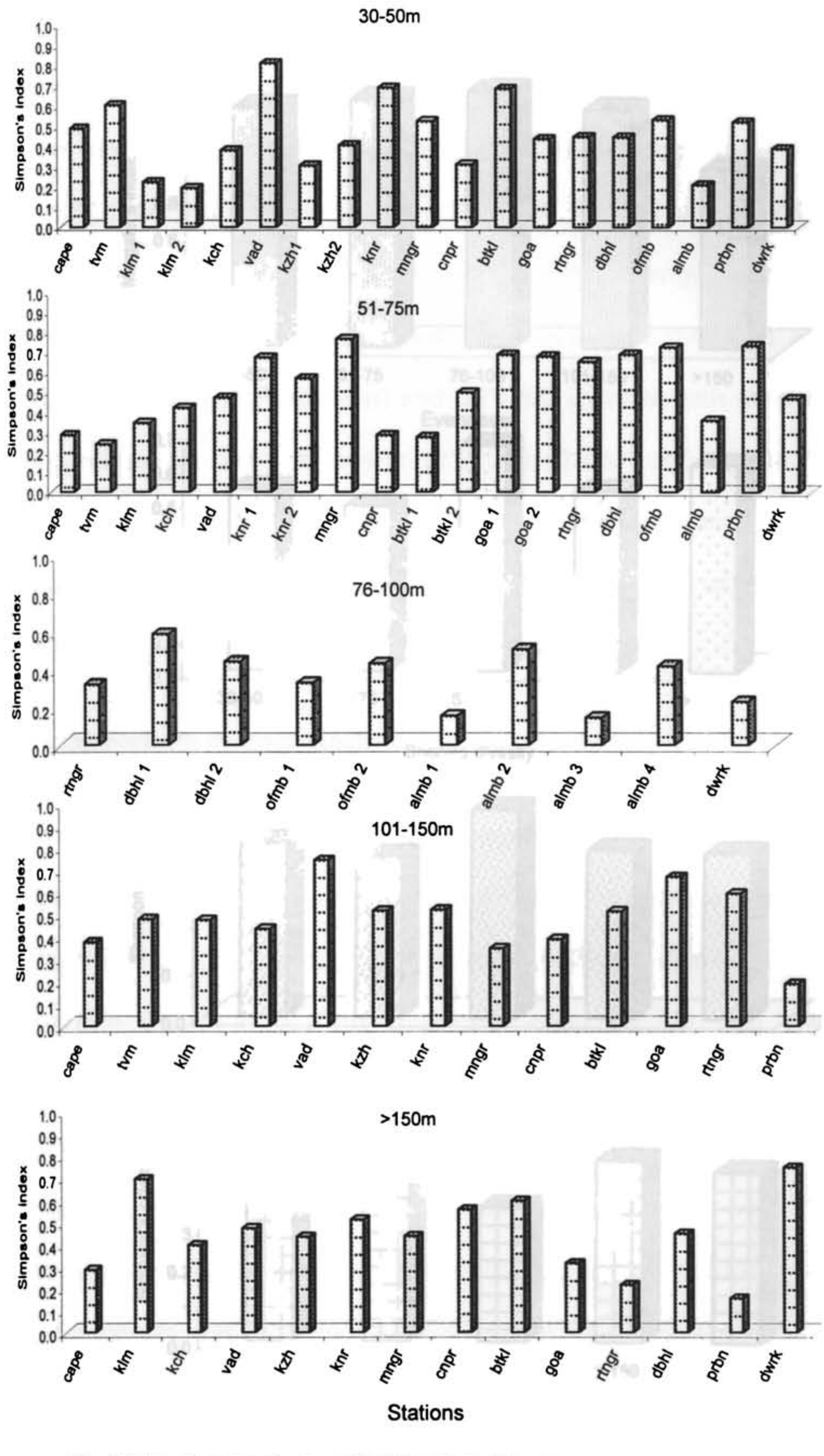


Fig. 6.9. Dominance of groups in different depth ranges.

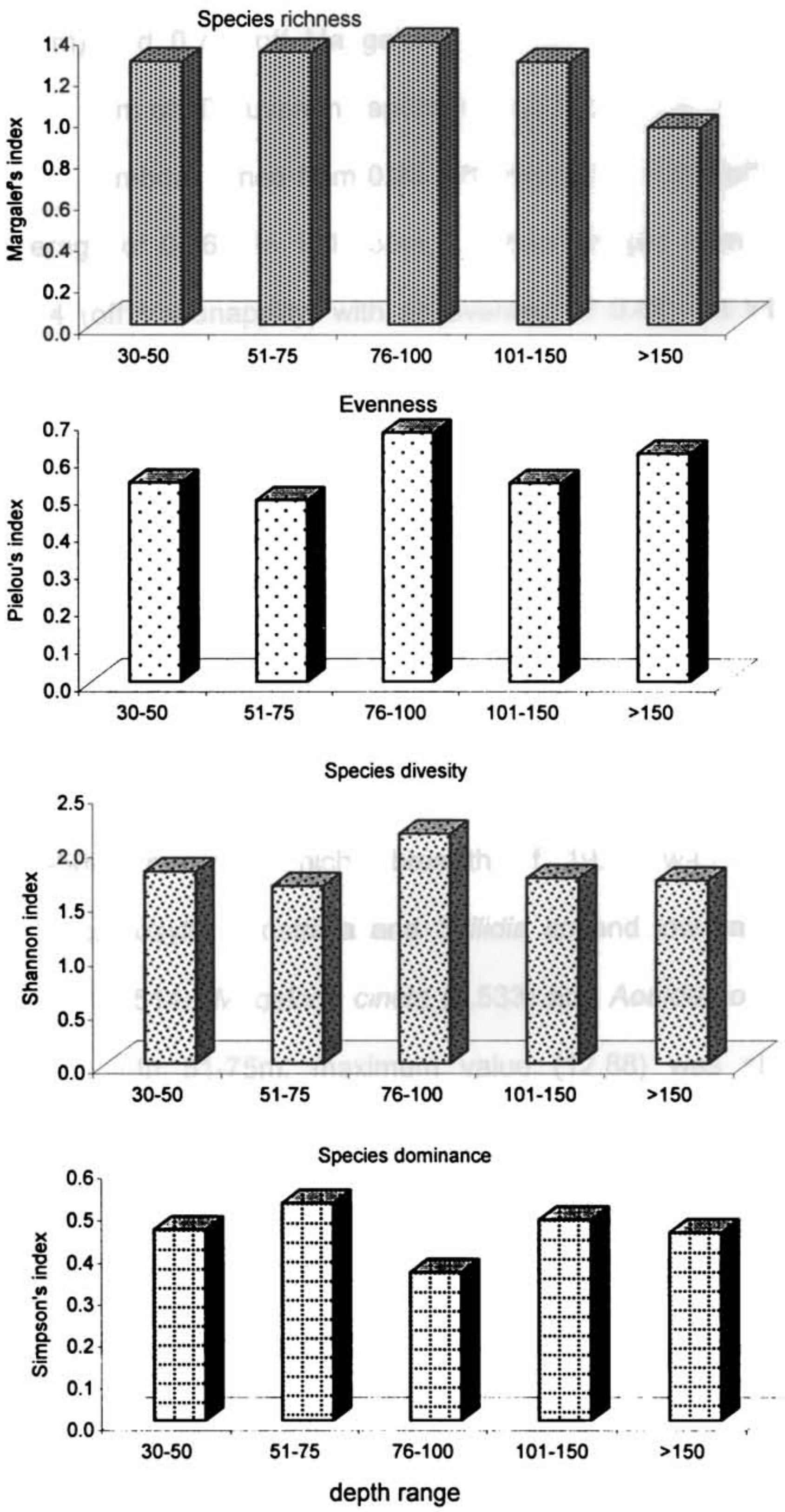


Fig. 6.10. Average diversity indices of groups in different depth ranges.

an average of 0.46. In 51-75m, Lambda' varied between 0.24 (off Thiruvananthapuram) and 0.77 (off Mangalore) with an average of 0.52. It showed an increase from off Thiruvananthapuram to off Mangalore in this depth range. In 76-100m, Lambda' varied from 0.23 (off Dwarka) to 0.58 (off Dabhol, 96m) with an average of 0.36. In 101-150m, Lambda' ranged from 0.19 (off Porbandar) to 0.74 (off Vadanappilly) with an average of 0.48. In >150m, it ranged between 0.16 (off Porbandar) and 0.75 (off Dwarka) with an average of 0.45. Latitudinal variation was less in 101-150m (29.80) and high in 76-100m (41.17%). Average Lambda' showed minimum species dominance in 76-100m, above and beyond that it was high, the highest being observed at 51-75m (0.52) (Fig. 6.10).

6.2.4. Niche breadth of polychaetes

In the 30-50m, maximum niche breadth of 19.00 was shown by *Phyllodoce spp, Ancistrosyllis* constricta and *Syllidia sp* and low values were shown by *Tharyx sp* (1.514), *Magelona cincta* (1.533) and *Aonides oxycephala* (1.627) (Table 6.1). In 51-75m, maximum value (12.88) was shown by *Lumbrineris latreilli*, followed by *Nephtys dibranchis* (12.49) and minimum was shown by *Cirratulus sp1* (2.02), followed by *Arabella iricolor iricolor* and *Paraonides sp* (2.74). In 76-100m, maximum niche breadth was shown by *Ancistrosyllis parva* (7.18), followed by *Nephtys sp2* and *N. polybranchia* (6.95) where as minimum was exhibited by *Cirratulus sp1* (1), followed by *Pista spp* (1.36). In 101-150m, maximum niche breadth was exhibited by *Aricidea sp1*

0.59) and *Magelona cincta* (10.01) and minimum was shown by *Dasybranchus* sp and *Pista quadrilobata* (1.76). In >150m, maximum niche breadth was shown by *Pista ?unibranchia* (8.68) and minimum was by *Prionospio* *obranchiata* (1.313).

6.2.5. Niche breadth of groups

At 30-50m, niche breadth (Table 6.5) was maximum (12.62) for polychaetes and minimum for sponges and stomatopods (3.83). Higher niche breadth was also noticed for Cake urchin (12.3) and Sipunculid (12.3). About 24% of the groups had <5 as the niche breadth. At 51-75m, maximum niche breadth was noticed for polychaetes (13.17), followed by hydrozoan, flatworm, mysid, sergestid, cake urchin and echiurid (11.51 each). Minimum niche breadth was observed for sipunculid (2.511) and foraminifera (2.516). About 32.14% of the groups had >10 as the niche breadth value. In the 76-100m depth, niche breadth ranged between 2.73 (cake urchin) and 8.75 (amphipod). Here about 32% of the groups had <5 as the niche breadth value. In 101-150m, the niche breadth was observed to be highly variable, ranging between 2.46 (brittle star) and 11.34 (polychaetes). About 22.7% of the groups had niche breadth <5. In >150m, the range for niche breadth was 1.33 (ostracod) and 9.47 (decapod). 63% of the groups had niche breadth value <5.

6.2.6. Similarity index

Similarity between stations in each depth range with respect to polychaete

Table 6.5 Niche breadth of groups

30-50m			51-75m			76-100m			101-150m			>150m		
groups	mean no	nichebreadth	groups	mean no	nichebreadth	groups	mean no	nichebreadth	groups	mean no	nichebreadth	groups	mean no	nichebreadth
Sponge	2.63	3.831	Foraminifera	4.47	2.516	Foraminifera	12.00	3.583	Nematode	20.00	6.1965	Foraminifera	1.43	5.370
Hydrozoan	1.05	10.657	Hydrozoan	0.53	11.507	Hydrozoan	1.00	5.655	Polychaete	598.08	11.3417	Sponge	5.71	2.145
Sea anemone	0.53	12.303	Nematode	7.63	7.503	Sea anemone	2.00	5.406	Amphipod	136.15	4.1447	Hydrozoan	5.36	2.952
Nematode	2.37	9.641	Flatworm	0.53	11.507	Nematode	6.00	5.346	Caprellid	20.77	7.8723	Sea anemone	0.71	8.451
Polychaete	1193.95	12.620	Polychaete	1037.89	13.174	Polychaete	555.00	6.802	Isopod	33.46	7.5595	Nematode	10.71	2.488
Amphipod	315.53	5.072	Amphipod	151.32	9.331	Amphipod	99.00	8.754	Tanaid	5.38	5.0898	Polychaete	447.86	8.309
Caprellid	46.84	7.895	Caprellid	20.53	10.628	Caprellid	13.00	5.970	Copepod	26.54	3.6963	Amphipod	61.43	3.485
Isopod	60.79	10.669	Isopod	25.00	9.300	Isopod	14.50	7.719	Cumacea	5.38	6.0661	Caprellid	30.00	5.696
Tanaid	21.05	4.502	Tanaid	22.89	3.369	Tanaid	4.00	3.546	Ostracod	17.31	5.3645	Isopod	36.79	5.593
Copepod	140.26	7.671	Copepod	99.74	3.071	Copepod	69.00	7.371	Pycnogonid	5.38	9.1148	Tanaid	2.14	5.829
Cumacea	13.68	8.332	Cumacea	14.21	7.564	Cumacea	6.00	3.725	Mysid	0.77	7.7244	Copepod	178.57	3.208
Ostracod	7.37	6.102	Ostracod	7.89	8.037	Ostracod	69.50	4.803	Decapod	48.85	10.4571	Cumacea	2.14	7.604
Pycnogonid	4.21	10.685	Pycnogonid	2.11	9.695	Pycnogonid	17.00	3.412	Stomatopod	0.77	7.7244	Ostracod	45.71	1.329
Mysid	2.11	7.356	Mysid	0.53	11.507	Mysid	1.00	5.655	Sergestid	0.77	7.7244	Pycnogonid	4.29	4.645
Decapod	65.26	10.657	Decapod	55.26	1.269	Decapod	46.00	7.131	Bivalve	10.77	9.1474	Decapod	37.86	9.469
Stomatopod	1.05	3.831	Stomatopod	5.00	8.449	Stomatopod	1.00	5.406	Gastropod	0.77	7.7244	Stomatopod	4.29	8.451
Sergestid	2.63	8.665	Sergestid	1.58	11.507	Sergestid	2.00	5.655	Brittle Star	13.85	2.4585	Sergestid	0.71	7.621
Bivalve	45.79	3.978	Bivalve	20.53	9.004	Bivalve	14.00	7.421	Sea urchin	0.77	7.7244	Bivalve	9.29	4.126
Gastropod	9.74	7.853	Gastropod	2.37	7.652	Brittle Star	6.00	4.237	Cake urchin	1.15	5.9975	Gastropod	0.71	8.451
Dentalium	1.05	5.974	Brittle Star	7.11	7.284	Sea urchin	1.00	5.655	*Amphioxus*	7.69	4.3292	Dentalium	0.71	8.451
Brittle Star	2.63	8.048	Sea urchin	2.63	5.413	Cake urchin	6.00	2.730	Fish	2.31	7.1129	Fish	0.71	8.451
Sea urchin	1.58	7.853	Cake urchin	0.53	11.507	Sipunculid	6.00	3.217	Nemertine	12.31	4.3720	Nemertine	7.14	5.352
Cake urchin	1.05	12.303	Star fish	2.11	4.282	Echiuroid	1.00	5.655						
Star fish	0.53	3.874	Sipunculid	46.58	2.511	Fish	1.00	5.655						
Sipunculid	38.16	12.303	*Amphioxus*	1.84	6.502	Nemertine	1.00	5.655						
Amphioxus	0.53	4.151	Echiuroid	0.53	11.507									
Echiuroid	4.74	10.696	Fish	5.26	8.450									
Fish	6.05	9.814	Nemertine	25.26	8.409									
Nemertine	42.11	9.814												

species and also with respect to groups together were calculated using PRIMER 5 for windows. The clustering of stations was also done using the same package.

6.2.6.1. Similarity with respect to polychaetes: Similarity between stations with respect to polychaete species is presented in Table 6.6 and Fig. 6.11. In 30-50m, the similarity ranged between nil to 63.38%. No similarity was noticed between off Kochi and off Cape comorin and off Kochi and off Kollam. Maximum similarity was noticed between Goa off and off Mumbai. More than 50% similarity was noticed between off Kannur and off Mangalore (62.45%), off Kannur and off Mumbai (52.76%), off Mangalore and off Coondapore (58.99%), Mangalore and Goa (57.77%), off Mangalore and off Mumbai (50.14%), off Goa and off Ratnagiri (61.22%), off Ratnagiri and off Mumbai (54.11%) and off Coondapore and off Dabhol (55.57%).

In 51-75m, the similarity between stations ranged from 8.72% (off Cape Comorin and off Porbandar) to 63.87% (off Goa and along Mumbai). More than 50% similarity was noticed between along Mumbai and off Dwarka also.

In 76-100m, the similarity ranged between nil to 50.38%. No similarity was observed between off Dabhol (96m) and along Mumbai (95m), off Dabhol (94m) and along Mumbai (95m) and 79m and 95m depths along Mumbai. Maximum similarity was noticed between off Ratnagiri and off Mumbai (96m).

In 101-150m, the similarity varied from 3.18% (between off Cape Comorin

Table 6.6. [illegible] dissimilarity index between stations [illegible]
Table 6.6a. 30-50m depth ranges.

	cape	tvm	klm1	klm2	kch	vad	kzh1	kzh2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	ofmb	almb	prbn
cape																		
tvm	14.20																	
klm1	29.56	23.85																
klm2	19.47	3.05	23.10															
kch	0.00	7.49	4.48	0.00														
vad	10.20	14.71	26.11	12.92	4.56													
kzh1	16.68	16.94	25.92	24.59	17.32	22.77												
kzh2	16.67	24.16	20.72	34.62	4.75	22.49	20.80											
knr	16.16	5.51	33.12	25.22	5.03	29.27	29.48	13.05										
mngr	13.22	9.22	30.42	28.94	6.20	28.58	27.04	23.83	62.45									
cnpr	13.69	15.65	32.99	30.71	6.04	28.65	50.95	27.96	37.06	58.99								
btkl	9.46	25.33	27.94	26.95	3.24	40.56	32.40	24.16	52.24	49.20	47.96							
goa	13.33	5.54	23.81	14.83	5.08	28.06	19.05	12.56	59.36	57.77	35.72	49.00						
rtngr	19.95	15.21	25.99	24.51	4.02	25.79	17.02	20.03	45.97	50.53	29.44	42.90	61.22					
dbhl	9.05	12.63	35.01	24.07	6.56	33.11	36.28	27.44	28.77	53.08	55.57	39.48	39.81	33.95				
ofmb	13.99	6.18	25.97	30.12	12.53	28.00	43.82	18.05	52.76	58.60	41.48	50.14	63.38	54.11	46.92			
almb	18.50	9.65	29.64	18.19	4.30	17.66	20.08	11.74	32.93	34.76	31.92	37.22	36.62	38.02	31.85	45.12		
prbn	11.48	13.41	27.25	15.79	7.40	31.18	24.71	18.67	29.40	36.02	39.78	36.17	28.66	23.94	45.99	35.59	24.29	
dwrk	18.83	27.81	25.05	21.97	0.00	25.78	14.52	35.87	15.80	24.93	21.60	32.38	15.28	23.84	27.18	21.77	19.50	23.25

Table 6.6b. 51-75m depth ranges.

	cape	tvm	klm	kch	vad	knr1	knr2	mngr	cnpr	btkl1	btkl2	goa1	goa2	rtngr	dbhl	ofmb	almb	prbn
cape	0.00																	
tvm	20.21																	
klm	25.86	33.31																
kch	13.42	14.15	12.35															
vad	14.31	23.48	23.67	27.39														
knr1	18.86	18.31	22.82	21.22	27.08													
knr2	23.40	17.01	26.29	40.17	28.71	33.93												
mngr	15.84	14.57	17.64	28.59	30.53	41.98	40.20											
cnpr	13.44	21.01	20.56	11.14	27.67	23.08	21.47	19.81										
btkl1	26.72	31.38	17.65	22.74	20.00	31.64	33.30	32.65	18.06									
btkl2	22.68	29.93	32.88	13.00	16.77	32.87	35.76	25.21	11.61	27.62								
goa1	16.73	12.05	16.07	25.81	22.04	37.01	38.98	40.45	26.21	25.72	25.22							
goa2	23.88	22.60	27.46	23.78	32.23	33.47	45.63	40.46	22.14	29.54	42.29	32.57						
rtngr	13.31	16.97	23.77	19.61	18.57	31.37	25.66	25.09	19.37	30.14	36.34	44.82	21.99					
dbhl	17.96	26.52	24.54	20.64	33.69	34.08	25.33	32.54	23.93	26.47	17.71	42.79	19.51	30.75				
ofmb	18.09	21.35	13.89	20.36	30.58	25.73	25.06	25.73	18.60	26.15	18.94	36.65	24.42	39.82	26.64			
almb	21.31	18.34	28.57	24.49	26.61	40.22	49.62	45.60	28.39	31.89	20.87	63.87	33.62	41.62	43.99	33.14		
prbn	8.72	16.37	17.71	17.52	21.38	36.68	14.35	47.05	18.96	23.31	12.50	33.46	24.45	31.12	34.10	22.77	33.28	
dwrk	15.55	18.51	29.50	20.16	21.07	41.52	32.42	42.17	21.00	25.82	16.98	47.62	27.69	33.81	42.76	25.73	54.68	44.47

dbhl1	30.66								
dbhl2	28.61	41.87							
ofmb1	50.38	23.10	17.32						
ofmb2	28.70	12.13	7.65	26.05					
almb1	32.17	12.58	14.33	24.76	34.13				
almb2	43.92	26.84	26.75	30.53	23.97	19.55			
almb3	13.88	3.63	4.59	8.39	23.36	26.62	14.05		
almb4	14.43	0.00	0.00	8.80	8.65	0.00	4.21	0.00	
dwrk	46.54	35.22	31.79	43.99	27.34	22.19	48.82	8.77	4.49

Table. 6.6d. 101-150m depth ranges.

	cape	tvm	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr
cape												
tvm	38.46											
klm	12.97	22.06										
kch	25.67	43.23	18.67									
vad	21.82	32.75	13.65	37.57								
kzh	21.58	20.50	12.83	34.59	29.79							
knr	19.33	26.28	16.62	34.98	38.58	37.64						
mngr	3.18	12.60	11.70	6.67	19.15	12.33	37.47					
cnpr	18.49	25.13	9.72	23.35	38.96	15.23	31.58	27.03				
btkl	16.76	29.37	19.12	37.44	32.52	34.50	54.99	31.68	21.62			
goa	27.90	29.20	12.39	32.35	32.88	36.27	34.69	25.06	12.05	52.39		
rtngr	33.22	37.27	17.62	33.59	21.87	29.62	22.79	12.86	16.46	37.39	39.99	
prbn	13.95	31.28	17.26	29.70	25.18	32.45	29.22	31.14	19.84	36.42	35.17	28.50

Table. 6.6e. >150m depth.

	cape	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr	dbhl	prbn
cape													
klm	19.40												
kch	19.62	16.47											
vad	32.86	17.61	30.15										
kzh	26.82	19.08	19.42	22.19									
knr	30.70	15.04	35.36	32.41	67.50								
mngr	0.00	26.77	12.31	0.00	0.00	7.15							
cnpr	11.75	0.00	13.62	13.92	7.50	17.46	0.00						
btkl	4.67	34.09	13.42	5.75	0.00	7.67	61.78	0.00					
goa	15.02	22.25	36.33	18.98	27.06	26.70	12.34	0.00	13.99				
rtngr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
dbhl	9.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
prbn	12.23	0.00	17.33	14.88	0.00	14.25	8.78	13.72	9.59	12.26	0.00	0.00	
dwrk	5.19	0.00	11.91	6.55	0.00	9.18	0.00	17.49	0.00	0.00	0.00	0.00	24.12

