Temporal Changes in the Abundance of Macrobenthos in the South China Sea, Area I: Gulf of Thailand and East Coast of Peninsular Malaysia

Montira Piamthipmanus

Department of Fisheries

ABSTRACT

The ecology of macrobenthic fauna in the Gulf of Thailand and the east coast of Peninsular Malaysia was studied for two periods of time at pre NE monsoon (4 Sep.- 4 Oct. 1995) and post NE monsoon (23 Apr. -23 May, 1996).

It was found that the overall abundance of macrobenthic fauna presented the highest density at station 52 (920 ind.m^{-2}). Polychaete was the dominant group in the benthic comunities.

The result of the survey of the ecology of benthic fauna shows that the fauna density increases with a decreasing water depth. Polychaete, Crustacea and Echinoderm groups displayed a marked change in density with the during period of the monsoon and the diversity index showed different patterns during the pre and post NE monsoon periods.

Key Words : Macrobenthic fauna, Abundance, Gulf of Thailand, East Coast of Peninsular Malaysia

Introduction

The abundance of benthic fauna is a biological parameter that may indicate overall aquatic fertility of the bottom sediments. They are also the main source of food for both migratory and permanent fauna, higher predators in the food chain. Moreover, benthic communities are widely used in monitoring the effect of marine pollution as the organism are mostly sessile and integrate the effects of pollutants over time (Gray *et al*., 1990). It is also suggested that benthic fauna can be used as an integrating indicator of water quality within an area (Wass, 1967; Reish, 1972; Holland *et al*.,1973). Any fluctuation in either their quality and quantity will directly affect the abundance of demersal fishes which are an important fishery resource in the sea. Therefore, a benthic study may be used as baseline information to evaluate the existing demersal stocks and may also serve as a baseline study of future investigations on environmental changes in this area.

The present investigation of macrobenthic fauna is part of the biological oceanographic data survey under a collaborative research project between SEAFDEC's Training Department (TD) in Thailand and Marine Fisheries Resources Development and Management Department (MFRDMD) in Malaysia. The objectives of the collaborative research project are to collect and analyze data in order to provide information necessary for management of the environment and fishery resources in the South China Sea. The first survey area was the western part of the Gulf of Thailand and the east coast of Peninsular Malaysia within the exclusive economic zones of Thailand and Malaysia.

Macrobenthic studies have been previously conducted in the Gulf of Thailand by Charoenruay and Nateewathana,1978; Piyakarn *et al*.,1978; Charoenruay and Ketsamut,1979; Ketsamut *et al*.,1980 a and b; Charoenruay and Piamthipmanus,1981; Thanapong and Mhordee,1982; Charoenrauy *et al*.,1983; Piamthipmanus *et al*.,1984; Piamthipmanus,1984; Piamthipmanus *et al*.,1985.

The purpose of this study is to report the qualitative distribution and faunal composition of the macrobenthos in the Gulf of Thailand and east coast of Peninsular Malaysia, and also to examine

changes in the density and diversity of macrobenthic fauna between the pre and post NE monsoon, providing preliminary information on benthic communities.

Materials and methods

Sampling

Sampling area

The survey areas are in the Gulf of Thailand and east coast of Peninsular Malaysia (Lat.12.20.00-01.48.54 N; Long.100.15.00-104.45.26 E; Fig.1). A total of 81 survey stations were set up for the collaborative research project (Fig.2). Two monsoon seasons can be distinguished: SW monsoon period from June to October and NE monsoon season from November to February. The collaborative research project was carried out on board MV SEAFDEC from 4 September-4 October, 1995 and 23 April-23 May, 1996. The first cruise was in the pre NE monsoon and the second was in the post NE monsoon period.

Sampling methods

At each station (station 27 excluded in the first cruise), two random samplings of bottom sediment were collected using a Smith-McIntyre grab (area coverage 0.05 m^2). The sediment was washed through a set of sieves, the smallest one with a mesh size of 0.5 mm. Benthic animals were collected and fixed in 10 % formaldehyde solution in sea water on board and were subsequently sorted and preserved in 70% ethyl alcohol in the laboratory. The sorted macrobenthic fauna was identified and counted separately for each taxa. The number of individuals of six taxonomic groups (Polychaeta, Crustacea, Mollusca, Echinodermata, Fishes and Other groups) were recorded.

