anthropogenic activities such as reclamation, dredging, clearing of mangroves, dumping of dredge spoil, recreational boating from an adjacent marina and shipping in the busy East Johor strait. These impacts have resulted in the input of different kinds of pollutants into the system, resulting in an overall imbalance in the resident biotic communities.

The study is divided into two parts—intensive field monitoring studies and mesocosm studies. The intensive monitoring involved 24 sampling spaced at fortnightly interval over one year. Spatio-temporal variations in 30 parameters were studied, looking into the effect of pollutants such as heavy metals, total petroleum hydrocarbons and organic carbons on biotic components such as plankton, periphyton and heterotrophic bacteria. The results reveal an imbalance resulting in eutrophication due to inhibition of heterotrophic bacteria by high concentrations of petroleum hydrocarbons discharged by the boats and the ships. Besides this, we are looking into the possible effect of dredging and subsequent light reduction on the overall and the size fractionated primary production in the ecosystem. Mesocosm studies would be carried out to 'ground truth' the findings from the monitoring studies. In these studies, concentrations of a particular pollutant would be made up and added into mesocosm set-ups that would be monitored over a period of time to validate the findings from our field observations.

The Change in land-sea silicate fluxes through the Chao Phraya River

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There are several examples of changes in silicate fluxes due to land use changes, for example on the Danube and Nile River System. The Gulf of Thailand and adjacent coastal area also had undergone by changing land use activities such as dam construction for irrigation and production of hydroelectric power and deforestation to make way for agricultural practice. These changes are expected to have impacts on nutrient composition in the gulf, which have a direct impact to captured fisheries, marine biodiversity and carbon cycle. This study focuses on two areas of interest: the seasonal change in silicate and other nutrients in the Chao Phraya River in 1999 and possible historical change in biogenic silica in seven sediment cores and one 40-year-old coral core from the Gulf of Thailand. The main objective is to try to understand the relationship between silicate fluxes in the past with the historical land use changes in the Central Plain of Thailand.

The year-round average of dissolved silicate concentration in the Chao Phraya River in 1999 was 181.58 mM, which was normal in natural freshwater. However, the concentration in the wet season was higher, which was probably due to higher soil erosion by surface runoff. Dissolved silicate concentration in the river water decreased toward the river mouth through a mixing process with low-silicate seawater. In sediment core, we had expected that the biogenic silica concentration accumulated in sediment should be higher in the deeper part before construction of major dams upstream. However, we found no clear systematic change in downcore concentration of biogenic silica in sediments even in the sediment from upper area of the Gulf of Thailand, which is directly influenced by the Chao Phraya River. This was probably due to the fact that fragile siliceous shells are more soluble in the tropical marine environment, thus only a small amount of it remained in sediment. Another possible reason was a disturbance of surface sediment by bottom trawling. Although silicate cannot show a clear relationship with land use in this research, there are still several nutrients that we can use. One of these elements is Aluminium which its flux also has a close relationship with land use. Additionally, we also expected that biogenic silica recorded in coral bands would be able to show historical changes in land use activities as well.

Ecological status survey of the intertidal macrofauna of the Sikka & Vadinar coast off gulf of Kachchh, India

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The intertidal zone is considered as the most productive with the greatest diversity of plant and animal life of any ecological area of the world. The intertidal ecosystem represents rather special type of environment, which contrasts sharply with conditions that prevail elsewhere in the sea. The life in the intertidal zone needs special adaptations that are required by the organisms to inhabit therein which is alternatingly marine and terrestrial.

Gujarat state of India is gifted by Nature with two Gulfs; Gulf of Cambay and Gulf of Kutch. The Saurashtra coastline (Western part of India) is having a broad continental shelf harbouring very rich biota. With the changing scenario of rapid industrialization of Saurashtra coastline, it is absolutely necessary to obtain a baseline data on the status of the marine fauna present today, before it is too late. This database will be a vital component to assess the impact of the industries and human pressure on the marine biota, in time to come.

