Species Composition, Abundance and Biomass Distribution of Zoobenthos in Vietnamese Waters

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ABSTRACT

The benthic invertebrate (zoobenthos) fauna in Vietnamese seawaters was surveyed in April - May, 1999. Zoobenthos specimen were sampled by Smith-McIntyre grab on 38 stations and 180 species were recorded and composed of 5 major groups: Polychaeta, Crustacea, Mollusca, Echinodermata and others.The total of density and biomass zoobenthos in Vietnamese seawaters was 156.7 ind/m^2 and 5943.0 mg/m^2 respectively. Polychaeta and Mollusca were groups with the highest abundance in every cases considered. The remaining groups of zoobenthos such as Crustacea and Echinodermata which were lower in abundance but higher in biomass.

There was a remarkable variation of zoobenthos both in species composition and density with the depth, substrate and spatial distribution. Abundance was higher in some subjects considered such as: in depth of 0 - 60m or in types of sandy components or in the Tonkin gulf and the Southeast regions. All diversity indices shown that water quantity in Vietnamese sea offshore in survey time was just satisfactory and good.

Key words: zoobenthos species, composition, abundance, distribution, diversity, Vietnamese waters

Introduction

Benthic fauna in the Vietnamese seawaters was being surveyed because it is an important components of every marine ecosystems, such as littoral, mangrove, seagrass, coral reef, subtidal ones etc. Benthic organisms are considered a major food item for the bottom feeders like demersal fish. Moreover many of them are important commercial value in exploiting, culturing, for example, the prawn, crabs, cockles. Collaborative survey team of China-Vietnam, 1962; [Chung *et al*., (1971)]; [Gurjanova E.F. (1972)]; [Trong. (1996)].

In addition, benthic communities are also considered as biological indicators for assessing marine water quality because the organisms are mostly sessile and affected by factors causing environment pollution [Trong *et al*., (1998)].

Therefore, a study on benthic fauna in general and benthic invertebrates in particular may be used as an important information to contribute to assess and manage fishery and environment in the Vietnamese sea waters.

Under the collaborative framework of the project on Marine Fishery Resource in the South China Sea, an integrated survey cruise was carried out in Vietnamese seawater - area IV on 30 April - 29 May, 1999 by M.V. SEAFDEC. A collection of benthic invertebrates was a part of the biological oceanographic data of this survey.

This report presents some results on distribution of fauna composition, abundance, biomass

and diversity of marine benthic invertebrates (hereinafter called Zoobenthos) at this area.

Materials and Methods

Sampling

Sampling areas and time

The survey areas are along coastal waters from the North to the South of Vietnam from Latitude 21°00.0' - 09°00.1' N to Longitude 107°55.0' - 104°30.5' E. A total of 58 stations of the project were set up but only on 38 stations were sampled zoobenthos. In the rest 20 stations it was too deep or it's substrates too hard to sample [Fig. 1].

The cruise was carried out on board M.V. SEAFDEC from 29 April to 29 May, 1999. Among these stations, 7 stations (1 - 7) belong to Northern sea region (Tonkin gulf), 9 stations (8 - 29) belong to Central sea and 17 stations (38 - 53) belong to South east sea region and the rests (St. 54 - 58) belong to Southwest sea region [Fig. 1].

Sampling methods

On almost stations, three random samples of bottom sediment were collected by Smith-McIntyre grab with its area coverage 0.05m^2 but only 2 stations (43, 46) could collect 2 samples on each because some physical factors (wave, wind and current) that were so strong which caused more difficult for sampling. The sediment was wash through a set of 4 sieves (2.0, 1.0, 0.5 and 0.1 mm in meshes) with the smallest one lies under the rest. Benthic animals were picked up and fixed in 10% buffer solution in seawater on board (according to Puget sound water quality Authority - 1997). Then they were preserved again in 70% ethyl alcohol in the laboratory.

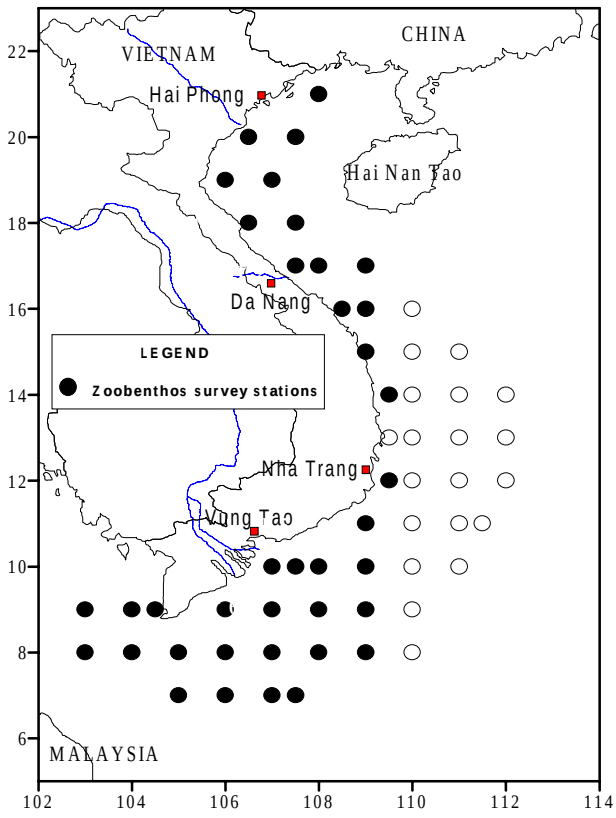

Fig. 1. Map showing survey stations on zoobenthos in area IV.

Identifying

(a) In the laboratory benthic animals were sorted out in major taxonomic groups, such as Polychaeta, Crustacea, Mollusca, Echinodermata and other groups (which composed of Coelenterata, worms). They were identified to the species level as well as possible and counted separately for each taxa. Specimens were weighed on an electronic balance "Satorius - Germany" with accuracy of 0.1 mg. Quantity unit of every taxa was calculated equivalent number of individuals or mg per m^2 of substrate (bottom).

(b) Documents

Some major documents were used for identifying groups of organisms as follow:

- For Polychaeta: [P. Fauvel (1953)], [M. Imajima and O. Hartman (1964)], [J. Day (1967)], [Wu Baoling *et al*. (1986)].
- For Crustacea: [FAO species catalogues (1991)] - Lobsters; [T. Kakai (1976)] - Crabs; [Dai Ai-yun (1991)] - crabs, [K.K. Tiwari (1963)] - Shrimp, etc.
- For Mollusca: [R.T. Abbott *et al*. (1990)] - Mollusca in general; [Tchang -Te *et al*. (1960,1964)] - Gastropoda; [Kevin L. Lamprell & John M. Healy (1998)] - Scaphopoda.
- For Echinodermata: [Tchang Phang Dzoanh *et al*. (1964)], [Walter K. Fisher (1922)]; [R. Koeler (1922)], etc.