Fig. 6.11a. Similarity between stations (Polychaetes): 30-50m depth range

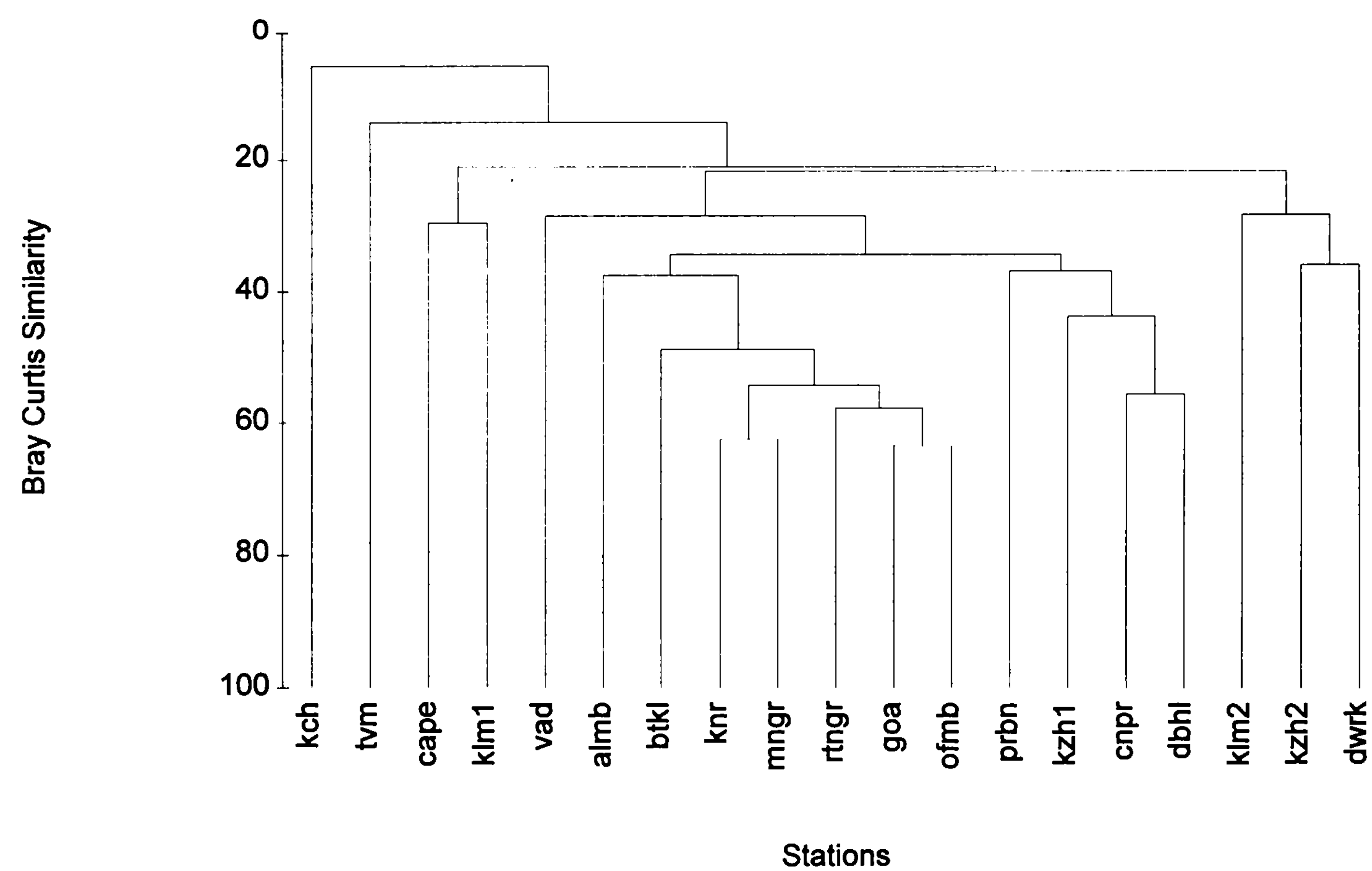


Fig. 6.11b. Similarity between stations (Polychaetes): 51-75m depth range

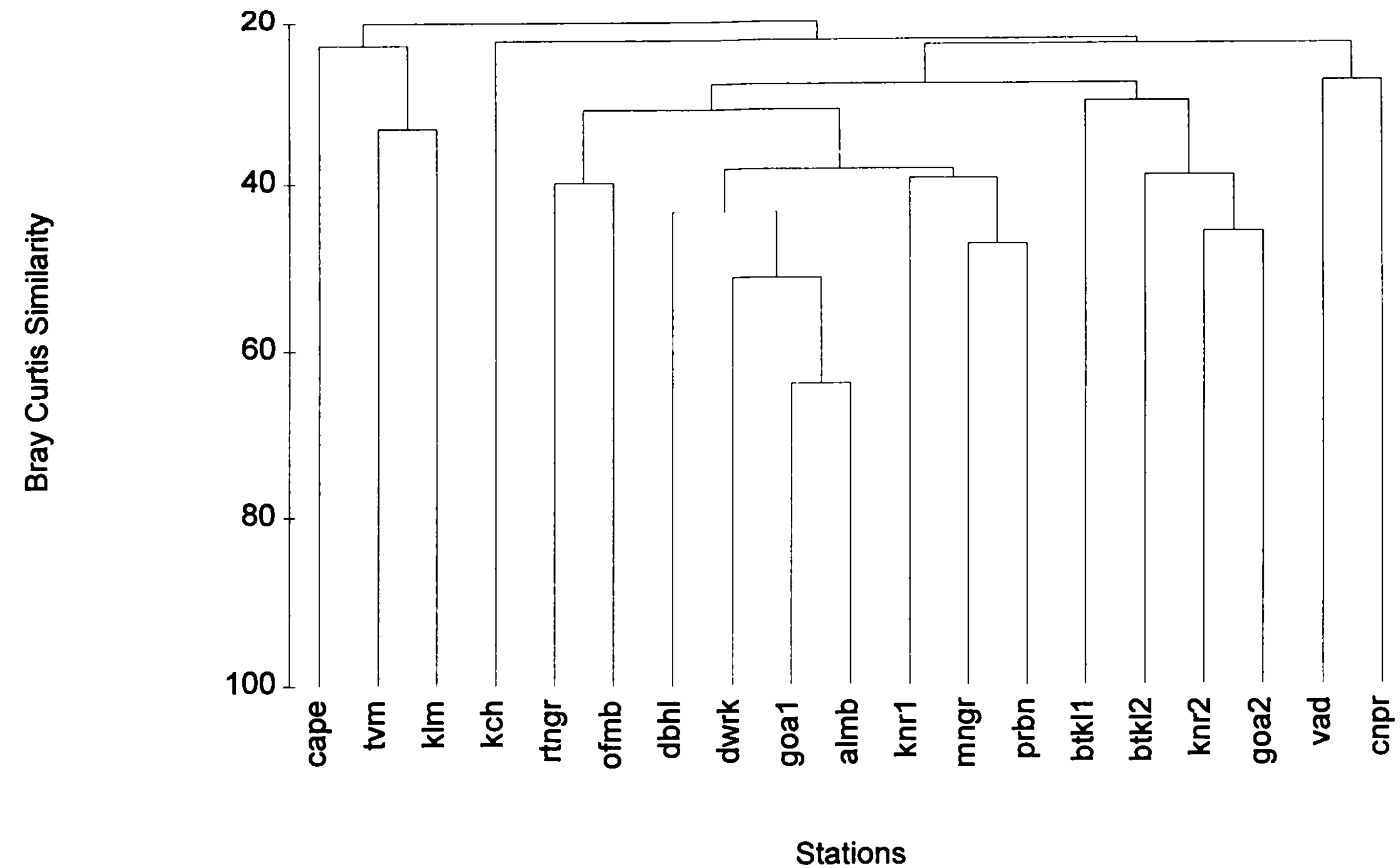


Fig. 6.11c. Similarity between stations (Polychaetes): 76-100m depth range

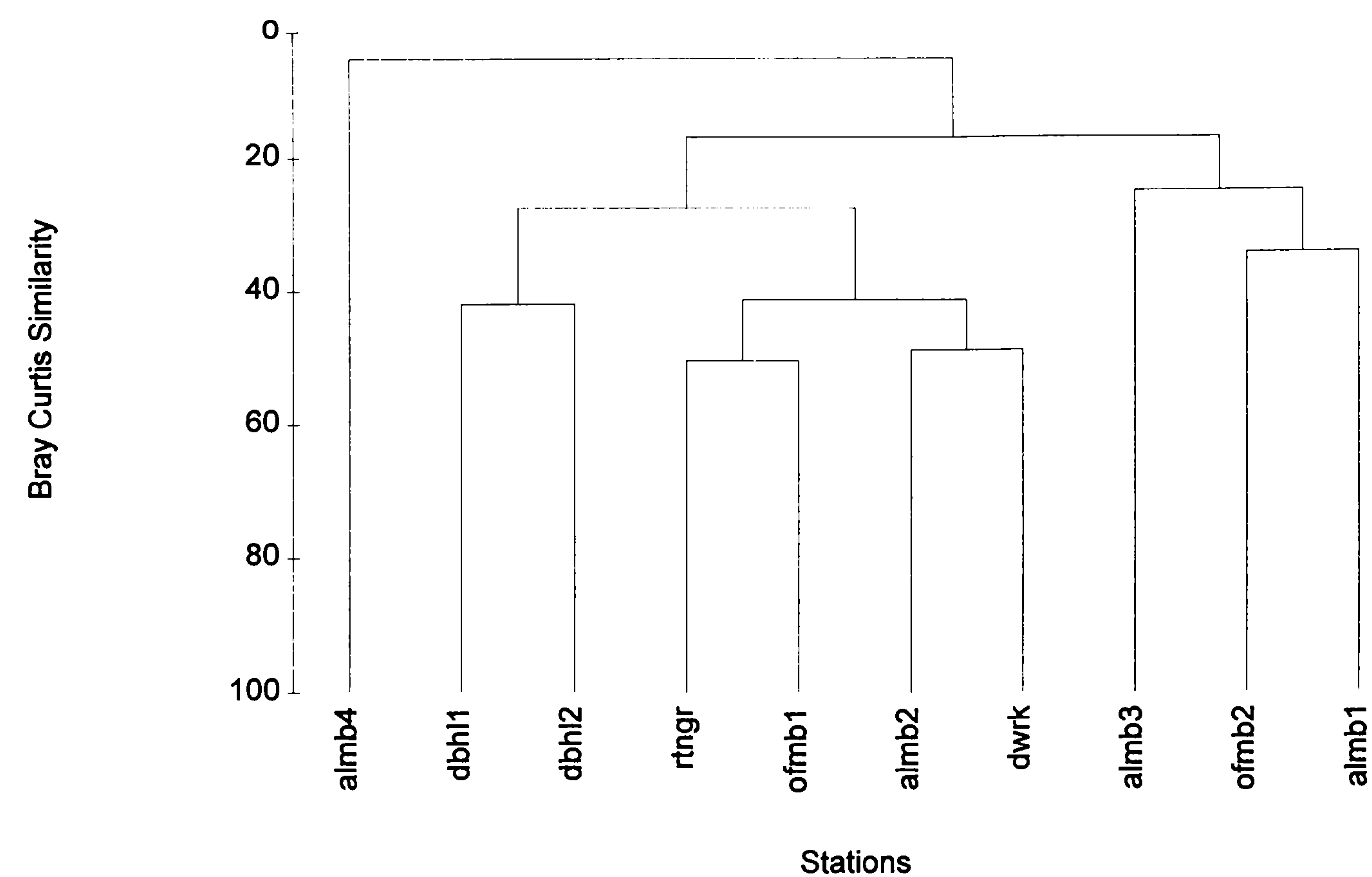


Fig. 6.11d. Similarity between stations (Polychaetes): 101-150m depth range

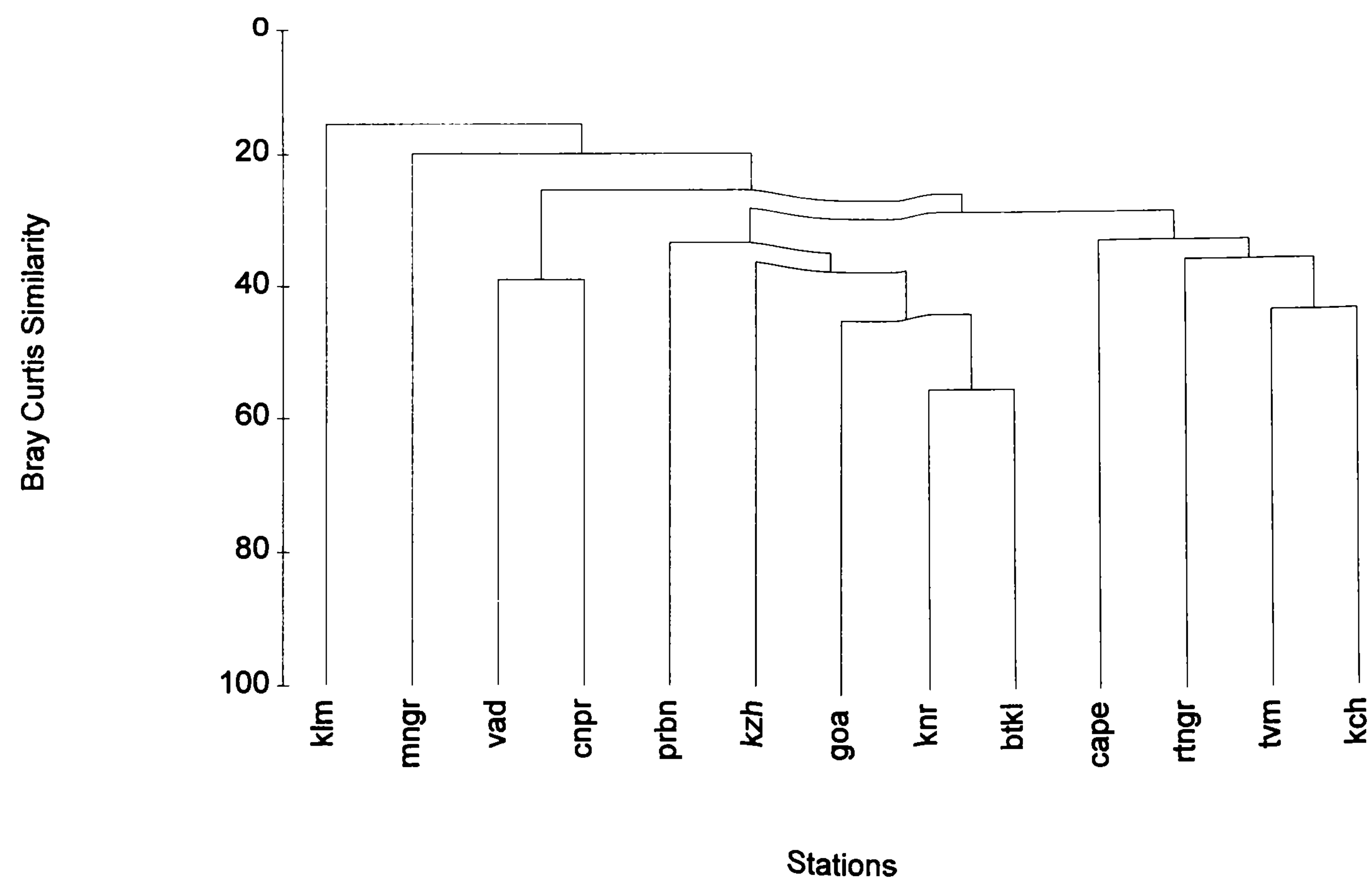
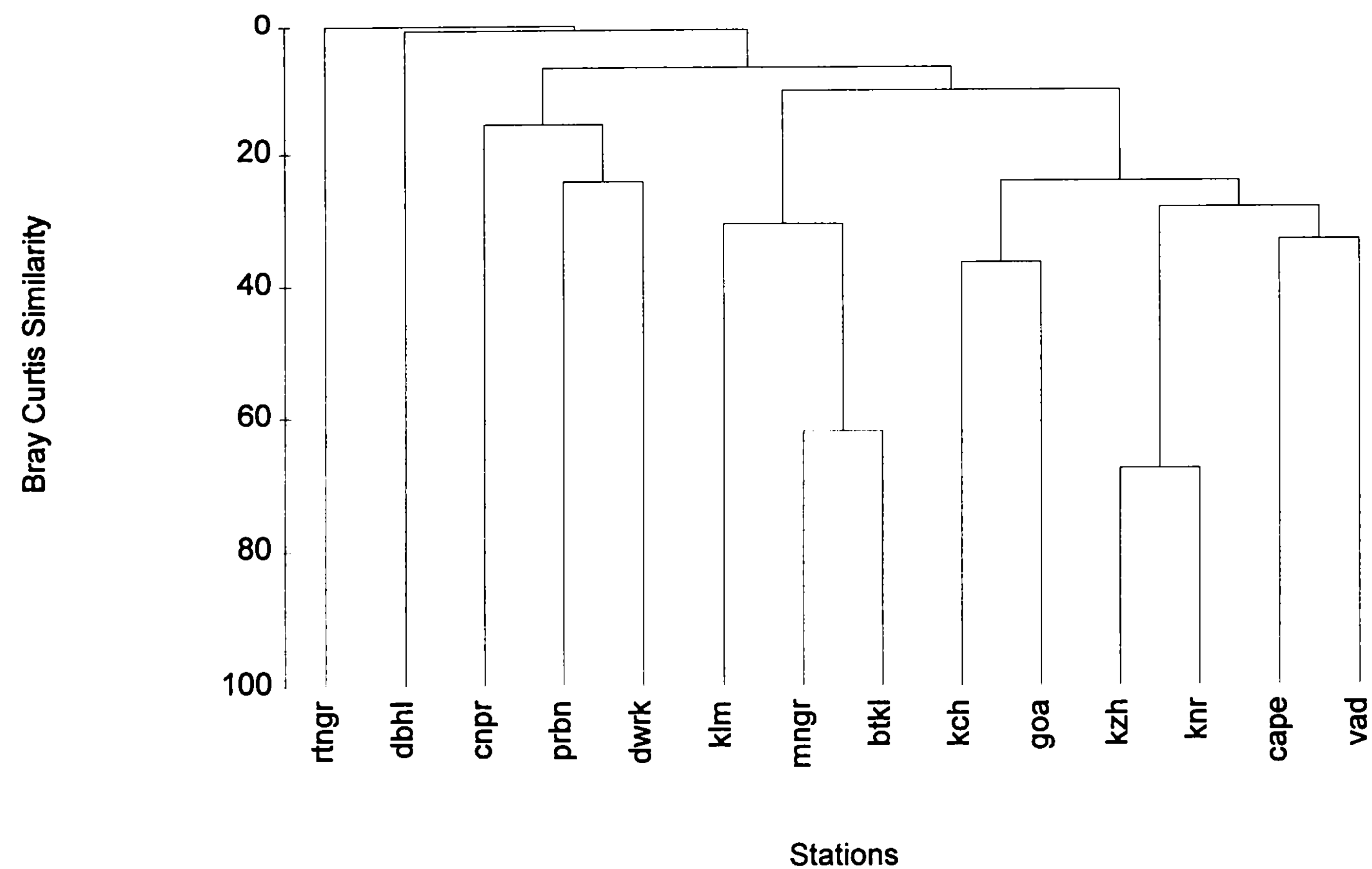


Fig. 6.11e. Similarity between stations (Polychaetes): >150m depths



and off Mangalore) to 54.99 (off Kannur and off Bhatkal). Off Bhatkal and off Goa showed 52.39% of similarity.

In >150m, the similarity ranged from nil to 67.50%. 36% of the combinations had no similarity at all. Maximum was noticed between off Kozhikode and off Kannur. Significant similarity was noticed between off Mangalore and off Bhatkal (61.78%).

6.2.6.2. Similarity with respect to groups: Similarity between stations with respect to groups is presented in Table 6.7 and Fig. 6.12. In 30-50m, similarity ranged from 29.07 (between off Kochi and off Cape Comorin) to 77.27% (between off Ratnagiri and off Bhatkal). 30m and 50m off Kollam also showed high similarity index.

In 51-75m, minimum similarity of 35.36% was noticed between off Porbandar and off Mumbai and maximum of 80.83% was noticed between off Kannur (67m) and off Ratnagiri. A similarity of 76.50% was observed between Goa (72m) and Bahtkal (68m). In this depth range, four more occurrences were noticed with more than 75% of similarity. They are between off Kochi and off Kollam, between 51m and 67m depths off Kannur, 72m and 52m off Goa and off Mumbai and off Ratnagiri.

The range of similarity index at 76 to 100m depth was between 21.93% (between along Mumbai, 95m depth and off Dabhol, 96m) and 76.6% (between

Table 6.7 Similarity index between stations with respect to groups

Table 6.7a 30-50m depth ranges.

	cape	tvm	klm1	klm2	kch	vad	kzh1	kzh2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	ofmb	almb	prbn
cape																		
tvm	48.36																	
klm1	46.59	69.81																
klm2	52.04	68.56	76.07															
kch	29.07	51.90	47.71	54.26														
vad	37.21	62.06	49.06	52.09	34.80													
kzh1	32.14	50.39	53.79	54.09	63.40	36.96												
kzh2	45.82	43.88	41.30	51.07	38.72	47.07	46.22											
knr	34.15	59.72	53.30	55.63	48.00	51.34	51.23	42.82										
mngr	33.37	51.31	45.57	52.81	53.19	52.07	50.60	55.68	62.57									
cnpr	39.38	46.92	46.98	53.37	36.94	58.27	41.38	55.87	52.67	59.26								
btkl	40.67	61.06	46.95	50.77	37.98	71.91	40.68	58.66	57.17	55.53	56.75							
goa	41.64	61.79	55.50	56.56	43.40	68.71	47.65	55.43	69.42	66.27	70.35	67.13						
rtngr	40.62	54.04	42.92	44.27	42.37	58.65	38.79	60.95	61.13	57.11	58.22	77.27	64.09					
dbhl	33.09	50.17	49.06	56.99	50.50	52.72	50.88	55.03	56.15	73.37	60.67	53.59	68.77	52.67				
ofmb	33.38	50.29	51.53	58.62	66.25	46.99	58.30	60.72	64.20	69.25	54.07	56.73	58.62	65.30	74.20			
almb	50.02	59.80	57.52	60.91	36.63	60.74	41.65	53.03	49.45	54.49	70.80	59.99	67.46	57.69	49.35	47.21		
prbn	40.15	69.87	59.28	61.55	41.21	65.21	47.32	55.50	58.70	65.05	56.29	65.83	70.93	59.61	57.95	53.94	64.50	
dwrk	58.50	61.67	47.82	55.31	43.70	53.62	44.73	53.34	62.75	58.04	50.24	70.48	62.46	62.02	50.73	51.46	61.35	57.56

Table. 6.7b. 51-75m depth ranges.

	cape	tvm	klm	kch	vad	knr1	knr2	mngr	cnpr	btkl1	btkl2	goa1	goa2	rtngr	dbhl	ofmb	almb	prbn
cape																		
tvm	62.94																	
klm	63.11	52.31																
kch	49.02	46.94	75.60															
vad	45.86	50.41	57.25	63.55														
knr1	54.17	59.05	58.33	66.86	61.38													
knr2	50.95	52.59	69.94	70.34	62.81	76.28												
mngr	46.75	53.51	64.05	55.85	49.38	63.81	66.91											
cnpr	58.66	61.61	68.83	55.69	48.49	59.58	52.94	57.18										
btkl1	63.58	50.17	70.81	51.48	54.16	53.79	62.40	53.62	61.15									
btkl2	61.13	65.02	74.77	58.05	52.33	64.36	59.85	67.70	70.44	70.19								
goa1	56.10	56.21	54.70	52.63	55.36	68.66	64.08	66.51	49.52	65.45	66.88							
goa2	54.00	59.92	57.78	59.19	59.42	70.42	60.69	72.01	56.20	54.00	76.50	75.39						
rtngr	57.34	48.98	64.91	70.38	69.43	74.48	80.83	55.08	47.79	59.70	61.90	69.29	65.09					
dbhl	38.21	48.39	47.52	49.27	58.83	67.03	60.91	73.38	45.36	49.54	58.08	70.52	66.69	54.84				
ofmb	42.65	39.02	61.74	73.82	61.89	69.70	74.47	51.08	47.88	53.51	51.08	55.21	55.61	76.16	54.63			
almb	56.52	53.23	56.53	50.16	44.03	56.96	55.43	52.11	53.22	54.73	63.21	59.72	58.02	55.18	55.74	40.34		
prbn	42.28	43.80	45.93	40.44	39.62	49.25	41.20	55.09	46.08	40.96	50.90	54.16	52.73	39.67	51.74	35.36	51.52	
dwrk	57.69	47.32	46.76	41.87	34.32	48.87	49.11	62.81	41.99	42.91	52.49	67.33	60.06	48.10	56.44	37.33	62.79	68.67

[illegible]

	rtngr	dbhl1	dbhl2	ofmb1	ofmb2	almb1	almb2	almb3	almb4
rtngr									
dbhl1	63.73								
dbhl2	63.38	68.38							
ofmb1	67.79	52.78	58.12						
ofmb2	70.70	46.57	51.87	67.86					
almb1	72.83	50.51	57.75	62.91	60.79				
almb2	58.77	69.06	76.60	58.19	51.92	57.82			
almb3	58.26	44.46	60.63	62.48	56.01	55.12	55.13		
almb4	40.50	21.93	30.00	42.07	47.42	33.35	30.04	50.12	
dwrk	67.27	59.84	63.49	54.21	58.00	75.41	66.16	46.67	26.26

Table 6.7d. 101-150m depth ranges.

	cape	tvm	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr
cape												
tvm	71.01											
klm	43.62	55.87										
kch	62.13	71.88	67.25									
vad	52.82	64.55	54.59	55.52								
kzh	37.47	48.02	72.13	54.79	61.11							
knr	54.46	67.63	61.38	66.27	60.38	65.49						
mngr	48.59	49.80	61.58	55.88	61.39	68.10	62.52					
cnpr	49.72	60.99	69.80	67.87	55.59	52.39	59.13	53.94				
btkl	60.43	67.80	68.90	74.90	65.25	62.26	74.28	70.74	61.11			
goa	46.06	58.97	61.51	69.64	57.33	57.24	67.89	52.06	61.49	60.58		
rtngr	57.79	69.74	57.86	67.13	64.76	51.91	69.31	55.71	65.06	62.65	70.26	
prbn	57.69	54.20	51.18	54.52	47.59	44.61	56.67	48.95	47.13	56.89	51.02	59.64

Table 6.7e. >150m depth.

	cape	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr	dbhl	prbn
cape													
klm	48.32												
kch	36.13	48.39											
vad	41.96	35.29	23.14										
kzh	45.64	49.04	66.45	29.00									
knr	45.03	57.33	64.14	33.07	76.70								
mngr	40.70	51.15	67.24	30.81	59.60	69.12							
cnpr	46.80	50.09	54.80	40.64	52.86	60.88	63.62						
btkl	30.29	47.71	62.40	31.53	74.36	72.22	67.90	49.30					
goa	30.73	32.05	52.72	22.27	57.22	49.98	41.17	40.94	39.76				
rtngr	30.74	18.06	25.64	14.05	34.91	31.53	27.14	25.44	11.20	30.31			
dbhl	47.30	47.52	54.02	39.24	57.19	62.08	62.85	59.40	48.93	47.75	33.31		
prbn	61.05	31.49	43.41	36.37	52.91	46.40	44.73	51.29	34.86	41.67	31.22	48.46	
dwrk	45.84	25.77	36.02	40.42	49.91	38.16	36.00	39.33	28.94	42.14	33.34	42.17	63.15