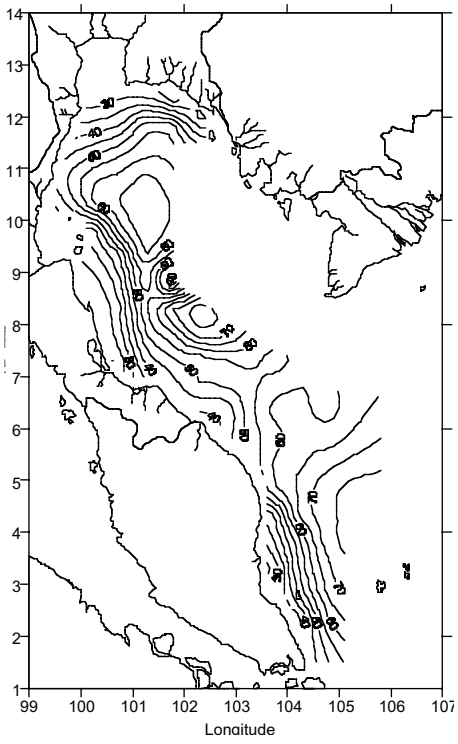

Fig. 1. Characteristics of coastal-line and water depth (m) of study area

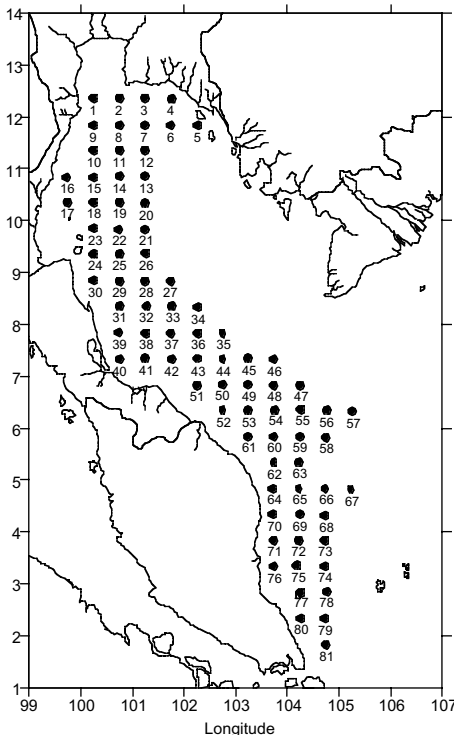

Figure 2. Survey area and sampling stations

Sediment Analysis

A sample of approximately 200 g sediment was collected from the surface of the grab sample to determine grain size composition (clay, clayey sand, sandy clay and sand) by the Wentworth scale (1922) and Shetard (1954) methods.

Analysis

i) Estimation of the difference in abundance of macrobenthic fauna (ind.m^{-2}) in the Gulf of Thailand and the east coast of Peninsular Malaysia between pre NE monsoon and post NE monsoon periods. The results of these calculation are summarised in the table (- decrease, 0 no difference, + increase).

ii) Estimation of species diversity of macrobenthic fauna in the Gulf of Thailand and the east coast of Peninsular Malaysia for 4 different types of sediment were calculated from Shannon and Weaver's (1949) formula.

Diversity Index or Shannon' Index (H′)

$$H' = -\sum (P_i \ln P_i)$$

Results

The abundance and distribution of macrobenthic fauna

The six groups of macrobenthic fauna found in the Gulf of Thailand and the east coast of Peninsular Malaysia are Polychaeta, Crustacea, Mollusca, Echinodermata, Fishes and Others, composed of 57.8 % polychaete, 25.4 % crustacea, 8.6 % echinoderm, 5.4 % other groups, 1.6 % fishes and 1.1 % of mollusca (Table 1). The overall average of the benthic fauna abundance in the Gulf of Thailand and the east coast of Peninsular Malaysia was 88 ind.m^{-2} in the pre NE monsoon period and 97 ind.m^{-2} in the post NE monsoon. Polychaete and Crustacea were the numerically dominant taxa in the benthic communites; all other taxa being relatively sparse. The total average abundance of macrobenthic fauna varied from 0 to 590 ind.m^{-2} in the pre NE moonsoon period and 0 to 700 ind.m^{-2} in the post NE monsoon. High density areas of total macrobenthic fauna occurred at station 76 in the pre NE monsoon and station 52 in the post NE monsoon (Fig. 3 and 4).

Table 1 Average abundance of the macrobenthic fauna in the pre and post NE monsoon periods.

Macrobenthic fauna	Abundance ind.m^{-2}(%)		Total
	pre	post	
Polychaete	48 (54.6%)	59 (60.8)	107 (57.8%)
Crustacea	24 (27.3%)	23 (23.7%)	47 (25.4%)
Mollusca	1 (1.1%)	1 (1.0%)	2 (1.1%)
Echinodermata	9 (10.2%)	7 (7.2%)	16 (8.6%)
Fishes	1 (1.1%)	2 (2.1%)	3 (1.6%)
Others	5 (5.7%)	5 (5.2%)	10 (5.4%)
Total	88 (100%)	97 (100%)	185 (100%)

Polychaete

The polychaetes dominated the macrobenthic communities and were well represented at almost every station except stations 14, 23, 27 and 30. Their average abundance was 48 ind.m^{-2} (54.6%) varying from 0 to 340 ind.m^{-2} in the pre NE monsoon cruise and 59 ind.m^{-2} (60.8%) varying from 0 to 390 ind.m^{-2} in the post NE monsoon period. High density areas of polychaetes occurred at station 76 in the pre NE monsoon and station 52 in post NE monsoon period (Table 1 and 2). A total of 35 families of polychaetes were identified and Syllidae were present in most stations (Table 3).

Crustacea

The crustaceans were the second most abundant group of macrobenthos. They live on the sediment surface, and dwell in a hole or in a tube, or burrow freely within the sediment. The fast moving and swimming species were seldom caught by grab. Generally, the crustaceans were of small size, i.e. amphipods, isopods and ostracod, while larger crabs and shrimps were rare, only small shrimp *Callianassa* spp. were found to be most abundant in the survey area. Crustaceans averaged 24 ind.m^{-2} (27.3%) varying from 0 to 130 ind.m^{-2} and 23 ind.m^{-2} (23.7%) varying from 0 to 210 ind.m^{-2} in pre and post NE monsoon periods respectively with the highest density occurring at station 52 both in the pre and post NE monsoon (Table 1 and 2).

Mollusca

The molluscs were mostly of small size and not economically important. They were very few in number. They were missing completely from most of the samples. Mollusca averaged only 1 ind.m^{-2} (1.1%) both in pre and post NE monsoon periods; ranging from 0 to 10 ind.m^{-2} and 0 to 20 ind.m^{-2} (Table 1 and 2).

Echinodermata

Brittle stars and heart urchin were found in large numbers at station 71 and 76 in pre NE monsoon period. The echinoderms averaged 9 ind.m^{-2} (10.2%) ranging from 0 to 150 ind.m^{-2} in the pre NE monsoon and 7 ind.m^{-2} (7.2%) ranging from 0 to 50 ind.m^{-2} in post NE monsoon cruise. Densities of 150 ind.m^{-2} of heart urchin were found at station 76 (Table 1 and 2).

Fishes

The menbers of this group are gobiid fish and eels which live in holes or burrow in the sediment. The average abundance was only 1 ind.m^{-2} (1.1%) in the pre NE monsoon and 2 ind.m^{-2} (2.1%) in the post NE monsoon periods, ranging from 0 to 10 ind.m^{-2} both in the pre and post NE monsoon periods (Table 1 and 2).

