Temporal Changes in the Abundance of Macrobenthos in the South China Sea, Area II: Sarawak, Brunei and Sabah

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ABSTRACT

The macrobenthic fauna in the South China Sea (Sarawak, Brunei and Sabah) was surveyed during pre NE monsoon (4 Jul.- 8 Aug. 1996) and post NE monsoon (25 Apr.-31 May 1997). Over 90 species were collected by Smith-McIntyre grab of 47 stations.

The overall density of macrobenthic fauna in Sarawak, Brunei and Sabah area was 100 ind. m^{-2} on average in the pre NE monsoon and 167 ind.m^{-2} on average in the post NE monsoon. Most species were carnivore/scavengers followed by deposit-feeder and fewer suspension-feeder or herbivores both in the pre and post NE monsoon. There was a marked seasonal variation in faunal composition between the pre and post NE monsoon. During the pre NE monsoon polychaeta was the most abundance followed by crustacea while during the post NE monsoon crustacea was the most abundance followed by polychaete and the remaining groups of macrobenthic fauna which were poorly represented in the survey areas both in the pre and post NE monsoon periods. All the diversity indecies decline from the pre to post NE monsoon.

Key words: Macrobenthic fauna; Abundance; Sarawak, Brunei and Sabah

Introduction

There are many reports on pollution impact to benthic fauna and benthic succesion after local extinction of native fauna such as Pearson (1975), Tsutaumi and Kikuchi (1983). Therefore, The benthic fauna continue to be the subject of much research in the fields of hydrobiology and ecology because of the important of benthic organisms in the nutrition of fishes and as biological indicators of marine pollution.

Since the South China Sea has supported a commercial fishery such as purse seine and trawl fisheries for many decades but little work has been done on biological oceanography in this area. Therefore, the collaborative research project between SEAFDEC's Training Department (TD) in Thailand and Marine Fisheries Resources Development and Management Department (MFRDMD) in Malaysia have initiated a research programme survey on biological oceanography in the South China Sea which aim at providing a necessary information for management of the environment and fishery resources in the South China Sea. The first survey area had already been done in the western part of the Gulf of Thailand and the east coast of Peninsular Malaysia within the exclusive economic zones of Thailand and Malaysia during 1995-1996 and the second survey area is now carried out in Sarawak, Brunei and Sabah area between 1996-1997.

The study of macrobenthic fauna is part of the biological oceanographic data survey under the collaborative research project since benthic study may serve as base line information to evaluate the existing demersal stocks and may also serve as a baseline study of future investigations on environmental changes. Therefore, any fluctuation in either their quality and quantity will directly affect the abundance of demersal fish which are an important fishery resources in the sea.

In this study will examine in some detail of distribution and seasonal change of faunal composition, density and diversity of macrobenthic fauna in the South China Sea along Sarawak, Brunei and Sabah.

Materials and methods

1) Sampling area

The survey areas are in the South China Sea along Sarawak, Brunei and Sabah. A total of 79 survey stations were set up for the collaborative research project but the survey of macrobenthic fauna were sampled only 47 stations with water depth between 20m to 240m, due to the limitation of time and equipment to depth (Fig.1). The investigations were carried out on board MV SEAFDEC from 4 July -8 August 1996 (pre NE monsoon) and 25 April - 31 May 1997 (post NE monsoon).

2) Sampling methods

One sample of bottom sediment was collected using Smith-McIntyre grab (area coverage 0.1 m^2) at 47 stations. The sediment was wash through a set of sieves, the smallest one with a mesh sieve of 0.5 mm. The benthic animal remaining on the sieve was sorted out and fixed in 10% formaldehyde solution in sea water on board and were subsequently identified and count separately for each taxa in the laboratory. The number of individuals of 5 taxonomic groups (Polychaeta, Crustacea, Mollusca, Echinodermata and Other groups) were recorded. The individuals of each species group were counted and placed into different feeding type- herbivores, deposit-feeders, carnivores/scavengers and suspension-feeders by consulting Fauchald (1977) and Day (1967) for polychaetes and Ruppert and Barnes (1991) for the remaining phyla.

3. 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.

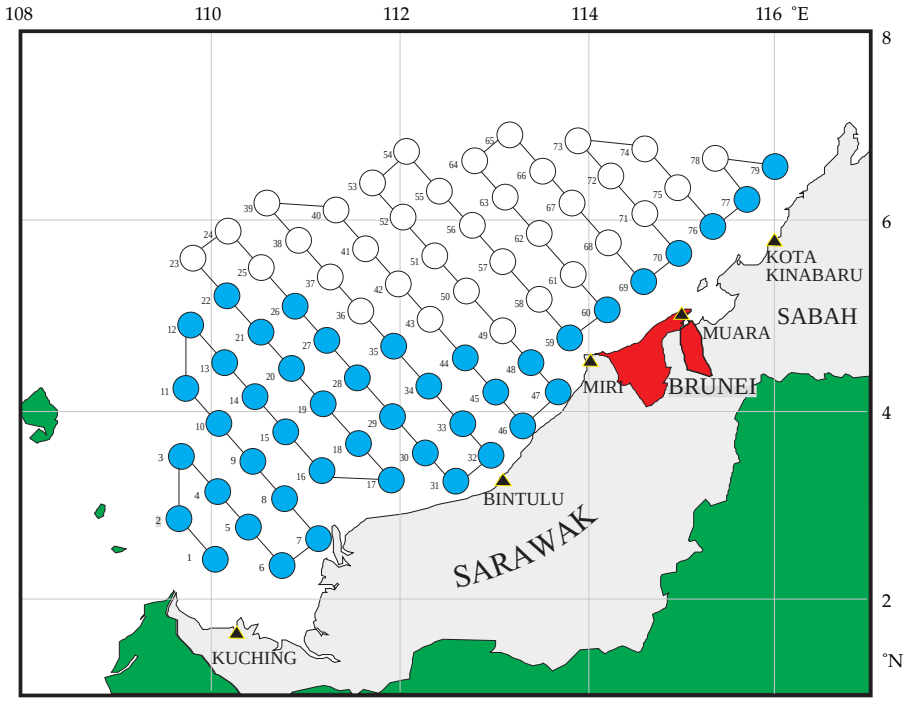


Fig. 1 Survey area and sampling stations

○ The Oceanographic stations

● Macrobenthic sampling survey stations

4. Analysis

i) Estimation of the difference in abundance of macrobenthic fauna (ind. m^{-2}) in the South China Sea (Sarawak, Brunei and Sabah) between the pre and post NE monsoon periods. The results of these calculations are summarised in the Table (- decrease, 0 no difference, + increase).

