

Chapter 2 Survey Methods

2-1 Survey Procedure

The survey of this year is the first year of Stage II Phase 2 Program started from the year 2003, and the survey was carried out for the understanding of manganese nodule resources potential within the Exclusive Economic Zone (EEZ) of Niue.

The Niue sea area is situated in the western vicinity of the EEZ of the Republic of the Cook Islands, where a high potentiality of manganese nodules resources has been confirmed in the surveys of previous years, and a similar occurrence of manganese nodules is expected to continue toward west to the EEZ of Niue.

For the collection of manganese nodules and sea-bottom materials by using free fall grab (FG) and Spade Corer (SC) sampler, a total of 14 sampling stations were set on 60 nautical mile grid spacing which correspond to intersections of cardinal number of latitude and longitude of approximately one degree interval.

The sampling of 3FG/station x 2 stations or combination of 3FG/station x 1 station and (2FG + 1SC)/station x 1 station were routinely conducted each day for collecting manganese nodules and sediments.

Bathymetric survey by acoustic soundings was conducted as efficiently as possible to collect maximum data, and it is basically conducted during nighttime when sampling work was not carried out.

For the environmental survey, surface sediments and benthos were sampled by SC. The sampling was done along the line of longitude 169° W to understand the variation of environmental characteristics on N-S direction of the sea area

2-2 Numbering

(1) Numbering of Track Lines

The track lines of acoustic soundings (NBS, PDR, SBP and MFES) were numbered such as 03S1117A or 03S1117B for identification of the date and the order of work. For nighttime cruising, "N" was added at the end of numbers such as 031117N. In above cases, "03" indicates the fiscal year of the survey (2003). "S" denotes SOPAC. "1117" shows month and date (November 17), and "A" and "B" the order of track line on that date.

(2) Numbering of Stations and Sampling Points

The station was numbered sequentially in the order of sampling, starting from 03501. For 03501, "03" indicates the fiscal year of the survey (FY 2003), "5" the fifth

cruise of this year, and "01" sampling number (Fig. 2-2-1).

The sampling site was numbered putting 03S (03 for fiscal year 2003, S for SOPAC) at the beginning. The survey area was divided into quadrilaterals bounded by longitudinal and latitudinal lines at interval of one degree. To those quadrilaterals, four-digit area-code numbers were given (Fig. 2-2-2). In these numbers, the first two digits designate the latitude of southern end of quadrilaterals and the last two digits indicate the longitude, starting from 11 at 175 ° E and incremental toward east such as 12, 13, 14, and so on. The samplings in each quadrilateral area were sequentially numbered adding survey methods. For example, 031827FG01 indicates the first sample (01) by the Free-Fall Grab (FG) method in the 1827 area in fiscal year 2003.

2-3 Ship Positioning

During the survey, all the ship positions were determined by the global positioning system (GPS).

The locations of sampling point, launching location for FC and bottom touch location of SC, were determined by GPS installed beside the gallows, and water depth of the sampling points were determined by MBES.

The ship clock was adjusted to local time (GMT + 13 hours) and the coordinate system used during the survey was WGS84.

2-4 Bathymetric and Acoustic Surveys

The bathymetric and acoustic sounding data were collected during the sailing between sampling points and nighttime at vessel cruising speed of 10 to 12 knot. The MBES (frequency 15kHz) sounding was carried out at every 8 to 16 seconds and every 12 seconds for NBS (frequency of 30kHz). During the bathymetric survey, acoustic reflection intensity was measured by MBES and acoustic pressure distribution map was made.

2-5 Surface Sediments Survey

The survey of the sub-surface sediments was carried out by SBP (frequency 3.5kHz) on all the track lines simultaneously with bathymetric survey.

From the pattern of SBP profiles, basic information of sub-surface sediments such as thickness of uppermost transparent layer and acoustic stratigraphic types were obtained. These data were read at every 5 minutes and the distribution maps of SBP types and thickness of the uppermost transparent layer were drawn.