The Saurashtra coast, on the western side of India, harbours a wide variety of marine fauna, some of which are economically important. Thus, for a proper management of these resources, detailed ecological studies are being conducted at different sites on the Saurashtra coast. The coastline between Jamnagar and Salaya off the Gulf of Kachchh is a favourite location these days. Many companies are setting up mega-industries like Integrated Petrochemical Refinery at Sikka (RPL) and Vadiner (Esser, IOC); Thermal Power Project, Cement Factory & Fartilizer Factory at Sikka. Since, the operation of these mega industries and associated industries, which is cropping up, may affect the fragile marine ecosystem of the Gulf of Kachchh. The focus of the present study is to furnish a baseline data of the marine biota of the coastline around Sikka, off the Gulf of Kachchh.

The entire coastline between Sikka and Vadiner is divided into five main sampling sites. Highly important aspect is to survey and enlist major groups of the intertidal macro fauna present in the sampling sites. Some of these intertidal animals act as *biological indicators* of the water and sediment quality, and thus, as indicators of marine pollution. In the ecological studies, the structural attributes of the intertidal fauna were studied by transect method. Among the attributes, abundance, density and frequency of each major species in each sampling site were calculated for each season. The results are expressed in terms of coast characteristics, a checklist of marine macrofauna and seasonal variations of their attributes in relation to the probable industrial and anthropogenic pressure.

In addition to this, toxicological studies were also done to understand the Chromium (VI) stress (chromium is found in the effluents of various industries situated in this area) on the membrane ATPase enzyme system of few vital organs of a coastal mudskipper species *Periophthalmus dipes*.

FOREWORDS

The coastline between Jamnagar and Salaya off the Gulf of Kachchh is a favourite location these days. Many National and Multinational companies are setting up mega-industries like Integrated Petrochemical Refinery at Sikka (RPL) and Vadiner (Esser, IOC); Thermal Power Project, Cement Factory & Fartilizer Factory at Sikka. Since, the operation of these mega industries and associated industries, which is cropping up, may affect the fragile marine ecosystem of the Gulf of Kachchh. The focus of the present study is to furnish a baseline data of the marine biota of the coastline around Sikka, off the Gulf of Kachchh. The entire coastline between Sikka and Vadiner is divided into five main sampling sites. The principal aspect is to survey and enlist major groups of the intertidal macro fauna present in the sampling sites. Some of these intertidal animals act as *biological indicators* of the water and sediment quality, and thus, as indicators of marine pollution.

THE EXPERIMENTAL PROTOCOL

During the study, the entire coastline was extensively surveyed during the low tide. Various zones were identified and studied for coast characteristics. The intertidal macro fauna observed in the five specified sampling sites, during our surveys, were recorded and later systematically classified. Thus, animals under various phyla were noted and a checklist was prepared. Only those animals, which could not be identified during field surveys, were collected and brought to the laboratory for identification. The quantitative structural attributes of the intertidal fauna were studied by transect method. At least 100 quadrates (0.5 m×0.5 m) were laid vertically across the complete intertidal area from upper littoral to lower littoral zone for recording the attributes. The quadrates were laid about 10 m apart and thus, at least 1 km of intertidal zone was covered in each sampling site for collection of data. The quantitative studies were done during three seasons, winter (from November to late February), summer (from March to June) and Post-monsoon (from July to October). Among the attributes, abundance, density and frequency of each major species in each sampling site were calculated for each season. Similarity Index (C) and Shannon Diversity Index were calculated from the collected data.

THE INTERTIDAL MACROFAUNA

Corals: In all the five sampling sites, about 16 types of hard or stony corals and two species of soft corals are recorded. Amongst these, stony corals like *Portis*, *Goniastraea*, *Favia*, *Madrepora* and the Brain Coral *Meandrina* dominated the coastline. However, the study indicates that concentration of corals is highest in site 5, followed by site 2, and least in site 4. The corals are seen in the sites in small patches and most of the coral area at sampling sites 1, 2, 3 and 4 are partly covered with silt.