Others

This category includes the nemerteans, sipunculans, anthozoa and the cephalochordata amphioxus. On average these groups contributed 5 ind.m^{-2} (5.7% and 5.2%) both in the pre and post NE monsoon periods, ranging from 0 to 40 ind.m^{-2} and 0 to 120 ind.m^{-2} in pre and post NE monsoon respectively. Densities of 120 ind.m^{-2} were found at station 70 (Table 1 and 2).

Sediment Characteristics

The dominant characteristic of sediment in the Gulf of Thailand and the east coast of Peninsular Malaysia consists mainly of clay, clayey sand, sandy clay and sand. Sandy clay was the largest sediment fraction in the whole survey area . It accounted for 50% total for the survey area. The latter

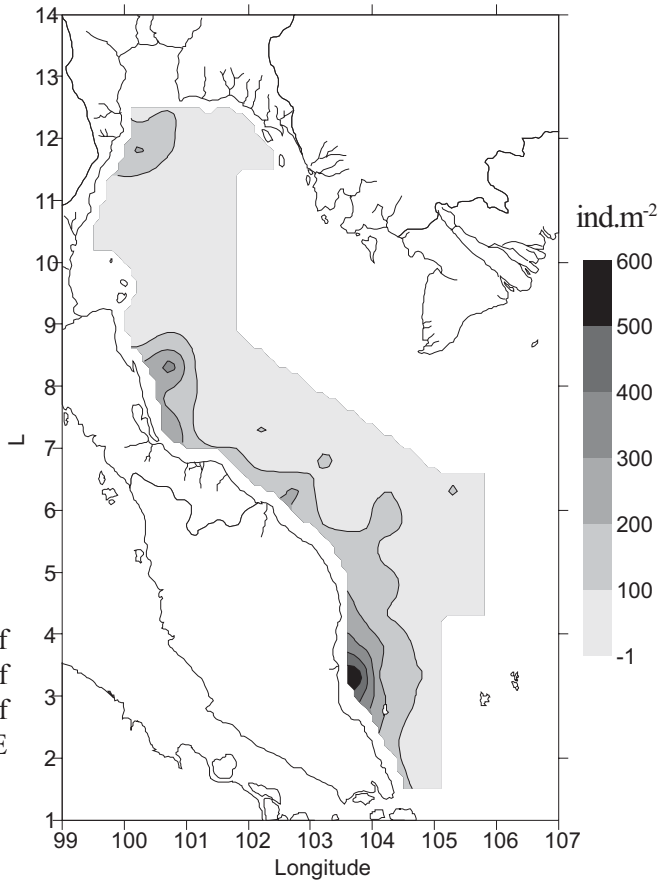

Figure 3 Abundance and distribution of macrobenthic fauna in the Gulf of Thailand and esat coast of Peninsular Malaysia in pre NE monsoon (4 Sept. - 4 Oct. 1995)

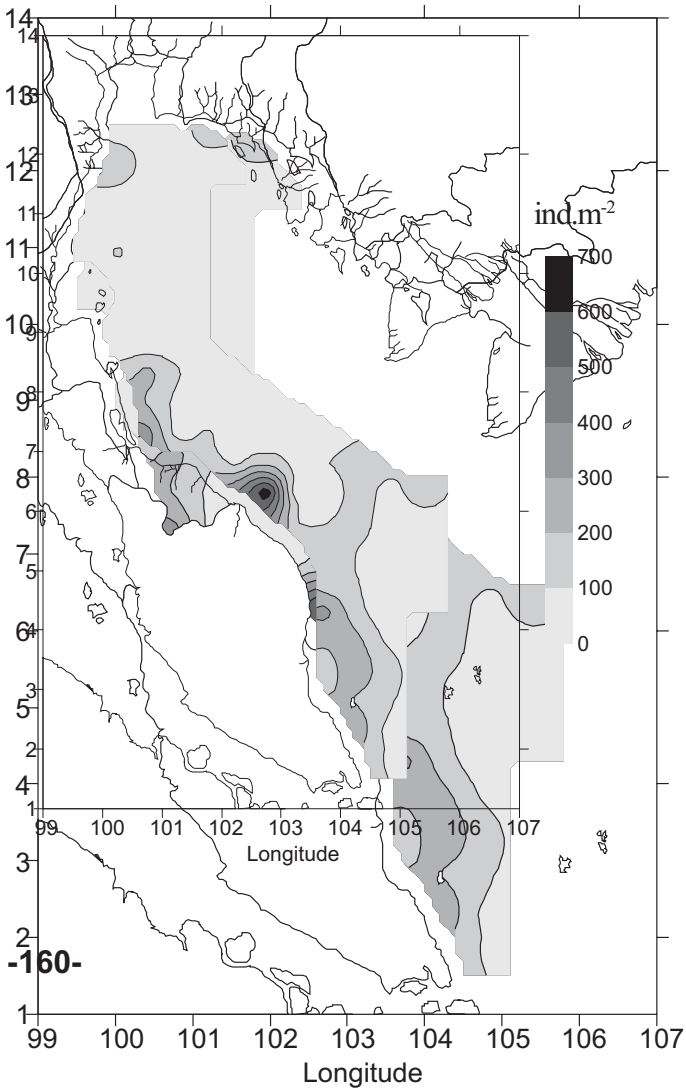

Figure 4 Abundance and distribution of macrobenthic fauna in the Gulf of Thailand and esat coast of Peninsular Malaysia in post NE monsoon (23 April - 23 May, 1996)

are clay and clayey sand which account for 28.75% and 15% respectively. About 6.25% or 5 of 81 stations of the survey area accounted for sand sediment which is the lowest sediment fraction in the survey area (Table 4 and Fig. 5).

Analysis

The difference in abundance of macrobenthic fauna between the pre and post NE monsoon periods in the Gulf of Thailand and the east coast of Peninsular Malaysia.