Fig. 6.12a. Similarity between stations (Groups): 30-50m depth range

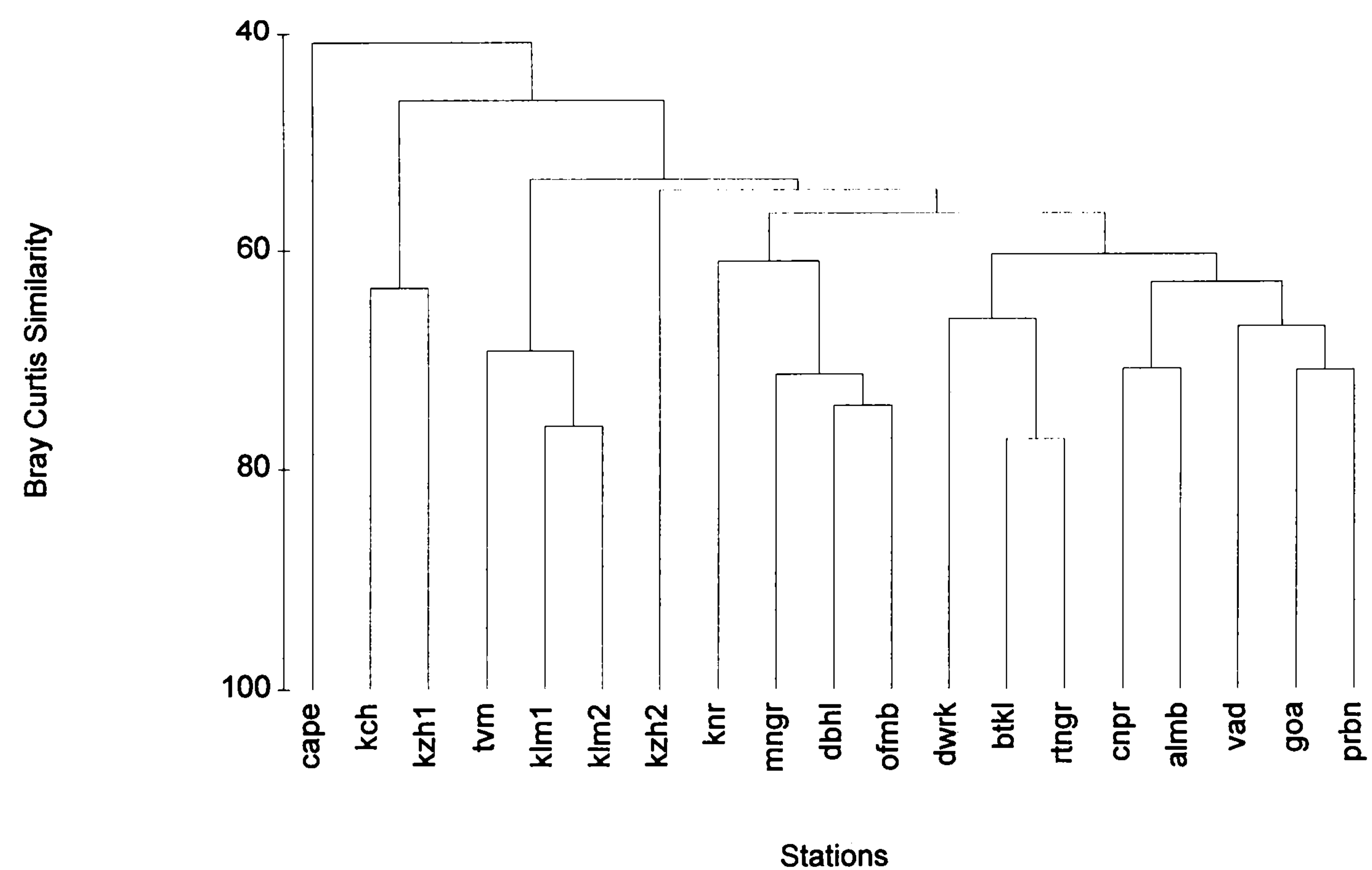


Fig. 6.12b. Similarity between stations (Groups): 51-75m depth range

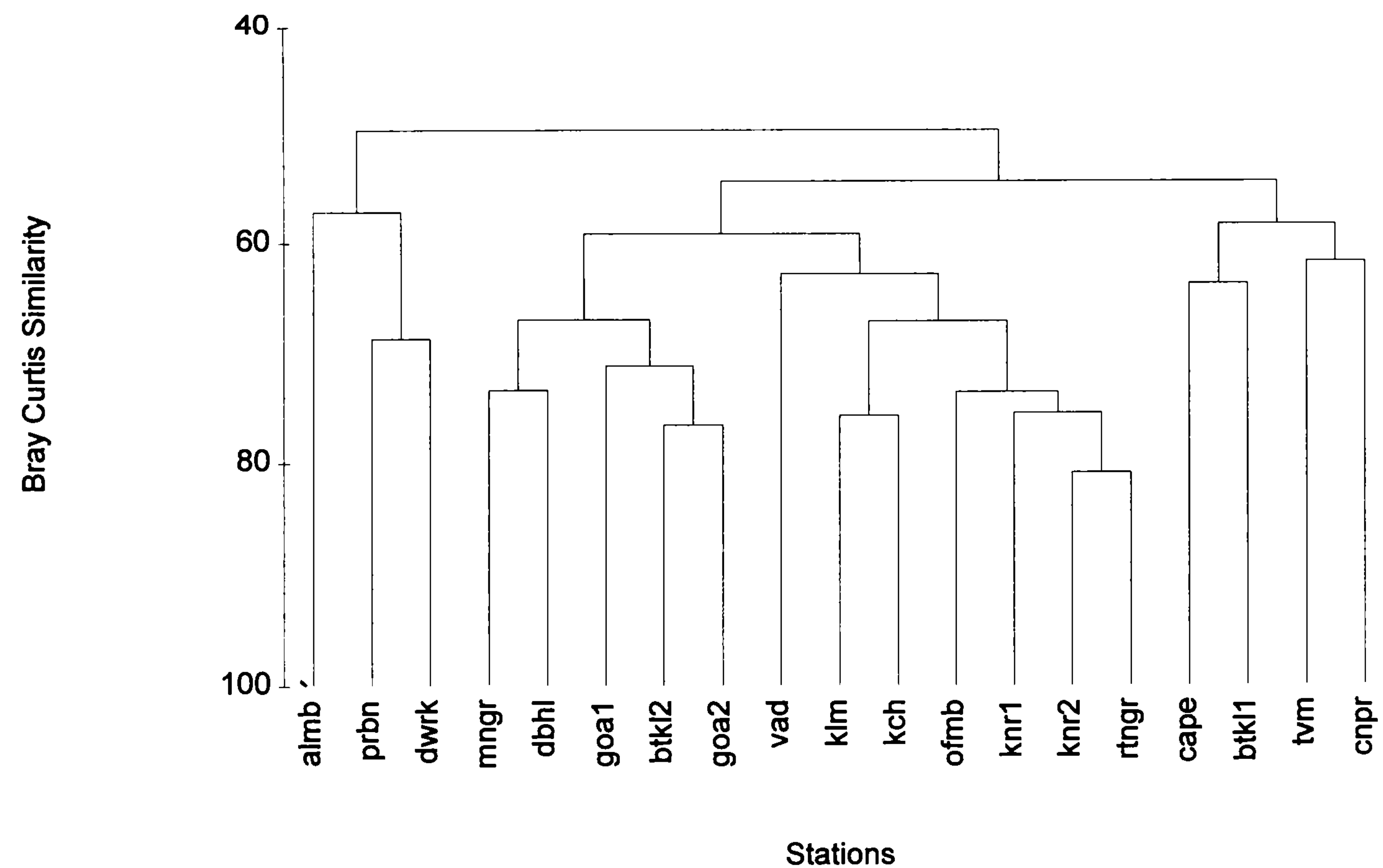


Fig. 6.12c. Similarity between stations (Groups): 76-100m depth range

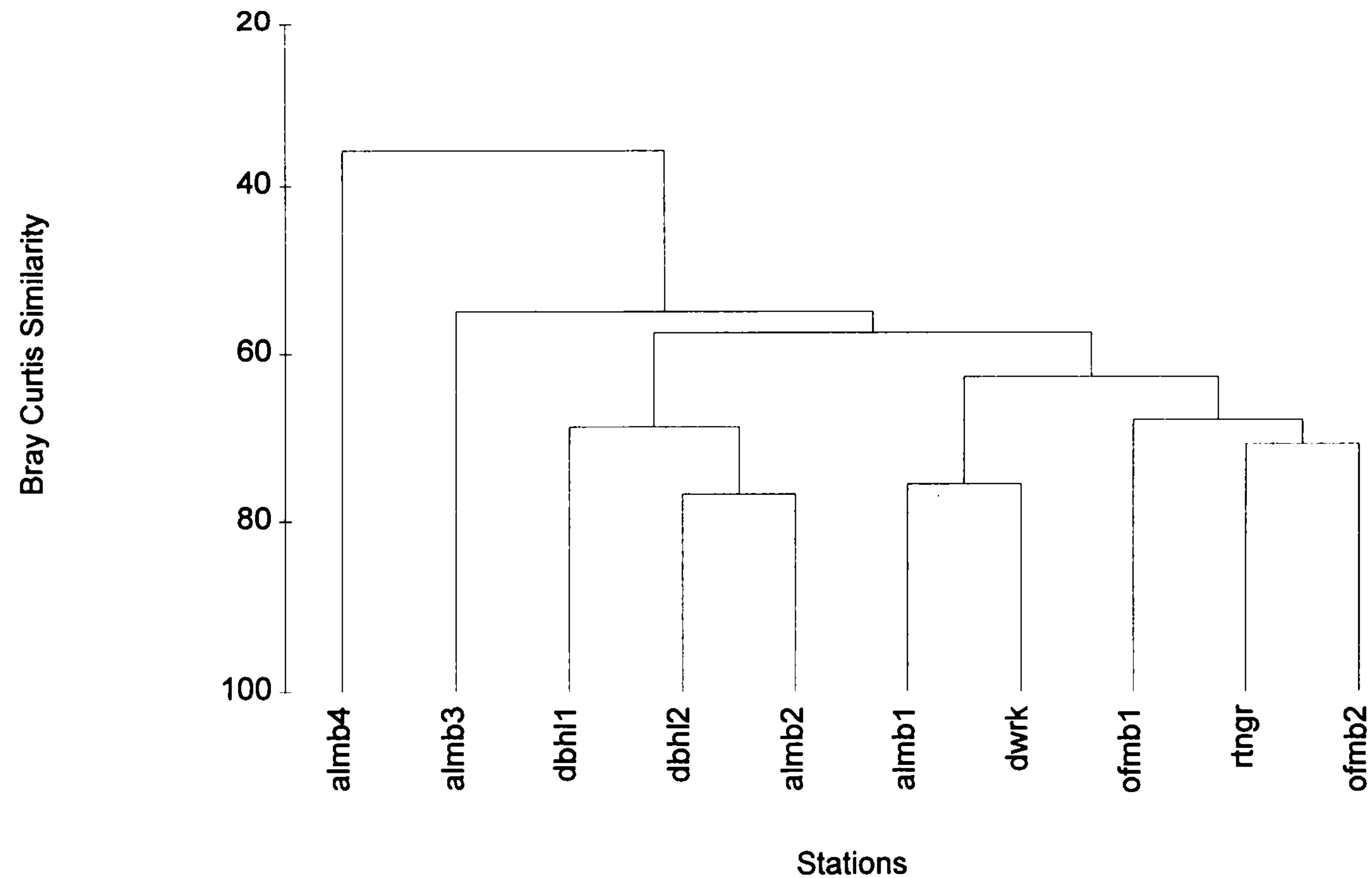


Fig. 6.12d. Similarity between stations (Groups): 101-150m depth range

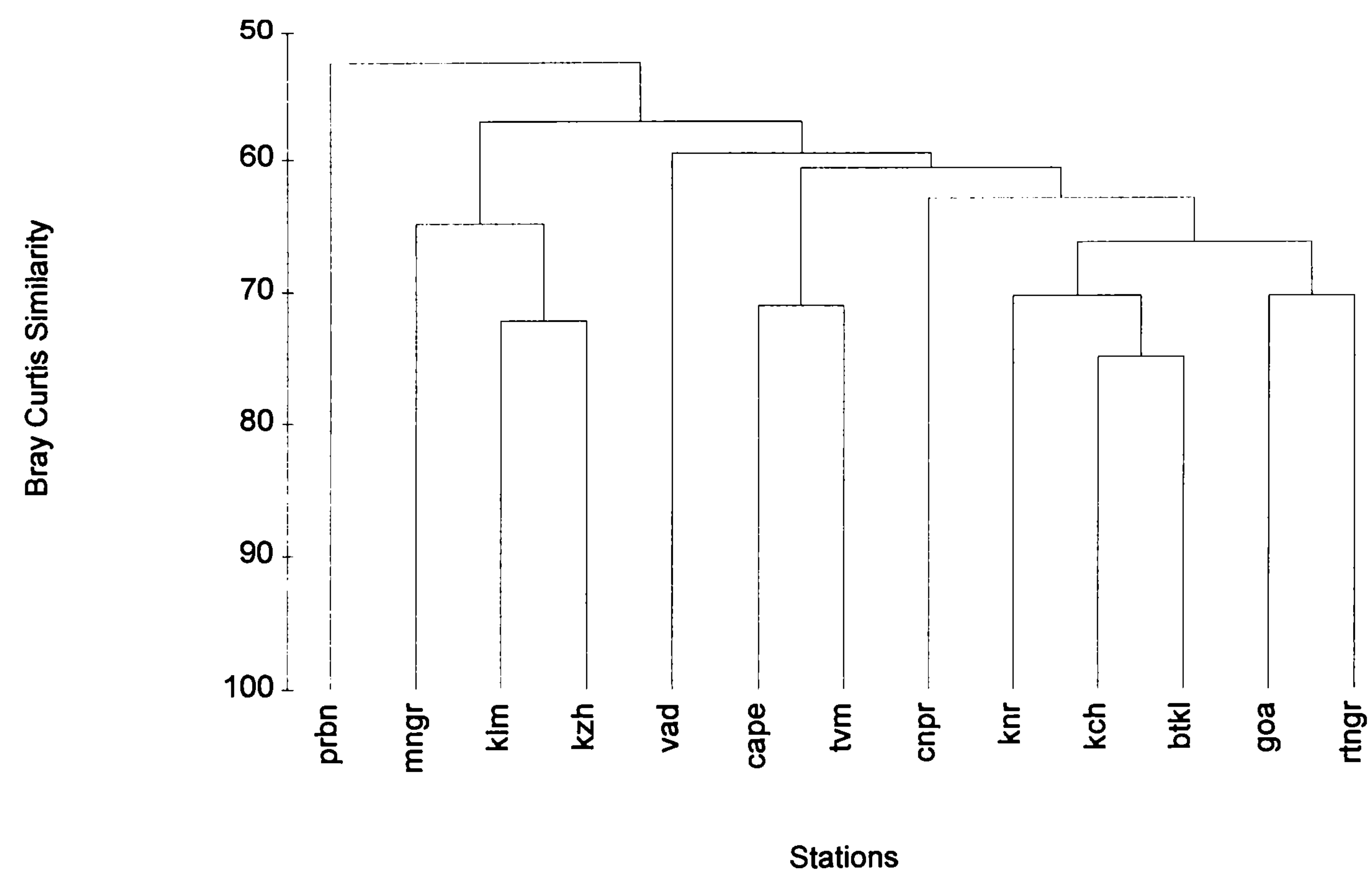
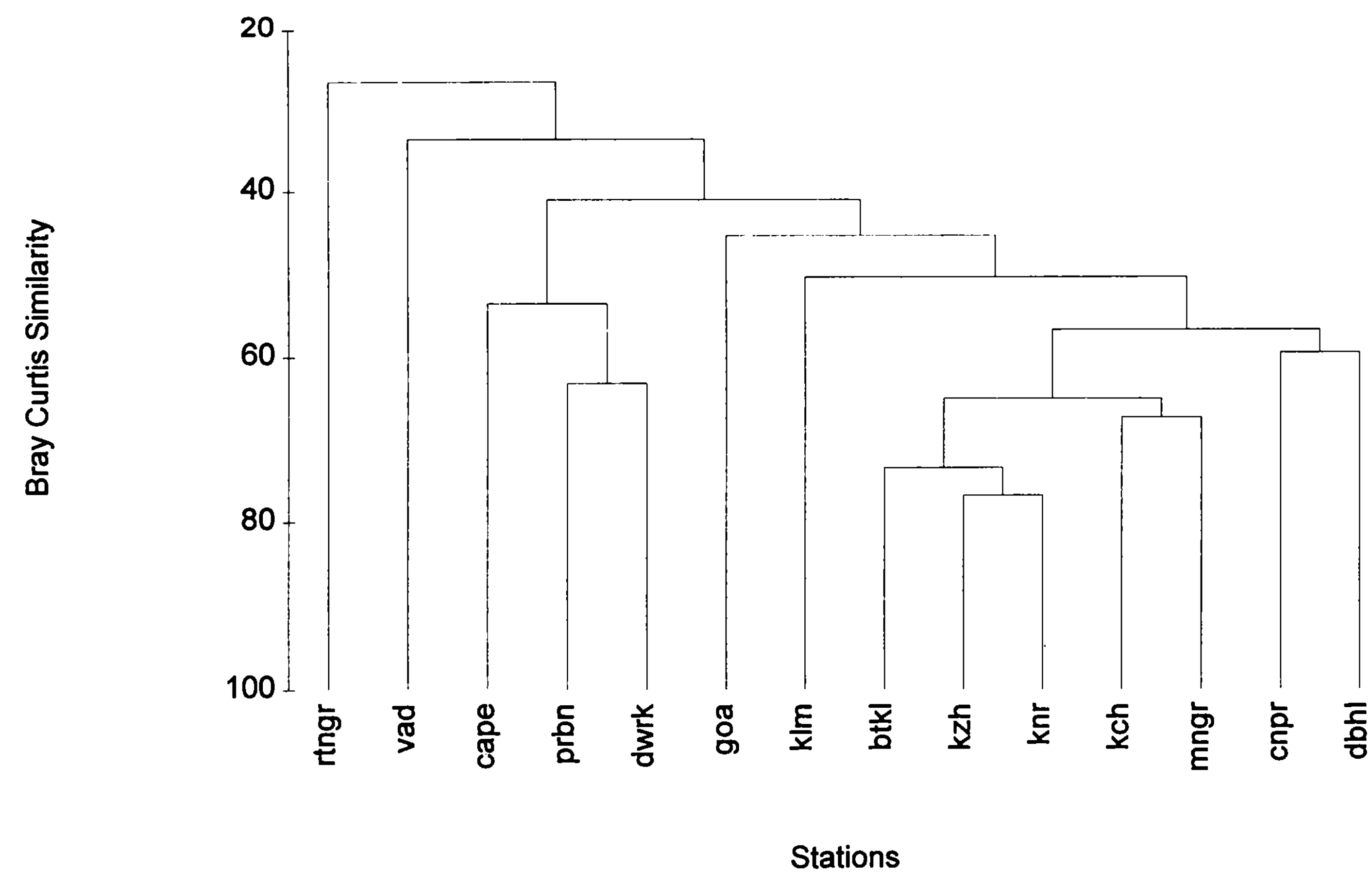


Fig. 6.12e. Similarity between stations (Groups): >150m depths



along Mumbai, 85m and Dabhol, 94m). High similarity was also noticed between off Dwarka and along Mumbai, 79m.

In 101-150m, more than 75% similarity was not noticed in any case. It ranged from 37.47% (between off Kozhikode and off Cape Comorin) to 74.90% (off Bhatkal and off Kochi).

In >150m, similarity ranged from 11.20% (off Ratnagiri and off Bhatkal) to 76.70% (off Kannur and off Kozhikode).

5.2.7. **Predictive Regression Model**

30-50m depth: The regression model of abundance of total polychaetes on the parameters temperature, salinity, DO, organic matter, sand, silt and clay could explain only 14.26% of the spatial variation in polychaete distribution. The best regression model was the model of total polychaetes (Y) regressed on the parameters, salinity (X1), organic matter (X2), silt (X3) and clay (X4) and their first order interaction effects. The model equation is:

$$Y = 0.1758 + 0.9908X1 - 0.4577X2 + 3.3041X3 - 3.4224X4 + 2.6950X1X2 - 0.8954X1X3 + 1.3725X1X4 + 0.6586X2X3 - 2.6821X2X4 + 5.2551X3X4$$

This model could explain about 61.44% of variation in the distribution and abundance of polychaetes $F (10,8) = 3.8679$, ($p<0.05$)

The relative importance of the parameters is graded as:

X3X4>X4>X3>X1X2>X2X4>X1X4>X1>X1X3>X2X3>X2

This implies that silt and clay are the parameters controlling the polychaete distribution at this lower depth.

51-75m depth: The linear regression on each of the parameter on individual effects separately explained about 25.10%, 18.34%, 18.12%, 14.35% and 8.95% for the parameters temperature, salinity, sand and clay and silt respectively. But the model which could explain the maximum variability of 88.64% was the model of total abundance of polychaetes (Y) regressed on temperature dissolved oxygen, organic matter, sand and silt. The model equation is:

$$Y = -9.6543 + 9.1446X1 - 2.1934X2 - 1.4899X3 + 2.8455X4 + 9.7070X5 + 0.10336X1X2 - 0.52885X1X3 - 2.5503X1X4 + 4.8856X15 - 11.0026X2X3 + 3.5321X2X4 - 1.32646X2X5 - 3.577X3X4 + 0.10336X3X5 + 3.5046X4X5,$$

$F(15,3) = 10.3663$, ($p<0.05$)

When sand is replaced with clay about 82.21% of the spatial variability is explained by the parameters.

76-100m depth: In this depth range individual effect of parameters alone could not predict the polychaete abundance. Sand was the only exception which could explain about 14.0939% of the variation in the distribution of polychaetes. Sand and salinity combination accounted for 27.12%, dissolved oxygen with sand accounted for 20.21% of the variation, while organic matter and sand gave a better quantity (32.98%). The best predictive model is that of total polychaetes on emperature, organic matter and clay with an explained spatial variability of :1.73% $\{F_{(6,3)} = 17.6$ $(p<0.05)\}$. The model equation is:

$$Y = -0.2929 + 0.23099X1 + 1.0694X2 - 0.9282X3 - 1.2523X1X2 - 1.4949X1X3$$
$$\cdot 0.6012X2X3$$

The grading of parameters is:

X1X3)>(X1X2)>X2>(X2X3)>X1. Of these I, 2 and 4 are limiting factors whereas, 3,5 and 6 are controlling factors.

<u>00-150m depth:</u> At this depth stratum also individual effect of parameters are ess compared to the interaction effect of parameters. The best model is that of emperature, organic matter, sand and clay, explaining 97.51% of the spatial variability in the distribution of polychaetes. The combination of salinity, dissolved oxygen, organic matter and sand explains about 93.46%. The best model equation is:

$$Y = 1.6958 - 3.5745X1 + 0.8306X2 - 5.0745X3 - 0.2905X4 - 4.1297(X1X2) +$$
$$.005229(X1X3) + 7.2203(X1X4) + 1.0999(X2X3) - 2.1362(X2X4) -$$
$$.4456(X3X4).$$

Relatively important parameters are:

X1X4)>X3>(X1X2)>(X3X4)>(X2X3)>X2>X4>(X1X3). Of these factors, 1,7,8 and 9 are controlling distribution whereas the other factors are limiting the abundance.

>150m depth: At this depth stratum, individual effects could explain about 56.77% of the spatial variation in the polychaete abundance and distribution. The best predictive model is that of total abundance on temperature, salinity, silt and clay and it is:

Y = -0.26945 + 0.96108X1 – 2.30217X2 – 2.7768X3 + 3.3833X4 – 0.6484(X1X2) - 0.10106(X1X3) – 1.2256(X1X4) + 3.1938(X2X3) – 2.4912(X2X4) + 0.176838(X3X4). This could explain about 89.85% of the spatial variation in the distribution and abundance of polychaete; $F(10,3) = 12.5028$, ($p<0.05$). The combination of temperature, dissolved oxygen, organic matter and silt could predict the total polychaete abundance with 88.847% efficiency.

Unexplained variability was maximum beyond 150m (38.56%) and least (2.49%) in 100-150 m depth stratum.

5.3. Discussion

5.3.1. Faunal composition

According to the present study, polychaetes are the major macrobenthic forms. It contributed 56.18% of total individuals. Previous workers also have reported the dominance of polychaetes in various regions of the western continental shelf (Damodaran, 1973; Harkantra *et al.,* 1980; Harkantra and Parulekar, 1981; Visakat *et al.,* 1991; Venkatesh Prabhu *et al.*, 1993; Harkantra & Parulekar, 1994). A prominent variation in faunal composition was noticed with depth. Although 165 polychaete species were identified from the whole shelf rea only 22 were observed in all the depth ranges. There was a progressive decrease in species number with increase in depth. Number of polychaete species decreased from 117 species in 30m to 52 species in >150m. The decrease was 2.56% from 30-50m to 51-75m, 41.23% from 51-75 to 76-100m. From 76-100m, it increased 34.33% to 101-150m and again decreased 42.22% to >150m.

Of the total 32 polychaete families, which were noticed all along the shelf, only 18 families occurred in all the depth ranges: 8 families from Errantia and 10 from Sedentaria. These families were Aphroditidae, Amphinomidae, Phyllodocidae, Pilargidae, Hesionidae, Neridae, Nephtidae, Glyceridae and Eunicidae from Errantia and Spionidae, Magelonidae, Cirratulidae, Orbinidae, Paraonidae, Cossuridae, Maldanidae, Ampharetidae, Terebellidae and Sabellidae from Sedentaria. In general, Pilargidae, Nephtyidae, Glyceridae, Eunicidae, Spionidae, Magelonidae, and Cossuridae were the families, which made significant contribution with respect to more number of individuals. So far most of the qualitative studies on macrobenthos in the west coast of India were limited to various regions and the number of species reported were considerably less than the present study, such as 22 species of polychaetes belonging to 19 genera (Damodaran, 1973) and 10 genera of polychaetes (Harkantra & Parulekar., 1981).

Present study indicates that with increasing depth, some of the families lose their importance. Families like, Amphinomidae, Nephtyidae, Glyceridae, Eunicidae, Spionidae, Cirratulidae, Orbinidae and Paraonidae were most important in 30-50m, with respect to number of species. But beyond 150m only Spionids, Cirratulids and Paraonids seemed to contribute more number of species. Recently Levin *et al.* (2000) while studying the macro fauna of Oman region extending from 400 to 3400m noticed the prevalence of Spionids and Cirratulids in 400-700m. Results of the present study corroborate this observation. Although Cirratulids and Paraonids did not contribute heavily, their occurrence was more or less uniform in different depth ranges. This indicates the difference in tolerance level of polychaete species to depth, low oxygen and low temperature.

As far as family number, species number and abundance are concerned, sedentarians were important. They outnumbered errant polychaetes in all the depth levels. The abundance of sedentarians varied between 60% (76-100m) and 93% (>150m). It was due to sedentarian polychaetes like, *Prionospio pinnata*, *Magelona cincta*, *Cossura coasta* and *Sternaspis scutata* that unusually high numerical density was recorded in certain stations. No errant polychaete species contributed numerically to such a magnitude. Sedentarians formed a major component contributing 66.7% among the abundant species, 56.03% among the moderately present species and 58.82% among the rare species. But the dominance of errant polychaetes has been reported from the nearshore waters of the west coast (Harakantra & Parulekar, 1981; Venkatesh Prabhu, 1992).

There was no significant latitudinal variation with respect to family, species umber and population density in the case of polychaetes.

Of the non-polychaete taxa, crustaceans were the important ones. They ontributed 30.62% of total individuals. Other studies have also reported portance of crustaceans after the polychaetes (Harkantra *et al.*, 1980; arkantra and Parulekar, 1981). There was not much latitudinal difference in the ase of distribution of amphipods. They were common in all the depth levels, ough abundance decreased with depth. Like that, isopods also showed its currence in all the depth levels. Tanaids were common up to 75m depth pecially in the southern latitudes, but beyond that they were rare. Copepods ere significant numerically even >150m. Cumacea, Ostracods, Pycnogonids, sids and Stomatopods were present at all the depth levels but not significant merically and their abundance decreased with increase in depth.

The contribution of molluscs were insignificant compared to the above two xa. They contributed only 1.77% of total fauna. But previous studies have icated the predominance of molluscs in certain areas, which, were either due the sampling restricted to the nearshore region (Gopalakrishnan & Nair, 1998) only epifauna were considered for the study (Neyman, 1969). In the present dy, others were composed of 11 taxa, which together contributed 11.43%.

