F-5.2.1 Studies on the effects of change of water quality on biodiversity in coral reef areas

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Abstract The establishment of the method to monitor the healthiness of coral communities was studied by using the polychaete faunal composition of sandy bottom closely associated with the coral communities. Many indibiduals of high species diversity of meiobenthic polychaetes were sorted in rather small amount of sampling sand. The faunal compositions of samples from the same site are very similar each other. However, those are much different among the samples of different sites. Furthermore, there are many species appeared in one or two sites restrictively. These results show the high possivility of usufulness of polychaete species as good bio-indicators for monitoring of environments around coral communities.

Key Words Coral, Healthiness, Water quality, Monitoring method, Sandy polychaete fauna

1. Introduction

Coral reef areas have high biodiversity and high productivity. Therefor, it occupies a very impotant part of the global ecosystem of out planet. [1] Coral communities distributed over the tropical and subtropical areas, however, they are much damaged, mainly caused by the human activities. [2] Coral communities, chiefly consisting of hermatypic Scleractinian corals, are distributed the shallow water areas of rather warm regions between 30° N and 30° S. Japanese coral comunities belong to the northern limit population of the world, and those are very important concerning the academic interests and nature conservation. Unfortunately, the coral communities distributed in southern part of our nation have been damaged, and the conservation of them may be one of the most important dueties of the nation. [3]

Recognitions to the present state and also to the change of condition of coral communities are very important for conservation of them. Monitoring is very usefull method for recognizing the condition of coarl communities distributed rather wide areas. Coral reef ecosystem inculdes high species diversity. Because of this complexity, the human impacts may be detect in eary stages. Some marine species act sensitively against the change of environment, and change rapidly the mode of their presence. The sensitivity of these species may be very high comparing with the mechanical measurements, and these are thought as a good bio-indicators.[4]

Most important factor of environmental disturbance of coral communities may be the change of sea water quality surrounded the corals. Resently, butterflyfishes are shown to be a good bio-indicator,[4] and monitoring method by general people is now map out the program.[5] Butterflyfishes (Chaetodontidae) may have good factors of bio-indicator for coral reefs. They differenciated into many species, and distributed in coral reef areas.

And it is rather easy to recognize the species for us by obserrvation of the color pattern of their rather large- sized body sides. Therefor, many people can attend the monitoring programs using butterflyfishes in the wide region.

Butterflyfishes check is also better object for getting qualitative data, but is rather difficult for quantitative analysis. Of the other organisms for indicator of coral reefs, many groups of organisms live directly associate with the corals themselves. They are consisted of rather free moving animals, attaching organisms, and boring ones. But the bio- communities directly associated with corals in coral reefs generally show the great high species diversity (Uchida, unpublished). Therefor, it may be very difficult to identify the organisms from the coral communities, and analyze them for finding the good indicators. Futhermore, these organisms directly associated with corals are very difficult to draw from the corals, not only quantitatively, but qualitatively.

On the other hand, there are sandy bottom distributed everywhere nearby the coral communities of tropical and subtropical shallow water area. And the species diversity may not be so complex, comparing with those from corals themselves. The sampling of the sandy bottom biota may be rather easy comparing with biota directly from the corals, and quantitative treatment may be rather easy comparing with the data of swimming nekton (fishes).

2. Research Objective

Research for finding of probability of suitable bio- indicators for monitoring the sea water quality surrounded the coral communities from the biota in sandy bottoms situated closely near to coral communities.

3. Establishment of Sampling Method and Objective Organisms

Biota in sandy bottom is not so large. Therefor, two directions of sampling may be considerd, on the point of the sampling amount of sand and mesh size of filter for sorting of biota. Two different samplings were carried out for detemination of sampling method of sand. Result is as follows.

Sampling sand (kg)	Mesh size (mm)	Sorting	Biota (No. species / No. indib.)
17 ～ 33	1	naked eyes	16- 32 / 21- 47
ca. 6	ca.0.3	Binocular Microsc.	62- ca.200 / 545- 2300

The method of small amount of sand includes agitation of sampling sand with some amount of sea water, and the water is filtered by Mueller Guaze GG54 (mesh size 0.328mm) while the organisms are suspending. The small amount method shows the yield of enough numbers of species and indibiduals.