Other Coelenterates: Members of Phylum Coelenterata represented all the sampling sites. The richness of this group was solely due to the presence of genus *Zoanthus* on the rocks, forming small patches. However, they were partly or fully covered with mud or silt.

Sponges: A variety of sponges, about eight genera were identified in the sampling sites and were of encrusting types forming flat patches of colorful mats on the rocks. However, large isolated colonies of upright sponges were also observed.

The Worms: Though the members of this group are present in all sampling sites, their density was extremely low in the sites 1, 2, 3 and 4. This phylum is represented by about 7 genera with *Nereis* and tubeworms being the dominant species.

The Crabs: The phylum Arthropoda is well represented in all sampling sites except site 3. Phylum arthropoda was represented by about 22 genera with the barnacle *Balanas amphitrite*, and various species of hermit crabs as dominant ones.

The Starfish: Site 5 was the richest in phylum Echinodermata than any other sites. This group was represented by about 8 genera with Brittle Star and Dollar Star as the

dominant species.

The Molluscs: Members of the phylum Mollusca were more numerous than any other phylum or faunal group in the areas. The group was represented by about 28 genera. The dominant forms were Murexes, *Pectans*, Turbinid molluscs, Trochidis, *Telescopium* and other gastropod molluscs. It is interesting to note here that the sites 1 and 2 exhibited steady decline in the population density of molluscan over the seasons.

The Fishes: Mudskippers, like genus *Boleophthalmus* and *Periophthalmus* were dominant in all five sampling sites. The puffer fish Tetradon and sand gobies were among other common fish species. In deeper regions of these sampling sites fishes like Mugils, Pipe fish *Hemiranphus* and *Belone* were found to be caught by the local fisher folks.

THE MAIN FINDINGS

Sampling site 1 is predominantly muddy; however, the lower littoral zone is somewhat rocky-muddy which is well represented by various species of macrofauna. In the lower part of the middle littoral and the lower littoral zone, corals, sponges, molluscs and other macrofauna were present. The sedentary Coelenterate *Zoanthus* and small patches of live hard corals like *Portis*, *Goniastraea*, *Favia* and *Meandrina* cover a large part of the area. However, the corals and *Zoanthus* were found half-covered with mud. In general, this area is considered as a barren mud flat with scanty intertidal population.

Sampling Site 2 is predominantly muddy. However, the lower littoral zone being predominantly rocky, it harbours corals, anemones, molluscs, and echinodermates. Both the lower and middle littoral zones are well represented by *Zoanthus*. Sampling site 2, being a rocky-muddy area, is represented by all the major invertebrate phyla with varying degree of occurrence. Sponges, coelenterates and arthropods are the major groups. Dominat species of this site are *Zoanthus* (phylum Coelenterata), red and yellow sponges (phylum Porifera), barnacles, common shore crabs, hermit crabs (phylum Arthropoda) and few species of gastropods (phylum Mollusca).

Sampling site 3 is muddier and comparatively more disturbed. The upper and middle littoral zones are rocky-muddy, covered by thick layer of silt. This area is poorly represented by major invertebrate phyla. The dominant groups are Coelenterates, Arthropods and Gastropod molluscs. The dominant species are *Zoanthus* and barnacles in rocky areas and few gastropods in muddy areas.

Sampling site 4 is rocky-sandy with occasional rocky-muddy patches. Hermit crabs and polychetes dominate the upper and middle littoral areas respectively. However, the lower littoral zone is predominantly rocky and represented by corals, anemones, *Zoanthus*, gastropod molluscs and members of arthropods and coelenterates. The dominant species are *Zoanthus* and polychetes like *Chetopterus*, *Sabella*, *Terebella* and *Nereis*.