According to the results of the analysis of change in abundance of macrobenthic fauna in the Gulf of Thailand and the east coast of Peninsular Malaysia between the pre and post NE monsoon periods, it was found that Polychaete, Crustacea and Echinoderm groups show a marked difference in abundance between the pre NE monsoon (4 Sep.- 4 Oct 1995) and the post NE monsoon period (23 Apr. -23 May 1996). Meanwhile the abundance of Mollusc and fishes have remain steady for both the pre and post NE monsoon (Table 5).

Polychaete

In about half of the survey area it was found that the abundance of Polychaete during post NE monsoon increased during the pre NE monsoon whereas about 31% of the survey area shows a decline in abundance of this group during the post NE monsoon period when compared to the abundance during the pre NE monsoon. Only 18.75% of the area showed no difference in abundance between the pre and post NE monsoon periods (Table 5).

The increase in abundance of polychaete ranged from 10 to 120 ind.m^{-2}, except at station 52 (330 ind.m^{-2}). Mostly the increase in abundance was found to be 10 ind.m^{-2} . In addition, 50% of the increase in abundance was found to be 40 ind.m^{-2} (Fig. 6a). On the other hand, in about 31% of the survey area it was found that the abundance of this group decreased from the numbers in the pre NE monsoon period. The decrease in abundance ranged from 10 to 70 ind.m^{-2}, except at station 76 (240 ind.m^{-2}). About 50% of decreased abundance was found to be 30 ind.m^{-2} (Fig. 6b).

Crustacea

As can be seen from Table 5, about 32% of the survey area showed increased abundance, whereas, 41.25% of the surveyed area showed a decline of abundance of crustacea during the post NE monsoon period. Meanwhile, 26.25% of the survey areas showed that the abundance of crustacea during the post NE monsoon was no different compared to the abundance during the pre NE monsoon. The increase in abundance of this group ranged from 10 to 120 ind.m^{-2} and were mostly found to be 10 ind.m^{-2}. About 50% of the increase in abundance was 20 ind.m^{-2}. Whereas the decrease abundance ranged from 10 to 80 ind.m^{-2} and were mostly found to be 10 ind.m^{-2}. About 50% were 10 ind.m^{-2} (Fig.7a and b).

Echinoderm

About 46% of the survey area showed a change in abundance of echinoderm between the pre and post NE monsoon periods, whereas, about 50% of the abundance of echinoderm remained more or less at the same level between the pre and post NE monsoon periods. The increase in abundance of this group ranged from 10 to 30 ind.m^{-2} except at stations 71 and 76 (100, 150 ind.m^{-2}), whereas the decrease abundance ranged from 10 to 50 ind.m^{-2} and was mostly found to be 10 ind.m^{-2} (Fig.8 a and b).

Mollusca and Fishes

The abundance of these 2 groups was found to change slightly. About 85% of the survey area showed no difference in abundance between the pre and post NE monsoon periods with only a

Table 2 Average abundance of macrobenthic fauna (ind.m^{-2}) between the pre NE monsoon and post NE monsoon.

St.	Depth	Polychaeta		Crustacea		Mollusca		Echinodermata		Fishes		Others	
	(m)	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
1	27	40	50	40	20	0	0	0	0	0	0	0	0
2	30	50	30	60	0	0	0	0	20	0	0	0	10
3	31	50	40	0	0	0	0	0	0	0	0	0	0
4	23	0	110	30	50	0	0	0	0	0	0	0	0
5	34	60	40	10	0	0	0	0	0	0	0	0	10
6	51	30	10	10	0	0	0	0	0	0	10	10	10
7	54	10	20	0	0	0	0	0	0	0	0	0	0
8	40	60	30	50	30	0	0	0	0	0	0	0	0
9	36	90	130	130	50	0	0	0	0	0	0	0	0
10	48	40	50	30	10	10	0	0	0	0	10	0	0
11	54	10	20	0	10	0	0	0	0	0	0	0	0
12	58	0	20	0	0	0	0	0	0	0	0	0	0
13	62	20	0	10	0	0	0	0	0	0	0	0	0
14	61	0	0	20	10	0	0	10	10	0	0	0	0
15	56	30	20	10	20	0	0	10	10	0	10	0	0
16	50	0	40	0	0	0	0	0	0	0	0	10	0
17	46	40	10	10	0	0	0	0	0	0	0	0	0
18	61	0	90	20	20	0	0	0	10	0	0	0	0
19	63	20	0	30	10	10	0	0	10	0	0	0	0
20	71	30	30	0	0	0	0	0	10	0	0	10	0
21	69	10	0	0	0	0	0	0	0	0	0	0	10
22	59	40	30	0	0	0	0	0	0	0	0	0	0
23	34	0	0	0	0	0	0	0	10	0	0	0	0
24	29	0	10	10	0	0	0	10	0	0	0	0	0
25	40	60	20	10	0	0	0	0	10	0	0	0	10
26	66	40	10	0	10	0	0	10	0	0	0	0	0
27	78	-	0	-	20	-	0	-	0	-	10	-	0
28	58	10	10	20	10	0	0	0	0	0	0	0	10
29	32	100	30	10	0	0	0	0	0	0	0	0	0
30	24	0	0	0	0	0	0	30	0	0	0	0	0
31	29	220	160	120	70	0	0	0	10	10	0	0	0
32	55	20	80	10	20	0	10	0	0	0	0	0	0
33	73	20	20	10	0	0	0	0	0	0	0	0	0
34	78	10	10	10	0	0	10	0	0	0	0	10	0
35	72	10	10	0	0	0	0	0	10	0	0	0	0
36	72	10	20	0	0	10	0	0	0	0	0	10	0
37	58	0	10	0	0	0	0	0	0	0	0	10	0
38	49	30	40	40	20	0	0	0	0	10	0	0	0
39	28	100	170	40	20	10	0	0	0	0	0	10	0