ii) Estimation of species diversity, richness index and evenness index of macrobenthic fauna in the South China Sea (Sarawak, Brunei and Sabah) between the pre and post NE monsoon periods. Diversity Index was calculated from Shannon and Weaver's (1949) formula as reported in Ludwig, J.A. and J. F. Reynolds (1988).

$$H' = -\sum_{i=1}^{s}(p_i \ln p_i)$$

Richness index was calculated from Margalef (1958) formula.

$$R = (s-1)/\ln(n)$$

Evenness index was calculated by modified Hill's ratio (1973b)

$$E = (N_2 - 1)/(N_1 - 1)$$

where N_1 (number of abundant species in the sample) = $e^{H'}$

N_2 (Number of very abundant species) = $1/\lambda$

$$\lambda = \sum_{I=1}^{s} n_i(n_i-1)/n(n-1)$$

Results

Sediment characteristics

Sediment characteristics in the South China Sea (Sarawak, Brunei and Sabah) were described as sand, sandy clay, clayey sand and clay. The bottom sediment of the survey area is mainly covered by sandy clay. It accounts for 38.30% of the survey area. The latter are clayey sand and clay which account for 27.66 % and 19.15 % respectively. Sand sediment is the lowest sediment fraction in the survey areas which account for 14.89 % (Table 1 and Fig. 2)

1. The abundance and distribution of macrobenthic fauna

The overall average abundance of macrobenthic fauna in Sarawak, Brunei and Sabah was 100 ind. m^{-2} in the pre NE monsoon and 167 ind. m^{-2} in the post NE monsoon. The five groups of macrobenthic fauna found in Sarawak, Brunei and Sabah are polychaete, crustacea, mollusca, echinodermata and others. Polychaete was the dominant taxa (53.0%) in the benthic communities in the pre NE monsoon while crustacea was the dominant taxa (58.7 %) in the post NE monsoon (Table 2). The average abundance of macrobenthic fauna varied from 10 to 320 ind.m^{-2} in the pre NE monsoon and 20 to 670 ind.m^{-2} in the post NE monsoon. High density areas of macrobenthic fauna occurred in Sarawak area at station 30 with water depth of 34 m in the pre NE monsoon and station 46 with water depth of 22 m in the post NE monsoon (Table 3).

The abundance of macrobenthic fauna in Sarawak, Brunei and Sabah increased from the pre NE monsoon to post NE monsoon (Fig.3). Over 90 species of macrobenthic fauna were recorded both in the pre and post NE monsoon.

The feeding type of macrobenthic fauna presented in the survey areas were mostly carnivores/ scavengers (62.59%) followed by deposit feeders (35.02%), Suspension feeder (2.31%) and herbivore (0.08%) (Table 4).

Polychaete

Polychaetes were the most abundant group of macrobenthic fauna in the pre NE monsoon. The

