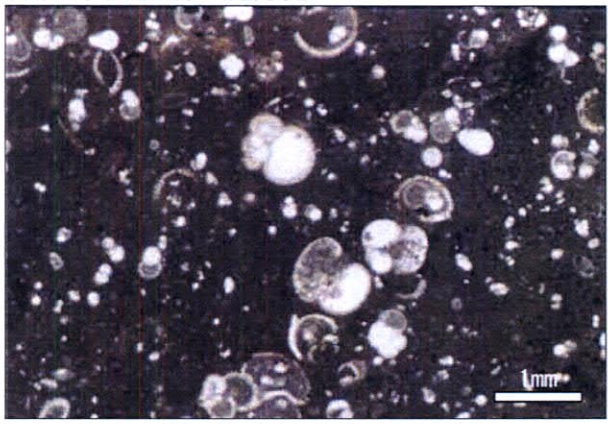
Plate VI Foraminifera

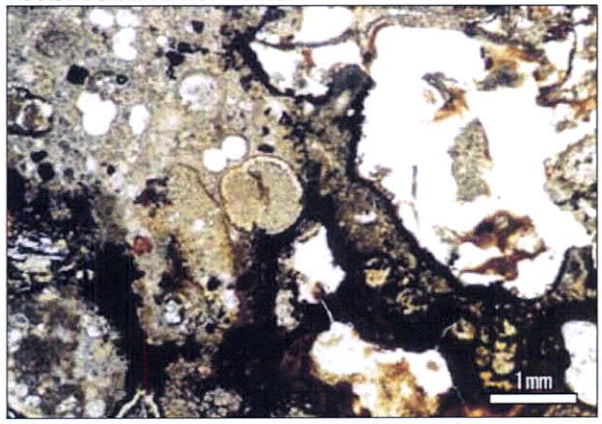
-Micrographs-

05SMC12AD20 FRC01



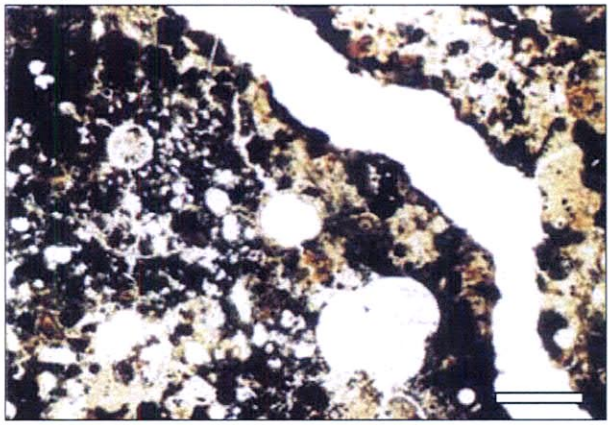
Limestone with planktonic foraminifera

05SMC12AD25 FR01



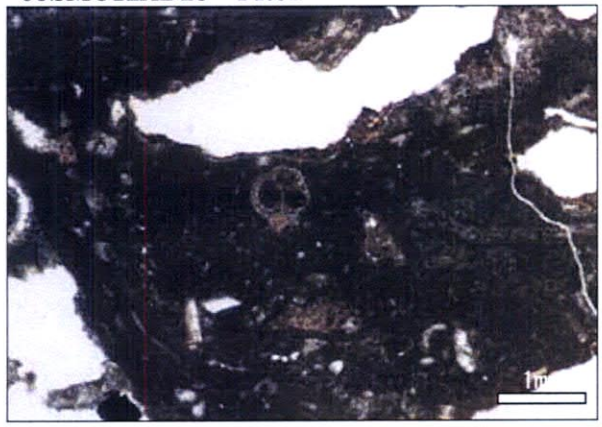
Calcareous conglomerate with planktonic foraminifera (G. binaiensis)

05SMC12AD29 FR01



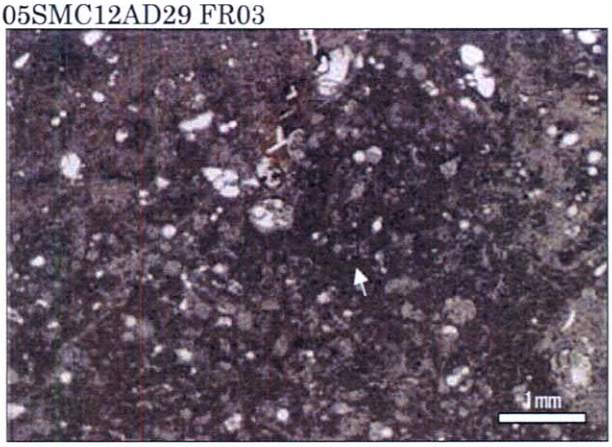
Limestone with planktonic foraminifera (Globigerina sp.)

05SMC12AD29 FR02



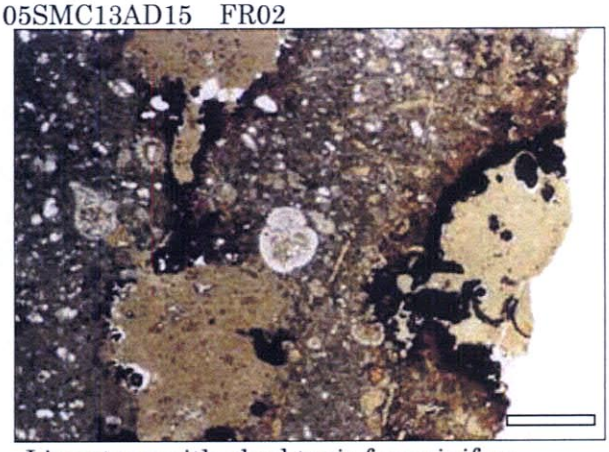
Limestone with planktonic foraminifera Glonigerinatheka sp., Middle Eocene

05SMC12AD29 FR03



Limestone with benthic Foraminifera

05SMC13AD15 FR02



Limestone with planktonic foraminifera *Glonigerinatheka* sp. , Middle Eocene

Plate - 1

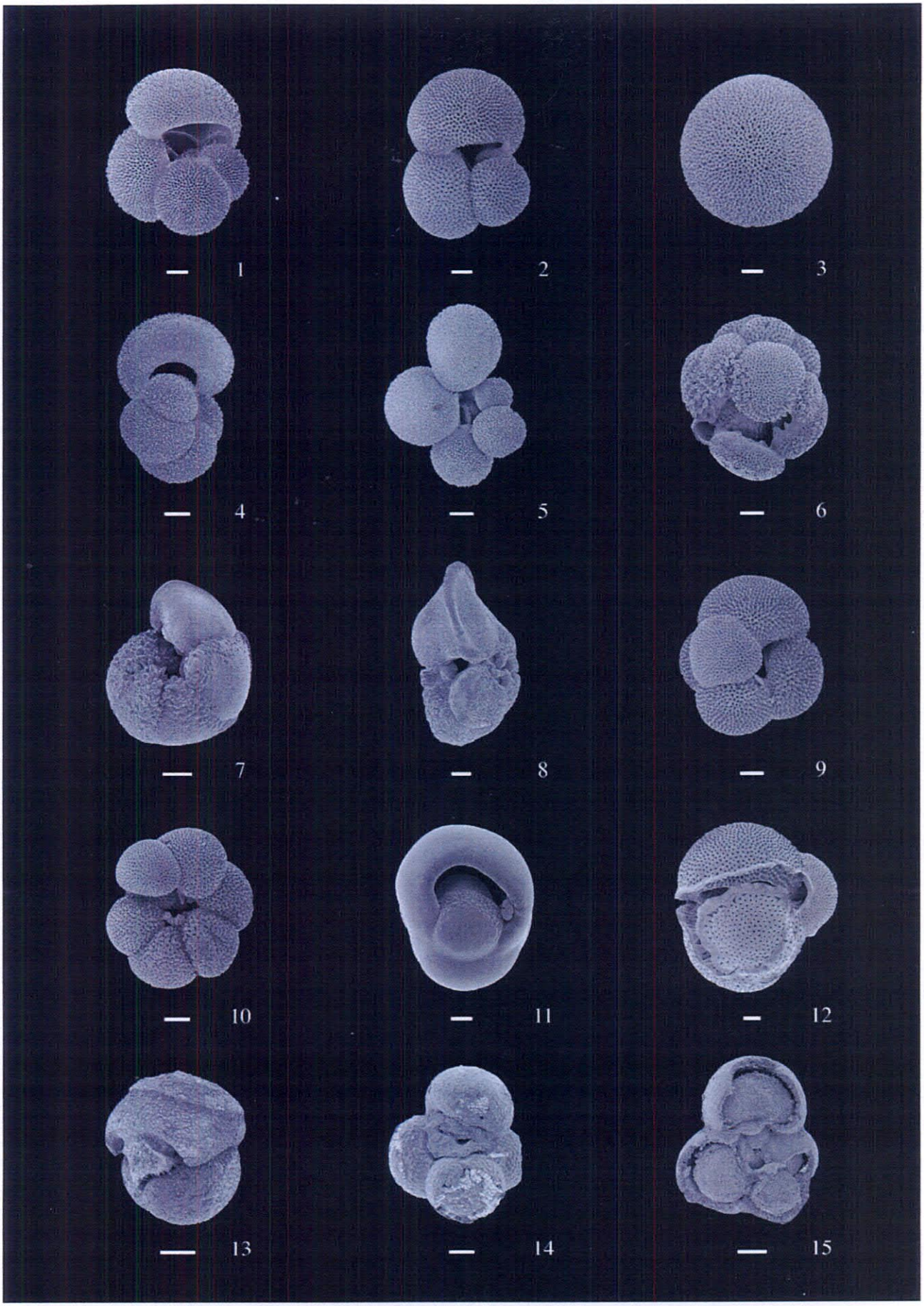


Plate 1. Planktonic Foraminifera SEM Micrograph

Fig.1, , *Globigerinoides conglobatus* (Brady)

MC13 Sea Moumtain, 05SMC13MC02FS02

Fig.2, *Globigerinoides sacculifer* (Brady)

MC13 Sea Mountain, 05SMC13MC02FS02

Fig.3 *Orbulina universa* d'Orbigny

MC12 Sea Mountain, 05SMC12MC01 FS01

Fig.4, *Globigerinella aequilateralis* (Brady)

MC12 Sea Mountain, 05SMC12MC01 FS01

Fig.5, *Globigerinella calida* (Parker)

MC12 Sea Mountain,05SMC12MC01 FS01

Fig.6, *Dentoglobigerina altispira* (Cushman and Jarvis)

MC13 Sea Mountain, 05SMC13MC01FS01

Fig.7, Globorotalia *truncatulinoides* (d'Orbigny))

MC12 Sea Mountain, 05SMC12MC01 FS01

Fig.8, *Globorotalia tumida* (Brady)

MC12 Sea Mountain, 05SMC12MC01 FS01

Fig.9, *Globoquadrina venezuelana* (Hedberg)