Table 2 continue

St.	Depth	Polychaeta		Crustacea		Mollusca		Echinodermata		Fishes		Others	
	(m)	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
40	22	210	310	80	20	0	10	0	10	0	0	0	0
41	41	30	30	0	20	0	0	0	0	0	0	0	0
42	49	50	80	40	30	0	0	0	0	0	10	0	0
43	51	60	20	30	10	0	0	10	0	0	0	10	0
44	56	0	50	0	0	0	0	0	0	0	0	0	0
45	57	10	30	0	0	0	0	0	20	0	10	0	0
46	52	30	40	10	0	0	0	0	0	0	0	10	0
47	60	0	100	10	30	0	0	10	10	0	0	0	0
48	58	10	70	0	0	0	0	0	20	0	0	0	10
49	56	90	40	10	10	0	0	20	0	0	0	10	0
50	51	0	90	10	60	0	0	0	0	0	0	0	0
51	48	30	40	20	20	0	0	0	0	10	0	0	0
52	39	60	390	130	210	0	0	10	50	0	0	20	50
53	53	20	10	10	0	0	0	0	20	0	0	0	0
54	61	0	20	30	0	0	0	30	10	10	0	0	10
55	61	30	30	50	70	0	0	20	30	0	0	0	0
56	58	20	60	0	10	0	0	0	0	0	0	10	10
57	62	70	120	20	0	0	0	0	0	0	0	20	0
58	62	40	40	0	10	0	0	0	0	0	0	0	10
59	64	80	80	60	30	0	0	10	30	0	0	10	10
60	57	40	70	0	20	0	0	10	0	0	0	0	0
61	52	50	40	10	20	0	0	20	30	0	10	0	0
62	61	120	90	50	80	0	0	0	0	0	0	20	10
63	64	40	50	0	40	0	0	0	0	10	10	0	0
64	59	110	70	10	20	0	0	40	20	0	0	10	0
65	66	50	50	80	30	0	0	20	30	0	0	0	0
66	73	20	40	10	0	0	0	10	0	0	0	0	0
67	76	0	70	0	10	0	0	0	10	0	0	0	0
68	71	40	0	10	30	0	0	10	0	0	0	0	0
69	67	60	120	20	10	0	0	0	0	0	0	10	10
70	39	100	140	40	50	0	10	40	20	0	0	30	120
71	35	180	150	10	30	10	20	100	0	0	0	10	10
72	55	100	100	70	40	0	0	0	50	0	0	20	50
73	72	40	40	40	40	0	0	0	0	0	0	10	10
74	72	40	80	40	60	0	0	30	0	0	0	0	10
75	50	30	90	50	170	0	0	20	20	0	10	10	0
76	25	340	100	70	30	0	0	150	0	0	0	30	0
77	48	90	60	70	100	10	0	0	10	0	0	10	20
78	65	60	90	20	20	0	0	10	0	0	10	0	0
79	59	10	60	10	10	0	0	0	10	10	0	0	0
80	34	50	170	30	100	10	0	10	0	0	0	40	10
81	51	60	70	10	20	0	0	0	0	0	0	0	0

Table 3 List of macrobenthic fauna in the Gulf of Thailand and east coast of Peninsular Malysia

Macrobenthic fauna	Stations
Phylum Coelenterata	
Class Anthozoa	72
Phylum Nemertea	2,5,6,16,20,21,25,28,36,37,39,43,48,52,54,56,57,58,59,62,64,69,,72,74,76,77,80
Phylum Sipuncula	34,46,49,52,57,62,71,72,73,75,76,80
Phylum Mollusca	
Class Gastropoda	19,70
Class Bivalvia	10,32,34,36,39,40,70,71,77,80
Phylum Annelida	
Class Polychaeta	
Fam. Orbiniidae	1,2,40,47,57,67
Fam. Paraonidae	1,6,9,10,29,31,42,49,69,72,74,75,76,80
Fam Cossuridae	
Cossura sp.	10,16,66
Fam. Spionidae	
Prionospio spp.	2,6,7,9,18,29,31,32,38,39,40,48,51,52,62,67,69,70,71,76,77,79,80
Fam. Magelonidae	
Magelona sp.	56,62,80
Fam. Trochochaetidae	
Trochochaeta sp.	31
Fam. Poecilochaetidae	
Poecilochaetus sp.	9,25,31,39,52,61,70,75
Fam. Cirratulidae	5,6,9,17,31,32,33,35,39,40,41,42,43,47,49,51,52,61,62,64,67,69,74,77,78,80
Fam. Capitellidae	1,2,3,8,9,15,18,20,29,31,32,35,39,40,41,42,43,45,46,49,51,52,55,57,59,60,61,62,63,64,66, 67,68,69,71,73,74,75,76,78,80,81
Fam. Arenicolidae	
Arenicola sp.	80,81
Fam. Maldanidae	5,10,18,20,22,25,29,31,32,39,40,41,42,43,44,46,48,49,51,52,54,57,58,59,62, 63,64,68,69,70,72,74,76,77,78,79,81
Fam.Opheliidae	
Armandia sp.	4,8,52,70,71,76,81
Ophelina sp.	4,32,72
Fam. Scalibregmidae	32,36,40,44,45,51,80
Fam. Phyllodocidae	72
Fam. Aphroditidae	3,77
Fam. Polynoidae	1,4,38
Fam. Sigalionidae	5,20,21,32,42,46,49,57,65,70,71,75,76,81
Fam. Hesionidae	78
Fam. Pilargiidae	17
Fam. Syllidae	3,20,22,26,29,33,34,36,39,40,41,43,46,47,48,49,50,52,55,56,57,58,59,60,62,64,66,69, 72,73,74,76,77,78,79,80,81
Typosyllis sp.	70,71
Fam. Nereidae	3,4,31,39,40,52,53,56,59,62,63,71,72,74,76
Fam. Glyceridae	
Glycera sp.	2,3,18,25,29,31,40,42,48,52,55,56,57,69,70,71,72,73,77,80,81
Fam. Goniadidae	38,49,60,65,72,77
Fam. Nephtyidae	
Micronephtys sp.	57,59,60
Aglaophamus sp.	1,4,7,9,12,16,40,50,70,78,80