Sampling site 5 is rocky-muddy with little amount of silt. This area harbours rich marine life. A few species of gastropods, crabs and polychetes represent the upper littoral zone. The middle littoral zone is rich in various types of coelenterates including corals, annelids such as *Nereis*, *Sabella*, *Terebella*, *Chetopterus* and a wide array of arthropods. The lower littoral zone is extremely rich in almost all-invertebrate phyla, especially huge colonies of live corals. This area is extremely rich in algal vegetation, thus also rich in associated fauna. Few rare animals like *Bonnelia* (phylum—echiuroidea), *Coeloplana* (phylum ctenophora), *Convoluta* and *Leptoplana* (phylum–platyhelminthis) and *Lineus*, (phylum nemartea) were found here.

Table 1. Intertidal macrofauna recorded at various sampling sites. A '+' or '−' sign against a species in the table indicate the presence or absence (not seen till the time of reporting), respectively.

CORALS

Phylum: Coelenterata

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Montipora explanata*	−	+	+	−	+
2	*Goniastraea aurea*	+	+	+	+	+
3	*Madrepora verrucosa*	+	+	+	+	+
4	*Meandrina arabica*	+	+	+	+	+
5	*Goniastraea pectinata*	+	+	+	+	+
6	*Favia favulus*	+	+	+	+	+
7	*Portis lutea*	+	+	+	+	+
8	*Flavellum caudatum*	+	+	−	−	+
9	*Montipora hispida*	−	−	−	−	+
10	*Goniopora planulata*	+	−	−	+	+
11	*Portis lichen*	+	+	−	−	+
12	*Platygyra sinensis*	−	+	−	−	+
13	*Hydrophora exesa*	−	−	−	−	+
14	*Portis stepheosoni*	+	+	−	+	+
15	*Goniopora lobata*	−	−	−	+	+
16	*Favia pallida*	+	+	+	+	+

Phylum: Coelenterata (Other than Corals)

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Goneonemus puctinata*	−	−	−	−	+
2	*Porpita porpita*	−	−	−	−	+
3	*Spongodes* sp.	+	+	+	−	−
4	*Dendrophylia minuscula*	+	+	+	−	+
5	*Metridium* sp.	+	+	+	+	+
6	*Tealia felina*	+	+	+	+	+
7	*Zoanthus oreolata*	+	+	+	+	+
8	*Turbinaria crater*	+	−	−	+	+
9	*Cryptodendrum adhesivum*	+	+	+	+	+
10	*Plumularia* sp.	−	−	+	+	+
11	*Lytocarpus philippinus*	−	−	−	−	+

SPONGES

Phylum: Porifera

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Leucosolenia punctata*	+	+	+	+	+
2	*Grantia grantia*	+	+	+	+	+
3	*Oscarella lobularis*	+	+	+	+	+
4	*Chondrilla* sp.	+	+	+	+	+
5	*Chalena* sp.	+	+	−	−	+
6	*Halichondria* sp.	+	+	+	+	+
7	*Microciona prolifera*	+	+	+	+	+
8	*Euspongia microfila*	−	+	−	−	+
9	*Leucettusa imperfecta*	−	+	+	−	+
10	*Hymeniacidon perleve*	−	−	−	+	+

Phylum: Ctenophora

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Cestum auratum*	−	+	−	−	+
2	*Coeloplana merina*	+	+	+	−	+

Phylum: Platyhelminthis

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Bipalium marinum*	+	+	−	−	+

Phylum: Nimartea

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Lineus marinus*	+	+	−	−	+
2	*L. sanguineus*	−	+	+	+	+