MC13 Sea Mountain,05SMC13MC01FS01

Fig.10,Neogloboquadrina dutertrei (d'Orbigny)

MC12 Sea Mountain, 05SMC12MC02FS01

Fig.11,Pulleniatina obliquiloculata (Parker and Jones)

MC12 Sea Mountain, 05SMC12MC01 FS01

Fig.12,Spharoidinella dehiscens (Parker and Jones)

MC12 Sea Mountain, 05SMC12MC01 FS01

Fig.13, Globigerina aff. ampliapertura Bolli

MC12 Sea Mountain, 05SMC12AD15 FR01

Fig.14, Globigerina aff. eocaena Guembel

MC12 Sea Mountain, 05SMC12AD15 FR01

Fig.15, Globigerina cf. praebulloides Blow

MC12 Sea Mountain, 05SMC12AD29 FR01

Scale bar:100μm

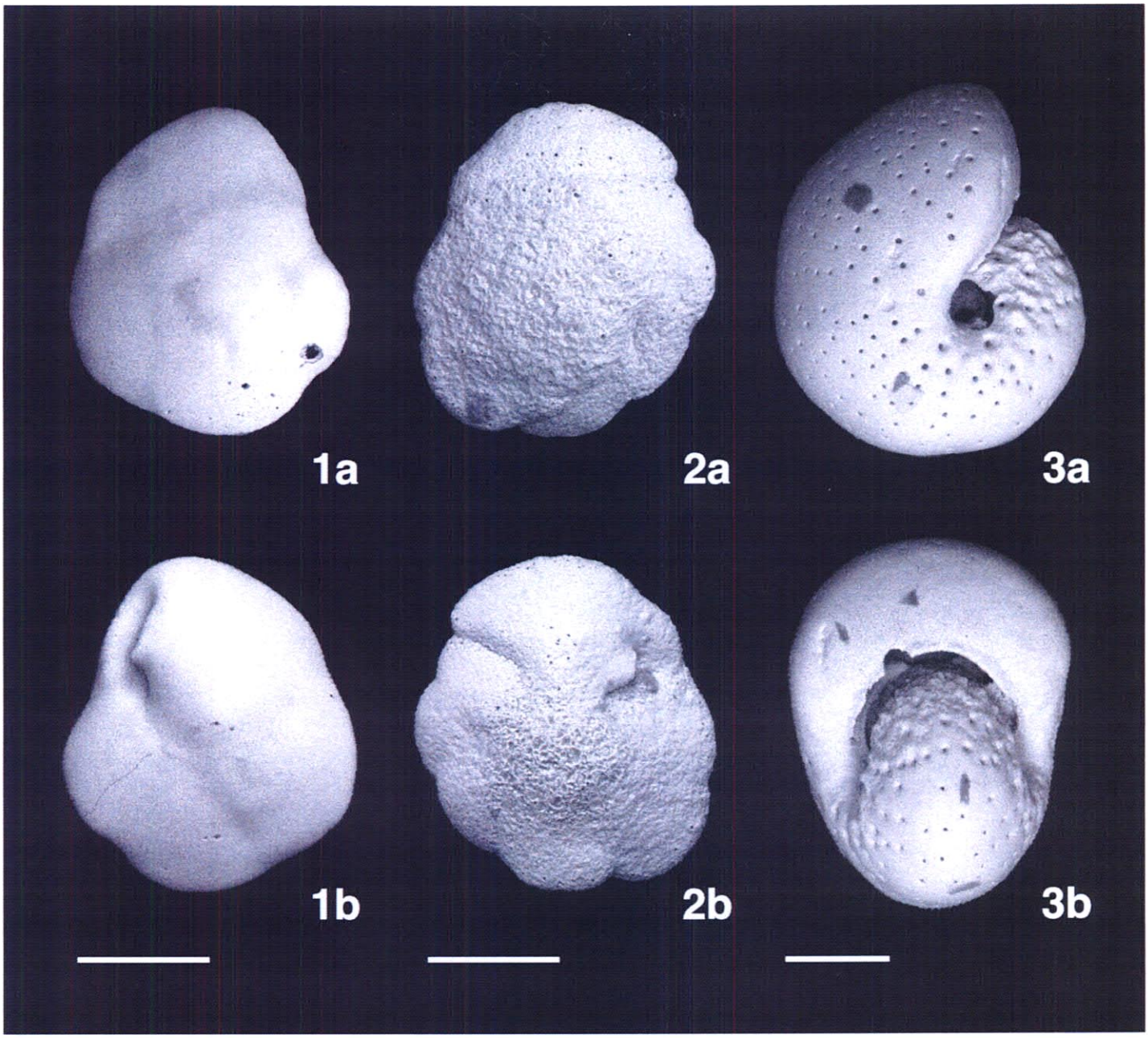

1a
2a
3a
1b
2b
3b

Plate 2 . Benthic Foraminifera SEM Micrograph

Fig. 1 a: Nuttallides umbonifera (Cushman), spiral side, b: umbilical side , X250, sample 05SMC13MC02-FS01.

Fig. 2 a: Peudoparrella exigua (Brady), spiral side, b: umbilical side, X250, sample 05SMC13MC02-FS01.

Fig. 3 a: Melonis sphaeroides Voloshinova, lateral side, b: apertural side, X200, sample 05SMC13MC02-FS01.

Scale bars show 100 μ m.

Plate VII Typical Calcareous Nannoplanktons

- Micrographs-

Plate

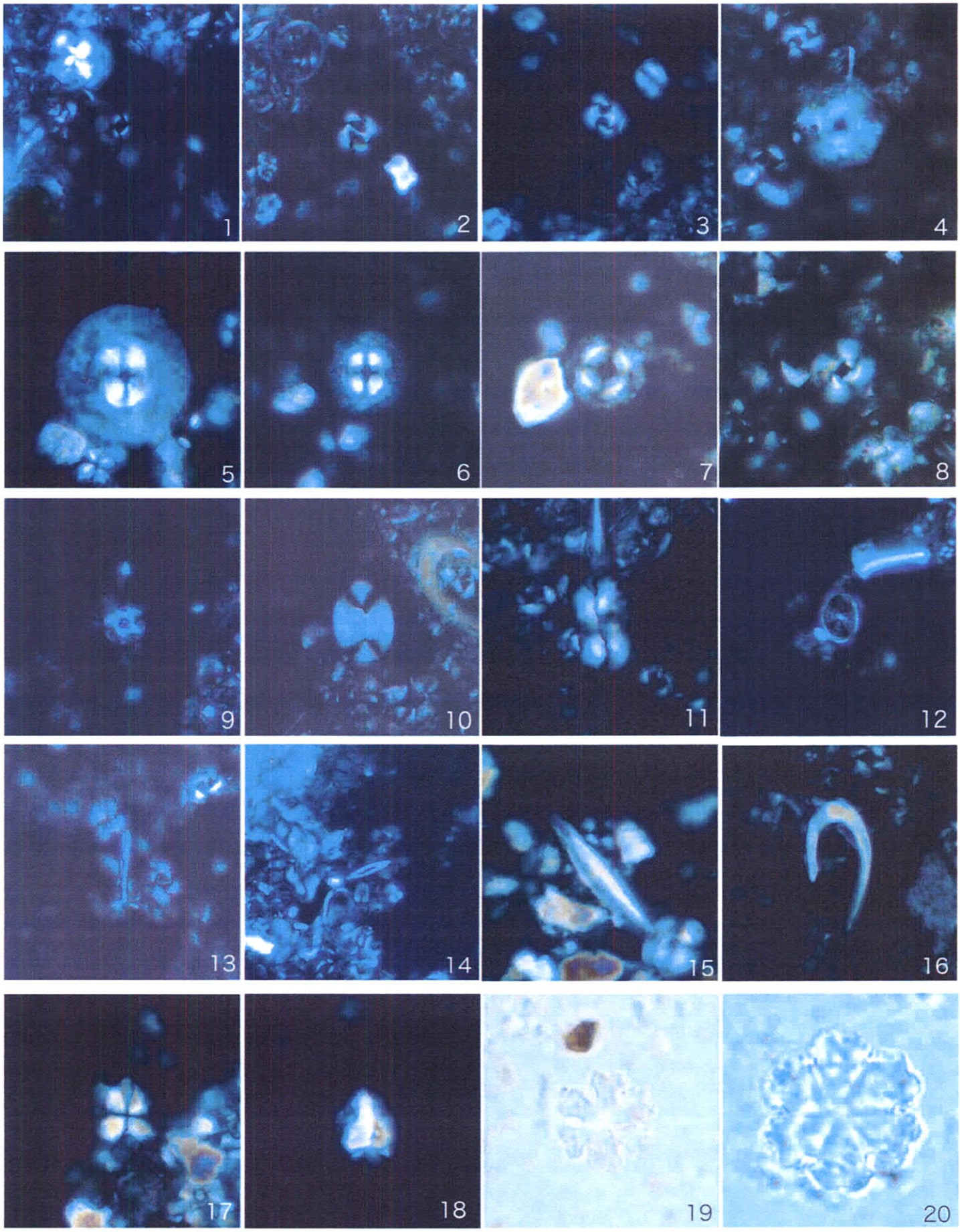


Plate 1

(scale bar: 10micron)

1. *Emiliania huxleyi* (Lohman) Hay and Mohler,

   sample 13MC02FS01

2. *Gephyrocapsa oceanica* Kamptner, sample sample 13MC02FS01

3. *Gephyrocapsa parallela* Hay and Beaudry, sample 13MC02FS01

4. *Calcidiscus macintyrei* (Bukry and Bramlette) Loeblich and Tappan, sample

   12MC01FS01

5. *Coccolithus miopelagicus* Bukry, sample 12AD25FR01

6. *Coccolithus pelagicus* (Wallich) Schiller, sample 13AD15FR02

7. *Calcidiscus formosus* (Kamptner) Loeblich and Tappan, sample 12AD299FR03

8. *Cyclicargolithus floridanus* (Roth and Hay) Bukry, sample 12AD25FR01

9. *Umbilicosphaera sibogae* (Weber-van Bosse) Gaarder

   sample 13MC02FS01

10. *Discolithina japonica* Takayama, sample 13MC02FS01

11. *Helicosphaera carteri* (Wallich) Kamptner sample 13MC02FS01

12. *Syracosphaera pulchra* Lohmann, sample 13MC02FS01

13. *Rhabdosphaera clavigera* Murray & Blackman

    sample 13MC02FS01

14. *Scapholithus fossilis* Deflandre, sample 13MC02FS01

15. *Triquetrorhabdulus carinatus* Martini, 12AD25FR01

16. *Ceratolithus cristatus* Kamptner, 13MC02FS01

17. *Sphenolithus moriformis* (Bronnimann and Stradner) Bramlette and

    Wilcoxon, sample 12AD25FR01

18. *Sphenolithus predistentus* Bramlette and Wilcoxon, sample 12AD20FR01

19. *Discoaster deflandrei* Bramlette and Riedel, sample 12AD25FR01

20. *Discoaster clculosus* Bukry, sample 12AD25FR01

Appendix 6

Environmental Survey

Appendix 6 Environmental Survey

Contents

1. Objectives

This environmental survey was carried out in designated areas as a baseline study in order to predict future impacts of deep-sea mining on the surrounding environment. This survey was divided into two main subjects with the objectives to understand: 1) the water quality and abundance of bacterioplankton; 2) the sediment properties and composition of benthic organisms.