Table 3 Con't

Macrobenthic fauna	Stations
Fam. Amphinomidae	
Chloeia sp.	70,72
Fam. Onuphidae	1,4,18,24,39,45,52,64,65,66,69,70,71,76,79,80
Fam. Eunicidae	
Eunice sp.	31,39,44,49,50,52,53,58,64,68,71,78,81
Marphysa sp.	4,5,9,10,63,80
Lysidice sp.	47,55,58,69,77,81
Fam. Lumbrineridae	
Lumbrineris sp.	1,2,8,9,25,26,29,31,40,42,43,44,47,50,52,59,60,61,66,71,72,73,74,75,76,77,80,81
Fam. Sternaspidae	
Sternaspis sp.	17,39,47,50,67
Fam. Flabelligeridae	
Piromis sp.	31
Pherusa sp.	28,50,54,55,57
Fam. Sabellariidae	8
Fam. Terebellidae	5,10,11,34,39,40,46,52,59,75,78,80
Fam.Trichobranchidae	
Terebellides sp.	8,9,12,13,16,18,25,26,31,38,42,56,57,60,62,70,81
Fam. Sabellidae	70,78
Fam. Serpulidae	69,70
Unidentified Polychaeta	1,2,3,5,6,7,8,9,10,11,13,15,17,18,19,20,22,25,26,28,29,31,33,36,37,38,39,40,41,43,44,46, 48,49,50,51,52,53,55,56,57,58,59,61,62,63,64,65,66,67,69,70,71,72,73,75,76,77,78,79,81
Crustaceans	
Class Ostracoda	8
Class Malacostraca	
Order Stomatopoda	9,42,73,77
Order Decapoda	
Metapenaeus sp.	1,76
Trachypenaeus sp.	80
Alpheus sp.	1,2,4,6,10,13,19,27,32,38,42,43,46,49,50,61,62,63,64,67,70,75,77,80
Leptochela sp.	28,52,70,78,80
Callianassa spp.	1,2,8,9,10,14,15,18,19,31,38,39,40,41,42,43,47,51,52,53,54,55,58,59,60,61,62,63,65,66,68, 69,70,72,73,74,75,77,78,79,81
Upogebia spp.	2,4,8,9,10,14,15,18,25,26,28,31,32,38,40,47,50,51,52,54,55,61,62,68,70,71,73,74,75,77,80
Unidentified shrimp	5,14,38,40,43,65,72,73,75,76,77
Unidentified crab	1,2,4,8,9,11,17,24,28,29,31,33,34,39,40,49,50,52,59,60,62,64,70,71,72,74,76,77,78, 79,80,81
Order Amphipoda	2,4,9,15,18,31,38,42,52,55,56,57,59,62,64,65,69,70,71,74,75,76,77,80
Order Isopoda	32,50,52,65,72,74,80
Phylum Echinodermata	
Class Ophiuroidea	2,14,15,18,19,20,24,25,26,35,40,43,45,47,48,52,53,54,55,59,61,64,65,66,67,68,70,71,72, 74,75,77,78
Class Echinoidea	30,71,76
Class Holothuroidea	2,23,31,45,49,55,59,60,75,79,80
Phylum Chordata	
Amphioxus	52,69,70,71,76,80
Fishes	6,10,15,27,31,38,42,45,51,54,61,63,75,78,79