Analysis method

Some diversity indices have been used:

(a) The Shannon - wiener index (H') (1949):

$$H¢= -\sum_{i=1}^{S} pi(\log_2 pi) \quad \text{or} \quad = -\sum \frac{ni}{N}\left(\log_2 \frac{ni}{N}\right)$$

Where: pi is equivalent with $\frac{n\,i}{N}$

ni : number of individuals in the i^{th} species

N : total number of individuals

(b) Eveness index (Pielou, 1996)

$$E = \frac{H'}{\log 2S}$$

Where: H¢ measured Shannon - wiener diversity

S : total number of species

E : eveness

(c) Margalef's species richness index

$$D = \frac{S-1}{\log eN}$$

Where: D : richness index

S : total number of species

N : total number of individuals

Results

Some major environmental parameters

The deep of sampling area

The measured deep of survey areas was from 22m (station 38) to 4140m (station 25) but the depth of sampling stations on zoobenthos was only from 22m (station 38) to 156m (station 35). There were 18 stations from 22m to 30m in depth, 10 stations from 31 to 60m and only 4 stations from 61 - 90 m, 3 stations from 91 to 120m and 3 station from 120 - 160m in depth [Table 1 and 8, Fig. 1]. Depth of the survey area was grouped in Table 1.

Table 1. The depth of the survey area.

Group of depth (m)	Stations	No. of station
0- 30	1,2,3,4,7,14,37,38,46,47,48,49,50,51,53,54,57,58	18
31- 60	5,8,9,13,29,36,39,45,52,56	10
61 - 90	6,35,44,55,	4
91 - 120	10, 12,28,	3
121 - 160	20,40,43,	3

Sediment characteristics

Sediment characteristics in the survey area were described in details [Table 2]

- Fine mud (9 stations), mud mixed shell (6 stations), muddy sand (3 stations), mud mixed detritus (1 station) and sand (13 stations), sand mixed shell (3 stations), sandy mud (2 stations), sandy stone (1 station).

- But in general, there were two types of major sediments which covered the survey areas were: muddy and sandy.

Table 2. The substrate characteristics in surveyed sea bed of survey area.

Major types of substrates	Types of common substrates in detail	No. of station
	Fine mud	3,6,9,13,35,52,54,55,58
	Mud & detritus	57
Muddy	Mud & Shell	1,4,5,7,8,56
	Sandy mud	10,20
	Muddy sand	12,14,28,53
	Sand	2,29,39,40,44,45,46,47,48,49,50,51
Sandy	Sandy- stone	43
	Sand & Shell	36,37,38

Salinity of the survey area.

All survey stations were of high depth area and far from coastal waters so they were in high salinity area of seawaters. The salinity of bottom water layer ranged from about 32.0% to about 34.5% in general the salinity of the survey area was rather high.

Species composition and its structure

About 180 benthic invertebrate species and 72 families, 130 genera, belonging to 5 main groups: Polychaeta, Mollusca, Crustacea and Echinodermata and others (Coelenterata, worms) were recorded from analyzing results at 38 stations of Vietnamese seawaters. Among them, species number of Polychaeta was the highest with 78 species and occupied 43.4% of total species, then to Mollusca - 49 species, 27.2 %; Echinodermata -26 species, 13.5 %; Crustaceans - 23 species, 12.8% and the other with 4 species, 2.2% [Table 3, 4]. Among 72 families, some families have higher species such as *Eunicidae* (Polychaeta) with the highest - 20 species and then to two *Maldanidae* (Polychaeta) and *Dentaliidae* (Mollusca) with 10 species for each. 28 families with 2- 7 species, 41 families with only 1 species [Table 3, Fig. 2].

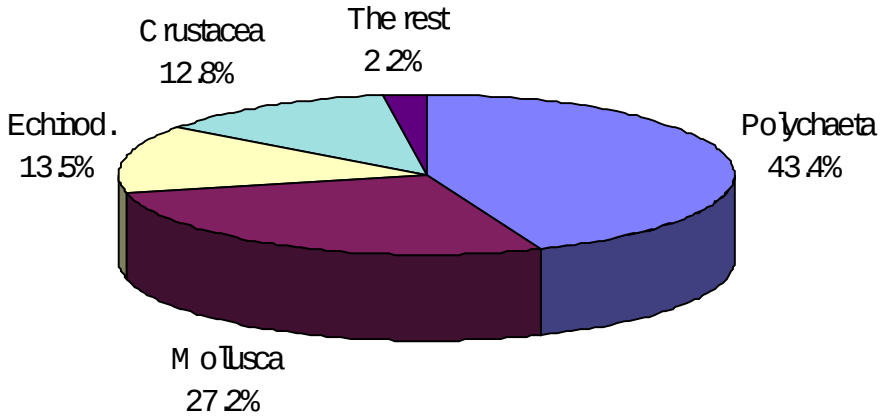

Fig. 2. Relative abundance of zoobenthos in survey area of Vietnamese waters.

Table 3. The checklist and distribution of zoobenthos on survey areas in Vietnamese Waters, Area IV (April - May, 1999).

No	Scientific name	Stations	Notes
	Polychaeta		
	1. Nephthydidae		
1	*Nephthys polybranchia*	10, 38, 46, 50	
2	*N. inermis*	54	
3	*Nephthys* sp.1	1	
	2. Ophellidae		
4	*Armandia lanceolata*	2	
5	*Ammotrypane aulogaster*	38, 51	
	3. Capitellidae		
6	*Capitellethus* sp.	7, 20, 35, 50	
7	*Dasybranchus* sp.	9, 38, 50	
8	*Notomastus* sp.	38	
9	*Heteromastides* sp.	36, 51, 53	
10	*Branchiocapitella* sp.	4	
11	*Pulliella sp.*	50	
12	*Axiothella australis*	14	
	4. Terebellidae	37, 53	
13	*Polymnia nebulosa*	1	
14	*Terebellides stroemi*	1, 37, 51, 57	
15	*Terebellidae gen* spp.	1,	
	5. Eunicidae	45, 49, 53	
16	*Eunice gracilis*	52	
17	*E. coccinea*	28	

Table 3. (Continued).