2. Survey Area

The survey was done at two stations (seamounts) within the Exclusive Economic Zone (EEZ) of the Federated States of Micronesia. MC12 is a 60 km ridge expanding on the north-northwest and south-southeast direction located at the center of 9° 20′ N, 146° 05′ E. The highest peak of this ridge is 2,800 m from the base and is 1,141 m from the sea surface. On the other hand, MC13 has a fairly level topography (plateau) situated at 4,000 m depth at the center of 10° 20′ N, 145° 00′ E. The height of the plateau is 2,200 m from the base and is 1,656 m from the sea surface (Figure 1-1 in the report)

3. Materials and Methods

3-1 Study Subjects

3-1-1 Water Quality and Bacterioplankton

Water Quality: water temperature, salinity, nutrients (PO_4-P, SiO_2-Si, NO_2-N, NO_3-N)

Microorganisms: Bacterioplankton

3-1-2 Investigation of Sediment and Benthic Organisms

(1) Sediment properties: water content, Total Organic Carbon (TOC), total nitrogen (T-N), specific gravity

(2) Benthic organisms: sedimentary bacteria, meiobenthos, macrobenthos

3-2 Survey Methods

3-2-1 Observation, Collection, and Processing of Samples

(1) Water quality and Bacterioplankton

Water temperature and salinity were measured using a CTD (SEA-BIRD: MODEL 9 PLUS) attached to a rosette sampler (RO). The instrument had a dropping speed of 0.5 m/sec, and measurement interval of once per second. Measurements of these parameters were carried out in different points from the surface layer to 10 m

depth above the sea floor.

Samples for nutrients and bacterioplankton were taken using a Niskin water sampler (1.7 L capacity) attached to an RO, at 12 layers (0 m, 50 m, 100m, 150 m, 200 m, 250 m, 300 m, 400 m, 500 m, 1000 m, 1,500 m, and 2,000 m) from the surface. Samples were treated accordingly as described in Table 3-2-1.

(2) Properties of Sediment and Benthic organisms

Samples for determination of sediment properties and composition of benthic organisms were collected using a multiple corer (MC). Prior to sampling, a video observation was carried out to select sites with ample accumulation of sediments.
To minimize the possibility of hitting gravels, thus reducing the incidence of core obstruction, the number of cores (with 95 mm diameter) was reduced to four. Samples were sliced every 1 cm from the surface to 10 cm depth of the sediment. Samples were then treated accordingly as described in Table 3-2-1.

Table 3-2-1 Sample processing and preservation

Subjects	Processing and preservation
Bacterioplankton	Fixed by glutaraldehyde (1 % v/v) and stained by DAPI (1μg/ml), filtered by nuclepore filter (0.2μm), mounted on a slide glass; frozen
Nutrients	kept in 500mL polyvials as untreated sample and frozen
Water content, Specific gravity	20g sample was frozen
TOC, T-N	0.5~1g sample was frozen
Sedimentary bacteria	0.5~1g sample was fixed in 10 ml glutaraldehyde (1 % v/v); refrigerated
Meiobenthos	1 cm-thick sample was fixed in neutralized formalin (10 % v/v) and stained by Rose Bengal; refrigerated
Macrobenthos	1 cm-thick was fixed in neutralized formalin (10 % v/v) and stored at room temperature

3-2-2 Methods of Analysis

(1) Water quality, bacterioplankton

1) Nutrients (PO_4-P, SiO_2-Si, NO_2-N, NO_3-N)

Nutrients were analyzed by the following methods:PO_4-P · Molybdenum blue (ascorbic-acid reduction) absorptiometry;SiO_2-Si · Molybdenum yellow absorptiometry; NO_2-N · Naphthylethylenediamine absorptiometry; NO_3-N · Naphthylethylenediamine absorptiometry after copper · cadmium column reducing.

2) Bacterioplankton

Bacterioplankton on the nuclepore filters were counted using an epiflourescence microscope. Abundance was expressed as the total number of bacteria per unit volume of seawater.

(2) Properties of sediment, benthic organisms

1) Water content

The wet sample was weighed and dried in an oven at 60➡C until a constant weight was obtained. Water content was determined from the ratio between the wet and dry weights of the sample.

2) TOC, T · N

After the water content had been determined, the dry sample was measured with a CHN analyzer (MT-5 made by Yanaco) to find the total amounts of carbon and nitrogen. The sample was treated with 4-N hydrochloric acid and reaction was allowed to occur for about one hour to remove the inorganic carbon. The sample was then desiccated again and measured with the CHN analyzer.

3) Specific gravity

Samples were dried to a constant weight at 110℃ and then milled in an agate mortar. Each sample was measured into a specific gravity bottle to about 10 grams. Distilled water was added into the sample and was heated in a water bath chamber for 4 hours. It was left untouched for a whole day after which, the temperature and weight of the specific gravity bottle were measured.

4) Sedimentary bacteria

Bacteria bonding to the bottom sediment particles were exfoliated using an ultrasonic treatment into a settled solution, and then a fractional quantitation of the supernatant liquid was taken. This was stained with a DAPI (with a final concentration of 1 μ g/ml) and filtered. The trapped sediment on a nuclepore filter was mounted on a glass slide and the number of bacteria was counted using an

epiflourescence microscope. The total amount of bacteria per unit quantity of dry sediment was calculated from the dry weight of the bottom sediment material, which had been measured separately.

5) Meiobenthos

The sample stained with Rose Bengal was sieved by of 32 μ m and 300 μ m mesh sieve. Organisms that were trapped in 32 μ m were identified and counted under a microscope.

6) Macrobenthos

The sample was sieved using a 300 μ m mesh sieve to separate out the sand and mud. Organisms that were trapped in the sieve were identified and counted.

4. Results

4-1 Survey Stations

Samples for determination of water quality and bacterioplankton were taken from sampling areas designated as 05SMC12RO01 (water depth: 3,696 m) at MC12 and at 05SMC13RO01 (water depth: 2,003 m) at MC13. On the other hand, surveys of sediment properties and benthic organisms were done at two sampling points at MC12, designated as 05SMC12MC01 (water depth: 3,315 m) and 05SMC12MC02 (water depth: 2,481m) and two points at MC13 designated as 05SMC13MC01(water depth: 2,358m, and 05SMC13MC02 (water depth: 3,163m)(Fig. 4-1-1 and 4-1-2).

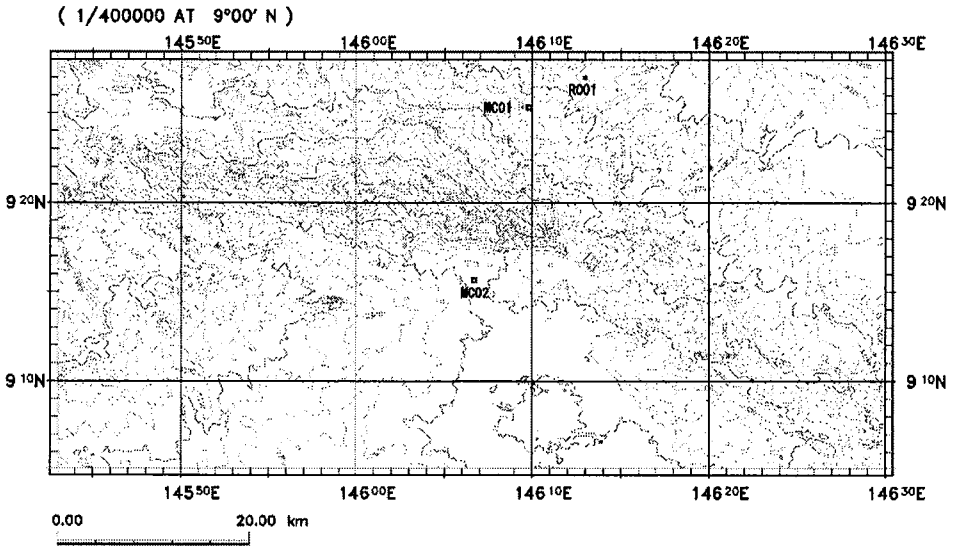


Figure 4-1-1 MC12

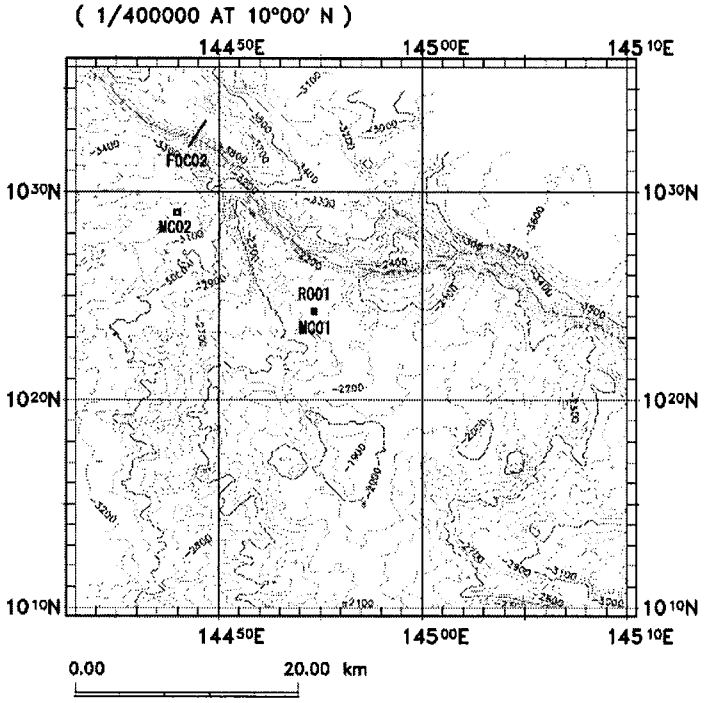


Figure 4-1-2 MC13

4-2 Water Quality, Bacterioplankton

4-2-1 Water Quality

(1) Water temperature

The water temperature ranged from 28.8°C (at the surface layer) to 1.5°C (at 3,696m depth) at 05SMC12RO01 and from 28.8°C (at the surface layer) to 2.1°C (at 2,003m depth) at 05SMC13RO01.

Water temperature was constant within 100m from the surface but decreased remarkably from 100m down to 300m. Temperature decreased slightly starting from 300m down to deeper layers (Fig. 4-2-1).