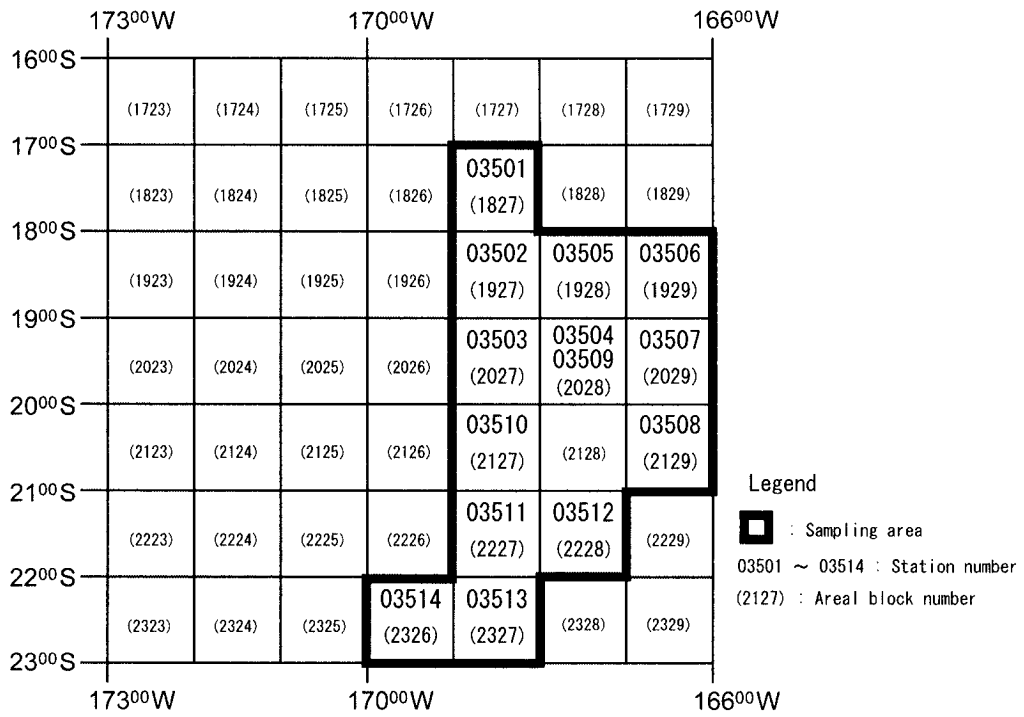


Fig 2-2-1 Location Map of Stations

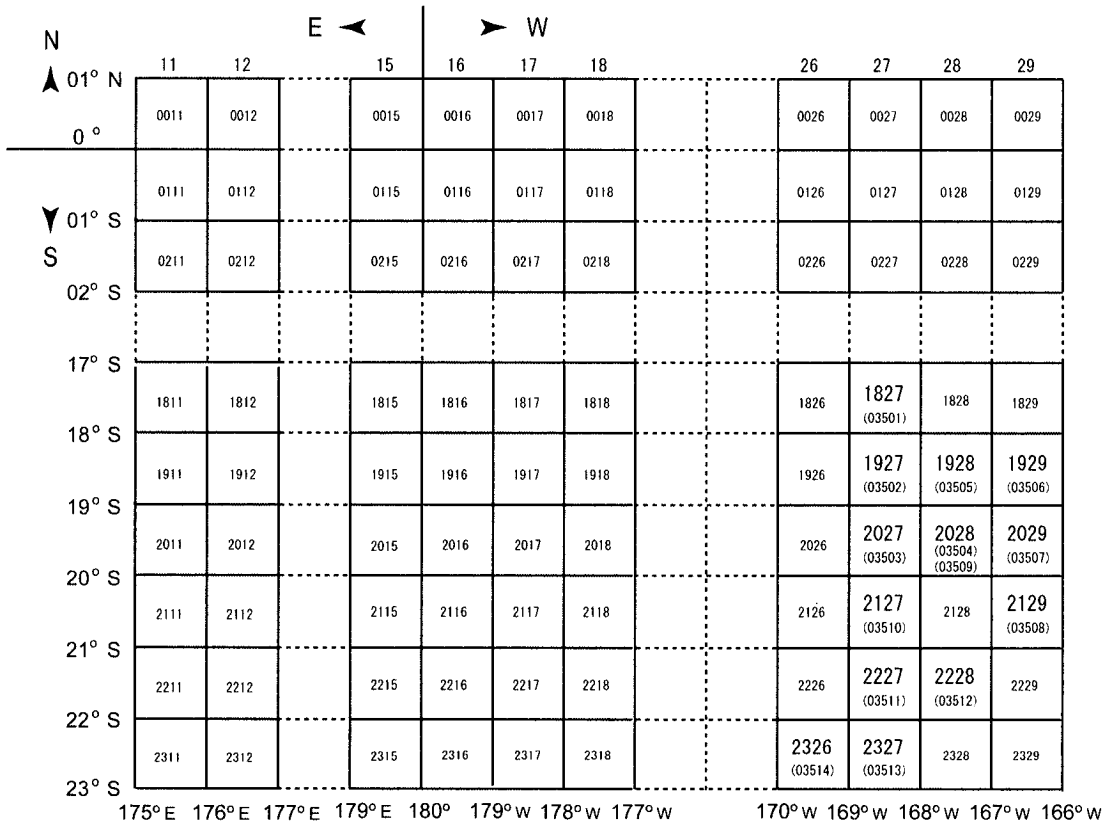


Fig. 2-2-2 Location Map of Area Codes

2-6 MFES Survey of Manganese Nodules

The distribution density (abundance) of manganese nodules was estimated by the Multi Frequency Exploration System (MFES) on all track lines simultaneously with bathymetric and sub-surface sediments surveys.

MFES data are calculated continuously from sound pressure data of the Narrow Beam echo Sounder (NBS), Precision Depth Recorder (PDR), and Sea-Bottom Profiler (SBP) at every 12 seconds. For elimination of noise and errors running average of 15 measurements was calculated by data processing system. The results of calculation and raw data were, respectively, stored in Sun mini-computer system and data acquisition system.

Using the stored data, abundance of manganese nodules map were drawn from off-line data processing system.

2-7 Sampling

Sampling was carried out mainly by Free-fall Grab (FG) and Spade Corer (SC) was used only at certain points. In addition to the sampling, photographs of seafloor were taken by deep-sea camera mounted on FG and SC.

Distance between each sampling station of this survey is 60 nautical miles. At each station, three samplings by FG were carried out in the following manner. Three sampling points were set to locate at three apexes of a right-angled isosceles triangle, base (right