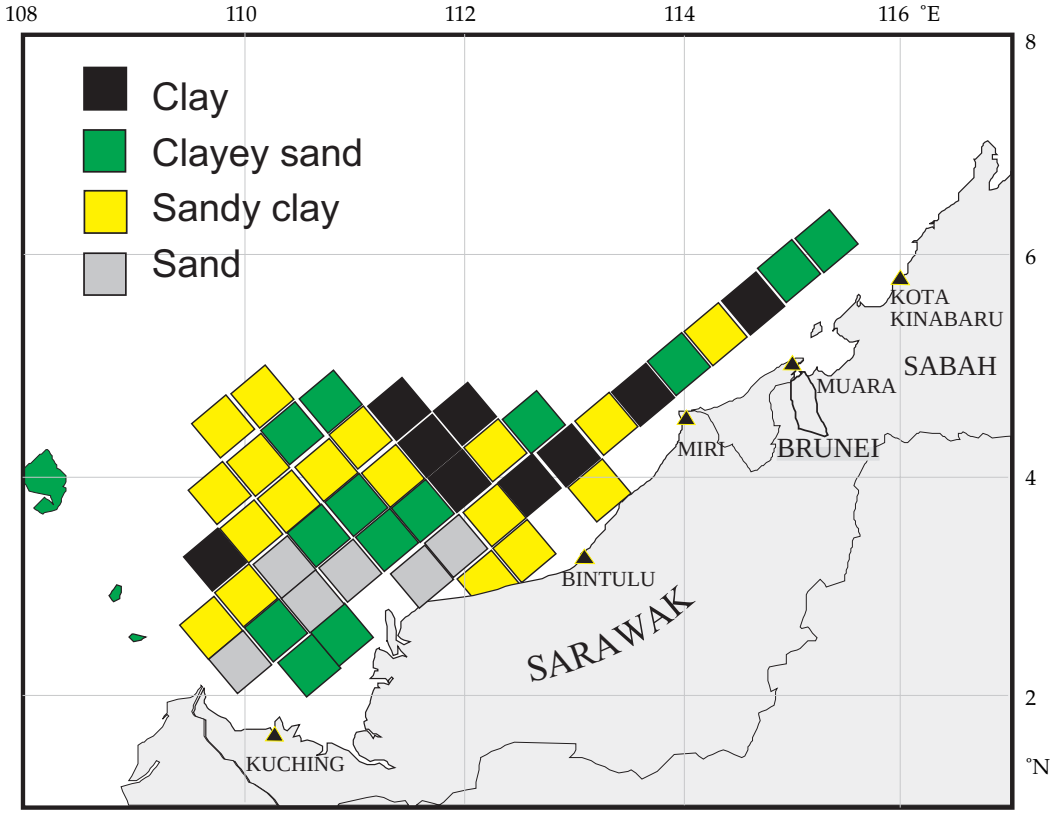


Fig. 2 The sediment types in the study area

overall average abundance of polychaete was 53 ind.m^{-2} (53.00%) in the pre NE monsoon and 60 ind.m^{-2} (35.90%) in the post NE monsoon (Table 2). During pre NE monsoon the abundance of polychaete varied from 10 to 230 ind.m^{-2} and most abundance at station 31 with water depth of 21 m where the sediment was sandy clay. While during the post NE monsoon, the abundance of polychaete varied from 10 to 180 ind.m^{-2} and the most abundance occurred at station 47 with water depth of 29 m where the sediment was sandy clay (Table 1 and 3). A total of 32 families of polychaete were identified and Capitellidae occurred at most stations (Table 4).

Crustacea

Crustaceans were the most abundant group of macrobenthic fauna in the post NE monsoon. The overall abundance of crustacea was 37 ind.m^{-2} (37.00%) on average which varied from 0 to 170 ind.m^{-2} in the pre NE monsoon and 98 ind.m^{-2} (58.70%) on average which varied from 0 to 500 ind.m^{-2} in the post NE monsoon. The highest density of crustacea occurred at station 9 and station 30 in pre NE monsoon and station 46 in post NE monsoon (Table 2 and 3). It should be noted that the bottom sediment of stations 9, 30 and 46 were all sand (Table 1). Amphipod was the most abundance and occurred every station in the survey area (Table 4).

Echinodermata

The overall abundance of echinoderm was 4 ind.m^{-2} (4.0%) varying from 0 to 40 ind.m^{-2} in pre NE monsoon and 4 ind.m^{-2} (2.4%) varying from 0 to 30 ind.m^{-2} in post NE monsoon (Table 2 and 3). Brittle stars was the most abundance of this group (Table 4).

Mollusca

This group was found very few in number. The abundance of mollusc was only 1 ind.m^{-2} on average both in the pre and post NE monsoon and ranged from 0 to 20 ind.m^{-2} and 0 to 10 ind.m^{-2} in

Table 1. The sediment types of sampling station.

Sediment types	Station number
sand	1,8,9,16,17,30,46
sandy clay	2,4,10,11,12,13,14,20,22,27,28,31,32,33,44,47,59,70
clayey sand	5,6,7,15,18,19,21,26,29,49,69,77,79
clay	3,34,35,36,43,45,48,60,76

Table 2. Average abundance of macrobenthic fauna in the first and second periods in the South China Sea (Sarawak, Brunei and Sabah).

Macrobenthic fauna	Abundance ind. m^{-2} (%)	
	First period	Second period
Polychaete	53 (53.00%)	60(35.90 %)
Crustacea	37 (37.00%)	98 (58.70%)
Mollusca	1 (1.00%)	1 (0.60%)
Echinodermata	4 (4.00%)	4 (2.40%)
Others	5 (5.00%)	4(2.40%)
Total macrobenthic fauna	100 (100%)	167 (100%)

the pre and post NE monsoon respectively (Table 2 and 3). It should be noted that mollusc were occurred in low density of the survey area.

Others

This category includes nemerteans, sipunculans, anthozoa, porifera, amphioxus and fish which were poorly represented in comparison with other major taxonomic groups. On average this group contributed 5 ind.m^{-2} (5.0%) in the pre NE monsoon. and 4 ind.m^{-2} (2.4%) in the post NE monsoon, ranging from 0 to 40 ind.m^{-2} in the pre NE monsoon and 0 to 20 ind.m^{-2} in the post NE monsoon (Table 3).

2. Variation in abundance with depth

It appears that the highest density of macrobenthic fauna were occurred at water depth of 0-60 m both in the pre and post NE monsoon with the highest density of polychaete in the pre NE monsoon and crustacea in the post NE monsoon. It is remarkable that polychaeta occurred at every range of water depth between 0-240 m both in the pre and post NE monsoon. The abundance of crustacea occurred at water depth between 0-240 m in the pre NE monsoon and occurred at water depth between 0-180 m in the post NE monsoon. Mollusc, echinodermata and others group were not found at water depth from 181 to 240m (Fig. 4 a and b).

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

The results of the analysis of changes in abundance of macrobenthic fauna in South China Sea (Sarawak, Brunei and Sabah) between the post and pre NE monsoon periods are presented in Table 5. About 85% and 90% of the survey areas show a marked difference in abundance of polychaete and crustacea groups respectively and about 50% of survey area show the difference in abundance of echinoderm while the abundance of mollusc has remained steadily for both pre and post NE mon-

Table 3. Average abundance of macrobenthic fauna (ind.m^{-2}) in the first and second survey periods.