(2) Salinity

The salinity at 05SMC12RO01 was increasing from the surface to 100m reaching a peak value of 34.9 PSU at 120m. It remarkably decreased to 34.6 PSU at 200m and became stable from this depth down to deeper layers (Fig. 4-2-1). Similar pattern was observed at 05SMC13RO01 wherein increasing levels was observed within 100m from the surface. Salinity showed a peak value of 34.9 PSU at 160m. It decreased abruptly to 34.4 PSU at 320m and became stable from 320 m down to deeper layers (Fig. 4-2-1).

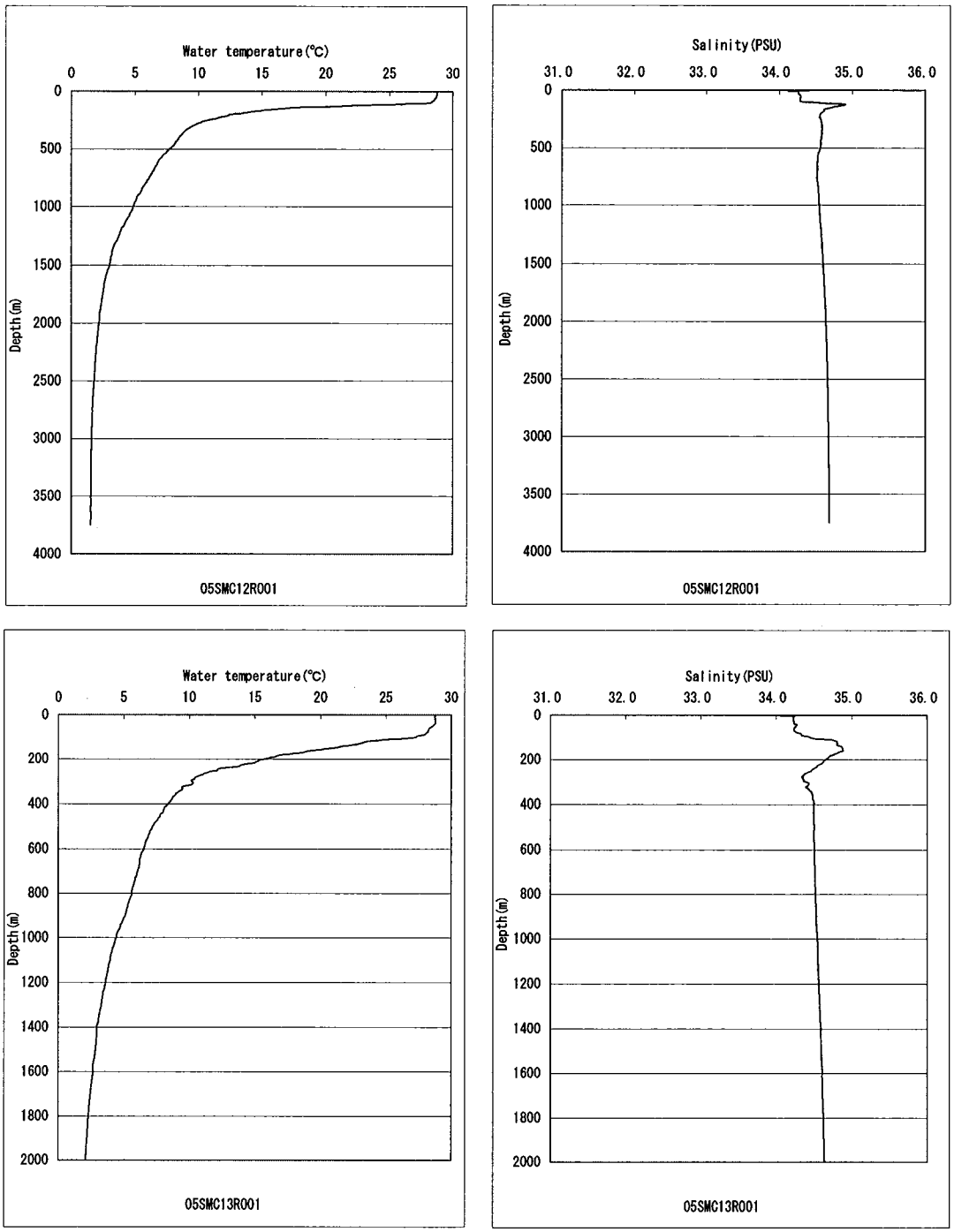


Figure 4-2-1 Vertical profiles of water temperature and salinity

(3) Nutrients

1) PO_4-P

The range of PO_4-P at 05SMC12RO01 was 0.003mg/l to 0.091mg/l from the surface to 1,500m and 0.003mg/l to 0.094mg/l from the surface down to 1,000m at 05SMC13RO01 (Fig. 4-2-2, Appendix 1). The vertical profile of PO_4-P in both stations showed similar trends. Very low levels of PO_4-P were observed within 100m but increasing between 100m to 500m depths, and becoming stable as depth increased (Fig. 4-2-2, Appendix 6-1).

2) SiO_2-Si

Very low levels of SiO_2-Si were observed within 150m in both stations (concentration was below detection limit at 100m). However, levels increased with depth, reaching a maximum level at 1,000m (2.00mg/l and 1.88mg/l at 05SMC12RO01 and 05SMC13RO01, respectively) and became almost stable from 1,500m and in deeper layers (Fig. 4-2-2, Appendix 6-1).

3) NO_2-N

Concentrations in all samples were below detection limit in both stations (Fig.4-2-2, Appendix 6-1).

4) NO_3-N

NO_3-N concentration ranged from less than 0.01mg/l (0～100m) to 0.45mg/l (2,000 m) at 05SMC12RO01. Similar observation was obtained at 05SMC13RO01 but maximum level was observed at 1,000m (Fig. 4-2-2, Appendix 6-1).

Concentrations of NO_3-N in both stations were below detection limit within 100m from the surface but increasing values were observed from 100m down to 500m. NO_3-N concentrations became stable from 500m and in deeper layers (Fig. 4-2-2, Appendix 6-1).

4-2-2 Bacterioplankton

Density of bacterioplankton at 05SMC12RO01 was 6.07×10^5 cells/ml to 1.07×10^4 cells/ml (0m - 2,000m) and 5.54×10^5 cells/ml to 1.30×10^4 cells/ml (0m- 2,000m) at 05SMC13RO01(Fig.4-2-3, Appendix 6-2).

There was a remarkable decrease in the density of bacterioplankton between 100m and 300m depths in both stations. However, a little decrease in density was observed from 300m down to 2,000m (Fig. 4-2-3, Appendix 6-2).

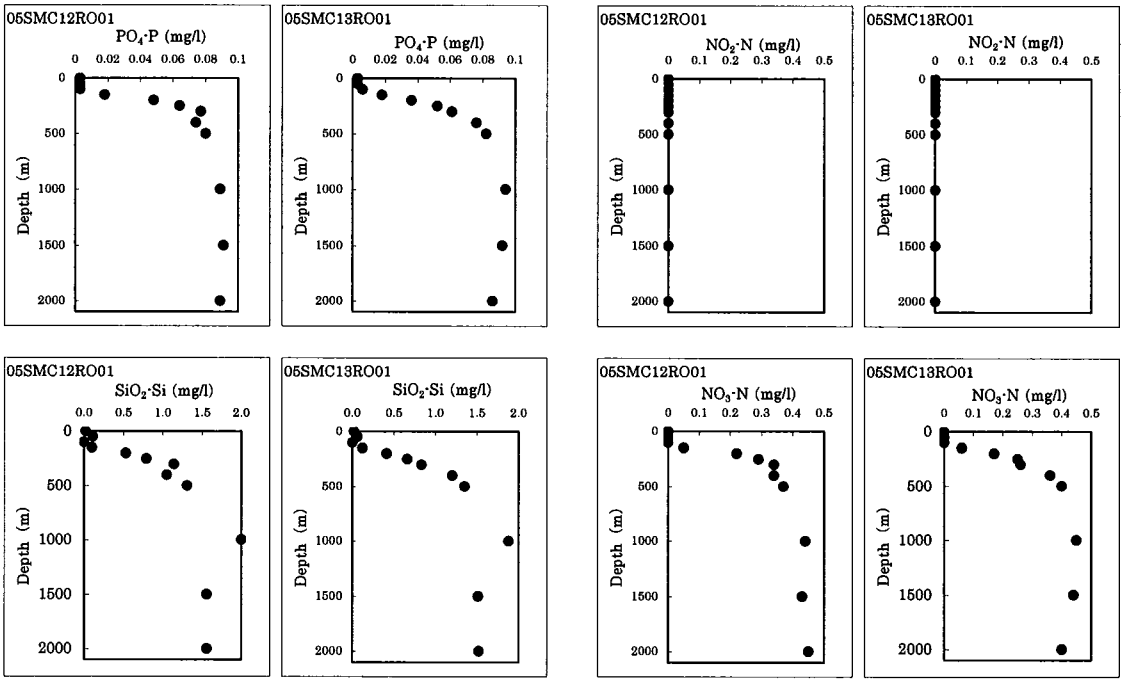


Figure 4-2-2 Vertical profiles of nutrients

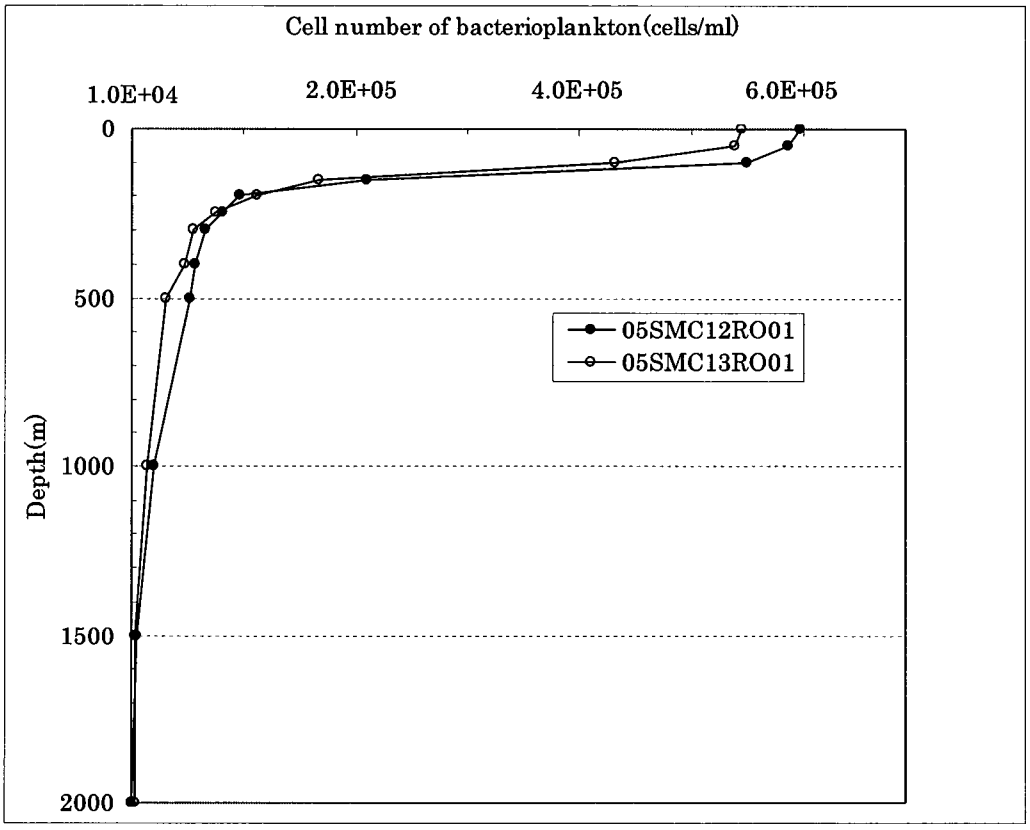


Figure 4-2-3 Vertical profiles of bacterioplankton

4-2-3 Summary

Water temperature and salinity showed similar vertical distribution in both stations. A mixed layer was observed at 100m depth and a thermocline was formed between 100m to 300m layers. Since the changes in the temperature and salinity were minimal at 300m and below, this environment could be considered stable.