angle apex) being set at north. The length of the base corresponds to 2 minutes of longitude (approximately 2 nm) and the distance between the south apex and the base line is 1 minute of latitude (approximately 1 nm). The sampling is started from the south apex point and then second (western apex of the base) and third point (eastern apex of the base) in clockwise direction.

Density (abundance) of manganese nodules of three points are averaged and treated as average abundance of a station. Geometry of three sampling points and the sampling order at a station is shown in Figure 2-7-1.

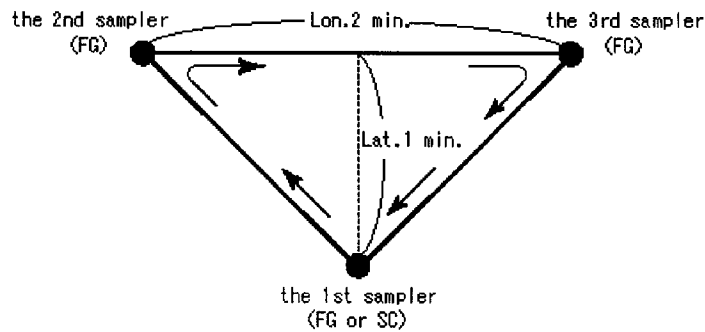


Fig. 2-7-1 Locations of Sampling Sites at Each Sampling Station

When SC is used for sampling instead of FG, it was conducted at the first point (south apex point).

In rare cases, FG sampling resulted in fail with insufficient amount of nodules because of troubles and accident, sea-bottom photographs are referred to calculate occupancy ratio of manganese nodules and the abundance of manganese nodules was estimated.

2-8 Sample Preparations, Analysis and Storage

Following the flow sheet in Fig. 2-8-1, collected samples (manganese nodules and sediments) were classified, described and prepared for laboratory work. After the cruise, laboratory work such as microscopic inspection, bulk chemical analysis, identification of fossils was conducted and the rest of samples were kept in storage.