.2 Community Structure

The most obvious gradient in marine biodiversity is that related with depth age, 1996). Sanders (1968) was the first to contradict the general opinion of at time, and established that the deep sea had higher diversity, after studying e benthic fauna of shallow estuaries, the Arabian Sea and the continental slope the deep sea. Later, others (Jumars, 1976; Gage, 1979; Grassle & Morse-rteus, 1987; Grassle, 1989) confirmed Sanders' finding of high number of ecies in the deep sea. But Poore and Wilson (1993) recorded more or less ame number of species in the continental shelf region of Bass Strait and the oining deep sea. Gray (1994) studied the benthic community of the orwegian continental shelf and compared the data of Grassle and Maciolek 92) from the deep sea off the east coast of USA and found that the Norwegian ntinental shelf had species diversity equal to that of deep sea. He questioned e paradigm that the deep sea has exceptionally high diversity.

In the present study, high species richness and species diversity of ychaetes were observed at 101-150m depth range and low species richness nd low diversity of polychaetes were noticed in the depth beyond 150m. The ecies richness calculated for groups also showed lower values beyond 150m pth. This decrease in species richness and diversity of polychaetes cannot be e to the lack of food, and only factor that appears to be limiting is dissolved ygen. From the low diversity of polychaetes in the shelf edge alone, it cannot e inferred that there is a decrease in total species diversity. Members of other a may maintain the species diversity. In the present study, though specific ails of the species composition of the crustacean fauna was not attempted, stacean abundance was higher than that of the abundance of the polychaetes articularly in the northern shelf edges. Whether crustaceans are compensating or the low diversity of polychaetes in the depth beyond 150m can be ascertained nly after the qualitative analysis of all the groups.

In the English Channel, Vallet and Dauvin (1998) noticed high diversity 3.58–4.75) in a depth range of 25-75m, because of the large number of species nd relatively high evenness (J' = 0.56–0.74). They attributed the high species ichness and species diversity to the more stable physical condition. Resource vailability for the benthos is a very important factor and has been shown to vary patially (Glover *et al.*, 2001). The diversity in terms of the actual number of pecies will vary over regional scales in response to changes in resource. Gage 1996) noticed that the species under-saturation of habitat might result in higher iodiversity because species population does not develop to levels where there s competition for resources. But so far the amount of sampling is vanishingly ess in relation to the huge total area of the benthic environment. Because of his even the order of magnitude of the real number of species present is still ighly uncertain (Gage, 1996).

3.3.3. Niche-breadth

The niche breadth calculated for the polychaete species showed that both are and moderately abundant species had higher niche-breadth where as highly bundant species had lower niche-breadth. The higher niche-breadth can be ue to the intra-specific competition and the low values noticed or highly abundant species can be due to the lack of intra-specific competition.

The analysis conducted for groups did not establish a clear trend. This can be due to the lack of understanding of the species composition of this group.

6.3.4. Similarity index

With respect to polychaetes more number of high similarity occurrences between stations were noticed in 30-50m depth range and lack of similarity between stations was more prominant in depth beyond 150m. Like the similarity of stations with respect to polychaetes, more number of higher similarity occurrences with respect to groups were present in shallow water area, but it did not show any lack of similarity in any of the depth ranges.

From the analysis of the similarity index worked out between stations it has been noticed that the main causative factor for the similarity between stations was the matching nature of the sediment in these stations. More over, in general, in these stations, the percentage of organic matter content was almost alike.

6.3.5. Predictive regression model

The analysis of the predictive regression model of polychaetes explained the relative importance of the parameters. It has been noticed that the major influencing parameters on polychaetes in the shallow water depths are the sediment nature and in the depth beyond 150m, temperature and dissolved oxygen play a major role in the distribution of the polychaetes.

Chapter 7

Standing stock

1. Introduction

Estimation of benthic standing stock is essential for the assessment of demersal fishery resources, as benthos form an important source of food for demersal fishes (Damodaran, 1973; Parulekar *et al.*, 1982). Between the primary production and the fish production, the role of benthic organisms, first as a feeder of plant material and detritus and in turn forming food of predators is now well understood.

Quantitative study of benthos attained importance after the work of Peterson (1911, 1913). Since then a lot of studies have been made in assessing the productivity of benthos. Belegvad (1930) found a relation between benthic biomass and plaice fishery in the Atlantic region. The study made by Sanders (1968, 1969) revealed the fact that biomass decreases with increase in depth. In Indian waters significant studies were made in this direction by Kurien (1967, 1971) Sanders (1968, 1969), Neyman (1969), Damodaran (1973), Ansari *et al.* (1977), Harkantra *et al.* (1980), Parulekar *et al.* (1980) and Harkantra and Parulekar (1981, 1994).

7.2. Results

In general polychaetes, crustaceans and molluscs contributed mainly to the biomass as well as abundance. But others, like sponges, echinoderms and fishes added their share substantially in many stations.

7.2.1. Depth-wise variation in each transect

Depth-wise variation of biomass (wet weight in g m^{-2}) and numerical abundance (no m^{-2}) in each transect is presented in Table 7.1 and Table 7.2.

Off Cape Comorin, biomass ranged between 3.730 g m^{-2} (208m) and 12.585 g m^{-2} (30.7m). There was a decrease of 57.48% in biomass as the depth increased from 30m to 50m. Further it showed an increase of 112.95% from 50 to 100m and again decreased to about 67.26% in 200m. Polychaetes (28%) and amphipods (27%) were the major groups at 30m, while the 50m depth range was characterized by the absence of a single dominant group. Decapods (35%) and nemertines (41%) were the major contributors to the very high biomass in 100m, whereas in 200m, it was the bivalves, which contributed 41% to the biomass.

Abundance of macrobenthos varied from 1840 m^{-2} (50m) to 4980 m^{-2} (30m). Numerical abundance varied considerably with depth. It showed a decrease of 63.05% from 30 to 50m. From 50 to 100m, an increase of 53.53% was observed and again a decrease of 20.71% was noticed from 100 to 200m.

Table 7.1. Biomass (wet weight in g m^{-2}) of the macrobenthic groups in each transect.

Transect	Station No	Depth	Polychaetes	Crustaceans	Molluscs	Others	Total
cape	1	30.7	3.545	5.376	0.000	3.664	12.585
	2	50.6	0.956	1.248	0.000	3.148	5.351
	3	101	1.466	4.731	0.000	5.199	11.395
	4	208	0.764	0.952	1.544	0.471	3.730
tvm	7	30	6.819	1.500	1.682	24.046	34.047
	6	59	1.325	7.185	0.728	7.694	16.932
	5	124	1.487	0.564	0.454	0.499	3.003
klm	8	30.6	3.466	0.864	0.830	0.914	6.074
	9	50	2.602	0.787	0.759	1.445	5.592
	10	73.7	0.097	0.365	0.458	0.147	1.066
	11	101	0.400	4.094	0.000	0.090	4.583
	12	238	0.625	0.006	0.000	0.516	1.147
kch	13	33.3	0.971	1.576	6.070	3.607	12.224
	14	51	1.722	0.067	0.165	0.904	2.857
	15	101	1.660	1.829	0.000	0.258	3.746
	16	202	0.244	0.051	0.000	0.103	0.398
vad	16d	36.2	5.360	0.913	0.290	0.065	6.628
	16c	52.6	4.280	0.500	0.237	0.095	5.112
	16b	103.4	1.895	2.182	0.100	3.341	7.518
	16a	197.3	4.260	1.816	0.000	0.790	6.866
kzh	17	31	0.396	0.223	10.521	1.010	12.149
	18	50	5.591	1.528	0.000	0.695	7.814
	19	102	0.900	1.642	0.031	0.014	2.586
	20	219	0.534	0.018	0.073	0.056	0.680
knr	25	31	2.433	0.443	0.498	3.009	6.382
	24	51.2	5.502	1.004	0.434	0.165	7.105
	23	67	4.030	0.550	0.237	0.052	4.869
	22	102	0.739	1.247	0.000	0.040	2.025
	21	202	0.407	0.625	0.000	0.050	1.082
mngr	26	31	1.819	0.044	0.000	0.276	2.138
	27	50.8	5.216	0.465	0.241	0.322	6.244
	28	101	0.398	5.570	0.000	0.107	6.075
	29	205	0.580	5.180	0.000	0.056	5.815
cnpr	29E	33.9	1.300	0.270	0.000	0.187	1.757
	29D	53.6	1.225	0.272	1.180	1.465	4.142
	29B	104.3	0.340	0.200	0.005	0.549	1.094
	29A	193	0.145	1.840	0.090	0.100	2.175

Table 7.1 continued.

Transect	Station No	Depth	Polychaetes	Crustaceans	Molluscs	Others	Total
btkl	34	31	2.421	4.320	0.106	0.125	6.972
	33	54.4	0.975	0.647	0.000	0.568	2.190
	32	68	0.658	2.687	0.000	0.263	3.607
	31	101	0.724	0.714	0.000	0.138	1.575
	30	206	0.316	1.635	0.000	0.322	2.272
goa	35	32	1.792	0.520	2.528	9.341	14.181
	36	52	2.217	1.737	0.000	5.571	9.525
	37	72	1.112	0.358	0.148	0.102	1.720
	38	101	0.419	0.161	0.000	0.060	0.640
	39	206	0.009	0.044	0.000	0.000	0.052
rtngr	40	32	1.047	6.458	0.000	3.630	11.135
	41	51.4	0.957	0.996	0.000	0.000	1.953
	42	76	1.248	0.055	0.828	0.018	2.148
	43	100.7	0.235	0.312	0.220	0.141	0.907
	44	211	0.001	0.086	0.000	0.003	0.090
dbhl	44A	35.3	1.330	0.045	0.070	0.295	1.740
	44B	57.1	7.140	1.131	0.072	1.265	9.608
	44C	95.7	2.840	0.785	0.000	0.510	4.135
	44D	94.3	1.250	0.280	0.070	7.080	8.680
	44E	191.6	2.280	3.740	0.000	15.200	21.220
ofmb	45	33	0.801	0.257	4.006	0.248	5.312
	46	51	4.790	0.521	0.022	0.574	5.906
	47	96	0.237	1.825	0.000	0.090	2.151
	48	89	0.633	0.044	0.000	0.080	0.757
almb	54	32	1.495	1.690	1.081	4.682	8.947
	53	51	1.165	2.665	0.000	6.744	10.574
	52	79	1.419	0.118	0.076	2.014	3.627
	51	85.3	0.800	0.447	0.940	5.852	8.039
	50	91	0.219	0.438	0.134	2.429	3.219
	49	95	0.300	0.005	0.055	0.036	0.395
prbn	58	33	3.644	0.256	0.345	4.089	8.333
	57	53	3.591	0.307	1.800	2.876	8.574
	56	101	1.647	0.428	0.033	1.955	4.062
	55	210	0.068	0.216	0.200	0.113	0.596
dwrk	59	33	2.388	0.560	0.029	5.455	8.432
	60	52	2.847	0.436	0.000	1.862	5.144
	61	100	0.762	0.974	0.029	0.670	2.434
	62	200	0.019	0.505	0.110	0.133	0.767

Table 7.2. Numerical abundance (no m^{-2}) of Macrobenthic groups in each transect.

Transects	St. No.	Depth	polychaetes	Crustaceans	Molluscs	Others	Total
cape	1	31	530	4370	0	80	4980
	2	51	470	1230	0	140	1840
	3	101	1325	1460	0	40	2825
	4	208	1000	1180	20	40	2240
tvm	7	30	1830	300	120	600	2850
	6	59	925	860	115	195	2095
	5	124	1110	380	30	160	1680
klm	8	31	615	385	230	250	1480
	9	50	390	515	45	400	1350
	10	74	420	225	20	185	850
	11	101	300	110	10	40	460
	12	238	690	30	0	130	850
kch	13	33	150	90	310	245	795
	14	51	285	130	30	80	525
	15	101	630	310	10	50	1000
	16	202	165	145	0	20	330
vad	16D	36	6080	600	50	40	6770
	16c	53	395	110	80	20	605
	16B	103	920	80	20	110	1130
	16A	197	2110	1150	0	100	3360
kzh	17	31	270	70	105	125	570
	18	50	510	290	0	80	880
	19	102	250	105	10	10	375
	20	219	215	90	10	30	345
knr	25	31	1115	150	10	200	1475
	24	51	790	130	15	90	1025
	23	67	420	120	10	70	620
	22	102	400	165	0	10	575
	21	202	345	105	0	50	500
mngr	26	31	660	245	20	100	1025
	27	51	1970	190	30	70	2260
	28	101	225	175	0	50	450
	29	205	275	95	0	105	475
cnpr	29E	30	615	1075	0	125	1815
	29D	53	680	325	70	1035	2110
	29B	104	400	170	10	200	780
	29A	200	540	175	10	150	875

Table 7.2 continued.

Transects	St. No.	Depth	polychaetes	Crustaceans	Molluscs	Others	Total
⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓
btkl	34	31	2635	505	15	260	3415
	33	54	410	395	0	305	1110
	32	68	885	320	0	115	1320
	31	101	625	255	0	30	910
	30	206	225	30	0	80	335
goa	35	32	1180	510	20	160	1870
	36	52	1320	260	0	50	1630
	37	72	1105	205	15	50	1375
	38	101	560	100	20	200	880
	39	206	65	60	0	0	125
rtngr	40	32	1350	780	0	95	2225
	41	51	500	125	0	0	625
	42	76	365	345	10	20	740
	43	101	620	130	20	140	910
	44	211	0	115	0	10	125
dbhl	44A	35	455	225	20	40	740
	44B	58	1360	210	30	100	1700
	44C	96	1655	480	0	80	2215
	44D	94	950	440	30	240	1660
	44E	192	360	120	0	80	560
ofmb	45	33	405	120	15	170	710
	46	51	420	55	10	40	525
	47	96	245	225	0	60	530
	48	89	355	190	10	70	625
almb	54	32	865	1490	85	470	2910
	53	51	670	1625	0	400	2695
	52	79	175	445	10	70	700
	51	85	1090	370	20	150	1630
	50	91	60	140	35	80	315
	49	95	50	50	10	10	120
prbn	58	33	1895	310	10	950	3165
	57	53	4320	265	10	1735	6330
	56	101	410	490	20	255	1175
	55	210	210	635	90	30	965
dwrk	59	33	1135	905	20	100	2160
	60	52	2375	1035	0	230	3640
	61	100	605	755	15	275	1650
	62	200	70	1735	20	40	1865

Amphipods constituted one of the major groups in all the depth and its number decreased with depth. Polychaetes dominated in the 100 and 200m depths.

Off Thiruvananthapuram, biomass ranged between 3.003 g m^{-2} (124m) and 34.047 g m^{-2} (30m) and there was a uniform decrease in biomass towards offshore. The biomass decreased by 50.27% from 30 to 50m and from 50m, it decreased by 82.26% in 124m. The abnormal increase in biomass in 30m was due to the presence of sponges and their contribution to the biomass was 67%. In 50m, major groups responsible for the higher biomass were decapods (37%) and starfishes (42%). In 124m, it was polychaetes (50%), which predominated.

The number ranged from 1680 m^{-2} (124m) to 2850 m^{-2} (30m). Like biomass, numerical abundance also decreased uniformly with depth. The decrease was 26.49% from 30 to 50m and 19.81% from 50 to 124m. Numerically polychaetes, which contributed more than 40% to the total, were the dominant group in all the depths.

Off Kollam, biomass ranged between 1.147 g m^{-2} (73m) and 6.074 g m^{-2} (30m). Biomass showed a decrease from nearshore to offshore except at 100m. A decrease of 7.93% in biomass occurred from 30 to 50m, 80.94% from 50 to 73m and 75.24% from 100 to 200m. The only exception was at 100m depth, where an increase of 330.04% was noticed in the biomass. In the 30, 50 and 200m depths, polychaetes (57%, 47% and 54% respectively) were the major groups, but in 73m, bivalves (43%) and in 100m, decapods (86 %) became the dominant groups.

The number varied between 460 m^{-2} (100m) and 1480 m^{-2} (30m). Except 200m depth, the abundance showed a decreasing trend with depth. The decrease was 8.78% from 30 to 50m, 37.04% from 50 to 74m and 44.88% from 74 to 100m. There was an increase of 84.78% in number from 100 to 200m due to the abundance of polychaetes. Polychaetes were the major groups in all depths, the percentage contribution of which varied from 29% in 50m to 81% in 200m.

Off Kochi, biomass ranged between 0.398 g m^{-2} (200m) and 12.224 g m^{-2} (30m). There was a decrease of 76.63% from 30 to 50m, whereas an increase of 31.12% was observed from 50 to 100m. Again, it showed a decrease of 89.39% from 100 to 200m. Higher biomass in 30m was due to bivalves (50%) and juvenile fishes (27%). Beyond 30m, polychaetes were the dominant groups.

In this transect, the number ranged between 330 m^{-2} (200m) and 1000 m^{-2} (100m). Numerical abundance did not show any gradation with depth. There was a decrease of 33.96% from 30 to 50m and it increased by 90.48% from 50 to 100m. Again it showed a decrease of 67% from 100 to 200m. Numerically, the major groups were polychaetes except at 30m, where bivalves contributed 39%.

Off Vadanappilly, biomass ranged between 5.112 g m^{-2} (50m) and 7.518 g m^{-2} (100m). A reduction of 22.87% in biomass was noticed from 30 to 50m, while an increase of 47.06% was observed from 50 to 100m. The biomass decreased by 8.67% from 100 to 200m. High biomass in 100m was due to the presence of small fishes, which contributed 44% of the biomass. Polychaetes were the dominant groups in all other depths.

Here, the number varied from 605 m^{-2} (50m) to 6770 m^{-2} (30m). The number showed wide fluctuations in different depths. Numerically, the percentage decreased by 91.06 from 30 to 50m and then increased by 86.78% from 50 to 100 and 197.35% from 100 to 200m. Polychaetes were the major groups in all the depths, which ranged between 63% (200m) and 90% (30m).

Off Kozhikode, biomass ranged between 0.690 g m^{-2} (200m) and 12.149 g m^{-2} (30m). A progressive decrease in biomass was observed towards offshore. The decrease was 35.69% from 30 to 50m, 66.9% from 50 to 100m and 73.7% from 100 to 200m. In 30m, bivalves contributed 87% to the total biomass. In other depths, polychaetes were the major groups. In 100m, stomatopods also made a significant contribution (36%).

The number varied from 345 m^{-2} (200m) to 880 m^{-2} (50m). It showed an increase of 54.39% from 30 to 50m, and then a decrease of 57.39% from 50 to 100m and 8.0% from 100 to 200m. Here, polychaetes dominated in all the depth levels which contributed to more than 45%.

Off Kannur, biomass ranged between 1.082 g m^{-2} (200m) and 7.105 g m^{-2} (50m). The biomass showed an increase of 11.32% from 30 to 50m and then it decreased by 31.47% from 50 to 67m, 58.41% from 67 to 100m and 46.57%

from 100 to 200m. Polychaetes were the major groups in all the stations. In addition, stomatopods contributed 40% of the biomass in 200m.

The number ranged from 500 m^{-2} (200m) to 1475 m^{-2} (30m). Unlike biomass, the number showed a progressive decrease with depth. The decrease was 30.51% from 30 to 50, 39.51% from 50 to 67m, 7.26% from 67 to 100m and 13.04% from 100 to 200m. Polychaetes were the major groups and contributed more than 66% in all the depths.

Off Mangalore, biomass varied from 2.138 g m^{-2} (30m) to 6.244 g m^{-2} (50m). The biomass showed considerable variation with depth. There was an increase of 192.11% from 30 to 50m. It decreased by 2.71% from 50 to 100m and by 4.27% from 100 to 200m. Polychaetes contributed to more than 80% in 30 and 50m whereas in 100 and 200m, crustaceans contributed more than 80%.

Here, the number ranged between 450 m^{-2} (100m) and 2260 m^{-2} (50m). It showed an irregular picture with respect to depth. There was an increase of 120.49% from 30 to 50m. From 50 to 100m, the number decreased by 80.09% and again showed a slight increase of 5.56% from 100 to 200m. Here also the dominant forms were polychaetes, which contributed more than 50% in all the depths. Decapods contributed 27.8% in 100m depth.

Off Coondapore, the biomass ranged between 1.094 gm^{-2} (100m) and 4.142 g m^{-2} (50m). An increase of 135.74% in biomass was observed from 30 to 50m. From 50 to 100m, there was a decrease of 73.59% and again the biomass decreased by 98.81% from 100 to 200m. In general, polychaetes were the major groups in all depths. However in 200m, decapods contributed to 80% of the total biomass due to the presence of *Alpheus malabaricus*.

Number ranged from 780 m^{-2} (100m) to 2110 m^{-2} (50m). The number showed an increase of 16.25% from 30 to 50m and then a decrease of 63.03% from 50 to 100m and again an increase of 12.18% from 100 to 200m. Crustaceans contributed approximately 60% in 30m depth due to the higher number of copepods whereas polychaetes dominated the rest of the depths.

Off Bhatkal, biomass varied between 1.575 g m^{-2} (100m) and 6.972 g m^{-2} (30m). There was an alternative increase and decrease in biomass between various depths in this transect. It showed a decrease of 68.59% from 30 to 50m, and an increase of 64.7% from 50 to 68m. The biomass again showed a decrease of 56.33% from 68 to 100m and finally an increase of 44.25% from 100 to 200m. In 30m and 50m, polychaetes were the dominant forms, whereas in 68m, it was the decapods (62%), which dominated. In 100m, polychaetes together with crustaceans mainly contributed to the biomass and in 200m, only crustaceans made a significant contribution to the biomass.

The number ranged from 335 m^{-2} (200m) to 3415 m^{-2} (30m). It showed a decreasing trend with depth with one exception. From 30 to 50m, there was a decrease of 67.5% and from 50 to 68m it increased by 18.92%. Afterwards, it kept on decreasing upto 200m. It decreased by 31.06% from 68 to 100m and

63.19% from 100 to 200m. Polychaetes were the major groups in all the depths. Crustaceans contributed to more than 35% in 50m depth.

Off Goa, the biomass ranged between 0.052 g m^{-2} (200m) and 14.181 g m^{-2} (30m). The biomass showed a decreasing trend with increase in depth. The decrease was 32.83% from 30 to 50m, 81.94% from 50 to 72m, 62.82% from 72 to 100m and 91.87% from 100 to 200m. In 30m, decapods contributed 64.51%, fishes (37%) in 50m, polychaetes (64%) in 70m and 100m, and crustaceans contributed about 84% of the total biomass in 200m.

The number ranged between 125 m^{-2} (200m) and 1870 m^{-2} (30m) and showed a decrease with increase in depth. The decrease was 12.83% from 30 to 50m, 15.64% from 50 to 70m, 36% from 70 to 100m and 85.8% from 100 to 200m. Numerically, polychaetes were the major groups in all the depths.

Off Ratnagiri, the biomass ranged between 0.090 g m^{-2} (200m) and 11.135 g m^{-2} (30m). With increasing depth, the biomass showed a decreasing pattern, with one exception. The biomass decreased by 82.46% from 30 to 50m, increased by 9.98% from 50 to 76m, decreased by 57.8% from 76 to 100m and decreased by 90.07% from 100 to 200m. In 30m, decapods (47%) were the major contributors, polychaetes (49%) and decapods (50%) in 50m, polychaetes (58%) in 75m, and isopods contributed 33% and 89% respectively in 100 and 200m depths.

The number ranged between 125 m^{-2} (200m) and 2255 m^{-2} (30m). There was considerable variation in number with depth. The number decreased by 71.91% from 30 to 50m and then showed an increase of 8.4% from 50 to 76m and 22.97% from 76 to 100m. Again there was a decrease of 86.27% noticed, from 100 to 200m. Polychaetes were the major groups upto 100m, which ranged between 49% (76m) to 80% (50m). However, at 200m, only crustaceans were significant.

Off Dabhol, biomass varied between 1.74 g m^{-2} (30m) and 21.22 g m^{-2} (200m). The biomass was increasing with depth with one exception. An increase of 452.18% in biomass was observed from 30 to 50m depth. A decrease of 56.96% was noted from 50 to 95m and then it showed a progressive increase of 109.92% from 95 to 94m and 144.47% from 94 to 190m. Polychaetes were the major groups (about 70%) upto 95m. At 94m, fishes contributed 75% and in 192m, domination by any particular group was not observed.

The number varied from 560 m^{-2} (200m) to 2215 m^{-2} (96m). There was an increase of 129.73% noted from 30 to 50m and 30.29% from 50 to 96m. From there, the number increased by 25.06% to the next depth level of 94m and decreased by 66.27% from 94 to 192m. Polychaetes (more than 56%) were the major groups in all the depths.

Off Mumbai, the highest biomass was at 50m (5.906 g m^{-2}) and lowest at 89m (0.757 g m^{-2}) depths. Biomass increased by 11.19% from 30 to 50m and then a uniform decrease of about 64% from 50 to 96m and from 96 to 89m was observed. Dominant groups in different depths were bivalves (75%) at 30m, polychaetes (81%) at 50m and (86%) at 89m and decapods (57%) at 96m.

The number ranged between 525 m^{-2} (50m) and 710 m^{-2} (30m). There was only slight variation in numerical abundance in this transect. A decrease of 26.06% was noted from 30 to 50m and then it increased by 0.96% from 50 to 96m and 17.92% from 96m to 89m. Polychaetes ranked first followed by crustaceans in all the depth levels.

Along Mumbai, the biomass ranged between 0.395 g m^{-2} (95m) and 10.574 g m^{-2} (51m) and showed noticeable variation with depth. The biomass increased by 18.18% from 30 to 50m and by 121.63% from 79 to 85m. A decrease of 65.7% from 50 to 79m, 59.96% from 85 to 91m and 87.74% from 91 to 95m was noticed. Juvenile fishes contributed more than 40% in 30 and 50m depths. Polychaetes contributed to 39% of the biomass at 79m and 76% at 95m. 73% of the total biomass at 91m depth was sea urchins.

The number varied from a low value of 120 m^{-2} (95m) to a high value of 2910 m^{-2} (30m). The number decreased with depth with one exception. The decrease from 30 to 50m was 7.39% and from 50 to 79m was 74.03%. Then an increase of 132.86% was observed from 79 to 85m. Again a decrease in abundance was noticed, 80.67% from 85 to 91m and 61.9% from 91 to 95m. Here, crustaceans were the major groups in all the depths except at 85m where polychaetes contributed about 67%.

Off Porbandar, biomass ranged between 0.596 g m^{-2} (200m) and 8.574 g m^{-2} (50m). Except a slight increase of 2.89% in biomass, from 30 to 50m, biomass showed a decreasing trend with depth, i.e., 52.62% from 50 to 100 and 85.33% from 100 to 200m. Polychaetes were the major groups upto 100m, which contributed more than 40%. At 200m, polychaete biomass was considerably less than the biomass of molluscs and crustaceans.

The number ranged between 965 m^{-2} (200m) and 6330 m^{-2} (50m). The increase from 30 to 50m was 100%, which was mainly due to the abundance of *Magelona cincta*. Then the number decreased by 81.44 from 50 to 100 and by 17.87% from 100 to 200m. Polychaetes were the major groups upto 50m. At 100m, polychaetes and crustaceans together contributed to the numbers substantially and in depths beyond 150m, the dominant form was crustaceans.