Organisms found in the sandy bottom belonged to many kinds of Inbertebrates animal groups, but no living plants nor parts of them appeared. And dominant groups of animals appeared are Nematoda, Polychaeta and Copepoda. Nematoda is very difficult to identify. Copepods also difficult for general people to identify, because the anatomy of appendages, especially mouth part, requires special technique, which is not suitable for researchers except for the specialists of Crustacea.

The remaining group, Polychaeta, is the most dominant animal group in sandy bottom animal communities, and most of them are small in size, belonging to meiobenthic fauna. The taxonomy of the group is hitherto not so studied, but the taxonomic characters of the group are almost externally, and they can be observed by microscope as hole mount

Table 1. Dominant Polychaeta species in each sample.
(Orders are the species with larger number of indibiduals in each sample.)

Order		1		2		3		4		5		6
St.	Sample No.	Species Number (No. of indibiduals)										
North Coast, Tidal												
1	1	8 (71)		26 (31)		32 (24)		4 (17)		7 (10)[1]		36 (6)
1	2	8 (219)		26 (37)		7 (32)[1]		32 (19)		4 (18)		22 (7)
1	3	8 (178)		26 (44)		7 (34)[1]		4 (25)		22 (13)		5 (10)
West Coast, Tidal												
2	1	7 (28)[1]		19 (6)		2 (4)						
2	2	7 (38)[1]		2 (3)	=	19 (3)						
2	3	7 (23)[1]		19 (6)		2 (4)	=	21 (4)				
East Coast, Moat												
3	1	30 (23)[a]		14 (15)		17 (11)		16 (9)	=	20 (9)[2]		15 (8)
3	2	16 (28)	=	18 (28)		30 (26)[a]		14 (25)		17 (24)		9 (18)
S- W Coast, Moat												
4	1	34 (119)		1 (27)[4]		11 (15)[3]		3 (14)[e]		31 (13)		20 (11)[2]
4	2	34 (184)		11 (28)[3]		1 (25)[4]		3 (22)[e]		23 (21)	=	31 (21)
North Coast, Patch Reef												
5	1	13 (51)[b]		25 (7)[c]		28 (3)		29 (2)[d]				
5	2	13 (116)[b]		25 (10)[c]		28 (7)		1 (6)[4]	=	29 (6)[d]		
West Coast, Patch Reef												
6	1	24 (81)		11 (58)[3]		6 (34)		33 (26)		10 (17)		27 (12)
6	2	24 (74)		11 (51)[3]		6 (49)		12 (36)		35 (22)		33 (21)
Between St. 5 & St. 6, but nearer to St. 5.												
7		B (11)		29 (6)[d]		13 (4)[b]	=	25 (4)[c]		C (3)		
Between St. 5 & St. 6, but nearer to St. 6.												
8		30 (35)[a]		A (34)		11 (24)[3]		29 (16)[d]		3 (14)[e]		

Species numbers:
1. *Glycera lancadivae*; 2. *Glycinde* sp. j.; 3. Gen. near *Giptis* sp. r.; 4. *Exogone dispar*; 5. *Exogone* sp. r.; 6. *Sphaerosyllis* sp. c.; 7. *Sphaerosyllis* aff. *glandulata*; 8. *Sphaerosyllis* aff. *magnidentata*; 9. *Opistodonta morena*; 10. *Pionosyllis* sp. y.; 11. *Pionosyllis* sp. l.; 12. *Plakosyllis brevipes*; 13. *Streptosyllis* sp. s.; 14. *Opisthosyllis* sp. m.; 15. *Typosyllis* aff. *alternata*; 16. *Typosyllis* aff. *variegata*; 17. *Typosyllis* sp. ≍ (?= *Ty.* aff. *variegata*); 18. *Pholoe* sp. m.; 19. *Pisionella* sp. r.; 20. *Pseudeurythoe* sp. m.; 21. *Kinbergonuphis* sp. y.; 22. *Protodorvillea* aff. *egena*; 23. *Protodorvillea mandapamae*; 24. Gen. near *Protoariciella*, sp. b.; 25. *Scoloplos (Scoloplos)* sp. r.; 26. *Aonides notosetosa*; 27. *Prionospio (Minuspio)* sp. f.; 28. *Prionospio (Prionospio)* sp. nr. o.; 29. *Rhynchospio* sp. p.; 30. *Acesta eximia*; 31. *Caulleriella alata*; 32. *Macrochaeta* sp. m.; 33. *Polyophthalmus pictus*; 34. *Capitomastus minimus*; 35. *Diplocirrus* aff. *capensis*; 36. *Polycirrus* sp. p.
A. *Micropodarke dubia*; B. *Pionosyllis* sp. m.; C. *Pseudophelia anomala* (?)