PO_4-P and NO_3-N profiles were similar in both stations. Concentrations were very low within 100m from the surface and increasing thereon as depth increased to 500m. Concentrations became stable in 500m and deeper layers. As regards to SiO_2-Si, its vertical distribution was similar with that of PO_4-P and NO_3-N except that maximum concentration of SiO_2-Si was observed at 1,000m.

Bacterioplankton density showed similar pattern of vertical distribution with that of water temperature – remarkably decreasing values were observed between 100m to 300m and stabilizing in depths more than 300m.

4-3 Properties of Sediment and Benthic Organisms

4-3-1 Properties of Sediment

(1) Water content

Vertical distribution of water content is shown in Fig. 4-3-1 Appendix 6-3. The maximum level and ranges of water content of sediment from the different stations were as follows: 69.5% (0-1cm) and 51.8～57.7% (>1cm) at 05SMC12MC01; 57.8% (0-1cm) and 48.3～52.3% (>1cm layer) at 05SMC12MC02; 46.0% (8-9cm) and 42.0-45.0% in other layers at 05SMC13MC01; 62.4% in (0-1cm) and 48.2-53.0% (>1cm) at 05SMC13MC02.

Water content of sediments at stations 05SMC12MC01, 05SMC12MC02, 05SMC13MC02 was higher in 0-1cm layer and showed decreasing values in deeper layers. Water content in the 0-1cm layer at 05SMC13MC01 was the lowest and generally have low values in all layers compared with other stations.

(2) TOC

Vertical distributions of TOC concentrations in all stations surveyed are shown in Fig. 4-3-1 and Appendix 6-3. Highest TOC concentrations were observed in the 0-1cm layer in all stations with values: 1.89mg/g-dry, 1.44mg/g-dry, 1.10mg/g-dry, 1.66mg/g-dry at 05SMC12MC01, 05SMC12MC02, 05SMC13MC01, 05SMC13MC02, respectively. TOC concentrations in all stations tend to be lower in layers deeper than 1cm. The ranges of concentration were: 1.08～1.61mg/g-dry, 0.93～1.22mg/g-dry, 0.73

～1.04mg/g-dry, 0.88～1.36mg/g-dry at stations 05SMC12MC01, 05SMC12MC02, 05SMC13MC01, 05SMC13MC02, respectively. TOC concentration in the near-surface layer at station 05SMC13MC01 was lower compared with other stations.

(3) Total Nitrogen (T-N)

Vertical distributions of total nitrogen concentrations are shown in Fig. 4-3-1 and Appendix 6-3. Highest T-N concentrations were generally observed in the 0-1cm layer in all stations (0.31mg/g-dry, 0.27mg/g-dry, 0.29mg/g-dry at stations 05SMC12MC01, 05SMC12MC02, 05SMC13MC02, respectively) except at 05SMC13MC01 where maximum concentration was found in the 9-10cm layer (0.22mg/g-dry). The ranges of T-N concentrations in layers deeper than 1cm were: 0.15～0.29mg/g-dry, 0.10～0.22mg/g-dry, 0.1～0.26mg/g-dry at 05SMC12MC01, 05SMC12MC02, 05SMC13MC02, respectively, while it was 0.12～0.20mg/g-dry in the layers other than 9-10cm at 05SMC13MC01.

Stations 05SMC12MC01 and 05SMC12MC02 have similar vertical distribution of T-N concentrations. T-N concentrations at 05SMC13MC01 and 05SMC13MC02 have also similar vertical distribution except that 05SMC13MC01 had lower T-N concentration in the near-surface layer than 05SMC13MC02.

(4) Specific gravity

The vertical distributions of specific gravity in each station surveyed are shown in Fig. 4-3-1 and Appendix 6-3. Specific gravity was nearly constant at 2.70 in all layers at all stations except in the 0-1cm layer of station 05SMC12MC02 (where it was lower) and in the deeper layers of station 05SMC13MC02 where specific gravity were quite higher than 2.70.

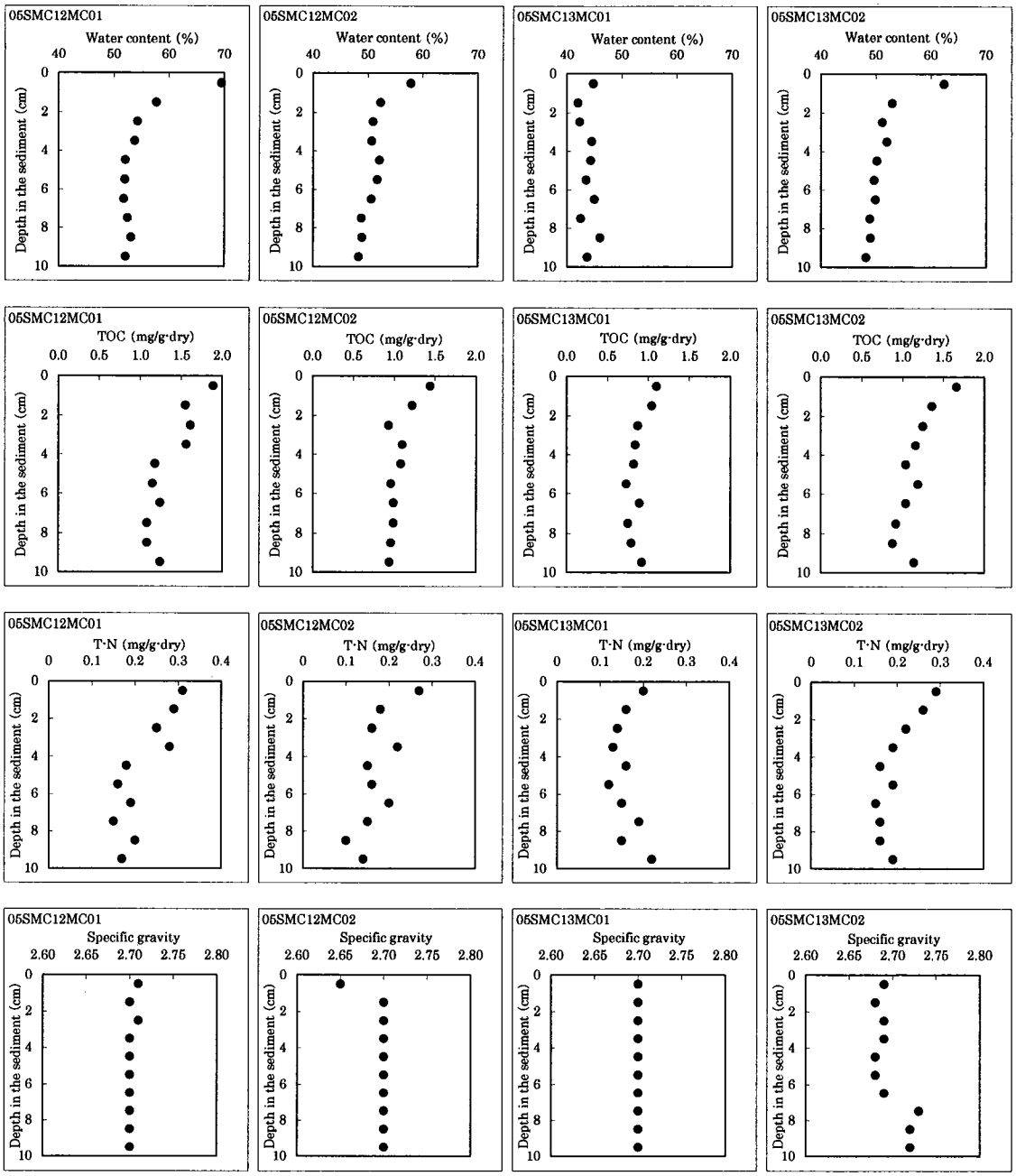


Figure 4-3-1 Vertical profiles of sediment properties

4-3-2 Benthic Organisms

(1) Sedimentary bacteria

The vertical distribution of the abundance of sedimentary bacteria in each station is shown in Fig. 4-3-2 and Appendix 6-4.

Generally, abundance of bacteria was highest in the 0-1cm layer in all stations

(8.36×10^7cells/g-dry, 2.60×10^8cells/g-dry, 7.82×10^7cells/g-dry at 05SMC12MC01, 05SMC13MC01, 05SMC13MC02, respectively) except at 05SMC12MC02 where abundance (2.33×10^7cells/g-dry) was highest in the 2-3cm layer. The ranges of abundance in layers deeper than 1cm were: 4.54×10^6～3.40×10^7cells/g-dry, 1.40×10^7～8.90×10^7cells/g-dry, 3.47×10^6 ～ 3.13×10^7cells/g-dry at stations 05SMC12MC01, 05SMC13MC01, 05SMC13MC02, respectively and 5.38×10^6～2.30×10^7cells/g-dry in layers other than 2-3cm at 05SMC12MC02.

Bacterial abundances in 0-1cm layer at stations 05SMC12MC01, 05SMC13MC01, 05SMC13MC02 were remarkably higher compared with that in station 05SMC12MC02. In addition, abundance of sedimentary bacteria in all layers at station 05SMC13MC01 was generally higher than all other stations surveyed.

(2) Meiobenthos

Fourteen taxa were identified in the meiobenthos samples, including the phyla Gastrotricha (1 taxon), Nematoda (2 taxa), Loricifera (1 taxon), Tardigrada (1 taxon), Annelida (3 taxa of Polychaeta), Arthropoda (5 taxa, consisting of 1 taxon of Arachnida and 4 taxa of Crustacea), and Ectoprocta 1 taxon) (Table 4-3-1). Nematoda, Polychaeta and Crustacea appeared in all stations.

The total abundance of meiobenthos in all layers for each station are the following: 143.6inds./10cm^2, 206.7inds./10cm^2, 30.6inds./10cm^2, and 119.1inds./10cm^2 for station 05SMC12MC01, 05SMC12MC02, 05SMC13MC01, 05SMC13MC0, respectively. Meiobenthos at station 05SMC13MC01 have a remarkably lower abundance compared with the other stations (Fig. 4-3-3). Nematoda was the most abundant in all stations (86%, 90%, 53%, 87% in station 05SMC12MC01, 05SMC12MC02, 05SMC13MC01, 05SMC13MC0, respectively).

