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Application of the IOCAS Large Volume Water Transfer System in the Research of the Tropical Western Pacific Seamounts

Yonghua Chen[1,a,*], Hegang Hu[1,2], Qingkui Liu[1], Bin Jiang[1]

[1]Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China
[2]University of Chinese Academy of Sciences, Beijing, China
[a]yonghuachen@aliyun.com
**Yonghua Chen*

Abstract: *Seamount refers to the uplift that is more than 1000 meters high from the seabed, but still does not protrude from the sea level. Seamounts are similar to ridges on land and the typical seamounts are formed by dead volcanoes. It is estimated that there are more than 30000 seamounts in the global ocean, more than 60% of which are distributed in the Pacific Ocean. According to reports, the main feature of seamounts is that they are rich in marine biodiversity. Understanding rare suspended particulate matter (including planktonic microorganisms) in the seamount is important but difficult to sample, for which we deigned a large-sized in-situ water sampler (200—1000L), i.e., a large volume water transfer and graded filtration system. The system comprises of a deep-sea pump assemble, a filtering device, data acquisition and control devices, a supporting frame, a power supply component, a connecting mechanism, and a flow meter, etc. The filtering device integrates membranes for three-graded filtration at 0.22, 1, and 5μm. The system has been applied for high-level multi-layer filtration to obtain planktonic microorganisms in tropical western Pacific seamounts of Yap seamount and Caroline seamount. The applications of the large volume water in-situ transfer in the seamounts practice show: The in-situ filtration completed by large volume water transfer system is an effective method, which has much more efficiency and simplicity than traditional method of taking water out and filtrating on deck. In situ filtration of the large volume water transfer system is of great significance in reducing the real community structure of deep-sea microorganisms. The deeper the sampling depth, the greater the loss caused by traditional methods, and this loss is biased, which will lead to the loss of nearly 50% of microbial species.*

Keywords: *Large volume water transfer system, in-situ filtration, seamount, particulate organic matter(POM), concentration of microorganism*

1. Introduction

Understanding rare suspended particulate matter (including planktonic microorganisms) in the deep sea, especially in the seamount, is important but difficult to sample, for which we deigned a large-sized in-situ water sampler (200—1000L), i.e., a large volume water transfer and graded filtration system. The system comprises of a deep-sea pump, a filtering device, data acquisition and control devices, a supporting frame, a power supply component, a connecting mechanism, and a flow meter, etc. The filtering device integrates membranes for three-graded filtration at 0.22, 1, and 5 μ m, and an additional membrane aperture upon the need. The control device adopts two working modes: depth trigger and time trigger. The system can be added with a CTD and a fluorescence meter, etc. In addition, for a stationed site survey, several sets (such as 3 sets) of the system can be fixed at an interval on the suspension cable to work at different depths simultaneously. The system can be applied for high-level multi-layer filtration to obtain suspended particles. The system has been applied in several marine expeditions. The development of this system provides an ideal tool for deep-sea in-situ sampling technology in China.

The primary condition for studying deep-sea suspended particulate matter (including planktonic microorganisms and trace elements) is to obtain a certain number of suspended particulate matter samples with in-situ characteristics[1]. The traditional method is mainly to use deep-sea water sampler to collect water, and then lift it to the laboratory on board to filter and obtain samples. Due to the low

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content of suspended particulate matter or plankton community or microorganism in most waters of the ocean, in order to carry out its research, it is sometimes necessary to collect the water from several hundred liters to 1000 liters[2], and it may be necessary to collect more water, even up to 4000 liters to carry out the research in the deep ocean[3]. However, the volume of sampling bottle is too small to obtain enough samples and complete community combination to meet the needs of analysis and research. That is to say, the samples from traditional sampling are sometimes difficult to meet the needs of the rapidly developing earth science, environmental science, marine biology and marine resources research[4]. Moreover, sometimes in order to study the suspended particulate matter or marine planktonic microorganisms at a certain station in the deep sea, it is necessary to take deep-water for many times, while a single deep-sea water intake takes several hours, which greatly prolongs the time of scientific research vessels. The cost of the scientific examination based on scientific vessel is more than ten thousand yuan per hour. At the same time, the deep-sea water sampler needs cooperation of many people, and the filtration in the ship's laboratory is also very time-consuming. All of this takes too much economic and human cost. Therefore, in view of the requirements of obtaining samples in deep-sea suspended particulate matter research, it is necessary to develop a simple, efficient and universal new sampling method and technology. The deep-sea in-situ microporous filtration sampling technology is a sampling method to obtain samples through in-situ filtration. The high-throughput deep-sea water sampling and grading filtration system based on this principle is successfully developed by the Institute of Oceanology, Chinese Academy of Sciences. The high-throughput deep-sea water sampling and grading filtering system is mainly composed of pumping and filtering control and power supply system, deep-sea pump, filtering chamber, one-way valve and flow meter (Figure 1). It can be used to collect samples of plankton, trace metals and sedimentary particles in oceans, lakes, rivers, reservoirs and other water.