Off Dwarka, biomass ranged between 0.767 g m^{-2} (200m) and 8.432 g m^{-2} (30m). A progressive decrease in biomass was noticed towards offshore. It was 38.99% from 30 to 50m, 52.69% from 50 to 100 and 68.51% from 100 to 200m. At 30m, sea urchin contributed 59% to the total biomass, at 50m, polychaetes contributed to 55% and at 100 and 200m, crustaceans contributed more than 40% to the total biomass.

The number varied from 1650 m^{-2} (100m) to 3640 m^{-2} (50m). The number increased by 68.52% from 30 to 50m and then it decreased by 54.67% from 50 to 100m and by 13.03% from 100 to 200m. Polychaetes ranked first at 30 and 50m, while crustaceans were more in number at 100 and 200m.

7.2.2. Latitudinal variation in different depth ranges

Latitudinal variation of biomass and numerical abundance are presented in Tables 7.3, 7.4 and Figs 7.1, 7.2. Higher biomass was noticed in inshore areas, whereas, comparatively lower biomass was observed in deeper areas.

In the 30–50m depth range, higher biomass was noticed off Thiruvananthapuram 34.047 g m^{-2}, where the abundance of the sponges accounted to about 67% of the biomass. Off Kochi, *Musculista sp,* and *Arca sp,* and off Kozhikode and off Goa, sea cucumbers contributed to the biomass significantly. The lowest biomass was recorded off Mangalore (2.138 g m^{-2}). The average biomass of this depth range was 9.076 g m^{-2}.

Number varied from 570 m^{-2} (Kozhikode, 30m) to 6770 m^{-2} (Vadanappilly) with an average of 2168 m^{-2}. In the southern latitudes, the number showed a decreasing trend off Cape Comorin to Kochi, then a sudden increase at this depth range off Vadanappally. A drop in number could be found off Kozhikode and it then showed an increasing trend upto off Bhatkal. In the northern latitudes, fluctuation in number was less. This region maintained a moderate number except off Dabhol and off Mumbai, where the number was below 740m^{-2}. Off Vadanappilly, the highest number was due to the abundance of polychaetes (90%), whereas off Cape Comorin, it was amphipods (68%), which contributed to the higher abundance. Off Bhatkal ranked third in abundance, where, polychaetes contributed to 77% of the biomass. Polychaetes were the major groups off Thiruvananthapuram, Vadanappilly, Kannur, Bhatkal, Goa,

Table 7.3a Biomass of the macrobenthic groups of the shelf waters of the west coast of India (g m^{-2})
30-50m depth

Transect→	cape	tvm	klm 1	klm 2	kch	vad	kzh1	kzh2	kanr	mngr	cnpr	btkl	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk
Station No→	1	7	8	9	13	16d	17	18	25	26	29E	34	35	40	44A	45	54	58	59
Depth→	30.7	30	30.6	50	33.3	36.2	31	50	31	31	33.9	31	32	32	35.3	33	32	33	33
Hydrozoan	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
Sea anemone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.095	0.000	0.000	0.000	0.000
Polychaete	3.545	6.819	3.466	2.602	0.971	5.360	0.396	5.591	2.433	1.819	1.300	2.421	1.792	1.047	1.330	0.801	1.495	3.644	2.388
Amphipod	3.349	0.040	0.041	0.065	0.025	0.035	0.006	0.022	0.009	0.017	0.025	0.279	0.055	0.936	0.025	0.003	0.578	0.047	0.440
Caprellid	0.656	0.000	0.032	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.000	0.000	0.010	0.002	0.000	0.001	0.002	0.002	0.000
Isopod	0.783	0.379	0.563	0.419	0.049	0.330	0.101	0.000	0.026	0.000	0.120	0.241	0.022	0.014	0.000	0.012	0.027	0.119	0.022
Tanaid	0.060	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cumacean	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.007	0.000
Copepod	0.000	0.000	0.008	0.000	0.000	0.065	0.000	0.000	0.004	0.020	0.060	0.006	0.043	0.000	0.020	0.002	0.129	0.036	0.002
Pycnogonid	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.013	0.002	0.000	0.005	0.000	0.000	0.000
Ostracod	0.000	0.000	0.000	0.000	0.000	0.060	0.000	0.000	0.000	0.000	0.010	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Sergestid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
Stomatopod	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.514	0.404	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Decapod	0.494	1.080	0.219	0.302	1.502	0.418	0.116	0.991	0.000	0.000	0.040	3.792	0.379	5.506	0.000	0.234	0.945	0.046	0.097
Bivalve	0.000	1.290	0.222	0.759	6.070	0.140	10.521	0.000	0.498	0.000	0.000	0.106	2.528	0.000	0.070	4.006	0.915	0.345	0.029
Gastropod	0.000	0.392	0.608	0.000	0.000	0.150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000
Starfish	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brittle star	2.421	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050
Sea urchin	0.000	0.000	0.000	0.000	0.000	0.000	0.162	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.970
Sea cucumber	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.992	0.000	0.000	0.000	9.157	0.000	0.000	0.000	0.000	0.000	0.000
Sipunculid	0.000	0.000	0.601	1.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.300	1.139	0.000
Fish	0.000	0.000	0.000	0.000	3.308	0.000	0.773	0.082	0.000	0.233	0.000	0.000	0.000	3.510	0.000	0.058	4.080	1.981	0.000
Sponge	0.000	22.684	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nemertine	0.772	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.72	0.000
Others	0.471	1.362	0.313	0.245	0.299	0.065	0.075	0.574	0.017	0.043	0.187	0.125	0.185	0.120	0.200	0.190	0.302	0.249	0.428

Table 7.3b. Biomass of the macrobenthic groups of the shelf waters of the west coast of India (g m^{-2})
51-75m depth

transect→	cape	tvm	klm	kch	vad	kanr 1	kanr 2	mngr	cnpr	btkl 1	btkl 2	goa 1	goa 2	rtngr	dbhl	ofmb	almb	prbn	dwrk
Station No→	2	6	10	14	16c	24	23	27	29D	33	32	36	37	41	44B	46	53	57	60
depth→	50.6	59	73.7	51	52.6	51.2	67	50.8	53.6	54.4	68	52	72	51.4	57.1	51	51	53	52
Hydrozoan	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.462	0.000	0.000
Polychaete	0.956	1.325	0.097	1.722	4.280	5.502	4.030	5.216	1.225	0.975	0.658	2.217	1.112	0.957	7.140	4.790	1.165	3.591	2.847
Amphipod	0.734	0.078	0.018	0.029	0.000	0.046	0.025	0.023	0.137	0.055	0.044	0.116	0.012	0.011	0.016	0.026	0.044	0.299	0.050
Caprellid	0.138	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.010	0.000	0.000	0.003	0.002	0.000	0.006
Isopod	0.121	0.346	0.097	0.004	0.000	0.013	0.157	0.265	0.000	0.000	0.039	0.000	0.037	0.000	0.000	0.000	0.099	0.005	0.018
Tanaid	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Cumacean	0.000	0.017	0.000	0.008	0.000	0.000	0.000	0.000	0.010	0.000	0.004	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000
Copepod	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.001	0.016	0.002	0.003	0.000	0.040	0.000	0.277	0.003	0.012
Pycnogonid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.028	0.004	0.000	0.000	0.000	0.000	0.000	0.000
Ostracod	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.010	0.054	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stomatopod	0.000	0.000	0.000	0.000	0.000	0.000	0.350	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.225	0.000	1.964	0.000	0.000
Decapod	0.087	6.221	0.239	0.013	0.490	0.032	0.013	0.005	0.000	0.392	2.247	1.557	0.077	0.984	0.850	0.457	0.000	0.000	0.000
Other crustaceans	0.160	0.524	0.005	0.013	0.010	0.913	0.006	0.131	0.115	0.144	0.316	0.033	0.202	0.000	0.000	0.036	0.280	0.000	0.351
Bivalve	0.000	0.689	0.458	0.165	0.235	0.434	0.237	0.241	1.180	0.000	0.000	0.000	0.000	0.000	0.072	0.022	0.000	1.800	0.000
Gastropod	0.000	0.039	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.148	0.000	0.000	0.000	0.000	0.000	0.000
Starfish	0.000	7.085	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brittle star	1.251	0.000	0.048	0.000	0.000	0.000	0.000	0.015	0.000	0.046	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sea urchin	0.000	0.099	0.000	0.000	0.000	0.000	0.000	0.000	0.570	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sea cucumber	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.385	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sipunculid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.101	1.230
Fish	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.062	0.000	0.035	0.000	3.558	0.000	0.000	1.110	0.000	4.500	0.000	0.632
Nemertine	1.315	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.411	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.782	0.000	0.000
Others	0.582	0.510	0.099	0.904	0.095	0.165	0.052	0.245	0.484	0.063	0.263	2.013	0.102	0.000	0.135	0.574	0.000	0.775	0.000

Table 7.3c Biomass of the macrobenthic groups of the shelf waters of the west coast of India ($g\ m^{-2}$)
76-100m depth

transect→	rtngr	dbhl 1	dbhl 2	ofmb 1	ofmb 2	almb 1	almb 2	almb 3	almb 4	dwrk
Station No→	42	44C	44D	47	48	52	51	50	49	61
depth→	76	95.7	94.3	96	89	79	85.3	91	95	100
Hydrozoa	0.000	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000
sea anemone	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Polychaete	1.248	2.840	1.250	0.237	0.633	1.419	0.800	0.219	0.300	0.762
Amphipod	0.031	0.045	0.060	0.130	0.028	0.052	0.061	0.023	0.001	0.147
Caprellid	0.000	0.000	0.000	0.001	0.003	0.003	0.003	0.002	0.000	0.009
Isopod	0.001	0.000	0.100	0.040	0.004	0.011	0.012	0.001	0.000	0.175
Tanaid	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cumacea	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
Copepod	0.019	0.025	0.030	0.008	0.000	0.018	0.003	0.001	0.000	0.011
Pycnogonid	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
Ostracod	0.001	0.085	0.020	0.000	0.000	0.000	0.015	0.000	0.000	0.113
Stomatopod	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Decapod	0.000	0.000	0.000	1.225	0.000	0.000	0.163	0.383	0.000	0.398
Other crustaceans	0.000	0.130	0.060	0.421	0.007	0.035	0.192	0.028	0.004	0.115
Bivalve	0.828	0.000	0.070	0.000	0.000	0.004	0.940	0.018	0.055	0.029
Gastropod	0.000	0.000	0.000	0.000	0.000	0.072	0.000	0.116	0.000	0.000
Brittle star	0.000	0.000	0.000	0.000	0.000	1.070	1.459	0.000	0.000	0.000
Sea urchin	0.000	0.030	0.000	0.000	0.000	0.000	3.949	2.338	0.001	0.000
Sipunculid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.060
Fish	0.000	0.000	6.540	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nemertine	0.000	0.000	0.000	0.000	0.000	0.944	0.000	0.000	0.000	0.000
Others	0.018	0.430	0.540	0.090	0.055	0.000	0.444	0.091	0.035	0.610

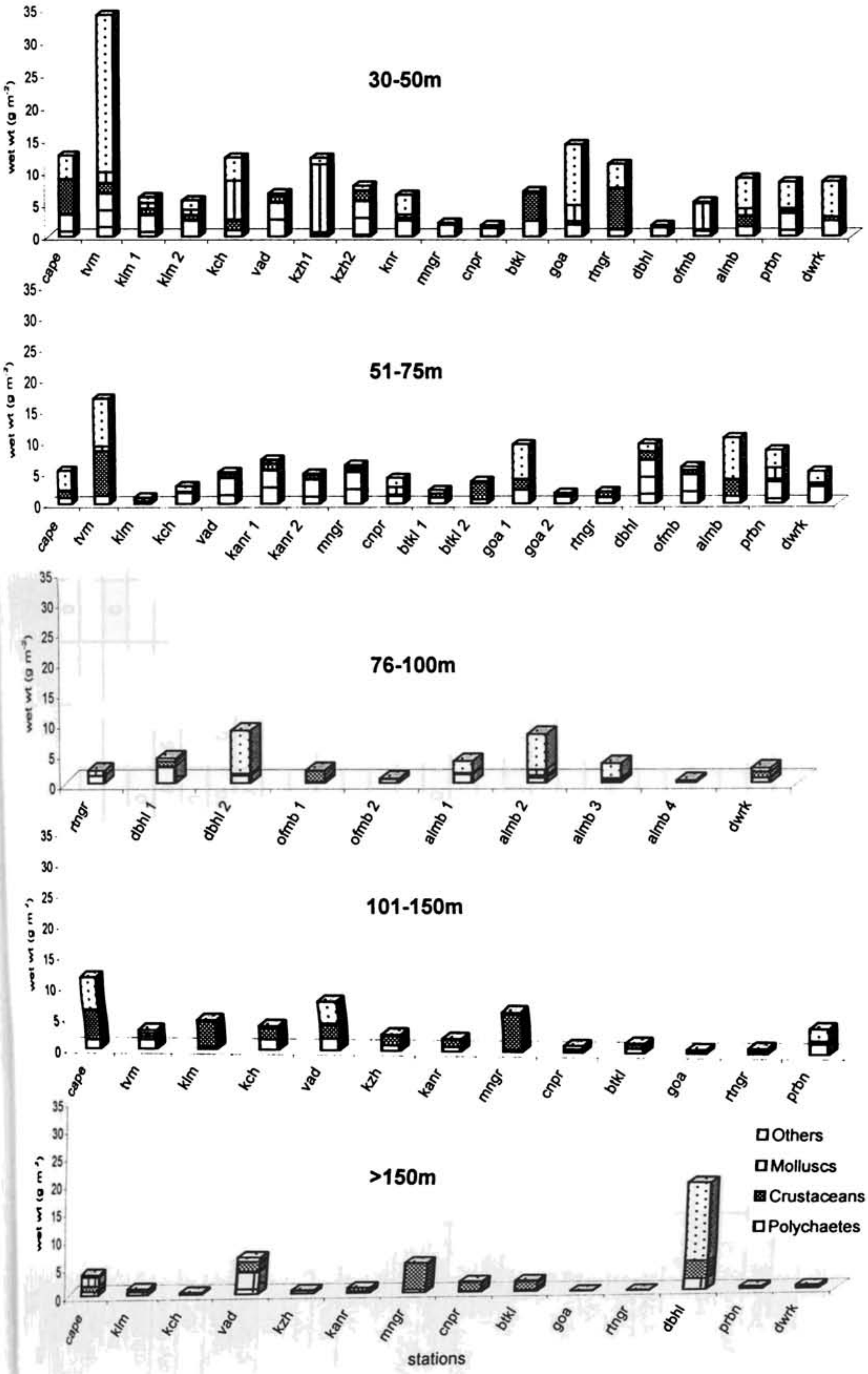
Table 7.3d. Biomass of the macrobenthic groups of the shelf waters of the west coast of India (g m^{-2})

101-150m depth

transect→	cape	tvm	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr	prbn
Station No→	3	5	11	15	16b	19	22	28	29B	31	38	43	56
depth→	101	124	101	101	103.4	102	102	101	104.3	101	101	100.7	101
Polychaete	1.466	1.487	0.400	1.660	1.895	0.900	0.739	0.398	0.340	0.724	0.419	0.235	1.647
Amphipod	0.321	0.054	0.041	0.041	0.010	0.000	0.006	0.013	0.090	0.022	0.000	0.001	0.037
Caprellid	0.151	0.012	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.003	0.000	0.000	0.001
Isopod	0.214	0.089	0.054	1.065	0.000	0.000	0.085	0.006	0.000	0.047	0.155	0.301	0.134
Tanaid	0.003	0.010	0.000	0.001	0.000	0.000	0.000	0.000	0.010	0.000	0.001	0.000	0.000
Cumacea	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.004	0.000	0.001	0.020
Copepod	0.000	0.000	0.000	0.000	0.002	0.000	0.005	0.004	0.000	0.000	0.000	0.009	0.037
Pycnogonid	0.000	0.000	0.011	0.005	0.000	0.000	0.019	0.000	0.000	0.003	0.000	0.000	0.000
Ostracod	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.090	0.010	0.000	0.000	0.037
Sergestid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Stomatopod	0.000	0.000	0.000	0.000	0.000	0.941	0.287	0.000	0.000	0.000	0.000	0.000	0.000
Decapod	3.973	0.000	3.951	0.000	2.170	0.076	0.000	3.177	0.010	0.000	0.000	0.000	0.000
Other crustaceans	0.070	0.400	0.037	0.718	0.000	0.625	0.825	2.356	0.000	0.626	0.006	0.000	0.163
Bivalve	0.000	0.454	0.000	0.000	0.070	0.031	0.000	0.000	0.005	0.000	0.000	0.220	0.033
Gastropod	0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Brittle star	0.517	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.650
Sea urchin	0.000	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.657
Fish	0.000	0.000	0.000	0.000	3.311	0.000	0.000	0.078	0.000	0.105	0.000	0.000	0.000
Nemertine	4.682	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.490	0.000	0.000	0.000	0.648
Others	0.000	0.209	0.090	0.226	0.030	0.014	0.040	0.029	0.059	0.033	0.060	0.141	0.000

Table 7.3e. Biomass of the macrobenthic groups of the shelf waters of the west coast of India (g m^{-2})
>150m depth range

Transect→	cape	klm	kch	vad	kzh	kanr	mnr	cnpr	btkl	goa	rtngr	dbhl	prbn	dwrk
Station No→	4	12	16	16a	20	21	29	29A	30	39	44	44E	55	62
Depth→	208	238	202	197.3	219	202	205	193	206	206	211	191.6	210	200
Hydrozoan	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sea anemone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.000	0.000	0.000
Polychaete	0.764	0.625	0.244	4.260	0.534	0.407	0.580	0.145	0.316	0.009	0.001	2.280	0.068	0.019
Amphipod	0.188	0.000	0.032	0.000	0.001	0.014	0.000	0.050	0.000	0.000	0.000	0.000	0.026	0.015
Caprellid	0.081	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.013	0.012
Isopod	0.668	0.006	0.019	0.000	0.000	0.060	0.010	0.000	0.090	0.042	0.081	0.000	0.023	0.037
Copepod	0.000	0.000	0.000	0.040	0.000	0.000	0.002	0.010	0.000	0.000	0.005	0.000	0.068	0.298
Pycnogonid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000
Ostracod	0.000	0.000	0.000	0.090	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sergestid	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.020	0.000	0.002	0.000	0.000	0.000	0.003
stomatopod	0.000	0.000	0.000	0.000	0.000	0.434	2.720	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Decapod	0.000	0.000	0.000	1.676	0.000	0.000	0.000	1.740	0.000	0.000	0.000	3.740	0.000	0.000
Other crustaceans	0.015	0.000	0.000	0.000	0.010	0.118	2.448	0.020	1.545	0.000	0.000	0.000	0.079	0.142
Bivalve	1.544	0.000	0.000	0.000	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.165	0.085
Gastropod	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.035	0.025
Dentalium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.090	0.000	0.000	0.000	0.000	0.000	0.000
Fish	0.000	0.000	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nemertine	0.000	0.000	0.000	0.740	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sponge	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.200	0.000	0.000
Others	0.471	0.516	0.040	0.050	0.056	0.050	0.000	0.020	0.322	0.000	0.003	0.000	0.113	0.133



1. Biomass of macrobenthic groups in various depth ranges (in g/sq m)

Table [illegible] Numerical abundance of macrobenthos of the shelf waters of west coast of India (no. m⁻²)

30-50m depth

Transects→	cape	tvm	klm	klm	kch	vad	kzh1	kzh2	knr	mngr	cnpr	btkl	goa	rtngr	dbhl	ofmb	almb	prbn	dwrk
Station No. →	1	7	8	9	13	16D	17	18	25	26	29E	34	35	40	44A	45	54	58	59
Depth →	31	30	31	50	33	36	31	50	31	31	30	31	32	32	35	33	32	33	33
Sponge	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrozoan	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	10
Sea anemone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
Nematode	0	0	0	10	0	0	0	0	0	0	0	10	0	0	0	0	15	0	10
Polychaete	530	1830	615	390	150	6080	270	510	1115	660	615	2635	1180	1350	455	405	865	1895	1135
Amphipod	3410	30	0	10	10	115	0	170	0	70	100	295	125	290	40	20	520	90	700
Caprellid	310	70	130	170	10	10	20	0	30	0	30	0	20	20	10	10	40	10	0
Isopod	310	90	175	155	20	70	40	0	40	35	10	20	20	10	0	10	55	45	50
Tanaid	210	50	10	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	90
Copepod	0	20	20	70	10	215	0	0	40	140	765	20	295	20	155	20	725	125	25
Cumacea	80	10	10	20	0	20	0	30	0	0	0	0	10	0	0	0	50	30	0
Ostracod	0	0	0	0	0	50	0	0	0	0	50	10	0	10	0	0	20	0	0
Pycnogonid	0	0	10	0	0	10	0	0	0	0	0	10	10	20	10	10	0	0	0
Mysid	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0
Decapod	30	20	30	70	20	100	10	90	40	0	70	150	20	410	10	50	70	10	40
Stomatopod	0	0	0	0	0	10	0	0	0	0	0	0	10	0	0	0	0	0	0
Sergestid	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0
Bivalve	0	110	100	45	310	40	105	0	10	20	0	15	20	0	20	15	30	10	20
Gastropod	0	10	110	0	0	10	0	0	0	0	0	0	0	0	0	0	55	0	0
Dentalium	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brittle Star	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Sea urchin	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	10
Cake urchin	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
Star fish	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
Sipunculid	0	40	170	80	0	0	0	0	0	0	0	0	0	0	0	0	40	395	0
Amphioxus	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echiuroid	0	0	0	0	0	0	0	0	60	0	0	0	30	0	0	0	0	0	0
Fish	0	0	0	0	10	0	10	15	0	10	0	0	0	15	0	20	15	20	0
Nemertine	30	20	60	30	0	20	40	30	0	0	90	40	110	0	10	0	250	50	20
Others	10	490	20	280	235	20	35	25	130	90	35	210	20	80	20	150	150	485	30

Table 7.4b. Numerical abundance of macrobenthos of the shelf waters of west coast of India (no.m^{-2})

51-75m depth

Transects →	cape	tvm	klm	kch	vad	kanr 1	kanr 2	mngr	cnpr	btkl 1	btkl 2	goa 1	goa 2	rtngr	dbhl	ofmb	almb	prbn	dwrk
Station No. →	2	6	10	14	16c	24	23	27	29D	33	32	36	37	41	44B	46	53	57	60
Depth →	51	59	74	51	53	51	67	51	53	54	68	52	72	51	58	51	51	53	52
Foraminifera	0	0	0	0	0	0	0	0	85	0	0	0	0	0	0	0	0	0	0
Hydrozoan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
Nematode	10	0	35	0	0	0	0	0	35	25	30	0	0	0	0	0	10	0	0
Flatworm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
Polychaete	470	925	420	285	395	790	420	1970	680	410	885	1320	1105	500	1360	420	670	4320	2375
Amphipod	820	135	120	60	0	30	40	30	155	130	105	105	45	20	15	20	105	225	715
Caprellid	60	90	10	10	0	20	10	10	10	10	10	20	30	10	0	10	10	0	70
Isopod	75	120	10	10	10	10	10	10	70	0	20	0	10	10	0	0	60	20	30
Tanaid	100	275	0	0	0	10	10	0	0	0	0	10	0	10	0	0	10	0	10
Copepod	10	10	10	0	20	0	10	50	0	20	50	20	60	10	150	0	1295	20	160
Cumacea	10	85	15	10	0	0	0	20	20	0	70	0	30	0	0	0	10	0	0
Ostracod	0	10	20	0	0	0	10	20	50	25	15	0	0	0	0	0	0	0	0
Pycnogonid	0	0	0	0	0	0	0	10	0	0	0	10	10	0	0	0	0	0	10
Mysid	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decapod	145	105	40	40	80	30	20	20	10	210	40	85	20	65	30	25	65	0	20
Stomatopod	0	10	0	0	0	30	10	20	0	0	0	0	0	0	15	0	10	0	0
Sergestid	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	20
Other crustaceans	10	10	0	0	0	0	0	0	10	0	10	0	0	0	0	0	60	0	0
Bivalve	0	95	20	30	70	15	10	30	70	0	0	0	0	0	30	10	0	10	0
Gastropod	0	20	0	0	10	0	0	0	0	0	0	0	15	0	0	0	0	0	0
Brittle Star	40	0	20	0	0	0	0	40	10	15	10	0	0	0	0	0	0	0	0
Sea urchin	0	35	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0
Cake urchin	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
Star fish	0	40	0	10	0	0	0	0	0	0	0	0	0	0	0	0	180	455	220
Sipunculid	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphioxus	25	0	10	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
Echiuroid	0	0	0	0	0	0	10	20	0	10	0	10	0	0	30	0	10	0	10
Fish	0	0	0	0	10	30	0	0	170	40	20	10	20	0	10	0	20	30	0
Nemertine	40	80	0	0	10	60	60	10	735	195	40	30	30	0	50	30	180	1250	0
Others	25	40	100	70															

Table 7.4c Numerical abundance of macrobenthos of the shelf waters of west coast of India (no.m-1)

76-100m depth

Transects→	rtngr	dbhl 1	dbhl 2	ofmb 1	ofmb 2	almb 1	almb 2	almb 3	almb 4	dwrk
Station No. →	42	44C	44D	47	48	52	51	50	49	61
Depth →	76	96	94	96	89	79	85	91	95	100
Foraminifera	0	20	40	0	0	0	0	60	0	0
Hydrozoan	0	0	0	0	10	0	0	0	0	0
Sea anemone	0	10	0	0	0	0	10	0	0	0
Nematode	10	10	0	0	0	20	0	0	0	20
Polychaete	365	1655	950	245	355	175	1090	60	50	605
Amphipod	75	40	130	90	50	165	130	60	50	200
Caprellid	0	0	10	10	10	10	30	10	0	50
Isopod	10	10	20	35	0	20	20	10	0	20
Tanaid	0	0	30	0	0	10	0	0	0	0
Copepod	170	140	120	50	20	70	50	30	0	40
Cumacea	10	0	0	0	0	10	0	0	0	40
Ostracod	20	220	110	0	0	10	120	10	0	205
Pycnogonid	10	0	0	0	10	70	0	0	0	80
Mysid	0	0	0	0	0	0	10	0	0	0
Decapod	50	60	10	30	90	80	10	20	0	110
Stomatopod	0	10	0	10	0	0	0	0	0	0
Sergestid	0	0	10	0	0	0	0	0	0	0
Other crustaceans	0	0	0	0	10	0	0	0	0	10
Bivalve	10	0	30	0	10	10	20	35	10	15
Brittle Star	0	10	0	0	0	30	20	0	0	0
Sea urchin	0	0	0	0	10	0	0	0	0	0
Cake urchin	0	0	0	0	0	0	50	10	0	0
Sipunculid	0	0	0	0	0	20	0	0	0	40
Echiuroid	0	10	0	0	0	0	0	0	0	0
Fish	0	0	10	0	0	0	0	0	0	0
Nemertine	0	0	0	0	0	0	0	0	0	10
Others	10	20	190	60	50	0	70	10	10	205