1) ～4), a) ～e) show the same species appeared in the different stations
1) ～4) mean that only 4 species were in common among different stations.
a) ～e) are new additions of the same species for additional survey of 2 stations (Sts. 7- 8) situated between St. 5 and St. 6.

preparations.

As mentioned above, Annelida Polychaeta is the most promising group of bio- indicators among the sandy fauna of coral reef areas.

4. Result of Polychaeta Analysis and Discussion

Sand samplings were carried out at six different stations around Kuroshima (24° 15′ N, 124° 00′ E), Yaeyama group, Nansei Islands, Japan. 2 stations (Sts. 1- 2) are situated on sandy beach and baech of small pebbles respectively, and 3 samples each were collected at these stations. Remaining 4 stations are situated just beside of coral communities of different types each other, and 2 samples were collected at each station. Samples of each station included 255 - 894 indibiduals of 28 - 98 different species of Polychaeta, exept for St. 2, in which, 132 indibiduals of 12 species of Polychaeta were found. And more than 220 species of Polychaeta of 117 genera in 35 different families were identified.

Table 1. shows the dominant species in each sample. It is clearly shown that the polychaete faunal compositions in the same station are very similar, but very different between any two stations. The result suggests that the polychaete species compositions may largely differ according to rather small difference of environmental condition of sandy bottom. On the main factors of differece of condition of sandy bottom for polychaete species, two important factors are supposed.
They may be water quality and grain size of sand. Rough survey on grain size analysis shows no significant differences among stations, except for St. 2, mentioned elswhere. Therefor the difference of species compositions may be resulted from the water quality.

Further two stations (Sts. 7- 8) were surveyed. These stations are situated between St. 5 and St. 6. St. 7 is nearer to St. 5, and St. 8 is nearer to St. 6. If the differences is resulted from water quality, the species compositions of Sts. 7- 8 is expected intermediate of those of Sts. 5- 6, and if it is resulted from grain size, the species composition is expected not so. The results (Table 1) is clearly shown that the former case. The species composition of St. 7 is rather similar to St. 5, and those of St. 8 is rather similar to St. 6, or St. 4. The results suggest the presence of the gradient of water quality from St. 5 to St. 6.

Another kind of survey was carried out as follows, for check of influence of presence of coral communities on polychaete species composition. Two lines were situated to the directions of west and south respectivery, from the western- and soutern- most pont of a patch reef (same site of St. 1 in Table 1), and each 5 survey points were situated along the lines at interval of 10m. Results are shown in Tables. 2- 3.

Table 2 is for the environmental condition of each station, also with the grain size analysis, and amount (wet weight) of small dead pieces of algae. Table 3 is for the polychaeta dominant species, just same form in Table 1. All stations have similar species composition, exept for W- line 0m (Table 3). Species composition of West line 30m (★), especially, almost same as those of St. 5 in Table 1, and those of South line 20m and 30m (☆) also similar to those of St. 5 in Table 1. Environmental conditions of all stations are also similar, and it is easy found that W 0m differed from all other points on the larger amount of algal pieces. The amount of algae (5g) was not so large comparing with toral amount of sampling sand (ca. 10kg). It may be true that the algal pieces changed water quality near or inside of the sand layer, rather than that the presence of the algal pieces themselves induced sertain species of Polychaeta. Futhermore, the result shows that the presence of coral communities themselves may not affected on species composition of Polychaeta living in the sandy bottom situated beside them.

Table 2. Some environmental condidtions in line survey.