The vertical distributions showed that meiobenthos were most abundant in the 0-1cm layer comprising the following percentage: 56%, 59%, 58%, 69% in station 05SMC12MC01, 05SMC12MC02, 05SMC13MC01, 05SMC13MC02, respectively (Fig. 4-3-4).

(3) Macrobenthos

Eight taxa were identified in the macrobenthos samples including the phyla Nematoda (1 taxon), Mollusca (1 taxon), Annelida (3 taxa of Polychaeta), and Arthropoda (3 taxa of Crustacea) (Table 4-3-2).

Total abundance of macrobenthos in each station were: 0.8inds./10cm^2,

0.5inds./10cm^2, 0.2inds./10cm^2, 0.6inds./10cm^2 at station 05SMC12MC01, 05SMC12MC02, 05SMC13MC01, 05SMC13MC02, respectively. Abundance of macrobenthos was lowest in station 05SMC13MC01 (Fig. 4-3-5).

Macrobenthos tend to be most abundant in the 0-1cm layer while they were not found in layers deeper than 3cm (Fig. 4-3-6).

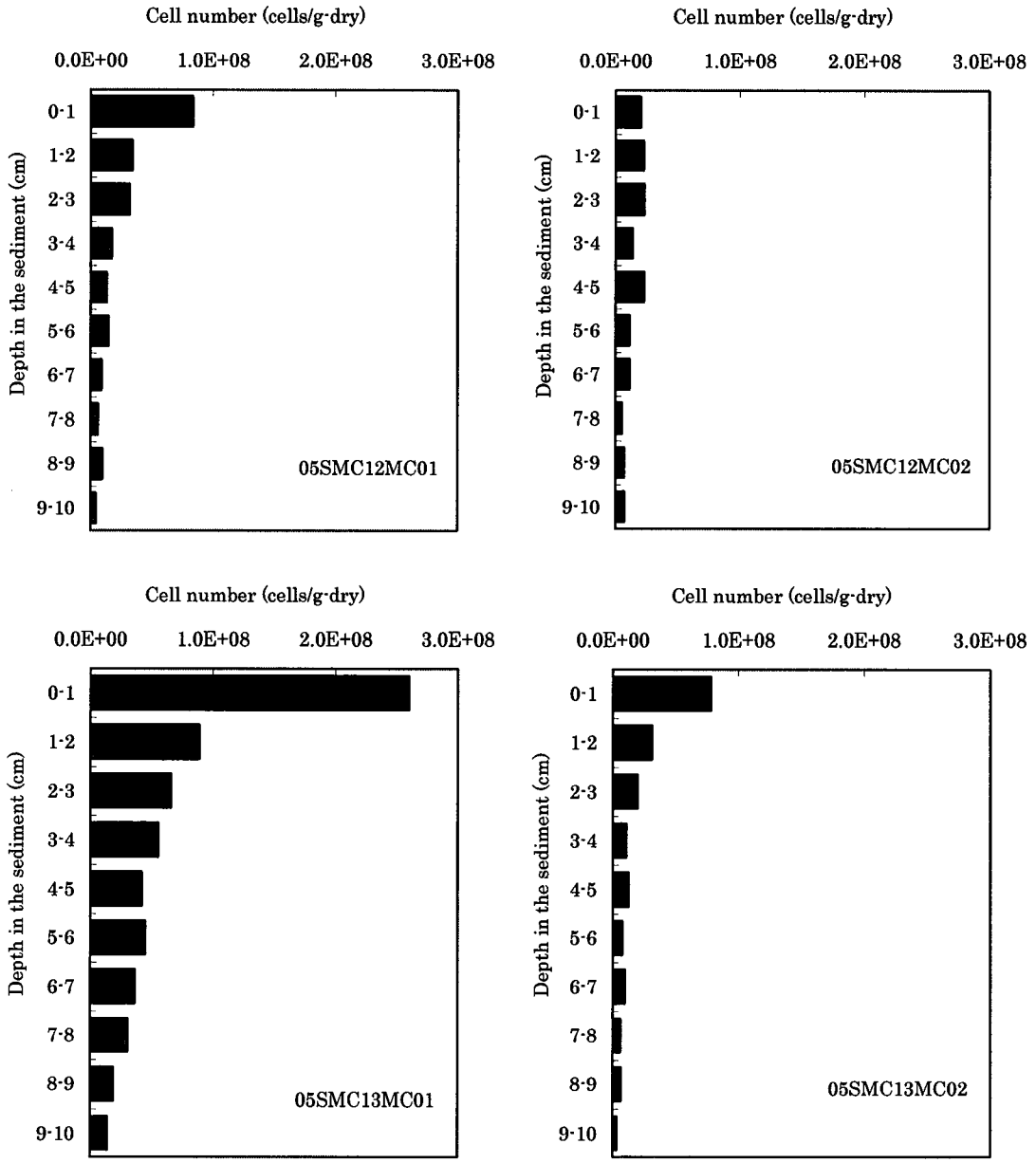


Figure 4-3-2 Vertical profiles of sedimentary bacteria

Table 4-3-1 Species and abundance of meiobenthos at each station

unit : inds./10cm^3

No.	Phylum	Class	Taxa	05SMC12MC01 (cm)									
				0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	GASTROTRICHA	–	GASTROTRICHA										
2	NEMATODA	–	NEMATODA	44.2	18.6	4.1	9.7	4.5	4.5	2.3	3.4	5.6	1.1
3			NEMATODA(Desmoscolecidae)	17.5	1.1		2.3	1.1	2.3	1.1			
4	LORICIFERA	–	LORICIFERA										
5	TARDIGRADA	–	TARDIGRADA										
6	ANNELIDA	Polychaeta	Cirratulidae		0.1								
7			Sabellidae										
8			Polychaeta	0.3									
9	ARTHROPODA	Arachnida	Acarina										
10		Crustacea	Ostracoda	0.6	0.6		0.6						
11			Harpacticoida	8.3								0.6	
12			Nauplius	9.0									
13			Isopoda	0.1									
14	ECTOPROCTA	Gymnolaemata	Nolellidae										
			total	80.0	20.4	4.1	12.6	5.6	6.8	3.4	3.4	6.2	1.1

No.	Phylum	Class	Taxa	05SMC12MC02 (cm)									
				0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	GASTROTRICHA	–	GASTROTRICHA	0.6									
2	NEMATODA	–	NEMATODA	88.6	18.2	14.1	8.0	4.5	9.7	6.4	8.5	3.4	6.2
3			NEMATODA(Desmoscolecidae)	14.7	2.3	0.6		1.1					
4	LORICIFERA	–	LORICIFERA										
5	TARDIGRADA	–	TARDIGRADA										
6	ANNELIDA	Polychaeta	Cirratulidae										
7			Sabellidae	0.1									
8			Polychaeta	0.7									
9	ARTHROPODA	Arachnida	Acarina										
10		Crustacea	Ostracoda	0.7									
11			Harpacticoida	11.2	1.3	0.1				0.6			
12			Nauplius	4.5	0.6								
13			Isopoda										
14	ECTOPROCTA	Gymnolaemata	Nolellidae										
			total	121.1	22.4	14.8	8.0	5.6	9.7	7.0	8.5	3.4	6.2

No.	Phylum	Class	Taxa	05SMC13MC01 (cm)									
				0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	GASTROTRICHA	–	GASTROTRICHA	0.7	0.3					0.1			
2	NEMATODA	–	NEMATODA	6.5	1.4	1.4	0.8	0.6	0.4	0.4	0.3	0.1	0.1
3			NEMATODA(Desmoscolecidae)	1.7	0.4	0.4	0.3	0.6	0.7	0.1			
4	LORICIFERA	–	LORICIFERA	0.6									
5	TARDIGRADA	–	TARDIGRADA	0.6									
6	ANNELIDA	Polychaeta	Cirratulidae										
7			Sabellidae										
8			Polychaeta		0.3	0.1	0.4	0.1		0.1			
9	ARTHROPODA	Arachnida	Acarina	0.1	0.1	0.1	0.1						
10		Crustacea	Ostracoda	1.3	0.3		0.1						
11			Harpacticoida	4.1	0.6	0.1	0.4	0.1	0.1				
12			Nauplius	2.3	0.3	0.3	0.3		0.1	0.3			
13			Isopoda										
14	ECTOPROCTA	Gymnolaemata	Nolellidae										
			total	17.9	3.7	2.4	2.4	1.4	1.3	1.0	0.3	0.1	0.1

No.	Phylum	Class	Taxa	05SMC13MC02 (cm)									
				0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	GASTROTRICHA	–	GASTROTRICHA										
2	NEMATODA	–	NEMATODA	54.9	18.9	4.2	3.0	4.7	3.4	1.1		1.7	0.1
3			NEMATODA(Desmoscolecidae)	11.3									
4	LORICIFERA	–	LORICIFERA	0.6									
5	TARDIGRADA	–	TARDIGRADA	1.1									
6	ANNELIDA	Polychaeta	Cirratulidae										
7			Sabellidae										
8			Polychaeta	1.7									
9	ARTHROPODA	Arachnida	Acarina										
10		Crustacea	Ostracoda	1.1									
11			Harpacticoida	4.4									
12			Nauplius	6.8									
13			Isopoda										
14	ECTOPROCTA	Gymnolaemata	Nolellidae	0.1									
			total	82.0	18.9	4.2	3.0	4.7	3.4	1.1	–	1.7	0.1