St.	Depth	Polychaeta		Crustacea		Mollusca		Echinodermata		Others		Total	
	(m)	first	second	first	second	first	second	first	second	first	second	first	second
1	38	10	30	20	170	0	0	0	0	0	20	30	220
2	55	30	50	10	410	0	0	10	0	0	0	50	460
3	81	20	90	110	50	0	0	0	10	0	10	130	160
4	66	70	60	80	20	0	0	0	10	10	0	160	90
5	79	50	20	20	0	0	0	10	0	10	0	90	20
6	43	40	10	90	240	0	0	10	0	0	0	140	250
7	33	80	10	40	260	0	0	0	30	10	0	130	300
8	40	30	10	20	20	10	0	10	0	10	0	80	30
9	68	10	20	170	50	0	0	10	0	10	0	200	70
10	87	40	20	0	70	0	0	0	0	0	0	40	90
11	101	30	60	60	60	0	0	0	0	0	20	90	140
12	118	60	50	20	30	0	0	0	0	0	0	80	80
13	115	30	50	60	50	0	0	0	20	10	0	100	120
14	93	60	40	60	30	0	0	10	0	10	0	140	70
15	66	20	50	80	110	0	0	0	0	0	10	100	170
16	66	150	90	40	30	0	10	0	20	10	10	200	160
17	33	40	40	40	230	0	0	0	10	10	10	90	290
18	49	0	60	20	130	0	0	10	10	10	0	40	200
19	71	50	60	40	140	0	0	0	0	10	0	100	200
20	90	60	30	50	90	0	0	0	0	0	20	110	140
21	119	40	20	0	290	0	0	0	0	0	0	40	310
22	146	20	60	0	90	0	0	0	0	0	0	20	150
26	123	60	40	50	0	10	0	0	0	10	10	130	50
27	95	30	70	30	60	0	0	20	10	10	20	90	160
28	80	70	80	0	60	0	0	0	0	10	0	80	140
29	56	70	70	10	180	0	0	10	0	10	0	100	250
30	34	140	130	170	280	0	0	0	10	10	10	320	430
31	21	230	150	30	130	0	0	0	10	10	0	270	290
32	34	40	90	80	130	0	0	10	0	10	20	140	240
33	51	80	110	70	130	20	0	10	0	0	10	180	250
34	73	30	30	10	60	0	0	0	10	0	0	40	100
35	88	10	70	0	30	0	0	0	0	0	0	10	100
36	110	50	50	10	0	0	0	0	0	0	0	60	50
43	105	10	30	0	0	0	0	0	0	0	0	10	30
44	89	30	30	10	20	0	0	0	0	0	0	40	50
45	67	60	20	10	10	0	0	0	0	0	0	70	30
46	22	140	140	90	500	0	0	0	10	40	20	270	670
47	29	70	180	20	190	0	0	40	20	0	0	130	390
48	78	60	40	10	10	0	0	0	0	10	0	80	50
49	106	40	30	30	0	0	0	0	10	0	0	70	40
59	96	50	120	0	40	0	0	0	0	10	0	60	160
60	233	60	60	20	0	0	0	0	0	0	0	80	60
69	100	10	40	0	20	0	0	0	0	0	0	10	60
70	140	50	110	0	20	0	0	0	0	0	10	50	140
76	109	40	100	0	50	0	0	0	0	0	10	40	160
77	96	30	80	50	70	0	0	10	10	0	0	90	160
79	57	110	50	20	30	0	0	0	10	0	0	130	90

Table 4. List of macrobenthic fauna in the South China Sea (Sarawak, Brunei and Sabah)

Macrobenthic fauna	F	Stations
Phylum Porifera	S	15,16,17,18,20,27,29
Phylum Coelenterata		
Class Anthozoa	S	11,26,46,
Phylum Nemertea	C	1,4,5,7,11,14,17,19,20,26,27,28,32,46
Phylum Sipuncula	D	1,3,29,31,32
Phylum Mollusca		
Class Gastropoda		
Fam. Nassariidae		
Zeuxis sp.	C	16
Fam. Strombidae		
Terebellum sp.	H	33
Class Pelecypoda		
Fam. Veneridae	S	8
Pitar sp.	S	26
Fam. Solecurtidae		
Azorinus sp.	S	33
Phylum Annelida		
Class Polychaeta		
Fam. Orbiniidae		
Orbinia sp.	D	18,49
Fam. Paraonidae	D	4,7,32,47,60,70
Fam. Cossuridae		
Cossura sp.	D	45,60
Fam. Spionidae	D	30,31,44,46,60,70,76,79
Prionospio sp.	D	4,10,13,14,16,21,26,28,31,32,33,35,44,46,47,59,77,79
Fam. Magelonidae		
Magelona sp.	D	59,60
Fam. Trochochaetidae		
Trochochaeta sp.	D	79
Fam. Poecilochaetidae		
Poecilochaetus sp.	D	11,19,22,30,31,43,47,70
Fam. Cirratulidae	D	1,2,4,6,13,27,28,30,31,36,45,60
Fam. Capitellidae	D	3,4,7,10,13,14,15,16,18,20,22,26,27,28,30,31,32,33,34,36,43,45, 60,69,70,76,79
Fam. Maldanidae	D	3,10,13,14,15,16,17,19,21,22,27,28,29,30,31,33,34,35,36,45,47,59, 76,79
Maldane sp.	D	26
Fam. Opheliidae		
Armandia sp.	D	32
Ophelina sp.	D	15,33,70,76,79
Polyophthalmus sp.	D	1,
Tachytrypane sp.	D	46
Fam. Scalibregmidae	D	13,48,49,70
Fam. Phyllodocidae	C	9,19,33
Fam. Aphroditidae	C	30
Fam. Polyodontidae	C	46
Fam. Sigalionidae	C	2,6,8,16,21,22,30,33,43,46,47,59,76,79
Fam. Hesionidae	C	12,49
Fam. Pilargiidae	C	43,46,49,59
Fam. Syllidae	C	3,4,5,7,10,11,13,14,20,22,29,30,33,35,45,46,48,69,70,76,79
Fam. Nereidae	C	12,31,46,47,59,76
Fam. Glyceridae		
Glycera sp.	C	4,8,11,12,14,15,27,28,31,32,36,46,70
Fam. Goniadidae		
Goniada sp.	C	5,15
Fam. Nephtyidae	C	11,12,16,79
Aglaophamus sp.	C	2,4,8,17,28,31,33,34,35,36,45,46,48,60,76
Inermonephtys sp.	C	30
Micronephthys sp.	C	29,31,32,47
Fam. Amphinomidae		
Chloeia sp.	C	17,19,49
C. flava	C	30,46