	Depth (m)	Sand (kg)	W. temp. surface	W. temp. bottom	Salinity	Grain size	Algae (g)
West line	(1998/04/18)						
0m	5.4	9.4	26.6	26.6	35.9	95- 3- 1- 1	5.0
10m	5.8	9.5	26.6	26.6	35.7	96- 2- 1- +	0.50
20m	6.3	8.9	26.6	26.6	35.5	95- 3- 1- 1	0.23
30m	6.6	8.9	26.6	26.6	35.5	92- 5- 2- 1	0.54
40m	7.1	9.1	26.6	26.6	35.6	95- 3- 1- 1	0.39
South line	(1998/04/19)						
0m	4.0	9.2	26.4	26.6	35.8	94- 4- 1- 1	0.05
10m	4.2	9.1	26.6	26.5	35.8	91- 7- 2- 1	0.22
20m	4.5	9.0	26.5	26.5	35.4	95- 3- 1- 1	0.07
30m	4.7	9.7	26.5	26.5	35.4	96- 3- 1- +	0.20
40m	4.8	8.8	26.5	26.5	35.4	97- 2- +- +	+

Grain size composition a- b- c- d means a < 500 μ m < b < 1mm < c < 2mm < d

Table 3. Dominant Polychaeta species in each sample in line survey.

Order	1	2	3	4	5	6	
	Species Number in Table 1 (No. of indibiduals)						
West Line							
0m	30 (16)	J (12)	25 (10)	13 (9)	34 (8)		
10m	13 (94)	I (10)	H (7) =	25 (7) =	29 (7) =	L (7)	
20m	13 (103)	E (16)	28 (6) =	29 (6)	30 (5)		
30m	13 (66)	25 (11) =	28 (11) =	29 (11)	G (6)		★
40m	13 (52)	E (12) =	N (12)	25 (11)	F (10)		
South Line							
0m	13 (53)	D (28)	30 (19)	29 (11)			
10m	13 (107)	D (9)	29 (5)	30 (4)			
20m	13 (132)	30 (10)	K (7)	25 (6)	29 (4)		☆
30m	13 (144)	30 (14)	25 (4) =	M (4) =	O (4)		☆
40m	13 (145)	30 (12)	M (7)	K (6)	L (3)		

Species numbers: see Table 1.

Others: D. *Microphthalmus* sp. m.; E. *Pionosyllis* aff. *magnifica*; F. *Streptosyllis* sp. j.; G. Gen. near *Langerhansia*, sp. a.; H. *Lumbrineris shiinoi*; I. *Aricidea* sp. f.; J. *Armandia* sp. f.; K. *Armandia* sp. m.; L. Gen. of Capitellidae, sp. y.; M. *Notomastus (Notomastus) polyodon*; N. Gen. near *Filibranchus*, sp. p.; O. *Chone filicaudata*

All of the results suggests that small Polychaeta species living in the sandy bottom show the prefference of the small and delicate difference of sea water conditions. The high sensitivity toward the change of environmental conditions is caused by the high species diversity of Polychaeta, and short life- span of them. They can quickly disperse thier habitats in any sandy bottom of the suitable condition, and can inclease the population for a short time because of thier short life- span. And all the results show the high possibility of usufulness of Polychaeta living in the sandy bottom as suitable bio- indicators of sea water quality.

6. References

1) Odum, H. T. & E. P. Odum. 1955. Trophic structure and productivity of a Windward Coral Reef community on Eniwetok Atoll. Ecol. Monogr., 25: 291- 320.
2) Birkeland, C. (ed.) 1977. Life and Death of Coral Reefs. 536 pp., Chapman & Hall.
3) Veron, J. E. N. 1992. Conservation of biodiversity: a critical time for the hermatypic corals of Japan. Coral Reefs, 11: 13- 21.
4) Roberts, C. M., R. F. G. Ormond & A. R. D. Shepherd. 1988. The usefulness of butterflyfishes as environmental indocators on coral reefs. Proc. 6th Internat. Coral Reef Symp., 2: 331- 336.
5) Crosby, M. P. & E. S. Reese, 1996. A manual for monitoring coral reefs with indicator species. Butterfly fishes as indicators of change on Indo- Pacific reefs. 6th Internat. Coral Reef Symp., 2: 331- 336.