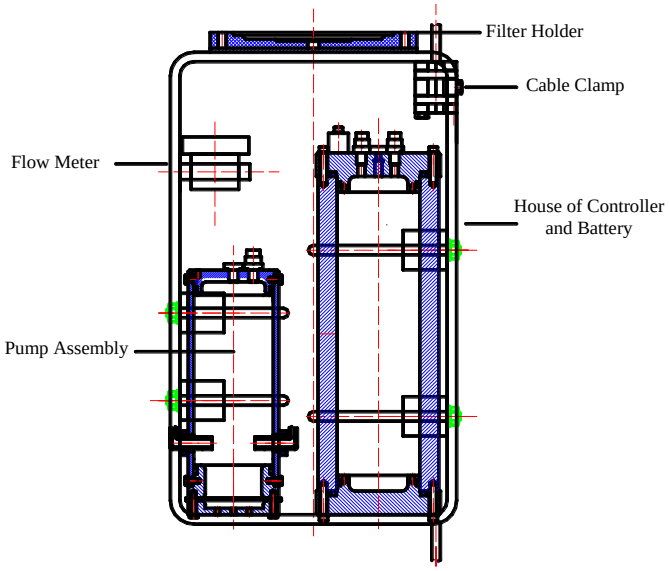

Figure 1: The sketch of the large volume water transfer and graded filtration system.

Technical Specifications is shown in Table 1.

Table 1: Technical specifications of the large volume water transfer and graded filtration system for in-situ sampling in deep-sea.

Specifications	Data	Specifications	Data
Maximum Depth	4000m	Pressure Accuracy	0.1% (FSO)
Work Mode	Triggered by Depth or Time	Flow Rate	About 5L/min
Filter Number	≥3	Flow Error	<5%
Filter Diameter	200mm	Dimensions	(Lenth:90×Width:57×Height:26)cm3
Continue Work Time	>26h	Weight	35kg(In air)

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2. Application in the Research of the Tropical Wester Pacific Seamounts

Based on the research needs, the application system structure is shown in the Figure 2.

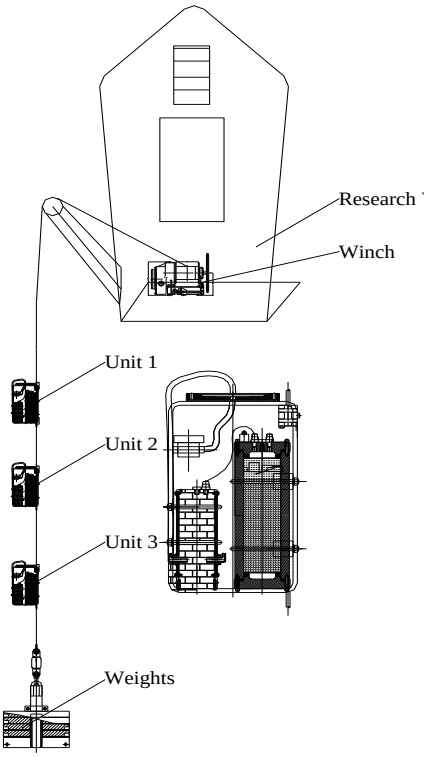

Figure 2: Multi layer synchronous implementation scheme of deep sea in situ filtration.

A few in-situ large volume water transfer and filter samplers are laid on the mooring line of the shipborne winches in layers. If the sample system is composed of three high-throughput seawater sampling and grading measuring devices, enough samples of deep-sea suspended particles or planktonic microorganisms can be simultaneously obtained in multiple layers (such as 100m, 1000m, 2000m, etc., as shown in Figure 2).