Table 4. Continue

Macrobenthic fauna	F	Stations
Fam. Onuphidae	C	1,2,4,7,11,19,20,26,27,30,31,32,36,44,45,46,48,59,77
Diopatra sp.	C	8,14,33,46,77
Fam. Eunicidae		
Eunice sp.	C	4,5,19,20,29,31,69,76
Lysidice sp.	C	2,5,29
Marphysa sp.	C	22,26,31,32,70
Nematonereis sp.	C	76
Fam. Lumbrineridae	C	2,3,4,12,14,16,17,21,26,28,29,30,31,32,33,45,46,47,59,60,70,77,79
Fam. Sternaspidae		
Sternaspis sp.	D	9,16,28,29,31,33,47,49
Fam. Flabelligeridae	D	5,70,77
Pherusa sp.	D	16,29,31,47
Fam. Terebellidae	D	3,19,30,44,46
Pista sp.	D	2,12,28
Fam. Trichobranchidae		
Terebellides sp.	D	3,7,20,21,28,31,47,70,76
Fam. Sabellidae	S	6,13,18,26,32
Chone sp.	S	12
Unidentified Polychaeta		1,2,3,4,6,7,9,10,11,12,14,16,17,18,19,20,22,26,27,28,29,31,32,33, 34,35,36,44,46,47,48,49,59,60,77,79
Crustacea		
Class Malacostraca		
Order Stomatopoda		
Fam. Squillidae	C	16
Clorida sp.	C	6
Levisquilla sp.	C	13,27,32,79
Oratosquilla sp.	C	33
Order Decapoda		
Metapenaeus sp.	C	18
Alpheus sp.	C	3,6,9,11,17,19,20,21,28
Leptochela sp.	C	17,18,19,27,77
Ogyrides sp.	C	29
Callianassa spp.	D	1,3,4,6,7,9,10,11,12,13,14,15,17,19,20,21,22,26,27,29,30,31,32,33, 46,47,59,77,79
Upogebia spp.	D	1,17,29,31,32,33,49
Unidentified shrimp	C	15,17,18,29,30,31,32,46,47
Fam. Raninidae		
Raninoides sp.	C	34
Fam. Parthenodidae	C	4
Fam. Portunidae		
Portunus sp.	C	9,30
Fam. Leucosidae		
Arcania sp.	C	1,21,30
Fam. Goneplacidae	C	20,29
Eucrate sp.	C	1,7,15,18,33
Fam. Pinnotheridae	C	9,29,47
Fam. Xanthidae	C	4
Liagore rubromaculata	C	16
Fam. Ocypodidae		
Macrophthalmus sp.	C	69,77
Unidentified crab	C	2,6,7,16,18,33,34,44,45,47,59,79
Order Amphipoda	C	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,26,27,28, 29,30,31,32,33,34,35,44,46,47,48,49,59,60,69,70,76,77,79
Order Isopoda	C	2,7,8,10,13,17,21,27,29,30,32,46,48
Unidentified crustacea	C	3,6,8,13,20,36,46,76
Phylum Echinodermata		
Class Ophiuroidea	D	2,3,4,5,6,7,9,13,14,16,17,18,27,29,30,31,32,34,46,47,49,77,79
Class Echinoidea		
Fam. Brissidae		
Brisopsis luzonica	D	18
Fam. Loveniidae		
Lovenia sp.	D	27
Fam. Spatangidae		
Maretia sp.	D	8

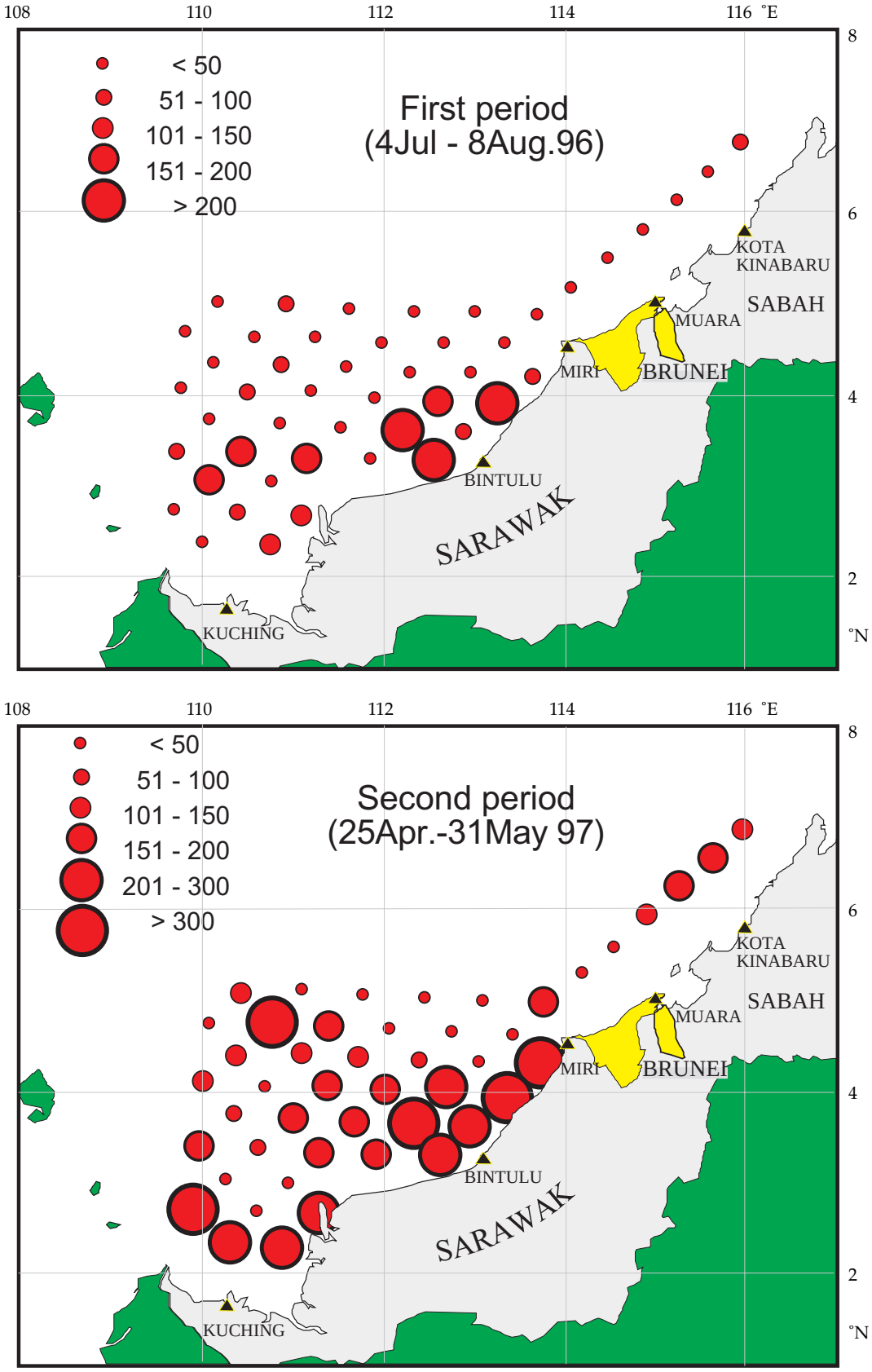


Fig. 3 The abundance of macrobenthic fauna (ind. m^{-2}) in the South China Sea (Sarawak, Sabah and Brunei Darussalam).