"–" : absent

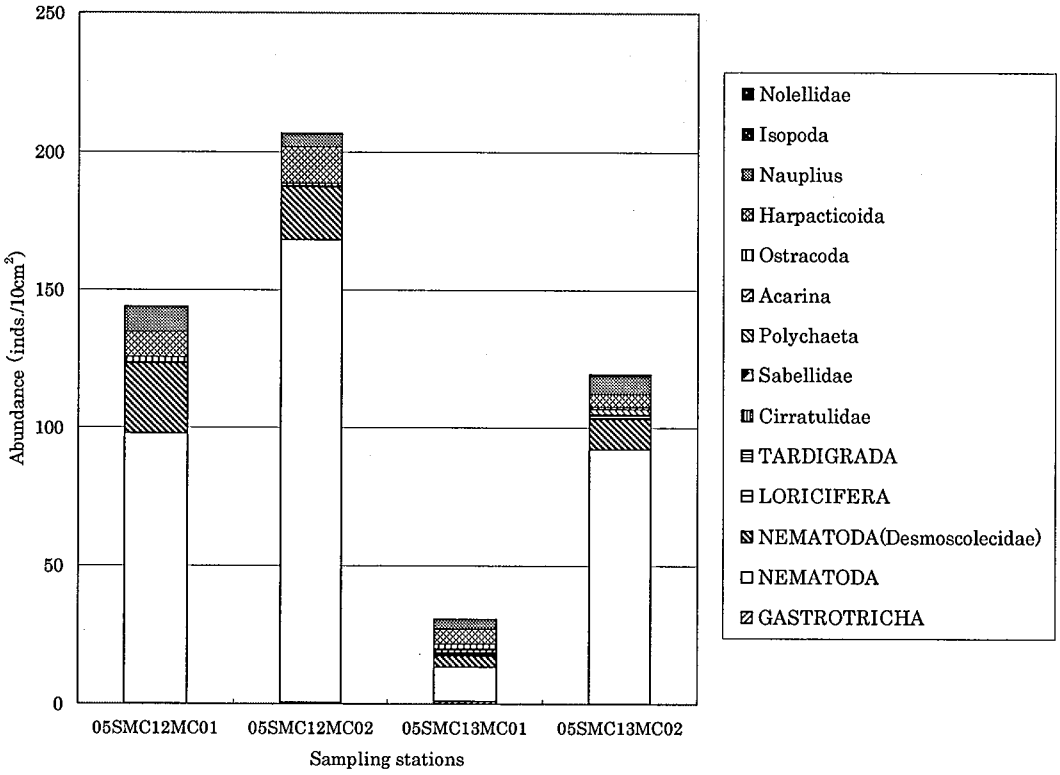


Figure 4-3-3 Abundances of meiobenthos at each station

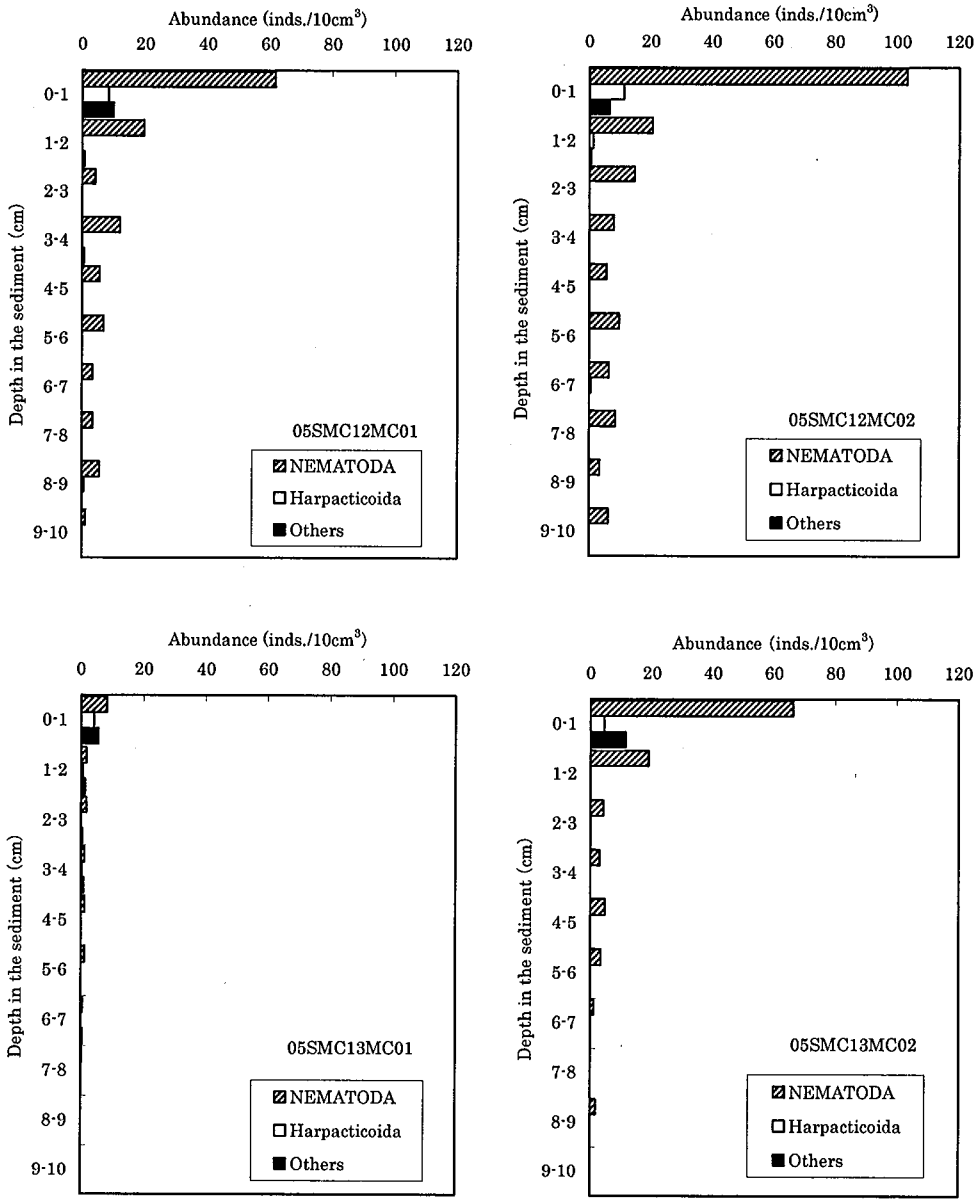


Figure 4-3-4 Vertical profiles of meiobenthos at each station

*Abundance of Nematoda in this figure is the sum of that of 「Nematoda」 and 「Nematoda (Desmoscolecidae)」 in Table 4-3-1

Table 4-3-2 Species and abundance of macrobenthos at each station

unit : inds./10cm^3

No.	Phylum	Class	Taxa	05SMC12MC01 (cm)									
				0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	NEMATODA	–	NEMATODA	0.1									
2	MOLLUSCA	Bivalvia	Bivalvia										
3	ANNELIDA	Polychaeta	Cirratulidae										
4			Sabellidae	0.1									
5			Polychaeta	0.1	0.1								
6	ARTHROPODA	Crustacea	Ostracoda										
7			Harpacticoida	0.1									
8			Isopoda	0.3									
			total	0.7	0.1	–	–	–	–	–	–	–	–

No.	Phylum	Class	Taxa	05SMC12MC02 (cm)									
				0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	NEMATODA	–	NEMATODA	0.1		0.1							
2	MOLLUSCA	Bivalvia	Bivalvia										
3	ANNELIDA	Polychaeta	Cirratulidae										
4			Sabellidae										
5			Polychaeta	0.3									
6	ARTHROPODA	Crustacea	Ostracoda										
7			Harpacticoida										
8			Isopoda										
			total	0.4	–	0.1	–	–	–	–	–	–	–

No.	Phylum	Class	Taxa	05SMC13MC01 (cm)									
				0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	NEMATODA	–	NEMATODA		0.1								
2	MOLLUSCA	Bivalvia	Bivalvia										
3	ANNELIDA	Polychaeta	Cirratulidae										
4			Sabellidae										
5			Polychaeta										
6	ARTHROPODA	Crustacea	Ostracoda	0.1									
7			Harpacticoida										
8			Isopoda										
			total	0.1	0.1	–	–	–	–	–	–	–	–

No.	Phylum	Class	Taxa	05SMC13MC02 (cm)									
				0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1	NEMATODA	–	NEMATODA										
2	MOLLUSCA	Bivalvia	Bivalvia	0.1									
3	ANNELIDA	Polychaeta	Cirratulidae	0.1									
4			Sabellidae										
5			Polychaeta	0.3									
6	ARTHROPODA	Crustacea	Ostracoda										
7			Harpacticoida										
8			Isopoda	0.1									
			total	0.6	–	–	–	–	–	–	–	–	–