Phylum: Echiuroidea

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Bonnelia* sp.	−	−	−	−	+

Phylum: Annelida

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Nereis dumerilii*	+	+	+	+	+
2	*Heteroneris fasciata*	+	+	+	+	+
3	*Eunice viridis*	+	+	+	+	+
4	*Glycera meckelii*	+	+	−	−	+
5	*Chetopterus pergamentaceus*	+	+	+	+	+
6	*Sabella pavonica*	+	+	−	+	+
7	*Terebella nebulosa*	+	+	+	+	+
8	*Sabellastarte indica*	−	−	−	−	+
9	*S. magnifica*	−	−	−	−	+

Phylum: Echinodermata

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Antedon bifida*	+	+	−	+	+
2	*Pentaceros ciliaris*	+	+	+	+	+
3	*Anthena* sp.	+	+	−	−	+
4	*Ophioderma* sp.	+	+	+	+	+
5	*Echinus* sp.	−	−	−	−	+
6	*Strongylocentrotus* sp.	−	+	−	−	+
7	*Clymeaster* sp.	−	+	−	−	+
8	*Holothuria* sp.	−	+	+	+	+

Phylum: Hemichordata

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Hadmania indica*	+	+	+	+	+

Phylum: Chordata

Class: Pisces

Sr. No.	Name	Occurrence in sampling sites				
		Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Hemiramphus georgii*	−	−	+	+	+
2	*Mugil jerdoni*	−	+	+	+	+
3	*M. poicilus*	+	+	+	+	+
4	*Boleophthalmus dentatus*	+	−	−	+	−
5	*Periophthalmus dipes*	+	−	−	+	−
6	*Tetradon inermis*	+	+	+	+	+
7	*T. viridipunctatus*	−	−	−	−	+
8	*Belone strongylurus*	−	−	+	−	+
9	*Gobius cristatus*	+	−	+	+	+

Phylum: Arthropoda

Sr. No.	Name	Occurrence in sampling sites Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Balanus amphitrite*	+	+	+	+	+
2	*Lepas lepus*	−	−	+	+	−
3	*Squilla squilla*	+	+	+	+	+
4	*Pagurus longicarpus*	+	+	+	+	+
5	*Hippa* sp.	+	+	−	−	+
6	*Carcinus maenas*	+	+	+	+	+
7	*Parapenaeopsis sculptilis*	−	−	−	−	+
8	*Palinurus* sp.	−	+	+	+	+
9	*Clibanarius zebra*	+	+	+	+	+
10	*C. nathii*	+	+	+	+	+
11	*Scopimera globosa*	+	+	+	+	+
12	*Neptunus pelagious*	+	−	−	+	+
13	*Carybdis ammulata*	−	−	−	+	+
14	*Atergatis integerrimus*	−	−	−	−	+
15	*A. roseus*	+	−	−	−	+
16	*Platypodia cristata*	+	−	−	+	+
17	*Leptodius euglyptus quadrispinasus*	−	−	−	−	+
18	*Actaea savignyi*	−	−	+	+	+
19	*Etisus laevimanus*	+	−	−	+	+
20	*Pilumnus longicornis*	−	−	−	+	+
21	*Litocheira angustiforms*	−	−	−	+	+
22	*Gelasimus annulipes*	−	−	−	+	+
23	*Periclimenes brevicarpalis*	+	+	+	+	+

Phylum: Mollusca

Sr. No.	Name	Occurrence in sampling sites Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
1	*Loritta loritta*	+	+	+	+	+
2	*Cypraea moneta*	+	+	+	+	+
3	*Haliotis tuberculata*	+	+	−	−	+
4	*Murex virgineus*	+	+	+	+	+
5	*Aplysia oculifera*	+	+	−	−	+
6	*Doris tuberculata*	+	+	+	+	+
7	*Aeolis papillosa*	−	+	−	−	+
8	*Mytilus viridis*	+	+	+	+	+
9	*Mya arenaria*	+	+	+	+	+
10	*Venus* sp.	−	+	+	−	+
11	*Ostrea* sp.	+	+	+	−	+
12	*Pecten maximus*	−	+	−	−	+
13	*Pinctada* sp.	+	−	−	−	+
14	*Pinna bicolor*	+	+	+	+	+
15	*Octopus vulgaris*	+	−	−	−	+
16	*Siphoneria siphoneria*	+	+	+	+	+
17	*Turbo coronetus*	+	+	+	+	+
18	*T. intercostalis*	+	+	+	+	+
19	*Cellana radiata*	+	+	+	+	+
20	*Cerithium caeruleum*	+	+	+	+	+
21	*Clypeomorus moniliferus*	+	+	+	+	+
22	*Perna indicus*	+	+	+	+	+
23	*Trochus radiatus*	−	+	−	−	+