From March to April 2016, we carried out the sampling application in Yapu seamount area with the "science" research vessel, and took samples from six stations. The filter membrane used in the sampling station was 0.22 μ m at the bottom layer, middle layer 1 μ m and top 5 μ m. The filtration time is 20 minutes and the water sample is 50-80 liters.

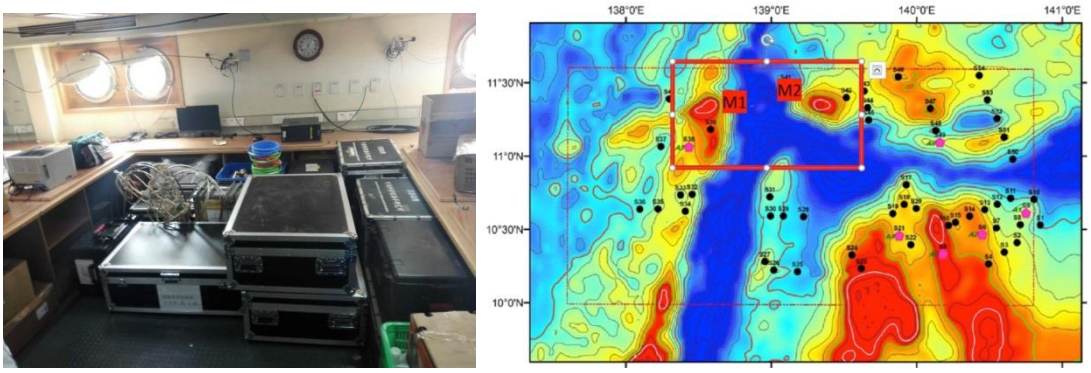

Figure 3: Equipment on board and test station in Yapu seamount.

From August to early September 2017, the ship "science" carried out the voyage application in Caroline seamount. During this voyage, The samples obtained from the large volume in-situ filtrations and the deck filtration of the water collected by the water sampler were compared and tested. The test application site is shown in Figure 4. A total of 45 membrane samples were obtained with 200 liters of water filtered on the deck. 36 membrane samples were obtained by in-situ filtration at the same position, and a total of 81 membrane samples were obtained.

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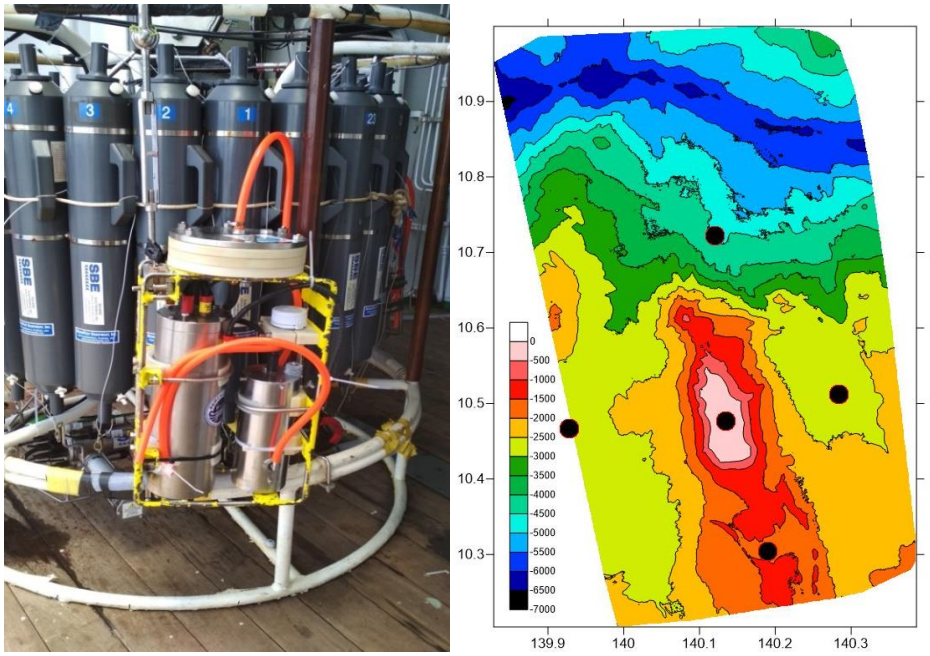

Figure 4: Application of Caroline seamount Voyage.

3. Analysis of Experimental Results

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According to the samples obtained during the voyage of Yapu seamount, POM of the sea surface and maximum chlorophyll layer were analyzed and the δ13Cand δ15Nwas determined. The results show that POM is effective and the levels of δ13C is about - 26 ‰(As shown in Figure 5). The data is reasonable, which provides important data support for the determination of food sources of zooplankton.