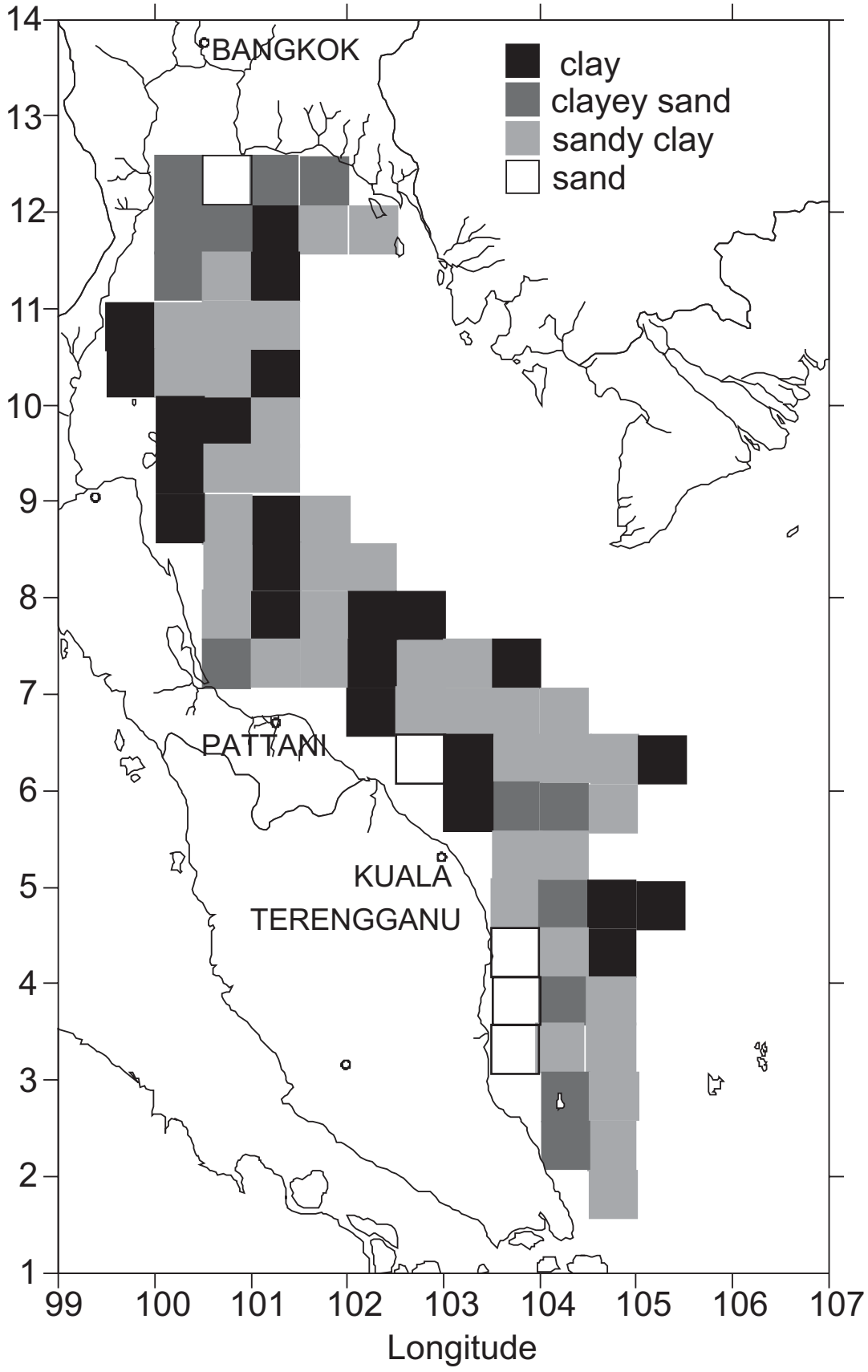

Fig. 5 The sediment types of the study area.

Table 4. The sediment types of each sampling station.

Sediment types	Station number
Clay	7, 12, 16, 17, 20, 22, 23, 24, 28, 30, 32, 35, 36, 38, 43, 46, 51, 53, 57, 61, 66, 67, 68
Clayey sand	1, 3, 4, 8, 9, 10, 40, 59, 60, 65, 72, 77, 80
Sandy clay	5, 6, 11, 13, 14, 15, 18, 19, 21, 25, 26, 27, 29, 31, 33, 34, 37, 39, 41, 42, 44, 45, 47, 48, 49, 50, 54, 55, 56, 58, 62, 63, 64, 69, 73, 74, 75, 78, 79, 81
Sand	2, 52, 70, 71, 76

Table 5 Changes in abundance of macrobenthic fauna between post NE monsoon (23 Apr. - 23 May 1996) and pre NE monsoon (4 Sep.- 4 Oct. 1995)

Diff. bet. post & pre NE monsoon	no. of st.					
	Polychaete	Crustacea	Mollusca	Echinoderm	Fishes	Others
+	40(50%)	26(32.5%)	5(6.25%)	16(20%)	5(6.25%)	13(16.2%)
0	15(18.75%)	21(26.25%)	69(86.25%)	43(53.8%)	67(83.8%)	52(65%)
-	25(31.25%)	33(41.25%)	6(7.5%)	21(26.2%)	8(10%)	15(18.8%)

slightly change for 15% of the survey area (Table 5).

Variation in abundance with depth

The total abundance gradually decreased with increasing water depth below 22 meters (Fig.9). At less than 30 meters, the average abundance was 183 ind.m^{-2} in the pre NE monsoon and 135 ind.m^{-2} in the post NE monsoon period; 31-60 m, 76 ind.m^{-2} in pre NE monsoon and 102 ind.m^{-2} in post NE monsoon; and 63 ind.m^{-2} (pre NE monsoon),70 ind.m^{-2} (post NE monsoon) at 61-90 depth.

Changes in diversity of macrobenthic fauna between the pre and post NE monsoon periods.

More than 64 species of macrobenthic fauna were identified. The shanon diversity index never exceeded 3.3 both in pre NE and post NE monsoon periods. The lowest value (2.87 for 28 species) was recorded in sand areas during the pre NE monsoon. During the pre NE monsoon, the diversity index increased from the sand areas to clayey sand. Meanwhile, during the post NE monsoon the diversity index showed a slight increase from clay areas to clayey sand (Fig. 10).

Discussion

The results show that the quantity and species diversity of macrobenthic fauna were more abundant near shore rather than in offshore areas, in both the pre and post NE monsoon periods. This finding corresponds with the Piamthipmanus, 1984's study using a similar methodology to this study. It should be noted that most benthic community studies in the Gulf of Thailand have been carried out near shore using a dredge apparatus while this study is offshore using a Smith McIntyre grab. More than 50% in numbers of macrobenthic organisms were polychaete, but the overall abundance of macrobenthic fauna never exceeded 920 ind.m^{-2}. The density and diversity of macrobenthic fauna on the east coast of Peninsular Malaysia were more abundant than in the Gulf of Thailand both in the pre and post NE monsoon periods (Figs. 3 and 4). This is probably due to the bottom sediment in the Gulf of Thailand being disturbed by heavy trawl fishery. .

Bakus (1990), also stated that the effect of depth, sediment grain size, salinity and predation

Frequency	Stem & Leaf	Frequency	Stem & Leaf
12.00	1 . 000000000000	2.00 Extremes	(-240), (-70)
4.00	2 . 0000	1.00	-6 * 0
3.00	3 . 000	.00	-5 .
5.00	4 . 00000	1.00	-5 * 0
3.00	5 . 000	.00	-4 .
4.00	6 . 0000	4.00	-4 * 0000
2.00	7 . 00	.00	-3 .
.00	8 .	6.00	-3 * 000000
2.00	9 . 00	.00	-2 .
2.00	10 . 00	5.00	-2 * 00000
1.00	11 . 0	.00	-1 .
1.00	12 . 0	6.00	-1 * 000000
1.00 Extremes	(330)		
Stem width :	10	Stem width :	10
Each leaf:	1 case (s)	Each leaf:	1 case (s)
a) increase (40 stations)		b) decrease (25 stations)	