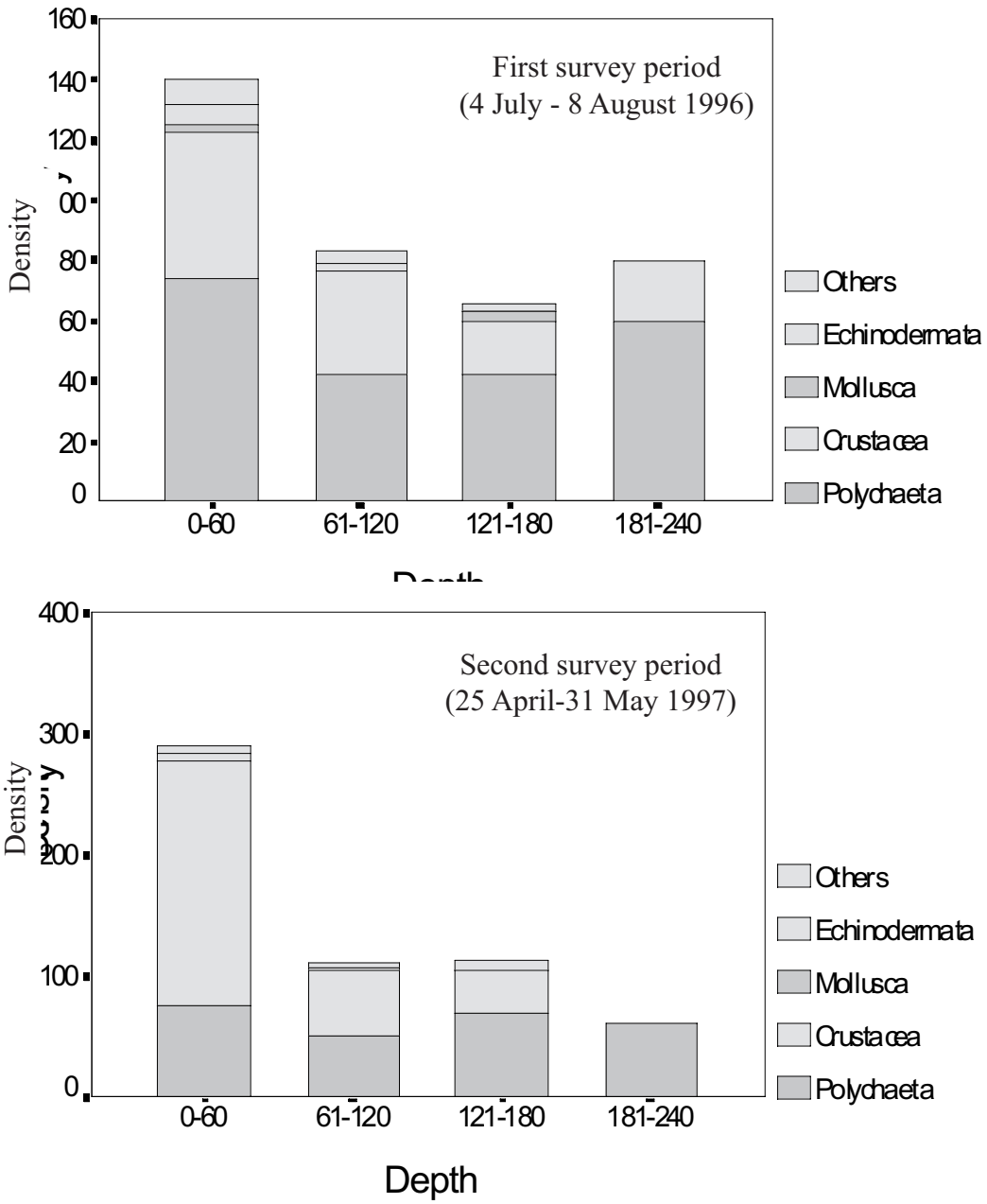


Fig. 4 The total density of macrobenthic fauna (ind.m^{-2}) as a function of depth (m) in the first survey period and second survey period

soon. By and large, nearly 98% of the survey area show a marked difference in abundance of macrobenthic fauna between the post and pre NE monsoon periods.

Polychaete

It was found that nearly 47% of the survey area show the increase in abundance of polychaete from pre NE monsoon to post NE monsoon periods. The increase in abundance of this group ranging from 10 to 110 ind.m^{-2} with 50% of the increase in abundance was found 35 ind.m^{-2}, whereas about 38% of the survey area show the decrease in abundance of this group from the pre to post NE monsoon period. The decrease of the abundance ranging from 10 to 80 ind.m^{-2} with about 50% of

decreased abundance was found 20 ind.m^{-2} (Fig. 5a and b).