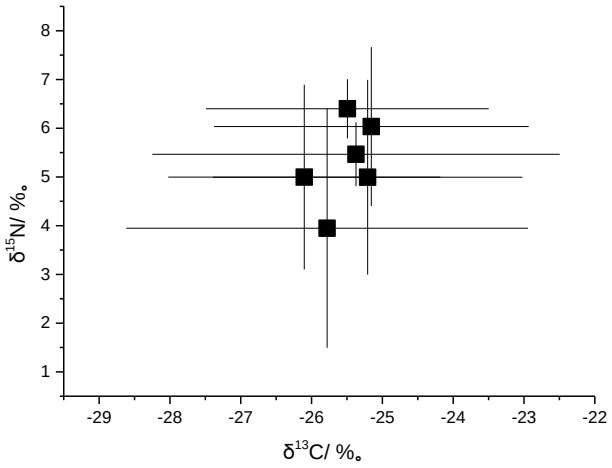

Figure 5: Content of the the δ13Cand δ15N in the sea surface and chlorophyll maximum layer.

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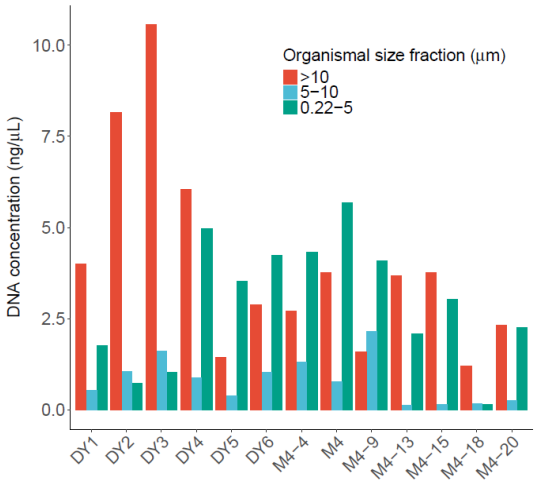

Figure 6: DNA concentration in different test station.

The samples from Caroline seamount area were analyzed and the total DNA content of 0.015 – 0.045 μ g was obtained. The results show that the Caroline seamount is oligotrophic sea area with low microbial content. On the basis of DNA extraction, amplification sequencing and other analysis were carried out. As shown in Figure 6, after multistage filtration, the biological content intercepted by 5 μm pore size membrane was the lowest. The total DNA content of each particle size class showed a trend of high content at the top and foot of the seamount and low on the hillside. The biological content of upstream was higher than that of downstream. The total amount of DNA in surface of upstream was the highest, and that in chlorophyll layer of downstream was the highest. And with the decrease of latitude, there is a trend of miniaturization.

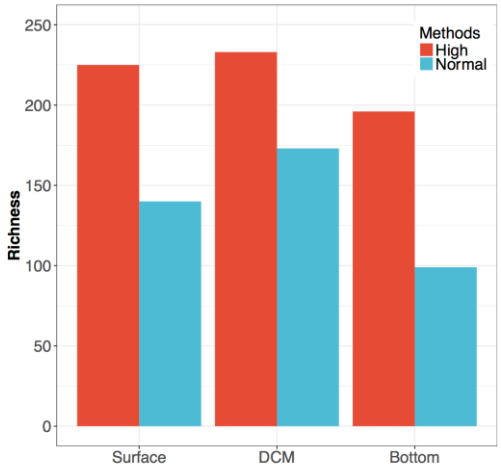

Figure 7: Comparison of different methods for obtaining microbial richness.

As shown in Figure 7, more species can be obtained by in situ filtration than by deck filtration. With the increase of depth, more species were obtained by in-situ filtration.

4. Conclusions

The in-situ filtration completed by large volume water transfer system is an effective method, which has much more efficiency and simplicity than traditional method of taking water out and filtrating on deck. The high-throughput deep-sea water sampling and grading filtration system based on this principle is successfully developed by the Institute of Oceanology, Chinese Academy of Sciences. In situ filtration of the large volume water transfer system is of great significance in reducing the real community structure of deep-sea microorganisms. The deeper the sampling depth, the greater the loss caused by traditional methods, and this loss is biased, which will lead to the loss of nearly 50% of

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microbial species.

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