Table 7.4d. Numerical abundance of macrobenthos of the shelf waters of west coast of India (no.m^{-1})
101-150m depth

Transects →	cape	tvm	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr	prbn
Station No. →	3	5	11	15	16B	19	22	28	29B	31	38	43	56
Depth →	101	124	101	101	103	102	102	101	104	101	101	101	101
Nematode	10	120	10	30	10	0	0	20	30	10	0	20	0
Polychaete	1325	1110	300	630	920	250	400	225	400	625	560	620	410
Amphipod	1100	215	70	60	10	20	25	10	120	65	0	10	65
Caprellid	60	50	20	60	0	0	20	10	0	20	10	0	20
Isopod	70	35	0	140	0	0	30	10	10	10	50	30	50
Tanaid	40	0	0	10	0	0	0	0	10	0	10	0	0
Copepod	50	10	0	0	10	0	20	0	0	0	0	40	215
Cumacea	20	0	0	0	0	0	0	10	0	0	0	20	20
Ostracod	30	0	10	10	0	10	0	10	0	70	0	0	85
Pycnogonid	10	10	0	10	0	0	10	0	10	10	0	10	0
Mysid	0	0	0	0	0	0	0	0	10	0	0	0	0
Decapod	70	60	10	20	60	75	60	125	10	70	30	20	25
Stomatopod	10	0	0	0	0	0	0	0	0	0	0	0	0
Sergestid	0	0	0	0	0	0	0	0	0	0	0	0	10
Other crustaceans	0	0	0	0	0	0	0	0	0	10	0	0	0
Bivalve	0	30	10	10	10	10	0	0	10	0	20	20	20
Gastropod	0	0	0	0	10	0	0	0	0	0	0	0	0
Brittle Star	10	10	0	0	0	0	0	0	0	0	0	10	150
Sea urchin	0	0	0	10	0	0	0	0	0	0	0	0	0
Cake urchin	0	0	0	0	0	0	0	0	0	0	0	0	15
Amphioxus	0	0	20	0	0	0	0	0	60	0	10	10	0
Fish	0	0	0	0	10	0	0	10	0	10	0	0	0
Nemertine	20	0	0	0	30	0	0	10	10	0	0	0	90
Others	0	30	10	10	60	10	10	10	100	10	190	100	0

Table 7.4e Numerical abundance of macrobenthos of the shelf waters of west coast of India (no.m^{-1})

>150m depth

Transects→	cape	klm	kch	vad	kzh	kanr	mngr	cnpr	btkl	goa	rtngr	dbhl	prbn	dwrk
Station No. →	4	12	16	16A	20	21	29	29A	30	39	44	44E	55	62
Depth →	208	238	202	197	219	202	205	200	206	206	211	192	210	200
Foraminifera	0	0	0	0	0	0	0	0	0	0	0	0	20	0
Sponge	0	0	0	0	0	0	0	0	0	0	0	80	0	0
Hydrozoan	0	0	0	0	0	0	65	0	10	0	0	0	0	0
Sea anemone	0	0	0	0	0	0	0	10	0	0	0	0	0	0
Nematode	30	120	0	0	0	0	0	0	0	0	0	0	0	0
Polychaete	1000	690	165	2110	215	345	275	540	225	65	0	360	210	70
Amphipod	550	0	0	0	40	5	0	20	0	10	15	10	150	60
Caprellid	210	20	10	0	10	20	10	10	10	0	10	0	60	50
Isopod	275	10	20	0	20	40	10	0	0	20	35	10	55	20
Tanaid	0	0	0	0	0	0	0	10	0	0	0	0	20	0
Copepod	75	0	0	500	0	0	10	15	0	0	35	60	240	1565
Cumacea	0	0	0	0	0	10	10	10	0	0	0	0	0	0
Ostracod	10	0	0	620	0	0	0	0	0	0	10	0	0	0
Pycnogonid	10	0	0	0	0	0	0	0	0	10	0	0	40	0
Decapod	50	0	115	10	20	30	55	100	20	10	0	40	60	20
Stomatopod	0	0	0	0	0	0	0	0	0	0	10	0	0	0
Sergestid	0	0	0	20	0	0	0	10	0	10	0	0	10	10
Other crustaceans	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Bivalve	20	0	0	0	10	0	0	0	0	0	0	0	80	20
Gastropod	0	0	0	0	0	0	0	0	0	0	0	0	10	0
Dentalium	0	0	0	0	0	0	0	10	0	0	0	0	0	0
Fish	0	0	10	0	0	0	0	0	0	0	0	0	0	0
Nemertine	0	0	0	10	20	40	0	0	30	0	0	0	0	0
Others	10	10	10	90	10	10	40	140	40	0	10	0	10	40

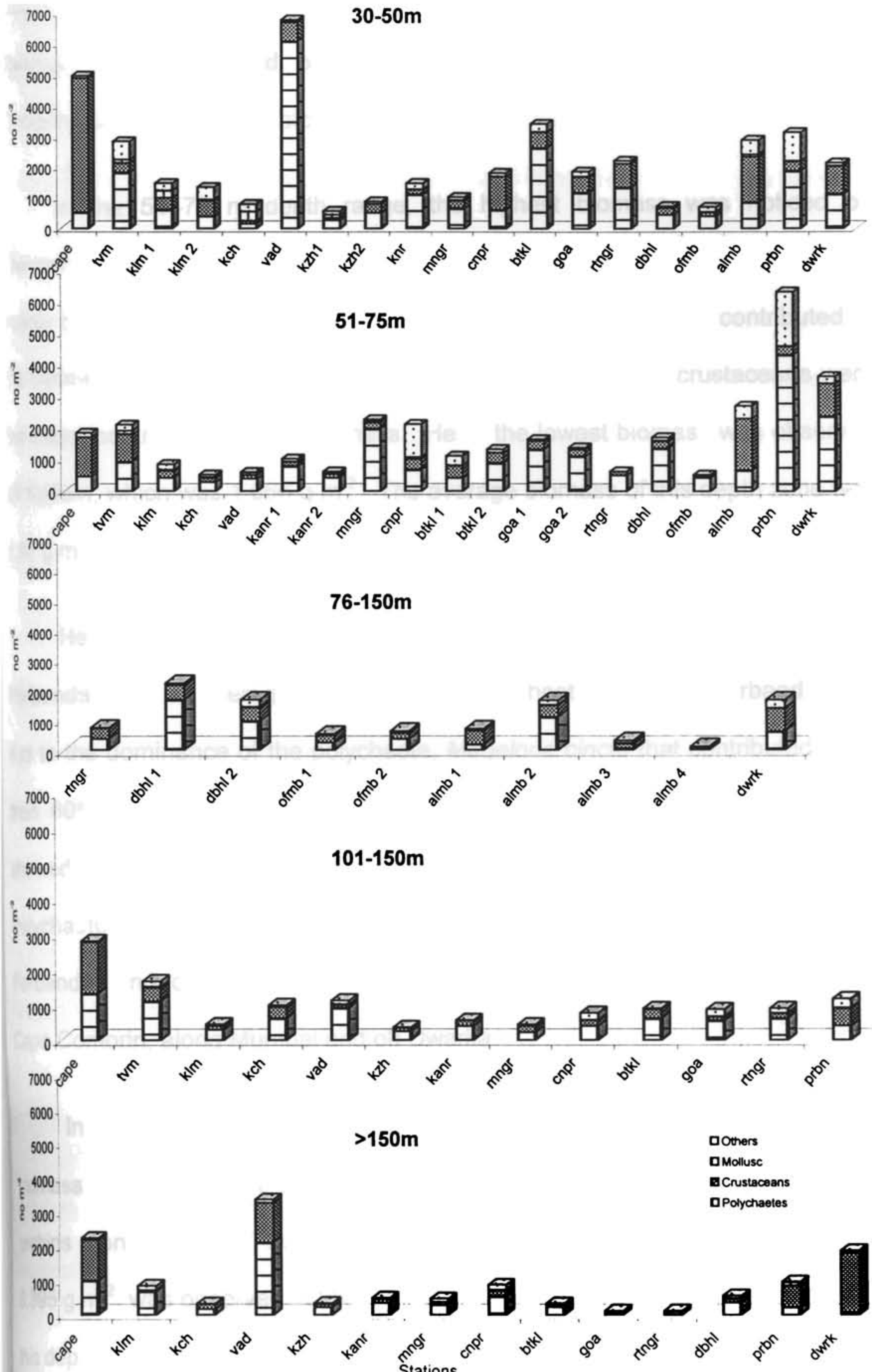


Fig. 7.2. Numerical abundance of macrobenthic groups in various depth ranges

Ratnagiri, Porbandar and off Dwarka. Crustaceans dominated off Cape Comorin, Coondapore and along Mumbai.

In the 51–75 m depth range, the highest biomass was noticed off Thiruvananthapuram, which was 16.932 g m^{-2}, where starfishes contributed mainly to the biomass. Off Goa and Along Mumbai, small fishes contributed to the biomass considerably. In other stations, polychaetes and crustaceans were the major contributors to the biomass. Here, the lowest biomass was observed off Kollam, which was 1.066 g m^{-2}. The average biomass of this depth zone was 5.92 g m^{-2}.

Here, the number varied from 525 m^{-2} (off Kochi) to 6330 m^{-2} (off Porbandar) with an average of 1731 m^{-2}. The highest number off Porbandar was due to the dominance of the polychaete, *Magelona cincta* that contributed more than 60% of the total macrobenthos. Here the extreme northern latitudes showed higher number and southern latitudes showed less number. Polychaetes contributed considerably in stations like off Mangalore, Goa, Dabhol, Porbandar and off Dwarka, whereas crustaceans contributed significantly off Cape Comorin, along Mumbai and off Dwarka.

In the 76–100 m depth range, the biomass was generally less. Higher biomass was noticed at 85m depth Along Mumbai (8.039 g m^{-2}), where sea urchins contributed to the biomass significantly. The lowest biomass of 0.395 g m^{-2} was observed at 95m depth Along Mumbai. The average biomass of this depth range was 3.558 g m^{-2}.

The number ranged between 120 m^{-2} (along Mumbai, 95m depth) and 1650 m^{-2} (off Dwarka) with an average of 1019 m^{-2}. Polychaetes contributed significantly off Dabhol and Along Mumbai (80m depth) and crustaceans dominated off Dwarka.

In the 101–150 m depths, highest biomass was noticed off Cape Comorin (11.395 g m^{-2}, where crustaceans contributed to the high biomass. The lowest was observed off Goa (0.64 g m^{-2}). The average biomass of this depth range was 3.785 g m^{-2}.

The number varied from 375 m^{-2} (off Kozhikode) to 2825 m^{-2} (off Cape Comorin) with an average of 1012 m^{-2}. Comparatively higher number was observed at southern latitudes than northern latitudes. Polychaetes contributed significantly off Cape Comorin, Thiruvananthapuram, Vadanappally, Bhatkal, Goa and off Ratnagiri. Crustaceans were significant only off Cape Comorin.

Beyond 150m depth, the highest biomass was observed off Vadanappilly (6.866 gm^{-2}), where polychaetes contributed 62%. The lowest biomass was noticed off Goa (0.052 g m^{-2}). The average biomass of this depth range was 3.349 g m^{-2}.

The number ranged between 125 m^{-2} (off Goa and off Ratnagiri) and 3360 m^{-2} (off Vadanappally) with an average of 925 m^{-2}. Polychaetes contributed significantly off Cape Comorin, Kollam and off Vadanappilly, whereas the significant contribution was made by crustaceans, off Cape Comorin, Vadanappilly and off Dwarka.

As a whole, the wet weight of the macrobenthos ranged between 0.090 gm^{-2} (off Ratnagiri, 200m) and 34.047 gm^{-2} (off Thiruvananthapuram, 30m). The major groups contributing to the biomass were polychaetes and crustaceans. Molluscs contributed only very rarely to the biomass. The other groups, which enhanced the biomass values in some of the stations are echinoderms, fishes and sponges. In general, biomass decreased with depth (Table 7.5 & Fig. 7.3). The average biomass for south west coast was 5.752 g m^{-2} and northwest coast was 5.303 g m^{-2} (Tables 7.6, 7.7, 7.8 & Figs 7.4, 7.5, 7.6). The average biomass of macrobenthos of the entire west coast shelf was 5.555 g m^{-2} (Table 7.9 & Fig. 7.7).

Along the shelf, the number varied from 120 m^{-2} (along Mumbai, 95m) to 5770 m^{-2} (off Vadanappillly). Numerically, polychaetes and crustaceans were the major groups. In general, the abundance also showed a decreasing trend with increase in depth (Table 7.10 & Fig. 7.8). The average numerical abundance for the south west coast was 1459 m^{-2} and, for northwest coast, it was 1488 m^{-2} Tables 7.11, 7.12, 7.13 & Fig. 7.9, 7.10 & 7.11). The average numerical abundance for the entire western continental shelf of India was 1471 m^{-2} (Table 7.14 & Fig. 7.12).

Table 7.5. Average biomass in different depth ranges

Depth range	Polychaetes	Crustaceans	Molluscs	Others	Total
30-50	2.590	1.454	1.517	3.515	9.076
51-75	2.621	1.218	0.301	1.780	5.920
76-100	0.971	0.497	0.213	1.878	3.558
101-150	0.947	1.821	0.065	0.953	3.785
>150	0.732	1.194	0.144	1.279	3.349

Fig. 7.3. Average biomass in different depth ranges

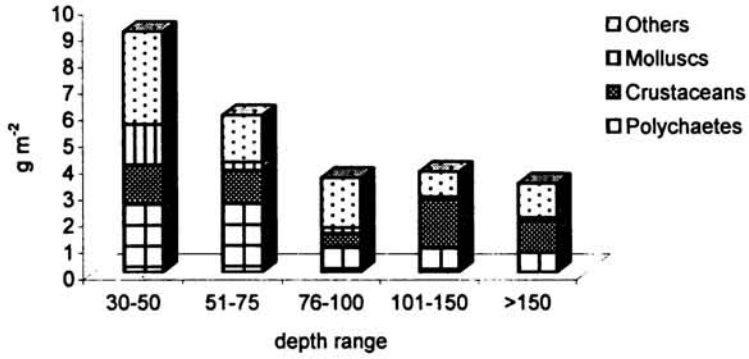


Table 7.6. Comparison of macrobenthic biomass in south west and north west coast of India

	Polychaetes	Crustaceans	Molluscs	Others	Total
SW	1.919	1.612	0.636	1.585	5.752
NW	1.536	0.860	0.388	2.519	5.303

Fig. 7.4. Comparison of macrobenthic biomass in south west and north west coast of India

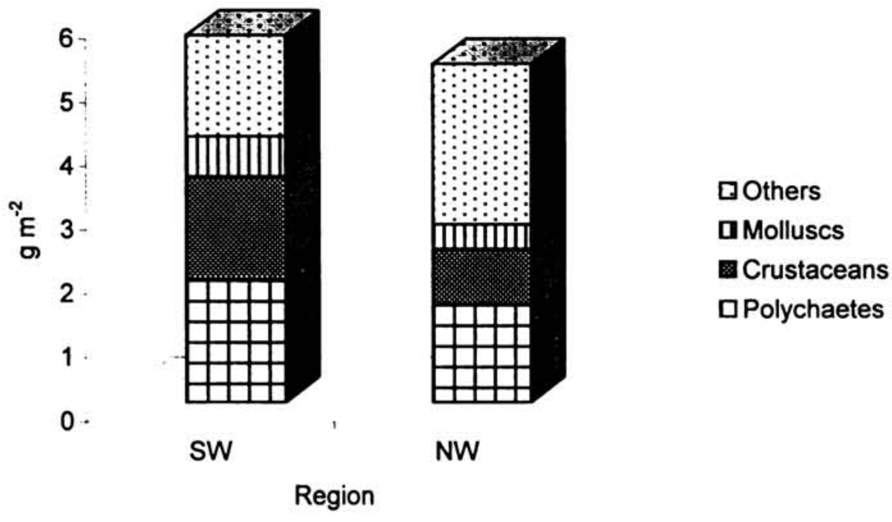


Table 7.7. Average biomass of macrobenthos in different depth ranges of south west coast of India

Depth range	Polychaetes	Crustaceans	Molluscs	Others	Total
30-50	3.060	1.487	1.730	3.253	9.530
51-75	2.362	1.363	0.335	1.347	5.407
101-150	1.001	2.277	0.059	1.023	4.360
>150	0.875	1.347	0.190	0.274	2.685

Fig. 7.5. Average biomass of macrobenthos in different depth ranges of south west coast of India

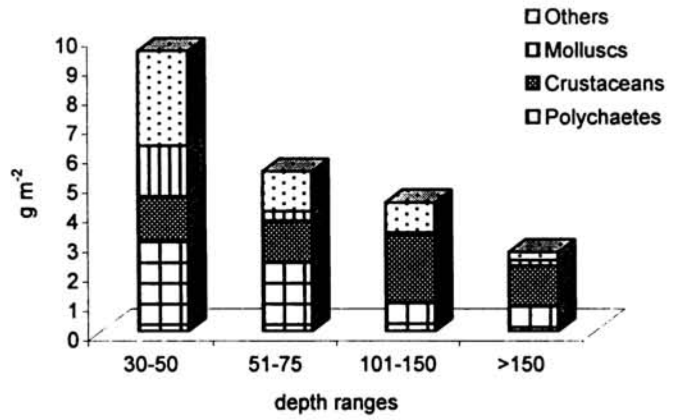


Table 7.8. Average biomass of macrobenthos in different depth ranges of north west coast of India

Depth range	Polychaetes	Crustaceans	Molluscs	Others	Total
30-50	1.785	1.398	1.151	3.963	8.297
51-75	2.977	1.019	0.255	2.374	6.625
76-100	0.971	0.497	0.213	1.878	3.558
101-150	0.767	0.300	0.084	0.718	1.869
>150	0.475	0.918	0.062	3.090	4.545

Fig. 7.6. Average biomass of macrobenthos in different depth ranges of north west coast of India

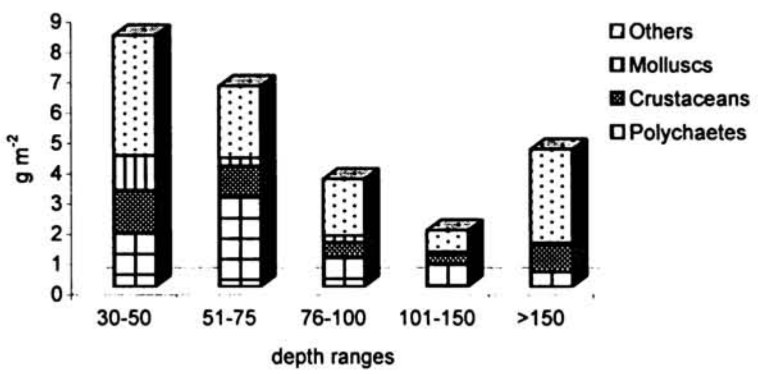


Table 7.9. Average biomass of macrobenthic groups in the continental shelf of west cost

	Polychaetes	Crustaceans	Molluscs	Others	Total
West coast	1.750	1.282	0.527	1.996	5.555

Fig. 7.7. Average biomass of macrobenthic groups in the continental shelf of west cost

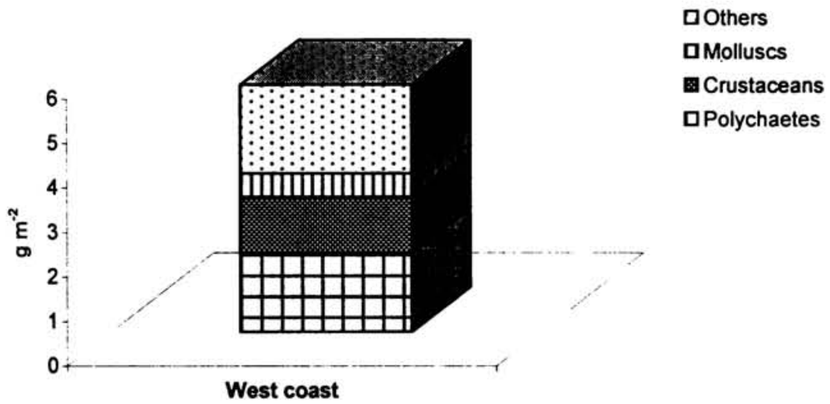


Table 7.10. Average numerical abundanceof macrobenthos in different depth ranges

Depth range	Polychaetes	Crustacean	Molluscs	Others	Total
30-50	1194	681	57	236	2168
51-75	1038	411	23	258	1731
76-100	555	344	14	106	1019
101-150	598	302	12	100	1012
>150	448	405	11	62	925

Fig. 7.8. Average numerical abundanceof macrobenthos in different depth ranges

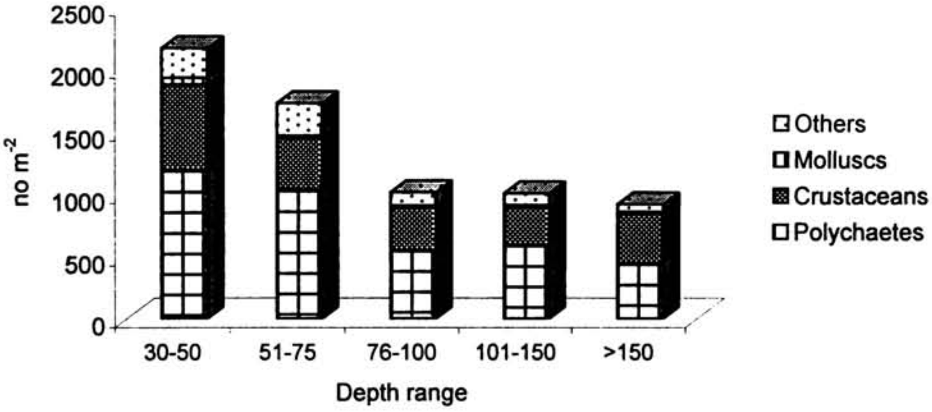


Table 7.11. Comparison of macrobenthic abundance in south west and north west coast of India

	polychaetes	Crustaceans	Molluscs	Others	Total
SW	829	449	33	148	1459
NW	824	453	17	194	1488

Fig. 7.9. Comparison of macrobenthic abundance in south west and north west coast of India

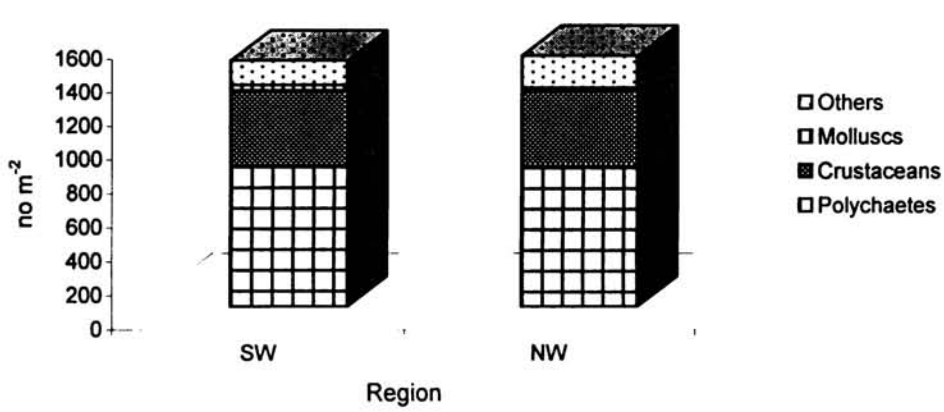


Table 7.12. Average abundance of macrobenthos in different depth lines of south west coast of India

Depth range	Polychaetes	Crustaceans	Molluscs	Others	Total
30-50	1283	716	75	209	2284
51-75	695	367	34	210	1305
101-150	619	321	9	70	1019
>150	618	333	4	78	1034

Fig. 7.10. Average abundance of macrobenthos in different depth lines of south west coast of India

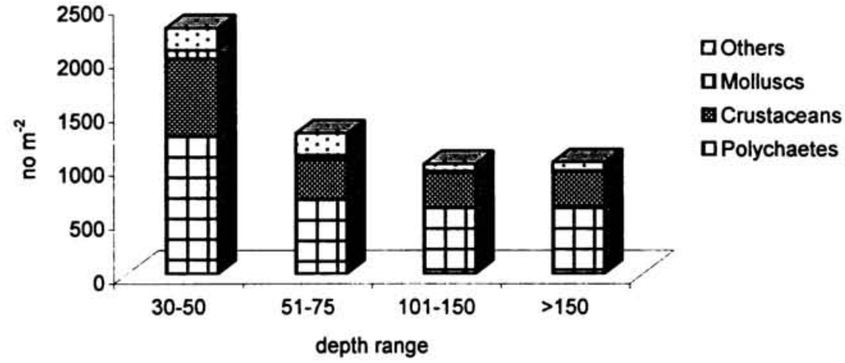


Table7.13. Average abundance of macrobenthos in different depth lines of north west coast of India

Depth range	Polychaetes	Crustaceans	Molluscs	Others	Total
30-50	1041	620	24	284	1969
51-75	1021	409	23	256	1709
76-100	555	344	14	106	1019
101-150	530	240	20	198	988
>150	141	533	22	32	728

Fig. 7.11. Average abundance of macrobenthos in different depth lines of north west coast of India

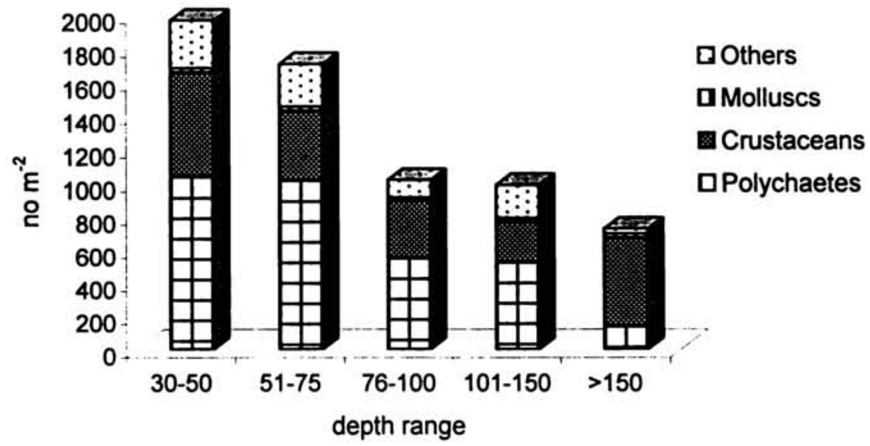
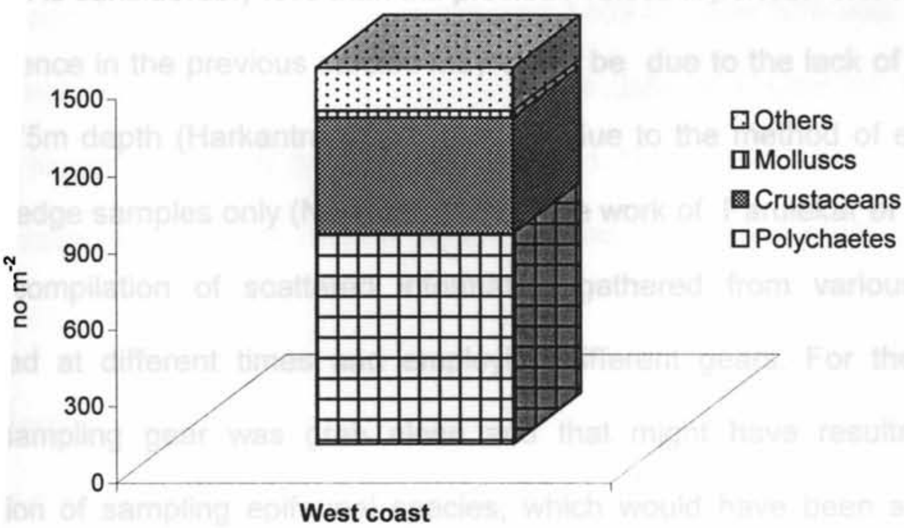


Table 7.14. Average abundance of macrobenthic groups in the continental shelf of west cost

	Polychaetes	Crustaceans	Mollusc	Others	Total
West coast	827	450	26	168	1471

Fig. 12. Average abundance of macrobenthic groups in the continental shelf of west cost



7.3. Discussion

Previous attempts to quantify the benthos of the western continental shelf of India are of (i) Neyman (1969), (ii) Harkantra *et al.* (1980) and (iii) Parulekar *et al.* (1982). Neyman (1969) reported an average value of 20 g m^{-2} from this region. Harkantra *et al.* (1980) reported 11.5 g m^{-2} in the innershelf of west coast of India. Parulekar *et al.* (1982) noticed an average value of 14.1 g m^{-2} as the standing crop of the macro and meiobenthos. The present study showed an average biomass of 5.555 g m^{-2} for the continental shelf of west coast of India. This value is considerably less than the previous values reported. The reason for the difference in the previous studies may either be due to the lack of sampling beyond 75m depth (Harkantra *et al.*, 1980) or due to the method of estimation using dredge samples only (Neyman, 1969). The work of Parulekar *et al.* (1982) was a compilation of scattered information gathered from various cruises conducted at different times and employing different gears. For the present study, sampling gear was grab alone and that might have resulted in the elimination of sampling epifaunal species, which would have been sampled if dredges were employed.