Frequency	stem & Leaf
3.00	0 . 111
8.00	0 t 22223333
4.00	0 f 4455
6.00	0 s 666677
.00	0 .
1.00	1 . 1
Stem width:	100
Each leaf:	1 case (s)

a) increase (22 stations)

Frequency	stem & Leaf
2.00 Extremes	(-80), (-70)
2.00	-6 . 00
.00	-5 .
1.00	-4 . 0
3.00	-3 . 000
6.00	-2 . 000000
4.00	-1 . 0000
Stem width:	10
Each leaf:	1 case (s)

b) decrease (18 stations)

Fig. 5 Stem and Leaf plot of changes in abundance of polychaete for 40 stations between the first and second survey periods

Crustacea

This group has shown a marked difference in abundance between the pre and post NE monsoon periods. Nearly 66 % of the survey area show the increase in abundance from pre to post NE monsoon. The increase in abundance of crustacea ranged from 10 to 290 ind.m^{-2}, except station 2 (400 ind.m^{-2}) and station 46 (410 ind.m^{-2}). In addition, 50% of the increase in abundance was found 60 ind.m^{-2}. On the other hand, about 23 % of the survey area show the decrease in abundance of this group from the pre to post NE monsoon. The decrease in abundance ranged from 10 to 60 ind.m^{-2} except at station 9 (120 ind.m^{-2}) with 50% of the decrease in abundance was found 30 ind.m^{-2} (Fig. 6a and b).

Frequency	stem & Leaf
11.00	0 . 11122233344
7.00	0 . 5556679
4.00	1 . 0011
5.00	1 . 55779
1.00	2 . 2
1.00	2 . 9
2.00 Extremes	(400), (410)
Stem width:	100
Each leaf:	1 case (s)

a) increase (31 stations)

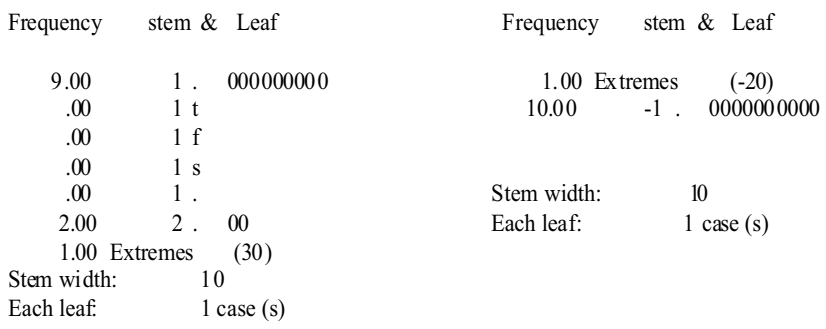
Frequency	stem & Leaf
1.00 Extremes	(-120)
2.00	-6 . 00
1.00	-5 . 0
.00	-4 .
2.00	-3 . 00
2.00	-2 . 00
3.00	-1 . 000
Stem width:	10
Each leaf:	1 case (s)

b) decrease (11 stations)

Fig. 6 Stem and Leaf plot of changes in abundance of crustacea for 42 stations between the first and second survey periods

Echinoderm

About half of the survey area show no different in abundance of echinoderm while 25 % of the survey area show the increase of abundance and 23.4 % of the survey area show a decline of abundance of this group during the pre and post NE monsoon periods. The increase in abundance of this group ranged from 10 to 30 ind.m^{-2} and were mostly found 10 ind.m^{-2}. Whereas the decrease of abundance ranged from 10 to 20 ind.m^{-2} and were mostly found at 10 ind.m^{-2} (Fig. 7a and b)



a) increase (12 stations) **b) decrease (11 stations)**

Fig. 7 Stem and Leaf plot of changes in abundance of echinoderm for 23 stations between the pre and post NE monsoon periods.

Mollusca

The abundance of this group nearly remained steady between the pre and post NE monsoon periods. About 92 % of the survey area show no different in abundance of mollusk between the pre and post NE monsoon periods (Table 5).

Table 5. Changes in abundance of macrobenthic fauna between the first survey period (4Jul.- 8A 1996) and the second survey period (25Apr 31 May 1997) .

Diff.bet. first &second	no. of station					
survey periods	Polychaete	Crustacea	Echinoderm	Mollusca	Others	Macrobenthos
+	22(46.81%)	31(65.96%)	12(25.53%)	1(2.03%)	10(21.28%)	33(70.20%)
0	7(14.89%)	5(10.63%)	24(51.06%)	43(91.49%)	22(46.80%)	1(2.10%)
-	18(38.30%)	11(23.40%)	11(23.40%)	3(6.38%)	15(31.91%)	13(27.70%)

Total macrobenthic fauna

When consider of total macrobenthic fauna, it was found that 70.20 % of the survey area show the increase in abundance of macrobenthic fauna between the pre and post NE monsoon periods. While nearly 28 % of the survey area show the decrease in abundance from pre to post NE monsoon. The increase in abundance of this group ranged from 10 to 270 ind.m^{-2}, except station 2 (410 ind.m^{-2}) and station 46 (400 ind.m^{-2}). About 50 % of the increase in abundance of total macrobenthic fauna was 90 ind.m^{-2}. The decrease in abundance of this group ranged from 10 to 80 ind.m^{-2} except station 9 (130 ind.m^{-2}) and about 50 % of the decrease in abundance was 40 ind.m^{-2} (Fig. 8a and b).

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

Over 90 taxa of macrobenthic fauna were identified both in the pre and post NE monsoon periods in the South China Sea (Sarawak, Brunei and Sabah). According to Table 6, all of the diversity indices declined from the pre to post NE monsoon. The Shannon diversity index never

exceed 3.56 both in the pre and post NE monsoon periods.

The richness index of macrobenthic fauna decreased from the pre to post NE monsoon periods. The large increase in the total number of individuals found in the post NE monsoon (7870 ind.m^{-2}) while the total number of individuals in the pre NE monsoon found 4710 ind.m^{-2}.

Evenness decrease from the pre to post NE monsoon sample. During the post NE monsoon a few species (7species) represented by a lot of indiviuduals in contrast with those in the pre NE monsoon a large number of species (21 species) represented by a lot of individuals (Table 6). Parker, 1975 mentioned that low diversity and high population levels of a few species denote some major stress condition which eleminates many species, but promotes survival of a few. Therefore, the shifting of monsoon may increase level of environment stress and will result on decrease diversity, decrease species richness, decrease evenness.