Fig. 6. Stem and Leaf plot of changes in abundance of polychaete for 65 stations between the pre and post NE monsoon periods

density are factors in controling the population density of macrobenthos and the most important factors are sediment size and predator density. Another indirect factor for faunal distribution and abundance is the monsoon. Hylleberg et al. (1985), reported that the amplitude and direction of the monsoon wind and the shifting of the monsoon has a considerable impact in terms of sediment disturbance, this would have an effect directly on the density and diversity of macrobenthic fauna. Different species react differently to changes of environment. As can be seen from this study, the density of polychaete, crustacea and echinoderm are greatly influenced by the monsoon. It was notable that the density of echinoderm was high at stations 71 and 76 in the pre NE monsoon. It was found that Ophiuroidea (brittle stars) and Echinoidea (heart urchin) were most abundant at station 71 and Echinoidea (heart urchin) was also found in great abundance at station 76 in the pre NE monsoon, but cannot be found in the post NE monsoon period. In addition , at station 76 the population density of polychaete (Onuphidae) was in much higher abundance during the pre NE monsoon than in the post NE monsoon period. Meanwhile, the abundance of mollusc and fish have remained more or less steady. .

Moreover, the diversity index of macrobenthic fauna presented slightly different patterns between the pre and post NE monsoon periods. During the pre NE monsoon, the diversity index showed a marked increase from sand area (2.87) to clayey sand (3.2). Whereas during the post NE monsoon the diversity index in sand and clay were equal and then started to slightly increase from clay to clayey sand.

It can be concluded that the duration of the monsoon will partly affect the density and diversity of macrobenthos in the Gulf of Thailand and the east coast of Peninsular Malaysia.

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Frequency	Stem & Leaf	Frequency	Stem & Leaf
11.00	1 * 00000000000	5.00 Extremes	(-80) , (-60) , (-50)
.00	1 .	3.00	--3 * 000
8.00	2 * 00000000	.00	-2 .
.00	2 .	8.00	-2 * 00000000
2.00	3 * 00	.00	-1 .
.00	3 .	17.00	-1 * 00000000000000000
1.00	4 * 0		
.00	4 .	Stem width :	10
1.00	5 * 0	Each leaf:	1 case (s)
3.00 Extremes	(70) , (80) , (120)		
Stem width :	10		
Each leaf:	1 case (s)		

a) increase (26 stations) b) decrease (33 stations)

Fig. 7. Stem and Leaf plot of changes in abundance of crustacea for 59 stations between the pre and post NE monsoon periods

Frequency	Stem & Leaf	Frequency	Stem & Leaf
8.00	1 * 00000000	2.00 Extremes	(-50.0) , (-40.0)
.00	1 .	5.00	-20 . 00000
4.00	2 * 0000	.00	-19 .
.00	2 .	.00	-18 .
2.00	3 * 00	.00	-17 .
2.00 Extremes	(100) , (150)	.00	-16 .
		.00	-15 .
Stem width :	10	.00	-14 .
Each leaf:	1 case (s)	.00	-13 .
		.00	-12 .
		.00	-11 .
		14.00	-10 . 00000000000000
		Stem width :	1
		Each leaf:	1 case (s)

a) increase (16 stations) b) decrease (21 stations)

Fig. 8 Stem and Leaf plot of changes in abundance of echinoderm for 37 stations between the pre and post NE monsoon periods.

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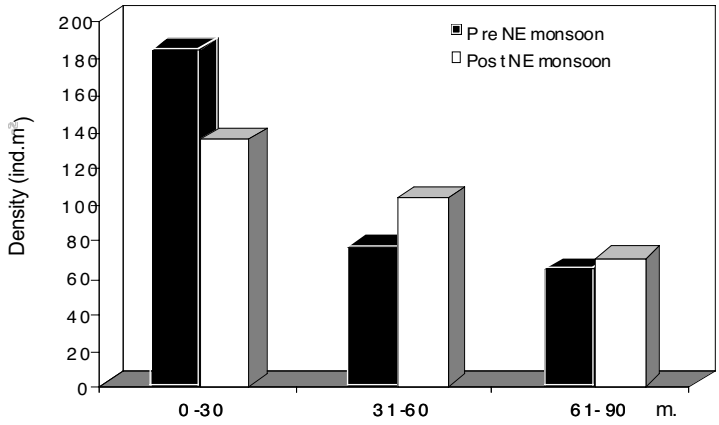

Fig. 9. The density (ind.m^{-2}) of macrobenthic fuana as a function of depth (m) in the Gulf of Thailand and East Coast of Peninsular Malaysia

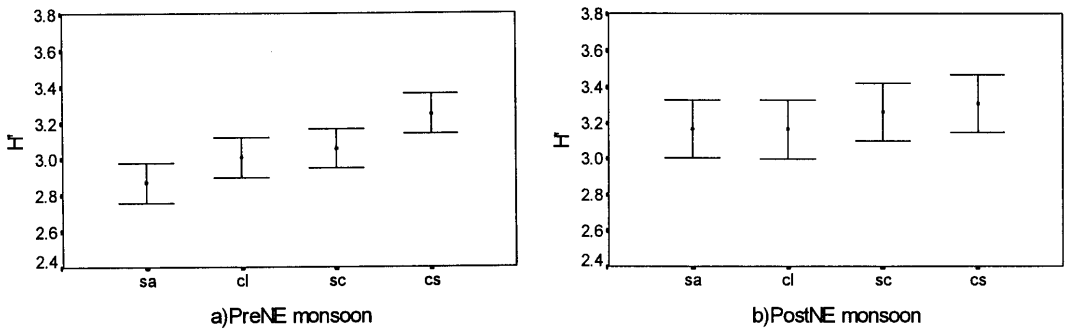

Fig. 10. Shannon diversity (mean and 95 % confidence limit) for the macrobenthic fauna in the Gulf of Thailand and the east coast of Peninsular Malaysia during the pre and post NE monsoon periods on 4 different types of sediment (cl:clay, cs:clayey sand, sc:sandy clay, sa:sand).

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