Earlier workers, while studying the macrobenthos of the entire shelf of the west coast of India, noticed marked difference in biomass and abundance along the SW and NW coasts. Neyman (1969) estimated an average biomass of the benthos from the northern region as 30 g m^{-2} and southern region as 5 g m^{-2}

and, divided the west Indian ocean shelf into these two regions on the basis of the biomass of benthos, and suggested that the boundary between these regions lie at approximately 15^{0}S (in the vicinity of Goa). Parulekar and Wagh (1975) noticed an average biomass of 30 g m^{-2} along the NW coast. Harkantra *et al.* (1980) observed higher values for biomass along the SW than the NW coast. They attributed this to the influence of equatorial waters and upwelling. Qasim (1982), reported an average biomass value of 6.74 g m^{-2} for the NW coast. But the present study showed no such prominent differences in either biomass or population density along SW and NW coasts. The biomass of macrobenthos was 5.752 g m^{-2} from SW and 5.303 g m^{-2} from NW region. Average population density of SW coast was 1459 m^{-2} and NW was 1488 m^{-2}. Joydas and Damodaran (2001), employing the data of Cruise no 162 alone showed higher values of biomass in SW and NW coasts, but after taking representation from all the degree squares in the west coast shelf, the picture changed.

Another important feature noticed was the progressive decrease of biomass and numerical abundance with increase in depth. This is in agreement with earlier reports (Kurien, 1953 & 1967; Neyman, 1969; Parulekar & Dwivedi, 1974; Parulekar & Wagh, 1975; Ansari *et al.,* 1977; Harkantra *et al.,* 1980; Parulekar *et al.*, 1982; Qasim, 1982; Venkatesh Prabhu *et al.,* 1993; Joydas & Damodaran, 2001). In general, the macrobenthic biomass and number was high in nearshore regions and low in deeper regions.

There was a 35% decrease in biomass from 30-50m to 51-75m depth range, 40% from 51-75m to 76-100m. There was a 6% increase in biomass from 76-100m to 101-150m depth range. Again it decreased by 12% from 101-150m to >150m. As a whole, there was a decrease of 63% from the 30-50m depth range to the edge of the continental shelf.

Like biomass, the numerical abundance also showed a decrease from 30-50m to >150m. The decrease was 20.15% from 30-50m to 51-75m, 41.13% from 51-75m to 76-100m, 1% from 76-100m to 101-150m and 8.5% from 101-150m to >150m. As a whole, the abundance decreased by 57.33% from shallow waters to the edge of the continental shelf.

In general, all the groups showed a decrease in biomass with increase in depth with the exception of crustaceans. The highest biomass of crustaceans was observed at 101-150m depth. This can be due to the comparatively large sized individuals among this group in this depth range.

Between 76 and 200m depth, the difference in average biomass was less. Numerical abundance also showed a decrease with increase in depth in all the groups. Between 76-100m, the total number was more or less same like the biomass.

High benthic biomass and abundance in nearshore areas can be due to the high primary productivity in nearshore waters, because the supply of food to subtidal benthic environment depends on proximity to shore and water depth

(Levinton, 1982). In the nearshore region, much of the primary production enters the food web as organic detritus. Though current transport may carry some organic detritus to the deeper region, the supply of detritus diminishes with depth and distance from the shore. This agrees with the benthic studies carried out in the nearshore regions of various parts of west coast of India, where high biomass is noticed. Venkatesh Prabhu *et al.* (1993) observed a high mean dry weight of 41.44 g m^{-2} in the 10m depth line, 36.83 g m^{-2} in the 20m depth line and 44.86 g m^{-2} in the 30m depth line of Gangolli region. Ansari *et al.* (1994) observed the biomass to be ranging from 2.54 to 46.02 g m^{-2} in Marmagao region. Gopalakrishnan and Nair (1998) noticed a higher biomass of 1100 g m^{-2} in the 20m depth line off Mangalore due to the abundance of bivalves.

A well-defined pattern in latitudinal variation in biomass or abundance was absent. But the variation observed along the latitudes in each depth range may be due to the impact of localized biotic and abiotic factors. The difference in the composition of fauna resulted in this variation. The high biomass observed towards extreme south, e.g. off Cape Comorin and off Thiruvananthapuram, can be due to the high primary productivity. The nature of substratum and physical oceanographic studies also indicate the dynamic nature of this area. In this area, filter feeding organisms were more. In these stations, apart from polychaetes, the main contributors of biomass were either crustaceans or other groups. Numerically, latitudinal variation was minimum (56.31%) at 101-150m, and maximum (122.51%) at >150m for polychaetes. For crustaceans, it was minimum (59.21%) at 76-100 and maximum (136.2%) at >150m. For molluscs, minimum (82.13%) was at 76-100m and maximum (224.07%) at >150m. For others, lowest variation of 74.82% was at >150m and highest variation of 164.81% was noticed at 51-75m. As a whole, the variation in total macrobenthic abundance ranged from 64.34% at 101-150m to 101.18% at >150m. In the case of biomass, for polychaetes, the variation ranged between 63.3% at 101-150m and 159.79% at >150m. For crustaceans, it was 101.00% at 101-150m and 133.67% at 51-75m. For molluscs, it was 157.75% at 51-75m and 282.94% at >150m. For others, it ranged between 134.17% at 51-75m and 313.71% at >150m. As a whole, latitudinal variation of the biomass of macrobenthos was 65.36% (51-75m) and 166.05% (>150m).

In general, polychaetes and crustaceans were the major contributors of biomass. However, unusually high biomass in certain stations was due to other groups like sponges off Thiruvananthapuram (30m) and fishes off Dabhol (200m). Numerically, polychaetes were the principal forms, followed by crustaceans. Among the crustaceans, gammarid amphipods, caprellids and copepods mainly contributed numerically. It was noticed that unusually high biomass was due to the abundance of large sized organisms. On the other hand, high numerical abundance was mainly due to polychaetes and the species contributed to this situation were: *Magelona cincta* off Vadanappilly (30m), Mangalore (50m) and off Porbandar (50m); *Prionospio pinnata* off Bhatkal (30m) and *Cossura coasta* off Dwarka (50m).

Chapter 8

Ecological relationships

8.1. Hydrography and fauna

Arabian Sea is unique for its seasonally oscillating environmental and biological parameters (Qasim, 1982). Monsoon and its allied phenomena like upwelling and turbidity are the main causative factors for this (Qasim, *loc. cit.)*. But seasonal changes diminish with increase in depth. Changes in hydrography and fauna are evident with respect to changes in depth and latitudes (Qasim, *loc. cit.*). In the deeper area, the temporal variations are less pronounced. Previous studies conducted in different parts of the world revealed that seasonal variations are rarely observed in the benthic community structure (Sanders, 1960; Nakao, 1982). From a review of information available on the hydrographical studies, it has become amply clear that no concerted effort has been made to delineate the fine relationships between fauna and the environmental conditions, within the benthic ecosystem of the western continental shelf of India.

From the details of the hydrography given in chapter 4, it is evident that there is a sharp decrease in temperature and dissolved oxygen with increase in depth. Likewise, observations noted in the chapter 7 describes a progressive decrease in the abundance and biomass of benthic fauna with depth. In general, the increase in depth in the continental shelf is often associated with the decrease in temperature and dissolved oxygen. Therefore it appears that the two factors, which make a pronounced impact on benthic fauna are the amount of dissolved oxygen and the decrease in temperature. Correlation analysis between hydrography and fauna indicates that only temperature and dissolved oxygen show a significant positive correlation with fauna (Table 8.1). The scatter diagrams also show the same pattern (Fig. 8.1). As per the scatter diagrams, total biomass, total abundance, polychaete biomass and polychaete number were high at temperatures above 22 ^{0}C. In the case of DO, at values below 3 ml l^{-1}, biomass and numerical abundance decreased considerably. Crustacean biomass and abundance did not show any direct correlation with temperature and DO. Their abundance was more or less same at high as well as low temperature and DO. It is unlikely that the salinity may be a controlling factor as far as benthic fauna is concerned as the bottom salinity variation with respect to depth is less pronounced.

Though there was a slight variation in temperature and salinity with latitudes in each depth range, it is not likely that it influences the faunal distribution. DO showed near-anoxic values in the depth >150m, especially in the northern shelf edge. In this zone, except Dabhol, the biomass was very low. Moreover, total abundance, average species richness and species diversity were also less compared to that of shallower region. This could be due to the prevailing anaerobic condition, which is not tolerated by all organisms. In Dabhol, high biomass was due to the presence of juvenile fishes, which

Table. 8.1. Correlation between Hydrography and fauna.

		Depth	Temperature	Salinity	DO
Biomass	Polychaete	-0.43*	0.37*	-0.31*	0.42*
	Crustacean	-0.04	0.03	-0.23*	-0.03
	Mollusc	-0.25*	0.19	-0.26*	0.19
	Others	-0.20	0.11	-0.20	0.18
	Total	-0.35*	0.25*	-0.38*	0.30*
Number	Polychaete	-0.28*	0.16	-0.07	0.25*
	Crustacean	-0.13	0.02	-0.27*	0.10
	Mollusc	-0.26*	0.25	-0.40*	0.24*
	Others	-0.28*	0.12	0.03	0.32*
	Total	-0.34*	0.16	-0.19	0.31*
Polychaetes	Richness	-0.43*	0.41*	-0.05	0.35*
	Evenness	-0.14	0.20*	-0.01	0.13
	Diversity	-0.40*	0.43*	-0.05	0.32*
	Dominance	0.19	-0.25*	0.02	-0.15
Group	Richness	-0.35*	0.34*	-0.08	0.39*
	Evenness	-0.23*	-0.17	0.01	-0.13
	Diversity	-0.02	0.03	-0.05	0.07
	Dominance	-0.07	0.07	0.04	0.00

*** Significant 0.05% level (>0.217) (Fisher & Yates, 1963)**

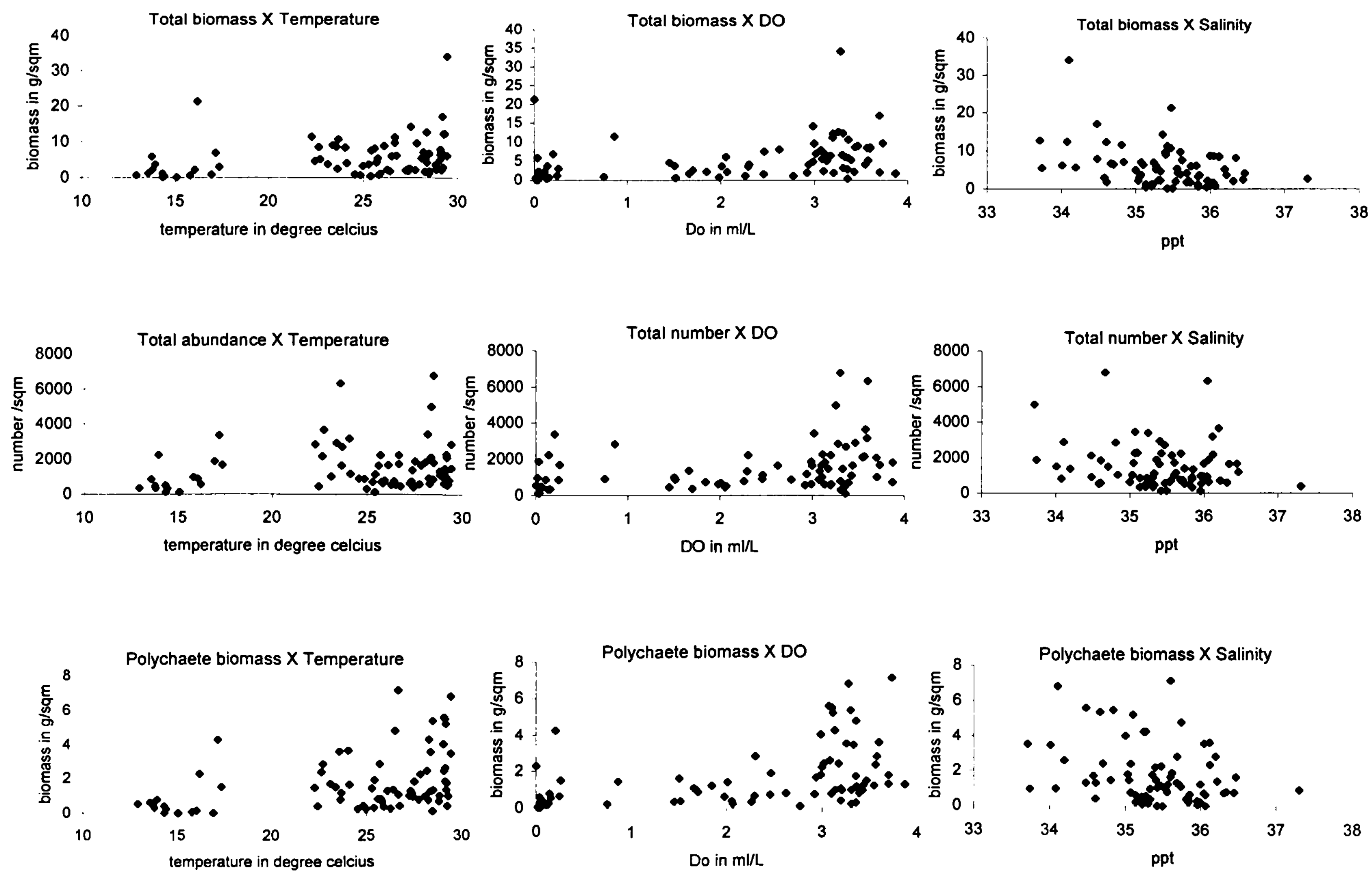


Fig. 8.1. Relation between physical parameters and macrobenthos

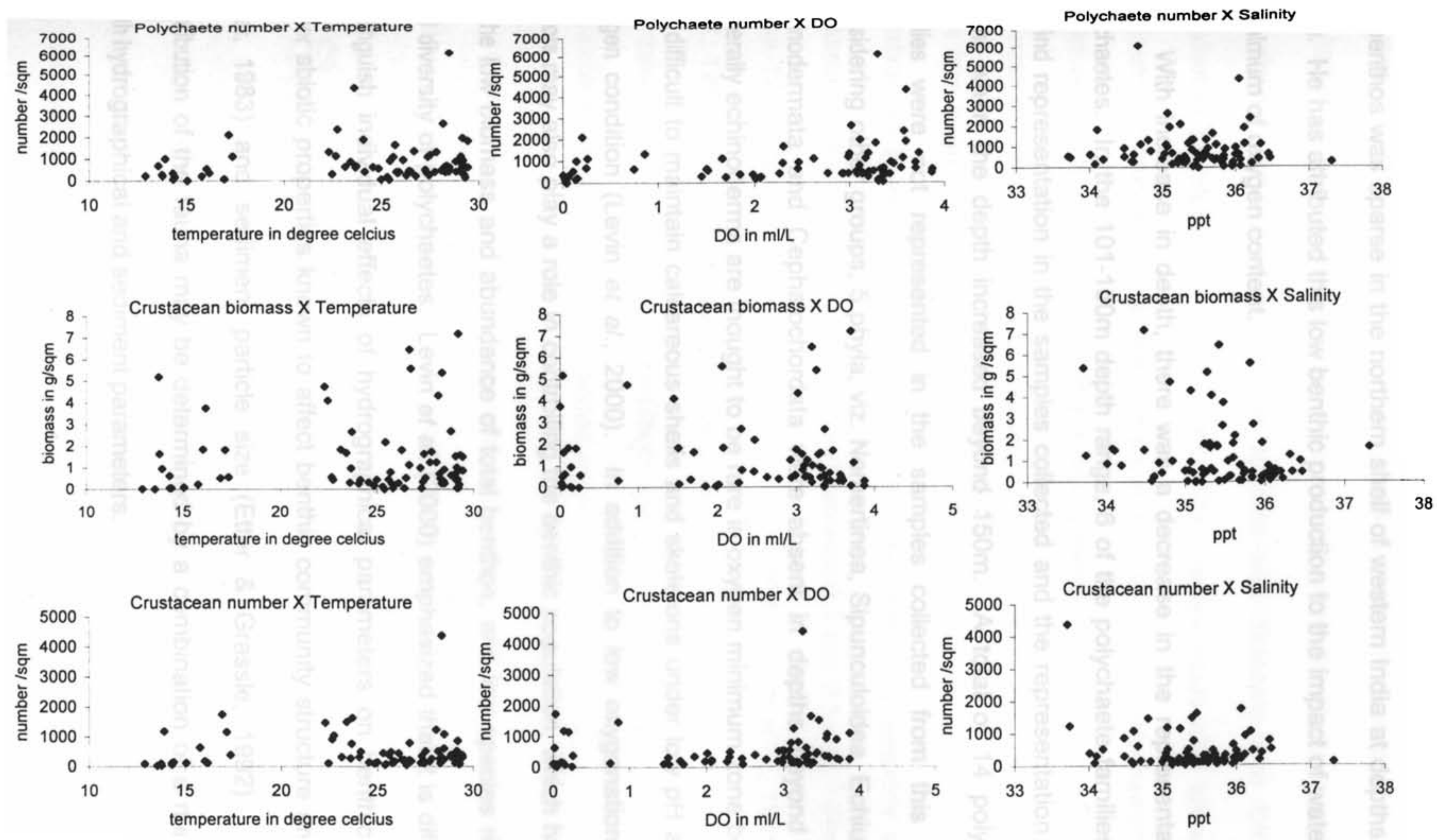


Fig. 8.1. Continued.

contributed to more than 70% of the total biomass. Neyman (1969) has shown that benthos was sparse in the northern shelf of western India at depths of 75-200m. He has attributed this low benthic production to the impact of waters with a minimum of oxygen content.

With increase in depth, there was a decrease in the representation of polychaetes. In the 101-150m depth range, 6 of the polychaete families could not find representation in the samples collected and the representation further shrunk when the depth increased beyond 150m. A total of 14 polychaete families were not represented in the samples collected from this region. Considering other groups, 5 phyla, viz. Nemertinea, Sipunculoidea, Echiuroidea, Echinodermata and Cephalochordata were absent in depths beyond 150m. Generally echinoderms are thought to be rare in oxygen minimum zone because it is difficult to maintain calcareous shells and skeletons under low pH and low oxygen condition (Levin *et al.*, 2000). In addition to low oxygenation, other factors may also play a role in controlling the benthic population, which have led to the low biomass and abundance of total benthos, and low species richness and diversity of polychaetes. Levin *et al.* (2000) emphasized that it is difficult to distinguish individual effects of hydrographical parameters on benthic fauna. Other abiotic properties known to affect benthic community structure are depth (Rex, 1983) and sediment particle size (Etter & Grassle, 1992). So the distribution of the fauna may be determined by a combination of a number of both hydrographical and sediment parameters.

In the oxygen minimum zone (>150m), most of the polychaetes were sedentarians. Their representation was 100% in some of the stations. Levin *et al.* (2000) have recorded that macrofauna present within the Oman margin OMZ were mainly soft-bodied polychaete species with Spionids and Cirratulids prevalent in the depth zone 400-700m. The present study also showed the dominance of spionids, cirratulids and paraonids among the polychaetes in this oxygen minimum zone. *Prionospio pinnata,* a member of Spionidae family was the most abundant polychaete species. Macrofaunal composition data from other low oxygen systems, e.g. Southern California border land basins and Scandinavian Fjords suggest that polychaetes, particularly spionids are the predominant taxa when oxygen values fall between 0.1 and 0.5 ml L^{-1} (Rhoads & Morse, 1971; Thompson *et al.,* 1985; Arntz *et al.,* 1991; Harper *et al.,* 1991; Levin *et al.*, 1991; Diaz & Rosenberg, 1995; Levin and Gage, 1998). This indicates that these organisms have low metabolic rates. The decrease in temperature with increase in depth may be an added advantage in this context.

Among the non-polychaete taxa, only amphipods and copepods were common. Molluscs were rare beyond 150m.

8.2. Sediment and fauna

Many studies have correlated the distribution of infaunal invertebrates with sediment texture, leading to the generalization of distinct association between animals and specific sediment types (Peterson, 1913; Ford, 1923; Davis, 1925;

Jones, 1950; Sanders, 1958; Jansson, 1967; Johnson, 1977; Nakao, 1982; Grant & Butman, 1987; Palacin *et al.,* 1991). Neyman (1969) noticed that in the muddy bottom of western Indian continental shelf region, at depths of 20-75m predominant fauna were Echiuroidea, Bivlavia (Tellinacea) and Polychaeta (Eunicidae, Spionidae, Ampharetidae and Terebellidae). But in the areas at the entrance to the Gulf of Cambay and at the southern extremity, filter feeders, mainly bivalves of the family Solenidae and solitary corals were the predominant forms. Parulekar and Ansari (1981) noticed richer fauna in clayey deposits and their admixture with sand and silt than in the sandy deposits or the coralline areas of Andaman Sea. Harkantra *et al.* (1982), while studying the benthos of the Bay of Bengal noticed that loose sands sheltered rich fauna whereas muddy substrata were relatively impoverished. Presumably fine particles of clay sediment result in the clogging of the filtering apparatus of the filter feeders. In such regions, deposit feeders abound provided there is an adequate supply of food. Venkatesh Prabhu *et al.* (1993) observed a direct relation between sediment composition and polychaetes and echiurids in off Gangolli region, with the polychaetes exhibiting greater abundance and diversity in clayey silt sediment. He attributed this to the fact that polychaetes prefer environment with limited water movement and sediment rich in fine particles. Ansari *et al.* (1994) noticed that the numerically dominant taxa occur over a variety of sediment types, responding to sedimentary gradients with changes in abundance.

Although a number of studies have been made in this respect there is little evidence that sediment grain size alone is the primary factor deciding in infaunal species distribution. A predominant generalization proposed by Sanders (1958) was that suspension feeders were more abundant in sandy environments and deposit feeders were more abundant in muddy environments. Critical re-examination of data on animal-sediment relationship suggests that many species are not always associated with a single sediment type, and that suspension and deposit feeders often co-occur in large numbers (Snelgrove & Butman, 1994). Further more, a number of species alter their trophic mode in response to flow and food flux conditions (Snelgrove & Butman, *loc. cit.*).

The present study also did not show any such clear-cut relation between sediment texture and fauna. However, in general, average total biomass was high in sand followed by silty clay and silty sand (Fig. 8.2). Highest average abundance of total benthos was noticed in silty clay substratum followed by sand and silty sand (Fig. 8.3).

As far as polychaetes are concerned, their average biomass was high in silty sand followed by silty clay, whereas their average abundance was high in silty clay followed by silty sand and sand.

Average crustacean biomass was high in sand followed by silty sand. Their average abundance was high in silty clay followed by sand and clayey silt.

Molluscans showed high average biomass in silty clay followed by clayey silt. The numerical abundance of molluscs was high in silty clay followed by sand.