No	Scientific name	Stations	Notes
18	*Eunice* sp.	3, 7, 8, 45	
19	*Onuphis holobranchiata*	2, 38, 43	
20	*O. eremita*	35	
21	*O. dibranchiata*	36	
22	*Onuphinae* sp.	29	
23	*Drilonereis filum*	1, 52	
24	*Lumbriconereis notocirrata*	2, 52	
25	*Lumbriconereis* sp.	54	
26	*L. impatiens*	8, 36, 46, 57	
27	*L. latreilli*	7, 47	
28	*L. simplex*	4	
29	*L. heteropoda*	53	
30	*M. stragulum*	6	
31	*M. fallax*	53	
32	*Marphysa* sp.1	2	
33	*Hyalinoecia tubicola*	29	
34	*Arabella* sp.1	56	
35	*Diopatra neapolitana*	57	
	6. Cirratulidae	52	
36	*Cirratulus filiformis*	20, 52	
37	*Tharyx filibranchia*	52	
38	*Th . multifilis*	5, 54	
	7. Chaetopteridae	50, 53, 55	
39	*Phyllochaetopterus* sp.	5, 35, 38, 39, 47, 53	
	8. Spionidae	37	
40	*Prionospio pinnata*	1, 2, 45, 50	
41	*P. krusadensis*	14,	
42	*Prionospio* sp.	35, 54	
43	*Nerine cirratulus*	1, 2, 14, 53	
44	*Nerine* sp.	9, 29, 35, 37, 50, 57	
45	*Scolelepis indica*	1	
46	*Laonice* sp.	38, 49	
	9. Glyceridae		
47	*Goniada emerita*	28, 53	
48	*Glycera longipinnis*	49, 50	
49	*G. alba*	14, 38	
50	*G. rouxii*	6	
	10. Ariciidae		
51	*Aricia cuvieri*	50	
52	*Nainereis laevigata*	13	
53	*Haploscoloplos* sp.1	49	
54	*Scoloplos kerguliensis*	10	
55	*S. marsupialis*	57	
	11. Maldanidae	5, 40, 52, 53	
56	*Euclymene lumbricoides*	50	
57	*Axiothella obockensis*	29, 38	
58	*Asychis* sp.1	2, 52	
59	*Maldane sarsi*	50	
60	*C. (Euclymene) annandalei*	6, 7,	
61	*Petaloproctus* sp.	20, 40	
62	*Clymenella* sp.1	52	
63	*Clymene (Euclymene) insecta*	7, 20	
64	*Clymene (Euclymene)* sp.	38, 52, 53	
65	*Maldanidae gen* spp.	14, 29, 35, 38, 54	

Table 3. (Continued).

No	Scientific name	Stations	Notes
	12. Aphroditidae	14	
66	*Eunoe pallida*	9	
67	*Polyodontes melanonotus*	9, 50	
	13. Amphinomidae		
68	*Pseudeurythoe paucibranchiata*	2	
69	*Chloeia rosea*	5, 43	
	14. Sternaspidae		
70	*Sternaspis scutata*	20, 36, 56, 57	
	15. Ampharetidae		
71	*Melina* sp.	20	
72	*Ampharetidae gen* spp.	35	
	16. Nereidae		
73	*Leptonereis* sp.	4	
74	*Tylonereis* sp.	5	
	17. Chloraemidae		
75	*Brada talehsapensis*	57	
	18. Heterospionidae		
76	*Heterospio sinica*	20	
	19. Owenidae		
77	*Owenia fusiformis*	49	
78	Polychaeta nonidentifyed	13, 40, 44, 46, 48, 57	
	Crustacea		
	20. Ocypodidae		
79	*Macrophthalmus* sp.1	58	
	21. Penaeidae		
80	*Metapenaeus* sp.	38	
	22. Alpheidae		
81	*Alpheus malabaricus*	38	
82	*Alpheus* sp.	7, 35	
83	*Synalpheus* sp.	12	
84	23. Palaemonidae	35	
	24. Upogebiidae		
85	*Upogebia* sp.1	1, 3, 4	
	25. Nephropidae		
86	*Nephropsis* sp.	2	
	26. Callianassidae		
87	*Callianassa* sp.1	5, 8, 9, 28, 29, 37, 47, 48, 50, 51, 53, 57, 58	
	27. Scyllaridae		
88	*Ibacus* sp.1	2, 46, 47	
	28. Galatheidae		
89	*Galathea* sp.	36	
	29. Goneplacidae		
90	*Camatopsis* sp.1	4	
91	*Carcinoplax* sp.1	39	
92	*Typhlocarcinus nudus*	50	
93	*Xenophthalmodes* sp.	48, 52	
	30. Pinnotheridae		
94	*Neoxenophthalmus obscurus*	54	
95	*Pinnotheres* sp.	1	
	31. Pandalidae		
96	*Pandalus* sp.	50	
97	Amphipoda	2, 4, 36, 37, 45, 47, 49, 53	
98	Isopoda	2, 28	

Table 3. (Continued).

No	Scientific name	Stations	Notes
99	Mysidacea	2, 5	
100	Other non-identified	47	
101	Entosnostraca	53	
	Mollusca		
	Scaphopoda	1, 6, 43	
	32. Dentaliidae	6	
102	*Dentalium aprinum*	4, 5, 20, 10, 28, 36, 37, 39, 44, 45, 47, 48, 50, 52	
103	*D. thetidis*	14	
104	*D. octangulatum*	36	
105	*D. elephantinum*	39, 50	
106	*D. hexagonum*	7, 8, 20, 28, 52, 53, 56, 58	
107	*Dentalium (D.) katowense*	51	
108	*D. bisexangulatum*	46	
109	*Dentalium* sp.	6, 10, 37, 50, 51	
110	*Graptaeme acutissimum*	58	
111	*G. aciculum*	56	
	33. Gadilidae		
112	*Gadila spretus*	4, 5, 29, 35	
113	*Deschides* sp.	39	
114	*Polyschides andersoni*	45	
115	*P. gibbosus*	12, 14, 28, 49, 57	
116	*P. prionotus*	20	
117	*Polyschides* sp.	5, 8, 40, 52	
	34. Laevidentaliidae		
118	*Laevidentalium lumbricatum*	36, 39, 40, 58	
119	*L. jaffaensis*	37	
120	*L. largierescens*	37	
121	*L. longitrorsum*	10, 37, 39, 47, 52, 55, 56	
122	*L. erectatum*	12, 38, 40, 51, 52, 53, 55, 58	
123	*Laevidentalium* sp.	36, 37, 38, 39, 40, 45, 46, 47, 48, 50, 56	
	35. Pulsellidae		
124	*Compresidens platyceras*	10, 20, 40, 52, 53, 56	
	36. Omnigliptidae		
125	*Omniglypta cerine*	47	
	Gastropoda		
	37. Pyramidellidae		
126	*Pyramidella* sp.	3	
	38.Bullidae		
127	*Atys cylindricus*	29	
	39. Turritellidae		
128	*Turritella bacillum*	36	
129	*Turritella terebra*	36, 45, 46, 47	
130	*Turritella* sp.	45, 50, 51, 53	
	40. Turridae		
131	*Turricula javana*	14	
132	*Turris* sp.	12	
	41. Terebridae		
133	*Hastula* sp.	13	
134	*Terebra funiculata*	45, 46	
	42. Conidae		
135	*Conus* sp.	43	
	43. Cancellariidae		
136	*Cancellaria* sp.	2	

Table 3. (Continued).