2-9 Processing and Analysis of Survey Data

Data processing and analysis were conducted following the flow sheet shown in Fig. 2-9-1. Preliminary processing and analysis were conducted on board. A part of the data processing left undone during the cruise and comprehensive analysis were continued after the cruise and the results were compiled in the report

2-10 Environmental Survey

(1) Objectives

An environmental survey was conducted as a baseline study to understand environmental situation of present day for future evaluation of potential mining impacts on the deep-sea environment. In this survey, properties of the sediment and distributions of benthic organisms were examined. These properties of the sediment are the key parameters affecting the habitat conditions of benthic organisms.

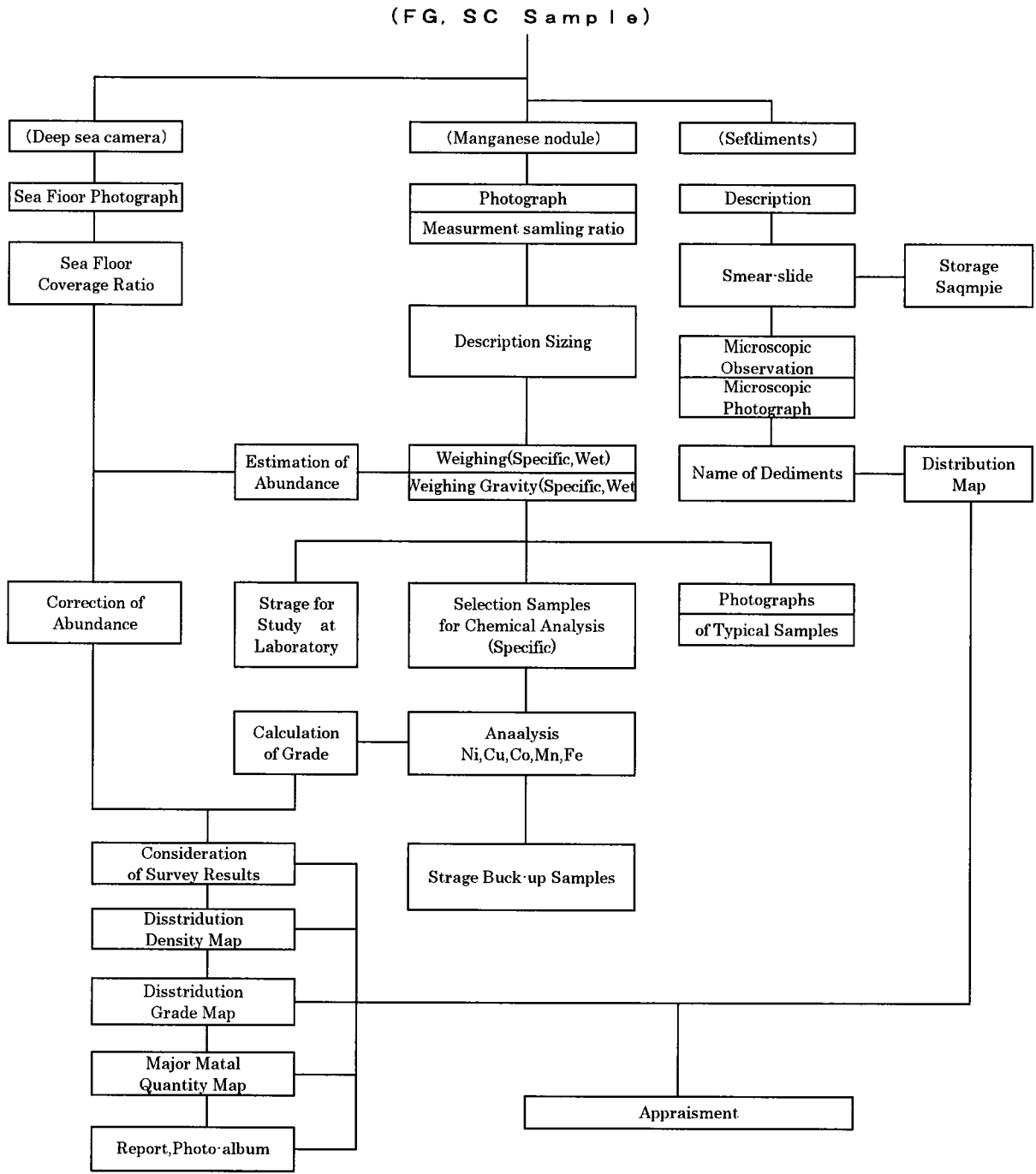


Fig. 2-8-1 Sample Preparation and Assaying Flowsheet

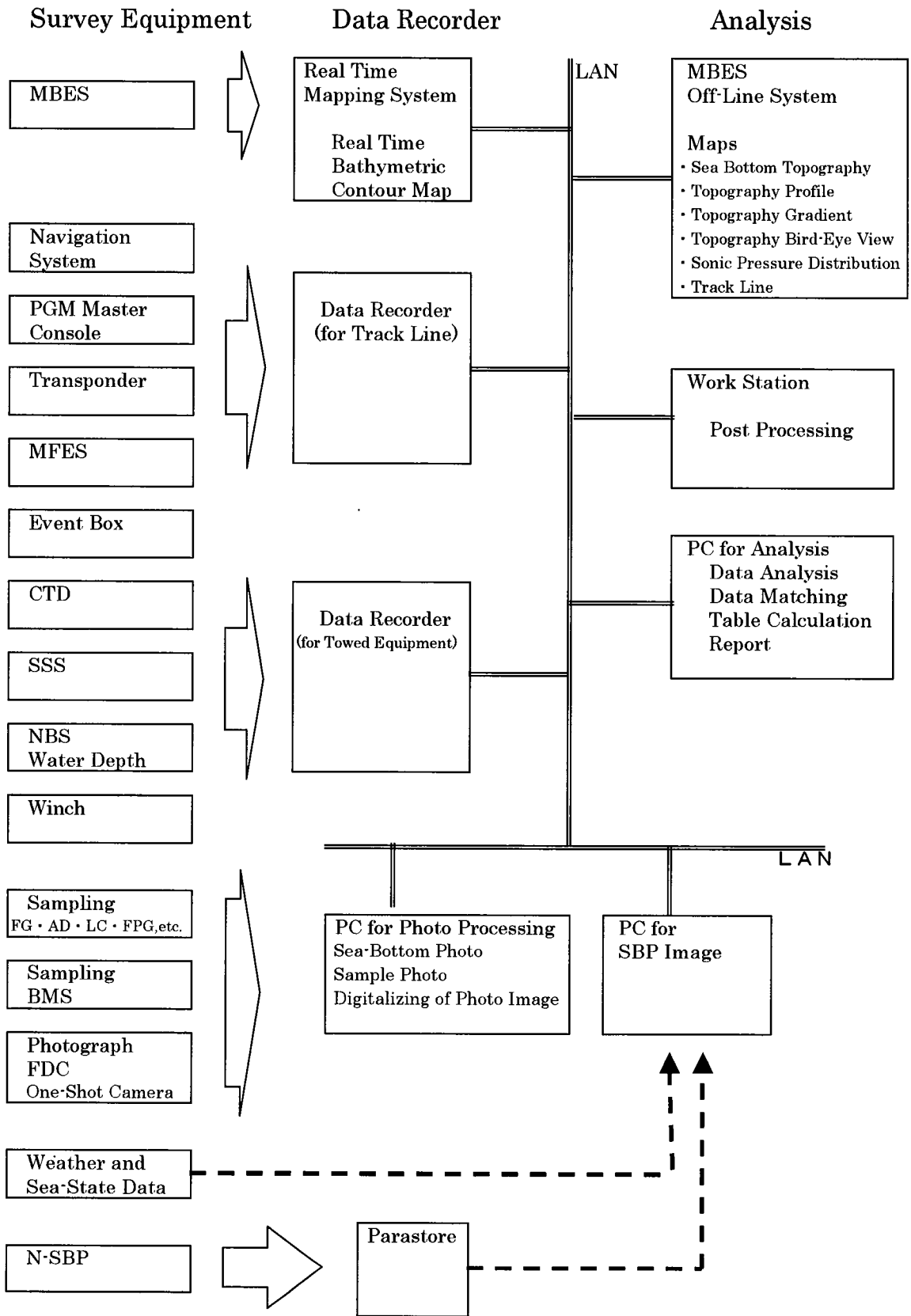


Fig. 2-9-1 Data Processing and Analysis Flowsheet

(2) Study Subjects

1) Sediment Properties

- i. Water content, ii. Specific Sediment Gravity, iii. Total Organic Carbon,
- iv. Total Nitrogen, v. Sediment Particle Size Distribution