Phylum: Mollusca (*Continued*)

Sr. No.	Name	Occurrence in sampling sites Site # 1	Site # 2	Site # 3	Site # 4	Site # 5
24	*Telescopium telescopium*	−	+	−	−	+
25	*Xancus pyrum*	+	−	−	−	+

Similarity index (C) of the intertidal macrofauna of the sampling sites

Similarity	Winter	Summer	Post-Monsoon
Between Site 1 & 2	0.91	0.91	0.85
Between Site 1 & 3	0.88	0.85	0.78
Between Site 1 & 4	0.91	0.85	0.88
Between Site 1 & 5	0.90	0.85	0.82
Between Site 2 & 3	0.82	0.85	0.83
Between Site 2 & 4	0.90	0.82	0.82
Between Site 2 & 5	0.95	0.91	0.93
Between Site 3 & 4	0.92	0.90	0.93
Between Site 3 & 5	0.85	0.84	0.85
Between Site 4 & 5	0.86	0.83	0.76

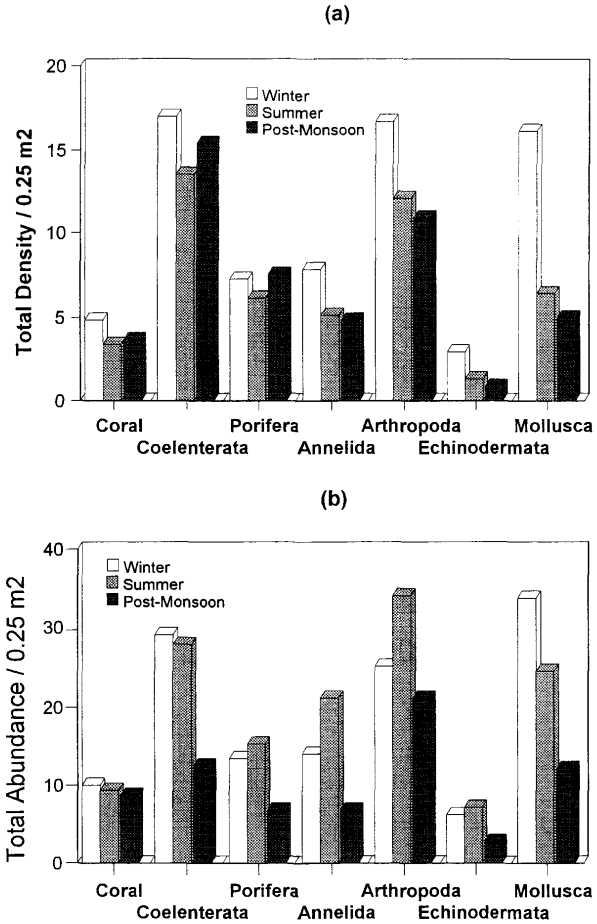

Fig. 1. The faunal structure at Site 1.