No	Scientific name	Stations	Notes
	44. Architectonidae		
137	*Heliacus* sp.	47, 53	
	45. Volutidae		
138	*Fulgoraria daviesi*	4	
	46. Acteonidae		
139	*Otopleura auriscati*	1	
	47. Naticidae		
140	*Polinices* sp.	2	
	48. Epitonidae		
141	*Amaea decussata*	49	
	49. Olividae		
142	*Ancilla* sp.	6	
	50. Cavoliniidae (Pteropoda)		
143	*Cavolinia tridentata*	12	
144	*C. uncinata*	7, 12	
	Bivalvia		
	51. Solenidae		
145	*Solen* sp.	36	
	52. Solecurtidae		
146	*Sinovacula* sp.	54	
	53. Glycymerididae		
147	*Glycymeris reevei*	51	
148	*Glycymeris sp.*	51	
	54. Veneridae		
149	*Dosinia* sp.	38	
	55. Donacidae		
150	*Donax* sp.	44	
	Echinodermata	6, 8, 20	
	56. Ophiactidae		
151	*Ophiactis savignyi*	1	
	57. Amphiuridae		
152	*Amphioplus praestans*	1, 48	
153	*A. retictus*	43	
154	*A. depressus*	49	
155	*Amphipholis kochii*	58	
156	*Amphiura* sp.	35, 38	
	58. Ophiolepididae		
157	*Ophioplocus japonicus*	5, 51	
	59. Ophiotrichidae		
158	*Macrophriothrix longipeda*	5	
159	*Ophiothrix striolata*	44	
	60. Ophiothrichidae		
160	*Ophiomusium altum*	51	
	61. Ophiocomidae		
161	*Ophiarthrum pictum*	9, 12	
162	62. Ophiuroidae (only legs)	39, 43, 48, 51	
	63. Trichasteridae		
163	*Asteronyx loveni*	39	
	64. Fibulariidae		
164	*Fibularia acuta*	2	
	65. Temnopleuriudae		
165	*Temnopleurus* sp.	36	
	66. Loveniidae		
166	*Lovenia trifolis*	38, 58	

Table 3. (Continued).

No	Scientific name	Stations	Notes
	67. Clypeasteridae		
167	*Clypeaster reticulatus*	44	
168	*Cl. virescens*	47	
	68. Laganidae		
169	*Laganum depressum*	46	
170	69. Echinometridae	5	
	Holothuroidea		
	70. Synaptidae		
171	*Potankya asymetrica*	1	
	71. Phyllophoridae		
172	*Actinocucumis typicus*	6, 56	
173	*Phyllophorus* sp.	56	
174	*Phyllophorus* sp. ef fragilis	36	
	72. Holothuriidae	14, 56	
175	*Actinopyga echinites*	36, 51	
	73. Molpadiidae		
176	*Molpadia* sp.	51	
	Coelenterata		
177	*Hydrozoa*	39	
178	Echiuroidea	7, 28, 51, 58	
179	Plathelminthes	5, 35, 36, 49, 51, 54	
180	Nematoda	35	

The structure of the species composition is correspondent with previous studies, it showed that, the Molluscean and Polychaeta play major role in the structure of zoobenthos species composition [Chung N. V., 1994]; [Trong P.D. *et al*. (1998)]. Some species were composed of *Nephthys polybranchia, Capitellethus* sp., *Terebellides stroemi, Lumbriconereis impatiens, Prionospio pinnata, Nerine* sp., *Phyllochaetopterus* sp. *(Polychaeta*); *Callianasa* sp. *(Crustacea*); *Dentalium* sp., *Laevidentalium* sp., *Gadila spretus, Polyschides gibbosus, Compresidens platyceras, Turritella* sp. *(Mollusca)*, with high occurrence in the survey area.

Distribution and abundance of zoobenthos

Distribution of species composition

The spatial distribution

Distribution of species composition on stations of the survey was very different. There were 4 stations (3, 4, 13, 55) which were of few species and changed from 2 species (station 3) to 5 species (station 44). Besides, on the 17 stations (1-2,14-20, 35, 36, 38, 39, 46, 47, 50, 51, 52, 53, 56, 57, 58) with higher number of species and changed from 9 to19 species/ station [Table 4].

The average index of species number on the whole of survey stations is 9.1 species per station [Table 4]. Besides from Table 4 also shown that:

- In the Tonkin Gulf, there were 7 stations (with 58 species) which had rather high average index of species number with 10.0 species/ station, so they were under the average index and changed from 2 to 16 species/ station
- In the Central sea, there were 9 stations (50 species) which had the lowest average index of species number with only 7.0 species/ station, and changed from 2 to 14 species/ station.
- In the Southeast sea, there were 17 stations (114 species) which had the highest average index of species number with 11.9 species/ station and varied from 5 to 19 species/ station.

- In the South west, there were 5 stations (35 species) which had low in this average index with 7.4 species/ station.

In general, average index of species number reached the highest in the Southeast and the lowest in the Central Sea.

Table 4. Species distribution on survey areas of Vietnamese waters.

Survey areas	Station	Species No.
Tonkin gulf (58 species)	1	14
	2	16
	3	2
	4	9
	5	14
	7	8
	6	7
Central sea (50 species)	8	6
	9	6
	10	6
	12	7
	13	3
	14	9
	20	11
	28	8
	29	7
	35	12
South - East (114 species)	36	17`
	37	9
	38	19
South - East (114 species)	39	11
	40	6
	43	6
	44	5
	45	8
	46	9
	47	12
	48	7
	49	8
	50	18
	51	15
	52	15
	53	15
South - west (35 species)	54	7
	55	3
	56	9
	57	9
	58	9
Average species index		**9.10**

Variation in species composition with depth

It was shown in Table 5. that:

- Species numbers on the 28 survey stations in depth of 0 - 60 m changed from 2 to 19 species/ station. Average index was 9.91 species/ station and reached the highest. Among them, 9 stations with higher in species number composed of: stations number 1(14 sps), 2 (13 sps.), 36 (14 sps.), 38 (19 sps.), 47 (10 sps.), 50 (18 sps.), 51 (14 sps.), 52,53 (15 sps.). Only station number 3 with the lowest species number (2 sps.).

- Species number on the 7 survey stations in depth of 61 - 90 m changed from 3 species (St. 55) to 10 species / St. (St. 39), average index of species reached only 6.7 species/station and was the lowest. Four stations with rather high in species number composed of stations number 45(8 sps), 39 (10 sps.).

- Species number on 3 stations in depth of 91 - 120m changed from 6 species (station 10) to 7 species (stations 12, 28) which had average index of 6.6 was the lowest as it was in depth group of 61 - 90m.

- On 4 survey stations in depth over 120 m, species numbers changed from 6 to 13 species/ station. It's order after that of station group in depth of 0 - 60m, average index was 9.0 species/ station and stood in second.

Table 5. Distribution of species number with depth in April-May,1999.(unit : species number/station).

Survey areas	Stations	Depth			
		<60 m	61 - 90m	91- 120m	121- 160m
Tonkin gulf	1	14			
	2	13			
	3	2			
	4	8			
	5	6			
	6		6		
	7	7			
Central sea	8	6			
	9		6		
	10			6	
	12			7	
	13	3			
	14	9			
	20				11
	28			8	
	29		7		
	35				13
Southeast	36	14			
	37	8			
	38	19			
	39		10		
	40				6
	43				6
	44		5		
	45		8		
	46	9			
	47	10			
	48	7			
	49	8			
	50	18			
	51	14			
	52	15			
	53	15			
Southwest	54	6			
	55		3		
	56	9			
	57	9			
	58	9			
Average species index		**9.91**	**6.7**	**6.6**	**9.0**

Distribution of species composition on the type of substrate

In general, from two types of major substrates which could be divided into 8 types substrate in detail such as fine mud, mud & detritus, mud & shell, sandy mud, muddy sand, sand, sandy stone, sand & shell [Table 2]. On every type there was different distribution of zoobenthos [Table 6].