Frequency	stem & Leaf
6.00	0 . 122233
11.00	0 . 55566777799
7.00	1 . 0001123
4 .00	1 . 5679
1.00	2 . 0
2.00	2 . 67
2.00	Extremes (400), (410)

Stem width: 100
Each leaf: 1 case (s)

a) increase (33 stations)

Frequency	stem & Leaf
1.00	Extremes (-130)
1.00	-8 . 0
3.00	-7 . 000
.00	-6 .
1.00	-5 . 0
3.00	-4 . 000
2.00	-3 . 00
1.00	-2 . 0
1.00	-1 . 0

Stem width: 10
Each leaf: 1 case (s)

b) decrease (13 stations)

Fig. 8 Stem and Leaf plot of changes in abundance of total macrobenthic fauna for 46 stations between the first and second survey periods

Table 6. Species diversity of macrobenthic fauna observed in two sampling periods in the South China Sea (Sarawak, Brunei and Sabah).

Indices	First survey period (4Jul.-8Aug. 1996)	Second survey period (25Apr.-31May 1997)
Diversity (H')	3.56	2.95
Richness (R)	12.51	10.5
Evenness (E)	0.6	0.35
N_1	35.08	19.08
N_2	21.45	7.25
Total no. of individuals	4710	7870

Table 7. Average abundance of macrobenthic fauna in the South China Sea (Area I and Area II)

Survey area	Macrobenthic fauna (ind.m^{-2})	
	1st survey period	2nd survey period
Area I: Gulf of Thailand and east coast of Peninsular Malaysia	88	97
Area II: Sarawak, Brunei and Sabah	100	167

Conclusion and discussion

It is appeared from the results that the overall abundance of macrobenthic fauna in Sarawak, Brunei and Sabah were different between the pre and post NE monsoon periods. During the post NE monsoon the density of macrobenthic fauna were more abundance than those in the pre NE monsoon and the density of macrobenthic fauna tended to increase with decreasing of water depth as can be seen from Fig. 4.

Similarly, the result of faunal composition show the different between the pre and post NE monsoon. During the pre NE monsoon polychaeta was the most abundance followed by crustacea and echinodermata etc.. Whereas during the post NE monsoon crustacea was the most abundance with the tremendous increase of amphipod, followed by polychaeta and echinodermata etc.. However when compare to the first survey in the Gulf of Thailand and east coast of Pennisular Malaysia (area I) by Piamthipmanus (1998), the faunal composition were similar both in the pre and post NE monsoon periods in that polychaete was the dominant group both in the pre and post NE monsoon periods.

In addition, the abundance of macrobenthic fauna in Sarawak area were more abundance than those in Brunei and Sabah area both in the pre and post NE monsoon periods. However, the stations in Brunei and Sabah were taken in an area in considerably deeper water than those in Sarawak. Bakus (1990) reported that the effect of depth is a factor in controlling population density of macrobenthic fauna.

It should be noted that the overall abundance of macrobenthic fauna both in the pre and post NE monsoon periods from the present investigation of Sarawak, Brunei and Sabah (area II) was much higher than those in the first survey of the Gulf of Thailand and east coast of Peninsular Malaysia (area I) by Piamthipmanus (1998) (Table 7). This probably due to the massive entry of trawlers in the Gulf of Thailand have damaged the sea bottom. Caddy (1973) also reported that scallop dredges, beam trawls and otter trawls with tickler chains have been shown to disturb the macrobenthic fauna and damage the sea bottom. It is also remarkable that the highest density of macrobenthic fauna both in the area I and area II occurred in sand area.

The diversity indices also show the decline from pre to post NE monsoon. Hylleberg *et al*. (1985) reported that the amplitude and direction of the monsoon wind and the shifting of monsoon has a considerable impact in term of sediment disturbance, this would have an effect directly on the density and diversity of macrobenthic fauna. Different species react different to change of environment. This is fairly clear from the density of amphipod during the post NE monsoon had increased more than fourfold of those in the pre NE monsoon.

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References

Bakus, G.J. (1990). Quantitative ecology and marine biology. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, 159 pp.

Caddy, J.F. (1973). Underwater observation on tracks of dredges and trawl and some effects of dredging on scallop grounds. J. Fish. Res. Board Can., 30, pp.173- 180.

Day, J.H. (1967). A monograph on the polychaeta of Southern Africa, part 1-2. Trustees of the Brithis Museum (Natural History), London. 878pp.

Fauchald, K. (1977). The polychaete worms, Definitions and keys to the orders, families and genera. Natural History Museum of Los Angeles county. Sciences Series 28, 188pp.

Hill, M.O. (1973b). Diversity and evenness: A unifying notation and its consequences. Journal of Ecology, 61, pp.225-236.

Hylleberg, J., A. Nateewathana, & B.Chantananthawej (1985). Temporal changes in sediment characteristics on the west coast of Phuket Island. Phuket Mar. Biol. Cent. Res. Bull., 37,16 pp.

Ludwig, J.A. and J. F. Reynolds (1988). Statistical ecology: A primer on methods and computing. John Wiley & Sons , NewYork, pp. 85-103.

Margalef, R. (1958). Information theory in ecology. General Systematics 3, pp.36-71.

Parker, R.H. (1975). The study of benthic communities a model and review. Elsevier Oceanography Series 9, Elsevier, Amsterdam, pp.235-248.

Pearson, T. (1975). The benthic ecology of Loch Linnhe and Loch Eil, a sea-loch system on the west coast of Scotland, VI. Changes in the benthic fauna attributable to organic enrichment. J. exp. mar. Biol. Ecol., 20, pp.1- 41.

Piamthipmanus, M. (1998). Temporal changes in the abundance of macrobenthos in the South China Sea, Area I : Gulf of Thailand and East Coast of Penninsular Malasia (in press).

Ruppert, E. E. and R. D. Barnes (1991). Invertebrate Zoology. Saunders College Publishing, Fortworth, 1056pp.

Tsutsumi, H. and T. Kikuchi (1983). Benthic ecology of a small cove with seasonaloxygen depletion caused by organic pollution. Publ. Amakusa Mar. Biol. Lab., pp.17-40.