"–" : absent

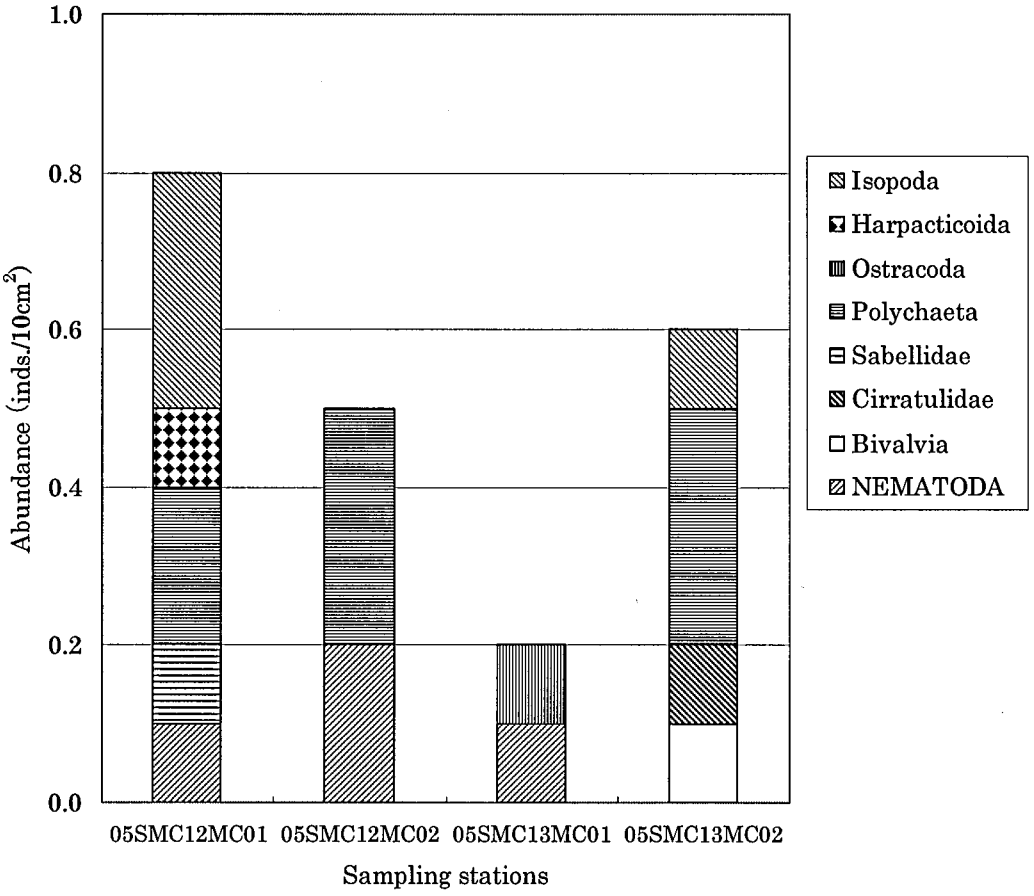


Figure 4-3-5 Abundances of macrobenthos at each station

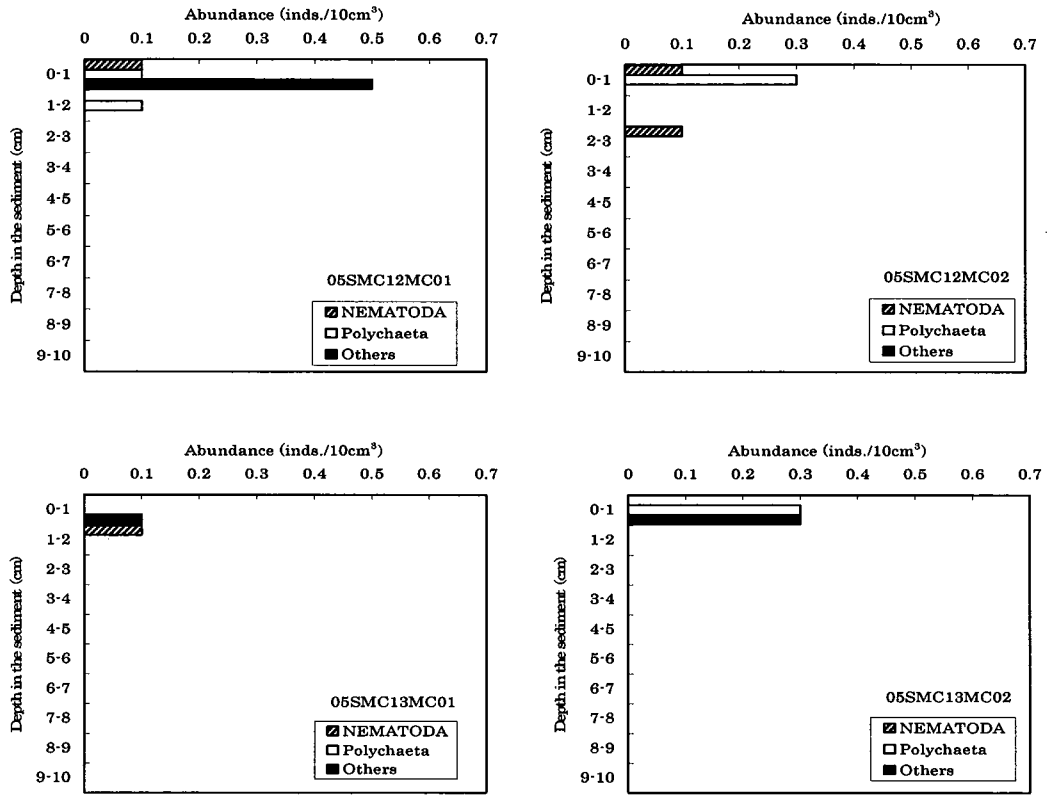


Figure 4-3-6 Vertical profiles of macrobenthos at each station

4-3-3 Summary

Vertical distributions of TOC and T-N were similar between stations 05SMC12MC01 and 05SMC12MC02. Similar patterns were also observed between stations 05SMC13MC01 and 05SMC13MC02 except that TOC and T-N concentrations in the upper layer were lower at 05SMC13MC01 compared with 05SMC13MC02. Station 05SMC13MC01 also showed the lowest water content in all layers compared with other stations.

Abundance of sedimentary bacteria was remarkably higher at station 05SMC13MC01. In contrast, however, meio- and macro-benthos have lower abundance in this station. This inverse relationship between the bacteria and abundance of benthic organisms (especially meiobenthos) could probably imply that there was a lesser grazing impact on the sedimentary bacteria due to the very low abundance of meiobenthos, thus paving way for the bacteria to increase its population.

5. Conclusion

Environmental investigations on water quality, bacterioplankton, sediment properties and benthic organisms were carried out in the Federated States of Micronesia as a baseline study in order to predict future impacts of deep-sea mining on the surrounding environment.

Vertical distribution of water quality and bacterioplanton were similar in both stations (05SMC12RO01, 05SMC13RO01). Although a mixed layer between the surface and 100m layers and a thermocline between the 100m and 300m layers were observed, layers deeper than 300m were considered stable due to the very minimal variation in temperature and salinity.

PO_4-P and NO_3-N vertical distribution were similar in both stations – low from the surface to 100m, increasing from 100m down to 500m and almost stable from 500m and deeper. As regards to SiO_2-Si, its vertical distribution was similar with that of PO_4-P and NO_3-N except that maximum concentration of SiO_2-Si was observed at 1,000m.

The vertical profile of bacterioplankton abundance was analogous to that of water temperature in both stations. Based from all these results, both stations have similar characteristics and are considered stable environments.

In terms of sediment properties, stations 05SMC12MC01 and 05SMC12MC02, 05SMC13MC01 and 05SMC13MC02 have similar vertical distribution pattern of TOC and T-N. Similar patterns were also observed between stations 05SMC13MC01 and 05SMC13MC02 except that TOC and T-N concentrations in the upper layer were lower at 05SMC13MC01 compared with 05SMC13MC02. Station 05SMC13MC01 also showed the lowest water content in all layers compared with other stations.

Generally, station 05SMC13MC01 is characterized by: high abundance of sedimentary bacteria but low abundance of meio- and macro-benthos. Based from the results of sediment properties and benthic organisms survey it may be assumed that benthic environment of station 05SMC13MC01 may be different from that of other station thus, a different population of benthic organism exist in this area. Even though both stations 05SMC13MC01 and 05SMC13MC02 belong to MC13 area, their benthic environmental characteristics were different. These differences maybe be attributed to the ocean current and their respective topography, however, the influence of these factors remain unclear.

Appendix 6-1 Analytical results for nutrients

Station	Depth (m)	PO_4-P (mg/l)	SiO_2-Si (mg/l)	NO_2-N (mg/l)	NO_3-N (mg/l)
05SMC12RO01	0	0.003	0.02	<0.001	<0.01
	50	0.003	0.11	<0.001	<0.01
	100	0.003	<0.01	<0.001	<0.01
	150	0.018	0.10	<0.001	0.05
	200	0.048	0.53	<0.001	0.22
	250	0.064	0.79	<0.001	0.29
	300	0.077	1.14	<0.001	0.34
	400	0.074	1.05	<0.001	0.34
	500	0.080	1.31	<0.001	0.37
	1000	0.089	2.00	<0.001	0.44
	1500	0.091	1.56	<0.001	0.43
	2000	0.089	1.56	<0.001	0.45
05SMC13RO01	0	0.003	0.02	<0.001	<0.01
	50	0.003	0.06	<0.001	<0.01
	100	0.006	<0.01	<0.001	<0.01
	150	0.018	0.12	<0.001	0.06
	200	0.036	0.41	<0.001	0.17
	250	0.052	0.66	<0.001	0.25
	300	0.061	0.83	<0.001	0.26
	400	0.076	1.20	<0.001	0.36
	500	0.082	1.35	<0.001	0.40
	1000	0.094	1.88	<0.001	0.45
	1500	0.092	1.51	<0.001	0.44
	2000	0.086	1.52	<0.001	0.40

Appendix 6-2 Analytical results for bacterioplankton

Station	Depth (m)	Cell number (cells/ml)
05SMC12RO01	0	6.07E+05
	50	5.96E+05
	100	5.60E+05
	150	2.20E+05
	200	1.06E+05
	250	9.16E+04
	300	7.62E+04
	400	6.63E+04
	500	6.17E+04
	1000	2.97E+04
	1500	1.51E+04
	2000	1.07E+04
05SMC13RO01	0	5.54E+05
	50	5.49E+05
	100	4.42E+05
	150	1.76E+05
	200	1.22E+05
	250	8.45E+04
	300	6.48E+04
	400	5.69E+04
	500	4.12E+04
	1000	2.42E+04
	1500	1.32E+04
	2000	1.30E+04

Appendix 6-3 Analytical results for sediment properties

Station	Layer (cm)	Water content (%)	TOC (mg/g-dry)	T-N (mg/g-dry)	Specific gravity
05SMC12MC01	0−1	69.5	1.89	0.31	2.71
	1−2	57.7	1.55	0.29	2.70
	2−3	54.3	1.61	0.25	2.71
	3−4	53.8	1.56	0.28	2.70
	4−5	52.1	1.18	0.18	2.70
	5−6	52.0	1.15	0.16	2.70
	6−7	51.8	1.24	0.19	2.70
	7−8	52.5	1.08	0.15	2.70
	8−9	53.1	1.08	0.20	2.70
	9−10	52.1	1.24	0.17	2.70
05SMC12MC02	0−1	57.8	1.44	0.27	2.65
	1−2	52.3	1.22	0.18	2.70
	2−3	50.9	0.93	0.16	2.70
	3−4	50.7	1.10	0.22	2.70
	4−5	52.1	1.08	0.15	2.70
	5−6	51.7	0.96	0.16	2.70
	6−7	50.6	0.99	0.20	2.70
	7−8	48.8	0.99	0.15	2.70
	8−9	48.9	0.96	0.10	2.70
	9−10	48.3	0.94	0.14	2.70
05SMC13MC01	0−1	44.8	1.10	0.20	2.70
	1−2	42.0	1.04	0.16	2.70
	2−3	42.3	0.87	0.14	2.70
	3−4	44.5	0.84	0.13	2.70
	4−5	44.3	0.82	0.16	2.70
	5−6	43.5	0.73	0.12	2.70
	6−7	45.0	0.89	0.15	2.70
	7−8	42.5	0.75	0.19	2.70
	8−9	46.0	0.79	0.15	2.70
	9−10	43.7	0.92	0.22	2.70
05SMC13MC02	0−1	62.4	1.66	0.29	2.69
	1−2	53.0	1.36	0.26	2.68
	2−3	51.2	1.25	0.22	2.69
	3−4	52.0	1.16	0.19	2.69
	4−5	50.2	1.04	0.16	2.68
	5−6	49.7	1.19	0.19	2.68
	6−7	49.9	1.04	0.15	2.69
	7−8	48.9	0.92	0.16	2.73
	8−9	49.0	0.88	0.16	2.72
	9−10	48.2	1.14	0.19	2.72

Appendix 6-4 Analytical results for sedimentary bacteria

Station	Layer (cm)	Cell number (cells/g-dry)
05SMC12MC01	0-1	8.36E+07
	1-2	3.40E+07
	2-3	3.16E+07
	3-4	1.72E+07
	4-5	1.32E+07
	5-6	1.49E+07
	6-7	8.92E+06
	7-8	6.15E+06
	8-9	9.56E+06
	9-10	4.54E+06
05SMC12MC02	0-1	2.05E+07
	1-2	2.26E+07
	2-3	2.33E+07
	3-4	1.39E+07
	4-5	2.30E+07
	5-6	1.15E+07
	6-7	1.13E+07
	7-8	5.38E+06
	8-9	7.03E+06
	9-10	7.04E+06
05SMC13MC01	0-1	2.60E+08
	1-2	8.90E+07
	2-3	6.59E+07
	3-4	5.53E+07
	4-5	4.20E+07
	5-6	4.47E+07
	6-7	3.64E+07
	7-8	3.05E+07
	8-9	1.87E+07
	9-10	1.40E+07
05SMC13MC02	0-1	7.82E+07
	1-2	3.13E+07
	2-3	1.98E+07
	3-4	1.10E+07
	4-5	1.29E+07
	5-6	7.68E+06
	6-7	9.86E+06
	7-8	6.17E+06
	8-9	6.64E+06
	9-10	3.47E+06