- On the fine mud: On these stations, species number changed from 2 to 15 species/ station and average 6.7 species/ station. There were 3 stations with the high species number such as station 35 (10 sps.), 52 (15 sps.), 58 (9 sps.) and 2 stations with the low species number such as station 3 (2 sps.), 13 (3sps.).

- On the mud and shell: On these stations, the species number changed from 6 to 14 species/ station and average index 8.8 species/ station. There were 3 stations with the high species number such

as station 1 (14 sps.), 5 (9 sps.), 56 (9 sps.) and 2 stations with the low species number such as station 7 (7 sps.), 8 (6 sps.).

- On the sandy mud: On these stations, the species number changed from 6 species (St. 10) to 11 species (St. 20)

- On the muddy sand: On these stations, the species number changed from 6 to 15 species/ station and average was 9.3 species/ station. There were only one station 53 with high species number (15 sps.) and the rest 2 stations with low species number such as station 12 (7 sps.), 28 (6 sps.).

- On the sand: On these stations, the species number varied from 5 to 18 species/ station and average species index was 9.6 species/ station. There were 4 stations with high species number such as station 39 (10 sps.), 47 (10 sps.), 50 (18 sps.), 51 (14), and 5 stations with low species number such as station 40 (6 sps.), 44 (5 sps.), 45 (8 sps.), 48 (7 sps.), 47 (8 sps.).

- On the sand and shell: On these stations, the species number changed from 8 to 19 species/ station and average of species index was 13.7 species/ station and only one station 38 with the highest species number (19 sps.) and the rest 2 stations with 14 species (St. 36) and 8 species (St. 37).

The survey results demonstrated that average of species number was the highest with 13.7 sps. /station on the substrate of sand and shell, the lowest on the fine mud (6.7 sps./station).

Relative abundance of zoobenthos

Species distribution of zoobenthos in the regions of the survey area were much irregular. There were 58 species in the Tonkin Gulf (occupied 32.2% of total species), 50 species in the Central sea (27.8%), 114 species in the Southeast (63.3%) and only 35 species in the Southwest (19.4%) [Table 7].

Relative abundance

Besides distribution species number in every stations on each region lead to different abundance of each taxonomic group. However the priority order on relative abundance of these groups was not changed.

Table 7 also shows that, in every regions, Polychaeta always occurred the most amount of species with 40% (in the south-west) to 54% (in the central). Mollusca having amount of species less than that of Polychaeta and this group abundance ranged from 20.7% (in Tonkin gulf) to 34% (in Central). The third position on abundance belongs to Crustacea in Tonkin gulf and Central or to Echinodermata in South-east and South-west [Table 7, Fig. 3].

Quantitative characteristics of benthic fauna and it's distribution

Common characteristics

Analyzing results on benthic fauna quantity were presented on table 9 and table 10, from these tables we can see that the priority order of quantity indices between groups as follows: Mollusca has the highest values with 66.9 inds./m^2 then to Polychaeta, Crustacea, Echinodermata and others with the lowest value of 9.6 inds./m^2 in density but in biomass these orders are changed, Echinodermata was the highest value with 2769.4 mg/m^2, then to Mollusca, Crustacea, Polychaeta and the lowest value was in Others with of 35.5mg/m^2. Density of zoobenthos reached the highest at station 2 with 399 ind/m^2 and the lowest at station 3 with only 13.2 ind/m^2. Biomass reached the highest at station 1 with 22766.4 mg/ m^2 and the lowest at station 13 with 106.5 mg/m^2. Quantity average of the whole area were 156.7 ind. and 5970.3 mg per m^2. [Table 8, 9]. There were two reasons contributing to largeness of abundance and biomass of zoobenthos. Firstly, regular distribution of organisms in the area. This matter importantly affected to their abundance, for example, Mollusca and Polychaeta having high occurrence with 94.7

and 97.4% respectively so this groups having also high density. [Table 3, 8, 9]. Secondly, individual's weight of organisms, almost species of Crustacea and Mollusca having heavy shell or some Holothurioms (Echinodermata) having bigger body measurement.

Table 6. Number species distribution on the types of substrates(number species/station) April-May, 1999.

Region	Stations	FM	M&D	M& Sh	SM	MS	S	SS	S & Sh
Tonkin gulf	1			14					
	2						13		
	3	2							
	4			8					
	5			9					
	6	6							
	7			7					
Central Sea	8			6					
	9	6							
	10				6				
	12					7			
	13	3							
	14					9			
	20				11				
	28					6			
	29						7		
	35	10							
Southeast	36								14
	37								8
	38								19
	39						10		
	40						6		
	43							6	
	44						5		
	45						8		
	46						9		
	47						10		
	48						7		
	49						8		
	50						18		
	51						14		
	52	15							
	53					15			
Southwest	54	6							
	55	3							
	58	9							
	57		9						
	56			9					
		6.66	**-**	**8.83**	**8.5**	**9.25**	**9.58**	**-**	**13.66**

Notes: FM: fine mud; M&D: mud &detritus; M&Sh: mud&shell; SM: sandy mud; MS: muddy sand; S:sand; SS: Sand stones; S&Sh: sand&shell.

Table 7. Distribution of Zoobenthos species number between regions in Vietnamese waters.

Region / Group	Tonkin Gulf	Central sea	Southeast	Southwest
Polychaeta	28/48.3*	27/54.0	46/40.3	14/40.0
Crustacea	10/17.2	3/6.0	14/12.2	3/8.6
Mollusca	12/20.7	17/34.0	33/29.0	10/28.6
Echinodermata	8/13.8	2/4.0	17/15.0	6/17.1
Others	0	1/2.0	4/3.5	2/5.7
Total species	**58/100.0**	**50/100.0**	**114/100.0**	**35/100.0**

[*] : density/percent [28 (ind./m^2 /48.3%]

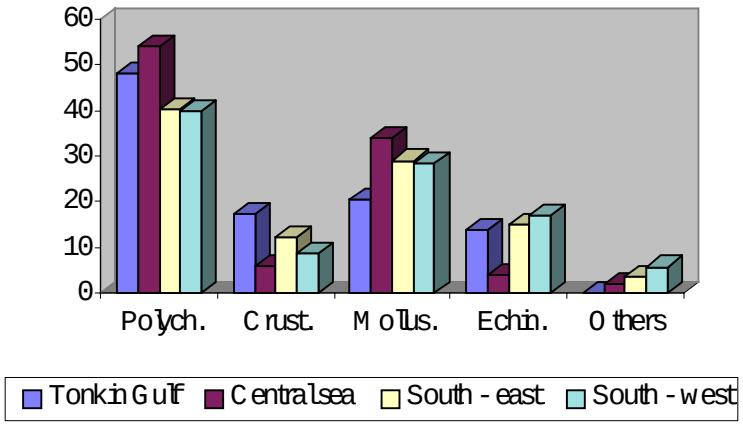

Fig. 3. Relative abundance of zoobenthos between seawaters regions of Vietnam in April- May,1999.