2) Benthic Organisms

- i. Meiobenthos, ii. Macrobenthos

(3) Methods

1) Sampling and Sample Processing

Spade Corer (SC) was used for collecting sediments samples and acrylic tube cores (inner diameter: 95 mm) were inserted into the sediments. A single core was used for both the analysis of specific sediment gravity and sediment particle size distribution. Duplicate cores were used for other analyses of sediment properties. The cores were sliced at every 1 cm from the surface to 5 cm depth for all analyses. Analyses of sediments at 10cm, 20cm and 30cm layers were carried out for water content, specific sediment gravity and sediment particle size distribution. For the benthic organism analysis, duplicate cores were used and were sliced at every 1 cm from the surface to 5 cm deep. After slicing, each sample was processed as described in Table 2-10-1 prior to analyses.

2) Analysis

a. Sediment Properties

• Water content

After measuring the wet weight (WW) of a suitable amount of the sediments, they were dried in an oven at 50°C, and then measured again to obtain the dry weight (DW). Water content of the sediments (WC) was calculated according to the following formula.

$$WC(\%) = (WW - DW) / WW \times 100$$

• Specific Sediment Gravity

The sediments were dried in an oven at 110°C, and then ground with a mixer. The specific gravity of the sediments was then determined using a picnometer.

Table 2-10-1 Analyses, Sample Processing and Preservation

Study Subjects	Number of cores	Sample processing and preservation
1)Sediment Properties		
i.Water Content	2	Sliced into 5 layers at every 1 cm, plus 10 cm, 20 cm, 30 cm and then kept frozen until the analysis
ii.Specific Sediment Gravity	1	Sliced into 5 layers at every 1 cm, plus 10 cm, 20 cm, 30 cm and then kept frozen until the analysis
iii.Total Organic Carbon	2	Sliced into 5 layers at every 1 cm and then kept frozen until the analysis
iv.Total Nitrogen	2	Sliced into 5 layers at every 1 cm and then kept frozen until the analysis
v.Sediment Particle Size Distribution	1	Sliced into 5 layers at every 1 cm, plus 10 cm, 20 cm, 30 cm and then kept refrigerated until the analysis
2)Benthic Organisms		
i.Meiobenthos	2	Sliced into 5 layers at every 1 cm, fixed and stained with neutralized formalin (10% V/V) with Rose Bengal and then kept refrigerated until the analysis
ii.Macrobenthos	2	Sliced into 5 layers at every 1 cm, fixed and stained with neutralized formalin (10% V/V) with Rose Bengal, and then kept refrigerated until the analysis

• Total Organic Carbon and Total Nitrogen

After the sediments were dried in an oven at 50°C, they were transferred into a combustion dish. A suitable amount of 4N HCl was then added and the samples were dried up in a dessicator to remove inorganic carbon. Subsequently, total organic carbon and total nitrogen were determined using a CHN analyzer (YANAGIMOTO Model MT-5).

• Sediment Particle Size Distribution

Particle size distribution of sediments was determined using a MICROTRAC (NIKKISO Model MT300). The range of particle diameter determined was 0.02~1400µm.

b.Benthic Organisms

Generally, benthic organisms are categorized by size. In coastal studies, a mesh size of 500µm or 1000µm is used to set the lower size limit of macrobenthic organisms, while in deep-sea studies, a mesh size of 32µm is used as lower size limit for meiobenthic organisms. But since deep-sea benthic organisms show the tendency to be

smaller than coastal organisms, meiobenthic and macrobenthic fauna was separated by using a smaller mesh size of 300µm in present studies.

- Meiobenthos

Materials were stained with Rose Bengal, and then sieved at 32 µm and 300 µm mesh sizes. Organisms, which passed through the 300 µm mesh and remained after sieving at 32 µm, were identified and individuals were counted. Foraminifera were excluded from the quantitative analysis, as they are fragile and difficult to count.

- Macrobenthos

Materials were stained with Rose Bengal, and then sieved at a mesh size of 300 µm. Organisms that remained on the mesh were identified and individuals were counted. As with the meiobenthos samples, faunal groups (Foraminifera and Porifera), which were difficult to count, were excluded from the quantitative analysis.