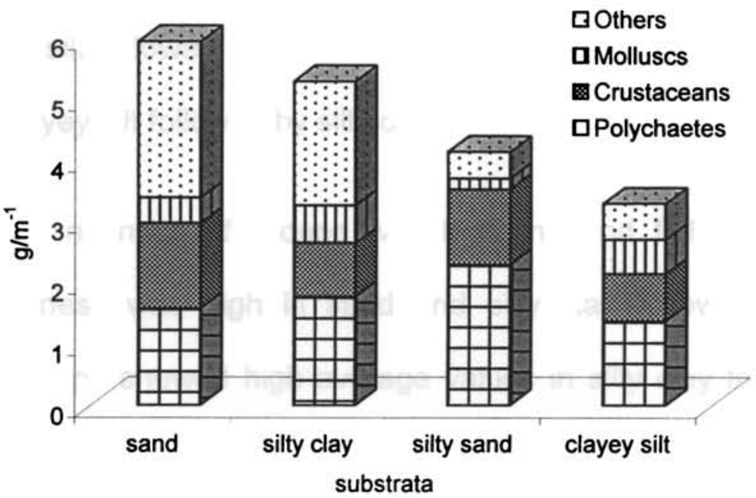


Fig. 8.2. Relation between substrata and biomass of fauna

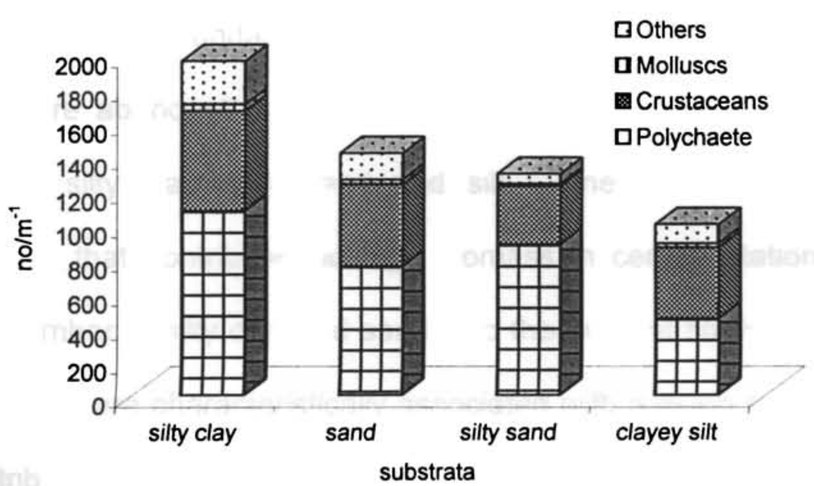


Fig. 8.3. Relation between substrata and numerical abundance of fauna

Average species richness and species diversity of polychaetes were high in sand followed by silty sand (Fig. 8.4). Average evenness of polychaetes was high in clayey silt followed by sand. Average dominance index of polychaetes was high in clayey silt followed by silty clay.

Average richness of groups was high in sand followed by silty clay. Average evenness was high in sand and silty clay followed by clayey silt. Diversity of groups showed high average values in silty clay followed by sand. High dominance of groups were noticed in clayey silt followed by silty sand.

Polychaete species such as *Magelona cincta, Prionospio pinnata, L. latrielli* showed its high abundance in sandy as well as muddy substrata. Amphipods were abundant in sand, silty clay and sand silt clay, whereas, isopods were abundant in sand and silty sand. Copepods were abundant in clayey silt, silty clay, silty sand and silt. One of the decapods, *Alpheus malabaricus* that contributed to high biomass in certain stations were equally good in number in silty clay and sand. So the present study shows that even if many species are characteristically associated with a given sedimentary habitat, their distributions are rarely confined to that environment. Some species show little affinity with any one particular sediment type, and the fauna within different sediment environments invariably show some degree of overlap.

The organic content of the sediment may be a more important factor than sediment texture in determining infaunal distribution, because, organic matter in sediments is a dominant source of food for deposit feeders and indirectly for

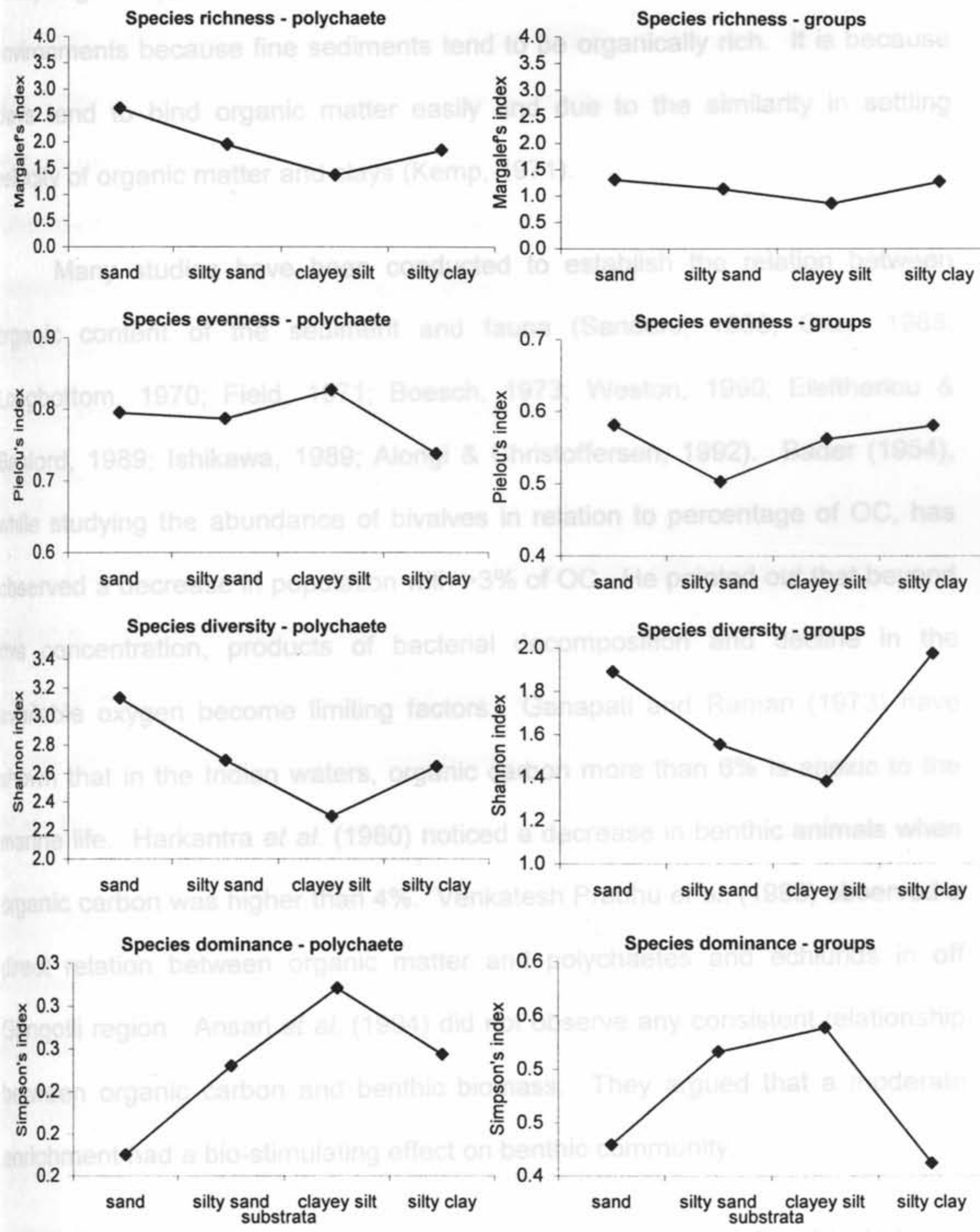


Fig. 8.4. Relation between diversity and sediment texture.

suspension feeders (Snelgrove & Butman, 1994). Indeed, Sanders's (Sanders, 1958) original hypothesis was that deposit feeders are more abundant in muddy environments because fine sediments tend to be organically rich. It is because clays tend to bind organic matter easily and due to the similarity in settling velocity of organic matter and clays (Kemp, 1971).

Many studies have been conducted to establish the relation between organic content of the sediment and fauna (Sanders, 1958; Gray, 1968; Longbottom, 1970; Field, 1971; Boesch, 1973; Weston, 1990; Eleftheriou & Basford, 1989; Ishikawa, 1989; Alongi & Christoffersen, 1992). Bader (1954), while studying the abundance of bivalves in relation to percentage of OC, has observed a decrease in population with >3% of OC. He pointed out that beyond this concentration, products of bacterial decomposition and decline in the available oxygen become limiting factors. Ganapati and Raman (1973) have shown that in the Indian waters, organic carbon more than 6% is anoxic to the marine life. Harkantra *et al.* (1980) noticed a decrease in benthic animals when organic carbon was higher than 4%. Venkatesh Prabhu *et al.* (1993) observed a direct relation between organic matter and polychaetes and echiurids in off Gangolli region. Ansari *et al.* (1994) did not observe any consistent relationship between organic carbon and benthic biomass. They argued that a moderate enrichment had a bio-stimulating effect on benthic community.

All these studies suggest that there is a strong relationship between organic matter and faunal distribution. However, it has been realized that bulk organic carbon measurements may not accurately reflect the amount of organic carbon that may actually be utilized by an organism (Tenore *et al.,* 1982, Cammen, 1989, Mayer, 1989, Mayer & Rice, 1992). In the controlled laboratory experiments on larval settlement, it was seen that the differences in organic carbon rather than grain size resulted in the selective settlement of larvae in organic-rich sediments, where they develop in to adults (Butman *et al.*, 1988, Butman and Grassle, 1992; Grassle *et al.,* 1992a, b). In field studies, several deposit feeding opportunistic species have been shown to colonize preferentially organic matter rich sediments over non-enriched sediment (Grassle *et al.,* 1985; Snelgrove *et al.*, 1992).

The way in which organisms are able to utilize different types of organic matter is a complex issue (Lopez & Levinton, 1987) and organic matter may take many different forms (Johnson, 1974; Whitlatch & Jonson, 1974; Mayer, 1989). These different forms of organic matter may be utilized in different ways (Tenore *et al.*, 1982).

Apart from the issue of quality of organic matter, there is some controversy over whether deposit feeders utilize primarily detritus or the microbes attached to it (Levinton, 1979; Cammen, 1989). Some studies have suggested that most detritus is not utilized (Newell, 1965; Fenchel, 1970; Hargrave, 1970; Lopez *et al.,* 1977), at the same time, others have pointed out that microbial carbon alone may be insufficient to support infaunal communities (Tunnicliffe & Risk, 1977; Cammen *et al.*, 1978).

It is an accepted fact that benthos depend up on overlying column of water for their energy requirements. The supply of food to subtidal benthic communities depends on proximity to shore and water depth (Levinton, 1982). Nearshore, shallow water localities are richly supplied with both benthic and planktonic primary production, much of which enters the food web as organic detritus. The pelagic supply of organic matter to the benthos similarly decreases with depth and distance from shore (Levinton, 1982).

The present study showed high biomass and high abundance in the nearshore regions and it decreased with increase in depth. One of the reasons for the high abundance and high biomass in nearshore region can be due to the labile nature of the organic matter in this region. This study showed high average OM content in the sediment of the continental shelf edge. The organic matter reaching the sea floor at great depths has previously been attacked by a variety of decomposers and so is probably more refractory than organic detritus reaching shallow bottoms adjacent to the shoreline (Levinton,1982). Most of the organisms may not be able to use this type of organic matter.

The present study did not show any significant correlation between OM and the fauna, its abundance, biomass and diversity (Fig. 8.5). It does not mean that the fauna is not influenced by OM, rather, what portion of the OM is actually available for benthic production is not known. So the quality of the organic matter present in the sediment is important.

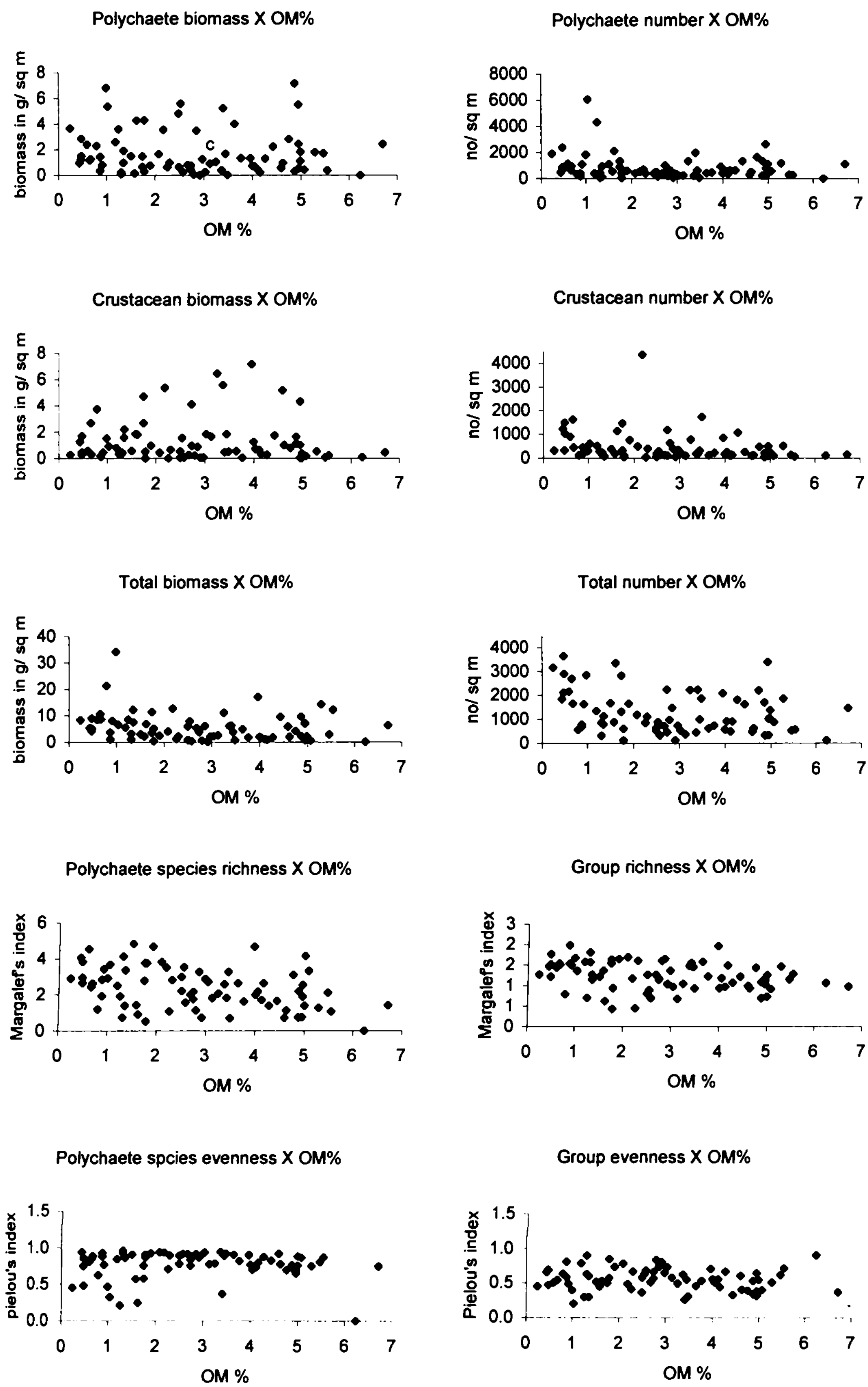


Fig. 8.5. Relation between fauna and OM%.

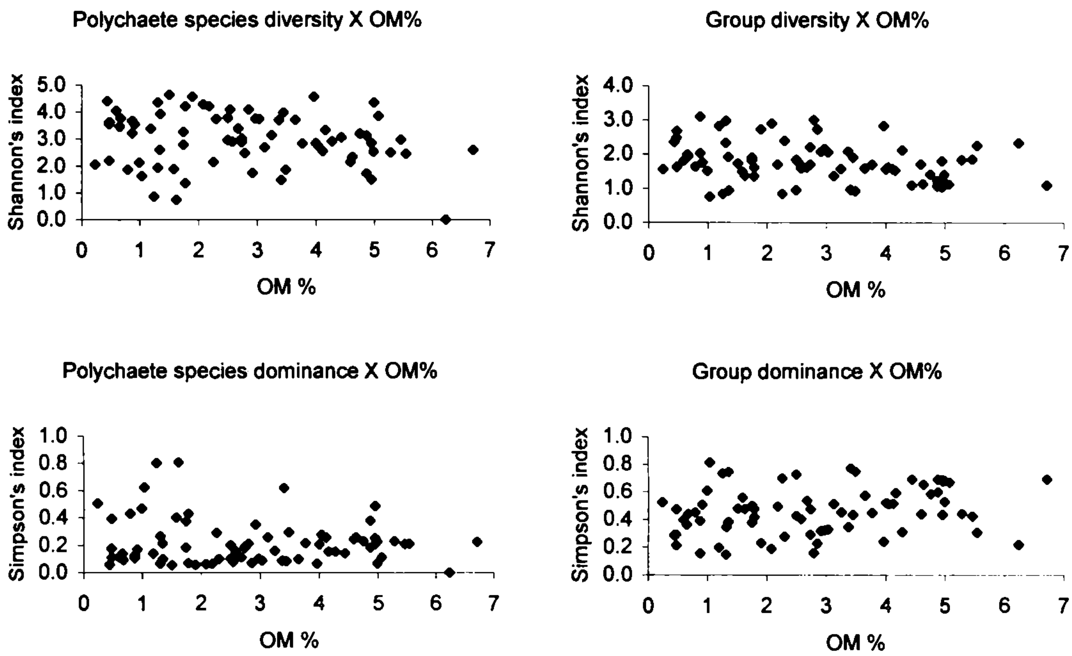


Fig. 8.5 continued.

8.3. Trophic relationships

Benthos form the basis for energy flow in the benthic eco-system (Parulekar *et al.*, 1980). The available information suggests that macrofauna makes a sizable contribution to the benthic energetics of certain regions of the continental shelf (Damodaran, 1973; Parulekar *et al.*, 1980; Harkantra *et al.*, 1980; Parulekar *et al.*, 1982; Ansari *et al.*, 1996). The role of benthos in sustaining the demersal fishery is well understood. So an estimation of the benthic standing crop and production can give an idea about the potential demersal fishery resources of the continental shelf (Parulekar *et al.*, 1982; Longhurst & Pauly, 1987). Among the benthic animals, polychaetes are the principal food items of the demersal fishes (Longhurst & Pauly, 1987). It has been confirmed that polychaetes dominate the benthos numerically over the continental shelf of west coast of India (Harkantra *et al.*, 1980; Parulekar *et al.*, 1982).

According to the present study, the average macrobenthic biomass along the continental shelf of the west coast of India is 5555 kg wet wt. km^{-2}. Using the conversion factors developed by Parulekar *et al.* (1980), the dry weight obtained is 601.3 kg km^{-2}. Since 34.5% of the dry weight is made up of carbon (Parulekar *loc. cit.*) the above value could also be expressed as 207.4 kg C km^{-2}. Most species of macrobenthos have got a life span of about one year and if suggestion of Sanders (1956), that there is a production of about twice the standing crop for these animals, is accepted, an annual macrobenthic production of about 414.8 kg C km^{-2} yr^{-1} would be obtained. This will call for a demand of 4148 kg C km^{-2} yr^{-1} for the macrobenthic production.

Simultaneous studies conducted along with benthic biomass estimation of the continental shelf of the west coast of India on primary productivity using C^{14} technique showed an annual primary production of around 2,44,185 kg C km^{-2} yr^{-1} (Madhu, personal communication). This observation proves that the primary production of overlying water is not a limiting factor for benthic production.

Various studies have pointed out the strong mutual links existing between meio and macrofauna (Tipton & Bell, 1988; Service *et* al., 1992; Giere, 1993). Meiofauna is intensively devoured by the multitude of macrofauna such as polychaetes, ophiurids, juvenile fishes and early ontogenic stages of shrimps and crabs (Giere, 1993). Sikora *et al.* (1977) emphasized that energetically, it is more economical to ingest one meiofaunal organism than numerous dispersed microorganisms of the same energetic value. Studies conducted on meiofauna along with macrofaunal sampling gave a dry weight value for meiobenthos as 1607 kg km^{-2} yr^{-1} (Sajan Sebastian, unpublished data). Conversion of this value to carbon content will give a value of 554.484 kg C km^{-2} yr^{-1}. The present estimate of macrofaunal biomass indicates that only a part of the energy requirement of macrofauna is met through meiofaunal link. The rest may be contributed through detritus, microalgae and bacterial production.

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The western continental shelf area is approximately 2,51,631.36 km^2. So the benthic production in terms of wet weight will be 3.4 million tones (1.4 million tonnes of macrobenthic production and 2 million tonnes of meiobenthic production). The total demersal fish production along the west coast of India in 1999 was 0.71 million tones (source: CMFRI). Since the transfer of energy from one trophic level to another is only about 10% efficient, we can approximate the requirement of 7.1 million tonnes or more for supporting this trophic level. The present estimation indicates that the benthic contribution to demersal fishery is around 48%. Limitations of the present estimation are that sampling was restricted to 30-200m only and epifauna were not taken in to account. The values indicate that the organic matter may be high in shallower regions also. So the remaining 52% may be contributed by (i) benthic production up to 30m, (ii) epifaunal production, (iii) microfaunal production and (iv) micro algal production.

Chapter 9

Summary and conclusion

The paucity of information on benthic fauna of the entire west coast of India prompted the present investigation. The present study is the first attempt to understand the infaunal community of the entire shelf region of west coast, extending from off Cape Comorin to off Dwarka with sampling upto 200m depth. The work was carried out with an objective to understand the quantitative and qualitative nature of the macrobenthos in relation to the hydrographical parameters and sediment characteristics. With the above aim, two cruises were conducted onboard FORV Sagar Sampada (162 & 192A) and samples were collected from each degree square of the western continental shelf.

The first chapter gives a brief **introduction** to the subject, emphasizing the scope of the work.

The second chapter presents **the review of literature** in which an overview of the history and present status of the benthic studies around the world as well as in Indian waters is provided.

The third chapter describes the **area of study and the methodologies** employed for measuring hydrographical data, sediment characteristics, collection and identification of macrobenthos plus the statistical tests used to delineate the interrelationships and co-existance of the various macrobenthic groups as well as the influence of abiotic parameters on their distribution and abundance. Sampling was conducted from 30, 50, 100 and 200m depths. Additional samplings from around 75m were made from certain stations where, the shelf width was more. 75 stations distributed along 17 transects extending from Cape Comorin off to Dwarka off were covered.

The fourth chapter is devoted towards an understanding of the **hydrography** of the study area. The bottom water temperature, salinity and dissolved oxygen were measured. The temperature and dissolved oxygen showed a decreasing trend with increase in depth, while salinity increased with depth. The data also exhibited a latitudinal variation. Temperature showed a decrease from south to north up to 100m depth, where as beyond 100m, it decreased from north to south. Salinity showed an increasing trend from south to north in all the depth ranges. Near zero values of dissolved oxygen were observed along the continental shelf edge particularly the northern continental shelf.

The fifth chapter provides a detailed account of the **sediment characteristics** of the study area. Seven different types of substrata were noticed. Among this, four were prominent, *viz.* sand, silty sand, clayey silt and silty clay. In general, substrata were muddy in nature in the 30-50m depth ranges and sand became the major substrata in depths beyond 50m. The percentage of organic matter ranged from 0.24% 6.71%. In general, organic matter showed an increasing trend with increase in depth. Finer sediments retained more organic matter than coarser ones.

The sixth chapter explains the **composition of macrobenthos**. Polychaetes were the dominant forms in all the transects. They contributed to 56.18% of the total number of individuals. A total of 165 species of polychaetes were recorded in which 6 species remained as unidentified. Of the identified, 70 species were from Errantia, belong to 13 families and 89 species were from Sedentaria, belong to 19 families. On the whole, 15 species were considered abundant, 116 moderately present and 34 rare. Among the polychaetes one species which has its distribution on the entire shelf in all the depths was *Prionospio pinnata*. With respect to the number of families and species present Sedentaria were dominant than Errantia.

Of the non-polychaete taxa, crustaceans were the most important groups comprising 30.62% of total individuals. Major groups were gammarid amphipods and decapods, followed by caprellid amphipods, copepods, isopods, tanaids, cumaceans, ostracods and pycnogonids in order of importance.

Molluscans contributed only 1.77% of total fauna. Their occurrence as a dominant goup was often rare. Among molluscs bivalves were significant and gastropod's representation was rare. Scaphopod made their presence felt only in a few stations.

The rest of the groups, contributed 11.43% in number and the groups that accounted for this were foraminiferans, sponges, hydrozoans, anthozoans, nematods, echinoderms, nemertines, sipunculids, echiuroids, *Amphioxus sp* and pisces.

Attempt has been made to understand the community structure of polychaete species as their qualitative composition is available for different regions. In addition to it community structure of total benthic population including polychaetes was also attempted. Average species richness and species diversity of polychaetes showed an increase upto 100-150m depth range, but beyond 150m, it showed a steep decrease. Evenness of polychaetes was maximum at 76-100m depth range and dominance was maximum at >150m depths. In the case of all macrobenthic groups, richness, diversity and evenness was maximum at 76-100m depth range and dominance was maximum at 51-75m depth range. Niche breadth calculated for the polychaetes separately and all the benthic groups together shows that in all depth ranges, rare groups as well as highly abundant groups have higher niche breadth, where as the moderately abundant groups have low niche breadth values.

From the analysis of the similarity index worked out between stations in each depth range, it was noticed that the similarity between stations occurred in cases where the nature of sediment was similar and the percentage of organic matter content was alike. These findings suggest the importance of the sediment characteristics on the distribution of fauna. Predictive regression model also showed that the distribution of polychaetes in shallow water are controlled by sediment parameters, while beyond 150m polychaete distribution was controlled by a combination of temperature, dissolved oxygen, organic matter and silt.

The seventh chapter on the **standing stock** of macrobenthos explains the depth-wise and latitudinal variation of biomass and numerical abundance of benthos on the shelf. The biomass and abundance were mainly contributed by polychaetes and crustaceans followed by molluscs. Other groups, *viz.* sponges, nemertines, sipunculids, echinoderms and fishes also contributed significantly in certain stations. As a whole, the wet weight of the macrobenthos ranged between 0.090 g m^{-2} to 34.047 g m^{-2}. The numerical abundance varied from 120 number m^{-2} (along Mumbai, 95m) to 6770 number m^{-2} (off Vadanappillly). The present study showed an average biomass of 5.555 g m^{-2} and average numerical abundance of 1471 m^{-2} for the shelf waters of the west coast of India. The biomass value obtained in the present study is considerably less than that reported by earlier workers. The studies conducted so far state that south west coast is richer in benthic biomass than the north west coast, but the present study indicate that there is no significant difference between the benthic biomass as well as numerical abundance of the west coast of India. The biomass of macrobenthos was 5.752 g m^{-2} from SW and 5.303 g m^{-2} from NW region. Average population density of SW coast was 1459 m^{-2} and NW was 1488 m^{-2}.

The depth-wise analysis of the biomass and number indicates a decline in biomass and number as the depth increases beyond 75m.

The **ecological relationships of the macrobenthos** are discussed in the eighth chapter. Among the hydrographic parameters temperature and dissolved oxygen were found as the most dominant environmental parameters that affect the benthic realm. The distribution and abundance of fauna could not be explained on sediment texture alone. However, in general, average total biomass was high in sand followed by silty clay and silty sand. Highest average abundance of total benthos was noticed in silty clay substratum followed by sand and silty sand. Dominant species did not show any substratum preference. The study indicates that understanding of the total organic matter is not sufficient to explain the abundance, biomass and diversity of benthos, but information on the detailed composition of organic matter may be needed to explain these relationships.

Present study indicates that surface production is not a limiting factor for benthic standing stock and the infaunal support to demersal fishery is around 48% and the remaining 52% may be contributed by (i) benthic production up to 30m, (ii) epifaunal production, (iii) microfaunal production and (iv) micro algal production.

A list of references consulted during the course of study has been presented at the end of the thesis.

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