Table 8. Quantitative distribution of zoobenthos in the Vietnamese waters, AreaIV (April-May,1999). Where: Density/Biomass: Inds./(mg/m^2).

Station	Depth (m)	Polychaeta	Crustacea	Mollusca	Echinodermata	Others	Total
1	34	86.2/ 366.6	93.2/ 21366.6	6.6/ 133.3	19.8/ 988.9	0	205.8/ 22766.4
2	29	72.8/ 452.9	39.7/ 1419.8	19.9/ 233.3	266.6/ 5266.6	0	399.0/ 7372.6
3	28	6.6/ 66.6	0	6.6/ 333.3	0	0	13.2/ 399.9
4	26,5	33.2/ 233.3	46.5/ 739.9	93.2/ 4133.2	0	0	172.9/ 5106.4
5	58	39.6/ 486.3	13.2/ 66.6	166.6/ 2833.2	39.8/ 2133.3	0	259.2/ 5519.4
6	80	19.8/ 46.5	0	19.9/ 133.3	19.9/ 399.9	0	59.6/ 579.7
7	40	26.4/ 1239.8	6.6/ 66.6	86.6/ 1200.0	0	6.6/ 66.6	126.2/ 2573.0
8	45	13.2/ 72.2	6.6/ 66.6	19.9/ 366.6	6.6/ 66.6	0	46.3/ 572.0
9	75	26.4/ 866.4	6.6/ 33.3	0	33.3/ 8266.6	0	66.3/ 9166.3
10	107	13.2/ 866.6	0	42.1/ 1066.5	0	0	55.3/ 1933.1
12	105	0	6.6/ 33.3	146.4/ 2133.2	6.6/ 2533.3	0	159.6/ 4699.8
13	42	13.2/ 39.9	0	6.6/ 66.6	0	0	19.8/ 106.5
14	36	46.3/ 453.0	0	39.9/ 699.9	6.6/ 133.3	0	92.8/ 1286.2

Table 8. (Continued).

Station	Depth(m)	Polychaeta	Crustacea	Mollusca	Echinodermata	Others	Total
20	143	46.2/ 513.0	0	53,2/ 766.6	6.6/ 66.6	0	106.0/ 1346.2
28	110	13.2/ 1006.6	13.2/ 99.9	39.9/ 733.2	0	6.6/ 6.6	72.9/ 1846.3
29	72	39.8/ 186.5	13.3/ 100.0	139.9/ 2599.9	0	0	193.0/ 2886.4
35	156	66.2/ 66.2	13.2/ 133.2	6.6/ 200.0	13.3/ 666.6	26.6/ 79.9	125.9/ 1145.9
36	45,5	26.4/ 679.8	13.2/ 46.6	233.0/ 9633.1	19.8/ 9533.3	6.6/ 6.6	299.0/ 19899.4
37	32	13.2/ 73.2	26.6/ 46.6	79.7/ 3266.4	0	0	119.5/ 3386.2
38	22	93.2/ 359.7	13.2/ 339.9	26.5/ 399.9	33.2/ 13133.2	0	166.1/ 14232.7
39	62	6.6/ 6.6	6.6/ 66.6	193.0/ 3199.8	13.2/ 333.3	6.6/ 66.6	226.0/ 3672.9
40	129	13.2/ 13.2	0	59.7/ 766.5	0	0	72.9/ 779.7
43	147	20/ 550	0	20/ 450	20/ 600	0	60/ 1600
44	79	6.6/ 6.6	0	13.2/ 266.6	13.2/ 1200.0	0	33.0/ 1473.2
45	61	13.2/ 66.6	6.6/ 6.6	306.4/ 9233.2	0	0	326.2/ 9306.6
46	51	30.0/ 30.0	10.0/ 1500.0	110.0/ 4050.0	10.0/ 3300.0	0	160.0/ 8880.0
47	42	13.2/ 39.9	73.1/ 173.1	73.1/ 2133.1	26.6/ 6866.6	0	186.0/ 9212.7
48	33	6.6/ 33.3	13.2/ 39.9	13.2/ 366.6	13.2/ 199.9	0	46.2/ 639.7
49	20	33.1/ 146.4	6.6/ 6.6	19.9/ 466.6	6.6/ 100.0	6.6/ 6.6	72.8/ 726.2
50	33	73.3/ 806.1	13.2/ 1066.6	59.6/ 1133.2	0	0	146.1/ 2005.9
51	44	19.8/ 106.5	13.3/ 33.3	33.6/ 699.9	39.7/ 2533.3	13.2/ 73.2	119.6/ 3446.2
52	51	52.8/ 172.9	6.6/ 33.3	73.1/ 1266.4	0	0	132.5/ 1472.8
53	34	6.6/ 86.7	33.2/ 139.9	66.6/ 1366.5	0	0	106.4/ 1593.1
54	26	39.7/ 126.4	6.6/ 333.3	6.6/ 1000.0	0	6.6/ 6.6	59.5/ 1466.3
55	70	6.6/ 6.6	0	39.9/ 600.0	0	0	46.5/ 606.6
56	57	13.2/ 466.6	0	59.7/ 1299.8	19.9/ 1666.6	0	91.8/ 3433.0
57	34	83.3/ 4046.4	6.6/ 66.6	6.6/ 333.3	0	0	96.5/ 4446.3
58	23,5	0	13.2/ 1333.3	86.4/ 1133.2	13.2/ 1533.3	6.6/ 6.6	119.4/ 4006.4

Polychaeta

Polychaeta was rather high density with 31.5 inds/m^2 and stood at the second position after that of Mollusca but its biomass was the lowest with only 410.7 mg/m^2 when comparing with four main taxonomic groups [Table 9]. Quantity averages per station of Polychaeta reached the highest with 93.2

ind/m^2 at station 38 and with 4046.4 mg/m^2 at station 57 but the lowest with 6.6 ind/m^2 at stations 3, 39, 44, 53, 55 and with 6.6 mg/m^2 at stations 39, 44, 55 [Table 8]. Some families which had high occurrence such as *Eunicidae* with 34 times per 24 stations, *Maldanidae* - 25 times per 18 stations, *Capitellidae* - 14 time per 10 stations, *Spionidae* - 21 times per 14 stations, play an important role in quantitative composition of this group [Table 3].

Table 9. Quantitative average value of benthic fauna.

Group	Polych.	Crustacea	Mollusca	Echinod.	Others	Total
Density	31.5	19.3	66.9	29.4	9.6	156.7
Percent (%)	20.1	12.3	42.7	18.8	6.1	100.0
Biomass	410.7	1087.3	1640.4	2796.4	35.5	5943.3
Percent (%)	6.9	18.3	27.6	46.6	0.6	100.0

Crustacea

Crustacea was the lowest density with 19.3 inds/m^2 but its biomass was the third position with 1087.3 mg/m^2 after that of Echinodermata and Mollusca groups [Table 9]. Quantity average per station of Crustacea reached the highest with 93.2 ind and 21366.6 mg/ m^2 at same station 1 but the lowest with 6.6 ind/m^2 at stations 5, 7, 8, 9, 12, 39, 45, 49, 52, 54, 57 and with 6.6 mg/m^2 at station 45. [Table 8]. Only two species with high occurrences were *Callianassa* sp.1 (13 times) and *Amphipoda* (8 times) and they played main role in quantitative composition of this group [Table 3].