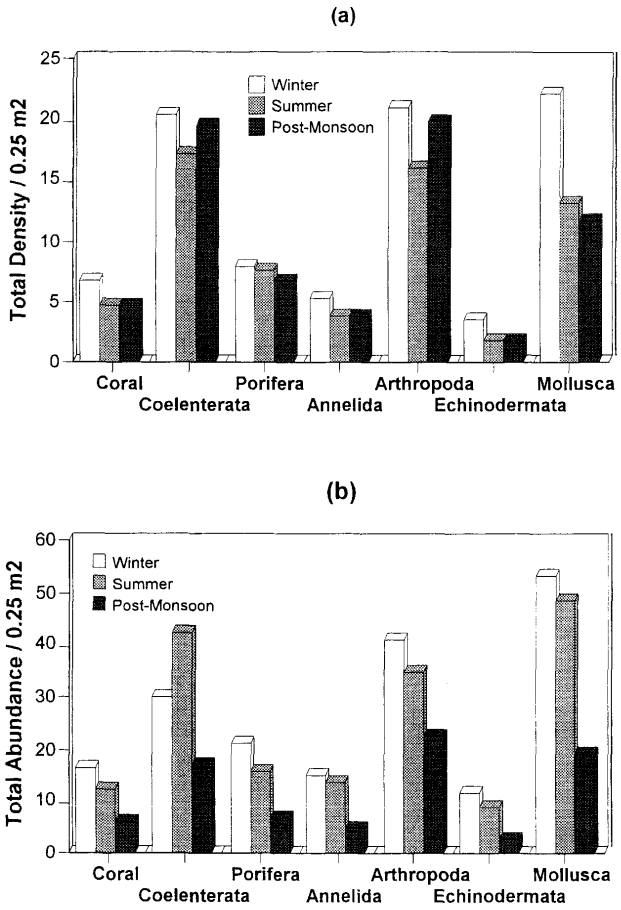

Fig. 2. The faunal structure at Site 2.

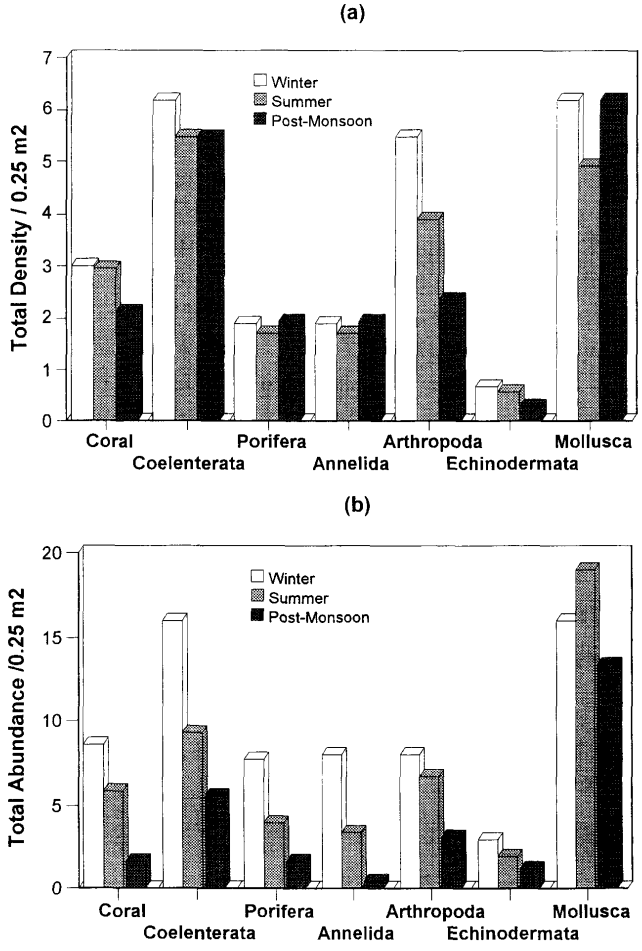

Fig. 3. The faunal structure at Site 3.