Mollusca

Mollusca was high quantity both in density and biomass. Density of this group was the highest with 66.9 inds/m^2 , its biomass was 1640.4 mg/ m^2 which was at the second position after that of Echinodermata group [Table 9]. Quantity average of Mollusca per station reached the highest with 306.4 ind. at station 45, with 9633.1 mg/m^2 at station 36 but the lowest with 6.6 ind/ m^2 at stations 1, 3, 13, 35, 54, 57 and with 66.6 mg/m^2 at station 13 [Table 8]. Remarkable contribution to quantitative composition of this group are families of *Scaphopoda*, such as *Dentalidae* (36 times of occurrence per 27 stations), *Laevidentalidae* - 32 times of occurrence per 18 stations and *Galididae* - 16 times per 15 stations. Among them some species composing of *Dentalium aprinum, Laevidentalium sp* were rather high occurrences with 14 times and 11 times for each separately [Table 3].

Echinodermata

Echinodermata was rather low density with 29.4 inds/m^2 and was at the third position after that of Polychaeta, Mollusca but was the highest biomass (2769.4 mg/m^2) in zoobenthos [Table 9]. Quantity average per station of this group reached the highest with 266.6 ind. at station 2 and with 9533.3 mg/ m^2 at station 36 but the lowest with 6.6 ind. at stations 8, 12, 20, 49 and with 66.6 mg/m^2 at stations 8, 20 [Table 8]. Echinodermata distributes in the area very thin, almost of species appeared only one time and only one family *Amphiuridae* with 15 species having 7 times of occurrences. Almost organisms of Echinodermata are of small measurement but some of them were more large, for example the presence of *Ophiarthrum pictum* in stations 9, 12 or of *Clypeaster virescens* in stations 47 contributed to raise biomass of Echinodermata in these stations unusually [Table 3, 8].

Distribution of abundance

Distribution of abundance with depth

The highest density of zoobenthos was occurred at water depth of 31 - 60m.with 141.7 ind/m^2 . At the depth of 0 - 30m and 61 - 90 m, density of zoobenthos was almost same largeness with 133.4 and 134.7 ind/m^2 then density decreased to the lowest value at the depth of over 120 m (79.7 ind/m^2). We can see that when the depth raised, common density of the fauna was decreased gradually. This trend occurred at almost taxonomic groups with various levels. Except three groups Crustacea, Echinodermata and others which were same decreasing trend in density mentioned, Mollusca and Polychaeta appeared a contract trend. Density of Polychaeta decreased gradually at the depth of 0 - 30m to 91 - 120m but it raised at the depth of over 120 m. Density of Mollusca raised rapidly at the depth of 0 - 30m to 31 - 60m but it was decreased at the depth of 131 - 160m. [Fig. 4].

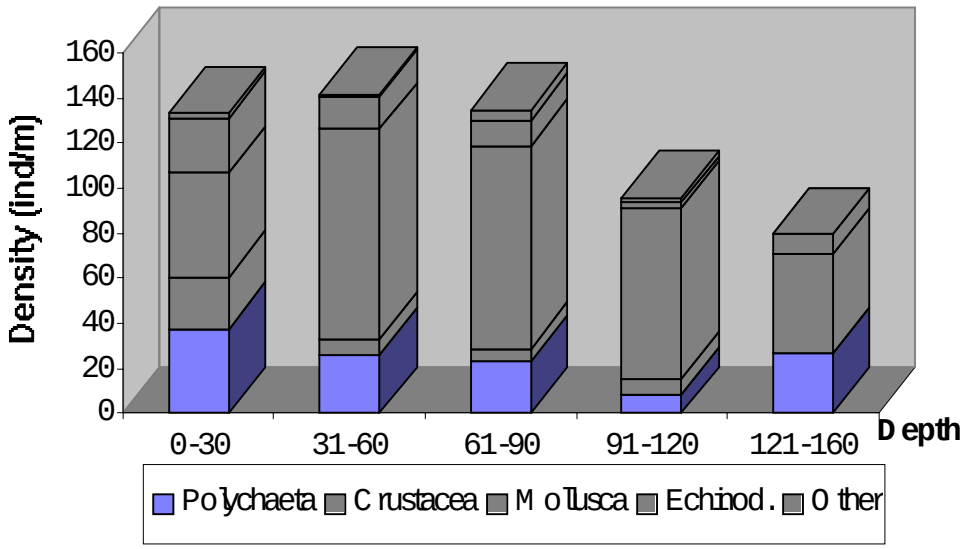

Fig. 4. Distribution of total density of zoobenthos fauna with water depth.

Variation in abundance with sediment

Substrate characteristics and its distribution in the survey area is mentioned above in details. Even distribution of benthic species is accounted. And of course, distribution of their abundance varies too from station to station and from type of sediment to type of it. Surveyed results show that, characteristics of sediment in the area is compounded and complicated one. The compound property is mixture of various sediments such as mud or sand, mud with shell, mud with detritus or sand with shell and sand with stone. The complicated property is the patch distribution of sediment, for example, sandy type could be seen in Tonkin Gulf (station 2) or in Central sea (stations 28, 29) and in South east sea, etc.

So in order to see more clearly different distribution of abundance of zoobenthos which depends on types of sediment, we grouped substrates into main groups and calculated results of abundance on each type of sediment as follows [Table 10].

Table 10 shows that, abundance of zoobenthos in fine mud was the lowest with average of 83.7 ind./m^2 but in sandy mud or muddy sand and in sand, abundance was higher with 138.1 and 210 ind./m^2 respectively.

Table 10. Distribution of zoobenthos abundance on main groups of sediment.

Group of sediment	Fine mud				Mud mixed shell			Sandy mud, muddy sand		Sand		
Sea region	1	2	3	4	1	2	4	2	3	1	2	3
Abundance in each group	26.4	43.0	129.2	80.5	176.6	46.3	91.8	103.4	172.8	399.0	133.0	97.6
Average	72.3				105.0			138.1		210.0		

Notes*:* 1: Tonkin Gulf with stations : 1 - 7
2: Central sea " : 8 - 29
3: South-east sea " :35 - 53
4: South west sea " : 54 - 58

Change of abundance between regions

Zoobenthos abundance differently varied from the North region to the South one. The highest abundance occurred in the North region (Tonkin Gulf) with 176.5 inds./m^2 then to the Southeast with 114.1 inds./m^2 and the lowest abundance occurred in the Southwest region with only 82.9 inds./m^2 [Table 11, Fig. 5].

Among benthic groups, Mollusca and Polychaeta always have higher abundance than that of the rest group [Table 11]. From Fig. 4. we can see that, Northern and Southeast was two regions which were rather high in zoobenthos abundance.

Table 11. Distribution of abundance between regions of Vietnamese waters.

Sea region	Polych.	Crust.	Moll.	Echin..	Others	Total
North (Tonkin Gulf)	40.7	28.5	57.0	49.4	0.9	176.5
Percent (%)	23.1	16.1	32.3	28.0	0.5	100.0
Central	23.5	5.1	54.2	6.6	0.7	90.1
Percent (%)	26.0	5.7	60.2	7.3	0.8	100.0
Southeast	29.1	14.6	81.6	12.3	3.5	141.1
Percent (%)	20.6	10.3	57.9	57.9	2.5	100.0
Southwest	28.6	5.3	39.8	6.6	2.6	82.9
Percent (%)	34.5	6.4	48.0	7.96	3.4	100.0

Diversity of zoobenthos in the survey area

As same as analysis on distribution of species composition and abundance of zoobenthos among regions of the Vietnamese sea, diversity indices of zoobenthos varied very differently among four sea regions [Table 12].

Table 12 shows that, diversity indices in the South-east region were the highest with 3.1465 in H' index, 2.2082 in richness and 0.9145 in eveness; then to Tonkin Gulf with 2.5972, 1.7092 and 0.8606 respectively and the Southwest region with 2.5267, 1.4823 and 0.8945 respectively. In the Central sea region, these indices were the lowest with 2.2075, 1.3647 and 0.8272 respectively.

Table 12. Diversity indices in Vietnamese seawaters in April - May, 1999.

Diversity indices	Tonkin Gulf	Central sea	Southeast	Southwest
H' index	2.5972	2.2075	3.1465	2.5267
Richness	1.7092	1.3647	2.2082	1.4823
Eveness	0.8606	0.8272	0.9145	0.8945

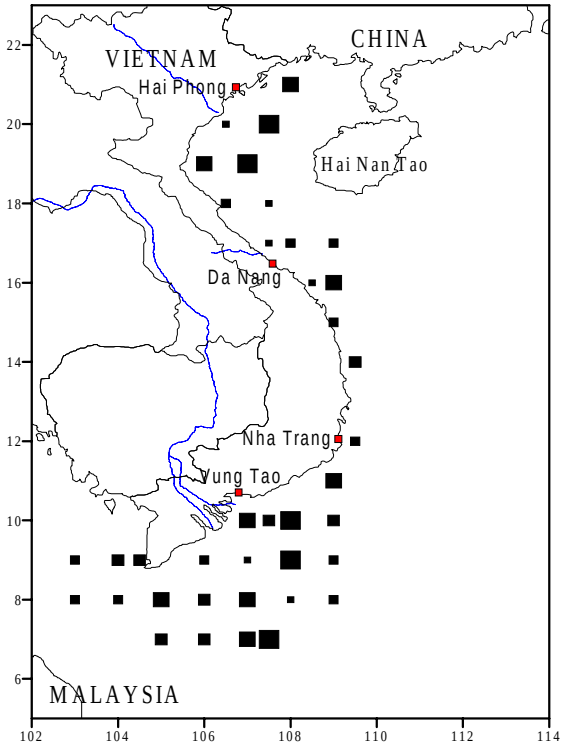

Fig. 5. The abundance of zoobenthos in the Vietnamese waters.

Discussion

It could be about 180 recorded invertebrate species did not reflect sufficiently richness and abundance of macrobenthic fauna of Vietnamese sea area. This is only a part of picture on species composition and its distribution in the offshore of Vietnam. In fact, only respective soft bottom community of a narrow area of the Northwest of Tonkin gulf called Hai Phong - Quang Ninh sea were recorded about 465 macrobenthic species (zoobenthos). While Tonkin gulf fauna is considered poorer than the south-east fauna [Chung N.V. (1994)].

However the recent surveyed results on zoobenthos permitted assess biological environmental status of the Vietnamese sea.

Firstly, it was affirmed that the structure of a soft bottom community composed of 4 major group (Polychaeta, Crustacea, Mollusca, Echinodermata). When this structure is changed it is question to environmental changes.

It is clear that, coastal zone of Vietnam runs from North to South with about 3260 km. Along this coastal line has four main river mouth systems. Among them Mekong river system in the Southeast is the largest then to Red river system. Every year this river system discharge into the sea hundreds or

even thousands of alluvium soil accompanying with rich nutrient substances. It may be one of the principal reasons causing different richness and abundance of zoobenthos among sea regions of Vietnam.

Analyzing results shown that the South-east region which was the richest species number (occupied 63.3% total fauna species) but abundance and biomass stood after Tonkin gulf region while species composition of Tonkin gulf was poorer and stood right way after that of Southeast and occupied of 32.2% total species. In general these two regions were higher both in species composition and abundance than those in the rest two regions.

Among major zoobenthos groups of soft bottom communities of the survey area, Polychaeta and Mollusca were always the most superior in abundance. Polychaeta was richer than Mollusca in species composition but poorer than Mollusca in density and biomass. This situation occupied both in the whole survey area in general and in every sea regions in particular.

In near-shore areas which located in the depths below 60m, zoobenthos concentrates more distribution. In these depths about 140 species (80% total species number) were recorded and their density reached the highest. It can see that near shore areas are strongly affected by environmental pollution so here considered the most sensitive places.

On the sea bed, especially on sandy component and muddy mixed shell which was more suitable for adaptable distribution of zoobenthos. So on these bottom areas abundance of zoobenthos was higher than that on other substrates especially on fine mud.

When comparing between abundance recorded in this survey with the previous results on same regions more changes in density of zoobenthos were seen. For example, density of zoobenthos among four regions such as Tonkin gulf, Central, Southeast and Southwest used to reach 103, 52, 193 and 257 ind/m^2 respectively [Canh N.T. (1996)] but recent survey results were about 178, 90, 141 and 83 ind/m^2 respectively. It is clear that there were more changes relating to environment issues in the whole of survey area. This matter is suitable completely with diversity indices recently calculated, that is abundance of zoobenthos in central sea region is always lower than that in other regions.

Conclusion

About 180 benthic invertebrate species (Zoobenthos) of 130 genera, 72 families belonging to 5 major groups were found out from specimen sampled on 38 survey stations in Vietnamese seawaters. Among zoobenthos groups, Polychaeta was the most abundance with 78 species, occupied 43.4% of total species, then to Mollusca - 49 species, 27.2%, Echinodermata - 26 species, 13.5 %; Crustaceans - 23 species, 12.8% and the others (Coelenterata, worms) - 4 species, 2.2%.

Quantity average of zoobenthos varied strongly among taxonomic groups or among regions and related to types of substrate or to water depth.

The superiority of species composition in general leads to their superiority of abundance in every landscape or in the sea regions. Especially, superiority of Polychaeta and Mollusca both in species composition and abundance can be seen in benthic fauna or in the sea regions.

So their variations were expressed in diversity indices. And it is very useful for us to use zoobenthos to assess sea water quality.

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