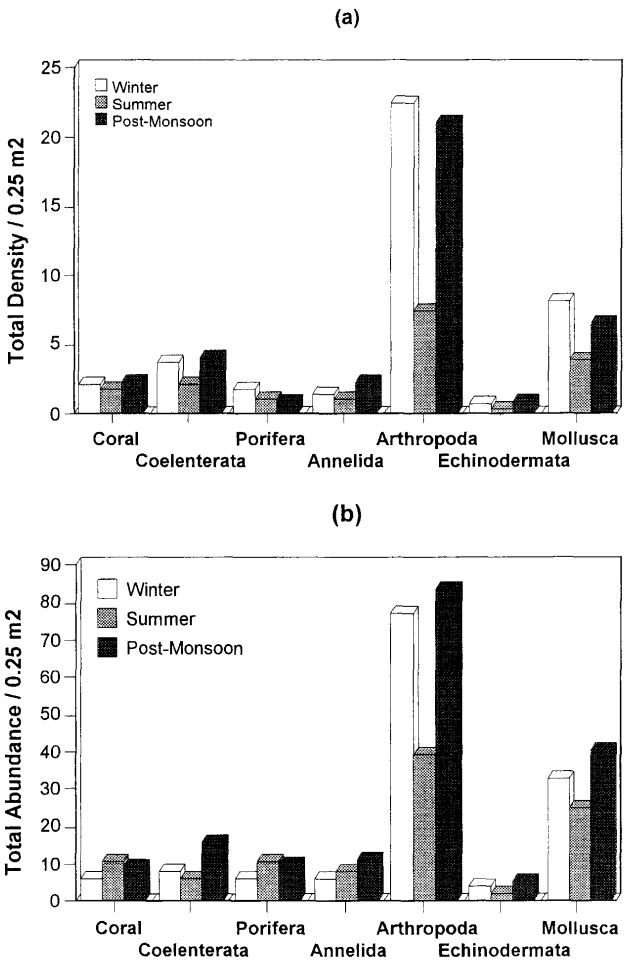

Fig. 4. The faunal structure at Site 4.

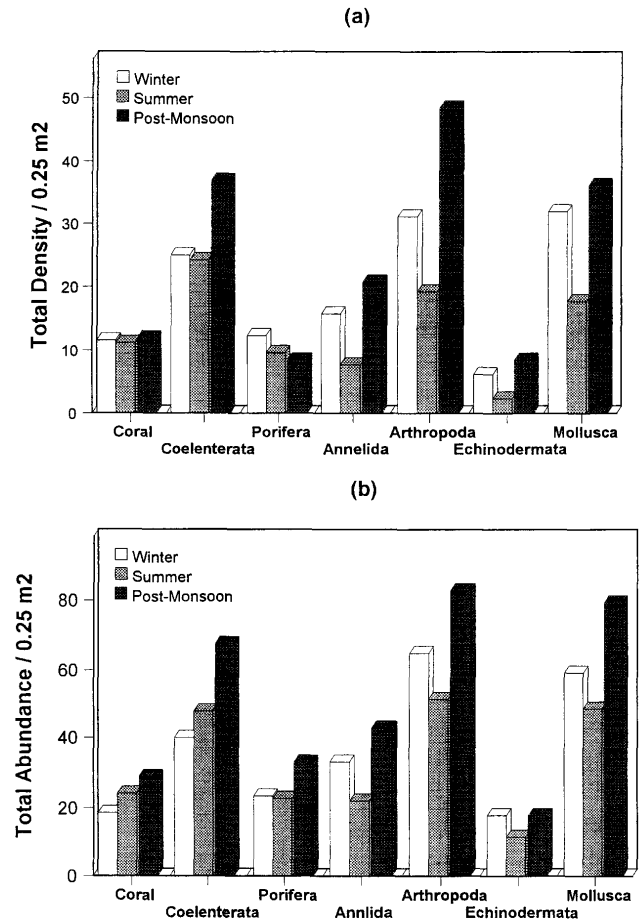

Fig. 5. The faunal structure at Site 5.